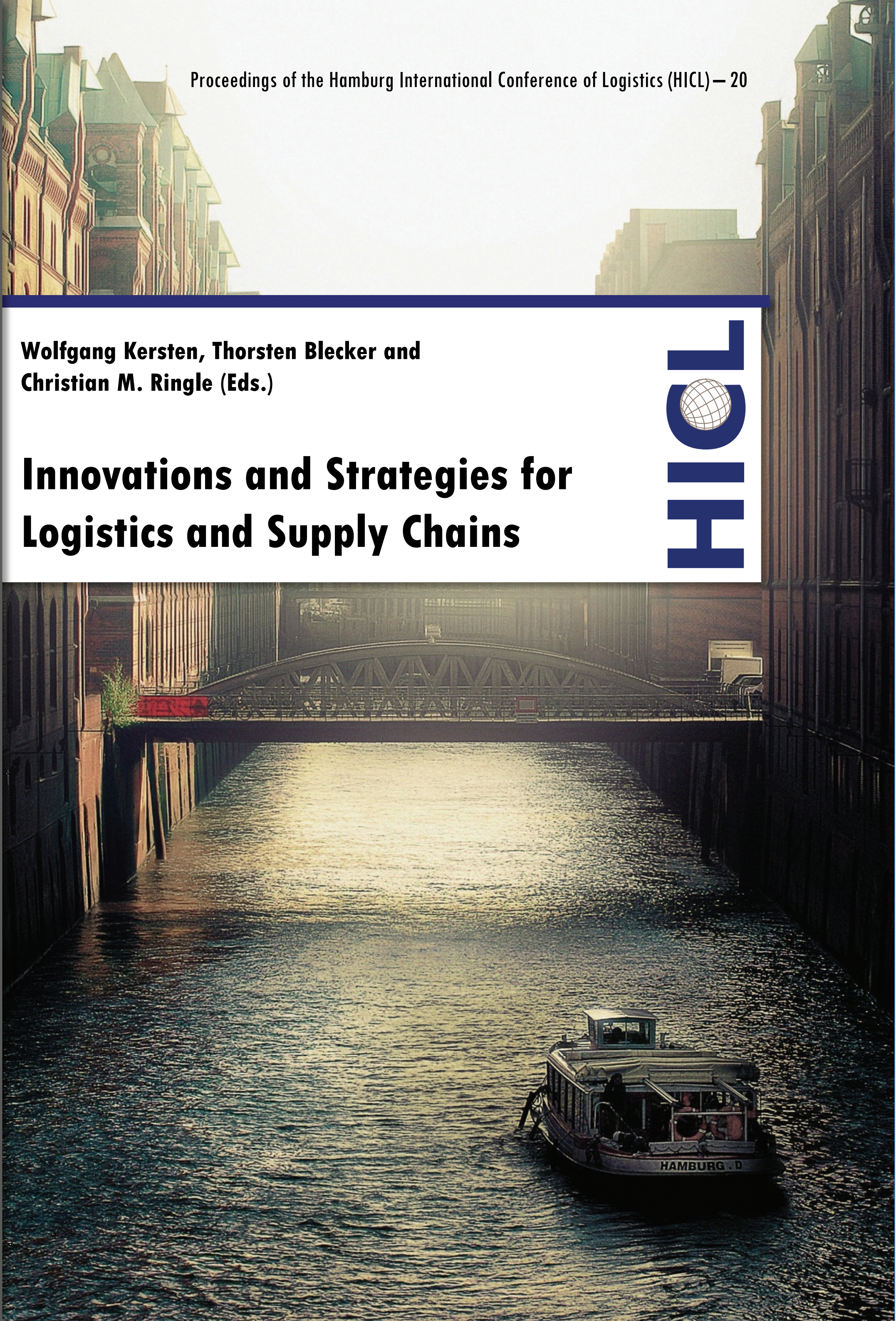
Proceedings of the Hamburg International Conference of Logistics (HICL) – 20

Wolfgang Kersten, Thorsten Blecker and
Christian M. Ringle (Eds.)

Innovations and Strategies for Logistics and Supply Chains

HICL



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Prof. Dr. Dr. h. c. Wolfgang Kersten
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(Editors)

Innovations and Strategies for Logistics and Supply Chains

Technologies, Business Models and Risk Management

Edition	1st edition, August 2015
Publisher	epubli GmbH, Berlin, www.epubli.de
Editors	Wolfgang Kersten, Thorsten Blecker and Christian M. Ringle
Series	Proceedings of the Hamburg International Conference of Logistics (HICL)
Volume	20
Series Editors	Wolfgang Kersten and Thorsten Blecker
Coverdesign	Moritz Petersen
Coverphoto	Nick Scheerbart / unsplash.com/nck
ISBN (print)	978-3-7375-7805-9
ISBN (online)	978-3-7375-4059-9
ISSN (print)	2635-4430
ISSN (online)	2365-5070
Layout	Pascal Freigang, Beverly Grafe, Julian Schäfer and Henning Schöpper

Preface

The HICL-Conference celebrates its 10th anniversary, indicating major interest in the research fields of supply chain management and logistics. Thanks to the large number of outstanding research contributions to this year's conference, the proceedings comprise three volumes. They are dedicated to make recommendations for new approaches and solutions that enable companies to cope with current and future challenges in supply chains and logistics.

The first volume of the 2015 conference addresses innovative and technology-based approaches for logistics and supply chains. It presents business models and investment options for enhanced strategic decision making as well as recent approaches for supply chain risk management.

We would like to thank the international authors for making this volume possible. Their research papers contribute to logistics and supply chain management research. This book would not exist without good organization and preparation. We would like to thank Niels Hackius and Irene Sudy for their efforts to prepare, structure, and finalize this book. We would also like to thank Pascal Freigang, Beverly Grafe, Julian Schäfer, and Henning Schöpper for their contributions to the print layout.

Hamburg, August 2015

Prof. Dr. Dr. h.c. Wolfgang Kersten

Prof. Dr. Thorsten Blecker

Prof. Dr. Christian M. Ringle

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Innovation Contests in Logistics

Birgit von See and Katharina Kalogerakis

Logistics is traditionally driven by operational demands. Therefore innovations are mainly based on direct customer requests. However, logistics service providers (LSPs) have started to realize the importance of proactive innovation to improve competitiveness. As they often lack internal competences and capacities, the open innovation paradigm (e.g. innovation contests) constitutes a promising way to improve their innovativeness.

The aim of this paper is to evaluate the use of innovation contests as an open innovation initiative for LSPs. Opportunities and challenges for LSPs to conduct an innovation contest are analyzed. An in-depth case-study of the company Hermes, a German parcel distribution service provider that has successfully run an innovation contest, is used to derive success factors.

Results indicate that LSPs can benefit from innovation contests, if they consider certain success factors. This study expands the discussion of open innovation to the logistics sector and supports LSPs in evaluating the potential of innovation contests for their business context.

Keywords: Innovation Contest, Logistics, Success Factors, Case Study

1 Introduction

The development of new service concepts enables LSPs to increase customer satisfaction and strengthen their competitiveness (Wagner, 2008, p.215; Wagner and Busse, 2008, p.2). Due to the fact that services cover specific characteristics, their development differs from traditional product development and requires adapted innovation management processes (Brentani, 1989, p. 256f.; Gallouj and Weinstein, 1997, p.540). The production of services usually requires the participation of customers. Furthermore, the presentation of prototypes to convince customers of new developed services is difficult. Hence, customer integration can be seen as a crucial success factor in the process of service innovation.

By now, systematic innovation management approaches in logistics are missing (Kersten, Seidel and Wagenstetter, 2012, p.31). Moreover, empirical studies demonstrate that LSPs in general have deficits in innovation management (Wagner, 2007, p.14). Logistics business is characterized by operational day-to-day business and fierce price competitions. Therefore, methodological expertise and resources needed for the creation of radical innovations are often lacking (Wagner and Busse, 2008, p.7).

Open innovation seems a promising way to overcome the barriers LSPs are facing (Kalogerakis and Wagenstetter, 2014, p.44). The concept of open innovation includes the integration of external resources into the innovation process (Chesbrough, 2006). Thereby, development time and risks can be reduced while the innovativeness of a company rises (Manceau, et al., 2012, p. 46; Poetz and Schreier, 2012, p.251ff.). Originally, the concept of open innovation has been described for the development of tangible products, but has further been expanded to open service innovation (Chesbrough, 2011).

In general, due to their nature service industries are far more open than manufacturing companies (Mina, Bascavusoglu-Moreau and Hughes, 2014, p.862). However, opportunities and challenges of open innovation in the logistics sector are so far not thoroughly understood. A first investigation has shown that the integration of customers as well as technology providers in innovation projects is important for LSPs (Kalogerakis and Wagenstetter, 2014, pp.43f.). Nevertheless, in the context of logistics, open innovation methods need further examination and advancement.

Innovation contests provide an opportunity to integrate external resources into the innovation process and can be classified as an inbound method of open innovation (Hjalmarsson, et al., 2014, p.5; Kalogerakis and Wagenstetter, 2014, p.31). Such contests can be traced back several hundred years (Adamczyk, Bullinger and Möslein, 2012, p.335; Boudreau, Lacetera and Lakhani, 2011, pp.843f.). Nevertheless, supported by the development of web 2.0, they recently gained further attention and application (Bullinger and Möslein, 2010, p.1; Füller, Hutter and Hautz, 2013, p.242). In the German logistics sector, innovation contests have already been run by key players like Deutsche Post DHL, Hermes as well as Lufthansa Cargo. The aim of this paper is to analyze under which circumstances innovation contests in logistics deliver valuable benefit.

In the following section, traditional innovation management processes in logistics are analyzed and the concept of innovation contests is introduced. The research approach described in section three includes a focus group workshop and a case study analysis. Findings are described and analyzed in section four with emphasis on opportunities and challenges as well as success factors. The paper concludes with a discussion of the results, limitations, and opportunities for further research.

2 Theoretical Background

2.1 Innovation Management in Logistics

Innovation management in logistics is triggered by increasing competition. Although megatrends like globalization and outsourcing offer growing demands in logistics (Anderson, et al., 2011, p. 97; Ellinger, et al., 2008, p.353) only low profit margins exists, because new LSPs are constantly entering the market. In this context, innovations provide LSPs a way to positively distinguish themselves from competitors to increase their market share.

However, empirical studies show that practical implementation of innovation management in logistics is lagging behind (Kersten, Seidel and Wagenstetter, 2012, p.31; Wagner, 2007, p.14). A field study by Göpfert and Wellbrock (2014, p.18) reveals that hurdles for efficient innovation management exist due to time and cost restrictions. Logistics innovations are usually developed ad hoc (Göpfert and Wellbrock, 2014, p.8) whenever customers seek for specific solutions (Burnson, 2013, p.64; Wallenburg, 2009, p.78). This reactive approach is often hampered by time pressure and thus far more difficult to manage than a proactive approach (Oke, 2008, p.21). Besides, proactive innovation approaches enable LSPs to develop standardized solutions that can be sold to more than one customer.

Without any doubt the integration of customers into the innovation process seems to be a necessary step to improve the performance of LSPs (Busse and Wallenburg, 2011, p.200f.; Kalogerakis and Wagenstetter, 2014, p.43).

This is especially important as innovation activities in logistics aim at improved or even new services. Furthermore, according to Flint et al. (2005, pp.116f.) customer value constitutes an important element in the innovation process. Due to dynamic changes, integration of customers is essential in order to determine their perceptions and concerns. The identification of future customer needs in logistics can either be based on the demands of multiple customers in order to generate broad knowledge or on direct interaction with single customers aiming at a deeper under-standing of their needs (Mota Pedrosa, Blazevic and Jasmand, 2015, p.328). Findings from Wagner and Sutter (2012, p.954) further indicate that LSPs profit from integrating customers, who seek for new solutions, into innovation management practices.
In summary, innovation management of LSPs is hindered by limited resources and the need to successfully integrate customers in the innovation process. Innovation contests as inbound open innovation initiatives constitute a promising way to overcome these hurdles.

2.2 Innovation Contests

Innovation contests aim at integrating innovative users and their expertise into the innovation process (Füller, Hutter and Hautz, 2013, p.241). They can be defined as "IT-based and time-limited competitions arranged by an organization or individual calling on the general public or a specific target group to make use of their expertise, skills or creativity in order to submit a solution for a particular task previously defined by the organizer who strives for an innovative solution" (Adamczyk, Bullinger and Möslein, 2012,

p.335). Especially through the widespread adoption of the internet, innovation contests have become popular and constitute an essential element of open innovation activities. This intensification of use during the last twenty years led to several and diverse contributions in scientific research, but sufficient understanding is still missing (Bullinger and Moeslein, 2010, p.1).
While in literature as well as practice different terminologies like "innovation tournament" (Terwiesch and Ulrich, 2009), "idea competition" (Mortara, Ford and Jaeger, 2013), or "idea contest" (Füller, Hutter and Hautz, 2013) are used, the general term "innovation contest" is applied in this paper. This term is widely spread (Adamczyk, Bullinger and Möslein, 2012, pp. 338f.) and covers contests implemented during the entire innovation process (Hallerstede and Bullinger, 2010, p.2).
Mortara, Ford and Jaeger (2013, p.1564) note that innovation contests have several intersections with crowdsourcing, but can be distinguished due to their innovation focus. While crowdsourcing activities not necessarily focus on innovation topics (e.g. Amazon Mechanical Turk as a platform to outsource small and simple tasks to a crowd), innovation contests aim at solving innovation related questions by a crowd. The general process of crowdsourcing can be classified into five different phases: preparation, initiation, implementation, evaluation and utilization (Gassmann, Friesike and Daiber, 2014, pp.78ff.) as depicted in Figure 1.

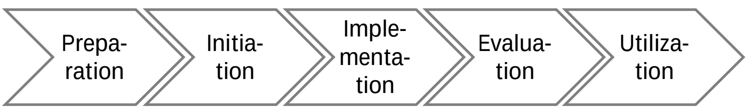

Figure 1 Phases of a crowdsourcing process (modelled after Gassmann, Friesike and Daiber, 2014, p.78)

Based on a literature review, Bullinger and Moeslein (2010, pp.3f.) identified ten elements (media, organizer, task specificity, degree of elaboration, target group, participation, contest period, reward/ motivation, community functionality and evaluation) recommended for the design of innovation contests. Subsequent research has primarily been focusing on these elements as well as their interrelations (Bayus, 2013; Boudreau, Lacetera and Lakhani, 2011; Zheng, Li and Hou, 2011; Armisen and Majchrzak, 2015). Walter and Back (2011, p.9), for example, further investigated effects design elements have on the quality (answer type and market maturity) and quantity (rewards, duration, market maturity and brand-strength) of submitted ideas.

Apart from design elements, only a few contributions focus on the challenges of innovation contests (Wikhamn, 2013; Füller, Hutter and Hautz, 2013, p.243ff.) or crowdsourcing (Gassmann, Friesike and Daiber, 2014, pp.84ff.). These include efforts, motivation, compensation, and legal aspects (Gassmann, Friesike and Daiber, 2014, pp.86f.) as well as quality and evaluation of submitted ideas (Füller, Hutter and Hautz, 2013, p.243; Wikhamn, 2013, p.139ff.).

So far, research on innovation contests has been done mostly independently from industrial sectors like IT, manufacturing or logistics. Furthermore, although case studies for service companies exist (Pfeifer and Gebauer, 2013), little is known about differences between innovation contests with a service focus and product oriented innovation contests (Schuhmacher and Kuester, 2012).

As innovation contests have rarely been conducted with a logistics focus, experiences as well as research results are limited. In a previous study conducted in mid-2014, experiences of LSPs with innovation contests were identified. First results are described by Kalogerakis and Wagenstetter (2014, pp.42f.). Although innovation contests are generally well known, none of the interviewed experts had actually conducted one within the company. Managers of LSPs are afraid of problems concerning intellectual property (IP), especially when innovation contests are related to customer specific requests. Nevertheless, some opportunities are also mentioned, as for example PR (public relation) effects and integration of technology providers within a contest.

3 Research Approach

The research design is based on the results of the previous study described above. In order to enter this new field of research a qualitative approach was chosen (Myers, 2013, p5f.). It uses two sources of empirical data - a focus group and a case study (cf. Figure 2).

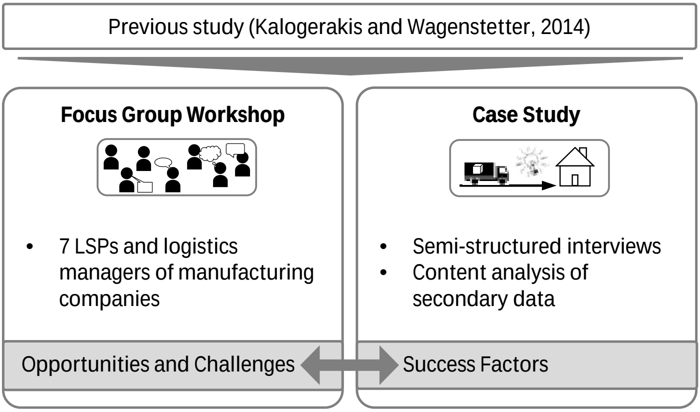

Figure 2 Research design

First, in order to deeper analyze opportunities as well as challenges of innovation contests in logistics a focus group workshop was conducted. This group included a typical amount of seven members who share a similar background (Flick, 2006, p.193) as managers of LSPs or logistics managers from manufacturing companies. In a second step, the Hermes innovation contest "Getting, Delivering…what else" was analyzed as a case study (Yin, 2014) of an already realized innovation contest in logistics. The aim of this case study is to further derive requirements for innovation contests in logistics based on lessons learned. The Hermes case study is premised on a content analysis of secondary data followed by semi-structured interviews with two main internal actors of the contest. From the data captured success factors are deduced.

4 Results

4.1 Focus Group Workshop

The previous study (Kalogerakis and Wagenstetter, 2014, p.42f.) indicated that innovation contests in logistics are rare. Managers of LSPs have, so far, seen more risks than advantages concerning the realization of an innovation contest. Based on this rather reluctant attitude towards innovation contests in logistics a focus group workshop was hold. As introduction, some general information about open innovation and successful examples of innovation contests were presented to the participants of the focus group workshop. Afterwards, the participants were asked what kind of opportunities and challenges LSPs could expect from this open innovation effort. While opportunities are recognized in terms of innovation and PR aspects, challenges (e.g. invested resources, quality of ideas, reputation) dominated the discussion (cf. Figure 3).
Several opportunities are identified concerning the innovative output of innovation contests. As expected from an open innovation initiative, participants of innovation contests bring new perspectives into innovation activities of a company. Hence, it is believed that truly new "out-of-the-box" ideas that are new to the business can be submitted. Thereby, LSPs can gain first mover advantages resulting in an improved competitive position. Furthermore, positive PR effects are anticipated. By conducting an innovation contest the LSP can signal to its customers that it is seeking dialogue with them and position itself as an innovative company.

Opportunities

Innovation
- Identification of "out-of-the-box" ideas
- Deployment of "first-mover" advantages
- Possibility to implement or combine specific elements of ideas
- Generating new ideas and innovation fields

PR / Customer Orientation
- Positive PR effects
- Signaling dialogue to externals
- Creating needs

Challenges

Quality of Ideas
- Decision on participants
- Decision on incentives
- Decision on steering vs. freedom of ideas

Reputation
- Results unknown
- Willingness to implement

Resources needed
- Necessary resources for monitoring
- Idea selection and assessment

Figure 3 Opportunities and challenges of innovation contests identified by logistics focus group

However, several challenges were also identified. First, doubts exist concerning the quality of incoming ideas. Diverse instruments were discussed that might help to influence the qualitative output of ideas, e.g. which participants to integrate and which incentives to provide. Furthermore, it was discussed what kind of resources are needed to transform an innovation contest into a positive endeavor. Constantly monitoring the contest results increases resources needed, but will probably also increase the usefulness of incoming ideas. A design challenge by the fast-moving consumer good company Henkel for example has shown that contests might lead to PR disasters (Keinz, Hienerth and Lettl, 2012, pp.24f.). Once the idea contest is implemented, the company has to be willing to realize the winning idea. Therefore, thorough preparation as well as monitoring of the contest are seen as essential activities.

4.2 Case Study - Hermes Innovation Contest

The German 2C (to consumer) parcel distribution service provider Hermes Logistik Gruppe Deutschland (Hermes) launched an innovation contest at the beginning of 2013 asking for new ideas about services that facilitate their customers' daily life. The aim of this contest was to discover suggestions for new business models. Hermes incorporated an intermediary, the Innovationskraftwerk, who provided a platform with an existing community of 4.000 innovators and creative people. Additional participants were acquired by Hermes via website and newsletter announcements. In order to attract many participants, incentives in the form of monetary and immaterial rewards were given. In total 377 ideas were submitted in a period of eight weeks. After an intensive assessment and selection process, the ten most promising ideas were judged by a jury, consisting of internal as well as external experts. The final winning idea "Hermes Store In: storage and simultaneous packet delivery" was further developed by a business incubator to a new self-storage concept. By now, the resulting "Send & Store" service has been implemented as a subsidiary of Hermes.
In the following sub-chapters an in-depth analysis of the Hermes innovation contest is provided adhering to the phases of a crowdsourcing initiative (cf. Chapter 2.2). Success factors for each of the phases were derived together with Hermes from a retrospective point of view.

4.2.1 Preparation and Initiation Phase

The preparation phase of the innovation contest started soon after formalizing innovation management at Hermes. This process was supported by consultants of the Otto Group which is the parent company of Hermes. Investigations, trend analysis and customer insights provided fields for future innovation activities. Nevertheless, the question was raised which new and rather open concept of idea generation could be used in order to expand the Hermes innovation toolbox. The decision in favor of an innovation contest was supported by the management board.

The aim of the contest was to generate new business and service ideas as well as to test this new feature. In order to conduct the innovation contest, no additional organizational structures had to be provided. Nevertheless, one Hermes employee was assigned fulltime to the topic, supported by two consultants from the Otto Group. Furthermore, the innovation contest platform Innovationskraftwerk was chosen as a professional partner to realize the contest. Among other reasons this platform was seen as a suitable partner, because its community is mostly situated in Germany just like most of Hermes customers are.

A main task of the initiation phase was the choice of an adequate question to be addressed in the contest. Therefore, Innovationskraftwerk organized a workshop with Hermes in order to decide on an adequate question and a way how to promote the innovation contest. Key questions within this workshop focused on the scope of the question and its link to logistics. As previous customer insights had shown, the shipping process is often seen as a black-box. Hence, the focus of the contest was decided to be on services instead of process innovations. Developing an appropriate question for the contest turned out to be a difficult task, because conflicting objectives existed. On the one hand, openness for new ideas was sought and on the other hand submitted ideas should not drift too far away from the core business of Hermes. Finally, the question was formulated very open in order to enable a maximum of creativity without excluding ideas by setting the boundaries too tight. Pictures were integrated to stimulate participants' creativity. The contest was realized as a half-open variant - only registered community members were able to read the whole description of ideas - in order to minimize the risk of knowledge transfer to competitors.

4.2.2 Implementation Phase

The implementation phase started with the launch of the innovation contest on the Innovationskraftwerk platform in February 2013. Supported by previous marketing initiatives in terms of customer newsletters, promotion on websites, social media as well as via existing networks (e.g. universities) already on its first day 88 ideas were submitted. During the contest efforts for monitoring and moderation were necessary to ensure high quality as well as quantity of submissions. New ideas were commented on a daily basis by moderators from either the intermediary or Hermes. Although there was an option for participants to comment on ideas posted by others, this was not extensively used by the community.

Already during implementation phase a pre-assessment and selection process was initiated. The preselection included the following criteria: comprehensibility, company fit, novelty and doubling. Community assessment was enabled through a like-function. Weekly winners were voted by the community and awarded with soccer tickets. In total 377 ideas were submitted during the eight weeks of the contest phase by a core group of 129 participants.

4.2.3 Evaluation and Utilization Phase

Preselection already during implementation phase guaranteed that ideas which would not fit with Hermes' business model (19 % of the ideas, e.g. passenger transport) or already existing services were excluded. During the subsequent evaluation phase, ideas were categorized as improvement suggestions (18.5 %), marketing concepts (17.5 %), and service/ product/ business ideas (64 %). Ideas in the field of receiver services, food logistics, packaging, lending models, and data mining concepts dominated. An intensive screening of the submitted ideas was conducted to further analyze whether parts of ideas could be used as an input for innovation management at Hermes. Due to the fact that many ideas were new to Hermes, intensive research was necessary in order to analyze their potential. A further assessment concerning strategic importance and feasibility resulted in ten top ideas. These ideas were then assessed by the official jury of the contest. The jury, consisting of representatives from Hermes and the Otto Group plus an external expert, evaluated their potential and customer value.

Finally, the winning ideas were officially announced and rewarded with monetary prizes as well as a hub visit. The third price "Hello Neighbor" is a bonus card to reward customers receiving packages for their neighbors with free shipping. In contrast, a product oriented idea won the second prize. The "Hermes Inflatable Package (System)" challenges the problem of unused packaging volume and wasted material in parcel shipping. The winning idea was the service concept "Hermes Store In: storage and simultaneous packet delivery". This concept offers customers the possibility to store boxes temporarily and book individual pick-up and delivery services.

The three winners were invited to present their ideas at an awarding ceremony. During the ceremony Hermes informed them about subsequent utilization and further development of their ideas.
After further internal evaluation, 19 ideas were assigned to the Hermes Innovation Roadmap and given to special departments of Hermes. Additional 10 ideas were taken into the innovation pipeline of the central innovation management team. This team, however, first focused on the winning idea. As internal standard processes seemed not adequate for a fast implementation of the new business concept, an incubator was chosen to realize the idea. LiquidLabs, an incubator of the Otto Group, provided the opportunity to start fast and independently from formal implementation processes. The idea was thus implemented as a lean-startup meaning that a "minimum-viable-product" was tested and gradually expanded with additional features. In the end, the idea was transferred into a business model within a quarter of a year.
Hermes not only utilized the ideas submitted but profited from the whole innovation contest in several instances. Lessons learned are used for further open innovation initiatives, e.g. on co-creation processes using innovation workshops with external experts.

4.2.4 Success Factors

The analysis of the Hermes innovation contest underpins that challenges in conducting an innovation contest exist. Following certain success factors (cf. Figure 4) derived from the case study as well as formulated by Hermes challenges can be mastered.

Preparation and initiation of an innovation contest can be seen as crucial steps. These phases include the decision about central questions: Whom are we going to involve? What question are we going to raise? Selection and formulation of an adequate question is challenging (Sieg, Wallin and Krogh, 2010, pp.6f.; Hallerstede, 2013, pp.193ff.). Especially in logistics, these questions need to be discussed in detail. As process experience is missing, customers often only see the result of the service and respectively tend to complain whenever problems occur. Investing adequate effort in problem formulation and visualization of the question can therefore be seen as a key success factor, which was also identified by Lüttgens, et al. (2014, pp.355f.). Based on the experience of the interviewees involving a multi-disciplinary team consisting of representatives from different departments might help to formulate an adequate task for the innovation contest. Furthermore the described process helps in self-reflecting what exactly the aim of the contest is.

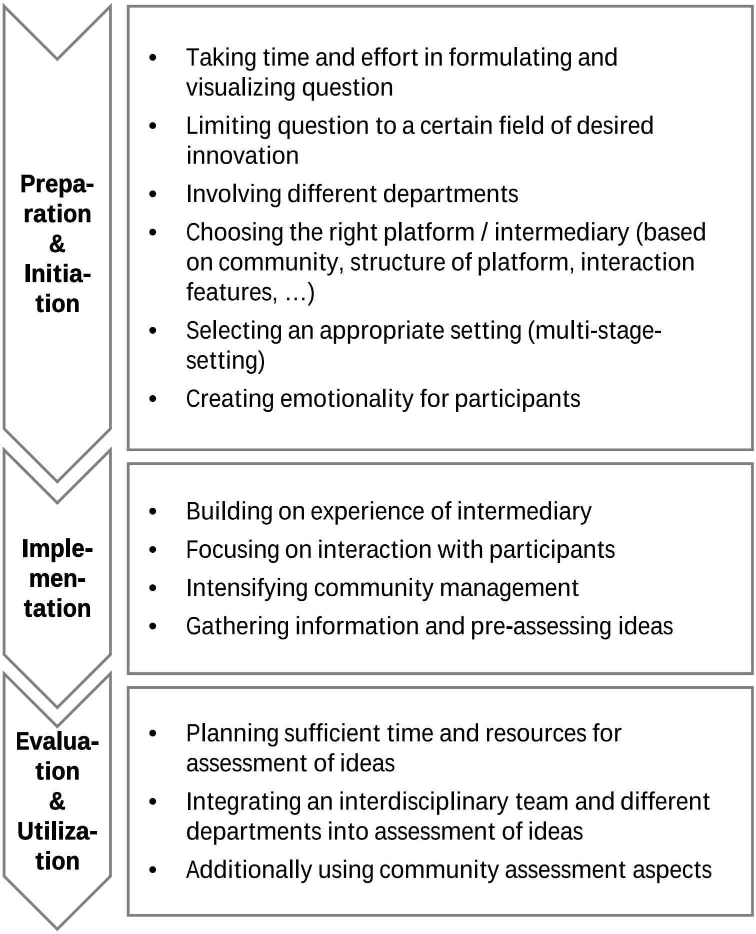

Figure 4 Success Factors in Innovation Contests derived from the Hermes Case Study

After the goal is clear, an adequate platform and setting for the contest has to be chosen. For the execution of the contest involvement of competent partners e.g. intermediaries with broad experience and knowledge in community management seems to be beneficial. In order to choose the right platform an assessment of different options concerning experience, community functionalities and participants should be made.

Using a multi-stage setting is suggested: In a first step ideas are submitted by a crowd and in second step further developed within a smaller group of experts. Terwiesch and Xu (2008, pp.29f.) discuss a similar setting and suggest adapted awarding structures.

Real time interaction with participants during the implementation phase helps to improve submitted concepts and to overcome the challenge that ideas seldom build on previously submitted ones (Füller, Hutter and Hautz, 2013, p.248). It further causes learning effects on both sides - for participants as well as organizers. This phenomenon has also been observed in the "Innovation Challenge" conducted by Lufthansa Cargo (Pfeifer and Gebauer, 2013, p.54). Guidance by the organizer of the innovation contest during implementation phase ensures that previously set goals are met at their best. Furthermore, this interaction with participants can be seen as ideal preparation for the assessment phase. Due to the fact that participants have diverse backgrounds, submitted concepts and ideas are often new to the business. An intensive discussion with participants helps to have an established basis for decision-making. Furthermore, potentials and obstacles are easier identified together with the participants of the contest and an intensive moderation results in further development of submitted ideas by the community. Heterogeneous price structures, e.g. announcing

a price for the most valuable comment and not only for the best ideas, enforce co-creation (Füller, Hutter and Hautz, 2013, p.248).
Investing sufficient resources and building an interdisciplinary team for the evaluation of ideas can be seen as key success factors. Integrating diverse persons into the evaluation process helps to identify ideas already been discussed within the company and to evaluate ideas for which expertise otherwise would be missing (Lüttgens, et al., 2014, p.356).
At last, resources and time necessary to conduct an innovation contest should not be underestimated. Innovation contests are classified by Keinz, Hienerth and Lettl (2012, p.24) as a "harvesting user innovation strategy". The case study presented has shown, however, that the harvest is only as good as the seeds you plant and the care you take during maturity. Following the presented success factors will enable LSPs to minimize challenges and maximize opportunities in conducting an innovation contest.

5 Conclusion

5.1 Contributions and Implications

The aim of this paper was to evaluate the use of innovation contests in logistics. First, a focus group workshop with logistics managers on expected opportunities and challenges in conducting an innovation contest was hold. Though opportunities in generating innovative solutions as well as positive PR effects exist, this discussion shows that LSPs see challenges due to several unknown components. These challenges are related to the quality of ideas, resources needed, and effects on their reputation. Not knowing where the journey will take the company seems to be a great barrier.

Second, a deep analysis of the Hermes innovation contest shows how to minimize challenges of innovation contests in logistics and how to profit from positive results. The fuzzy front end of an innovation contest, namely the preparation and initiation phase can thereby be seen as crucial. The case of Hermes has indicated that these early phases have an impact on the effort necessary during later phases of the contest as well as on the output generated.

Logistics can be divided into several subject areas, e.g. distribution and maritime logistics. Each of those requires specific expertise and knowledge. The question within a contest therefore should be articulated goal-oriented and cover a specific field of interest. This will limit broadness of ideas suggested and help in evaluation. An innovation contest can also be used as a source to identify knowledge-carriers.

This paper expands the discussion on innovation contests to the logistics industry. Furthermore, lessons learned were drawn from an in-depth case-study. Resulting success factors will help logistics companies to conduct innovation contests in the future. Besides, the presented success factors will help other logistics companies in deciding on whether to use this open innovation initiative or not.

Though the success factors are derived from an LSP point of view, they seem to be applicable to any service industry, thus emphasizing existing research on innovation contests and expanding discussion on key elements in crowdsourcing processes (Gassmann, Friesike and Daiber, 2014, p.85). This expansion includes the selection of an adequate platform and setting,

pre-assessing ideas already during implementation phase as well as the integration of sufficient resources within the evaluation phase (e.g. interdisciplinary team, community assessment).
Compared to innovation contests focusing on tangible goods, especially the domain of logistics seems to require an intensive elaboration and formulation of the question.

5.2 Limitations and Further Research

Contribution and implications were taken from an explorative, qualitative approach which is why the results have limitations.
Though several instruments have been chosen in favor of construct validity, e.g. triangulation of dataset (multiple interviewees and enrichment through content analysis of secondary data), review by key informants as well as external experts, results cannot be generalized, because findings are based on a single case. The reliability of findings is provided by a case study protocol (Ellram, 1996, pp.104ff.). In order to increase external validity, analysis of further cases of innovation contests in logistics is suggested. The case study presented was focusing on a 2C perspective. Due to the fact that many logistics companies are working in B2B (business to business) context further research should analyze differences between innovation contests in B2B and B2C settings (Kärkkäinen, Jussila and Multasuo, 2012, p.139). Thereby implications for successful implementation of innovation contests in B2B logistics can be derived. While Prandl (2014, p.79) questions the applicability of innovation contests in B2B contexts in general, the Lufthansa Cargo Innovation Challenge has shown that innovation contests in B2B logistics can be successful (Pfeifer and Gebauer, 2013, p.54). First

comparisons indicate that B2B innovation contests in logistics require much more effort in community building as the group of direct customers is limited and special expert knowledge is sought.

Acknowledgements

This research was partially supported by Hermes Logistik Gruppe Deutschland GmbH. We thank Daniela Kirchner and Roger Hillen-Pasedag who provided insight and expertise that greatly assisted the research.

Financial Disclosure

This IGF-project 18082 N of the research association 'Bundesvereinigung Logistik e.V. - BVL', Schlachte 31, 28195 Bremen was funded by the Federal Ministry for Economic Affairs and Energy (BMWi) via the AiF as a part of the program for Industrial Community of Research and Development (IGF) because of a resolution of the German Bundestag.

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The Impact of Industry 4.0 on the Supply Chain

Hans-Christian Pfohl, Burak Yahsi and Tamer Kurnaz

Disruptive innovations are currently changing the landscape of many industries and their business models. Because of increasingly digitalized processes and an exponential growth of sensible data, supply chains are also impacted by the fourth industrial revolution. The strategic management requires a more transparent understanding of the currently available and interrelated technologies and concepts. Since the supply chain will obviously undergo an organizational change, a theoretical framework is necessary to understand which activity is impacted from a holistic management-perspective. In this paper, the term "Industry 4.0" is defined and its seven characteristic and interrelated features are highlighted. Furthermore, related technologies and concepts are validated to determine their contribution to the future development of the industrial revolution. Out of initially 49, the 15 most relevant technologies and concepts are identified through a conceptual analysis. A theoretical framework is proposed to evaluate key technologies and concepts with respect to their impact on the supply chain. According to Cachon (2012), three interesting hypothesis are stated, concluding on the impact of Industry 4.0 from a structural, technological and organizational perspective. All results are based on a structured literature review.

Keywords: Industry 4.0, Supply Chain, Organizational Change, Innovation

1 Introduction

First, the development of steam machines drastically changed the production processes. Electrical drives, combustion engines and the innovative assembly line production systems then initiated the second industrial revolution. The third industrial revolution was mainly characterized by the enormous automation of the production processes (Bauernhansl, ten Hompel and Vogel-Heuser, 2014), which is the basis for the ongoing fourth industrial revolution, where we face complex systems of hardware, data centers and software components in one single product (Brettel, et al., 2014). Traditional barriers for products and their value proposition are extremely extended and therefore, existent value chains and the respective supply chains are to be rethought (Porter and Heppelmann, 2015).

As an early example, General Electric started a billion-dollar-project in 2011 to install sensors in their production-machinery and to invest in product-embedded software (Iansiti and Lakhani, 2015). Whilst many more companies are already investigating how to react to the current trend of implementing "Industry 4.0" technologies and concepts, recent research with respect to this term is highly diverse and limited to the operational implementation of technologies and concepts on the production process-level (Herman, Pentek and Otto, 2015).

Figure 1 visualizes the fact that most scientific papers and articles with respect to "Industry 4.0" can be allocated to cluster A. Here, the research is focusing exploratory questions on how "Industry 4.0" technologies and concepts can be implemented within the company's supply chain on the process-level (Bauernhansl, ten Hompel and Vogel-Heuser, 2014; Parlikad and McFarlane, 2010).

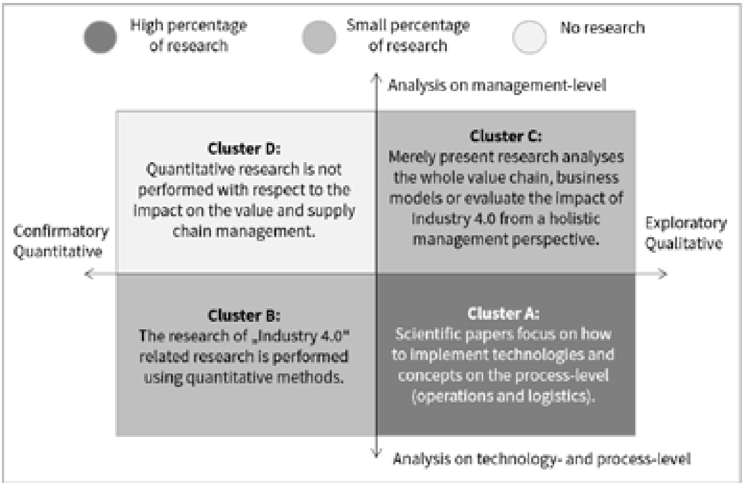

Figure 1 Clustering the research-fields with respect to "Industry 4.0"

The confirmatory research in cluster B adds quantitative methods to the analysis and provides implementation models for specific technologies (Mohanarajah, et al., 2015). This paper can be allocated to cluster C, as it widens the horizon of the currently explorative research to the management-level. Based on a structured literature review, a theoretical framework is developed and applied to understand the impact of the fourth industrial revolution on the supply chain from a holistic management-perspective. This qualitative analysis will be the basis for further quantitative research in cluster D, where the hypotheses in this paper can be validated in expert interviews and questionnaires.

All research results given in this paper are based on a structured literature review executed according to Baker (2000) and Cooper (1988). This review includes high-rated international journals which were published since

2010. The following journals were selected according to the VHB-ranking of Hennig-Thurau (Walsh and Schrader, 2014) and their relevancy with respect to the scientific topic: Management Science, Operations Research, Journal of Management Studies, Organization Science, M&SOM, Transportation Science, Information Systems Research. Other scientific databases like EBSCOHOST were added to sources of the literature review, as currently most of the relevant published articles with respect to “Industry 4.0” can be found in scientific magazines and lower-rated journals. Studies published by companies (e.g. consulting firms like Roland Berger) or research institutes were validated as well and bring up interesting hypotheses and results, especially in the German literature. The key words were chosen according to the research topic and the included technologies and methods described within this paper. Articles and studies identified by a keyword-search were first validated by their title, their abstract and then by their content with respect to their relevancy. In total, 674 published articles, scientific papers and books were reviewed throughout this analysis.

2 Management Approach

In this chapter, a management approach is proposed that supports the companies to understand which organizational changes are to be expected for their respective supply chain (figure 2).

First, the strategists must make the term “Industry 4.0” and its characteristic features more transparent and communicate a common definition to all company members. At this stage, it is important for all executive members of a company to know which levers can be tackled to enable and to streamline the innovation adoption process in the organization and in the supply chain. Chapter 3 helps the organizations by stating a definition of the term "Industry 4.0" and highlighting its characterizing features.

Second, relevant technologies and concepts have to be identified, clustered and analyzed by the corporate management according to their relevancy for the company. Chapter 4 brings up a mind-map of all currently discussed technologies and concepts with respect to the research-field of "Industry 4.0". These are clustered into four dimensions and allocated to the earlier described characteristic features. A conceptual selection process is developed and applied to evaluate the relevancy of all technologies and concepts according to the characterizing features of the term "Industry 4.0". The strategic management of a company may apply the same approach to identify respectively relevant technologies and structures within workshops.

Third, the management needs to evaluate how their supply chain will be impacted by the relevant technologies, i.e. which challenges and potentials are to be expected with respect to the primary supply chain activities. Chapter 5 proposes a theoretical framework that allows the evaluation of the impact of each relevant technology with respect to their impact on the supply chain from a holistic management-perspective. At the end of chapter 5, three main hypotheses are proposed after executing the analysis for all relevant technologies and concepts.

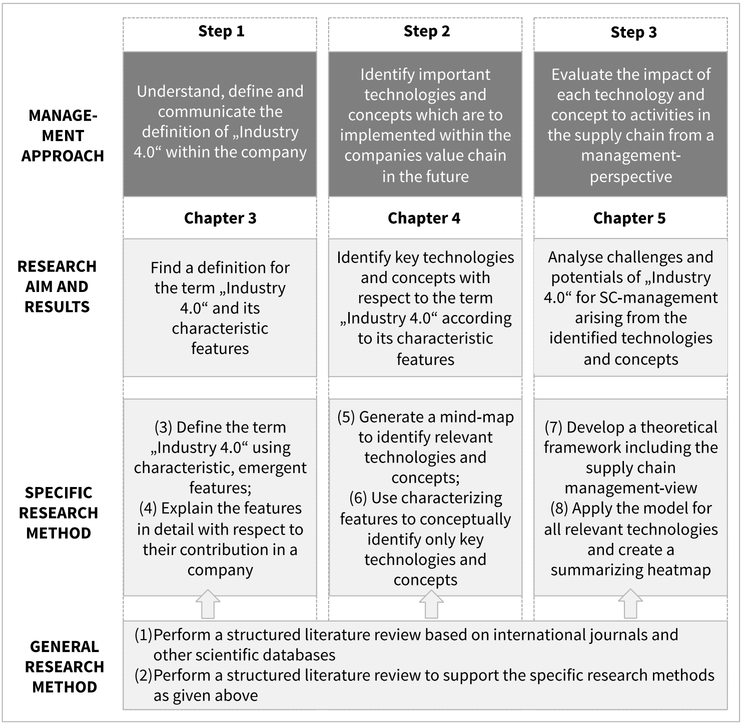

Figure 2 Management approach and the relevancy of single chapters

3 Defining the Term “Industry 4.0”

Since the term “Industry 4.0” is not ultimately defined (Brettel, et al., 2014), this paper states a definition using characterizing features. All currently discussed characteristic features of the term “Industry 4.0” were collected based on the structured literature review and included within a conceptual analysis, in which all mentioned technologies and concepts in chapter 4 were validated with respect to the question: Does this technology or concept enable innovations in the supply chain of an organization according to the specific characteristic feature? For example, the technology of Cloud Computing enables digital processes and value propositions (this means a count for the feature “Digitalization”) and increases the modularization and scalability of products, processes and facilities in the supply chain (this means a count for the feature “Modularization”).

Figure 3 summarizes the results of the analysis for all 49 technologies and concepts. The features marked dark are the most relevant (above 30 counts) and hence, these are used to define the term “Industry 4.0” and are explained in detail. The result leads to the following definition: Industry 4.0 is the sum of all disruptive innovations derived and implemented in a value chain to address the trends of digitalization, autonomization, transparency, mobility, modularization, network-collaboration and socializing of products and processes. In the following, the seven characterizing features are reflected and described in detail.

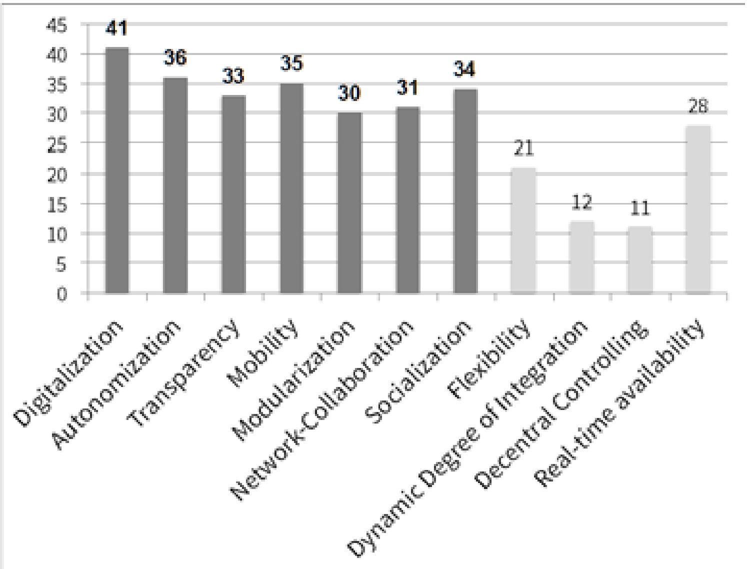

Figure 3 Results of the analysis of characteristic features

(1) Digitalization: The companies' internal processes, product components, communication channels and all other key aspects of the supply chain are undergoing an accelerated digitalization process (Geisberger and Broy, 2012). According to the conceptual analysis visualized in figure 3, the digitalization process itself is the most important characteristic feature and enables all other characterizing features.

(2) Autonomization: "Industry 4.0" technologies and concepts are enabling machines and algorithms of future companies to make decisions and perform learning-activities autonomously. This autonomous decision-making

and learning is based on man-made algorithms and enables whole factories and manufacturing facilities to work with minimum human-machine-interaction (Angelov, 2013).
(3) Transparency: While global supply chains are characterized by highly complex structures, the available “Industry 4.0” technologies are increasing the transparency of the whole value creation process. Through this increase in transparency, decision-making in the company will be more collaborative and efficient. Not only the supply chain processes, but also the behavior of corporate partners and customers will be more transparent to the company (Wang, Heng and Chau, 2007).
(4) Mobility: The dissemination of mobile devices makes communication, data sharing and generation of values possible from all over the world. The mobility of devices is changing the way customers are interacting with companies, and the communication and interaction of machines in the production process (Schweiger, 2011).
(5) Modularization: “Industry 4.0”-technologies are enabling the modularization of products and the whole value creation process, e.g. manufacturing facilities. Modular production facilities can be adjusted in their quantity autonomously, which is increasing the flexibility of the production processes (Koren, et al., 1999; Putnik, et al., 2013).
(6) Network-Collaboration: Just as human beings in our society are interacting in social networks, the companies’ processes will be defined and activities will be decided through the interaction of machines and human beings within specific networks in and out of the companies organizational borders (Bauer, et al., 2014).

(7) Socializing: The collaboration in networks is enabling machines (not only smartphones) to start communicating and interacting with other machines and/ or humans in a socialized manner. Herewith, the collaboration with machines is socialized, since humans are able to get into a conversation with the machines (Oswald, 2014).

4 Identify Key Technologies and Concepts

The next goal of this paper, and the second step according to the management approach, is to understand the relevance of the many interrelated technologies and concepts discussed with respect to the fourth industrial revolution. For this purpose, a three-step approach was applied. First, a structured literature review was performed to create a mind-map (figure 4). This mind-map summarizes frequently discussed technologies and concepts within the validated literature and allocates them to the previously identified key characteristics of "Industry 4.0". As shown in the mind-map, the technologies and methods can be summarized into four clusters according to the highest relevance of the earlier described characteristic features. During the evaluation of a specific technology or method, the corporate management may use this mind-map to understand its interrelations with other technologies.

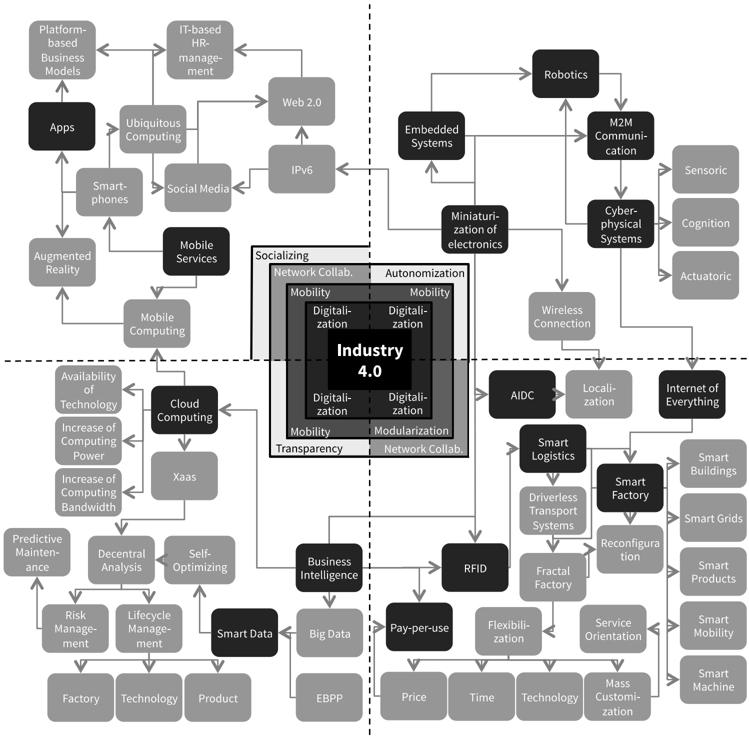

Figure 4 Mind-map of discussed technologies and concepts within the relevant literature

Second, all technologies and concepts were conceptually validated to understand whether or not these are enabling the digitalization, autonomization, transparency, mobility, modularization, network-collaboration and socialization of processes and products within the supply chain. Hence, figure 5 sorts all technologies of the mind-map according to the number of the respectively supported characterizing features of "Industry 4.0".

According to the analysis of this paper, the most relevant and contributing technologies and concepts are in the far left part of the density-function given figure 5 and are discussed in detail in the following.

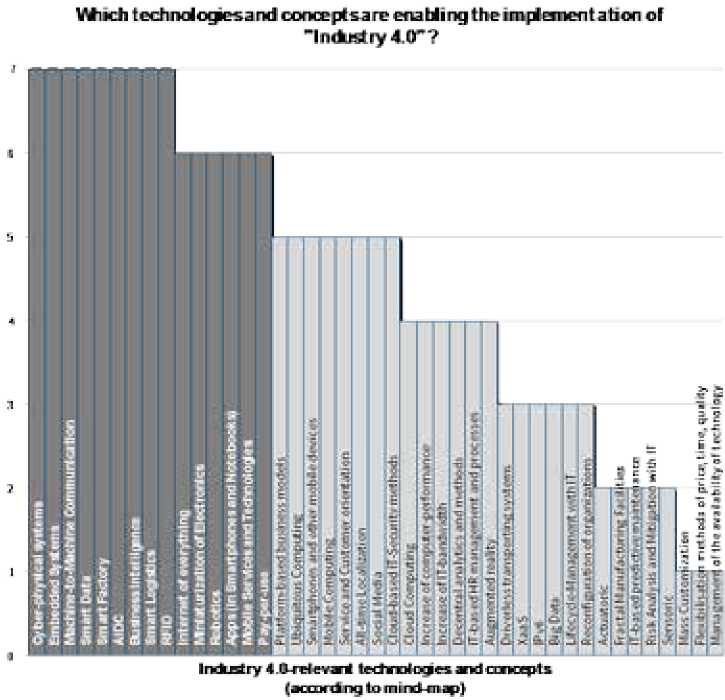

Figure 5 Density-function to validate the importance of technologies and concepts of "Industry 4.0"

A very important technology is the miniaturization of electronics, which means the manufacturing of smaller mechanical, optical and electronic products and devices (Feldmann, Franke and Schüßler, 2010). It is a main enabler for the automatic identification and data collection (AIDC) and radio-frequency identification (RFID) technologies, which help to collect, manage and analyze data within transportation processes in the supply chain (Smith and Offodile, 2002). In fact, AIDC- and RFID-technologies belong to the so-called embedded systems. These are microprocessor-based systems, which are built into physical products to control a function or a range of functions (Heath, 2002). On the other hand, the field of Robotics is closely related to the miniaturization of electronics as well, as it is the branch of technology that deals with the design, construction, operation, and application of robots (Demetriou, 2011). Machine-to-Machine Communication (M2M) can be described as the autonomous and bilateral communication of machines (Zaus and Choi, 2014).

Business Intelligence (BI) is often referred to as the techniques, technologies, systems, practices, methodologies, and applications that analyze critical business data to help an enterprise better understand its business and market and make timely business decisions (Chen, Chiang and Storey, 2012). Based on the BI-technology, the concept of a Smart Factory increases the information transparency and enables the autonomous control of a manufacturing facility (Radziwon, et al., 2014). When pay-per-use licensing is applied within smart factories, pricing is based on the actual amount of the used software, measured in units of use, such as the number of users or the number of transactions (Tukker, 2004). The term of the Smart Factory includes the concept of Smart Logistics, which describes the application of ubiquitous technologies to logistics processes for efficiency improvements in transport, warehousing and storage processes (Resch and Blecker, 2012). Smart Data, as a related concept, helps to collect, manage and analyze data from across an increasingly complex investment universe. Big Data, the massive collection and storage of data in real-time, becomes Smart Data when its objective is understood (Klinck, 2014).

5 Impact of Industry 4.0 on the Supply Chain

This paper proposes a theoretical framework to assess challenges to and potentials of the supply chain management arising from the fourth industrial revolution (visualized in figure 6 and 7 below). The vertical dimension reflects the supply chain according to MEYR and WAGNER (2004 cited in Kannegiesser, 2008, p. 14) with the categories procurement, production, distribution and sales. Herewith, core activities in the supply chain are captured. The horizontal dimension is oriented towards the model of LEAVITT (1965, pp. 1144-1170), who has developed a theory with respect to organizational changes and finds answers to the following question: By which variables is the innovation adoption process in a company impacted? According to this theory, every organization consists of four interactive and highly interdependent components: people, task, structure and technology. It is the interaction between these four variables that determines the success of organizational changes. While the variable “people” obviously refers to the human domain within an organization, this framework includes all human-related issues, from hiring and education of the personnel to the interaction of the organization in social systems out of the borders of the own supply chain. According to LEAVITT, the variable "structure" means all systems of communication, systems of authority, and system of workflow within an organization. This paper sticks to this definition. The variable "technology" is described as assets - either physical assets like machinery or knowledge-based ones like patents. Since the tasks according to LEAVITT are redundant to the primary activities given in the vertical dimension, this component is excluded from the theoretical framework. The combination of both theories creates a theoretical STP-framework enabling a holistic view on the management issues arising from the planned and ongoing implementation of "Industry 4.0" technologies within the supply chain. At this stage, the strategic management of an industrial company must have evaluated which specific characterizing features of "Industry 4.0" are important for their respective supply chain activities, and must have identified relevant technologies and concepts according to the method given in chapter 3 and-4.

This paper evaluates the impact of all technologies identified and classified as relevant in chapter 4. Figure 6 summarizes the results in a heat-map. Note that during this analysis, weighting factors were not used. For example, the results for the technology CPS were included within the summarized heat-map with one single point each in the respective field. This is valid for all validated technologies and concepts. This heat-map will be used in the following to state three main hypotheses with respect to the expected organizational changes from a structural, technological and humanistic perspective.

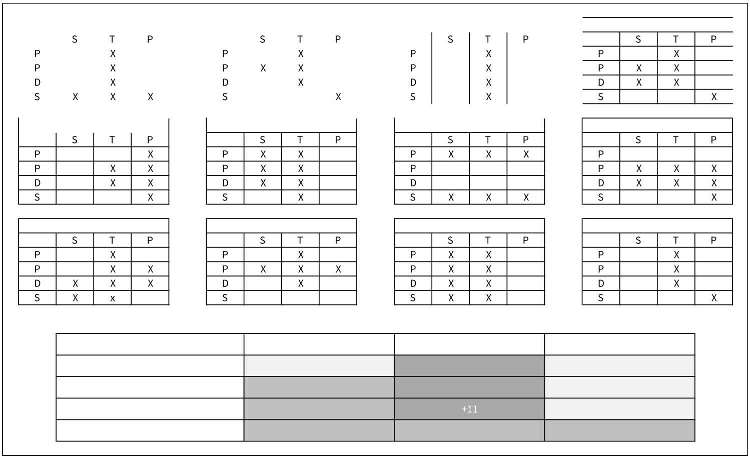

Figure 6 Summarizing view of the impact analysis in a heat-map

With respect to the structural variables described by LEAVITT, we understand from the density function given in figure 6 that the biggest impact and organizational changes are to be expected for the production and distribution processes. Whilst the sales processes face a relatively moderate impact from the "Industry 4.0" technologies and concepts, the procurement processes are impacted least. The biggest impact on the structure of the supply chains is to be expected from the concepts of Smart Logistics and Smart Factory. With their implementation, the whole supply chain will be affected from a structural and technological perspective, as all supply chain activities undergo a digitalization process. For example, Smart Factories will include intra-logistic processes which support the manufacturing systems with sophisticated applications, such as cyber-physical systems and driverless-transporting-systems execute intra-logistics processes within the manufacturing factory of companies (Dangelmaier, et al., 2001).

The distribution activities will be rethought and new technologies will be implemented as well (Kawa, 2012), since with transporting systems performing autonomous decisions based on pre-implemented algorithms, the logistics processes are already within the autonomization process (Coyle and Ruamsook, 2014). Algorithms may also enable products to make autonomous decisions during outbound-logistics activities in the digitalized supply chain of the future. This could be a real-time analysis of the currently existent quality on their way to the customer. Autonomization in logistics therefore means the autonomous decision-making, controlling, planning and initiation of logistics activities (Broy, 2011). Robotics may reduce the costs of production that arise from a reduced dwell-time and automated processes (Potkonjak, et al., 2000). Even the IoE will have an influence on the structural organization of supply chains. For example, the company's supply chain management could install an algorithm which reacts to bad-weather information autonomously and chooses a different transporting system (Li, et al., 2014). With the details given above, and the score shown in the heat-map (figure 6), we come up with the following first hypothesis: The supply chain will undergo an organizational change mainly with respect to the production and distribution processes from a structural perspective. The most impact will arise from the M2M-communication, and Smart Factory including Smart Logistics.
In the following, we examine the expected organizational changes with respect to technological variables. Compared to the other two variables "structure" and "people", organizational changes on the supply chain due to technological developments come out on top. Furthermore, we understand that the biggest impact is to be expected within the procurement,

production and distribution processes. Within our following detailed impact analysis, we limit our documentation to the technologies and concepts which have an influence on all supply chain activities (see figure 6). Through the miniaturization of electronics, the costs of transporting, warehousing and production can be reduced (Keyes, 2000). Based on this miniaturization process, AIDC- and RFID-technologies enable the digitalization process of the supply chain, and deliver real-time information about the current status of logistics activities. With this, the truck-delivery of specific products could be optimized (Lee, Padmanabhan and Whang, 2004; Geisberger and Broy, 2012). For example, the delivery information of transported products could be changed in real-time and whenever needed (Whang, 2010). This way, a product that is already on its way to the initially targeted customer could be routed to another nearby customer if the delivery was aborted. Hence, with the digitalization of all logistics processes through AIDC- and RFID-technologies, even problem management can be carried out centrally and online. For example, truck drivers may easily communicate with other machines (e.g. the loading area of the target delivery location) and inform the company about the expected delivery time (Botthof and Hartmann, 2015). Machine-to-Machine Communication impacts the supply chain, as it enables the automated recording and communication of process information in the production facilities and in the distribution networks. It furthermore supports the maintenance of machines, provides new paying methods for the sales function of a company and new services such as fleet management or track and trace systems. Challenges with respect to the machine-to-machine communication arise from the need for standardized communication protocols and cyber-security (Chen, Wan and Li, 2012). Technologies and IT-infrastructure elements, which fall under the term Business Intelligence, will impact the supply chain activities through cost-reduction opportunities and an increase of the process-transparency. Furthermore, processes will be more digital and technological, where the company's personnel are able to acquire and share information using the BI-technology from anywhere (Zheng, Fader and Padmanabhan, 2012). Especially procurement processes can be optimized, as suppliers can be fully flexible and autonomously chosen by specific software (Mishra and Agarwal, 2010). Smartphone apps, as described in chapter 4, will have an impact on the organization of the supply chain activities from a technological perspective as well. In future, each employee will be equipped with this kind of mobile devices, interact with colleagues, perform time-management and execute specific activities in the manufacturing process with the smartphone. Specific apps will be created to enhance the efficiency of the production processes, e.g. a track and trace system of specific product components, or by assisting software for the human activities in the company. A leading industry which is already including the smartphone apps within its supply chain is the medical industry (Xu, et al., 2011). With this analysis, we come to the following hypothesis: If companies implement Industry 4.0 technologies and concepts, the supply chain will mostly undergo a technological change, and mainly with respect to the procurement, production and distribution processes. The biggest influence will arise from BI-technologies, Smartphone Apps, AIDC- and RFID-technologies and the miniaturization of electronics.

The smallest organizational changes are to be expected from the variable "people". Despite the sales processes, where interactions with customers will face a huge impact from "Industry 4.0" technologies, the other supply chain activities will remain the same. The biggest impact on the organization of the supply chain arises from Smart Data tools and Smartphone apps and hence, these will be included in the documentation of our analysis. Smart data tools require specific knowledge from the people within the organization. Leading companies will change their requirements when hiring personnel from supply chain understanding to knowhow with respect to the topics of mathematical and statistical analysis, cyber-security data science and programming of algorithms. This knowhow will be needed throughout the whole supply chain to validate the huge amount of available data and to implement Smart Data tools and analytics (Lazovic, Montenegro and Durickovic, 2014). Despite the digitalization of physical logistics processes, the delivery of a digital value proposition to the customer is considered even more strongly (Preiß, 2014). Through Smartphone Apps, it may allow a quick response with targeted advertising to ecological and social trends discussed in social networks (Ghose and Han, 2014). Even new business models can arise from this opportunity, and new customers can be reached in different markets (Shin and Choo, 2012). This connection to social networks enabled by the IoE creates an interface with multiple other devices (e.g. servers, data bases, notebooks, tablets or mobile phones) and increases the awareness concerning IT- and cyber-security issues (Krumm, 2010). Hence, closed systems which were acting independently are now connected to other devices and networking (Zhu and Kraemer, 2002). These enable the integration of people within the production, distribution and sales processes (Zhu, 2004). During the manufacturing processes not only specific machines, but whole fractions of the production facilities may be managed using apps via a mobile device. The distribution process is already including smartphones in the process, as truck drivers can update the intra-logistic departments of the receiving companies about the most likely time of arrival (Sha, et al., 2013). The sales processes will face huge impact from smartphone apps due to ubiquitous computing and the worldwide availability of technology. Products are sold on online platforms wherever and whenever a customer wants to reach the company (Swaminathan and Tayur, 2003). A huge autonomization is to be expected for the interaction of sales people and customers in the sales departments of companies. Hence, influences of social networks may also be of high importance. Furthermore, co-operations within the logistics process can be better organized within a pre-defined network of logistics companies. This way information about the weather or the traffic status will be better communicated within a specific network (Zammuto, et al., 2007). With this analysis, we come to the following hypothesis: With respect to the people-driven changes to the organization, the biggest impact is to be expected for the sales activity in the supply chain from the usage of Smartphone Apps and Smart Data tools.

6 Summary

Based on a structured literature review, we were able to understand that current research with respect to the term "Industry 4.0" is limited to specific, qualitative and quantitative analysis of technologies and their implementation within the company's value chain. We first stated a definition for the term "Industry 4.0" based on the characteristic features digitalization, autonomization, network-collaboration, socializing, modularization, transparency and mobility. This was the basis for an additional analysis, which contributed to the research by the creation of a mind-map, including significantly important technologies and concepts discussed within the relevant literature. The respective management of companies from all industries can apply the method used in this paper to identify only relevant technologies with respect to their own supply chain. We have analyzed all technologies and concepts given in the mind-map with respect to the following question: Does the technology/ concept contribute or enable product or process innovations within the organization according to the identified characteristic features of "Industry 4.0"? We came to the conclusion that in total, 15 out of 49 identified technologies and concepts are of high importance. We furthermore contributed to the research by developing and applying a management-model that provides a holistic management-perspective on challenges and potentials arising from the implementation of "Industry 4.0" technologies within the organization. This model combines two theories: The theory of organizational change by LEAVITT and the supply chain activities model by MEYR and WAGNER. In the end, we came up with three interesting hypotheses with respect to organizational change driven by the interdependent categories of structure, technology and people. The biggest impact from the "Industry 4.0" technologies and concepts is to be expected from a technological view especially for the procurement, production and distribution activities in the supply chain. The organization of the supply from a technological view will mainly change due to the implementation of BI-technologies, Smartphone Apps, AIDC- and RFID-technologies and the miniaturization of electronics. However, structural changes to the organization are to be expected mainly in manufacturing processes. Impacting technologies are the M2M-communication, and Smart Factory including Smart Logistics. With the combined implementation of Smartphone Apps and Smart Data tools, the interaction of people within the supply chain will face a huge impact in the sales departments of companies, where the customer can be integrated and organizational borders are eliminated.

As this analysis was performed based purely on the results of the structured literature review, a quantitative analysis to validate the results must be performed in future research and to confirm the hypotheses. Furthermore, the summarizing model in chapter 5 does not weigh the factors with which the specific challenges or potentials are operationalized in the framework. In future analyses, the importance of specific challenges and potentials has to be analyzed and validated in conjunction with experts in respective interviews.

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E-commerce Last-mile Supply Network Configuration and Logistics Capability

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The exact mechanism as to how last-mile supply network (LMSN) configuration influences performance has been relatively undeveloped, and with mixed results in the extant literature. This paper argues the difficulty in arriving to a convergent understanding because of a missing link that connects the relationship between configuration and performance. Specifically, it is posited that the missing link lies in the mediating role of logistics capability (comprising demand-management interface; supply-management interface; information management; and co-ordination) on the relationship between LMSN configuration and performance. Using the configurational approach, six configuration dimensions are identified: consumer portfolio; product portfolio; network structure; network flow; relationship and governance; and service architecture. By incorporating greater precision and additional theoretical considerations, this paper presents a conceptual framework through a set of propositions that provides greater depth of insight regarding the relationship between the influencing factors on LMSN configuration with logistics capability and performance.

Keywords: Last-Mile Supply Network, Configuration, Logistics Capability, E-Commerce

1 Introduction

The extant academic studies addressing issues related to e-commerce driven last-mile supply network (hereafter LMSN) and last-mile logistics (LML) have predominantly adopted a reductionist (or contingency) view (e.g., Esper, Jensen et al., 2003a, Punakivi, Yrjola et al., 2001). While such studies enhance the understanding of the causal relationships between select constructs, they are not able to capture the system dynamics and interrelationships between parts (Flynn, Huo et al., 2010), which are crucial in the dynamic LML context. Hence, a configurational approach adopting a holistic view can complement the contingency approach to enhance existing understanding and perhaps offer new insights. Since the seminar work of Singh Srai and Gregory (2008) and Neher (2005) represent early efforts to cross-fertilize configurational theory to the supply chain domain, the relationship between configuration and performance remains relatively undeveloped.

Research trend on configuration within the strategic management field on the other hand has taken a more active approach to studying the link (e.g., Ketchen, Combs et al., 1997, Leask and Parker, 2007, Short, Ketchen et al., 2007), as well as between capability and performance (e.g., Barney, 1991, Pavlou and El Sawy, 2011). While the link between capability and performance (Ferdows and De Meyer, 1990, Flynn and Flynn, 2004, Peng, Schroeder et al., 2008) appears to be well established, results linking configuration and performance have been mixed (e.g., Barney and Hoskisson, 1990, Ketchen, Combs et al., 1997, Thomas and Venkatraman, 1988). In the same light, several studies within the logistics domain have supported the link between logistics capability and performance (Cho, Ozment et al., 2008, Lu and Yang, 2006, Zhao, Droge et al., 2001), while those between configuration and performance are scarce (e.g., Chow, Heaver et al., 1995). This paper attempts to explain the difficulty in arriving to a convergent understanding because of a missing link that connects the relationship between configuration and performance. Specifically, it is posited that LMSN configuration influences performance through logistics capability.

The purpose in this research is to provide a theory-based explanation to clarify the role of LMSN configuration and the configuration dimensions on logistics capability and propose a conceptual framework that explicates the relationship between the influencing factors on LMSN configuration, with logistics capability and performance. This is done by addressing the intrinsic capabilities derived from configurations that have been largely overlooked in prior research. The three research questions this paper aims to answer are: RQ1) what are the main dimensions of LMSN configuration; RQ2) how are the configuration dimensions link to logistics capability; and RQ3) what are the drivers of logistics capability?

This paper is organized as follows. Section 2 provides the theoretical background. Section 3 describes the conceptual framework. Section 4 presents the framework in detail and the propositions. Section 5 discusses the implications on research and practice, while conclusion is drawn in Section 6.

2 Theoretical Perspectives

Two well established theoretical perspectives that describe the effects of configuration on performance are summarized here: configurational theory and supply network configuration; and resourced-based theory. The purpose is to highlight some of the limitations that arise from applying these perspectives to illustrate the need for additional insight.

2.1 Configurational Theory and Supply Network Configuration

Originated primarily from the strategic management field, Miller and Friesen (1984) define configurations as the "commonly occurring clusters of attributes or relationships […] that are internally cohesive". Since configurations are composed of tight constellations of mutually supportive elements, they are considered predictively useful as the presence of certain elements can lead to the reliable prediction of the remaining elements (Miller, 1986). Several academics have since consented that configuration can generally be defined as the harmonic interaction of commonly occurring clusters of attributes of strategy, structure, process (or activities) and context (or environment) (e.g., Hambrick, 1984, Miller, 1990, Peter, Deborah et al., 1996).

Scholars who have adopted the configuration approach in the operations management domain include: Fisher (1997), Lee (2002), Neher (2005), and Singh Srai and Gregory (2008) in SCM; and Klaas (2003) in logistics who identified some logistically relevant variables grouped into context and design variables and highlighted that firms displaying a harmonic patterns of logistics configurations would be more efficiently organized and therefore more successful in their struggle for competitive advantage. Others have attempted to empirically show the linkage with performance as a result of better 'fit' among the configuration dimensions (e.g., Bowersox, Closs et al., 1999, Chow, Heaver et al., 1995). The theory of configuration therefore suggests that because the attributes describing configurations are interdependent, limited varieties exist, and configurations that display harmonic patterns tend to result in better performance.

2.2 Resource-based Theory

Early literature on how firms create economic rents can be explained through two distinct causal mechanisms, resource-based view (selecting resource or resource picking) and the dynamic capabilities (deploying resource or capability building) (Makadok, 2001). The resource picking mechanism codified as resource-based view suggests resource ownership as the primary means to create economic rents and takes places before the acquisition (Conner, 1991, Makadok, 2001). The capability building mechanism codified as dynamic capability view suggests that firms' capabilities can only generate economic rents after resource acquisitions (Teece, Pisano et al., 1997). However, the idea of dynamic capability is actually better understood as the particular non-imitability capacity that a firm possesses to shape, reshape, configure and reconfigure its assets with the object of being responsive to changing technologies and market conditions (Teece, Pisano et al., 1997).

Resources are generally referred to the tangible and intangible assets owned by the firm that could be productively used (Grant, 1991), while routines are organizational processes that employ clusters of resources to achieve certain desired outcomes (Teece, Pisano et al., 1997). Capabilities are then described as high-level bundles of interrelated yet distinct routines (Amit and Schoemaker, 1993, Hult, Ketchen Jr. et al., 2003, Winter, 2003). As opposed to resources, routines and capabilities are generally "embedded in the dynamic interactions of multiple knowledge sources and are more firm-specific and less transferable, thus leading to competitive advantage" (Peng, Schroeder et al., 2008).

Some scholars highlighted that the concept of capability has been relatively abstract and high-level, and attempted to operationalize the concept (e.g., Pavlou and El Sawy, 2011, Peng, Schroeder et al., 2008). For example, Peng, Schroeder et al. (2008) argue that routines are a critical source of operation capabilities, and provided empirical evidences linking routines with operational performance.

2.3 Limitations of Configuration and Resource-based Theory

A configurational perspective of LMSN can facilitate a comprehensive analysis of LML system dynamics. The patterns of configuration might impact performance but current studies have either explored various configurations without an explicit link with performance, or have yet to provide further explanations to the mechanisms or how they impact performance.

Beyond the notion of routines that define capabilities, there is not yet a holistic view of the specific sources of capabilities where routines are embedded. This could be explained by the relatively abstract concept of capability and the fact that studies pertaining configuration and capabilities have largely been carried out in silos.

Since configuration comprises structures, processes, relationships, and service architecture, which are in fact sources of capabilities where routines are embedded, there is a significant potential to integrate knowledge in these two domains to shed light on how configurations have intrinsic (or latent) capabilities that drive performance.

3 Conceptual Framework

Based on a synthesis of the information and insights from the extant theories and literature, six configuration dimensions are identified (Lim and Srai, 2015): 1) product portfolio; 2) consumer portfolio; 3) network structure; 4) network flow; 5) relationship and governance; and 6) service architecture. A model linking the influencing factors on LMSN configuration dimensions with logistics capability and performance is conceptualized (see Figure 1 and 2). Both product portfolio and consumer portfolio impact performance in an offline retail setting. Logistics capability modeled as a formative second-order model comprising network structure, network flow, relationship and governance, and service architecture as the sources (or drivers) of capability mediates the relationship between product and consumer portfolio, and performance prevalent in the online retail context. The relationship between the first-order and second-order constructs can either be reflective or formative (Edwards, 2000). A formative second-order model is more appropriate to represent logistics capability, as the four configuration dimensions are complementary to each other.

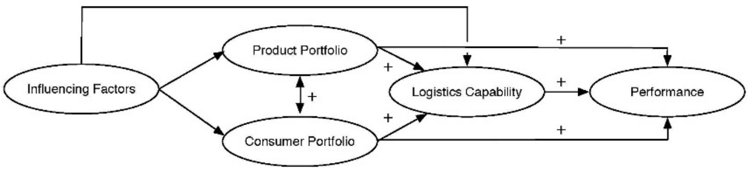

Figure 1 Conceptual Framework

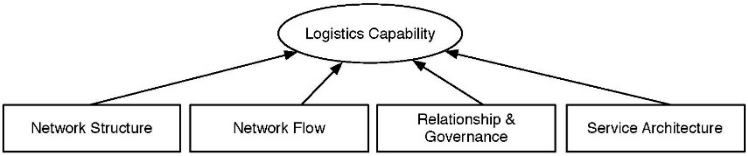

Figure 2 Drivers of Logistics Capability

Several studies have empirically tested the link between logistics capability and performance (e.g., Cho, Ozment et al., 2008, Zhao, Droge et al., 2001). This research adopts Cho, Ozment et al. (2008)'s measurement items to operationalize performance viz. profitability; sales growth; customer satisfaction; and overall performance. In addition, there is a set of external (Knudsen, 1995), and internal (Piotrowicz and Cuthbertson, 2014, Stock, Greis et al., 1998) factors influencing the configuration dimensions particularly, product and consumer portfolio mix, as well as the logistics capabilities required which in turn impact the drivers.

4 Framework Development

In this section, a model of propositions that address the causal means by which the configuration dimensions influence performance is developed. In the previous sections, several studies that support the positive association between logistics capability and performance have been highlighted, and thereby introduce the first proposition:
Proposition 1. Logistics capability is positively associated with the performance of a firm within the LMSN.

4.1 Influencing Factors

Influencing the configuration and logistics capabilities is a set of external (Knudsen, 1995), internal (Stock, Greis et al., 1998), and operational factors (Piotrowicz and Cuthbertson, 2014) that impact the product and consumer portfolio mix as well as the logistics capabilities required. The external factors are conceptualized in terms of competitive environment/dynamics (Hines, 2004); and internal factors in terms of strategy and competitive scope (Stock, Greis et al., 1998), and operational requirements in cross-channel visibility prevalent in the omni-channel retailing context (Piotrowicz and Cuthbertson, 2014).

The following propositions to capture the effects of the influencing factors on configuration are offered next:

Proposition 2a. External factors (in terms of competitive dynamics) influence product portfolio, consumer portfolio, and logistics capability.

Proposition 2b. Internal factors (in terms of strategy and competitive scope, and operational requirements in cross-channel visibility) influence product portfolio, consumer portfolio, and logistics capability.

4.2 Consumer Portfolio

Consumer portfolio is defined as the "collection of mutually exclusive customer groups that comprise a business' entire customer base". The ability of a firm to serve a wider array of different customer segments makes for a stronger business model and hence increases the potential of performance (Johnson and Selnes, 2005). While most firms would desire to serve as many segments as possible, resource limitation forces firms to only select a handful to focus their efforts and resources to develop the relationships (Terho, 2009).

Consumer portfolio is a construct conceptualized with four key constituents (see Figure 3):

(1) Characteristics, determined by means of market segmentation comprising demographics, psychographics, geographic and behavioral (Buttle, 2009, Solomon, Bamossy et al., 2006);

(2) Strategic importance, determined by the volume or dollar value of purchases, potential and prestige of account, customer market leadership and the overall account desirability (Fiocca, 1982, Yorke and Droussiotis, 1994);

(3) Difficulty in managing each account, determined by product characteristics, account characteristics, and competition for the account (Fiocca, 1982, Yorke and Droussiotis, 1994); and

(4) Profitability, determined by gross revenue less costs incurred (Yorke and Droussiotis, 1994).

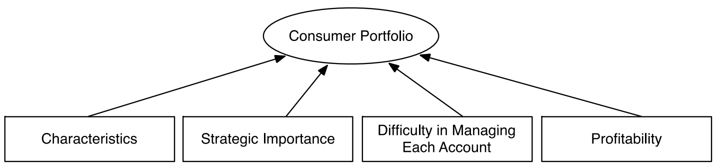

Figure 3 Proposed Model of Consumer Portfolio

Yorke and Droussiotis (1994) argue that the product mix purchased by consumers is critical to profitability. For instance, low profit margin products such as groceries can incur losses if ordered in small quantities and have to be delivered to consumers' homes. Hence, firms typically attempt to offer products of specific characteristics to particular consumer segments (Buttle, 2009, Solomon, Bamossy et al., 2006). It is therefore intuitive that characteristics of the consumer portfolio would influence a firm's product portfolio.

The prevalence of omni-channel retailing has resulted in the proliferation of channels, product formats and consumer profiles, and firms are increasingly challenged to offer a wider range of products and formats to serve their consumers' needs. Heterogeneity in consumer profiles necessitates firms to develop varying levels and types of logistics capabilities in pre- and post-sale customer service, flexibility, delivery speed and reliability.

Considered in all, firms that can manage a wider consumer portfolio in which to develop relationships would likely result in higher performance. This potential increases when the accounts are of strategic importance with lower difficulty of account management and higher profitability. This leads to the following proposition:

Proposition 3. Breadth (or variety) of consumer portfolio (in terms of distinct types of consumers that the firm can serve) characterised by strategic importance, management difficulty and profitability is positively associated with firm's performance.

Proposition 4a. Characteristics of consumer portfolio influence the characteristics of product portfolio.

4.3 Product Portfolio

A product portfolio represents the collection of products including stock keeping units (SKUs) and formats offered by a firm for the types of consumers it desires to develop relationships (Fixson, 2005).

In a study, Berger, Draganska et al. (2007) examine the impact of portfolio variety on consumer choice and show that larger numbers of product variants were associated with a perception of higher line quality. Hence it can be implied that increasing the breadth (or variety) of product portfolio through optimum selection has the potential to increase firm's performance by being able to meet consumer needs (Kaul and Rao, 1995). From another perspective, consumer needs influence a firm's product portfolio mix (Jiao and Zhang, 2005).

Product portfolio is a construct conceptualized with two key constituents:

(1) Product characteristics, determined by cost and frequency of purchase, value proposition (i.e., perishability), and the degree of differentiation (Peterson, Balasubramanian et al., 1997); and

(2) Demand variability, determined by the level of demand uncertainty (Lee, 2002).

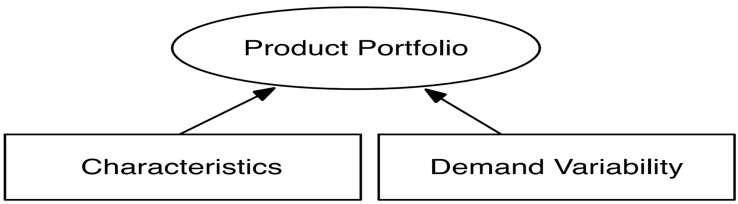

Figure 4 Proposed Model of Product Portfolio

Product portfolio can influence the types of logistics capabilities required. For instance, products of low demand variability drive efficient and low distribution cost capability while products of high demand variability drive the need for capability in flexibility.

Considered in all, firms that can manage a wider product portfolio would likely lead to greater potential for performance. This potential increases when the demand variability is low which allows firms to maximize the efficiency of the associated operating processes. Integrating these arguments lead to the following proposition:

Proposition 4b. Characteristics of product portfolio influence the characeristics of consumer portfolio.

Proposition 5. Breadth (or variety) of product portfolio (in terms of distinct types of product/SKU) characterised by demand variability is positively associated with a firm's performance.

4.4 Logistics Capability

Logistics capability is a construct conceptualized with four first-order variables: network structure; network flow; relationship and governance; and service architecture. These are in fact the identified configuration dimensions where we argue routines are embedded. Firm-level capability is typically associated with cost, quality, flexibility and dependability while at the operational level, capability is usually associated with performance measures (Ghosh, 2001).

The work of multiple papers that discussed logistics capabilities relevant to the e-commerce context have been synthesized, and subsequently categorized into four types: demand-management interface (i.e., flexibility, presale and post-sale customer service, delivery speed and reliability, and responsiveness to target market), supply-management interface (i.e., widespread distribution coverage, selective distribution coverage, and low total cost distribution), information management (i.e., information technology and sharing, connectivity, delivery information communication, and web-based order handling), and co-ordination capability (i.e., internal and external). Each capability can be evaluated based on the measurement items proposed by the respective authors (Morash, Droge et al., 1996, Zhao, Droge et al., 2001, Cho, Ozment et al., 2008, Mentzer, Min et al., 2004).

While product portfolio and consumer portfolio can directly impact firm's performance, their real impacts are only realized when the right product(s) can be delivered to the right consumer(s) at the right time and place in the e-commerce context. Hence, a partial mediation exists where logistics capability mediate the relationship. Due to the inherent characteristics of product portfolio, different product attributes suit different types of distribution schemes and thus capabilities to efficiently and effectively transport and deliver the product(s) from the fulfillment location to the consumers. Indeed, some authors state that firm performance is a function of the coherent alignment between product variety and supply chain structure (Childerhouse, Aitken et al., 2002, Randall and Ulrich, 2001).

Similarly, different types of consumers might prefer a particular distribution (or reception) scheme over others. For example, online grocery shoppers doing their main shopping mission would likely prefer direct home delivery service, while shoppers preforming 'top-up' purchases of specific items might prefer a "buy online pick-up in-store" (BOPS) service (IGD, 2014). Either would require different fulfillment and distribution structure, and by extension different logistics capabilities. The preceding theoretical development and examples lead to the following two propositions:

Proposition 6a. Logistics capability mediates the relationship between consumer portfolio and performance of the firm within a LMSN.

Proposition 6b. Logistics capability mediates the relationship between product portfolio and performance of the firm within a LMSN.

4.4.1 Network Structure

Network structure is operationalized as a first-order variable described by the degree of: structural (de-) centralization; vertical and horizontal integration; and geographic dispersion (see Figure 5). A high degree of logistics infrastructure centralization permits firms to leverage on economies of scale both in transportation and warehousing (Cooper, 1983). Firms adopting this structure benefit from having lower inventory level through consolidation, and gain the ability to deal with demand variability. On the other hand, a de-centralized structure allows faster order to consumer cycle speed as facilities are located closer to the consumers (van Hoek, 1998). Therefore, a centralized structure would have an intrinsic capability of flexibility, while a de-centralized structure would have higher delivery speed, lower total cost distribution costs and higher responsiveness to target market.

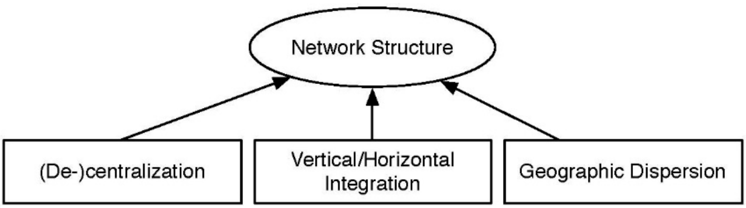

Figure 5 Proposed Model of Network Structure

Vertical integration relates to the extent in which a firm owns the various stages of the upstream to downstream supply chain (Stock, Greis et al., 1998), while horizontal integration relates to the level of multiplicity of the same stage/function (Klaas, 2003). A low vertical and high horizontal integration allows firms to be more flexible in reconfiguring their distribution networks to adapt to market dynamics (Gunasekaran, Patel et al., 2004), while a high vertical and low horizontal integration reduces co-ordination complexity and increase control over service quality to maintain brand reputation (Esper, Jensen et al., 2003b).

A high degree of horizontal integration would gives firms the capability of resilience and the ability to cope with disruptions through alternate nodes that provide similar capabilities. Therefore, a network structure characterized by the degree of vertical integration relates to the intrinsic capabilities of information sharing, delivery information communication and internal co-ordination while the degree of horizontal integration relates to capabilities of flexibility, and responsiveness to target market in terms of the ability to handle frequent small orders.

Geographic dispersion refers to the extent in which facilities and operations in the distribution network are dispersed geographically (Stock, Greis et al., 1998). Low geographic dispersion exhibits a high proportion of facilities and operation concentration in a specific region. Typically, this means the ability to provide high level of delivery service within a localized region. Hence, a low geographic dispersion structure has intrinsic capabilities of delivery speed, ease of co-ordination, and higher pre- and post-sale customer service due to proximity, while a high geographic dispersion structure would have capabilities of widespread distribution coverage, and the ability to select distribution coverage.

4.4.2 Network Flow

Network flow is operationalized as a first-order variable described by the degree of: flow integration; and flow co-ordination (see Figure 6).

Co-ordination and integration mechanisms are the key dimensions characterizing distribution network flow and dynamics (Cooke, 1997, Lee and Ng, 1997, Stock, Greis et al., 1998). Rai, Patnayakuni et al. (2006) highlight that enabling intra- and inter-firm process integration and co-ordination would result in the development of higher-order capabilities, such as streamlined material, and information flows across the supply chains.

Co-ordination can be defined as a pattern of decision-making and communication among a set of actors who perform tasks to achieve goals (Malone, 1987). Lee and Ng (1997) highlight that gains from increased efficiency of supply networks can be achieved through the coordination of multiple flows in a supply network.

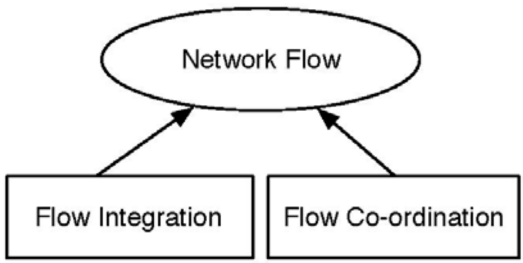

Figure 6 Proposed Model of Network Flow

Network flow dynamics characterized by the degree of flow co-ordination would allow firms to achieve varying levels of internal and external co-ordination capability, as well as information management capability (in terms of information sharing, connectivity, delivery information communication and web-based order handling).

The concept of integration as a mechanism to support supply chain and logistics processes is closely linked to the effort required to overcome intra- and inter-organizational boundaries, and to achieve a shift from local to system optimization (Romano, 2003). However more often than not, the major obstacles to fully integrate the entities in the value network lie in the inadequacy of internal management systems, high level of fragmentation in information flows, and lack of integration among different information systems (Forza, Romano et al., 2000, Simchi-Levi, Kaminsky et al., 2000). Cross-channel integration is critically important to enable omni-channel retail. The consequences of high integration are: significant cost reductions, the simplification or elimination of activities and the synchronization of all the production and distribution operating systems (e.g., Hammer, 2001, Rosenzweig, Roth Adela et al., 2003).

In all, network flow dynamics characterized by the degree of flow integration would result in varying levels of information management capabilities in terms of information technology, delivery information communication and information sharing.

4.4.3 Relationship and Governance

Relationship and governance is operationalized as a first-order variable described by: the degree of interdependence; and networked governance structure (see Figure 7).

Some scholars highlight that the key factor in gaining competitive advantage in supply chain is the formation of interdependence (Lejeune and Yakova, 2005, O'Keeffe, 1998) and is a necessary condition for obtaining the desired outcomes (Mentzer, Min et al., 2000). Interdependence refers to the degree in which the success of each firm in a relationship depends on the actions of the other firms (Stock, Greis et al., 1998).

The descriptors adopted for interdependence follow the work developed by Lejeune and Yakova (2005) in which they characterized interdependence as form and depth with each operationalized via two attributes: trust and decision-making for form; and information sharing and goal congruence for depth.

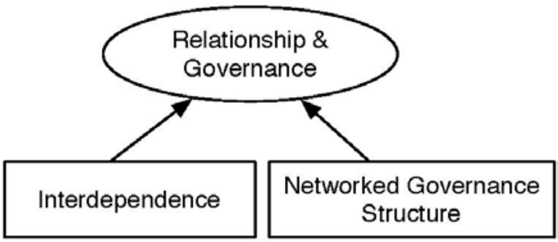

Figure 7 Proposed Model of Relationship and Governance

At one end of the continuum is a relationship builds upon goodwill trust, 'dyadic' parity-based decision-making process, supply-chain-wide information sharing and true goal congruence. Such relationships are typically long-term where firms are interdependent and minimum transaction costs are incurred due to the high level of trust that neither party would exhibit opportunistic behavior. In addition, due to the high level of information sharing, such relationship structures have intrinsic capabilities in external co-ordination and information management giving firms the ability to respond to demand variability and supply disruptions. At the other end, a relationship builds upon deterrence-based trust, 'myopic' decision-making process, nearest-neighbor information sharing, and absence of goal congruence represents a weak relationship that is typically short-term characterized by sporadic information flow, and high transaction costs incurred to govern opportunistic behavior(s).

Networked governance structures (NGS) can be defined as the "economic forms of organization that are built on reciprocal exchange patterns, enabling firms to obtain resources and services through dyadic relationships with other organizations, as well as through broader relational links where these relationships exist" (Rabinovich, Knemeyer et al., 2007).

NGS is characterized by the governance mechanism (Barney, 1999) and the strength of NGS (Rabinovich, Knemeyer et al., 2007). The types of mechanisms can generally be grouped into three categories: market governance; intermediate governance; and hierarchical governance (Barney, 1999).

On strength of NGS, firms typically attempt to increase the strength when the associated transaction costs are higher than what could be obtained outside the firms' boundaries, and the key determinants include level of asset specificity and uncertainty faced by firms (Rabinovich, Knemeyer et al., 2007). Rabinovich, Knemeyer et al. (2007) argue that the development of stronger networked structure becomes more viable when asset specificity decreases as the cost of safeguarding (or policing) incurred by the focal firm decreases. This allows firms to access to greater externalities in terms of access to users and capabilities, and complementariness (Katz and Shapiro, 1994). Similarly lower uncertainty motivates firms to leverage on the capabilities of network partners as resources required to manage relationships reduces.

In all, the degree of interdependence and networked governance structure would give firms varying levels of access to demand-management interface and supply-management interface capabilities.

4.4.4 Service Architecture

Service architecture is operationalized as a first-order variable described by the degree of: architecture decomposition; and service modularity (see Figure 8).

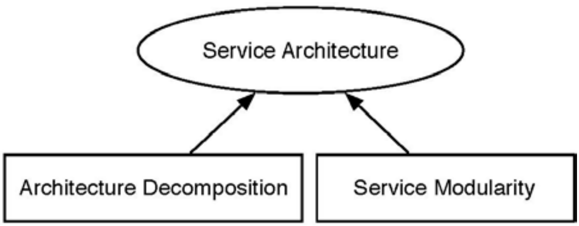

Figure 8 Proposed Model of Service Architecture

Voss and Hsuan (2009) define service architecture as "the way the functionalities of the service system are decomposed into individual functional elements/modules to provide the overall services delivered by the system". Essentially, the process of decomposition allows firm to gain deeper insights into the modules (or parts) that form the service system, identify the ratio of unique to standard service nodes that gives an indication of the degree of competitive advantage, and at the various levels of decomposition to identify sources of logistics capabilities or the lack of them. Several scholars have recognized that having modular architectures vis-à-vis integral architectures enable greater mass customization capability in terms of service variety and flexibility to respond to consumer needs (e.g., Pekkarinen and Ulkuniemi, 2008, Voss and Hsuan, 2009).

Pekkarinen and Ulkuniemi (2008) define service modularity as the "usage of reusable process steps that can be combined ("mixed and matched") to accomplish flexibility and customization for different customers or situations in service implementation". Modularizing services facilitate the division of tasks within the network (Leseure, Bask et al., 2010) that yields economies of scale and scope, and provides the foundation for customization through structuring services and/or processes to facilitate outsourcing (Voss and Hsuan, 2009). Higher degree of modularity enables firms to easily make in-sourcing and outsourcing decisions due to the higher level of specification and standardization (Mikkola, 2007). Hence, service architecture characterized by the degree of decomposition and modularity appears to have intrinsic capability in flexibility and customization, and the process of decomposition helps to establish this analysis in terms of modularity and integrality of the service modules and elements.

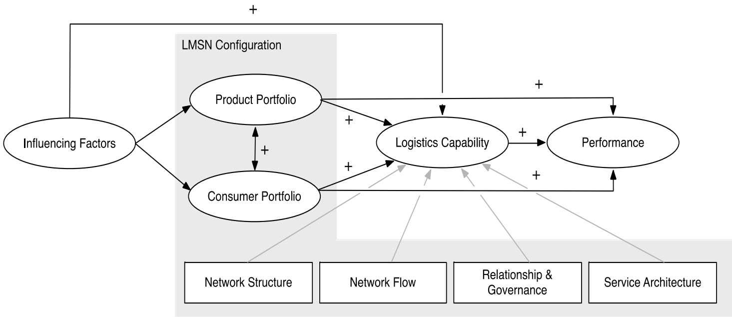

Figure 9 Detailed Conceptual Framework

Integrating the presented evidences and studies from the six configuration dimensions lead to the final proposition (see Figure 9):

Proposition 7. LMSN configuration influences performance through logistics capability.

The above proposition is derived based on the arguments that both the product portfolio and consumer portfolio drives the types of logistics capabilities required, while network structure, network flow, relationship and governance, and service architecture have intrinsic (or latent) logistics capabilities that influence performance.

5 Implications for Research and Practice

In this paper, configurational theory is combined with resource-based theory to offer new theoretical insights that link configuration with capability and performance. This paper creates the foundation for empirical work to test and refine the relationships expounded. The potential contribution of this line of research is the identification of emerging patterns of LMSN configurations, as well as understanding how the configuration dimensions drive logistics capabilities, and the propensity to develop dynamic capabilities.

The identification of a comprehensive yet limited number of dimensions would allow managers to focus on the specific areas of importance that actually influence performance. Through the elements that operationalized each dimension, the framework provides guidance on what exactly can be reconfigured to offer new configuration mix that impact capability. This is important since capabilities developed can be lost very quickly through replications by competitors (Teece, Pisano et al., 1997). The drivers (or sources) of logistics capabilities determine the propensity to develop dynamic capabilities.

6 Limitation and Conclusion

By incorporating greater precision and additional theoretical considerations, this paper provides greater depth of insight regarding the relationship between the influencing factors on configuration, with logistics capability and performance; specifically highlighting the intrinsic capabilities embedded in configuration. The framework conceptualises six configuration dimensions: product portfolio; consumer portfolio; network structure; network flow; relationship and governance; and service architecture with the latter four being the drivers of logistics capability.

This paper assumes the established positive relationship between logistics capability and performance to focus the discussion on configuration and capability. Future research could explicitly ascertain the triad relationship. The discussions have hitherto limited to the LMSN considering portfolios of consumers and products. However, it is not difficult to foresee that the arguments would apply to the consumer and product level as well if greater granularity is required. The variables conceptualized within consumer and product portfolio can easily be applied to the unit level. External influencing factors are also limited to competitive dynamics. Future research could also consider the impact of distribution infrastructure and freight regulations on LMSN configuration.

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Logistics of E-Groceries.de

Amardeep Banerjee and Franziska Siemens

Attended home delivery and customer retention remain the biggest challenges for an e-grocer. Same day delivery resulted in death knell for Webvan one of the pioneers of e-groceries. On time, reliable delivery of groceries is a competitive differentiator and enhances customer loyalty, understating the importance of the last mile problem. The following work aims to find out the key factors characterizing the fulfilment strategy for a German online grocer in solving the last mile delivery problem. Literature analysis and study of business models form the basis of the conceptual framework. Furthermore, expert interviews from retailers using two different business models i.e. multi-channel grocer and pure e-grocer are conducted for practical insights and validation of the work.

Keywords: E-fulfillment, Last Mile Problem, Omni Channel Groceries, KPI

1 Introduction

The increased usage of internet has fuelled great interest in "point and click" way of living. Instead of traditional store shopping, goods are ordered online which need to be shipped to the final customer (Bubner et al., 2014). E-commerce sales in Germany are expected to reach 900 billion Euros by 2018, which is double the value of the present sales (eMarketer, 2014b). According to a recent study, the online grocery market in Germany had a turnover of 1.08 billion Euros and it is expected that the market grow by 44.4% to 1.56 billion Euros. (IGD report, 2013). The fact that an average consumer visits a grocery shop 2.2 times a week (Kahn and McAlister,1997) and 82 % of the online shoppers bought grocery online as a substitute to their frequent visits to the grocery store rather than one off stocking up or special occasion activity (Sneader et.al, 2000) makes online grocery an attractive preposition. Delivering the right product at the right time to highly price sensitive and internet-powered consumers is no easy task. The last mile is defined as the final stage in the distribution process in online retailing and is one of the most challenging parts of the supply chain (Esper et al., 2003). Recently, there has been increased usage of innovation and technology like usage of drones, smart bikes and referigated lockers (Gevaers, 2014) for on-time distribution of goods ordered online. For example, DHL implemented a research project for using drone delivery to the north German island of Juist. By using drone delivery, DHL wants to overcome infrastructural and delivery time related issues (Deutsche Post DHL, 2014b). It is estimated that the last mile accounts for 30% - 70% of the total logistics costs in a supply chain (Gevaers et al., 2011). The last mile problem becomes increasingly important for the grocery sector due to delivery of order promised within fixed time windows and perishability aspect of groceries (Punakivi et al., 2001; Agatz et al., 2008a). Section 2 will discuss the state of the art studies in e-groceries and last mile. This is followed by identification of different factors important for efficient and responsive e-grocery supply chains.

2 Literature Review

Geoffrion and Krishnan (2001) identify three major parts of e-commerce i.e. consumer-oriented activities, business-oriented activities and the infrastructure oriented activities that are needed for the former two other parts to function. Multi-channel retailers are also referred to as “bricks-and-clicks” retailers (Xing and Grant, 2006). For outlining the scope of the work, it is important to differentiate that pure and multi-channel retailers face different logistical challenges and trade-offs (Johnson and Whang, 2002; Agatz et al., 2008b). Pure players do not sell their products via physical store presence but via the means of electronic networks whereas multi-channel retailers rely on a combination of traditional retail stores and online services. Pure players are exposed to complex logistical decisions. Order picking, routing and order delivery are three logistical processes to be performed (ring and Tigert, 2001). In particular, demand variance has contributed to the development of different logistics approaches and business models (Kämäräinen et al. 2001a).

2.1 State of Art on E-Groceries

An e-grocer has the advantage of comparatively low initial investment but needs to very efficient yet responsive to sustain the competition in a price sensitive grocery market. According to Pyke et al. (2001), supply chains for online retailers compromise processes under two main categories i.e. supply management and order fulfilment. Supply management deals with the management of the supply and the inventory of the products, whereas order fulfilment includes all the processes from the point of a customers' buying decision until the moment when the good has been received. Different logistical processes will be triggered when a customer orders a product online. E-groceries are plagued with a variety of challenges ranging from design of a website to the pricing and execution of the final delivery process.

Challenges arise on different planning horizons from long term (e.g. network design) to short-term decisions (how to execute the final transportation). Delivering a product or a service to the customer has been proven as one of the most challenging tasks within the order fulfilment processes (Fernie and Sparks, 2009). Table 1 summarizes the recent studies related to framework development in online groceries. On a strategic and tactical planning level, providers have to make decisions choosing a certain delivery service level that balances customer convenience and efficiency in terms of costs (Agatz, 2008b).

Table 1 Recent studies on framework for online Groceries

Reference	Focus area and Methodology
Lunce(2006)	Descriptive framework for Strategic problem
Agatz (2008b)	Strategic, Tactical, Short term order routing
Boyer (2009)	Analytical and Simulation approach to the strategic problem.
Colla (2012)	Descriptive framework for Strategic problem
Ehmke (2014)	Analytical model for Short term routing

The presented frameworks have looked into short-term order routing strategic and tactical planning problems. Research methodologies used for these studies are literature overview, descriptive framework, analytical modelling, empirical studies or simulation based studies and case study research. The focus has been on analytical models for routing problems and development of descriptive frameworks. E-Grocery research has primarily delved into three areas i.e. customer service quality, design of conceptual frameworks and higher-level strategy based papers (Kuhn et al. 2014). On the strategic and tactical planning level of the last mile delivery, providers have to make decisions like choosing a certain delivery service level that needs to balance consumer convenience and efficiency in terms of costs (Chakravarty, 2014, p. 153; Agatz et al., 2008b). There exists a gap in literature regarding innovation in the last mile problem of e-grocers. Literature studies with respect to online groceries can be divided into two distinct periods. There has been an abundance of research interest in the early 2000's and renewed interest 2010 onwards. There has also been increased attention on carbon emissions of different fulfilment methods (Loon, 2014), (Belavia, 2014).

2.2 Customer Behavior and Last Mile

A number studies have looked at the effect of consumer behaviour in e-commerce. For example, Reibstein (2002) finds that customers in online sales are very heterogeneous and that the price of the products plays in important role in the purchase process even though it is no guarantee for customer loyalty, concluding that on-time delivery is important. Hsiao (2009) evaluates a study comparing buyer preference choices between online and offline stores concluding that the monetary value of the delivery time is highly valuated by the customer. Corresponding with Hsiao (2009), Zhang (2008) identifies the delivery time as one important element in the transaction process. It can therefore be concluded that delivery times play an important role in e-Commerce logistics effecting customer behaviour and preferences (Esper et al., 2003). Furthermore, Swaminathan and Tayur (2003) argue that customer expectations in e-Commerce in terms of delivery time and timeliness have increased in e-commerce. Xing and Grant (2006) emphasize high consumer expectations in terms of reliable and fast deliveries at convenient times. Boyer et al. (2003) show that late deliveries result in customer dissatisfaction.

Boyer and Hult (2005) examine case studies in the grocery industry to survey customer behavioural intentions. They conclude that e-Business quality (i.e. ease of use), product quality (i.e. assortment and quality) and service quality (i.e. credibility and communication) have a significant impact on customers buying intentions. In addition, they indicate that convenience in receiving a delivery is more important than the actual price. Brusch and Stübner (2014) examine customer expectations in terms of delivery times for German online shoppers. They find that there are differences in expectations within different clusters of consumers, e.g. frequent online shoppers are interested in fast deliveries. Schnedlitz et al. (2013) states that online-shoppers prefer home delivery to alternative delivery solutions such as a collection delivery point. Blauwens (2010), state that logistics provider should offer specific time windows for delivery (Agatz et al., 2008a). Boyer et al., (2004) show that offering narrow delivery time windows is a great opportunity to induce customers. Specific time slots for delivery can help improve the customer service and efficiency of the delivery (Agatz et al., 2011). In conclusion, corresponding customer behaviour in e-Commerce has a big relevance in terms of logistical processes and services. Småros et al. (2000) argue that customers' needs need to be considered first before implementing new services. High consumer expectations and preferences are main drivers for efficiency of the delivery. Yrjölä (2001) formulates the cost structure of different steps of the supply chain and develops a model for traditional grocery stores that want to enable electronic grocery shopping. The findings from this paper are closely related to Punakivi and Saranen (2001). A number of researchers (Gevaers et al., 2014; Fichter, 2003) support the idea of developing a cost simulation tool as there exists a lack of available real cost data. Gevaers et al. (2014) developed a tool that simulates based on a time and distance function. The last mile delivery costs per unit delivered are calculated taking into account several characteristics related to the last mile delivery (for example potential delivery time windows, pooling effects and customer density) into account.

3 Conceptual Framework

The following chapter will deal with the development of a qualitative model, which incorporates potential effects of innovation on costs.

3.1 Factor Analysis

In order to establish the last mile cost factors, different cost factors and drivers need to be identified. The last mile factors are subdivided into delivery related, innovation and external factors.

3.1.1 Delivery related factors

Multiple deliveries and FTHR (First Time Hit rate) have an influence on the last mile costs (e.g. Vanelslander et al., 2013; Gevaers, 2014). The term FTHR implies the percentage that a product can be successfully delivered to a customer at first try. If a product cannot be delivered to a customer at first try, the FTHR decreases because the product has to be taken back by the delivery provider. In case of a failed delivery, repeated deliveries are necessary which result in higher costs (e.g., Song et al., 2012; McLeod et al., 2006).

To avoid multiple deliveries and increase the FTHR, alternative solutions are being evaluated and currently being tested in practice. Additionally, alternative delivery concepts like unattended home deliveries, collection deliver points and store based pick up can increase the FTHR and help to avoid failed deliveries (Morganti et al., 2014b). The dropping factor describes the average number of parcels that are being delivered per stop (Gevaers, 2014; Schnedlitz et al., 2013). In order to lower delivery costs, a higher dropping factor implies better cost efficiency as more packages can be dropped at one stop resulting in time savings (Schnedlitz et al., 2013).
The dropping factor has a direct effect on the delivery efficiency in terms of costs. The higher the dropping factor, the lower the costs of the last mile delivery. Collection delivery points wherein more than one customer is served at once can influence the dropping factor in the last mile delivery, but requires high constant demand. The density of customers has a direct influence on the last mile delivery costs and is directly associated with the miles that have to be travelled (Boyer et al., 2009).

3.1.2 Innovation Factors

The vehicle factor contains the vehicle operating costs, which are directly related to the distance travelled (Pulido et al., 2014; Vanelslander et al., 2013). Vehicle operating costs are time and distance-related costs. Vehicle operating costs are related to the distance travelled and include several factors such as drivers' wages, fuel consumption and maintenance. The driver wage covers the costs involved in navigation of the vehicle, serving of the customer and maintenance or safety checks on the vehicle (Koether, 2014, p. 86; Vanelslander et al., 2013). Innovation can influence the different operating costs with regard to the vehicle use. Different types of vehicles can have a different impact on the last mile delivery costs and offer scope for innovation. For example, delivery by drones can result in savings in time and Labor costs.

3.1.3 External Factors

A delivery needs to be planned taking into account external factors. For example, delivery to city locations might be subjected to travel legislations like restricted time slots for entering different regions (Quak and de Koster, 2009). Infrastructure restrictions are considered as external factors. For example the limited number of delivery vehicles allowed entering densely populated urban areas in peak evening hours. Customer density and infrastructural restrictions can affect the dropping, stopping factor and the vehicle operating costs (e.g. Boyer et al., 2009).

3.2 Framework for Solving the Last Mile

The framework has to be interpreted as outlined in the following. From a supply chain perspective, the model looks at key performance indicators to manage supply and demand. Four set of KPI’s are identified and there are number of levers that have a direct and indirect effect on these KPI’s.

Table 2 KPI's for the last mile

KPI	Factors	Reference
Product Assortment	Inventory optimization Demand forecasting	Agatz (2008) Agatz (2008)
Delivery Profile	Number of Time windows Length of Time windows Frequency of Time window Delivery Factors	Punakivi (2001) Punakivi (2001) Boyer (2009) Gevaers (2014)
Degree of Innovation	Process + Service Innovation	Gevaers (2014)
Value Based Pricing	Pricing of Time windows Minimum order quantity	Agatz (2008)

Table 2 describes the KPI and the corresponding lever important in solving the last mile problem. The KPI's are decisions belonging to different planning levels of a supply chain. Innovation and value based pricing are two factors, which can be a good basis for service differentiation. Innovation (e.g. service and process), not only implies a change in some predominant components of order picking and order delivery, but also influences time or distance-related variables.

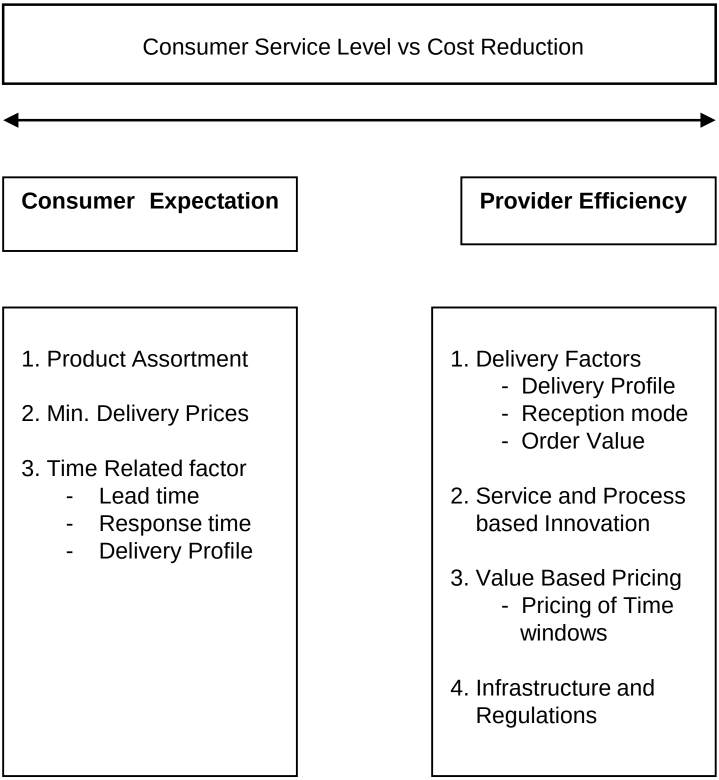

Figure 1 Factors for solving the Last Mile Problem

The first KPI, product assortment determines the assortment size i.e. number of products to be sold and the corresponding inventory policy for each of these products sold. High availability of the right product assortment gives an e-grocery player the necessary scale to compete with several multi-channel retailers. The strategy here can be niche based either product assortment or a whole range for product assortment. Managing capacity and inventory are important levers for ensuring right size of product assortment. The time and speed of delivery are important factors as they have a direct effect on the last mile and corresponding customer satisfaction. With gradual increase in volume of the online grocery market, there will be less scope for changes in assortment size or time of delivery.

As mentioned before, the provider has to fulfill consumer expectation ensuring high efficiency in terms of cost, the key performance indicators and factors are grouped into two categories namely customer expectations and provider efficiency in figure 1. One of the main challenges of the last mile is inefficient delivery routing due to unreliable deliveries that need to be made to remote areas. In order to implement innovation, laws and legislations need to be taken into account. The proposed framework combines different factors identified in the state of the art and can be used a guideline for e-grocery business in handling the logistical challenges.

Practical insights from the industry are always helpful in validating the work. The following sections will first discuss the existing business models and strategies in Germany. Insights from two German e-grocery retailers will be discussed.

4 Business Practices in Use

The market is characterized by price sensitive customer evident by the high presence of discount stores that consists of approximately 44% of the total retail chains (AT Kearney, 2012 p.2). Multi-channel retailers REWE, Edeka along with Lidl-Aldi dominate 70% of the market share in Germany (planet retail.net, 2015). German e-grocers use a variety of business models for fulfillment. Aldi, Lidl primarily use physical stores for selling grocery and online channel only as a catalogue where orders cannot be placed. Traditional multi-channel retailers like REWE, which actively use online and offline for selling groceries. Drive in concepts are currently tested by multi-channel retailers like Edeka drive (planetretail.net, 2015). The drive in fulfilment model saves in order delivery costs and uses its physical store as collection point for a number of deliveries. Shopwings.de is a Berlin based start-up, which gives customers options to their product assortments from different supermarkets in their vicinity. The purchase will be compiled in a regional grocery store and delivered by personal shoppers in their private vehicles. If an item in the desired supermarket does not exist, the personal shopper purchases a replacement item. Delivery is possible within two hours after the order. The variable delivery fee is dependent on the size of the basket. With conditions of anonymity or non-quantitative data in some cases, managers from two different German e-groceries agreed to share their insights in a semi-structured interview. A logistics routing manager was interviewed first as a sample interview. We intended to interview C-Level senior managers who have ample decision-making powers and work experience. Furthermore, two conversations were held with the respected

expert, first being an unbiased general perspective on the e-grocery fulfillment and last mile problem. The factors identified and the developed model was send well in advance to ensure the expert has ample time to reflect on the interview.
The interviewed managers were selected because of the different business model and fulfillment methods used. Triangulation was obtained with two different practical perspectives and a revisit interview on the same model.

4.1 Insights from Shopwings.de

The fact that all the existing players are currently experimenting with their fulfillment methods makes case study based or empirical data simulation study difficult. The following section discusses practical insights regarding the factors affecting online grocery obtained in the form of a semi structured telephonic interview.

4.1.1 Important Factors for E-Grocery

The representatives from Shopwings.de foresee the current German market as underdeveloped as compared to markets like the United States. They identified the lack of best strategy for online grocery in Germany. According to the interviewee, multi-channel retailing or a global network model is the way forward. Furthermore, they emphasize on need for collaboration between online and offline channels for maximizing the pooling effect and avoid cannibalization of sales. Accordingly, speed and same day delivery are the most important performance factors for success in e-grocery. The interviewee emphasize on speed because of high competition and perishability factor of groceries. They state that Amazon has set same day delivery as the ultimate benchmark for success in e-commerce. Low volume and low value orders with limited lifetimes and the fact that the majority of orders are to be delivered in presence of the customer i.e. attended home delivery differentiates home delivery of groceries from Amazon. Furthermore, they acknowledge the importance of inventory management for prevention of stock outs, but state that customers are generally willing to accept replacements.

4.1.2 Innovation and Future of E-Grocery

Regarding usage of drones and innovation in online grocery, the interviewee stated that it could be seen as a possible means of online distribution in the future. Regarding order pricing and time windows, the interviewee were ambivalent. Vehicle routing is done automatically by the use of software. The interviewee state that innovation is an important factor but more in terms of distribution. For example, inclusion of B2B grocery services and introduction of clusters of third party delivery services to serve the rural population. The interviewee state that the German grocery retailer can take a cue from the French model of collection delivery points for order fulfilment. Collection delivery points in gas stations are also a norm for UK based grocery retailers considering the limited amount of available space for physical stores. Furthermore, online grocers can benefit by dedicated collaboration with supermarkets or cash and carry chains.

4.2 Insights from a Multi-channel Player

It was interesting to observe that the same set of questions yielded different opinions from a logistics manager of a leading multi-channel player.

The interviewee was positive about the future of pure online grocery players but did not see them as a threat to multi-channel retailers.

4.2.1 Important Factors for E-Grocery

The interviewee stated that the current German grocery market is highly cost dependent and costs are the primary drivers for the different fulfilment strategies. The interviewee was in agreement with the factors discussed in the model. The interviewee was particularly in agreement with product assortment factor that is an indication of product availability. The seasonality of products coupled with uncertainties in delivery of the product by supplier affect the order picking processes. The interviewee stated that customers are unforgiving for either mistakes in order delivery that are related to unavailability of inventory or error in order pricking. Regarding comparison with crowd sourcing based delivery, the interviewee emphasized on the trust factor. Customer trust and delivery personnel behaviour are two important factors.

4.2.2 Innovation and Future of E-Grocery

The lack of alignment and internal conflicts between the different departments regarding acknowledgement of costs related to low valued inventory products play a role. The interviewee gives an analogy of spare products industries, characterized by high number of products that are of low value.

Regarding usage of drones, the interviewee was positive in general but was not sure of the weight bearing capacity of drones. The interviewee opined that innovation is important but right now, the grocers need to optimize the current situation and get their basics right before thinking of automated warehouses. The interviewee states that delivery of groceries in offices or collection was imaginable in cities like Berlin.

According to the interviewee, another possibility could be introduction of community trucks for the weekdays with complete refrigeration systems at convenient pick points as an alternative to home deliveries.

The literature review, the developed framework and the practitioners' acknowledge the importance of the last mile problem. The practitioners focus more on getting the operational issues right for ensuring the delivery of the product. Furthermore, the practioners focus on intra-organizational coordination and human factors of the delivery personnel. The literature study showed that various deliveries related factors like FTHR, vehicle-operating factor, dropping factor significantly affect the costs of the last mile delivery. As seen in literature, innovation is not clearly linked as a solution to the last mile problem. The practioners view innovations like drone delivery as a possibility for the future. Currently standard routing software is used for vehicle routing and planning of delivery in practice. There has been less focus in practice and literature on the usage of pricing mechanisms for exploiting customer heterogeneity in online groceries.

Furthermore, in practice pricing is not explicitly seen as a key tool for managing demand and capacity. Dynamic or differentiated order based delivery fees based on length of time window and the time of ordering can result in higher revenues. Two main shortcomings of the work can be from a theoretical and practical perspective. A specific analytical model for the last mile and KPI based studies (Grégory, 2014) could have been discussed in detail to form the basis for the theoretical model. Furthermore, the results do not address interdependencies among the different KPIs. A detailed survey of the existing grocery business models in Germany and comparison with other western European grocery markets for operational leanings can give more practical insights and relevance to the model.

5 Summary and Conclusion

This work is closely related to Agatz (2008) Gevaers (2014) in terms of the central theme of online groceries and model development. Specific Factor based analysis for the last mile and validation for a German player differentiates this work from the after mentioned papers. Relevant problems underlying the last mile delivery were identified by the use of press releases, literature and different studies. It was shown that innovation (independent of its type) could have effects on different factors that drive the costs for the last mile delivery. Innovation can be profitable in terms of costs but it cannot be concluded how much it has an effect on customer service level.
Future studies can prioritize the factors according to their affect and current relevance in solving the last mile problem. Efforts should be directed towards incorporating service level aspects like lead-time and response time explicitly. Value based pricing can be the basis for development of a revenue management model for stochastic demand distribution and unknown customer classes. The effect of returns and environmental regulations (Weltevreden, 2008) on the last mile problem specific to online groceries is also a possible area for future research.

E-commerce players (multi and pure players) can use the model as a guideline to evaluate which cost factors could affect the last mile problem. In addition, an important managerial implication is that there exists no right strategy for solving the last mile fulfillment problem. Nevertheless, this model shows the relation between different costs factors but not their extent of effects. With the help of quantitative data such as sales volume, investment costs and implementation costs a business case study can be developed.

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Crowd Logistics – A Literature Review and Maturity Model

Jens Mehmann, Volker Frehe and Frank Teuteberg

Crowd Logistics (CL) is identified as a topic of high importance in the area of logistics. From the practical point of view, initial experiences and realizations have already been gained, however, scientific research regarding Crowd Logistics is still in its infancy and multiple research questions are still unexplored. By means of a systematic literature review (LR) as well as a quantitative data analysis (QDA) of existing business models, we obtained a scientific definition of the term Crowd Logistics. Furthermore, we set up a research agenda to counter the open research questions. Additionally, based on the results of the LR and the QDA as well as the knowledge gained in field studies, we developed a Crowd Logistics Maturity Model (CLMM). We evaluated the CLMM by the use of an existing company.

Keywords: Crowd Logistics, Maturity Model, Literature Review, Qualitative Data Analysis

1 Introduction

Currently, the topic of Crowd Logistics (CL) is of crucial importance. Uber for instance is a successful logistics provider, who is following the Crowd Logistics business model (Applin, 2015). In this business model the service is mostly yielded by the crowd (and not by the staff of the company). The persons within the crowd either demand or provide a service. Thereby, the company itself solely acts as a mediator. The mediator is responsible for the coordination and therefore mostly provides an IT platform capable to track communication, manage master data and fulfil payment transactions. This new business model is based on the idea of sharing economy through crowdsourcing and crowdfunding and benefits from short innovation to market time and new ways of customer communication (Bubner, et al., 2014, p. 22). In June 2015, also Amazon decided to use their customers (the crowd) for the last-mile-delivery (Fortune, 2015). This again shows that the topic Crowd Logistics is of great interest for practice and science alike.

In our paper, we want to analyze Crowd Logistics from the scientific and practice-oriented perspective. The aim is to give a comprehensive assessment of the status quo. We conducted a systematic literature review to capture the scientific knowledge. In order to understand the viewpoint of the industry, we performed a quantitative analysis of several case studies.

We aspire to answer the following research questions:

- How can Crowd Logistics be defined (RQ1)?
- What is the current status quo in science and practice (RQ2)?
- How can Crowd Logistics business models be assessed (RQ3)?

Our paper is structured as follows. In Section 1 we briefly describe our motivation to address the topic. Section 2 explains the applied research methodology. The definition of Crowd Logistics will be detailed in section 3. Subsequently, in section 4, we present the results of the qualitative data analysis (QDA), discuss and formulate a research agenda. On the base of these results, as well as through a broad case study analysis, we build a Crowd Logistics Maturity Model (CLMM) (cf. section 5), whereas an evaluation of our CLMM is presented in section 6. The paper concludes with a summary in section 7.

2 Research Methodology

2.1 Systematic Literature Review & Case Study Research

We performed a systematic literature analysis (Fettke, 2006) in order to gather the scientific knowledge about Crowd Logistics. We used the keyword phrase <crowd AND (logistic* OR transport*)> and the databases EBSCOhost (all fields) and Google Scholar (only title), which resulted in 1,481 papers. These papers were checked for relevance. As the word crowd in combination with logistics is often used with the meaning "logistics FOR the masses", we identified many irrelevant papers. We only considered papers, in which the word crowd was used with the meaning "logistics BY the masses". Therefore, we first checked the abstracts. In cases where the relevance of a paper was still unclear, a second person was involved and further parts of the paper were included in the investigation. By means of this approach, we identified 14 relevant contributions which represent the final database for our analysis.

In order to gather information about Crowd Logistics from the practice, we used the methodology of case study research (Myers, 2009, pp. 73-91). Therefore, we performed an internet search (using the search engine Google) by the use of the search term "Crowd Logistics". This yielded in more than 2,150 results, which were successively further investigated. By analyzing the results we identified 79 case studies in the area of Crowd Logistics among the first 190 results. As no further relevant case study could have been identified among the results 191 to 250), we then terminated our search.

Afterward the identified 79 case studies have been completely read by three scientists. Any documents which were rather promotion than a case study as well as documents without any information about business processes or models have not been considered further. As a result, 59 relevant case studies have been identified.

2.2 Qualitative Data Analysis

The Qualitative Data Analysis (QDA) was performed with the Software QDA Miner and the extension WordStat. The Software was used to perform Text Mining as well as Content Analysis for both, the paper and the case studies. Prior to the analysis, we prepared the data according to the recommendations of Provalis Research (2010, pp.1-127) in five steps:

1. Spellchecking to avoid any spelling mistakes
2. Deletion of hyphenation, brackets and unnecessary information (like headers / footers, author information, etc.)
3. Lemmatization and stemming whereby synonyms are removed
4. Deletion of stop word
5. Review results and extension of stop word list

After the data preparation, word frequencies (word count in a paragraph) and word co-occurrences (word pairs in a paragraph) are calculated. Subsequently, a cluster analysis was performed according to Jaccard similarity coefficient (Backhaus, et al., 2011, p. 403). The results were visualized in form of dendrogramms and 2D graphics for illustrative purposes.

3 Definition of Crowd Logistics

Crowd Logistics has its origin in the term crowdsourcing. Crowdsourcing is a neologism of the words "crowd" and "outsourcing" (Howe, 2008, p. 1), whereby "crowd" is defined as a mass of people and "outsourcing" describes the shift of processes, functions and duties to third parties. A first form of crowdsourcing was crowd working, where the crowd members act like an employee and take over the work which was previously performed "within" an enterprise (Blohm, Leimeister and Zogaj, 2014, p. 52). The development of new forms of work is massively supported by the increasing digitization of the society (Unterberg, 2010). Crowd working is organized through an information and communication platform, operated by an enterprise or an intermediary (Blohm, Leimeister and Zogaj, 2014, p. 53), which can be accessed externally via internet or internally via intranet (Leimeister, 2012, p. 390). Due to the extreme pooling of knowledge as well as the expected economic benefits, the potential of crowd sourcing is considered to be very high (Howe, 2006). However, there are no sound and reliable scientific studies on opportunities and risks (Blohm, Leimeister and Zogaj, 2014, p. 62).

A variation of the term crowdsourcing is the term crowdfunding. It is described as an innovation within the financial services industry and denotes a form of investment banking (Kuti and Madarász, 2014, p. 355). Investors buy parts of companies or invest in projects (Wieck, Bretschneider and Leimeister, 2013, p. 5) and thus become venture capitalists (Gobble, 2012, p. 4). The handling is performed on (internet-based) crowdfunding platforms, where the project is described and investments can be executed. Open research issues are seen in the field of risks and legal requirements as well as in the area of acceptance of the investors. However, crowdfunding is still in its infancy and qualitative as well as quantitative research is still missing, e.g. Ordanini, et al. (2011, pp. 443–470) and Lehner (2013, pp. 289–311). This can be assumed for Crowd Logistics as well, so that we adapt these research methods to this new realm.

As there is, to the best of our knowledge, no broadly accepted definition of Crowd Logistics, we want to characterize it by adapting the ideas of crowdsourcing, crowdfunding and crowd working to the field of logistics.

Therefore, our definition is:
"Crowd Logistics designates the outsourcing of logistics services to a mass of actors, whereby the coordination is supported by a technical infrastructure. The aim of Crowd Logistics is to achieve economic benefits for all stake- and shareholders."
The technical infrastructure is mostly used as a communication medium. Therefore, an IS platform is provided, which can be accessed in a multitude of ways (mobile phone, web browser, etc.). The aim of the platform is to coordinate demand and supply for transport services. In addition, also management processes and invoice processing are tasks that are performed on the platform. The economic benefits are based on the sharing economy, a concept where an increased prosperity is achieved through sharing of goods (services, etc.) among market participants (Weitzmann, 1986, p. 470).
Following our definition, Crowd Logistics enable the generation of new logistics services and the improvement of existing logistical services (e.g., last-mile transport) in the range of volume, speed and flexibility (Bubner, et al., 2014, p. 22), which will cause economic win-win effects for all stakeholders. In general, the inquirer will get a more convenient and flexible logistics service, and the supplier achieves advantages of monetary value which would not be possible without Crowd Logistics (Pfenning, 2014, p. 4).
The potential of Crowd Logistics can also been seen from various successful companies, e.g. the taxi service Uber, the last mile delivery service Algel or the service tiramizoo, which provides same-day delivery of online purchased articles (Bottler, 2014, p. 28).

Thus, Crowd Logistics can already be seen as a competitive alternative to traditional courier express package service providers (CEP).

4 Development of a Research Agenda

4.1 Results of Qualitative Data Analysis

In our QDA of scientific articles, we analyzed the 30 most frequent words. Conducting a cluster analysis by using the Jaccard similarity coefficient (Backhaus, et al., 2011, p. 403), six clusters were identified (cf. Figure 1). The size of the circles corresponds to the number of word mentions; the proximity of the circles to each other describes the proximity of the words in the analyzed papers.

The white diagonal striped as well as the white cluster is not investigated further, as these topics are mentioned in most analyzed papers.

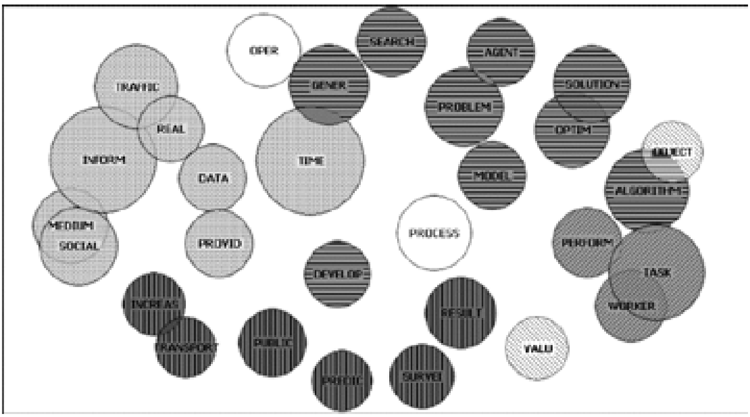

Figure 1 Cluster Analysis Result of Scientific Paper

The grey dotted cluster describes the usage of social media and real time data for traffic information systems. Pender, et al., (2014, pp. 501–521) conducted a literature review, which is about a network control system based on social media data. The use of real-time information for intelligent transport systems (e.g., for traffic jam management) is described by Lee, Tseng and Shieh (2010, pp. 62–70).

The dark grey vertical striped cluster deals with public transport. However, this cluster describes urban transport planning from a strategic, organizational point of view. Poister and Thomas (2007, pp. 279-289) describe how prediction can be used as an alternative for a survey, whereas Pender, et al. (2014, pp. 501–521) investigate how crowdsourcing can be used for disaster management and unplanned transit disruption.

However, Mulaik (2010, p. 34) investigates the field of crowd engineering (as part of in-house logistics) to build smart workforces. This is rather the same focus as in the case of the grey diagonal striped cluster: performance optimization of work tasks and the worker itself.

The grey horizontal striped cluster shows that optimization, modeling and algorithms are big topics in the field of Crowd Logistics. Sheremetov and Rocha-Mier (2008, pp. 31-47) describe, e.g., how supply chain net-work optimization can be addressed locally in order to globally optimize structures by the use of Collective Intelligence (COIN) theory and Multi-Agent Systems (MAS).

We use the information gathered from these journals as well as the identified open research questions to build the research agenda in section 4.3.

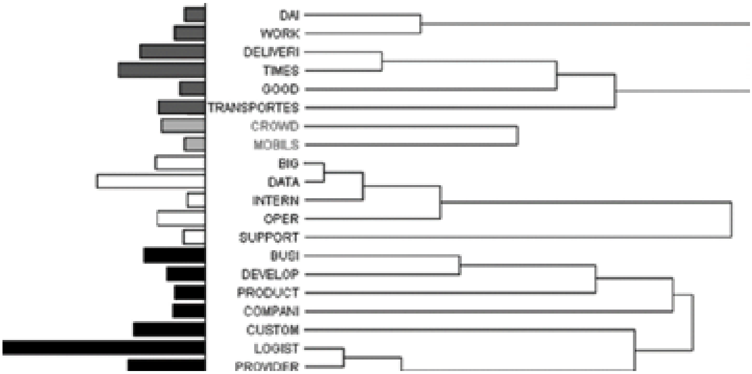

Figure 2 Cluster Analysis Result of Case Studies

The QDA of the case studies was performed in a synonymous way to the literature QDA analysis. The cluster analysis, using Jaccard similarity coefficient (Backhaus, et al., 2011, p. 403), resulted in five clusters (whereby three irrelevant clusters, that consisted of a total of nine words, have been removed from the analysis). Figure 2 shows the results of the cluster analysis in form of a dendrogramm.

The result is comparable with the result of the paper analysis. The dark grey cluster deals with delivery time optimization in the area of transport, whereas the light grey cluster mainly addresses mobile crowd solutions in the area of public transport. The topic of (real time) Big Data is described in the white cluster, whereby this data is mainly used for internal process optimization. The large black cluster again deals with strategies in form of business models and product development in the area of logistics service providers. A detailed analysis of these case studies is accomplished in section 5. The information gained is used to build the maturity model.

4.2 Result Analysis

Due to the fact that 46 % of the analyzed papers address the topic of urban passenger transport, this seems to be the most important topic in the area of Crowd Logistics. In this context, the complexity of routing algorithms is mentioned as an aggravating factor by 31 %. For a further 15 %, data heterogeneity represents an obstacle. Communication (38%) and real time data processing, however, are seen as enablers. By analyzing the papers as well as the case studies, we identified several open research topics. We summed up the research theses and displayed them in table 1.
Further research is needed to explore these research theses. Therefore, we provide a research agenda in section 4.3.

Table 1 Research Thesis in the Realm of Crowd Logistics

Research Thesis		Based on
RT1	Big Data (Social Media) Analysis improves the prediction of Crowd Logistics.	(Pender, et al., 2014)
RT2	There is a need for new algorithms to manage and control the crowd, which uses the services.	(Mousavi et al., 2012, p. 2589)
RT3	Uncertainty has a negative influence on the CL algorithm forecasting quality.	(Chen, et al., 2014, p. 39)
RT4	Sustainability has an influence on Crowd Logistics.	(Echenique, et al., 2012, p. 136)
RT5	The acceptance of Crowd Logistics (Services) depends on the diffusion of the service.	(Hellerstein and Tennenhouse, 2011)
RT6	Political acceptance is an essential condition for a successful and sustainable deployment of Crowd Logistics services.	(Hellerstein and Tennenhouse, 2011)
RT7	Simulation (sentiment analysis) may discover influencing factors regarding the efficiency of CL transport networks.	(Sheremetov and Rocha-Mier, 2008, p. 45)

4.3 Crowd Logistics Research Agenda

Based on the systematic literature review, we identified future research needs in the area of Crowd Logistics. With the help of our research agenda, these starting points can adequately be addressed (cf. Figure 3). The focus is on the development and evaluation of new business models and innovative technologies like algorithms. Moreover, also studies of acceptance and diffusion of these business models are necessary.

In section 4.1 and 4.2, we carried out the first step of our research agenda (collection of theoretical and practical knowledge) in order to uncover research needs and topics (cf. problem definition in figure 5). The next step (construction) is to build a hypothesis model to answer RT1 to RT4. Additionally, expert surveys as well as case study analyses can be used to strengthen or extend the hypotheses. In addition, a maturity model can be built (cf. section 5) based on the insights gained from practice (case study analyses, expert interviews). In the evaluation phase, the hypothesis model can be validated in the form of an exploration model phase by quantitative cross-sectional analyzes (e.g., surveys) and further analyses of the design science approach (Hevner, et al., 2004).

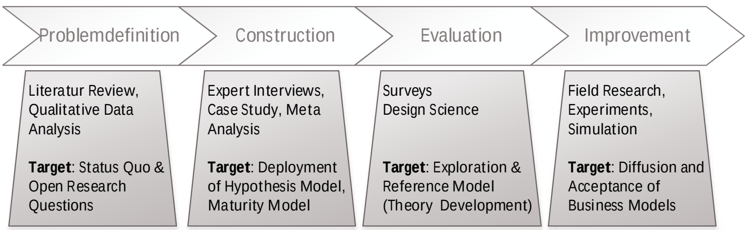

Figure 3 Crowd Logistics Research Agenda

Subsequently, the exploration model can be used for the improvement phase in order to make continuous adjustments and further developments. Therefore, the analysis of acceptance factors (RT5 and RT 6 in table 1) can be evaluated, e.g., via the Technology Acceptance Model (TAM) (Venkatesh and Bala, 2008), by the use of the "short scale for detecting technology readiness" (Neyer, Felber and Gebhard, 2012) as well as by means of other methods from the realm of field and action research.

5 Crowd Logistics Maturity Model

A maturity model (MM) consists of different maturity levels by which objects (e.g., processes, software products or business models) can be assessed (Becker, Knackstedt and Pöppelbuß, 2009, p. 213). Though, MM can also be used for benchmarking, as quality and performance criteria are rated by the use of specified criteria. Each maturity level has different criteria which must be fulfilled to achieve the level. There are four or five maturity levels (Martens, Teuteberg and Gräuler 2010, p. 56). Normally, a self-assessment is performed to define the maturity of an object. However, it is also possible to use available information about an object for the definition of its maturity. Based on the evaluated level, new targets (e.g., company's strategy orientation) can be defined.
The development of our maturity model is based on recommendations of Becker, Knackstedt and Pöppelbuß (2009, pp.213-222), who suggest an iterative process of development and improvement. The model presented in this paper is the result of a comprehensive literature search and a broad case study analysis (problem definition). Thereby, the case study analysis

incorporates input from thirteen companies (Bringbee, Uber, Lyft, Algel, MyWays, Hailo, GetTaxi, myLorry Food Express, checkrobin, mytaxi delivery, mytaxi, blackbay and MOBMover). The goal of our MM is to uncover improvement opportunities for Crowd Logistics Provider. Attention should, however, be paid to the fact that we present the results of the second iteration of the development process. A corresponding improvement will follow shortly (cf. section 7). We performed the development of our MM in 2 steps: Definition of the maturity criteria (step 1) and definition of maturity levels (step 2). Step 1 is divided in 4 sub-steps.

The first sub-step defines the model content by identifying the relevant design level. We considered organizational and subject-specific aspects and used existing maturity models in the area of logistics and business information systems for adaption.

The second step is to analyze and define possible dimensions for the MM. Therefore, we used dimensions from existing maturity models (like CMM (Paulk, 1993) and SPICE (El Emam, Drouin and Melo, 1998) and adapted them to the area of Crowd Logistics. Further, by means of the case study analysis, we identified additional dimensions. Then, we grouped the identified four main dimensions in categories.

The third sub-step is to devise the attributes for each dimension. As the assessment and definition of the maturity are based on an achievement of these attributes, they form an important pillar. The aim is to ensure significance, comprehensibility, identifiability and objectivity. As it is the objective to further develop the MM, the attributes should be flexible and extensible. The results from the QDA provided first ideas for the creation of attributes. By the use of creativity techniques, three researchers performed the further development.

As a last step, we defined which attributes of each dimension are connected to the individual maturity levels. We decided to use a four-level structure, as this is adequate to ensure a differentiation. Moreover, this approach allows for enough flexibility needed for further development. Afterwards, we analyzed the dependencies of the attributes for each dimension. As some attributes require prior attributes and build on one another, an individual analysis was not possible, which is why we executed a holistic examination. By investigating the dependencies and the structure, the different attributes were assigned to the different maturity levels, whereby a cumulative approach was used at some dimensions. For all dimensions, we considered the possibility for further development.

We followed the assessment of the Spice model, where the criteria are rated by percentages of the achieved status. The classification as shown in table 2 can be used to compute the state for each criterion.

Table 2 States for Criteria Assessment

State	Percent	Commentary
Not achieved (N)	0-15%	Criteria not or poorly fulfilled.
Partially achieved (P)	16-50%	Criteria partially fulfilled. Improvements are possible and recommended.
Largely achieved (L)	51-85%	Criteria largely fulfilled. Only little improvements are still possible.
Fully achieved (F)	>85%	Criteria completely fulfilled. No deficiencies.

In order to achieve a maturity level, the requirements of the respective level must at least be rated "L" (largely achieved), and the requirements of the preceding level must be fully achieved "F" (Hoermann, et al., 2008, p. 10). Thus, a higher level of maturity can be reached by achieving an improvement of at least one criterion.

Table 3 contains the Crowd Logistics Maturity Model. The left-hand column shows the different maturity dimensions. The remaining columns show the attributes (requirements) of each dimension for the different levels. The "++" indicate that it is a cumulative attribute and all prior attributes must explicitly be fulfilled.

Table 3 Crowd Logistics Maturity Model

Maturity Level	1 Restrictive	2 Functional	3 Effective	4 Innovative
Environment				
Strategy	Trade Platform	Service provision	++ Service Billing	++ Service Optimization
Market	Regional	National	International	Worldwide
Acquisition	/	Internet Advertising	++ Social Media Advertising	++ bonus program
Cooperation	/	1-2 Partner	5-10 Partner	>10 Partner
Economy				
Revenue	/	Transaction based	++ Provision based	++ Subscription
Payment	/	Cash	Online-(Banking)	Secure payment
Billing	/	Paper	Digital	Monthly digital

Maturity Level	1 Restrictive	2 Functional	3 Effective	4 Innovative
Communication				
Access	Phone	++ Online Portal	++ App	++ Master User
Contact	/	E-Mail	++ Hotline	++ Portal
Certainty				
Transparence	/	Valuation of Company	Ranked Valuation of Service	Ranked Valuation of Service & Supplier
Supplier Verification	/	Registration	++ Authorization	++ Qualifying Certificate
User Verification	/	Registration	++ User Profile	++ Identity check
Security	/	Legally enforceable	++ Insurance	++ Tracing

A detailed version of the CL MM with precise explanations for each attribute can be accessed via http://bit.ly/CL-MM.

6 Evaluation

In order to evaluate our developed Maturity Model (cf. section 5), we analyzed the company Algel. By this approach, we demonstrate how the MM can be used to determine the Maturity level and how recommendations can be derived from it. Algel (acronym for "Alles geliefert"; in English: "all delivered") is a German Crowd Logistics Provider which enables customers to generate an online shopping list. Purchasing agents (from the crowd) get the list, buy the articles at partner stores and deliver it to the costumer. Therefor they get a provision.

Table 4 Maturity Level Assessment of a Company

Maturity Level	Reached Level	Explanation
Environment		
Strategy	3 F; 4 N à 3	A service as well as billing is provided.
Market	1 F; 2 L à 2	The service is available in 4 German cities and it is expanding
Acquisition	3 F; 4 N à 3	There are all forms of commercials; however, there is no bonus program.

Maturity Level	Reached Level	Explanation
Cooperation	2 F; 3 L à 3	There are several local supermarkets integrated as well as 3 supermarket chains.
Economy		
Revenue	3 F; 4 N à 3	Provision based payment is implemented as well as transaction based payment. However, there is no subscription model.
Payment	4 F à 4	Secure payment is offered.
Billing	4 F à 4	Suppliers get a monthly bill. The customer pays directly to the supplier.
Communication		
Access	3 F; 4 N à 3	There is a portal and an app. However, there is no user management that would enable to integrate master users.
Contact	4 F à 4	Email, hotline as well as a form on the portal are provided.

Maturity Level	Reached Level	Explanation
Safeness		
Transparence	4 F à 4	The suppliers, the service, the customers and the company can be rated.
Supplier Verification	3 F; 4 N à 3	Suppliers must be authorized, but do not have to provide a certificate.
User Verification	3 F; 4 L à 4	User have to register, a user profile is generated. However, an identity check is possible but not obligatory.
Security	2 F; 3 N à 2	If a service is booked, it's legally binding. No insurance is provided.

As can be seen in table 4, the company would gain an overall maturity level of 2, as this is the lowest level reached at the different items. There are two items (market and security) where the level 2 is reached. The recommendation for the company would be to integrate an insurance (e.g., a third-party insurance), to improve the security level as well as to extend the service to new cities.

For each category of the maturity model, we can sum up the reached levels. For instance, if we want to compute the overall maturity level for the category communication, we will have to proceed as follows: use the level 3 (access) and 4 (contact), build the corresponding percentage, based on the highest level 4 (this will result in 75% for access and 100% for contact), and then calculate the mean (in this case 87.5%). Analogously, this needs to be done for all categories.

As is clear from figure 4, the created company performs well in almost every category, except in the category environment. This underlines our recommendations. Our recommendation to expand into new cities will lead to a higher market value. The recommendation to raise the security measures will finally lead to a higher distribution of the service, which in turn may result in an increased request for the service, also in regions where the company's service is not yet implemented.

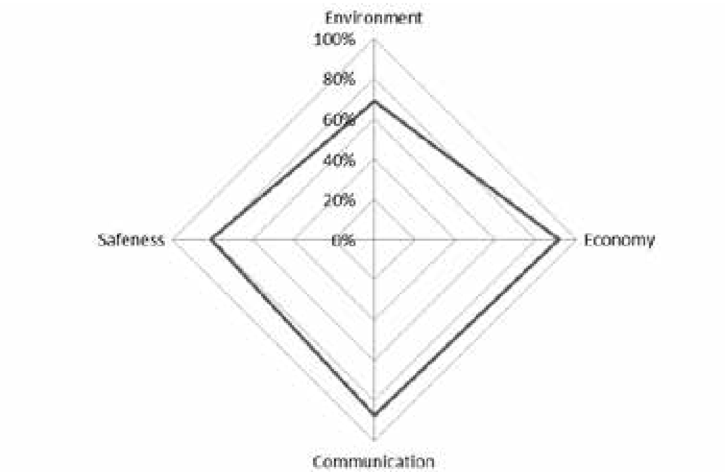

Figure 4 Strength and Weakness of the CL Company business model

Furthermore, it is possible to use the chart shown in figure 4 to benchmark the company's own development or to benchmark with competitors. Therefore, the results of different analyzes can be laid on top of each other, which makes changes directly visible.

7 Conclusion

As we have seen, research in the area of Crowd Logistics is still in its infancy and only few high quality studies are available. For this reason we have first shown a definition of Crowd Logistics. Our literature reviews revealed only a few tentative research approaches. In practice, however, there are several companies and case studies providing insight in the current state. Primarily in the area of passenger transport and last-mile delivery, the potential is seen in an optimized use of resources (based on monetary issues and with respect to sustainability). In this respect, the main driver is the digitization of the society.

The case studies show that there are several ideas that deserve further investigation. As the considered case studies encompass several business models and different stages of realization, a cross case analysis led us to the development of our Crowd Logistics Maturity Model. It is the aim of our MM to identify weaknesses of the selected business models and to deliver suggestions for improvement. With the help of a fictive company, we have shown how the MM can be used and which recommendations can be derived from the results. Furthermore, the MM enables a benchmarking against competitors as well as a historical analysis and a demonstration of the past development.

However, we are aware of the limitations of our research. First of all, we have only investigated companies and case studies from Germany. Beyond, the MM has been developed with publicly available information only, a deeper knowledge of internal processes and the IT/IS systems is thus missing.

But as in every paper, the limitations serve as a guide for future research. In the meantime, we have conducted two iterations of MM development. Moreover, we currently conduct expert interviews in order to enhance our MM by means of sound expertise. First insights show that two new categories will be implemented (the IT/IS category and the internal process category).

Furthermore, the potential strength of Crowd Logistics should be further investigated. In this respect, quantitative data analyses as well as simulations could deliver new insights (compare phases Evaluation and Improvement of figure 3 in section 4.3).

Last but not least, the risks of crowd logistics business models should be identified, quantified and valued. First analyses show, that the government and the legal regulation play a major role for the acceptance and diffusion of Crowd Logistics services (cf. table 1 in section 4.2). The implementation of standard and new regulations may lead to further diffusion.

Acknowledgement

The authors would like to thank the anonymous reviewers as well as Ms. Marita Imhorst, who provided valuable insights, help and substantive feedback during the research process. This work is part of the project “Sustainable Consumption of Information and Communication Technologies in the

Digital Society – Dialogue and Transformation through open innovation". The project is funded by the Ministry for Science and Culture of the Land of Lower Saxony and the Volkswagen Foundation (VolkswagenStiftung) within the grant programme "Niedersächsisches Vorab" (grant number VWZN3037).

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3D Printing and Supply Chains of the Future

Sebastian Mohr and Omera Khan

When discussing emerging supply chain trends of this decade 3D printing (3DP) has become one of the most disruptive phenomena to impact supply chains and the global logistics industry. The technology has already made a notable impact in the manufacturing sector and is now starting to enter homes and schools as well. However, while the expansion of 3DP into the private consumer sector is an interesting development in its own right, the biggest potential for disruption clearly lies in the industrial applications and how they will influence supply chains in the next decade. This study reveals that various points of the supply chain are likely to be impacted by 3DP.

Among the findings are such examples as the implications for inventory and logistics, its contribution to mass customization and portable manufacturing, the relevance for digital supply chains and other supply chain trends such as cloud manufacturing. Thus this study highlights a key trend that will significantly shape and influence the next decade for logistics and supply chain.

This study utilizes primary and secondary data. First, the extensive amount of literature that is available for supply chains and 3DP alike is analyzed. Then, connections between the technology characteristics and current supply chain trends are drawn, uncovering potential impact areas. Secondly, in-depth interviews are conducted with supply chain managers from different industries to gain first hand insights about the current impacts of 3DP. The analysis examines both opportunities and risks emerging from this technology.

Keywords: 3D Printing, Supply Chain Risk Management, Technology Impact, Industry Study

1 Introduction

3D printing has accelerated strongly in recent years (Wohlers, 2014). The technology has come a long way from simple prototyping to fully integrated utilizations in direct manufacturing and because of its many forms of application, 3D printing is said to be one of the most significant industrial developments of this decade (Manners-Bell and Lyon, 2012). This has lasting implications on many companies in multiple industries such as production, research, business development and design (Cohen, Sargeant and Somers, 2014). The impact of the technology on supply chains in particular has been very strong and gave rise to new opportunities but also new risks in this discipline.

Wohlers (2014) anticipate that the global market size for 3D printing will grow from 3 billion USD in 2013 to 13 billion USD by 2018, and surpass 21 billion USD by the year 2020. Gartner reports similar numbers, forecasting the market to reach a size of 13 billion USD in 2018 (Basiliere, 2013). These numbers clearly show that the consensus among experts is that this technology is expected to keep growing, which makes it an important element in the future of supply chains. This is why supply chain managers and academics alike must follow the trends and developments of this technology closely. This is the motivation for this research study.

The ongoing increase in market size is driven by the sheer variety of opportunities that 3D printing holds. The spectrum of applications ranges from simple modeling tools used by hobbyists in their own home, over specialized machines that create replicas of products as testable prototypes in the development department of companies, to sophisticated industrial printers that are used for the direct production of finished components (Cohen, Sargeant and Somers, 2014). Likewise, there is an abundance of producers of 3D printing machines, spanning models that are targeting the commercial market exclusively, and models that are focused on high-end industrial use (Parker, 2014). This diversity has enabled the technology to find its way into many areas of both commercial and private use.

Numerous cases from the industry especially in the global manufacturing sector are proof of the ongoing success of 3D printing. Large global manufacturers such as General Electric, Siemens and Airbus are using the technology to produce fuel nozzles (General Electric, 2015; Catts, 2013), gas turbine components (Kleinschmidt, 2014) and aircraft parts (Airbus, 2014; Simmons, 2015). Other firms like the automotive company Ford use the technology to produce tools for their production process, such as molds for casting (Ford, 2015). The consumer industry is embracing 3D printing in various ways as well, with the candy goods manufacturer Hershey's employing the technology to create customized pralines (Goldin, 2014), and IKEA experimenting with 3D printing in the context of design and the concept of the connected home (Fawkes, 2014).

Academic research about 3D printing has accelerated alongside the emergence of the technology in recent years, and while the topic of supply chains has increasingly gained more attention in this respect, it remains an area that is largely underdeveloped compared to other domains. Therefore, there is a strong need to address the underrepresentation of research that is specifically concerned with the impacts of 3D printing on supply chains and supply chain management. This study attends to this issue by focusing its investigation on the impacts of 3D printing on the supply chain. Here, the term 'Impacts' specifically refers to the risks and opportunities created as a consequence of 3D printing technology. Furthermore, the study makes recommendations on how to manage these impacts.

2 Literature Review

Many of the studies on the common impacts of 3D printing blend in with research about its impacts on supply chains. This is due to the fact that when authors describe the effects of the technology in general, they also touch upon issues that are related to supply chain management (Birtchnell, Urry, Cook and Curry, 2013; Huang, Liu, Mokasdar and Hou, 2013; Rayna and Striukova, 2014). Other publications are concerned with the indirect impacts of 3D printing on businesses and societies, regularly investigating phenomena that are potentially relevant for supply chain management as well (Burke, 2014; Huang et al., 2013; Neely, 2014). These works are supplemented by studies that are focused directly on the impacts of 3D printing on supply chains, of which there are only a few academic works (Bhasin, Bodla, Division. and Phadnis., 2014; Nyman and Sarlin, 2014). Conclusively, a lot of information about the impacts of 3D printing on supply chain management can be gathered from related publications in the academic literature as well as in practitioner journals and periodicals.

Table 1 below shows an overview of the impacts of 3D printing on supply chains as mentioned in the literature, as well as the corresponding authors, their studies and sources which are investigating these topics in their respective publications.

Table 1 Overview of the impacts of 3D printing on supply chains and supply chain management. Listed in the table are the specific impacts, their corresponding categories and the sources supporting the research on each of them (Source: Created by the author)

Impact	Categories	Sources
Mass customization	Customer co-creation Maker movement Prosumers Democratization of design Markets-of-one Postponement	(Birtchnell et al., 2013; Janssen, Blankers, Moolenburgh and Posthumus, 2014; Kara and Kaynak, 1997; Petrick and Simpson, 2013; Rayna and Striukova, 2014; Tanenbaum, Williams, Desjardins and Tanenbaum, 2013; Tien, 2012; Walter, Holmström, Tuomi and Yrjölä, 2004)
Changing view on resources	Circular economy Higher material/resource efficiency Sustainability attitude	(Bak, 2003; Giurco et al., 2014; Janssen et al., 2014; Reeves, 2009; Sacharen, 2014; Wigan, 2014)

Impact	Categories	Sources
Decentralization of manufacturing	Local sourcing Re-shoring Dispersed manufac-turing Reaching discon-nected markets	(Beyer, 2014; Birtchnell et al., 2013; Farrell et al., 2003; Janssen et al., 2014; Kianian, Larsson and Tavassoli, 2013)
Reducing complexity	Reducing assembly steps Reducing parts and SKUs Reducing the sup-plier base New design possibili-ties	(Cohen, Sargeant and Somers, 2014; Janssen et al., 2014; Kieviet, 2014; Manners-Bell and Lyon, 2012; Novak and Ep-pinger, 2001; Petrick and Simpson, 2013)
Rationalization of stock and logistics	Print on-demand Shipping designs, not products Digital inventory Change of inventory mix	(Bhasin et al., 2014; Char-ron, 2014; Janssen et al., 2014; Lee, 2013; Manners-Bell and Lyon, 2012; Mokasdar, 2012; Walter et al., 2004)

Impact	Categories	Sources
Changing value adding activities	New sources of profit New cost base Changing capital requirements Collaborative manufacturing 3D printing services	(Cohen, Sargeant and Somers, 2014; Janssen et al., 2014; Kara and Kaynak, 1997)
Disruptive competition	Reduced barriers to entry Niche markets Producer = investor = founder Printing away from control	(Cohen, Sargeant and Somers, 2014; Tanenbaum et al., 2013; Waller and Fawcett, 2014)

2.1 Impacts of 3D Printing on Supply Chains

According to Birtchnell et al. (2013), Janssen et al. (2014), Tuck and Hague (2006) and Walter et al. (2004), by being a very strong enabler of product customization, 3D printing can have remarkable impacts on downstream sections of the supply chain, such as production and distribution. Tailoring individualized offers to each customer and the involvement of clients in design and production activities hold potential for a shift in priorities of cost and profit management, and late stage postponement can make the supply chain more agile and flexible to react to changes in the marketplace.

The effect of 3D printing on supply chain sustainability is under heavy debate. While researchers and practitioners agree that the technology offers various benefits for preserving natural resources and reducing the global footprint of manufacturing companies, whether this is enough for a fundamental shift in attitude towards a more preservative, protective view on natural resources is yet to be confirmed or refuted by additional studies and empirical evidence (Campbell, Williams, Ivanova and Garrett, 2011; Lipson and Kurman, 2013; Nyman and Sarlin, 2014).

The impact on 3D printing on the global setup of supply chains can be very disruptive. With the potential to support reshoring and local sourcing, the technology can basically turn established global supply chain structures on their heads (Nyman and Sarlin, 2014; Lipson and Kurman, 2013). Furthermore, extraordinary applications such as the establishment of supply chains that can reach disconnected markets and remote locations enhance the impact potential of the technology additionally (Cohen, Sargeant and Somers, 2014; Janssen et al., 2014).

Academic researchers agree that 3D printing is a powerful tool to reduce complexity in the supply chain in a variety of approaches (Cohen, Sargeant and Somers, 2014; Janssen et al., 2014; Nyman and Sarlin, 2014; Petrick and Simpson, 2013). The initial benefit of the technology lies in the consolidation of components into a single product, which consequently leads to a reduction in SKUs and thus inventory complexity, the removal of assembly and pre-assembly steps, and the potential to reduce the supplier base of the company.

Authors generally agree that the impacts of 3D printing could have devastating outcomes for the logistics and inventory sector (Elms and Low, 2013;

Janssen et al., 2014; Kianian, Larsson and Tavassoli, 2013; Manners-Bell and Lyon, 2012; World Economic Forum, 2013). Through the enablement of reshoring and local-for-local manufacturing hubs, 3D printing could initiate a reduction in demand for global transportation, supported by a substitution of physical flow by digital file transfers. Lastly, inventory could be affected by the on-demand production possibilities of 3D printing, and the change of inventory mix can have lasting effects on supply chains and supply chain management as well.

Many authors accredit 3D printing with notable potential to impact the way supply chains add value within many of its sections (Geelhoed, 2014; Petrick and Simpson, 2013; Tudball, 2013). Especially the manufacturing sector could experience significant changes initiated by the technology, such as the emergence of new 3D printing services and other business models like collaborative manufacturing and small scale production.

Academic research reveals that the impacts of 3D printing on the competitive situation in the manufacturing sector can have lasting effects on existing supply chains (Birtchnell et al., 2013; Campbell et al., 2011; Petrick and Simpson, 2013). In addition to that, these impacts can also lead to the creation of new supply chain concepts such as small maker businesses that are based on direct delivery through express services. These companies could be funded through crowdsourcing, and compete in niche markets for a very small group of customers.

2.2 Findings of the Literature Review

Reviewing the literature regarding the impact of 3D printing on supply chains has revealed that the consensus among researchers and practitioners is that the technology has enormous potential to reshape the landscape of supply chain management. Many studies show that part of this potential has already materialized especially in the manufacturing and design sections of the supply chain, but much of it remains untapped. The future impact of the technology on supply chains strongly depends on the various risks and opportunities, which are explained in many of the publications, and to the development of which close attention must be paid by academics and practitioners alike.

The findings of the literature review are shown in Figure 1.

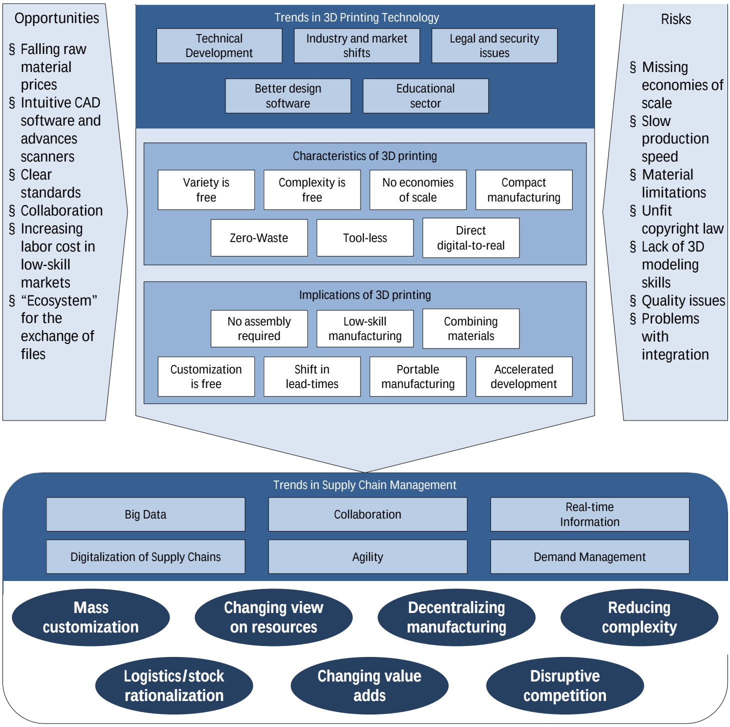

Figure 1 Summary of the literature review, showing how barriers and enablers affect 3D printing in impacting supply chains. (Source: Created by the author)

3 Methodology

The aim of this study is to investigate the impacts of 3D printing on supply chain management, and to identify the risks and opportunities that companies in different industries face from this technology. The aim is furthermore to analyze how companies manage these impacts with means of leveraging opportunities and mitigating risks.

Thus, the scope of this study covers three subject areas: 3D printing technology, supply chain management and the management of risks and opportunities. It addresses the knowledge gap in the academic literature regarding the impacts of 3D printing on supply chains, and gives insight into the topics that are valuable to practitioners of supply chain management as well as scientists from the same area of expertise.

The subject areas and scope of this study as described above are illustrated in Figure 2 below.

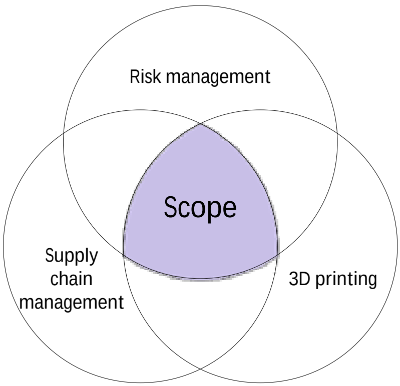

Figure 2 Three subject areas and scope of this study (Source: Created by the author)

In order to follow a structured approach towards filling the scope of this study, the overarching aim is divided into three research questions. Each of these questions targets the information that is required in order to achieve the aim of the study.

- RQ1: What are the impacts of 3D printing on supply chains and supply chain management?
- RQ2: What are the resulting risks and opportunities emerging from 3D printing for supply chains?
- RQ3: What actions do companies take to respond to these risks and opportunities?

Secondary data for this study was acquired through an extensive literature review. For this literature review, the main resources were the online literature databases of the Technical University of Denmark Findit (Technical University of Denmark, 2015) and Google Scholar (Google Inc., 2015). In order to supplement information from the literature with primary data, the method of open-ended, qualitative interviews has been chosen.

3.1 Extended Research Framework

The utilization of the appropriate techniques and strategies that are required in order to fulfill the research objectives, answer the research questions, and ultimately achieve the aim of this study are illustrated.
Figure 3 below shows the extended research framework including all the elements and the structure of this study.

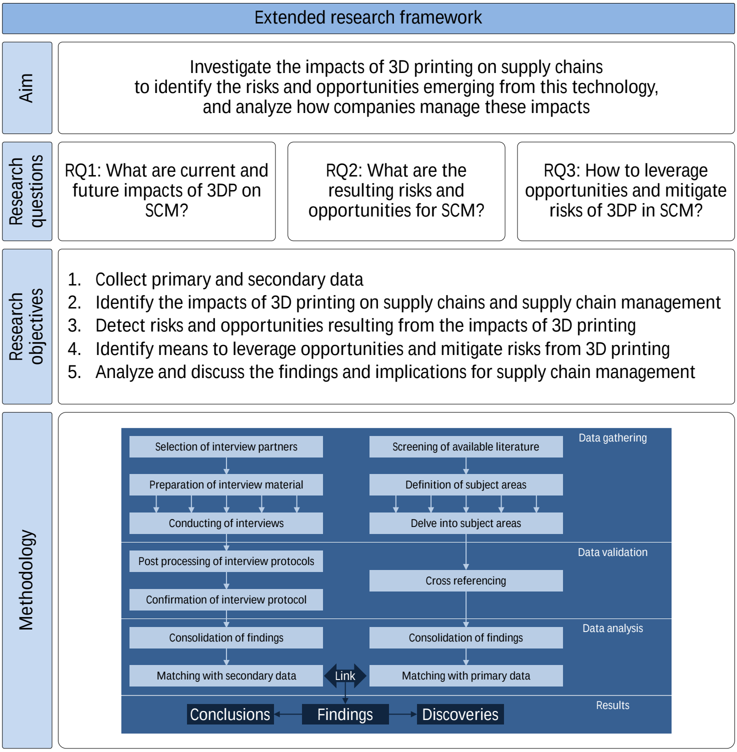

Figure 3 Extended research framework (Source: Created by the author)

3.2 Company Information

Table 2 Overview of the interview dates, times and participating organizations and people (Source: Created by the author)

ID	Date & Time	Organization	Interviewee
01	03-05-2015, 17:00 CEST	General Electric Healthcare	Mechanical and Materials Engineering Manager for X-Ray Tubes
02	27-04-2015, 15:00 CEST	Haldor Topsoe A/S	General Manager – New Business Development Manager
03	26-05-2015, 10:00 CEST	Ford Motor Company	Additive Manufacturing Technical Specialist - Prototype Manufacturing Test and Development
04	28-05-2015, 09:00 CEST	GN	Vice President Global supply chain
05	28-05-2015, 10:00 CEST	GN	Director of Tools and Concept Development
06	25-05-2015, 13:00 CEST	A-dec	Prototype, Test, and Lab Services Supervisor

4 Conclusions

4.1 RQ 1: What are Current and Future Impacts of 3DP on SCM?

Through the investigation of both primary and secondary data in this study, a variety of impacts of 3D printing on supply chain management has been identified. The outcome of the literature review forms the basis for this list of impacts, which is supplemented by findings from the interviews with industry experts. The following is an exhaustive list of the main impacts and their explanations as identified in this study.

3D printing as a manufacturing technology enables companies to customize their products to a very high degree at low cost, and without sacrificing too much efficiency in the production process. This can have significant impacts in the area of mass customization in supply chain management.

Due to the additive nature of 3D printing, the use of natural resources and raw materials is a lot more efficient compared to many other technologies. Thus, with less waste and lower material requirements, the technology has potential to initiate a change in the underlying assumptions about supply chain sustainability.

The high ratio of production volume to space occupied makes 3D printing a favorable option for applications constrained by the limitation of available space. This aspect opens a variety of opportunities in the area of supply chain decentralization and local-for-local manufacturing.

By consolidating parts into single components, and enabling the production of complicated tooling assets, 3D printing enables organizations to reduce the supply chain complexity in their network significantly. This can make the entire supply chain more agile and resilient against disruptions.

Utilizing the digital supply chain by sending files instead of physical goods, 3D printing has the potential to rationalize global logistics and inventory activities. This aspect is supported by the on-demand availability of products, and shortened lead-times that 3D printing offers.

Because 3D printing holds the opportunity to turn manufacturing on its head, value adding activities across the supply chain could essentially be redefined and reprioritized. This can have significant successive impacts on supply chain designs and strategies.

3D printing has enabled small scale manufacturers to establish a viable business model without the need for big upfront capital investments, and thus the technology can reshape the laws of competition in certain industry sectors. This shows the disruptive potential of the technology for domestic and international markets alike.

4.2 RQ 2: What are the Resulting Risks and Opportunities for SCM?

The analysis of the impacts that were identified in this study revealed that a variety of risks and opportunities are attached to each of these impact categories. These risks and opportunities are very much dependent on the context of the investigation, the involved parties, their area of expertise as well as the industry sector and business model in question. The following paragraphs elaborate on the key risks and opportunities that were uncovered in this study.

The perception whether an impact of 3D printing on a supply chain represents a risk or an opportunity is subject to the evaluation of the outcome of this impact. For example, the opportunity of rationalizing logistics and inventory is to reduce the supply chain cost base by saving cost on labor, storage and transport, but the risks of this impact are major layoffs and a reduced safety stock for periods with peak demands. Furthermore, the decentralization of manufacturing in favor of a local-for-local approach holds the opportunity for supply chains to be more agile in the marketplace and having lower logistics cost, but at the same time it bares the risk of increased manufacturing cost and missing economies of scale. Lastly, inhouse prototyping is a great opportunity for the focal company to reduce cost and shorten lead-times, but a trend in this direction is likely to have strong negative effects on the prototyping services industry. These examples illustrate that the context of the evaluation is critical when defining risks and opportunities of 3D printing for supply chain management.

Furthermore, there is a variety of tradeoffs between risks and opportunities that are connected to certain impacts of 3D printing on supply chains. In these cases, it is crucial to identify both positive and negative aspects of the impact, and include them equally in the assessment. For example, while 3D printing has the potential to reduce supply chain complexity by consolidating parts and inventory, testing and quality assurance processes can be a lot more complicated as a result of using this technology, which increases downstream supply chain complexity. Moreover, for product design, 3D printing can significantly reduce supply chain lead-times by producing prototypes quick and inexpensive, which can speed up the entire development process. However, these changes in the process can lead to the creation of other bottlenecks in the process, which can in turn have a negative effect on lead-times. Lastly, one of the key benefits of 3D printing is the resource efficiency of the technology, holding the opportunity for improved supply chain sustainability. However, because 3D printing enables engineers to do more iteration steps while creating and testing prototypes, using more material in the process bares the risk of negative impacts on supply chain sustainability as a potential consequence. The examples in this paragraph show that many of the impacts of 3D printing on supply chains are in fact tradeoffs between risks and opportunities.

Nonetheless, while some of the impacts require an evaluation in the context of different environments and perspectives in order to determine whether they can be categorized as risks or opportunities, in many cases the assessment is more straightforward. For example, mass customization with the help of 3D printing and the resulting trend towards customer co-creation is a big opportunity for the manufacturing sector to serve what has become known as markets-of-one. Companies can utilize a high level of late stage postponement with 3D printing to serve their customers, which is an opportunity for better agility and flexibility of the supply chain. The technology also holds opportunities for new sources of profit, a focus on the key value adding activities in a supply chain as well as new possibilities in product design. In contrast to that, the main risks of 3D printing are the lack of quality and accuracy for advanced applications as well as the uncertainty about the future technical developments and the corresponding financial risks of an investment.

4.3 RQ 3: How to Leverage Opportunities and Mitigate Risks of 3DP in SCM?

The previous section lists the risks and opportunities that are emerging from the impacts of 3D printing on supply chain management. The analysis in this study has revealed a variety of actions that can be taken in order to leverage the benefits and mitigate the risks. Especially during the expert discussions with company representatives from the industry, many best practices of supply chain management and 3D printing have been discovered. The following is a comprehensive summary of these actions.

In order to leverage the benefits of 3D printing for a supply chain, the technology requires the responsible supply chain manager to have a clear vision for its purpose as well as dedicated leadership from high level management for its integration. Acceptance for the technology must be ensured by educating and informing all involved parties about the intended role of 3D printing in the supply chain, as well as by a clear ownership of the technology by supply chain managers. Failing to do so can result in the cancellation of projects or in ignoring the opportunities of the technology altogether.

By utilizing the reduced labor requirement of 3D printing, supply chain reshoring and offshoring initiatives can benefit significantly from the technology. The case example from one of the participating companies illustrates how a 3D printing driven manufacturing setup in a low-cost country enabled their organization to reduce supply chain lead-times to as low as a five day turnover. The key to success in this case was the identification of the output as a highly customized product, for which 3D printing is a very favorable manufacturing method. Other leveraging factors include the re-design of products to circumvent shortcomings of the technology in terms of production speed as well as a focus on value adding activities in the home market.

Knowing the limitations of 3D printing, and thus defining a suitable purpose for the technology within supply chain management is essential for avoiding potential risks for the supply chain. Many experts have identified the material quality of 3D printed parts as one of the key issues, but few have suggested or implemented mitigating actions to solve this problem. One of the companies in this study has managed to bypass this issue by using the technology for indirect components that are not part of the final product. This solution can help realizing opportunities in a variety of fields, such as the production of tools, supporting structures and equipment for the testing and cleaning procedures of parts.

In preparation for the risks and opportunities of 3D printing, it is critical to include all potential impacts of the technology on a supply chain in the evaluation process. Many of the implications that are the result of an integration of 3D printing into a supply chain setup are not immediately obvious and can have largely disruptive impacts, if they are not uncovered in phases early on during the assessment. An end-to-end supply chain perspective is therefore necessary to identify all risks and opportunities, and develop appropriate actions. This practice is important, irrespective whether the area of impact is supply chain cost, complexity, leadtime or flexibility.

Using the unique capabilities of 3D printing to differentiate it from other manufacturing techniques is an essential element for leveraging the opportunities of the technology for the supply chain. Two of the biggest advantages of 3D printing are the freedom of complexity and the freedom of variety, which makes 3D printing a perfect method for applications that require a high degree of customization or a high degree of structural complexity in the components, or both. Many of the industry experts who were interviewed in this study have identified this aspect, and are using the technology for the best possible applications, such as direct manufacturing of highly customized products, tooling or prototyping in the development process.

4.4 Conclusions

In investigating the impacts of 3D printing on supply chains and supply chain management, this research project has explored a new scope of research as defined by the aim of the study presented in the methodology chapter earlier. The aim of this study focuses on the intersection between three distinct research areas: supply chain management, 3D printing and risk and opportunity management. Thus, one of the theoretical contributions of this study is the opening of a novel scope of investigation in the academic field.

Furthermore, the basic and the extended version of the research framework that are presented in the methodology of this study were developed specifically for this research project. Therefore, these frameworks represent an important contribution in the form of an addition to the scientific methods and materials that are used in the context of research about the topic of 3D printing impacts on supply chains. Thus, the development of these frameworks is an additional theoretical contribution of this study.

Finally, the results from this study can serve as a valuable basis for further research in the scientific area of the impacts of 3D printing and corresponding risks and opportunities for supply chains. The findings that were uncovered herein present a comprehensive collection of insights about the research area. At the same time, the gaps between literature and industry that have been uncovered by this research project leave open opportunities to expand the body of knowledge in breadth and depth.

To summarize, this research project has filled a gap in the academic literature that is characterized by the intersecting scientific subjects of 3D printing, supply chain management and risk and opportunity management. This is an important addition of knowledge to the academic sector, and thus forms the key theoretical contribution of this study.

The main practical contribution of this study is tied to the findings of the literature review and the analysis, namely a listing of potential future impacts of 3D printing on supply chain management. First and foremost, the literature review herein provides an extensive evaluation of the current state of knowledge in academia about the research topic. It lists potential implications of 3D printing as identified by scientific authors, and translates these implications into impacts on supply chains in the future from an academic perspective.

Furthermore, the analysis in the previous chapter supplements the theoretical findings about the research topic with practical insight from industry experts, therefore providing an understanding as to how the practical perspective of this research topic fits into the overall body of knowledge. This comparison, which is drawn between the scientific and industrial sector, results in the identification of risks and opportunities emerging from the technology, and in addition, discovers best practices and actions to mitigate the risks and leverage the opportunities of these impacts. This information is especially useful for practitioners and their applications.

Overall, this study provides comprehensive insight into the future impacts of 3D printing on supply chains by combining primary and secondary data in an extensive and structured analysis. This is a valuable contribution to the practical field of research in this area.

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Toyota Kata: Empowering Employees for Target-Oriented Improvement - A Best Practice Approach

Matthias Ehni and Wolfgang Kersten

In western companies Lean Management is often falling short of expectations. Normally, the reason for this is the focus on a methodological approach concurrently neglecting behavioral aspects. The article based on a case study approach offers a holistic approach to Lean Management implementation by empowering employees for a decentralized and goal-oriented improvement process considering behavioral aspects.

Keywords: Lean Management, Employee Empowerment, Toyota Kata, Case Study

1 Introduction and Problem Statement

Business environments are characterized by global competition, saturated markets and differentiated customer requests. Long-term survival in these environments claims for entrepreneurial agility and continuous improvement of business processes. An approach to handle these challenges is Lean Management (LM).

1.1 Lean Management - An Introduction

The term Lean Management originates from the book "The machine that changed the world" by Womack, Jones, und Roos (1991). It summarizes the results of a study on the performance of automobile manufactures, which identifies the performance superiority of Toyota compared to other manufactures. Womack, Jones, und Roos (1991) trace the performance superiority of Toyota to the applied production method, which they name Lean Management after the focus on waste elimination within the value-adding process. LM focuses on the customer´s need to which corporate activities are aligned. Focusing on these value creating activities from a customer´s perspective enables two major opportunities: First, non-value adding activities (waste) can be minimized, which results in cost reduction. Second, by producing according to customer needs the customer satisfaction is achieved, which results in sales increase. As both of the results enable competiveness, LM has drawn attention from companies worldwide as an effective instrument for the development of companies´ performance.

However, LM implementation efforts often do not provide the desired efficiency increase in western companies (Blanchard 2009; Abele, Cachay, und

Witecy 2012). Liker (2012) and Rother (2009) name the way to LM as the cause for this underperformance. Western companies mostly approach the lean philosophy by setting up projects, who apply lean methods like value stream mapping and kanban to smooth the processes and thereby improve the process flow. This results in a significant process improvement first; but after the project end, the process will not be further improved and stay, in the best case, at the created level.

Toyota follows a different approach, whereby employees on the shop floor-level are entrusted with the task of process improvement. Their goal: a consistent and target-oriented development of new standards in the processes of value creation. This strongly emphasis a mixture of soft factors like leadership skills for empowering the employees and hard factors like methods to analyze the processes.

Liker (2007) underlines this hypothesis by referencing to an internal Toyota Document, which describes the fundamental Toyota Principles guiding the way to a LM Implementation, named the 4P-Model (Figure 1). Thereby, the fundament is laid by a philosophy, achieving a long-term vision, which in the Toyota case is a just in time process (Rother 2009). The second layer is a guide for process development following certain principles, i.e. leveraging the customer needs and creating flow, to approach the vision. The third and fourth layer emphasize the importance of soft factors, like the way of collaboration between employee and supervisor, as a basis for process improvement at the shop floor-level, which has been neglected in western LM approaches so far.

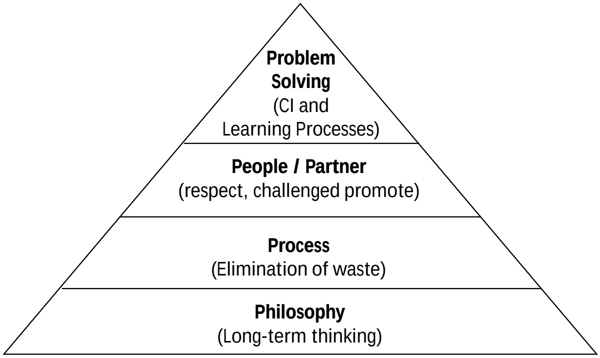

Figure 1 4-P Model of Toyota (Liker, 2007)

Aiming to fill the research gap, Liker and Franz (2011) as well as Rother (2009) focused their research on the questions how the improvement processes of Toyota are structured and how they could be integrated into the behavioral routines at the shop floor level. Liker and Franz (2011) identified the Toyota Business Practices (TBP) as the method used for continuous improvement (CI) at the shop floor level. The TBP are inspired by a simple PDCA cycle and follow 8 steps:

1. Define the problem in relation to the ideal state (Plan),
2. Capture the current state (Plan),
3. Identify the root cause (Plan),
4. Set an improvement target (Plan).
5. Select a suitable approach (Plan),
6. Experiment (Do),
7. Control the results (Check),
8. Adapt, standardize and spread the solution (Act).

For applying this procedure as a routine an internalization is needed. Toyota achieves this internalization by using the procedure at the shop floor under the guidance of a coach. This approach is didactically valuable, because it supports the following key assumptions of learning (J. K. Liker und Meier 2007):

- people learn by taking small steps through a long-term period,
- the knowledge should be transferred by a coach,
- the process should be undertaken as learning-on-the-job,
- the small learning steps should be integrated into a big picture and be standardized.

Rother (2009) carried out several experiments in which he derived a structure combining the 8 steps of problem solving and the key assumptions of learning. He named the procedure the Toyota Kata, referring to the martial art procedure of continuously repeating motion sequences till they become automatic routines. The Toyota Kata consists of the Improvement and the Coaching Kata. The Improvement Kata is the routine for a target-oriented improvement. It consists of four basic steps, which can be understood as an equivalent to the Toyota Business Practices (Figure 2):

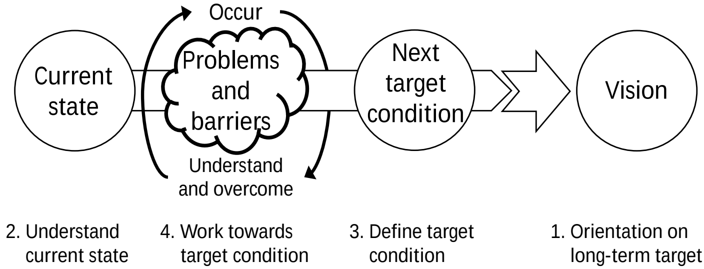

Figure 2 The 4 Steps of the Improvement Kata (Rother 2009)

The basic idea is the strategic orientation on a long-term target (step 1). In case of Toyota this is a Just-In-Time-Principle representing a process with no waste, which provides an orientation for the improvement activities. Step 2 is about understanding the current situation of the process in scope. Depending on the current situation, a reachable, short term target in direction towards the long-term target can be defined (Step 3). Step 4 is a step by step approach to reach the set target. For the step by step approach experiments are applied. Within these experiments a hypothesis is formulated first. Second, experiments are performed within the process. Third, result and hypothesis are compared. Fourth, if the hypothesis can be confirmed the experiment is standardized and implemented into the process.

The Coaching Kata on the other hand is the complementary routine to the Improvement Kata. It serves in providing the needed skillset for the improver, guiding him with questions by a coach through the improvement process (Figure 3).

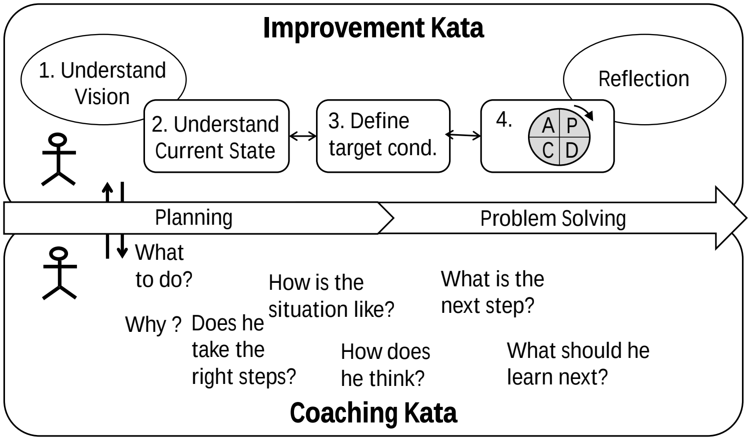

Figure 3 Interaction between Coaching and Improving Kata (Rother 2009)

1.2 Problem Statement and Research Aim

Liker (2011) and Rother (2009) provide an idea how the Toyota philosophy and process principles can be approached within operational processes and thereby provide a consistency of improvement at the shop floor. Nevertheless, they do not provide a holistic approach to implement the routines into companies as they neglect strategic aspects. The paper aims in filling that gap by the development of a holistic concept which provides answers to the following research questions:

- Which elements need to be considered in the concept?
- How should the elements be allocated?
- What does a suitable implementation approach look like?
- How should an evaluation of the approach look like?

The research questions will be answered through empirical research in companies, who apply a lean approach based on the fundamentals raised by Liker (2011) and Rother (2009). Therefore, section 2 provides a detailed view into the methodology applied, before the findings will be presented in Section 3. Finally, Section 4 discusses the findings and concludes the paper.

2 Research Methodology

The project aims at answering the research questions, which include subjective and interpretative parts as they deal with behavioral aspects (Frankel, Naslund, und Bolumole 2005). For obtaining scientific results in this area qualitative methods are particularly suitable (von Rosenstiel 2005, 238).

To meet this demand the research project follows a methodology suggested by Gläser and Laudel (2010). It is based on three steps,

1. Preparation of the empirical research,
2. Conducting the empirical research,
3. Analysis of the data, which are used to structure this section.

2.1 Preparation of the Empirical Research

Empirical research should ensure that the survey methods are following research standards and provide the requested answers to the research aim (Flick, Kardorff, und Steinke 2005).

To meet this demand the current state of research in the field was integrated by a comprehensive review, whereby the soft factors were considered particularly. The theory provides deep insights into the structure and application of CI at an operational level. Nevertheless, they show some shortcomings from a management perspective as they neglect strategic and normative aspects. These strategic aspects are relevant for implementation efforts dealing with an adaption of behavioral aspects. To integrate them, a generic approach from organizational theory constructed by Bleicher (2011) was selected and used for the embedment of LM theory. It will be introduced in the following.

2.1.1 Embedding Lean into the Management Approach by Bleicher

The approach by Bleicher (2011) offers a systematic procedure for the adaption of corporate-culture, in which normative and strategic as well as operative management perspectives are considered. It can be categorized as a socio-technical approach. Socio-technical approaches understand the organization as a system containing social and technical aspects, which have equal importance to the organization. In Bleicher´s work this is reflected by activities through the different management perspectives supporting the management aim. Those activities are supported by structural aspects referring to the hard facts as well as behavioral aspects referring to the soft facts. An overview about his management approach is offered in figure 4.

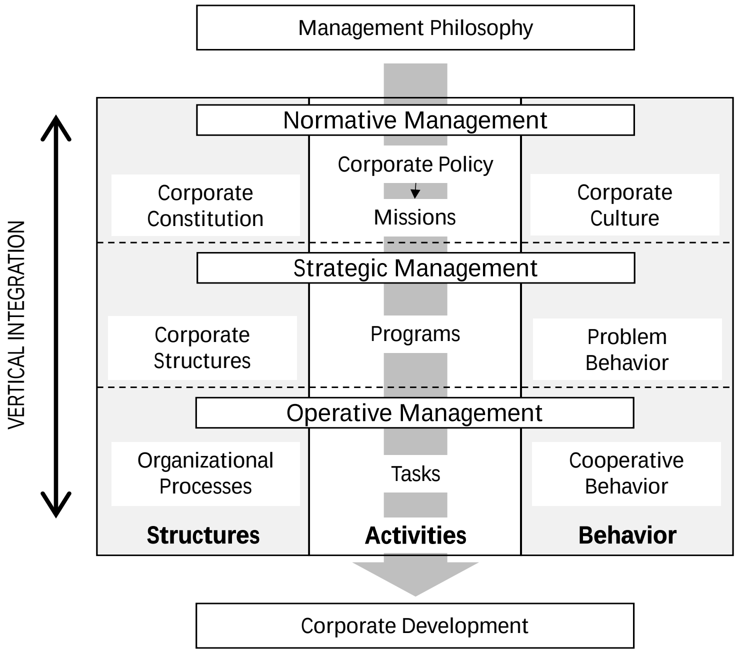

Figure 4 Management Approach for Cultural Adaption Considering Soft and Hard Factors (Bleicher 2011)

Into this generic approach the theory of lean management was embedded, filling every pillar from the normative to the operational management perspective. As a result a complete theoretical picture on implementing LM considering culture change through the different management perspectives was developed and used for the deduction of an interview guideline, confirming that important aspects were included.

2.1.2 Selecting Appropriate Cases

The selection of cases is an important part of case-study research as it defines the set of entities from which the sample is drawn and thereby has huge impact on the results (Eisenhardt 1989). In this case we tried to select companies, which have decent knowledge in the context of the research questions. Pilot interviews showed that randomized samples will not lead to suitable cases, as we just interviewed companies using technocratic approaches focusing on hard factors for implementing Lean Management. One Company used a CI-Process. But employees were restricted in empowerment and the process was not linked to the company's goals.

A consultant company collaborating with Mike Rother and collecting hands-on experience in this field could name two companies, who gained first experience with the concept of the Toyota Kata. These two companies, who can be categorized as OEMs, were contacted and selected as appropriate cases.

2.2 Conducting the Empirical Research

Guided by the constructed theoretical framework the companies and consultancy were interviewed. The persons interviewed were each responsible for the lean implementation efforts. Afterwards, if possible, a walkthrough in applying departments - investigating the procedures of the method - was done. Finally, a CI cycle was observed and the improver was interviewed. The collected data was additionally verified and completed using documents like presentations and data results of the CI processes. Table 1 summarizes the empirical research approach listing companies as well as the applied research methods.

Table 1 Overview of Methods Applied in the Observed Companies

Company	Interview time [hours]	Observa-tion of CI cycle	Interview with the Improver	Analysis of internal documents
A	5	Yes	Yes	Yes
B	1	No	No	Yes
Consul-tancy	5	Yes	Yes	Yes

2.3 Analyzing the Empirical Data

Analyzing the empirical data aims at an understanding for the different causal mechanisms of the LM approaches. By comparing the differences as well as the similarities of the concepts, a concept can be derived which is suitable for a generic LM approach and thereby provides an answer to the research aim (figure 5).

To make the empirical data comparable steps of extraction and preparation were applied (Gläser und Laudel 2010).

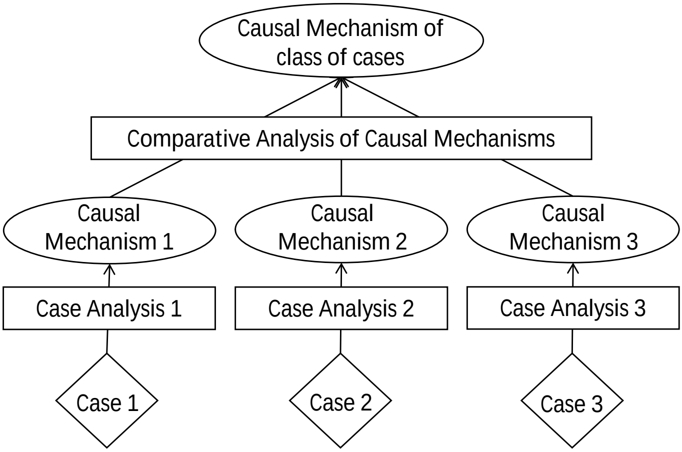

Figure 5 Procedure of Deriving a Causal Mechanism for LM Implementation (Gläser und Laudel 2010)

2.3.1 Extraction of Data

In this step relevant data for an understanding of the individual LM concepts is extracted. To identify the relevant data a search grip, based on the theoretical framework including its categories, was constructed and applied to the collected data. By aligning the research grip and its categories to the theoretical framework it was secured that the theoretical considerations guide the study (Gläser und Laudel 2010). Still, the categories within the research grid were openly shaped and could be adapted during the investigation, confirming that all relevant information could be considered.

2.3.2 Preparation of Data

This step aimed in quality improvement of the extracted data. Therefore, the raw data was checked for redundancy and contradictions. Then it was structured according to the categories (Gläser und Laudel 2010).
The result is a structured basis of information which summarizes empirical information about the investigated cases and contains the relevant information to answer the research questions.

3 Results / Findings

In this section the results of the case studies as well as the derived concept developed by the analysis of the cases are presented. The section will be structured, regarding to the research questions, in three sections. In the first section fundamental elements of the CI process as well as the process itself are described. The second section is presenting the derived implementation approach for the CI process. In the third and last section the evaluation approach for measuring the success of the concept is introduced.

3.1 Method of CI

Both companies as well as the consultancy applied a CI method which is very similar to the approach by Rother (2009). They used the Improvement as well as the Coaching Kata. Nevertheless, they added additional elements like roles, detailed procedures for process analysis and a procedure to transform the vision into individual improvement targets.

3.1.1 Transforming the vision into personal objectives

The first step of the Improvement Kata "Orientation towards a long-term target" implies the need for a suitable target condition on process level. Nevertheless, Rother (2009) is not explaining the way Toyota is deriving individual target conditions for the processes from the company´s vision. The observed companies as well as the consultancy used a structured procedure named Hoshin Kanri (Löfving u. a. 2014; Reitz 2008) for cascading the vision into target conditions. Thereby, the first step is the development of a vision for the company´s processes. It should reflect an orientation for development, i.e. a process which results in competitive advantages. Within Toyota the process vision is a Just-In-Time-process (JIT) picturing a process without waste (Rother 2009). In the sample companies the vision was developed in a workshop on Top-Management-level. In both cases the vision was inspired by a JIT process and expressed in numbers like 0 defects, 0 waste, and 0 work accidents. After the vision was approved by the committee, a challenge for the company was derived from it. A challenge is representing a mid-term target on the way towards the vision. The consultancy recommends a time horizon from 1-3 years for its realization. The companies developed 1 year challenges due to the fit of 1-year-objectives, which were embedded in the companies.

For the development of the challenge the current state on plant-level needs to be mapped as the target-setting is dependent from the current situation. The tool used to map the current state was value stream mapping, because it provides deep quantitative insights into the processes. In the workshop a quick mapping of the process was preferred. From that current state a target condition was constructed and accepted by the whole leadership team.

In a last step the challenge, which was on plant-level, was derived into targets for the different departments.

After the workshop the department managers conducted target agreement discussions with their employees. Input for the discussion was the target agreement of the department manager. His target agreement was then transferred into suitable targets for the employee applying the method of "catchballing". Thereby, the department manager asked the employee to check the target for feasibility. After a plausibility check the targets were either accepted or renegotiated. The process was repeated through all hierarchy levels to the level of the improver. This procedure, cascading the vision to the operational level, ensures that all operational improvement activities add to the big picture and thereby enhance the companies' targets (figure 6).

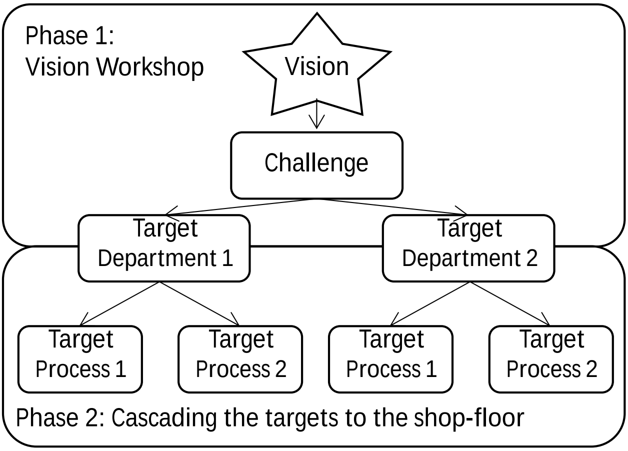

Figure 6 Setting Improvement Targets on Shop Floor Level

3.1.2 The Improvement Kata

In the observed companies the applied improvement routines on shop floor-level were similar to the procedure proposed by Rother (2009). The improvers followed the four basic steps introduced in Section 1.1. But the steps were extended by appropriate methods, i.e. to measure the current situation one of the companies applied a process analysis, consisting of four steps itself: The first step pictures the demand of the customer by calculating his tact time. In the second step, relevant process steps are mapped and delimited from processes out of scope. In step three, relevant data concerning process stability and process tact is collected. While in step 4 the collected data was compared to the customer demand. Comparing the customer tact to the current process tact allows the learner to set a target condition, which is reachable in a short-term horizon.

In the next step experiments to approach the target condition were selected. Thereby, in both companies certain criteria needed to be fulfilled. The process selected for the experiments should improve the whole system and thereby provide a systemic impact. This is i.e. achieved when the selected process is a bottle neck, which may be caused by a tact above the aimed process tact time or unstable performance. The experiments comprise of:

- a hypothesis, which should be measurable,
- the testing of the hypothesis by conducting the experiments,
- the check of success by comparing hypothesis and results,
- and the standardization of the result, which includes an adjustment of work instructions and standard costs when the hypothesis is confirmed.

To manage the experiments the interviewee emphasized that within an experiment only one factor should be varied and that a short feedback time should be provided, which is essential for assigning the root cause.
All results from each step (current state, target condition, experiment selection, hypothesis and result) were documented. One company used a board located at the process, while the other used result sheets. The improver had the possibility to work on a daily basis on the improvement of his processes. Therefore, an average time span of 10% of the total working time was allowed.

3.1.3 The Coaching Kata

The coach acted very closely to the questions suggested by Rother, which is very helpful to guide the improver through the process. The consultancy pointed out, that a very important step is the definition of the target condition. It should be placed in a so-called learning zone, where the target is challenging but not out of reach. Thereby, the improver does not get frustrated but motivated.
The companies were very strict on not providing decisions by the coach. Even if the improver had a suggestion, which obviously did not point in the right direction, the coach just led through questions. If the learner did not see the point, he did an experiment and gained experience.
Nevertheless, the two companies decided to add the role of a 2nd coach. The 2nd coach provides a feedback to coach on a regular basis and thereby develops the coaching skills. Coaching as well as the feedback through the

2nd coach were held on a regular basis. In the observed companies coaching took place once a week. The feedback from the 2nd coach was provided one to two times a month.

3.2 Implementation Approach

Within the analyzed cases the initial step of the implementation aimed in convincing the management team of the Kata Approach. Therefore, a workshop in which the managers applied the Improvement Kata from the improver perspective under guidance of the consultancy was conducted. It provided an understanding for the value of the approach and resulted in a management buy-in as an essential precondition for success.

3.2.1 Setting the Project Scope

After the management-buy-in the setting for the project was designed in cooperation with the consultancy. Therefore, the scope of the project regarding the companies' penetration as well as personnel and financial resources was set. Both companies started with a pilot area. Within the pilot area the total numbers of improvers, coaches and 2nd coaches were named. In the observed cases the role assignment was strictly oriented on hierarchy. The improvers were the team-leaders of the departments in scope. The next hierarchy level was entrusted with the task of the coaches, while the 2nd coach was either a lean expert or the department manager. The consultancy emphasized that a role allocation due to hierarchy is a reasonable approach, but is not mandatory. Other possibilities might be the integration of staff positions etc.

While one company just focused on the shop floor-level as the area of improvement, the other company wanted to implement the improvement routine through all hierarchy levels. A restructuring of the organization was in neither company in scope. The reason for this exclusion is an approach, which prefers "function before structure". On the one hand the companies stated that workflow-oriented structures might be helpful for reducing potential losses in interfaces between the departments. But on the other they wanted to focus on the change in the improvement culture. This is best achieved with trusted work relationship and thereby sticking to the old structures.

3.2.2 Roll Out Approach

For the role out, initial training was provided. Thereby, in phase 1 the top hierarchy level underwent an in-depth Improvement kata training under guidance of the consultancy. When the routine was internalized phase 2 begun. In phase 2 the top hierarchy level managers took the role of the coaches and trained the next hierarchy level in the Improvement kata. Within that training the top managers were supervised by the consultancy, taking the role of the 2nd coaches. In the next phases this procedure was repeated till the learners on operational level were trained. This top-down training approach, which follows best practices in learning, as you learn in small steps with a trusted coach in a working environment, is visualized in figure 7.

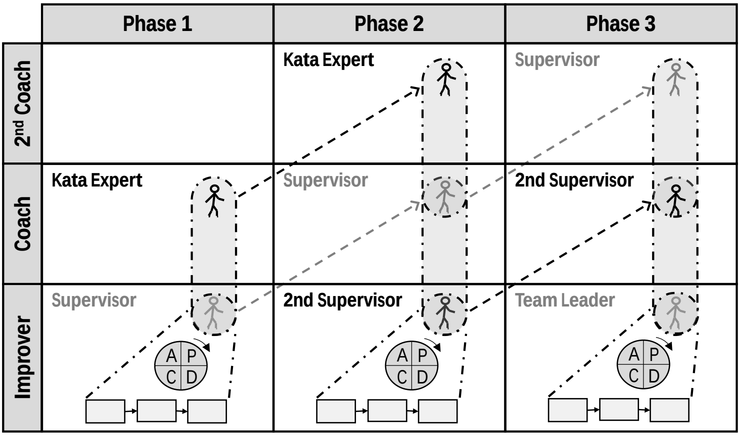

Figure 7 Top-Down Roll-Out Approach for Training the Staff

3.3 Evaluation Approach

To assess the success of the Kata Approach the companies applied monetary as well as non-monetary evaluations. The approaches are introduced in the following sections.

3.3.1 Monetary Evaluation Approach

The monetary evaluation aims at proofing short-term benefits of the approach. This is not the primary goal, but often a necessary prerequisite for realization as companies are more and more judged by short-term performance. In both cases the companies realized the monetary evaluation by a cost-benefit calculation. Thereby, all efforts for implementation like consulting fee, invested time for improvement efforts by the staff and experiments cost, were transferred into Euros and summed up. On the other side improvement efforts, which were tracked in the cost standards, were offset against.

In calculations of both companies benefits outweighed the costs. While one company didn’t name exact numbers, the other had a positive result better than 0.5 Mio € in 2013 and a total sum close to 1.8 Mio € within 4 years after the start.

3.3.2 Non-Monetary Evaluation Approach

The non-monetary approach focuses on the penetration of the program through the organization and its long-term development. Due to its program phase the non-monetary evaluation approach was just applied in one company.

It works by "evaluating the kata through the kata" as the interviewee said. It is basically done by setting a target condition and approaching it by evaluating the current situation and taking actions to develop in direction of the target. In case of the applying company the categories for target condition were the stability of the coaching's (measuring the regularity against planned coaching's) and the penetration through the organization.

The evaluation took place every year and was done by the consultancy. This is not mandatory, but provides neutrality which can be a factor if different departments are asseded. At the end of the evaluation, countermeasures were disused and a new target condition was set.

4 Discussion and Outlooks

The conducted study shows that LM implementation efforts towards a decentralized and target-oriented CI by empowered employees can be successfully achieved in Western Industry.

Key to success is considering and influencing behavioral aspects, which has been successfully done by applying the Toyota Kata. The companies, which have been observed, adjusted the routine by adding analysis tools and complemented it by a target cascading process to the shop floor level ensuring its contribution to the big picture. For the roll-out a Top-Down Training process supported the skill transfer which was needed to conduct experiments, as well as behavioral change. To evaluate the progress of the change monetary and non-monetary evaluation approaches were used. The concept of implementation is summarized in figure 8.

Nevertheless, normative and strategic structure aspects like cooperative constitution and structures were not integrated into the approaches. The more progressed company planned to integrate those structural aspects in the next years, which could be a research focus in the near future.

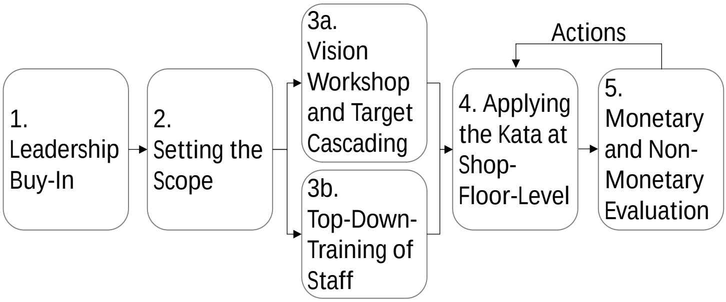

Figure 8 Summary of the LM Implementation Approach

As we could not find a consideration of behavioral aspects by randomly interviewing companies, we contacted a lean consultancy for accessing users of the behavioral LM approach. The potential integration of behavioral change without falling back to the consultancy is still to prove. The proof will be tested in a next research step, were the concept will be applied and further developed in a company.

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Data-Adaptive Simulation: Cooperativeness of Users in Bike-Sharing Systems

Thomas Preisler, Tim Dethlefs and Wolfgang Renz

Bike-sharing systems undergo a rapid expansion due to technical improvements in the operation combined with an increased environmental and health awareness of people. The acceptance of such system depends heavily on the availability of bikes at stations. In spite of truck-based redistribution efforts by the operators, stations still tend to become empty/full, especially in rush-hour situations. In this paper, we explore an incentive scheme that encourages users to approach nearby stations for renting or returning bikes, thereby redistributing them in a self-organized fashion. A cooperativeness parameter is determined by the fraction of users that responds to an incentive by choosing the proposed stations. The microscopic simulations of the actual bike-sharing system is based on data taken from Washington, D.C. (2014). From these data, stochastic parameters can be determined such as the rush of users for a station given as a function over time. Here, we propose a data-adaptive simulation approach to measure the impact of different cooperativeness parameters. The proposed approach realizes a data-adaptive simulation where the knowledge/data space of the application is filled on demand. If knowledge/data already exist, no further simulations are required. If not, the required microscopic simulations are executed and the data set is enriched with their results.

Keywords: Bike-Sharing System, Data-Adaptive, Simulation, Self-Organization

1 Introduction

Due to climate changes, declining inventories of fossil fuel, noise emission and congestion cars are in discussion as individual means of transportation in cities. Therefore, bikes are receiving an increased attention in city transportation, as they offer a healthy and environment-friendly way of transportation, while also allowing to reach areas in cities that do not have direct access to public transportation. This and technical improvements led to a rapid expansion of bike-sharing systems worldwide (Vogel & Mattfeld, 2010). In addition, younger generations and parts of urban population do not consider cars as status symbols anymore. Of course, bikes have drawbacks in comparison to other modes of transportation, as the usage of bikes strongly depends on the weather and topography of the city, making bikes more suitable for short trips (DeMaio, 2009). As consequence, modern bike-sharing systems are mainly used for short-term rentals. The increasing success of bike-sharing systems depends not only on the previous mentioned reasons but also on the introduction of information systems supporting the renting process (Bührmann, 2008). In order to improve respectively reduce inner-city air quality and congestion many cities aim at implementing bike-sharing systems (Midgley, 2009).
The operation of modern bike-sharing systems in big cities mainly depends on the availability of bikes at the stations, but the systems often exhibit the problem of reliability. According to rush-hour situations, stations may run out of bikes while others become full. Therefore, the planning and operating of redistribution attempts is essential to ensure proper reliability and user satisfaction. Several attempts have been ventured to overcome these problems in scientific research as well as in practice (Vogel & Mattfeld,

2010). For example, the availability of bikes at the stations in Barcelona's Bicing bike-sharing system has been analyzed by (Kaltenbrunner, et al., 2010) in order to detect temporal and geographic mobility patterns within the city, to predict the number of available bikes for stations ahead. Similar work, again for Barcelona's Bicing system, was done by (Froehlich, et al., 2009) where clustering techniques were used to identify shared behavior across stations in order to predict short-term station usage.

In this paper, an incentive scheme that encourages users to approach nearby stations for renting and returning bikes, thus redistributing them in a self-organized fashion is investigated. In order to do so, a microscopic simulation of an idealized Monday based on data from Washington, D.C. (2014) is realized. This simulation system will be used to measure the impact of a cooperativeness parameter determined by the fraction of users that responds to an incentive by allowing their trip to be detoured to proposed alternative stations. The approach picks up ideas from previous work, where first studies regarding the self-organizing redistribution of bikes based on an incentive scheme for the users were performed (Preisler, et al., 2013). This work is extended by a more sophisticated simulation system and approach.

The implemented simulation system is based on a data-adaptive simulation approach to measure different cooperativeness parameters. The approach realizes a data-adaptive simulation, where the knowledge of the application is filled on demand. If simulation results already exist for specific simulation parameters, no further simulations are required. If not, the required simulations are executed and the knowledge/data space is enriched with the results.

The remainder of this paper is structured as follows: Section 2 gives an overview about the historic development of bike-sharing systems in general and takes a closer look at Washington, D.C.'s bike-sharing system in particular. Section 3 describes the data-adaptive simulation as a service approach. The implemented bike-sharing simulation system and the results of the self-organizing redistribution strategy are described and discussed in Section 4. Finally, Section 5 concludes the paper.

2 Bike-Sharing Systems

This Section will give a short overview about the history of bike-sharing systems before the bike-sharing system of Washington, D.C. will be described and analyzed in detail. Data about the trips in Washington, D.C. in 2014 will be used as a foundation for the constructed simulation system used as a test-bed for the proposed incentive scheme.

2.1 History of Bike-Sharing

The history of bike-sharing systems is characterized by three different generations (DeMaio & Gifford, 2004). The first bike-sharing system was introduced in Amsterdam (the Netherlands) in 1965. The so called Witte Fietsen (white bikes) were ordinary bikes, painted white and provided for public uses. The bikes could be used to ride to the designated destination and be left there for the next user. Unfortunately, the program collapsed within days, as bikes were thrown into the canals or appropriated for private use (DeMaio, 2009).

The second generation started in the early 1990s in Denmark with small programs, like the 26 bikes at four stations in city of Nakskov (Nielsen, 1993). In 1995 the first large-scale 2nd generation bike-sharing system was launched in Copenhagen. The bikes were specially designed for intense utilitarian use equipped with solid tires and wheels as well as advertising plates. They could be picked up and returned at specific locations throughout the central city with a coin deposit. Even more formalized as the previous generation with dedicated stations and operated by a non-profit organization, the bikes were still stolen in many cases due to the anonymity of the users (DeMaio, 2009).

This led to a new generation of bike-sharing systems with improved user tracking. It started in 1996 at the Portsmouth University of England, where students could rent bikes with magnetic stripe cards. The 3rd generation of bike-sharing systems is based on a variety of technical improvements, including electronic locks, telecommunication systems, mobile phones and on-board computers. A noticeably impact on 3rd generation bike-sharing system in general had the introduction of the Velo'v system in Lyon, France with 1500 bikes. Until then the largest system at all. Over the next years, bike-sharing systems generated enormous interest and around the world and different programs were started worldwide. By the end of 2009 there were up to 120 3rd generation bike-sharing systems globally (DeMaio, 2009).

2.2 Bike-Sharing in Washington, D.C.

The Capital Bikeshare bike-sharing system in Washington, D.C. was started in September 2010. Until May 2013, when Citi Bike began operation in New

York City, it was the largest bike-sharing service offered in the United States (Martinez, 2010). Currently, the system has 345 stations and about between 2400 and 2900 bikes were available for usage in 2014. All data concerning the system is freely accessible using the Capital Bikeshare Dashboard (http://cabidashboard.ddot.dc.gov, retrieved June 25, 2015). Like in many other bike-sharing systems the pricing is based on the principle that the first 30 minutes of a rental are for free (except a fixed membership fee). Each additional 30 minutes require an additional fee. Figure 1 shows the system-wide number of trips by month for Washington, D.C. It illustrates a constant growth in the number of trips since its start in September 2010. Starting from about 4.000 trips to about 220.000 trips in September 2012 and 330.000 trips in September 2014. The Figure also shows how the number of trips peaks during spring and summer and decreases in fall and winter, as the usage of bikes strongly related to weather conditions.

To ensure the reliability of the system and therefore, both the availability of bikes and free docks at the stations, Capital Bike Share uses trucks to redistribute bikes (Maus, 2013). This redistribution and the anticipation, which stations will require more bikes or free slots in order to handle rush-hour situations is one of the main challenges when operating bike-sharing systems. Figure 2 shows the balancing efforts ventured by Capital Bikeshare in 2014. It becomes apparent that there is a correlation between the number of trips in this period (as shown in Figure 1) and the number of balancing efforts. If more trips are ventured, more rebalancing efforts are required to ensure the availability of bikes and free docks at the stations. Furthermore, the Figure shows that the operation of such a bike-sharing systems requires a significant amount of redistribution efforts.

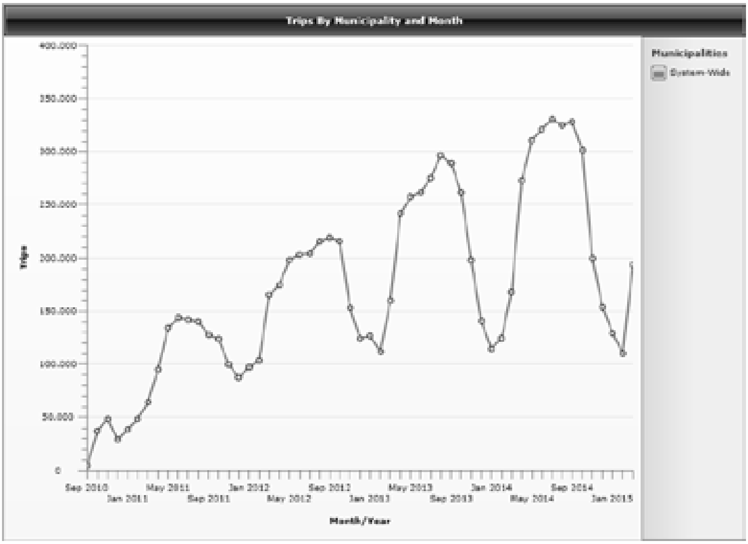

Figure 1 Capital Bikeshare system-wide number of trips by month from September 2010 until March 2015 (taken from Capital Bikeshare Dashboard)

However, stations still tend to become full or empty, as shown in Figure 3. With regard to Figure 1, the amount of full or empty stations correlates to the number of trips. When the number of trips rises, the number of full respectively empty stations also arises. The data in Figure 3 also shows that the amount of empty stations is higher than the amount of full stations, indicating that the stations may be designed to have spare capacities to increase the chance that a bike can be returned at a station. In conclusion, the Figure shows that despite the redistribution efforts that are already carried out, there is room for improvement. Either by increasing the number of truck-based attempts or through the introduction of new approaches, especially to overcome the problem of empty stations. The incentive scheme proposed in this paper, that encourages users to approach nearby stations for renting or returning bikes, aims at solving this open problem by redistributing bikes in a self-organized fashion.

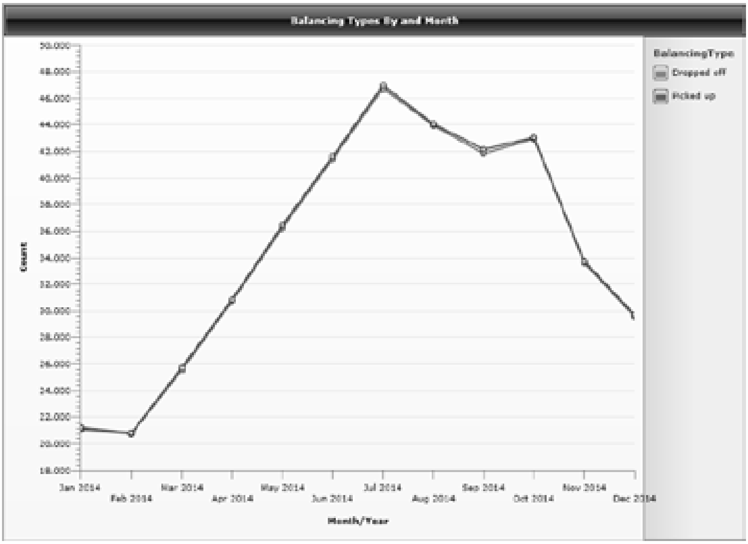

Figure 2 Capital Bikeshare balancing efforts in 2014 (taken from Capital Bikeshare Dashboard)

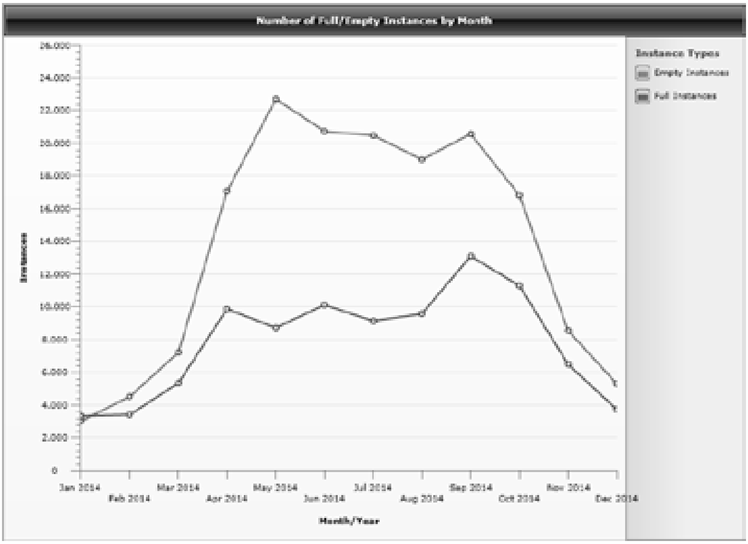

Figure 3 Number of full/empty stations in 2014 (taken from Capital Bikeshare Dashboard)

3 Data-Adaptive Simulation as a Service Approach

The simulation concept presented in this paper is based on two approaches. The first one regards the data-adaptivity of the simulation system. This mean that the system is adaptive with regards to its data, resulting in a data/knowledge space that is filled on demand. If the required data for a simulation request already exists it is returned directly, if not the required simulation is performed and the data/knowledge space is enriched with this information. This approach is depict in Figure 4. It is based on the concept, that a simulation system handles simulation requests for specific simulation component. These requests contain a variable tuple of criteria that parametrize the execution of the simulation component. The simulation systems forwards these requests to an active data/knowledge space, where the simulation results for different parameter tuples are stored. The space is active with regards to its ability to start the execution of the simulation component, in case the space does not already contain data for the given parameter tuple. In this case, the simulation component will be executed and the results are stored in the data/knowledge space and returned to the simulation system. Further simulation requests for this tuple of parameters do not require the anew execution of the simulation component instead the associated results can be read directly from the data/knowledge space.

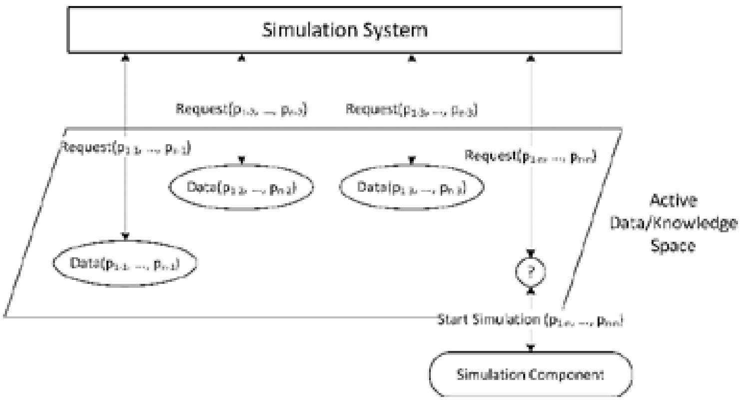

Figure 4 Data-Adaptive Simulation Approach

The second aspect of the approach focuses on service-orientation. Service-orientation is a design paradigm for software systems in the form of services. Its design principles strengthen the separation of concerns and a loose coupling in the resulting software system. Applying this approach results in entities of software partitioned into operational capabilities, each designed to solve individual interests. These units are qualified as services (Allen, 2006). Service-orientation has received a lot of attention since 2005 (Liebhart, 2007). The Simulation as a Service approach combines concepts from service-orientation with cloud computing technologies and aspects. Cloud computing (Sosinsky, 2011) is seen as a new approach to IT infrastructure management that facilitates a pay-as-to-go usage model. Computational resources are made available on a demand-driven basis; instead, of statically dedicated physical systems. Therefore, the approach minimizes idle times and optimizes the utilization of resources, leading to a minimization of resource dissipation. Cloud computing applications are typically built on the Infrastructure as a Service (Iaas) or Platform as a Service (PaaS) layer. On the IaaS layer, access to the cloud is granted by virtual machines that allow fine-grained control of the software stack and provide low-level aspects like operating systems. On the PaaS layer, a cloud operator establishes a new software layer with a dedicated middleware programming interface, and thus lower level details are abstracted. The Software as a Service (SaaS) layer are user-ready applications running in the cloud, which are typically built upon the IaaS or PaaS layer. The Simulation as a Service approach adopts this concept to the domain of simulations and provides simulations as a user-ready service in a cloud-computing infrastructure. Figure 5 shows the architecture of the data-adaptive simulation service approach designed to realize a simulation of Washington, D.C.'s bike-sharing system. The service encapsulates the actual implementation of the bike-sharing simulation component and the data-adaptive behavior. Following the data-adaptive approach, the simulation service checks whether its data/knowledge space contains results for the requested parameters (1). If so, the results are directly returned to the client. If not, the service executes the bike-sharing simulation component (2), stores the results in data/knowledge space for further requests (3) and returns the results to the client. In this case, the active behavior of the data/knowledge space is realized as part of the simulation service and the database just provides storing capabilities. Another possible realization is to implement this behavior as part of the database, e.g. as stored procedures.

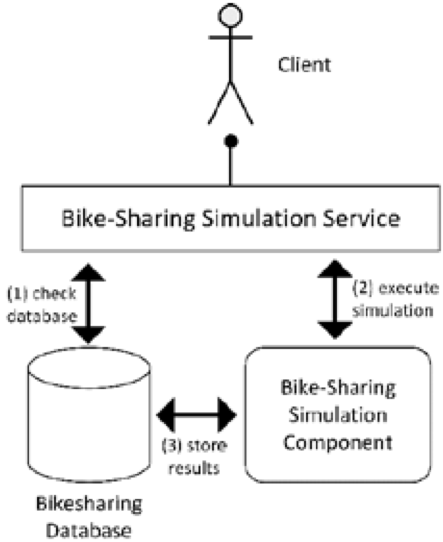

Figure 5 Bike-Sharing Data-Adaptive Simulation Service Architecture

4 Simulation of Washington, D.C.'s Bike-Sharing System

This Section describes the implementation details of the realized simulation system, as well as the analyzed simulation scenario, the self-organized redistribution strategy and the simulation results.

4.1 Implementation Details

Essentially, the implementation of the bike-sharing systems consists of three main components. The first component is the actual simulation system simulating the rental and movement of bikes in Washington, D.C. The second component is a relational database management system used to store the simulation results. The third and final component is the simulation service that encapsulates the two previous components and realizes the data-adaptive simulation approach.

The actual simulation system was realized using RinSim (van Lon & Holvoet, 2012), a logistics simulator written in Java. It supports (de)centralized algorithms for dynamic pickup-and-delivery problems (PDP). From a conceptual point of view, the simulation system bases on the paradigm of Multi-Agent Systems (Wooldrigde, 2009). The usage of agent technology for simulation has a long tradition in computer science and has successively replaced other approaches (Davidsson, 2001). The main advantage of agent-based simulation is the ability to model the characteristics of each entity individually. This allows building very close mappings between the considered systems and the generated model since there is no need to compress features of the modeled entities. The cyclists renting bikes at stations were realized as agents. They are created at a specific station, where they try to rent a bike and if a bike is available at the station, they drive it to their designated destination stations, where they return it. In order to map the road model of Washington, D.C., the corresponding area was extracted from OpenStreepMap (OSM) (Haklay & Weber, 2008) and transformed into the graph-based road model supported by RinSim. Thus, the movement of the cyclists along the roads can be simulated by moving them on the edges of the resulting graph. Following the PDP-modeling approach, the bikes were modeled as parcels and the bike stations as depots. Time in the simulation system is simulated in a discrete manner, divided into ticks of 60 seconds length. Therefore, the simulation of a whole day consists out of 1440 simulation ticks.

In order to store the results of a simulation run the open-source relational database management system MySQL (DuBois, 2013) was used. Each simulation run is identified by its simulation parameters. The most important parameter in the context of the ventured study is the cooperativeness of cyclists to rent or return a bike at an alternative station. Other parameters are the cyclists' speed, the initial number of bikes at the stations, the number of docks at the stations and the communication range of the bike-stations used for the self-organized redistribution of bikes. Therefore, the database stores a mapping of these parameters to the corresponding simulation results.

The final component was the bike-sharing simulation service to realize the data-adaptive simulation service approach. This component was realized using the Jadex Active Components Platform (Braubach, et al., 2014). This platform offers a middleware to implement service-oriented applications with focus on distribution transparency and supports the realization of cloud computing applications by providing a PaaS-layer infrastructure. Thus, the implemented simulation service can be executed on a cloud-infrastructure. It encapsulates the functionality offered by the simulation component and extends it with a data-adaptive behavior by interconnecting it with the database system to provide a data/knowledge space as described in Section 3.

4.2 Simulation Scenario

A typical Monday was examined in order to simulate Washington D.C.'s bike-sharing system and to evaluate the impact of the cooperativeness of users for the self-organized redistribution of bikes. Therefore, the trip history data for all Mondays (except holidays) from 2014 provided by Capital Bikeshare, was analyzed. To do so, the day was divided into 24 time slices, one for each hour of the day. For each of these 24 time slices the departure and dependent destination probabilities for the bike-stations were calculated based on the ventured trips. By counting all trips started at a specific station A in the considered time window and by dividing them by the total amount of trips in this time window, departure probabilities were calculated for all bike stations in the systems. To calculate the destination probabilities, as a dependent probability that if a user departs from station A it drives to station B, all departures of station A in the observed time window were counted. This value was then used to determine the specific destination probability for a station B, by counting all departures to B and dividing them by the total value. This resulted in a scenario configuration for the simulation that described an idealized Monday based on all trip data from 2014, divided into 24 time slices, where each time slice consists out of specific departure and dependent destination probabilities for each station. The number of docks and the initial occupancy of the bike stations were modeled as variable parameters of the simulation, because the trip history data does not contain information about the number of docks at the bike stations and their occupancy. The simulated idealized Monday scenario started at 12 a.m. In order to simulate the different rush at different times of the day, the median total number of trips for each of the 24 hours of the day was determined based on the trip history data. During the execution the simulation component generates the number of cyclist agents specified by the rush equally distributed for the currently simulated time slice. The according departure and destination probabilities for the stations are used to determine from which departure station the agent will rent a bike and drive it to which destination station. Besides their cooperativeness, the cyclists are simple agents that rent a bike from the departure station where they are created and drive it to their desired destination station where they return it. As a simplification, they all move with a constant speed along the graph-based road model. In order to find a route from the departure to the destination stations, they use a shortest path approach and traverse the edges of the graph road model, considering the edge weight as the distance to the next node. The simulation was configured to allow an overcrowding of bike stations, if no free docks are available. If a cyclist agent tries to rent a bike at and empty station, this incident is reported and the total number of rides that did not take place is returned as part of the simulation results for evaluation purposes.

4.3 Self-Organizing Behavior

In order to rebalance the availability of bike at the stations, as a possible addition to the truck-based redistribution efforts ventured by Capital Bikeshare, an incentive scheme for the users to stimulate them to redistribute bikes in a self-organizing fashion is proposed. The approach is based on the concept that whenever a user tries to rent a bike at an empty station, an alternative rental station with a sufficient amount of bikes is suggested to the user. Equivalent, whenever a user tries to return a bike at a full or critical occupied station, an alternative return station with a sufficient amount of free docks is suggested to the user. Thus, the distribution of bikes among the stations will be balanced in a self-organizing way, as users renting a bike are detoured from empty stations to, preferably full or critical occupied ones or at least non-empty ones. The same goes for the returning of bikes, where users are detoured from full or critical occupied stations to, preferably empty or at least non-full ones.

The approach strongly depends on the cooperativeness of the users to be detoured to an alternative rent or return station. Therefore, some sort of incentive scheme, that motivates the users to do so would raise their cooperativeness. The operator of a bike-sharing system realizing such a self-organized redistribution of bikes could, e.g. offer additional free minutes of usage. For the evaluation of the impact of the proposed self-organized redistribution strategy and the cooperativeness level of users, different cooperativeness values are used as simulation parameters and their results compared. Hereby, it is differentiated between the cooperativeness of a user to rent a bike at an alternative station and the cooperativeness to return it to an alternative suggested station. These are two independent values each ranging from 0%, meaning a user never follows such a suggestion to 100%, meaning the user always follows a suggestion.

A decentralized coordination approach is used in order to calculate the alternative rent and return stations that are suggested to the users. Therefore, each bike stations send its current occupancy rates to all other bike stations within a certain circular communication range every minute. The communication range determining which other bike stations are within reach is also a variable parameter of the simulation. Figure 6 shows an extract of the simulated map and displays how the communication ranges of different bike stations overlap. Bike stations receiving such status updates from other stations collect them and use them to calculate alternative rent and return stations in a decentralized way. Whenever such status updates are received, the receiving bike station determines the station with the lowest and the highest occupancy rate from the list of stations. The station with the lowest occupancy rate is selected as the alternative return station and the station with the highest occupancy rate is selected as the alternative rent station. These alternative stations are suggested to a user whenever it tries to rent a bike at the station when the station is currently empty, respectively when the user tries to return a bike at the station when it is currently full or critical occupied. So, the maximum detour distance equals the communication range of the stations, as only stations that are within a station's communication range are considered. The critical occupancy rate of stations is also a parameter of the simulation. For the simulated scenarios a critical occupancy rate of 75% is used.

4.4 Simulation Results

In order to evaluate the impact of the self-organizing redistribution strategy in correlation to the user cooperativeness a reference scenario without any self-organizing behavior was simulated. In this scenario and all of the following the cyclists moved with a fixed speed of 18km/h and all bike stations had a maximum number of 20 docks, whereof 10 were initially occupied.

The results of this reference scenario are shown in Figure 7. It shows the number of "normal" stations (neither empty nor full), the number of empty ones, the number of overflow stations (stations that are overcrowded) and the so-called "no bike" occurrences. These are the incidents when a cyclist could not rent a bike at an empty station and therefore, the trip could not be simulated. It is observable how the number of normal stations declines, while the number of empty and overflow ones rises with the morning rush-hour beginning at around 7 a.m. (minute 420). Over the day, these numbers fluctuate only a little with reoccurring no bike incidents (701 in total). In the late afternoon (around minute 1000) the number of normal stations recovers a bit, while both the number of empty and overflow stations also declines. This behavior can be explained by the rush-hour movements of commuters in the morning they drive from the suburbs to the city center and return in the afternoon. Stations in the suburbs tend to become empty during the morning rush-hour, while stations in the city center tend to become full or overcrowded. The returning commuters in the afternoon take bikes from the overcrowded stations in the city center and refill the empty ones in the suburbs when they return.

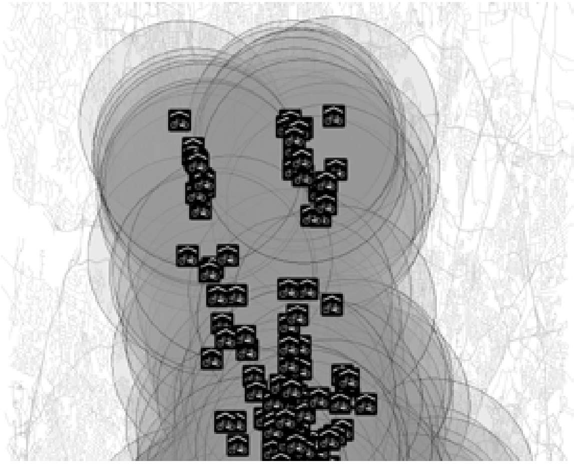

Figure 6 Extract of the simulated map showing the road model and some of the bike stations and their communication range

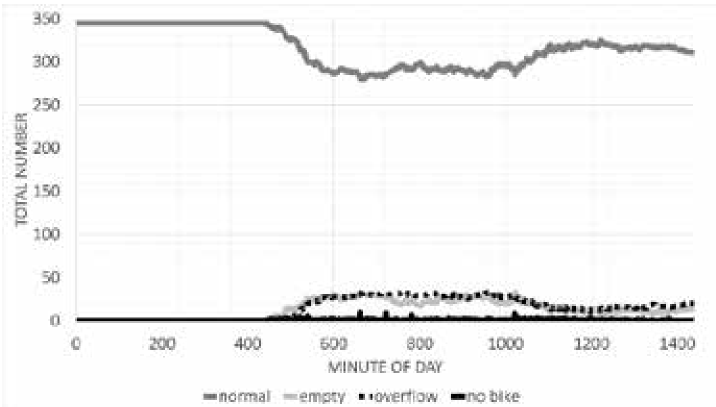

Figure 7 Results of the reference simulation scenario with no self-organizing behavior

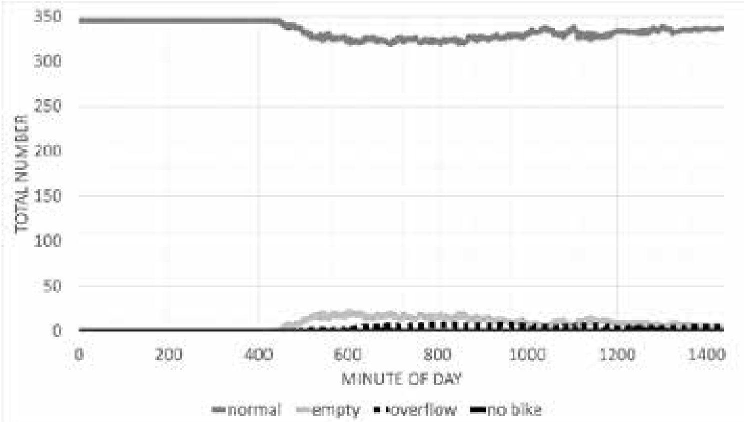

Figure 8 Results of the simulation scenario with 100% user cooperativeness (rental and return)

In order to measure the impact of the self-organizing redistribution strategy, a scenario with 100% user cooperativeness was simulated. In this case the users always follow a suggested detour to an alternative rental or return station. To simulate the reduced movement speed of the cyclist when they are detoured to an alternative rental station before they have picked-up a bike, their by-foot speed was reduced to 6 km/h. The communication range of the bike stations was limited to 1km, to narrow the possible detour distance for the cyclists. The results of this simulation scenario are shown in Figure 8. As in the simulation scenario with no self-organized redistribution of bikes, the number of normal stations declines with the beginning of the morning rush-hour, while the number of empty and overflow stations rises. However, due to the suggestion of alternative rental and return stations to the users and their cooperativeness to be detoured, noticeable

more stations stay in the normal state. In addition, the number of over-crowded stations is obviously reduced. The number of empty stations is also less in comparison to the reference scenario with no redistribution. Most significant is the reduction of the "no-bike" occurrences by 90.16% to 69 in total. The fact that these events still occur even with a 100% user co-operativeness to be detoured to an alternative rental station is based on the modeling decision that users only accept a suggested detour once. If they have already been detoured to an alternative rental or return station, they will not accept another detour. Thus, resulting in a no bike incident in case of a previous rental detour or the return of the bike at an already over-crowded station in case of a previous returned detour.
In order to evaluate the impact of the user cooperativeness in the proposed self-organizing redistribution strategy, a series of simulations with different cooperativeness parameters were performed. To measure and compare the impact of the users' cooperativeness to rent or return bikes at alternative stations two different cooperativeness parameters were introduced.
The rental cooperativeness describes the cooperativeness of a user to be detoured while trying to rent a bike and the return cooperativeness describes the user's cooperativeness to be detoured while trying to return it. The probed knowledge space contains independent cooperativeness value pairs ranging from 0% to 100% in 10% steps. The results of the first evaluation are shown in Figure 9. It contains the mean relative deviation of the number of normal stations in comparison to the previous described reference scenario with no self-organizing behavior. This value states how many more stations in average over the simulated day are in the normal state in comparison to the reference scenario (percentaged value). The results

show that the self-organizing redistribution strategy increases the number of normal stations about 9% at maximum. They also show that the return cooperatives has a higher influence on the overall improvement than the rental cooperativeness. This is because the cooperativeness of users to return bikes at an alternative station arranges an equal distribution of bikes at the stations, as the number of stations that are either full or tend to become full is reduced while empty stations are replenished at the same time. The reason is that the stations prefer empty stations while calculating alternative return stations.

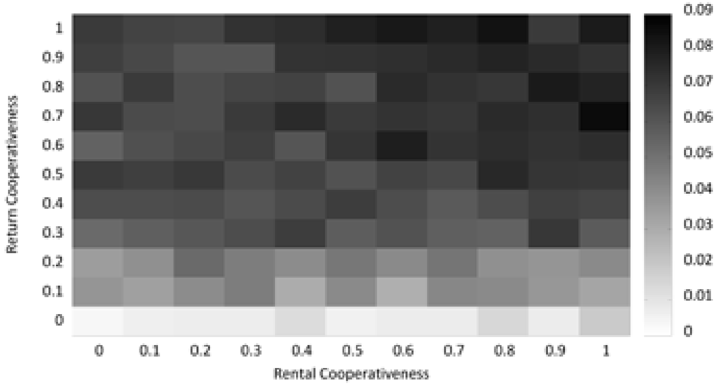

Figure 9 Mean relative deviation of the number of normal stations in comparison to the reference scenario with no self-organizing behavior

Besides the number of normal stations another important quality criteria is number of trips that could not be ventured, because of cyclists not being able to rent a bike at an empty stations. The so-called no bike occurrences. Figure 10 shows how the self-organizing redistribution strategy decreases the number of these incidents depending on the rental and return cooperativeness of the users. Again, the relative deviation to the reference scenario with no redistribution is taken as the quality characteristic. The results show that the number of no bike occurrences is reduced by slightly above 90% with total rental cooperativeness. Obviously the impact of the rental cooperativeness is much higher than the impact of the return cooperativeness, it directly influences the reduction of no-bike occurrences by detouring users in such an event.

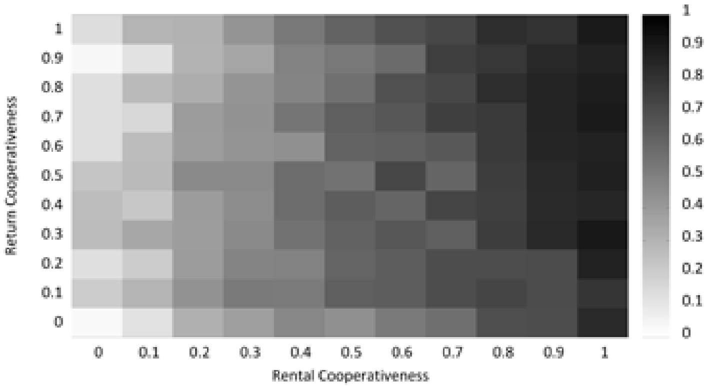

Figure 10 Relative decrease in the number of "no-bike" occurrences in comparison to the reference scenario with no self-organizing behavior.

5 Conclusion

The acceptance of bike-sharing systems depends heavily on the availability of bikes at the stations. In spite of truck-based redistribution efforts by the operators, stations still tend to become empty or full, especially in rush-hour situations. In this paper, we explored an incentive scheme that encourages users to approach nearby stations for renting or returning bikes to redistribute them in a self-organized fashion. Based on a microscopic simulation of a bike-sharing system based on data taken from Washington, D.C. (2014), we measured the impact of two independent cooperativeness parameters that determine the fraction of users that respond to an incentive to rent or return a bike at a suggested alternative station. Both results showed that in order to have a significant impact on the evaluated quality criteria a user cooperativeness, to rent or return bikes at suggested alternative stations, of above 50% is needed. This means, that operators of bike-sharing systems need to create significant incentives for the users to participate in the self-organizing redistribution of bikes, if they want to adopt this approach in order to extend their already established redistribution approaches. In this case, a cost analysis needs to be conducted in order to analyze if the increased costs caused by the incentives is worth the increased user satisfaction because of the increased reliability of the system. Such an analysis exceeds the scope of this paper, as it requires detailed information about the costs and gains of a bike-sharing system, which are not published openly by a bike-sharing system operators.

Based on a data-adaptive simulation approach, we showed how the proposed self-organized redistribution strategy increased the number of stations that are neither empty nor full and how the proposed strategy is able to reduce the number of incidents where a user is not able to rent a bike at an empty station in dependence of the users' cooperativeness. The facilitated data-adaptive simulation approach is based on the concept, that the simulation results stored in a database represent the knowledge about the system behavior that is enriched on demand by the execution of further simulation scenarios, if no results are available for the requested set of simulation parameters.

Acknowledgements

The authors would like to thank the developer of "RinSim" Rinde van Lon from KU Leuven for his support.

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II.
Business Models and Investment Options for Strategic Decision Making

Outsourcing to 4PLs – Opportunities, Challenges, Future Outlook

Denitsa Cherneva and Kai-Ingo Voigt

The need for a successful management of logistics services is becoming very acute, as nowadays it defines competitiveness on the global marketplace. Without doubt, the success of LSPs and their clients depends on the ability to vastly adapt to changing customer needs, innovate, develop and supply worldwide complex, high-quality and greener products and services at a competitive rate. In theory, the 4PL business model has emerged as a very promising breakthrough solution for these newly emerging supply chain (SC) challenges. By comprehensively integrating the competencies of multiple LSPs, best-of-breed suppliers and latest technology providers, 4PLs aim to leverage the skill and resource sets along the SC. In business practice, however, this asset-free approach still struggles to take hold. By means of a qualitative research this article provides a clear understanding of the current status and variations of the 4PL phenomenon, its opportunities and challenges for businesses as well as its future outlook in Germany. The results improve the customer perception and remove ambiguities. Therefore, they are relevant for both academicians and practitioners.

Keywords: Logistics outsourcing, 4PL, Opportunities, Challenges

1 Introduction

The increasing global competition, the rapid development of information technology (IT) as well as the fast changing customer requirements and business environment force businesses to pursue the simultaneous development of both lean and agile SCs (Saglietto, 2013; Saglietto and Pigni, 2009). As a result, over the recent years, the outsourcing of logistics functions to different types of LSPs has played an important role to the organization of end-to-end SCs and global markets as well (Saglietto, 2013). As a matter of fact, it represents an opportunity businesses cannot afford to miss out on (Bajec and Beškovnik, 2013; Saglietto, 2013).

In this sense, the various types of LSPs and the services they provide have been gaining in importance for both academia and practice over the last decade. Nowadays, the increase of direct sales is no longer a question of just price and cost reduction, but rather a result of a higher added value and quality for customers, greater agility and flexibility in responding to changing circumstances and effective performance. Thereby, the success of a new business approach depends on mutual risk sharing and investment, proactive and trusting cooperation between all partners as well as effective information flow and transparency throughout the entire SC. In this sense, more innovative outsourcing models such as a Fourth-Party Logistics Service Provider (4PL) differ from traditional outsourcing, whose main aims are the focus on core business, cost reduction and profit increase, while ignoring improvement of service performance and innovation (Bajec and Beškovnik, 2013).

Existing academic research focuses only on particular aspects of 4PLs in specific business relationships, based on descriptive or small-scale empirical survey analysis in a particular country. Thereby, it assumes that 4PL companies are a largely homogeneous amount of firms, whose activities can be clearly distinguished from other LSPs such as Third-Party Logistics Service Providers (3PLs) and Lead Logistics Service Providers (LLPs) (Saglietto, 2013). Although these academic works certainly contribute to the theoretical background on the 4PL business model, they still do not provide a universal identification pattern, which would help practitioners clearly understand the 4PL business concept, its advantages, drawbacks and future outlook. Furthermore, there exist inconsistencies and a general confusion with the 4PL terminology and main characteristics, which hinders the further expansion of the phenomenon (Juràskovà and Macurovà, 2014; Saglietto, 2013; Win, 2008).

Therefore, by conducting a literature review as well as an empirical survey, this article will tackle the following four basic questions:

1. How can the 4PL business model in logistics outsourcing be generally defined in the contemporary German market and what are its main characteristics?
2. What are the opportunities that a cooperation with a 4PL partner in terms of logistics outsourcing provides to businesses in the German market nowadays?
3. What challenges and risks do German companies currently associate with a 4PL venture and how do they deal with it?
4. What is the future outlook and potential of the 4PL business model in Germany?

The 4PL business concept represents the next generation tendency in terms of SC outsourcing (Saglietto, 2013). Although this phenomenon has been discussed in academic circles for a relatively long time, it still largely remains only a concept. However, most recent studies confirm its substantial implementation potential, which can evolve to a major competitive advantage in tomorrow's economy (Wagner, Ries and Pfohl, 2014; Saglietto, 2013). This is a good reason for companies to rethink their logistics outsourcing strategies and reshape their SCs. Since the evolution of LSPs largely impacts the commercial world, it is essential for entrepreneurs, consultants, logistics experts, managers and academics to understand the 4PL dynamics, opportunities and challenges.

This article is organized in five main sections. In the following section two, a review of recent relevant academic literature regarding the continuous evolution of LSPs from First-Party Logistics Service Provider (1PL) to Fifth-Party Logistics Service Provider (5PL) is provided. Thereafter, in section three, the qualitative research methodical approach and the data collection process are introduced and explicitly discussed. The findings of the empirical data collected are then summarized and analyzed in section four. In the final section five the article concludes with a summary of the results, limitations and paths for further research.

2 Literature Review on the Evolution of LSPs

In the context of Supply Chain Management (SCM), the classification of the various LSPs according to different criteria has attracted a great deal of attention (Saglietto, 2013). Therefore, the generally approved hierarchical division of LSPs into 2PLs, 3PLs, 4PLs and 5PLs shall be used as a starting point to provide an overview of the current situation on the global market for logistics outsourcing.

Until 1980s it is usually the manufacturing company, which executes its logistics activities (Büyüközkan, et al., 2009). Essential for the 1PLs is that they perform all logistics functions (transportation, storage and handling) within the company and using its own resources (Gattorna, 2000).

The 2PL business concept emerged in the early 1980s as a result of the internationalization of trade, the stronger competitive environment and the rising pressure to lower cost (Bajec and Beškovnik, 2013; Hanus, 2013). It consists in performing basic logistics functions as external LSPs using own capacities. In particular, for the first time companies start outsourcing logistics functions to traditional contractors, in order to concentrate on their core competencies (Büyüközkan, et al., 2009).

Beyond 2PL, the logistics activities are performed by external LSPs, broadening their service range and enhancing their complexity. With time the logistics functions provided by LSPs have evolved and adjusted to the changing customer demand pattern and business environment (Saglietto and Pigni, 2009). However, this consequent evolution has made the boundaries between some of the currently existing LSP business models hard to distinguish (Saglietto, 2013).

Many authors define the most important shift from services of 2PL operators to services of 3PLs in the fact that they evolve from individual transactions to system-oriented services within the scope of a long-term partnership, based on a predefined contract and mutual benefits (Juràskovà and

Macurovà, 2014). In fact, 3PLs provide integrated logistics services. This business concept consists in using external strategic partners to perform a broader range of service packages using their own capacities. The outsourced logistics functions include the organization and management of both flow of goods and information as well as financial services. Moreover, the service offerings can be customized, integrated and bundled together by the operator. Therefore, the cooperation with 3PLs is attractive for businesses – the increased service level combined with lower financial risks enables companies to concentrate on their core competencies and other value-added steps (Hanus, 2013; Rajesh, et al., 2012; Marasco, 2008).

It is fair to evaluate that the 3PL business concept is quite similar to its successor, the 4PL. What is more, there also exists a very successful, somehow of a hybrid business concept in-between 3PL and 4PL, which should also be considered (Rushton and Walker, 2007). LLPs are defined as 3PLs that can also carry out assignments of the 4PL type. In other words, LLPs seek to combine the best of the existing 3PL companies with some characteristics of 4PLs as a revolutionary response to the changing customer requirements. In fact, these LSPs might also be responsible for their clients' logistics performance, which gives them a clear incentive to provide high-quality services at low cost and to act as a single point of contact. Due to the vague boundaries between the 3PL, LLP and 4PL business concepts, many authors do not consider LLPs as an independent evolutionary stage of LSPs (Saglietto, 2013; Rushton and Walker, 2007). However, for the purposes of this article it is essential to compare and contrast these three forms of LSP (see table 1).

Table 1 Differences between the 3PL, LLP and 4PL business models (Source: Based on Saglietto, 2013; Huang, et al., 2010; Win, 2008; Rushton and Walker, 2007.)

Factor	3PL	LLP	4PL
Asset basis	Yes	Yes	No
Accountability	Part	Part/ Total	Total, singular
Role	Logistics	Typic. logistics	SCM
Log. expertise	Operative	Operative	No operative
IT expertise	Medium	High	Very high
Focus	Fundamentals	Fundamentals	SCM
Additional	Integration	Steering	None
Performance	Cost	Typic. cost	Value creation
Contact	Direct	Typic. direct	Single point

In the recent past, the 4PL business concept has received considerable attention from logistics scholars, resulting in a growing body of research as well as writing in this field. It emerged in the late 1990s as a breakthrough solution to newly emerging SC challenges (Büyüközkan, et al., 2009; Gattorna, 2000). The idea and first definition of this business model is proposed and registered as a trademark in 1996 by Arthur Andersen (now Accenture Consulting). He defines a 4PL company as "an integrator that assembles its own resources, capabilities and technology and those of other service providers to design and manage complex supply chains" (Bade and Mueller, 1999). In other words, 4PLs can exist as an independent entity, which takes the role of an intermediator between the primary client and multiple SC partners (e.g. LSPs, suppliers), aiming to not only contribute to cost reduction but mainly to the value creation process within the client organization. Moreover, a 4PL company assembles a coalition of the best available LSPs and, thus, using its own IT competence, ensures a cost-effective and sustainable SC solution, which goes beyond the knowledge and capabilities of any single organization. Furthermore, pure 4PLs do not own assets themselves, but instead function as an integrator, using design and planning expertise in combination with advanced IT solutions. A 4PL operator is also expected to take over the management of the client's entire SC. Therefore, the possibility for a large 3PL company to form a 4PL organization within its existing structure should also be considered (Saglietto, 2013; Büyüközkan, et al., 2009; Screeton, 2009; Win, 2008; Gattorna, 2000).

However, academicians as well as practitioners predominantly share Saglietto's (2013) opinion that in practice there are very few "pure perfect" 4PL players, which meet all the necessary criteria, derived from the relevant academic literature on the topic. Nevertheless, there exist several “imperfect” 4PLs that only partially fulfill the defined theoretical requirements. Furthermore, when looking at the services offered by the diverse 4PL operators in business practice, it is fair to evaluate that they seek to distinguish themselves from their competitors by emphasizing certain criteria, in order to obtain a competitive advantage, which is perceivable for their customers. This is due to the fact that it is difficult for a company to simultaneously sustain global competition across multiple industries, while also providing all the services (Saglietto, 2013).

Therefore, Saglietto (2013) suggests an updated, more precise definition of the 4PL business concept. According to it, 4PLs can be described as independent consulting firms, whose role is to design, organize and coordinate the client’s entire logistics, documentary and regulatory chains. For this reason, they are legally liable for the actions they manage in their own as well as their clients’ name over long time periods. Furthermore, 4PLs are companies with few or no physical assets of their own, who play a very important role as SC integrators. Thereby, they combine their own resources, IT expertise, capacities and technologies with these of other LSPs, in order to design and manage complex value chains. Moreover, they offer specific, turnkey global solutions either directly or through computer modeling and facilities management. In addition, as veritable network architects, 4PLs possess, either on their own or through partners, an international network to provide their clients with good coordination of flows abroad. Lastly, they respect the principles of sustainable development and charters of social responsibility (Saglietto, 2013). As this definition is the most up-to-date, precise as well as practically relevant understanding of this phenomenon, it is chosen as a theoretical basis, when executing the qualitative empirical research to this article. In particular, it is taken as a starting point, when developing the research questions, as a rather deficient and quite case-specific understanding of the 4PL business concept is expected from practitioners.

Last but not least, in the recent past, a new stage in the evolution of LSPs – the 5PL business concept, has been gaining in acceptance in the academic world. As a matter of fact, competitive pressures are leading to speculations about the future of LSPs in the form of potential 5PL services. Interestingly, the idea behind this business model is to provide high-quality 4PL services, while also turning the customers' SCs into functions that are completely driven by IT. Thereby, 5PL operators offer quite specific, system-oriented logistics services as well as SCM, which are able to link suppliers, buyers as well as all other partners along the SC network. In this sense, 5PL operators act as highly professional consultants, who base their operations on latest IT. However, the immense investment and continuous improvement needed, the increasing number of decision makers, the high uncertainty and change dynamics make 5PL quite challenging and hard to implement in business practice (Ivaschenko, 2014; Screeton, 2009).

To conclude, in comparison to all its forerunner business concepts, the 4PL business model incorporates the advantages of both insourcing and outsourcing, aiming to provide maximum benefits to the primary clients. What is more, compared to its successor, the 5PL, it represents a low-cost and low-risk opportunity more applicable in the current economic environment. However, nowadays, the cooperation with 4PLs still seems to remain rather a business opportunity than business practice (Wagner, Ries and

Pfohl, 2014; Rushton and Walker, 2007). This might be due to the fact that such a collaboration can only be successful, if the company's size, overall objectives as well as SC complexity suit the 4PL business model and can profit from it. Furthermore, the challenges and risks of such a cooperation have to be managed appropriately (Gattorna, 2000).

3 Methodical Approach and Data Collection

This study is designed as a bridge between the theory on the opportunities, challenges and future outlook of outsourcing logistics activities to 4PLs and the phenomenon's current understanding and characteristics in business practice in Germany. Therefore, on the one hand, the systematic review of recent relevant academic literature plays a very important role as a theoretical foundation for the study. On the other hand, semi-structured, in-depth interviews with experienced logistics experts were conducted, in order to get insights on the practical usability of the 4PL business concept as well as its understanding, benefits, risks and future implementation potential.

The use of semi-structured, in-depth interviews as specific qualitative empirical research method was chosen for the following reasons. Not only does it require a questionnaire that consists of several key questions, but it also allows the interviewer to diverge and pursue an idea or response in more detail, depending on the specific informant. This interview format is most frequently used, when exploring a new phenomenon, as it provides participants with some guidance on the topic of interest as well as more flexibility. Moreover, it also allows the elaboration of important information, which may not have previously been classified as pertinent by the researcher (Blumberg, et al., 2014; Saunders, et al., 2012).

In order to examine the present state of the German logistics outsourcing market, eight medium-level logistics and purchasing experts from leading organizations in Bayern, Germany, were interviewed from December 2014 to February 2015. The organizations, these experts are currently working for, reflect a variety of different industry sectors (e.g. global SCM, logistics, consulting), so that a holistic perspective on the topic is ensured (Creswell, 2013; Saunders, et al., 2012).

Additionally, for optimal results the particular predefined interview questions were adapted to the field of knowledge and expertise of each informant. In fact, most of the companies were visited in person. As expected, none of the eight logistics experts approved of recording the interview or revealing their company's name, because the research topic is confidential and commercially sensitive. Therefore, particular attention was paid to the anonymity of the interviewees and no basic company information was required (Blumberg, et al., 2014; Saunders, et al., 2012).

As soon as possible after the conduction of each interview, the scratch was reviewed and extended according to the expert's statements, as appropriately communicating with the informant and typing their entire answers simultaneously was a rather challenging task (Blumberg, et al., 2014; Saunders, et al., 2012). Data was initially analyzed using the theoretical insights gained on the topic. The analysis of each interview was partly carried out after each conduction, in order to develop a general understanding and refine the protocol and deep-dive questions for the next interviews. This enabled the data to be systematically collected and analyzed. Furthermore, follow-up telephone interviews or informal conversations with the informants were conducted, in order to clarify any ambiguities. Lastly, the interview material was reviewed and compared with secondary sources (e.g. companies' internal webpages, presentations), in order to make sure that the interview transcripts are interpreted legitimately. This also increases the reliability, generalizability and validity of the results (Yin, 2014; Saunders, et al., 2012).

4 Findings and Discussion

In this chapter the findings of the empirical research conducted will be discussed. Thereby, the outcomes of a practical study on the comprehension, contemporary spread, potential and challenges of the 4PL business concept in the German market, conducted by Wagner, Ries and Pfohl (2014), will also be taken into consideration, because using relevant existing research is regarded as both important and valuable source of data in qualitative studies (Maxwell, 2013).

4.1 Opportunities of Outsourcing Logistics Activities to 4Pls

First of all, in contrast to the recent publications (e.g. Wagner, Ries and Pfohl, 2014; Saglietto, 2013; Christopher, 2011), the majority of informants expresses certain skepticism in terms of reduction of capital expenditures within a 4PL venture. This might be due to the fact that large corporations achieve the needed synergy effects in terms of optimized fixed cost (economies of scale and scope, operational flexibility, etc.) on their own. Furthermore, the time spent by their senior management to coordinate and supervise the SC activities up- and downstream, is worth a substantial investment, because playing the role of the SC integrator represents their competitive advantage and main source of profit and, thus, lies “at the heart” of the company (Gattorna, 2000).

Nevertheless, regarding the opportunity of enhanced customer satisfaction, service capabilities and operational flexibility, both academicians and practitioners agree that large enterprises and SMEs experience difficulties in finding the right subcontractors, which maintain best-practice service levels throughout the business partnership. In that case, all companies can profit from a 4PL arrangement (e.g. Wagner, Ries and Pfohl, 2014; Saglietto, 2013; Win, 2008). Furthermore, logistics experts see a potential for reputation benefits, greater service capabilities and more successful new market entries due to the broad specific knowledge of the local customer requirements and reliable suppliers within a 4PL venture. In addition to the neutral position of the 4PL companies, especially SMEs can further take advantage of the broad IT knowledge, effectively shared within the SC network, the higher operational flexibility through risk-sharing and assets-renting, and the opportunity to work with companies on leading market positions (e.g. Wagner, Ries and Pfohl, 2014; Saglietto, 2013; Jensen, 2012).

Furthermore, particularly in terms of SMEs, both academicians (e.g. Wagner, Ries and Pfohl’s, 2014) and practitioners state that, by taking up a consulting role, 4PL companies provide their customers with high-quality logistics expertise and enhanced value chain integration. Moreover, they bring in expert knowledge and broad expertise in project management and employee motivation, which plays a very important role in change and innovation implementations (Saglietto, 2013). In this sense, academicians share the informants' opinion that the 4PL business model represents a comprehensive integrated SC solution through a hybrid organizational structure, which enables it to increase revenues as well as reduce working and fixed capital throughout the entire SC. Moreover, the 4PL business concept is considered as an innovative SC solution, which combines the capabilities of management consulting, IT providers and 3PLs, by acting as a single interface between the customer and multiple LSPs (Büyüközkan, et al., 2009; Win, 2008). Last but not least, by being the single point of contact, the 4PL company is able to simultaneously apply its logistics and optimization expertise along the entire SC, which is profitable for all partners in the long run (Papadopoulou, 2013; Jensen, 2012).

4.2 Challenges of Outsourcing Logistics Activities to 4PLs

In contrast to the results of Wagner, Ries and Pfohl's (2014) practical survey most of the interviewed logistics experts did not identify any substantial benefits from a potential 4PL venture for their corporations, industries or country. This might be due to the fact that the majority of the informants work for large German corporations. However, in alignment with the results of the academic literature review as well as the outcomes of Wagner, Ries and Pfohl's (2014) survey, the informants define relevant current inherent risks and challenges of a 4PL arrangement in business practice.

In terms of knowledge and understanding of the 4PL business concept, it is fair to evaluate that the results of the qualitative empirical survey executed are consistent with the findings of the theoretical research conducted (e.g. Saglietto, 2013) as well as with the outcomes of Wagner, Ries and Pfohl's (2014) practical survey. They state that currently the majority of logistics experts is not clearly familiar with the 4PL business model despite its substantial practical implementation potential and even though some of the companies are actively cooperating with LLPs. Logically, these experts do not consider 4PL operators as a relevant or possibly profitable business venture for their companies. This is one of the reasons why the potential of the 4PL phenomenon in the German market remains largely untapped (Wagner, Ries and Pfohl, 2014). As for the possible dependency on the 4PL operator, it is fair to say that on the German market generally exists a certain skepticism, reservation and a lot of legal requirements regarding new business concepts such as 4PL. Furthermore, the omission of logistics experts within the own company is associated with loss of know-how, market power and employee satisfaction. Moreover, academicians and practitioners agree on the existence of a "login-effect" with high exit barriers, where the client company gets vulnerable in the long run, as it becomes dependent on the 4PL's strategic decisions, performance and collaboration goals (Wagner, Ries and Pfohl, 2014).

Actually, regarding the potential loss of control and management of the outsourced logistics activities, the majority of informants shares the opinion that cooperating with a 4PL would mean at least partly giving up their identity, core competencies, added value and sources of profit to an external company. Moreover, as summarized in the literature review, beyond the reported lack of trust towards the 4PL partner, there exists general anxiousness about hidden cost, non-transparency, potentially missed innovation advantages, poor quality and unexpected relationship difficulties (e.g. opportunistic behavior), which hinders the further expansion of the 4PL business model in the German market and on a global scale (Wagner, Ries and Pfohl, 2014; Rushton and Walker, 2007).

Lastly, as far as the industry applicability of the 4PL business concept is concerned, Rushton and Walker (2007) state that large companies in high-technology and fast-moving consumer goods industries with increasingly global SCs have particularly high potential. Furthermore, Wagner, Ries and Pfohl (2014) define IT platforms for large companies as a substantial 4PL market opportunity in Germany. On the contrary, the majority of logistics experts interviewed defines SMEs in general, enterprises, which are looking forward to entering new markets in developing countries, and manufacturing companies, whose core competence does not lie in logistics, as the relevant market niche for 4PL companies in Germany. However, in terms of conservatism, both academicians and practitioners confirm that the German market for logistics outsourcing is relatively bureaucratic, skeptical and reserved in terms of changes, innovations and new business concepts. This fact, among others, currently prevents the 4PL business model from spreading more broadly (Wagner, Ries and Pfohl, 2014).

4.3 Future Outlook and Potential of the 4PL Concept

Academia and business practice agree that, due to the very competitive global business environment and rapidly changing customer needs, businesses will keep on seeking reliable and trustworthy LSPs, which can provide the resources and capabilities needed cheaper, better or more efficiently (Wagner, Ries and Pfohl, 2014; Saglietto, 2013). This can be traced back to the fact that nowadays agile, innovative and flexible SC networks compete, instead of single companies, and this tendency will remain in future (Christopher, 2011). Therefore, the trend to look for partnerships that are more strategic and collaborative will continue.

However, it is fair to evaluate that not all the strategic SCM tasks can be delegated to a LSP. In particular, the long-term planning of the logistics network is closely related to strategic decisions within the client company, which have a direct impact on multiple other corporate functions. Therefore, a central logistics department should be defined as a single, company-internal interface to communicate with the 4PL operator. This would help to mitigate the identified cooperation barriers in terms of high dependence on the 4PL operator and fear of loss of logistics expertise (Wagner, Ries and Pfohl, 2014).

Nevertheless, as SC competition and, thus, logistics outsourcing are globally gaining in importance, LSPs will continue developing innovative solutions to fulfill the various customer needs (Saglietto, 2013; Rushton and Walker, 2007). In fact, the majority of academicians and practitioners agrees that the theoretical, “pure” 4PL business model will hardly spread widely in Germany in the foreseeable future. However, in the role of logistics consultants, 4PL companies will continue to successfully support German companies regarding logistics, process optimization and IT systems. Furthermore, by founding a central department or a joint venture with a LSP in the form of an “internal 4PL”, the client can ensure the transparency, quality and efficiency along its SC network (Wagner, Ries and Pfohl, 2014). Last but not least, as a relatively small, neutral representation of a well-known 3PL company with local broad logistics experience (e.g. in BRICs), a 4PL unit can help companies efficiently manage and coordinate their SC networks in a new market.

To conclude, it is fair to evaluate that the future outlook of the 4PL business model in Germany remains highly controversial. On the one hand, this theoretical concept makes sense as its advantages represent a revolutionary response to newly arising SC challenges. On the other hand, however, logistics experts evaluate it as a rather complicated and risky undertaking, which has a major potential for a particular company in a certain situation, but rather reaches its limits when it comes down to a possible implementation in their company, industry or country, even in future. Nevertheless, enterprises should not underestimate the potential of the 4PL business concept, as it might turn out to be a typical disruptive innovation and, thus, an immediate competitive advantage on the future global market.

5 Conclusion

The need for a successful management of logistics services is becoming very acute, because nowadays it defines competitiveness on the global marketplace. Businesses strive to be more effective and that has led them to increase the number of outsourced logistics activities. Without doubt, the competitiveness of LSPs and their clients depends on the ability to innovate, develop and supply complex and high-quality products and services with higher value-added operations than their competitors. It is fair to say that a new paradigm of competition is currently emerging, in which the SC network provides a source of sustainable competitive advantage through enhanced customer value and efficiency in a globalized world, increasingly based on IT innovations. In this context, the 4PL business model has emerged as a breakthrough solution, due to the following reasons.

Firstly, a 4PL operator is legally and organizationally neutral of a logistics group. It is therefore free to provide independent solutions and establish external partnerships. Secondly, it provides a comprehensive multi-services, multi-techniques and multi-supports solution, which includes the best SC partners available on the market. Furthermore, as a global SC integrator, manager and unique value contributor, the 4PL operator acts as an interface and a single point of contact and accountability, which shares risks and benefits with its customers and makes sure that more agile responses are achieved. Thirdly, 4PLs offer a strong potential for human capital, which represents an inalienable and inimitable critical resource. Lastly, they are very creative, in constant search of innovative organizational concepts and techniques, in order to find new opportunities for their clients (Saglietto, 2013).

In business practice, however, this asset-free approach still struggles to take hold. In Germany in particular, the 4PL business model faces sobstantial implementation challenges due to companies' general distrust, apprehension of opportunistic behavior and unwillingness to share relevant information or competencies with a third party. Thereby, the loss or outsourcing of the own experts and know-how also plays an important role, because customers fear becoming vulnerable and dependent on the 4PL company. Hence, according to the informants, other business models such as LLP are more applicable and relevant.

Nevertheless, as far as the German market is concerned, locally presented well-known 4PL operators offer major opportunities for SMEs, for companies, which are looking forward to bringing new products to new markets, especially in developing countries (e.g. BRIC), and for manufacturing companies, whose core competencies are not in the logistics area. In this case, 4PL companies with a solid approach, broad logistics knowledge and experience, and up-to-date IT systems have a substantial implementation potential, when a suitable 4PL partner is chosen, a long-term trust-based partnership with mutual benefits is created and a full process transparency is ensured.

To conclude, the future outlook of the 4PL business model in the logistics outsourcing market in Germany is quite controversial. On the one hand, the trend for logistics outsourcing will continue to expand due to the globally rising competitive pressure. Thereby, besides cost and quality, efficiency, trust, value added, IT expertise and transparency of the handling processes will gain in importance for a successful logistics outsourcing collaboration.

These premises promote new breakthrough solutions such as the 4PL business model. On the other hand, however, particularly in the mature, highly competitive German market there generally exists a certain skepticism and reservation regarding innovative ideas as well as lots of legal requirements. Nevertheless, the substantial potential of the 4PL business concept should not be underestimated, as the phenomenon might turn out to be a typical disruptive innovation and, thus, a game-changing competitive advantage on the future global market.

As for the limitations of this article, it is fair to say that 4PL academic literature and surveys should distinguish between the research paths and results for large companies and SMEs, as there are substantial differences between these two groups in terms of 4PL implementation potential, advantages, drawbacks and future outlook. Furthermore, due to time and financial constraints, from the many possible companies the personal views of only eight logistics experts, who work for only four companies in three business segments in Bayern were explored. Moreover, only a fraction of the possible logistics outsourcing strategies within 4PL arrangements were discussed during the interviews. That is why, the research findings are limitedly transferable and cannot be assigned to the entire German market.

Nevertheless, the listed limitations draw attention to several future research paths. It would be worthwhile to conduct further qualitative and quantitative research on the company-, industry- and country-specific 4PL implementation potentials, as this article gives indications that there are major differences between 4PL perceptions in these three areas. Furthermore, it would also be interesting to compare and contrast 4PL logistics outsourcing practices and potentials between SMEs and large companies as well as between developed and BRIC countries and to verify the results of the present research. Moreover, there is a major research gap, when it comes down to quantitative and qualitative criteria for measuring the performance as well as success of 4PL ventures. Another interesting research path represents the development of a strategic approach for companies to choose a suitable 4PL partner, monitor and effectively direct the logistics outsourcing progress, and overcome traditional challenges. Lastly, there is a lack of empirically based large-scale studies on a global scale, including hypothesis, factors and relationship analysis regarding the opportunities and challenges of logistics outsourcing within a 4PL arrangement.

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Sustainable Business Development Models for Regional Airports

Anatoli Beifert, Gunnar Prause and Laima Gerlitz

As it was outlined in the EU Competition Policy Brief on the new state aid rules for a competitive aviation industry issued by the EU Competition Directorate–General in February 2014, the regulation for the financial public subsidies of any art on the EU national or regional level for the regional airports will be considerably striker. The strategic aims of these new regulations, among other things, are to motivate and encourage the Member States (here: regional airports) to implement more efficient market stimulation measures, make airports work on cost efficient and profit-able basis and establish transition periods for regional airports. In practice it means that public subsidies may be granted only to those regional airports that proved to have a sustainable and realistic business model that shall clearly demonstrate the durable financial stability. The authors took part in two air transportation initiatives in the Baltic Sea regions (BSR) and were lead partner in the EU Project Baltic.AirCargo.Net, which deployed a number of empirical measures in regional airports in the BSR. The paper will present and discuss success factors of sustainable business development models for the regional airports in the Baltic Sea Region based on cases studied during the project lifetime.

Keywords: Business Models, Regional Airports, Sustainability

1 Introduction and Problem Definition

The transport sector, in direct and indirect meaning, is one of the main driving forces of European and global economies. The White Paper on Transport that is the main policy document on transport policy in the EU states: "Transport is fundamental to our economy and society. Mobility is vital for the internal market (…) enables economic growth and job creation". According to the report of European Court of Auditors 2014, the air transport is considered to be one of the dominant modes for the passenger traffic over long and middle distances in Europe and worldwide. Air transport is playing also a vital role for the cargo with a high value added or time sensitive goods. European airports responsible for employment over a million people, working directly or indirectly in aviation business: e.g. airlines, technical aircrafts' maintenance, logistics or catering services, retailing and or traffic control, etc. The aviation business in total contributes more than 140 billion euro to the European GDP. Air transport is gaining more and more an important role for manufactures trade. IATA forecasts that the value of international trade shipped by air in the year 2015 will be 7,3 trillion USD and the passengers using air traffic tourists will spend a forecast 644 billion USD. Furthermore, the liberalisation of the aviation market in Europe over the last two decades has been one of the dominant factors improving European airports' operational environment. Such hard factors as emergence of air hubs outside the Europe and the efficient integration and use of the Internet Services have positively contributed to the commercial development of the European aviation sector. This liberalisation refers also to the certain information freedoms and operational flexibilities for airports and airlines alongside with the freedom of choice that is now available to passengers and logistics customers via Internet. However, in spite of the air transport importance, its growth and promising opportunities, ca. 48 % of Europe's airports were registered in 2010 as loss making (European Court of Auditors, 2014). That makes a special problem for small and regional airports. For such reasons as provision of accessibility or public socio-economic obligations, in spite of losses, the regional or national public authorities still keep on financing the airports. There are over 500 commercial airports in Europe that might be split into two categories (Horst, 2006): 1) Hub airports, which provide a full range of services, including business or leisure, domestic, European or inter-continental flights. The hub airports consolidate also air traffic from smaller and regional airports; 2) Regional airports connecting remote regions to the centres of economic activity, feeding hub airports but also having direct flights to other regional airports.

As it further stated in the Competition Policy Brief on the new state aid rules for a competitive aviation industry by the Competition Directorate–General of the European Commission in February 2014 it would be complicated for unprofitable airports, to get subsidies from the EU, national or regional public funds. In spite of the important social and economic role as well as positive impact of small airports on the regional development and general accessibility, the operating aid to the airports has to be cut out over a maximum of 10 years. Therefore, the majority of small and regional airports appeared to experience problems to cover at least their running operative costs. As it was further stated, the airport management is using the public funds mostly for hardware infrastructural investments, to cover operating losses or to attract price-sensitive airlines.

In comparison to the airlines, the airports possess a competitive advantage in form of diversity of business and service models in the nearest operational environment. Studies reveal that the Return on Capital (ROIC) for the players along the aviation value chain vary a lot, whereas the airlines noted the least ROIC index, i.e. practically every service, supply or distribution sector earned a higher return on capital than airlines. But same study also pointed out that ROIC of airlines suffer under a higher volatility and airports due to diversification options of airports related to a wider range of business models compared to airlines which are mainly active only in one business sector like pure passenger traffic. Thus, the airports due to business diversity possess a competitive advantage and the opportunity to develop in more sustainable, stable and profitable way.
The paper is organised as follows. The theoretical framework showcases key theoretical approaches, which serve for the analyses of regional airports performance. While the next section presents the methodology and results of the case studies analysed, the succeeding section formulates key implications for sustainable airport development and business sophistication. The paper ends with key concluding remarks showcasing tenets for regional airports business development across the Baltic Sea.

2 Theoretical Framework

The airport business is likely to experience a transformation, moving from the business based on growing traffic volumes, market share and political support. Stiffer competition and increasing role of networks and strategic positioning made the airports difficult to sustain their competitive position on the market. To overcome the retrenching performance, airports are subject to development of new strategies and business models adopted to new value propositions on the local, regional and global markets. By echoing practical experiences, the success of airports mostly lies in going beyond simple reflection the needs of customers and delivering a sufficient return to investors or other stakeholders. Strategic and operational success is rather likely to derive from three key tenets represented in different strategic management and business research streams, namely: diversity, differentiation and innovation of airport business (Feldman, 2009, p. 1).

For this, the theoretical framework of the current research needed to recall theoretical approaches pinpointing diversification, differentiation and innovation potential internally (i.e. regional airport) and externally (market) for regional airports: Resource-Based View (RBV) (Wernerfelt, 1984; Barney, 1991, etc.), competitive advantage and cluster theory by Porter (1991; 2000) including innovation management process (Tidd and Bessant, 2013).

In order to develop capabilities for diversification and differentiation, regional airports need to change their performance strategy internally (organisation-based) and externally (market-driven). Regional airports need to shift from being reliant on a single revenue source. For doing this, organisational success and performance is likely to depend on strategic utilisation of resources, such as human, physical capital, intangible assets that are valuable, rare, imperfectly imitable and non-substitutable (Barney, 1991, pp. 105-106; Boxall, 1996, p. 65). Following Wernerfelt, a resource can be anything that can contribute to a strength or weakness of a given organisation (Wernerfelt, 1984, p. 172). Strictly speaking, in the RBV resources are all tangible and intangible assets, capabilities, organisational processes, attributes, information and knowledge, which allow an enterprise to recognise and implement strategies that lead to organisational efficiency and efficacy (Barney, 1991, p. 101; Crook et al., 2008, p. 1150-1152). More specifically, a resource is a tangible or intangible asset and input to production that an organisation owns controls or has access to (Helfat and Peteraf, 2003, p. 999). The resource-based view model investigates the competitive environment from so called “inside-out” approach, dealing with the internal environment of a company (Prahalad and Hamel, 1990, p. 4).

According to the RBV, it is internal resources or capabilities that determine a future development or a strategic decision-making process and strengthen organisation’s competitive advantage (Prahalad and Hamel, 1990, p. 4; Porter, 1996, p. 70; Hoopes et al., 2003, p. 890). The core task of the management is to develop the demand and offer such products or services that potential customers surely need, but have not yet known or imagined them before. This brings to the second crucial element in the airport strategic plans – differentiation. Since today we face an increasing customer centricity, attempts to propose a unique, rare and valuable product or service to our customers, value proposition makes an important competitive advantage for regional airports. Echoing Feldman, airports now must to propose value that goes far beyond simply impressive architecture. Rather, at the core is customer experience associated with the airport, its products, services and assets, thus transforming airports into customer destination (Feldman, 2009, 4). In this regard, airports need to develop or recall such resources and capabilities that make them valuable among customers. Indeed, this can be facilitated by efficient marketing and branding activities of regional airports as well as additional products and services proposed to its customers, e.g. organisation's image or brand that can be hardly replicated; tacitness in relationships between the market players or market structure limiting new entry (Kai, 1993). Prahalad and Hamel recommend operating across organisational limits and benefit from the core competences of an organisation. Thus an organisation's core competences may be seen as a cluster of intangible resources that make it possible to achieve competitive advantage through: providing an access to a variety of markets; contributing to the perceived customer benefits of the end product and making imitation or replication process for the competitors as very difficult, thus sustaining of competitive advantage (1990, p. 82)

Linking up with resources and capabilities within organisations, a cluster of internal resources and capabilities residing in an organisation must be linked to the external environment. Following Porter, competitive advantage derives from an organisation's activities in the external environment or on the market, namely, how those activities fit strategically into the external environment or the market and, therefore, create economic and customer value (Porter, 1985, p. 35; 1991, p. 103). As a result, an enterprise gains a competitive advantage through fitting, for instance, its products, technology or marketing approach to the external setting (Porter, 1996, p. 70). Moreover, sustained performance is a result of relevant competitive advantages gained due to industry structure and appropriate positioning of an enterprise in an appropriate industry setting (Porter, 1991, pp. 99-100), i.e. cluster as "a proximate group of inter-connected companies and associated institutions in a particular field, linked by commonalities and complementarities. The geographic scope of a cluster relates to the distance over which informational, transactional, incentive, and other efficiencies occur" (Porter, 2000, p. 16). Porter argues that a cluster is not just a bundle of single industries, but rather a system of interdependent industries and business entities that cooperate and complement each other in a given economic landscape. They might include suppliers of specialised resources and services as well as providers of specialised infrastructure. The identified requirements to „create" a cluster are critical mass of companies in spatial proximity; companies, who's businesses are in the same business area; similar or supplementary business activities and common connections to branches (ibid., p. 16f).

A functioning cluster positively contributes to improving productivity and efficiency of the inter-related businesses, it stimulates a cluster-internal competition and innovations and finally a cluster provides a favourable framework for the new start-ups and entrepreneurial activities within the cluster. These positive effects are also achieved through efficient knowledge sharing and knowledge transfer within the cluster, multiplied by a learning process that does not require cost intensive investments; and where the cluster's players may utilise the cluster business canals to other economic spaces.

Most of the studied clusters in academic literature are related to ICT, life science, automotive industry and other industrial clusters, but there exists nearly nothing about logistics clusters until Yossi Sheffi (2012) published his book. In his understanding "logistics intensive clusters" are agglomerations of several types of firms and operations providing logistics services and logistics operations of industrial firms and operations of companies for whom logistics is a large part of their business. Such logistics clusters also include firms that provide services to logistics companies like maintenance operations, software providers, specialised law firms or international financial services providers (Sheffi, 2013). Thus, an airport together with its surrounding business network can be considered as a logistics cluster in a comparable way, like it is well known for seaport clusters (DeLangen, 2004). By doing so it means that an airport shall focus on strengthening efficient interconnections with all its relevant industries, operating institutions and organisations, therefore improving competitiveness and its own sustainability. For a regional airport e.g. prioritising the air cargo business cluster approach may mean building up logistical service centres that would create a network of regional logistic service providers, thus the single services might be enlarged, structured and improved. That may lead to improved tangible and intangible resources of the involved cluster participants and help to identify distinctive capabilities of an airport.

If one may assume an airport not as a single branch or an entity, but rather as a cluster, it may mean that an airport shall focus on strengthening efficient interconnections with all its relevant industries, operating institutions and organisations, therefore improving competitiveness and its own sustainability. For a regional airport e.g. prioritising the air cargo business cluster approach may mean building up logistical service centres that would create a network of regional logistic service providers, thus the single services might be enlarged, structured and improved. That may lead to improved tangible and intangible resources of the involved cluster participants and help to identify distinctive capabilities of an airport.

Coming to the third tenet – innovation, it is needed in order to stay ahead and develop future trends. As today's markets and customer needs evolve, inflexibility in terms of operations, strategy, etc. can be crucial for airport's failure. The importance nowadays about business model prototyping including identification of strategic supply and demand drivers, macroeconomic environment, megatrends, the level of innovation, business sophistication, technological readiness, financial market development, labour market efficiency, hard/soft infrastructure, etc. has been outlined and mentioned in a range of scientific publications and research papers (Eckert, 2014, pp. 7-9). Furthermore, the upcoming threat in form of so called "multipolar world", which describes the far-reaching changes in the relevant competitive fields as a result of the growing importance of emerging markets for economic development is about a global competition for labour, capital, commodities, new consumer markets and for innovations. (Scholtissek, 2008, p, 27f). Thus, it may be stated that the most intensive competition has been already started for the global innovation leadership. Innovation introduces a new meaning and value for its consumers, i.e. a new or significantly improved good or service, process or new marketing method, new organisational methods in business practice, workplace organisation or external relations (OECD/ European Communities, 2005, p. 46). Innovation implies a process during which all the necessary activities such as problem resolving and/or idea generation; development; manufacturing and marketing of a new construct (would it be product, service, or process itself) are effectively and efficiently managed and commercially and practically exploited to the market (Trott, 2012, p. 12-15). Innovation is to be viewed as a process of turning opportunity into new ideas, ensuring its practical application in the reality (Tidd and Bessant, 2013, p. 18-22) and bringing value through its availability and access to it for its users via the market and/or other channels or distributed peer-to-peer and/or by the market (Gault, 2011, p. 9). Launch of innovations also require specific capabilities, knowledge, skills, facilities, resources, market knowledge, financial resources and certain level of infrastructure. It is, in other words, knowledge and entrepreneurial know-how that makes innovations successful on the market. Innovations are likely to come to the market as a result of technology push (e.g. Christensen, 1997, p. 72f), can be pulled by the market after having analysed users' needs and in order to satisfy users needs by firms to increase revenues and safe costs.

Similar to well proved step-by-step innovation process including search for new ideas / opportunities; selection of ideas; implementation of ideas and capturing ideas and commercially benefiting form their exploitation (Tidd and Bessant, 2013, p. 47), Osterwalder and Pigneur (2010) identify five components that make up a business model, so-called “Business Canvas”. Nevertheless, a comprehensive business model developed by them include nine elements: customer segments, value propositions, channels, customer relationships, revenue sources, key resources, key activities, key partnerships and cost structure. The business model of Osterwalder and Pigneur may be considered as an example of an operative business model approach, which serves to derive from the corporate strategy, the operative business model as an intermediate step to the organisational model.

With the wide variety of definitions of terms related to innovation business models and a variety of approaches have appeared on how business models might be developed or redesigned within a company. It may be stated that those phase concepts are closely connected to the known phase concepts of strategic management, innovation management or even the transformation management.

With regard to all concepts integrated within this theoretical framework, it is argued here that regional airports as complex, open and multi-layer ecosystems can be analysed and assessed by applying different factors, which were found in the strategic management and business modelling literature discussed above, such as resources, value propositions, internal and external structures. It is evident that most of the theoretical approaches do share the same common thread – would it be processes (e.g. steps of identification, understanding, etc.) or resources, capabilities and other tangible and intangible assets within organisations and on the markets. For this reasons, the research introduced the following matrix when assessing and supporting airports development.

Table 1 Matrix for airports assessment and business model development

Business modelling criteria	Assessment criteria for business sophistication proposition
Diversification level	Analysis of resources: tangible; intangible; Analysis of resources: valuable, rare, imperfectly imitable and non-substitutable; Analysis of capabilities: tangible; intangible; information-based organisational process and intermediate goods

Business modelling criteria	Assessment criteria for business sophistication proposition
Business innovation level	Innovation capacity and readiness: product, service, process, organisational (horizontal and vertical dimension)
	Linkage of airports to innovation policies and R&D
	Governance level: local; regional; national
	Level of technological specialisation (e.g. ICT)
Differentiation level	Level of value proposition
	Level of customer experience creation (e.g. marketing, corporate identity and branding activities)
	Business sophistication (clustering activities, suppliers quality and quantity, value chain breadth, extent of marketing)

The authors of this paper argue that the above-presented matrix for the regional airports' assessment based on the consolidated theoretical frameworks of RBV by Prahalad and Hamel; Innovation Business Canvas of Osterwalder and Pigneur and Competitive Advantage and Cluster Theory of Porter enable comprehensive evaluation of airports.

3 Methodology

An evidence-based approach has been applied here to assess airports' competitive environment as well as investigating of favourable preconditions for the successful SMEs operations in the airports. The degree of competition between airports or the competitive constraints have not been included in this study.

Original primary and secondary data have been applied here. Expert interviews and empirical data were obtained in the frame of the project "Baltic.AirCargo.Net" financed by the EU the Programme "Baltic Sea Region Programme 2007-2013", ERDF Funds. The empirical material was collected from diverse sources of evidence over the period of project life cycle (2011-2013): qualitative observations of researchers involved into the project activities, external experts' evaluations, project documentation and observations gathered from respective project activities such as workshops, conferences as well as from the field notes from project meetings.

The following target groups participated in the surveys and expert interviews: a) representatives from Airport Management; b) representatives from Transport and Logistics companies from participating regions; c) representatives from the academic side, c) expert from the air cargo security and air cargo freight sector.

The above presented matrix for regional airports business assessment and development has been chosen as a basement to present the analysis of the selected airports.

Within the Baltic.AirCargo.Net project, a number of regional airports from the BSR have been analysed. Grodno Airport (Belarus) has been selected as a demonstration case for this study. The selected findings from Kalmar Airport (Sweden) will be used as supplementing case in order to outline the role of the efficient cooperation between an airport and relevant regional structures, including private and public sector as well as regional responsibility of an airport.

4 Case study: Grodno Airport (Belarus)

Grodno Airport is one of the five regional airports in the Republic of Belarus that is situated near Grodno city with about 325 thousand inhabitants in West Belarus. Grodno is located close to the borders of Poland and Lithuania (about 20 km and 30 km away respectively). Grodno is the capital of Grodno Region that may be considered as the airport's catchment area with a population of about 1,1 Mio. Road is the most used transport mode for the passengers and the cargo transport. One regular flight to Kaliningrad (2 times per week) is offered at the moment. The logistical and time distance from Grodno to: Minsk: 280 km, ca. 3,5 hours (via road); Vilnius: 167 km, ca. 2,5 hours (due to cross border procedure time costs of traveling to Vilnius may vary from 2,5 hours to 4 hours); Warsaw: 274 km, ca. 3,5 hours (due to cross border procedure time costs of traveling to Warsaw may vary from 3,5 hours to 5 hours). International Airports in Minsk, Vilnius and Warsaw are the main competitors for the Grodno Airport. Grodno Airport is a state-owned airport run by a special department of the national Transport Ministry. The main source of revenues for Grodno Airport is the navigation services for the over-flights that constitute up to ca. 85% of the total revenue income. Diversification analysis of Grodno Airport has shown a number of gaps in the evaluation between internal stakeholders and external experts. The interviewees evaluated the given criteria according to the following scale model: "poor", "satisfactory", "good".

Airports' internal stakeholders, incl. management team and the representatives from the governance body clearly tend to overestimate the quality of the distinctive resources. Favourable geographical location, radar/navigation (incl. supporting hard/software infrastructure), runway, internal security regulation system, low costs for aviation fuel were named by internal experts as distinctive competitive resources of the airport. External experts have identified the relative low costs of the aviation fuel as one of the main intangible distinctive resources of Grodno Airport for the potential refueling of the air cargo over flights Eastbound (e.g. Europe-China) direction. In contradiction to the evaluation of the internal stakeholders, it shall be noted that the external experts pointed out that the runway is obviously too short for large cargo aircrafts.

Table 2 Diversification evaluation of Grodno Airport

Assessment criteria	internal view	external view
Tangible; intangible resources	good	satisfactory
Valuable, rare, imperfectly imitable and non-substitutable resources	satisfac-tory	poor
Capabilities	good	poor

In the framework of the diversification analysis, the cross-referencing of the evaluations was done by the airport's stakeholders and external experts.

Table 3 Differentiation evaluation of Grodno Airport

Assessment criteria	internal view	external view
Level of value proposition	good	poor
Level of customer experience creation	satisfac-tory	poor
Business sophistication	good	poor

The cross-referencing of the results gained by internal and external experts in the framework of the differentiation assessment has demonstrated a tendency of overestimation of the assessment criteria by the internal stakeholders. The external experts identified specifically the following diversification criteria in Grodno Airport as "poor":

a. Poor availability, quality and level of value added services, including deficit of specialized services and support;
b. Poor availability, quality and level of specific and targeted marketing activities, including low regional image;
c. Poor level of competing sophistication mainly due to national regulations imposed by National airline, i.e. Belavia;
d. Low level of logistics services and absence of cargo terminal;

The evaluation of the business innovation criteria done by internal stakeholders and external experts have shown the following results:

Table 4 Differentiation evaluation of Grodno Airport

Assessment criteria	internal view	external view
Innovation capacity and readiness	good	poor
Innovation policies and R&D	satisfactory	poor
Governance level	good	satisfactory
Technological specialisation	good	poor

The airport's internal stakeholders identified linkages of the airport to public / private R&D and linkage with innovation policies as "satisfactory", the other business innovation criteria have been evaluated as “good”. The external experts evaluated the only criteria in Grodno Airport as “satisfactory”, i.e. governance level. It was mainly explained by the fact that the airport has a sustainable financial support, investments and also the guidance in terms of innovation hardware and software infrastructure that is regular monitored by the national Ministry of Transport of Belarus. On the other hand, the experts pointed out that too close attention and monitoring from the Government side might be a hinder for the realization of innovative business models, since e.g. it is linked to a relative high bureaucracy level and every tactical or operational decision shall be communicated and approved with / by the responsible government body.

5 Supplementing Case: Kalmar Airport

The following supplementing case is mainly based on the expert interviews carried out with the representatives of the Kalmar Airport Management and relevant public authorities from the City of Kalmar.

Kalmar Öland Airport is situated near Kalmar - a town with ca. 40 thousand inhabitants, located in South-East Sweden at the coastline of the Baltic Sea Region. In 1983 the city of Kalmar took over the airport's ownership the military forces. The airport's area and the corresponding infrastructure became the property of the city of Kalmar. The catchment area of Kalmar Airport consists of ca. 300 thousand people. The transport and time distance by road from Kalmar to the nearest airport hub Copenhagen is ca. 330 km or ca. 4 hours; and to Stockholm: 415 km and 4,5 hours correspondingly.

Due to a relative long traveling distance (here: by road) to the nearest air hub, in order support local business community, 5 daily flights to Stockholm–Arlanda are offered by SAS airlines. Beside that another 4 – 6 daily flights to the city airport Stockholm Bromma are offered as an important business destination. From 2013 the 5 daily flights to in Berlin-Tegel are offered by "Sparrow Aviation" (till 2014 "Flyglinjen"). Thus, Kalmar Airport with a catchment area that is almost 3 times less than in Grodno is capable to offer regular flights to the national and to international airport hub. Currently, the flights to and from Stockholm are filled by ca. 60% with the business travellers and 40% of leisure travellers. The leisure travellers fill up the empty business seats, so that the passenger load factor amounts ca. 70%.

Växjö Airport, that is situated ca. 100 kilometres westbound of Kalmar and close to a train link Malmö–Stockholm, has a lower demand for the aviation services.

The flights to Copenhagen and Stockholm are stopped during vacation time because of low demand in Växjö area during this time. Thus, it may be stated that an underdeveloped ground-based infrastructure in Kalmar region belongs to the competitive advantages of Kalmar Airport. This remote situation in South Sweden is also one main reason because Kalmar Öland Airport is outperforming in passenger growth with a sustainable development tendency compared to other regional airports in Sweden. Furthermore, the interviewees stated that since the airport's related decisions have to be taken locally in Klamar region, the regional responsibility for the airport, i.e. the needs for local skills, knowledge and political culture, increased considerable. Kalmar needed almost 20-30 years for building up efficient customer experience base, creation of operational effectiveness and quality of micro-economic business environment and the relevant local know-how. The City of Kalmar created a special fund-foundation to support marketing and to establish new flight links from Kalmar. Being aware of the role of Kalmar Airport for the accessibility, the local businesses also invested in this special supporting fund. The capital for the foundation originated 50% from City of Kalmar and the other 50% from local business sector. This is an important precondition, since the City of Kalmar on its own is not allowed to finance flights. This financial instrument makes development and implementation of new air routes possible and realistic (e.g. initiation of the Kalmar-Berlin air connection in 2013), since new flights, in general, need a pre-financing of ca. 1,5 year before a destination becomes profitable.

The current business plan for the Kalmar Öland Airport focuses on 3 main targets:

1. Increase of leisure flight passengers, especially for incoming flights
2. Increase of the attractiveness of the Kalmar region by offering charter flights and flights to Stockholm and Berlin
3. Improvement of the possibilities to do global business from and in Kalmar

6 Implications for Grodno Airport

In the long-term perspective, liberalization of the aviation market must be initiated in the Republic of Belarus. The development and planning of sustainable business models for Grodno Airport currently are only possible, if they do not contradict with the development strategies of the national Airline “Belavia” and national regulations. In the short-term and in the mid-term perspectives Grodno Airport may focus on:

a. Air Cargo Growth, including development and implementation of the Road Feeder Services (flying trucks) with the EU airports.
b. Fuelling and re-fuelling business opportunities.

Along with the availability of the internal resources one of the main reasons for recommending the Air Cargo Growth strategy are the legal frame-restrictions imposed by the National Airline, i.e. Belavia. In the short-term and mid-term run it might be realistic for Grodno Airport to start with the objectives that do not contradict with the current framework policy restrictions of Belavia that, among other things, makes it almost impossible in terms of inbound or outbound regulation of aviation traffic in Belarus for regional airports to cooperate with the non-national air lines, in spite of some potential requires from other airlines have been already received.

The development and implementation of the Road Feeder Services (flying trucks) connected to ACC3 certificated air cargo destinations outside the EU via Grodno Airport with other EU airports might be the first realistic step to enter air cargo market. Here a close collaboration with relevant national authorities, regional logistics companies (business Lobby) and foreign airlines will be necessary.

For the air cargo destinations outside the EU that do not have an ACC3 certification, Grodno Airport can be developed to a long haul air cargo base, due to its proximity to the EU transport corridors. The business model for Grodno Airport can be an air cargo link to non – ACC3 destinations, where incoming and outgoing cargo is forwarded by normal truck/rail e.g. via "Rail Baltica" and "East-West Transport Corridor" and Grodno over the Belarus border. This solution would offer an efficient air cargo link between the EU countries and long haul destinations without ACC3 certificate. However, it requires detailed action plan that shall make cross-border procedures between EU-States (here: Poland and Lithuania) and Belarus more time-efficient and reliable.

Geographical location has been identified as one of the distinctive intangible resources of Grodno airport. The close location to Lithuanian and Polish border obviously provides huge opportunities for the regional transport industry. The high cross-border procedures (e.g. 3-4 hours, esp. for the road transport) provides a certain advantage for the development of the Road Feeder Services or "flying truck" connections between Grodno Airport and other European air hubs. A flying truck connection e.g. between Grodno Airport and Vilnius Airport assumes that the normal cargo is officially declared, transferred and handled to air cargo in Grodno Airport security zone. Further is handled to the registered flying truck operating company and is transferred by a schedule road-“flight” to Vilnius Airport. This concept assumes also that the registered “flying trucks” must have a special treatment (here: "no control regime") on the cross-border, since among other things, they the flying trucks operate de-jure as an air cargo plane with an Air Way Bill letter and all security procedures that are applied to the air cargo. That implies that no border control for the secured and transported goods on the registered “flying trucks” is needed. Furthermore, the flying trucks will benefit from a certain number of privileges comparing to normal trucks, e.g. they dare operate during the official holidays or weekends.

In the long-term perspective such topic as liberalisation of the air market must be initiated. If we the possibilities of attracting new aviation businesses to Grodno Airport are considered, then it is most likely that international direct air-connections (from/to Grodno Airport) must be initiated. This assumption requires, however the most important prerequisite, i.e. liberalization of the air market in the Republic of Belarus. The realization of the business model of Kalmar Airport (Sweden), i.e. regionalization with the future option for privatisation also indirectly requires the fulfilment of the same preconditions, i.e. liberalization of the air market framework regulations in Belarus. The requirement is mentioned here as “indirect”, since even though the “technical” and / or “formal” fulfilment of the regionalization model might be possible and is not directly demanding the granting certain freedom of air to other national or international airlines in Grodno Airport, however the Kalmar Model makes only then sense, if the given freedom of air does already exist (e.g. 5th or 6th freedom of air as minimal prerequisites). Possible realization of the Costs Leadership might be implemented e.g. through formally existing branch of Belavia, i.e. Grodno Airline in form of establishing of the low cost carrier (LCC) strategy for Grodno Airline with the permission to serve domestic as well as international air routes.

Following the Kalmar Model the success example of "regional responsibility", Grodno Airport might be privatised, whereas the City of Grodno will be the co-owner. The board of Grodno Airport might involve experts from City of Grodno, Grodno Region and Free Economic Zone (FEZ) "Grodnoinvet" due to regional development character and the direct link between FDI and air connectivity (Sellner and Naglb, 2010; Banno et al., 2011). Further board members might be selected from regional business association(s). For a certain transition period a board members from the national level may be involved. It might be recommended in cooperation with Regional Development Agency, (here: Grodnoinvest) to consider perspectives of creation and development of so-called "Free Customs Zone" or "Bonded Industrial Park" in the area of Grodno Airport. A more detailed and deeper analysis on this matter must be fulfilled. In case of privatisation, financial sustainability of Grodno Airport shall be secured already at the initial stage, e.g. new investments, demand for the financial resources for the establishment of the new air connections between Grodno and other destinations since break-even time for new air connections may vary up to 1.5 years. This measure could be realised together with liberation of the Belarus air market so that the regional airports will be able to decide about the serving airlines and destinations. Concerning the passenger flights it is recommendable to establish regular flights from Grodno to 2 important air hubs. One hub might be in CIS area, i.e. air links to Minsk or Moscow; and to an international hub in Europe (e.g. Berlin or Vienna). Both links are important to allow business trips to support the economic development and to offers the possibility of one day business flights from Grodno to Europe and CIS countries.

7 Conclusions

Due to growing competition and changing frame condition of the EU, the European aviation business is in a reconstructing process. The majority of regional airports in the BSR does not reach the break-even point and relies to a large degree on different forms of public subsidies and aids. However, according to the new master plans of the EU, the subsidies to the airports, if not justifiable and sustainable, will be limited or cut in the short and mid-term perspective. Therefore, regional and small airports have to find sustainable business models to sustain cost efficiency and profitability of operations. According to findings of the Baltic.AirCargo.Net project, a number of regional airports continue focusing on passenger traffic, whereas the benefits of the airfreight market and air cargo related business opportunities are underestimated or even completely ignored. The considered cases pointed out how air cargo business can contribute to high revenue yield parts and open up international development possibilities towards airport clusters despite the fact that air cargo volumes may be small. The related business models can lead to sustainable development concepts for the regional airports and the surrounding business clusters.

The research results have also shown the lack and deficit of cooperation between the regional airports. Although the airports have been developing and implementing their business development plans and models, however this process takes place mostly isolated, i.e. experience, knowledge or even plans sharing between the airports has been hardly noticed. Therefore, it may be recommended to the airports' management to pay attention to the horizontal cooperation, learning from each other experiences. The availability of the needed tangible (e.g. required infrastructure, incl. runway, parking slots, security and screening equipment) and intangible resources (e.g. internal competences and skills) is considered as important preconditions for the airport's operations. However, those resources alone would never guarantee the sustainable and successful business growth. Nowadays, the airports shall identify and activate their distinctive tangible or intangible resources that shall further lead to provision of unique or innovative services, positively contribute to clustering activity and improve operational effectiveness and quality business environment on internal and external dimensions.

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Adaptive Intra-Logistics

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Many Intra-Logistics systems are designed over the course of several years in order to ensure the logistical supply of an assembly or production area for a fixed number of years. In the past this approach was economically successful. However, today's globalized markets require different procedures. Adaptive Intra-Logistics systems will be required in the near future in order to ensure adaptability to changes in assembly or production (e.g. volume fluctuations, additional products, changed geometry of products) without requiring costly new investments. The adaptability of these systems could be achieved through modular design and dynamic planning. In this paper a new planning methodology for Intra-Logistics systems is described. This planning methodology is based on features of Multi-Agent Systems such as self-organization. These characteristics of our planning methodology make it particularly suited for autonomous logistics modules and contribute to the adaptive Intra-Logistics systems. Furthermore, the current literature on the technical alternatives for reach adaptive Intra-Logistics is explored. Especially modular design is key to coping with rapidly changing production environments. Therefore, four different new logistics concepts, which have been selected using a rating matrix and questions catalogs, are presented. These concepts were verified and validated in simulations.

Keywords: Flexible Intra-Logistics, Modular Design, Multi Agent System, Automobile Logistics

1 Introduction

Intra-Logistics represent the internal flow of materials between different logistics nodes in a company - from materials handling in the production process to distribution centers right on up to airports and seaports - as well as to the corresponding flow of information (CeMAT 2015). Optimization of the Intra-Logistics is essential to ensure economical, high-quality and time-efficient operations in manufacturing. Intra-Logistics costs are a substantial component of the total costs in manufacturing. Tompkins et al. (1996) estimated that in a typical manufacturing operation, 25% of the number of employees, 55% of all plant area, and 87% of production time are assigned to Intra-Logistics systems and it accounts for between 15% and 70% of the total cost of manufacturing a product. Efficient operation of appropriate materials and information flow methods can contribute towards a reduction of manufacturing cycle time and work-in-progress inventory cost. An efficient Intra-Logistics system supports the production process, increases production and system flexibility, provides effective utilization of manpower and decreases lead time. The modern Intra-Logistics equipment's such as automated guided vehicles (AGV), electric monorail systems (EMS), pallet conveyors, rail-guided vehicles (RGV), transfer cars, and baggage handling systems, as well as sorters, automated storage and retrieval systems (AS/RS, stacker cranes) and shuttle systems are now widely used in many industries worldwide. The fast-growing sector of Intra-Logistics, consisting of equipment manufacturers, warehouse technology producers, software developers and even complete system providers facilitates optimum solutions for every individual application across many different industries (CeMAT 2015).

The competitive nature of global manufacturing forces companies to seek innovative approaches for improving and optimizing their processes. Due to large production numbers and complex products, the automobile industry always requires innovations in Intra-Logistics to reduce cost and improve productivity (Trappey 2010). Therefore our innovative Intra-Logistics concepts focus on this industry.

One of the key factors in manufacturing facilities, which are constantly being improved, is the design of adaptable processes that enable stable performance under changing conditions. In recent years much literature has been written on adaptable processes. The majority of the published articles deal with adaptability of manufacturing systems and Supply Chains (Barad 2003). Research on designing adaptable Intra-Logistics systems has received little attention. A truly adaptive Intra-Logistics requires a shift in approach. For most manufacturing companies, this means:

1. Reinventing Intra-Logistics concepts
2. Rethinking Intra-Logistics planning approaches

At the Institute of Logistics and Material Handling at the University of Stuttgart we have identified the need for change in the production logistics due to product changes, individualization, shifting customer needs and global supply chains. To develop innovative approaches to solving these challenges, we initialed two projects. The first (DFG project) focuses on the theoretical path of Intra-Logistics planning using agent approaches and the second project focusing on using the theoretical approach to create innovative Intra-Logistics systems for the heavily cost damaged automobile production logistics. In this article, these two important issues in developing adaptive Intra-Logistics systems are to be addressed. This includes the dynamic planning of Intra-Logistics systems (2) as well as modular design (3).

2 Planning of Intra-Logistics Systems

As mentioned in section 1, Intra-Logistics systems will have to behave like dynamic systems in the future. Organization, structure and features of Intra-Logistics systems should change continuously depending on the market and company requirements (Marrenbach 2008). It is acknowledged that the planning of Intra-Logistics systems design is highly complex due to a huge amount of technical and organizational implementation possibilities. The authors tackled this complexity by developing sequential iterative planning approaches. In the literature, planning methodologies with different steps can be found (Gu 2010). There are four common themes running through all of these methodologies:

1. The planning process starts with the conceptual and data acquisition.
2. Based on the result of the first step the planning team selects a few appropriate cost-effective alternatives.
3. At the end the best alternative is selected and then worked out in detail by means of simulation and other operation-research techniques.
4. The planning process finishes with the call for proposals and the selection of suppliers.

These steps are interrelated and a degree of reiteration is mostly necessary. Although many researches into the computer aided design techniques used within each of the steps was undertaken, the planning results are still highly dependent on the expertise of the planner, the development time is still long and the planning procedure is inflexible in dealing with changing requirements. These disadvantages lead on the one hand to uneconomic manufacturing systems and/or on the other hand to Intra-Logistics-systems that cannot match their respective required dynamic logistics service levels.

For several years, engineers of systems composed of a large number of elements have investigated solutions where those systems are composed of several (simple) elements which collectively produce 'something' more complex at the global level. This is what is frequently referred to as agent-oriented methodology. Our research applies this methodology to the planning of Intra-Logistics systems. This paper proposes an agent-based model for dynamic planning of Intra-Logistics systems in the next section.

2.1 Dynamic Planning With an Agent-based System Planning

Intra-Logistics systems are vastly different from one another. However, most of them share some general pattern of material flow including: receiving area, issuing area, assembly area, picking area, packing area etc. In these functional areas Intra-Logistics systems move, store, assemble, identify, label, separate, secure and sort goods. These groups of activities are referred to processes. These processes are executed by resources, such as forklift trucks, conveyer systems, storage racks and barcode scanners. In

this context, an Intra-Logistics system can be modelled as a swarm of interacting components. The planning process based on this decentralization could be realized as follows:
First the planning tasks and goals are fixed, the planning data is collected and analyzed and the planning object is functional decomposed. Each functional area in the system is described by its input and output stages. Goals and requirements are broken down and connected to the functional areas. The result of the first part is a functionaly decomposed description of the system including article flows, requirements and stages. In the second phase the synthesis of the system takes place. The system concept is developed in a bottom up direction by cyclic composition and configuration of functional areas, processes and resources. Based on compatibility checks the processes are connected with resources. The needed capacity of the function element is calculated. At the end of the composition and configuration procedure the solutions are ranked in a list. In the third phase the chosen concept is worked out to execute a call for proposals and a supplier selection. The key unit of this model is the intelligent planning object (IPO), which mimics the properties and behavior of requirements, resources processes and strategies. These IPOs are able to organize themselves autonomously and to interact internally and externally via standardized ports/protocols. Furthermore, one super-IPO assesses the final Intra-Logistics system configurations and transforms user requirements. Defining the required intelligence of the IPOs needs an understanding dynamics and providing means for managing the complexity (Wehking 2011).
To realize the decentralized planning concept, multi-agent systems are particularly suitable. To support the planners of an intralogistics system,

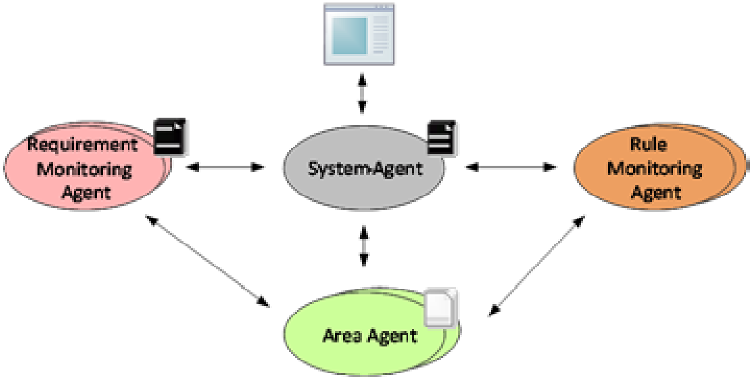

Figure 1 Top-level concept of the agent-based approach

agents can represent various parts of the system. Predefined engineering knowledge can be integrated into the multi-agent system. This provides the agents with the possibility to create realization proposals, which can be taken as baseline for further detailed planning. In Figure 1, the hierarchic structure of the different agent types is shown.

At the highest level there is the system agent. The system agent interacts with the planner and loads and evaluates the requirements, which are specified by the planner. Moreover, based on the given requirements the system agent defines the necessary functional areas and instantiates the respective area agents. The system agent creates an individual agent for each functional area, even if a functional area of the same type is already present. After generating adequate solutions to the specified problem, the system agent also post-processes the data before the output in form of evaluated realization possibilities is displayed. Besides the system agent, there are also other top-level agents, the requirement monitoring and rule monitoring agents that constantly monitor the fulfillment of the specified requirements and global rules, which are needed to be kept for the correct development of an Intra-Logistics system. These rules include, for example, which functional areas are needed. After generating the required area agents, each agent starts coordinating its respective functional area and identifies different possible sequences of the required functional processes and evaluates them since all realization possibilities have to be checked. These sequences are formed depending on the given requirements and then each potential solution is investigated separately by the area agent. For this purpose the area agent instantiates the demanded resource agents for each sequence and informs them of their respective neighbors. The resource agents represent a resource, which is connected to the required functional process. Each created resource agent then allocates the necessary resources to the corresponding process. To be able to pick correct resource agents, the area agent needs pre-specific knowledge about its corresponding functional area type. The necessary information on the resources required for each function is stored in a database in form of a resource catalogue. The described agent concept of a functional area is shown in Figure 2.

The result of the described process is a large number of resource agents that form a network, since every agent is connected to its neighbors.

After their instantiation each resource agent evaluates its represented resource against the given requirements that are made to the system beforehand. A specific requirement for the handling object, for example that palettes have to be transported, would lead to a removal of all resources,

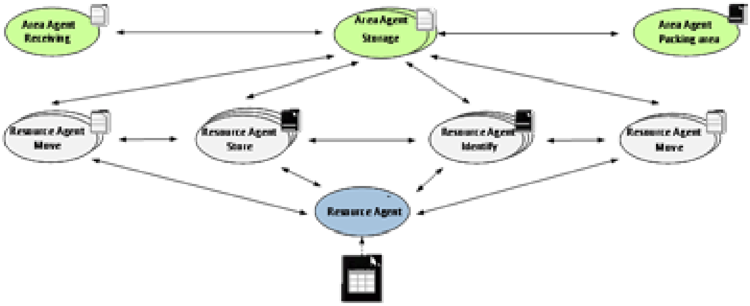

Figure 2 Agent concept of a functional area

which are only able to transport packages. These resource agents inform their neighbors that they are not compatible with the given requirements and switch themselves into a stand-by mode. To reactivate these agents the planner needs to change the systems requirements, which will lead to a reactivation of these agents by the requirement monitoring agent. The remaining of the network is hence a set of active agents, fulfilling the demanded requirements.

As the next step the connections between its neighboring resources has to be checked by each resource agent, to eliminate resource combinations that cannot be connected to each other. Each resource agent assesses the interfaces of its resource with its possible neighbors by matching the defined interfaces according to compatibility rules. For example, if packages have to be removed from a specific warehouse resource vertically, a withdrawal unit, which is only able to remove packages in horizontal direction, cannot be used in combination with this warehouse. If the compatibility check of a resource agent fails which indicates two neighboring resource with incompatible interfaces, the connection in the network is extinguished. While the resource agents are passing through the check of global requirement fulfillment and interface compatibility with their neighbors the Intra-Logistics system is composed. After the composition, the leftover active resource agents dimension their resources. The knowledge for the dimensioning of single resources is also deposited in a resource catalogue that is part of the knowledge database in the form of dimensioning parameterization rules. Since the compatibility to their neighbors also de-pends on the dimensioning of the resources, dynamic interdependencies arise between neighbored resource agents. Thus, for example, the choice of the withdrawal unit also depends on the height of an automatic ware-house. These interdependencies can lead to iterative re-dimensioning of a resource and if there is no compatible dimensioning solution with its neighbors, to an activation of the stand-by-mode for the incompatible agent. In the final step, the adaptation is reevaluated by requirement and rule monitoring agents. Within this phase, the planned Intra-Logistics systems can still be adapted quickly to changing requirements, caused for example by increasing individualization of production processes. The final result of this planning procedure is a network of resource agents containing all realization possibilities for the Intra-Logistics system in development. Every path in this network describes one possible realization option. To evaluate the generated solutions even further, these paths have to be extracted and valued according to different parameters, for example to the costs. Other parameters that are also relevant like for example the flexibility could be contrary to other e.g. to the costs. Since these qualitative requirements like efficiency, flexibility etc. usually decide which realization possibility is realized, the system agent interacts with the planner to find out which criteria are more important in the current scenario and ranks the realization possibilities accordingly.

In order to archive optimal realization options, the rules, which are needed to develop a material handling system, are deposited in the knowledge base, have to as precise as possible. These rules should be gathered from a broad audience of experience planners to support each individual planner that is using the support system. The whole planning procedure can then be executed iteratively and in parallel due to autonomous behavior of the agents. The presented methodology also enables a quick adaptation and change of the requirements to re-establish the consistency of the development automatically.

3 New Intra-Logistics Concepts

Today's automobile manufacturing systems are stiff and require a high amount of investment and time to allow changes. This leads to difficult situations in times of changing demands for certain models based on economic growth or market crisis. While the production and logistics systems in their basic structure have changed very little in the past 20 years, the customers are getting offered larger amounts of options on a high scale. This leads to high numbers for variants in the production cycle, which can be comprehended from the theoretical number of variations among European manufacturers, for example for the VW Golf = 10^{23} variations (Klug 2010).

Even with the difference between theoretical numbers and the ordered vehicle variations, only two of 1.1 m produced Mercedes A-class vehicles, were identical (Schlott 2005). While manufacturing has to adapt to different handling steps, the logistic needs to provide variant production materials at the right time and in the right place. This brings up the need for more flexible processes regarding the control and setup of Intra-Logistics systems. Some companies that struggle to handle the higher amount of variants prefer to push these problems towards external suppliers, offering a simple and quick solution for the production company, but implying higher costs for Intra-Logistics. Further increases in model and therefore material variants will lead to higher costs. To break with this circle, new Intra-Logistics concepts have to be used. Therefore we have focused on creating extremely flexible and universal Intra-Logistics systems. We used the above described decentralized planning methodology and defined our parameters. Furthermore on the path towards the development of these new systems we conducted an in depth analysis of the current situation as well as the clarification of disadvantages of today's Intra-Logistics concepts in regard to flexibility and high variant productions. Therefore we evaluated Intra-Logistics operation in different automobile assembly plants in Germany. One of the clearest results was the higher number of storage points and handling steps between the arrival at the factory premises and the point of production. The reason behind this system is the just-in-sequence delivery to the place of production. We estimate that these up to seven handling steps and storage points are accountable for a high amount of the total logistic costs. Therefore we developed ten logistics concepts in cooperation with logistics experts from automobile manufactures, focusing mainly on the reduction of handling steps. Some of these concepts differ only in certain aspects and therefore four completely different approaches can be filtered out. These are shown in Figure 3 and will be described individually in the following chapter. The concepts have been evaluated re-

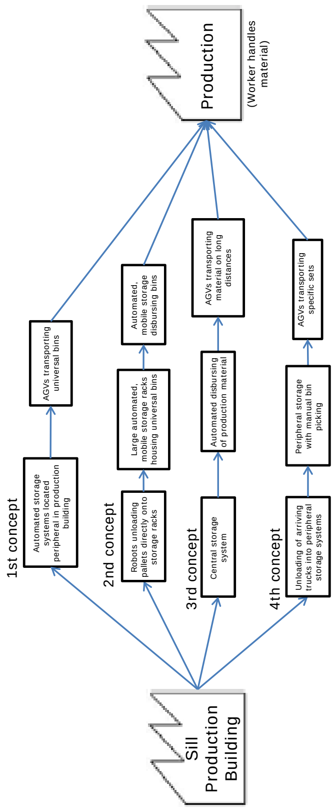

Figure 3 Innovative logistics concepts

garding categories like length of transportation routes for the AGVs, operational safety and potential reaction time regarding changes in the production program. To prove the feasibility of the four new concepts, we used original production data from a large premium automobile company and build up models in the program Plant Simulation, where we were able to simulate different production numbers. All four new concepts were shown as realizable based on the simulation data.

3.1 Detailed Description of the Concepts

The first concept focuses on the smallest number of handling steps out of all concepts. The materials arrive from the supplier and are stored directly in a high rack (HKL) or small-parts storage area (AKL). These storage areas are located peripheral inside the production building, to enable shorter routes for the AGVs. Each storage area delivers only material to the production areas which it is located close to. After receiving a demand signal from the logistics IT-system, the material is released from stock and loaded directly onto an AGV. The vehicle then drives to the production area and delivers the material. During this process, the material is kept inside a universal bin. The worker must only remove the material from the universal bin and the AGV transports the empty bin back to the sill of the production building, where the empty bin is loaded on a truck routed back to the supplier. The described routing for the material is shown in Figure 4.

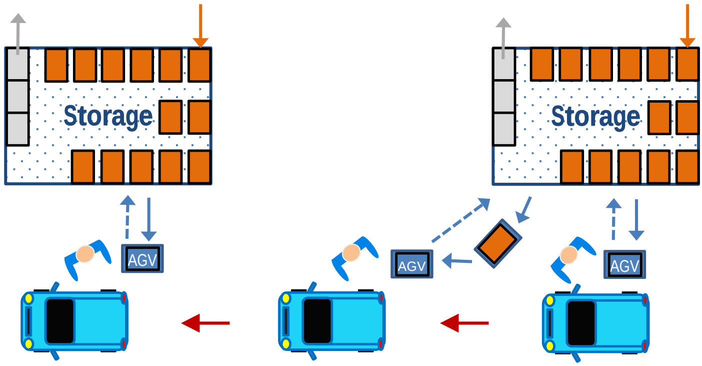

Figure 4 Peripheral storage with AGV concept

The second concept, named automated, mobile storage unit has special advantages for variant productions environments. The mobile storage unit gets loaded with universal bins directly in the receiving are of the production building. The load can be either 48 large universal bins (standardized by the VDA: 600 x 400 x 280 mm) or higher amounts for smaller universal bins (using shelf board as underlayment). The storage then makes itself on the way to the point of production where the material is needed.

This takes places using the built-in drive system and a guiding AGV, named follow-me AGV, which clips onto the mobile storage unit for driving. The clipping facilitates lower total system cost because expensive security systems (laser scanners) and navigation systems (localization, routing and mapping) have to be installed only inside the follow-me AGV and not in the mobile storage unit.

One follow-me AGV can assist multiple mobile storage units with their transport needs throughout the production day. After arriving at the point of production, the mobile storage unit automatically disburses the universals bins just in real time (JIRT), using a rack feeder, for the present production steps. The collection tray of the rack feeder holds the bin in ergonomic position for the worker. Once all universal bins are emptied, the mobile storage unit moves back to the goods receipt zone for refilling.

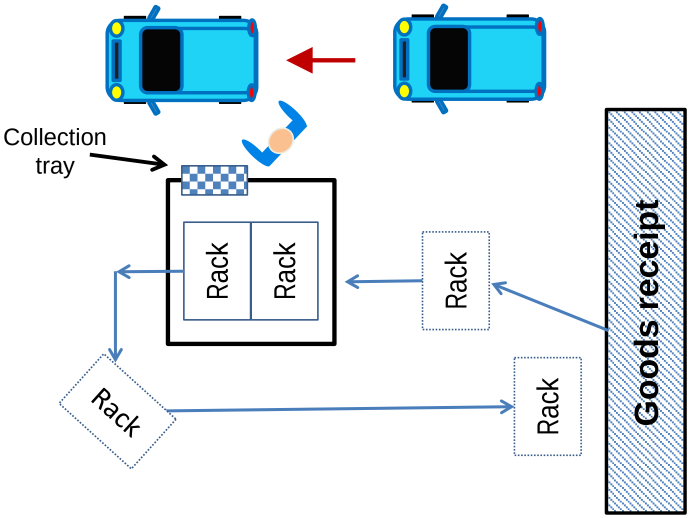

Figure 5 Automated, mobile storage unit concept

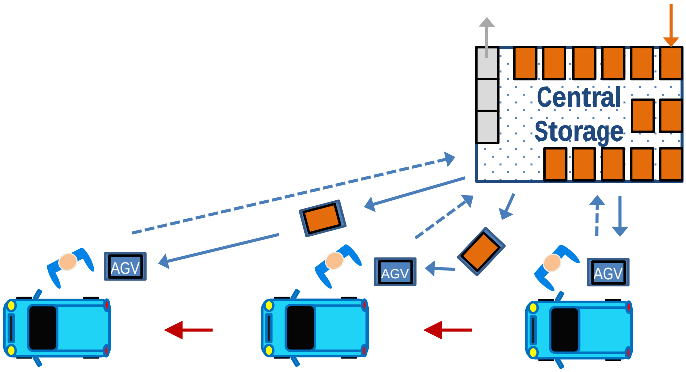

Figure 6 Central storage with AGVs

The idea behind the third concept is the saving of storage space. Using a high rack warehouse, the floor space required for provision of the material can be reduced. However the AGVs have to cover larger distances between the storage and the point of production where they deliver the material in the universal bin. The information for the release of the bin from the stock is initiated by the logistics system. Afterwards the high rack warehouse disburses the universal bin to the AGV.

The AGV drives to the production, the worker takes out the material and the empty bin gets transported back to the sill of the production building, ready for transport to the supplier. The concept is illustrated in Figure 6.

The fourth concept picks up the idea of specific production sets either by universal bins or directly with the material. In a picking area the needed materials are loaded onto a rack which itself stands on an AGV. When the demand signal from the logistics systems is sent, the AGV with the filled rack on top drives towards the first production station. Afterwards the AGV

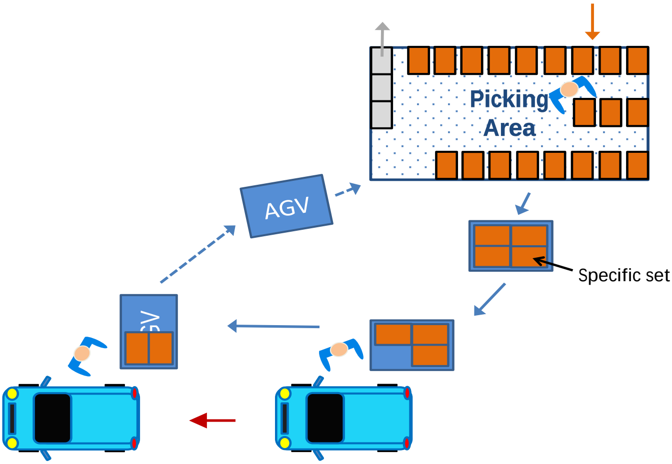

Figure 7 Specific set concept

with the specific set follows the production for a certain number of stations, depending on the size and amount of needed materials. After the last item or material has been taken from the rack or the universal bins, the AGV drives back to the central storage ready for the next routing. The described cycle is shown in Figure 7.

The four described logistics concepts are modular and therefore compatible with each other. In the second half of our project we are working on a selection tool, which suggests the optimal Intra-Logistics concept based on frequency, size and variation of the material together with production numbers. To understand the selection process in the next chapter, the different new Intra-Logistics concepts and their systems can be seen as agents. The results could be the following: Production station 1, 3 and 5 receive their material from systems using the first concept while the stations

2 and 4 have certain characteristics which make the third logistics concept the economical, optimal choice.

4 Summary

In this paper we described our current work with logistics modules and modular planning. The idea is the combination of different logistics concepts depending on the individual production station, the amount and variation of material with the aim of achieving higher flexibility and adaptability. Using different planning methods, we will be able to select the most suitable Intra-Logistics concept as well as the optimal storage type. This will lead to cost reduction in the Intra-Logistics and improve flexibility and adaptability. As described in chapter 2, we are working on the creation of a module catalogue selection tool, which should help in identifying the most suitable Intra-Logistics concepts for a specific production station based on material data. Later on the tool will be extended towards including a feasibility study based on controlling numbers from today's logistics concepts.

Financial Disclosure

The projects described in this paper are funded by the Deutsche Forschungsgemeinschaft (DFG) within the research project DEPIAS (WE 2187/27-1 and GO 810/32 - 1) and the state of Baden-Württemberg within the research project „Neuausrichtung der Produktionslogistik für die Automobilfertigung für eine bezahlbare Elektromobilität“.

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South African Wine Supply Chain Performance Measurement Framework

Corneli Jooste, Joubert van Eeden and Esbeth van Dyk

Wine cellars in South Africa are looking for ways to improve profitability. Improving the performance of their supply chains may lead to increased profitability, and will definitely increase competitiveness. Performance measurement can be used as a tool to collect information for making supply chain decisions. Currently there is no performance measurement framework for the wine supply chains of South Africa. Private and producer cellars struggle to improve and manage supply chain activities due to the lack of useful information and benchmarks. The research method that is presented describes how an agile design methodology was used to develop a performance measurement framework and address the problem. Through a process of interviews, discussion groups and practical measurements, industry and academic feedback continuously influenced the design. The aim of the framework is to improve supply chain performance, provide strategic direction and enable decision making. In this paper, focus was placed on the distribution channels of packaged products to the local market. Metrics of the framework are categorised according to the attributes of the Supply Chain Operations Reference (SCOR) model. Supply chain segmentation can have a significant impact on the usefulness of metrics and benchmarking. The data of these measurements that will be received from industry can provide insight on the competitiveness and performance of the industry.

Keywords: Performance Measurement Framework, Packaged Wine Supply Chain, Supply Chain Metrics, Benchmarking

1 Introduction and Background

In today's global world it is often not organisations, but rather supply chains that are competing against each other (Martinez-Olvera & Shunk, 2005). The importance of supply chain wide management and alignment is therefore recognised by more and more industries. As part of a plan to improve the performance of the wine supply chain in South Africa, this study aims to initiate supply chain performance measurements that can be used to provide industry benchmarks.

South Africa is a major player in the global wine industry. As the 12th largest producer of wine, South Africa contributes 4% of the global production of wine (SAWIS, 2014). The wine industry also plays a significant role in the South African economy, by accounting for 1.2% of the national GDP in 2013. The industry is creating jobs and increased the income towards agriculture, tourism, manufacturing, trade and hospitality by 37.8% from 2008 to 2013 (VinPro, 2015).

Although the wine industry is one of the oldest industries in South Africa, the concept of a wine supply chain and the management thereof is still new. Interest in the field of supply chain thinking was delayed until the industry was deregulated in 1993. During the time that the industry was regulated, wine could only be exported through one channel. Deregulation opened exporting opportunities and forced cellars to create international and local market channels for their products for the first time.

The concept of the South African wine supply chain was mentioned in a publication for the first time in 2010 when Stellenbosch University conducted a survey, as part of the PWC annual financial benchmarking of wine cellars, to gather supply chain information (Stellenbosch University &

CSIR, 2010). The term is currently still uncommon to a large number of participants in the chain, but it is becoming more prevalent. Industry bodies are recognising the importance of investigating the topic and within the next decade, it will feature more often when discussing matters of the industry.

Due to the absence of previous research on the subject, the study was approached with a strong focus on supply chain principles from literature. Applying the principles to the wine industry of South Africa required an understanding of this supply chain. In a similar study on the agri-food supply chain, Aramyan (2007) confirmed that it is vital to consider the intricacies of the supply chain that is measured. The possible features that could distinguish one supply chain from another are comprehensive. It is these features that cause management of the wine supply chain to be different from the management of other supply chains (Ouyang, 2012). The metrics that are selected for performance measurement and improvement should capture the essence of organisational performance (Gunasekaran & Kobu, 2007). Several frameworks have been developed to explain these features since they are relevant for performance measurement and for developing a supply chain strategy.

1.1 The South African Wine Supply Chain

To give background on the market and industry for which the performance measurement framework will be developed, some important characteristics of the South African wine supply chain are discussed. These relate to the various processes of the supply chain (source, make, plan, deliver) as well as the financial position of the industry.

Four supply chain segments have been identified through segmentation of the South African market. The four segments are: packaged wine for the local market, packaged wine for the export market, bulk wine for the local market and bulk wine for the export market. Bulk wine refers to large quantities of wine that has not been packaged yet.

Packaged wine for the local market, which is the focus of this framework, is mostly distributed to a variety of supermarkets and distributors (67.3%), but 30.2% is sold at restaurants or other on-trade events where the wine is consumed on the premises where it is bought (Marketline, 2014). Other markets such as online sales and wine clubs account for only 2.5% of the market volume.

Grapes are harvested once a year and this creates annual cycles and segments for inventory management of bulk and packaged wine. The implication for packaged inventory is that products are renewed and reviewed by customers every year. Bulk wine will be kept separate in the warehouse according to the year of harvest. Another natural classification of inventory is between red and white wine. This becomes less relevant from an inventory management perspective when the wine is packaged and distributed.

An illustration of the wine supply chain for local products can be seen in Figure 1.

Complexity of sourcing is relatively high due to long lead times of raw materials. Most raw materials are sourced locally from a variety of suppliers. Cellars usually source grapes from a specific group of grape producers and

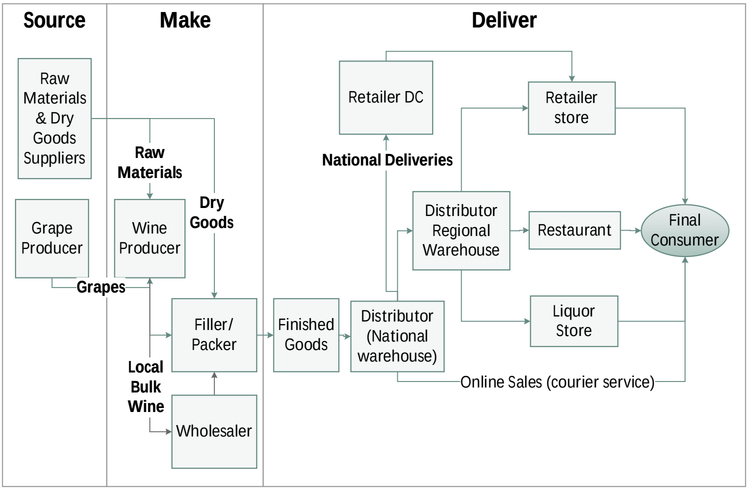

Figure 1 South African Local Wine Supply Chain (Internal project documentation)

have strategic, long term relationships. A lot of inventory is kept throughout the supply chain due to the long production process, distances from suppliers/markets and the importance of having the correct finished goods for orders. Inventory has to be financed, and this causes the wine industry to be very cash flow sensitive.

From discussions with industry, it is clear that cost is a main driver of the market. Transportation is a large cost component due to the long distances to most of the main local markets. Thus full truckloads are usually seen as compulsory for cost-effective distribution.

Before wine is bottled, it can be still be sold as a bulk or packaged product. However, once it is bottled and labeled, the options in terms of customers are much fewer. Currently there is a surplus of wine in the South African market and customers therefore often have the buying power.

2 Methodology

In order to address the problem identified in the South African wine sup-ply chain, a performance measurement framework was developed. Case studies and literature reviews played an important role in the development of the framework and benchmarks. The study commenced in 2014 and comprises of two work streams.

The first work stream performed case studies at 16 wine cellars to identify general issues in the supply chain. The second work stream developed a performance measurement framework and industry benchmarks for three of the four identified supply chains mentioned in section 1.1.

As part of the background study for the development of a performance measurement framework, initial measurements were collected from participating wine cellars in September 2014. The process of capturing information for the metrics introduced cellars to some important metrics. It also created awareness of the decisions involved in supply chain management. Feedback on the results created an opportunity to discuss future segmentation and the selection of metrics for the framework.

Parallel to the practical work, literature sources were consulted to investigate available solutions and methods. Subjects such as performance measurement, supply chain strategy, segmentation, performance measurement frameworks, strategic benchmarking and inventory management provided insight into the design process.

Developing a performance measurement framework for packaged wine in South Africa required an understanding of the business environment of every supply chain participant. Discussions with partners along the entire chain were conducted and included cellars, distributors and buyers at retailers.

The framework started as a selection of a few generic key performance indicators and developed into a balanced set of metrics that addresses the specific aims of the framework. This was achieved by following an agile and adaptable design process and incorporating the information that was gathered form industry and literature on a continual basis.

After an investigation of more than 15 supply chain frameworks, four relevant frameworks were identified. The selection criteria included the field of application, scope and recentness. Two of the frameworks apply to any supply chain, while the other two are developed for specific industries. Each metric of these four frameworks were considered, but only selected if its relevance in the local wine industry could be motivated and validated. The four frameworks are listed in Table 1 and their relevance is discussed below.

The first two frameworks in Table 1 are not industry specific and provide a wide range of metrics for any supply chain. SCOR provides a standard language for defining processes and metrics of any industry and supply chain. It is often seen as the industry standard for supply chain performance measurement and mapping (Stewart, 1997). Perez (2013) focused on the process of defining a supply chain strategy that is aligned with the business strategy. The framework was considered as a performance measurement framework since it provides metrics for each type of supply chain strategy.

Table 1 Relevant supply chain performance measurement frameworks

Framework	Application	Year
SCOR (Supply Chain Council, 2012)	Any supply chain	2011
Supply chain roadmap (Perez, 2013)	Any supply chain	2013
Measuring logistics performance in the wine industry (Garcia, et al., 2011)	Wine supply chain	2012
Measuring supply chain performance in the agri-food sector (Aramyan, 2007)	Agri-food supply chain	2007

Garcia et al. (2012) developed a framework for the wine industry in Argentina. The article identifies that there are different strategies and markets within the industry, but does not segment the industry. This framework assisted with providing metrics and especially definitions.

The research by Aramyan (2007) on the agri-food supply chain was considered due to the fact that a similar development process was followed to develop a framework. The wine industry forms part of the greater agri-food supply chain and therefore they have similar characteristics.

Most metrics were selected from the SCOR framework. The definitions of metrics were often adapted according to the industry specific frame-works. Adaptations were based on the specific characteristics seen in the wine industry and aim to increase the relevance of metrics.

Evaluation of the framework included feedback from academics and industry partners. An agile process was selected since the industry would have to be introduced to the metrics and start capturing some of the in-formation that is not available.

3 Literature Review

The literature review will discuss performance measurement, supply chain strategies, segmentation and benchmarking. Application to the wine industry is mentioned and indicates the relevance of the literature to the development of the measurement framework.

3.1 Performance Measurement

Performance measurement plays an important role in managing a business and achieving the desired goals (Langley, et al., 2008). The purpose of a performance measurement framework is to provide a set of metrics that can evaluate a complex process and measure the current level of performance. Supply chain processes are complex due to the fact that the cause and effect of supply chain decisions are often separated in time and location. Understanding the interdependencies of decisions enables management and improvement of activities (Holmberg, 2000). Performance is defined differently for organisations and depends on the business environment and strategy.

A performance metric describes the definition of what is to be measured. They are used to quantify the performance of an organisation through a process of performance measurement (Gunasekaran & Kobu, 2007). The term measurements therefore refer to the values of the metrics. It is important to have a balanced view of the performance of an organisation and also to consider it on a strategic, managerial and operational level (Gunasekaran & Kobu, 2007).

3.2 Supply Chain Strategy

A supply chain strategy is formulated to specify how the supply chain activities should be coordinated to achieve financial success. The motivation to select the correct strategy is driven by the competitive advantages and capabilities that can be achieved (Ambe, 2012). The differentiation in supply chain capability is defined by customer facing metrics as well as internal metrics. Customers experience a service and product based on the reliability (predictability), speed and agility that is presented to them. This experience of the customer is however enabled by a variety of internal capabilities that should be managed. The management of assets as well as the costs involved in creating the perceived value of the product and service should therefore be measured.

After involvement in more than 100 supply chain improvement projects, alignment was the characteristic that Bolstorff and Rosenbaum (2012) singled out as the key to supply chain success. Aligning the supply chain strategy with other components of the business and corporate strategy is of utmost importance (Perez, 2013).

The scope of a supply chain strategy should entail all the supply chain activities. Frazelle (2002) defines supply chain logistics as the flow of material, information and money from the suppliers' suppliers to the end consumer. The actual supply chain is the network of facilities, vehicles and logistic information systems. Some of the main activities that forms part of supply chain management are listed below.

- Warehousing and distribution centre operations
- Transportation
- Supply
- Inventory management
- Customer response

The goals and aims defined by the supply chain strategy should be translated into operational terms in order to make decisions and execute the strategy. This starts with an investigation process where the current activities are profiled, measured and benchmarked (Frazelle, 2002).

3.3 Segmentation

Segmentation uses the characteristics that differentiate one supply chain from another to determine the appropriate supply chain strategy. When benchmarking, segmentation is required so that organisations are able to compare themselves to similar processes of other organisations.

There are several methods for segmenting. Some authors and frameworks have segmented according to the following characteristics:

- Product types/requirements
- Customer types/requirements
- Uncertainty of supply
- Uncertainty of demand
- Customer buying behaviour
- Relevance of assets in total cost
- Market mediation costs

A generic supply chain strategy and configuration is usually then described for each of the segments. The most common strategies include: efficient, responsive, agile or lean supply chains (Ambe, 2012).

It is important to identify the various supply chains within an organisation, since none of the strategies apply to all products (Hilletofth, 2009). Managing several supply chains within an organisation is advised rather than selecting a strategy with multiple objectives (Perez, 2013). Using a supply chain framework such as SCOR assists benchmarking since it creates a common language for processes and relates it to metrics.

It has been mentioned that SCOR focuses on providing a framework for mapping supply chain processes rather than measuring performance (Cagliano, et al., 2014). The metric section consists of five attributes with more than 200 metrics and each metric is linked to a set of processes. The framework as a whole is rather comprehensive and applying it to an industry requires a good understanding of the industry and the framework.

3.4 Benchmarking

Benchmarking is all about determining the performance of an organisation and then comparing it to the performance of competitors (Garcia, et al., 2011). This concept and tool was made known by Xerox in the 1980's, when it was used to regain market share (Fong, et al., 1998). Supply chain benchmarking only received attention in the 1990's. At first benchmarking was discussed as part of the field of performance measurement. Wong & Wong (2008) identified the increased number of applications that were investigated, as the concept developed.

Supply chain benchmarking is more challenging than general performance benchmarking due to the complex level of collaborative joint decision making (Wong & Wong, 2008). The aim of supply chain benchmarking should therefore be to investigate the integration of performance measures. The lack of infrastructure and resources to support integration in organisations makes this difficult (Wong & Wong, 2008). Limited standardisation of supply chain measurements also creates challenges when benchmarking (Frazelle, 2002).

An important driver of successful benchmarking is a systematic process (Fong, et al., 1998). A systematic benchmarking process creates a framework through which the learning experiences seen from others can be explored (Kozak & Nield, 2001).

Benchmarking focuses on the creation of business knowledge. The transformation from data to information and then to knowledge is very important and benchmarking provides a structure that enables this. Comparing information can be used to create knowledge. Organisations therefore use the benchmarks to create business knowledge for their own organisation (Prasnikar, et al., 2005).

The process of benchmarking involves defining the supply chain strategy, measuring performance and performing the benchmark (Supply Chain

Council, 2012). The APICS SCC developed a 7 step process that can be used to complete a benchmarking study in this matter (Francis, 2012).

4 Performance Measurement Framework

The performance measurement framework is developed to assist wine cellars in South Africa in improving supply chain performance through performance measurement. The framework consists of a selection of metrics grouped according to the attributes of the Supply Chain Operations Reference (SCOR) model.

The wine industry share similarities with other industries, but several characteristics will be ignored if it is grouped together with other alcoholic beverages, retail products or agricultural products. Narrowing the scope of the framework to the wine industry, creates the opportunity for supply chain performance measurement to become part of the industry's management principles over the course of the next decade.

4.1 The Metrics

The framework is a balanced set of metrics that addresses three aims:

- Improving supply chain strategy formulation and execution
- Enabling decision making
- Indicating the diagnostic Key Performance Indicators (KPI's)

In order to formulate a supply chain strategy, information is required. This may differ from one industry to the next. The supply chain strategy is the starting point for most other supply chain decisions. Key performance indicators or diagnostic measures give an overview of the performance of the organisation as a whole and industry benchmarks can be created more easily for these metrics. Segmentation is key when defining supply chain strategies. A cellar should define and implement a separate strategy for each identified supply chain.

It was important to develop a practical tool that could be understood and used by all participants. The metrics had to relate to the processes and practices currently seen in the industry, but also provide strategic guidance on how to approach supply chain management on a strategic, tactical and operational level.

Segmenting the wine industry made sense since it enables cellars to compare themselves to realistic benchmarks. It identified those characteristics that distinguish cellars from each other based on the significant industry specific characteristics. It could be useful to perform customer segmentation for the local industry, since the inventory policy (make-to-stock or make-to-order) is usually influenced by the customer's characteristics. The conclusion from the case studies of work stream one indicated that inventory is the major supply chain issue for wine cellars.

By keeping the number of metrics few, cellars are able to implement the framework easily and identify where additional metrics will be required to measure and compare internal performance. The set of metrics is balanced since it evaluates the plan, source, make and deliver activities of a cellar.

The metrics of the framework can be seen in Table 2. Level one metrics are diagnostic metrics. They evaluate the overall health of the cellar in terms of the attribute and indicate where lower level metrics should be implemented. Level two metrics focus on indicating where changes can be made to the supply chain since they measure specific processes. In order to manage all supply chain activities with the necessary detail, level three, four and five metrics should be defined as part of the internal performance measurement system of the cellar. This can be done by first measuring the level one and two metrics and then adding metrics where problem areas occur or strategic value can be added.

Table 2 Performance Measurement Framework Metrics: Packaged Local

Attribute	Level 1	Level 2
Reliability	Overall Perfect Order Fulfilment	% On time deliveries
		% In full deliveries
		% Correct quality deliveries
		% Correct documentation deliveries
	Demand variation	
	Order Accuracy - Dry goods suppliers	

Attribute	Level 1	Level 2
Respon-siveness	Total Order Cycle Time	Internal Order Cycle Time
	Sourcing Cycle Time - Dry Goods	
Agility	Average Resource Utilization	Resource utilization
Cost	Total Logistics Cost	Product Supply Cost
		Packaging Cost
		Transportation Cost Relevance
Assets	Cash-to-cash Cycle Time	Inventory Days of Supply - Fin-ished Goods
		Inventory Days of Supply -Dry Goods
		Creditors Days
		Debtors Days

By measuring level one metrics of each of the attributes, a balanced view of a cellar can be represented on a scorecard. Cellars cannot excel in all of the attributes. It is therefore better to select two attributes for superior performance and have a defined strategy, than aiming to excel in all areas of performance (Perez, 2013). The five attributes will now be discussed individually to indicate their relevance in wine supply chain.

4.2 Reliability

Reliability is concerned with the experience of the customer (Supply Chain Council, 2012). A reliable organisation is able to consistently provide a predictable service and product. Perfect order fulfilment is the level one metric for reliability and provides information about how the customer experience the service of the organisation.

In the wine industry, a reliable service can create opportunities to form synergies and sell products to customers. Retailers demand orders to be perfect a certain percentage of the time and measure this continuously.

Product reliability and consistency is an important part of the end consumer's experience of the product (Louw, 2014).

Cellars are able to distinguish themselves from other competitors in the market based on the reliability of their service. Perfect orders create opportunities for close collaboration where mutual benefit can be experienced. If orders are not perfect, the problem may be caused by any of the activities preceding the final delivery. The first step towards identifying the root cause is to categorise the problems that occurred. The level two metrics for reliability are included in the framework for this purpose.

Demand variation and long lead times forces participants in the wine industry to carry inventory of dry goods and packaged finished goods. It is important to know how reliable dry goods suppliers are since additional uncertainty can arise in this section of the chain. The longest average lead time that was measured is 20 days. This is for the capsules used when bottling.

4.3 Responsiveness

Responsiveness refers to the speed of execution and delivery of customer orders. It is an attribute that relates to customer orders and order fulfilment cycle time is the main metric. The relevance of speed in the wine supply chain is high during some of the fulfilment processes, but less relevant in others. Due to the surplus of wine in the industry, responsiveness is most relevant when an order is placed by a final customer. This could be a retailer, independent liquor store or restaurant.

The metrics for responsiveness (order fulfilment cycle time) are only measured at level one in the framework and not broken down into lower levels since responsiveness is not critical at the cellars. Cellars do not easily distinguish themselves based on their cycle time except if they deliver directly to the final customer. To keep selling wine in any market it is, however, necessary to be able to deliver within the lead time required by the customer.

Responsive suppliers can enable a sourcing strategy where inventory of dry goods and finished goods are kept low at the cellar. The lack of dry goods inventory can easily cause customer orders to be late. Supplier responsiveness provides information that should influence the selection of suppliers for dry goods and raw materials.

Lead times have a significant influence on the wine industry. It is not uncommon for cellars to be far from the market and suppliers, since grapes are grown in specific regions. Longer lead times increases the amount of safety stock that should be kept. In an industry where cash flow is already a challenge, reduced amounts of inventory can provide financial benefits.

4.4 Agility

The purpose of measuring agility is to quantify or measure the ability of a cellar to sustainably increase and decrease the number and volume of completed orders. Agility in the wine industry relates to the level of postponement that can be applied to finished goods. An agile cellar would be able to postpone its packaging process until an order is received, and still be responsive. This is usually enabled by having spare capacity on packaging machines. Other influencing factors include the speed of processing orders (documentation) and the speed of decision making.

Agility should take longer and shorter term capabilities into account. Longer term considerations for a cellar include the capacity of wine making equipment, bulk storage space, packaged storage space and the capacity of packaging equipment. Shorter term considerations include the amount of additional wine bought in, possibilities to outsource packaging, speed of decision making, dry goods availability and spare capacity of current packaging equipment.

The recommended supply chain metric from the SCOR model (Upside and downside demand flexibility) was not used in this framework since a standard and representative definition of what to include and exclude could not be reached yet. This measure is complex since the wine making process takes months. It will take a much shorter time to upscale packaging and deliver processes.

An agile cellar is therefore one that can think creatively and make plans where capacity, inventory or any market related problems occur.

4.5 Cost

There are countless costs within a supply chain that are important. Measuring cost is definitely one of the most important sources of information for decision making and relevant data should be available. The framework only included cost that is linked to strategic decisions identified in the wine industry.

The total supply chain cost is usually defined as the sum of supply, production, inventory, warehousing, transportation and returns cost (Garcia, et al., 2011).

Financial information is always available in the form of income statements and balance sheets. Although these reports provide valuable information they are not created for the purpose of supply chain measurement.

Transportation cost is highly relevant for the South African wine industry due to the large distances travelled, high transportation costs and the lack of alternative methods to road transport. Full truckloads and reducing production costs are often more important than responsiveness due to low profit margins.

4.6 Asset Management

Asset management aims to measure how efficient the assets that an organisation owns is used (Supply Chain Council, 2012). Inventory strategies and the decision to in-source or outsource are important considerations for this metric.

Cash-to-cash cycle time is the level 1 metric for asset management. Cash flow is a big concern to wine cellars due to the aging process that can take up to 24 months. Grape producers and other creditors must be paid much sooner. Cash flow constraints influence outsourcing and distribution decisions since outsourcing can create opportunities to reduce inventory or receive payments earlier.

Inventory management creates the most challenges for a cellar and reducing inventory will have a significant financial impact. The consequences of a stock out however have short and long term effects.

4.7 Application and Implementation

Implementing the framework requires that cellars should measure each of the metrics for their cellar. Industry benchmarks can then be provided by combining the information. Cellars can use benchmarking information to set performance goals and decide whether it would be feasible and profitable to enter a new market. The metrics also create a platform from which cellars should select more detailed supply chain metrics.

Definitions for each metric is provided, but cellars should understand their supply chains well to be able to apply the definitions to their operations, costs, customers and products. Segmentation and demographic information is used to add value to the results.

An example of relevant demographic data include the location of the cellar or the inventory policy. If one cellar uses a make-to stock policy for most inventory, their cycle time might be shorter, but inventory days of supply or costs might not be as low and agility will decrease. All cellars will measure cycle time as the time from receipt of an order until delivery, but it would be useful to also compare those cellars using similar policies.

The framework has already been implemented partially in the wine industry through the first round of measurements. Six of the metrics were measured during this round and feedback was provided to the 16 cellars that participated in the study. Valuable information that was retrieved from the process is that segmentation should continue to be an important focus.

The results from the first measurements are shown in Table 3. The overall average refers to the average of all segments together. The difference between the two averages indicates the importance of segmentation and why cellars cannot be compared as a whole. The significant differences for order fulfilment cycle time and inventory days of supply are mostly due to differences between bulk and packaged products. Once the wine is packaged, it is stored for as short as possible.

Being able to view the performance of all five attributes simultaneously portrays the strategy of a cellar and provides a holistic view of performance, rather than simply indicating good and poor performance. This concept can be seen in Table 3, where the measurements for one specific cellar (cellar x) is shown next to the best performance of the packaged local segment.

The lower performance in order cycle time and order fulfilment rate may be understood when the superior performance of inventory days of supply is taken into account. Cellar x may be following a make-to-order strategy for most products. High storage cost might be a concern since very little inventory is kept. Information on the type of storage that is used can help with root cause analysis.

Table 3 Results from first measurements

Metric	Overall average	Packaged local average	Best in class	Cellar x
Perfect order fulfilment	95%	94%	98 %	90 %
Order fulfilment cycle time	11.5 days	3 days	2 days	4 days
Upside supply chain flexibility	25 days	22 days	21 days	21 days
Storage cost	R0.07 per liter	R0.09 per liter	R 0.06 per liter	R 0.12 per liter
Transportation cost	R0.43 per liter	R1.43 per liter	R1.40 per liter	R1.40 per liter
Inventory days of supply	191 days	34 days	12 days	12 days

A second round of measurements is currently being collected. The number of measurements was increased from the first round. Representing a larger part of the industry and providing better definitions for the metrics are important in this round. Demographic data such as the type of storage that a cellar uses, will also be captured.

5 Conclusion

This article presented a performance measurement framework that can be used to quantify the performance of wine cellars in South Africa. By implementing the metrics and calculating industry benchmarks, information is provided that will assist with supply chain decision making and strategy formulation. The framework design process focused on applying literature to the local wine industry and recognising the features that differentiate the wine industry form other industries. These characteristics were identified through interviews with industry participants.

The framework should be implemented over a period of time. Through this process supply chain performance measurement and benchmarking will become a standard practice in the industry. The performance measurement framework has the potential to provide the building blocks that are necessary for the wine industry to achieve supply chain excellence within the next five to ten years.

Financial Disclosure

Financial support for the project is provided by VinPro, Winetech and the National Research Foundation (NRF) for 2014, 2015 and 2016.

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Value of Flexibility in Gas Pipeline Investments

Katerina Shaton

Investments in upstream gas transport pipelines are characterized by significant economy of scale: there is a low additional cost to establish capacity in excess of the committed volumes. The excess capacity provides flexibility for cost-efficient expansions of the transportation system if there are new discoveries in the future. Therefore, investments in excess pipeline capacity may have a significant value for the gas sector in general, which is disregarded by the private decision-makers. The flexibility to expand the transportation network can be regarded as an option, which can be exercised if there are new discoveries and market conditions are favorable. The objective of this paper is to consider how Real Options thinking can be applied to estimate the monetary value of the flexibility provided by excess capacity in gas transport pipeline investments. The proposed method is based on the binomial lattices and allows including both market and project-specific risks. An example demonstrates how this value can be used by a public decision-maker in the evaluation of infrastructure projects in the Norwegian gas transport sector.

Keywords: Gas pipeline Investments, Excess Capacity, Value of Flexibility, Real Options

1 Introduction

Relatively low coal prices and low prices on carbon currently challenge the competitive position of natural gas in the European power market. However, it remains one of the main energy sources in the European energy mix: 23.2% of the total energy consumed was covered by natural gas in 2013 (Eurostat, 2014). In the longer run, with a higher carbon price, natural gas is expected to gain more importance in the energy mix due to its abundance, cost competitiveness, and a low carbon footprint. Well-functioning of the gas market depends on the availability of transport infrastructure and its efficient operations. Norway, which is the second largest supplier of natural gas to the EU after Russia, supplied about 21% of its total demand in 2013 (EIA, 2014). The natural gas infrastructure on the Norwegian Continental Shelf (NCS) is represented by a system of platforms, processing plants, receiving terminals and an extensive network of pipelines, with the total length of about 8000 km and transport capacity of 120 billion Sm3 per year. This transportation network connects gas producers on the shelf of Norway with the end-users markets in Germany, Belgium, the United Kingdom and France. Historically, investments in gas transport infrastructure have been made on the basis of financial analysis performed by investing companies and political considerations of the government (see e.g. Holden (2013) for a comprehensive overview of the Norwegian policy in the petroleum sector). The choice of a transport solution is a matter of negotiations between petroleum companies and authorities. Companies base their decisions on a least cost planning method, and due to high required rates of return, their planning horizon is rather short. The authorities consider infrastructure development from the perspective of the long-term management of petroleum resources on the Norwegian continental shelf (NCS). In cases of major infrastructure developments, this means that not only the fields that trigger a gas transport need are included in the analysis, but also contingent resources and undiscovered resources are taken into account.

A relevant example of an infrastructure development is the ongoing discussion of a transport solution in the Barents Sea. Exploration interests of petroleum companies move further to the North. According to the estimates provided by the Norwegian Petroleum Directorate, on average, about 43% of all undiscovered petroleum resources on the NCS are attributed to the Barents Sea (NPD, 2014). The only gas transport infrastructure in the region available at the moment is the LNG (Liquefied Natural Gas) facility at Melkøya, which processes the gas from Snøhvit, the only gas field operating in that region. The operator of the field considers the expansion of the production and, accordingly, the expansion of the LNG facility. The main advantage of this solution is the market flexibility: a producer is not locked into the European market; the gas can be shipped by vessels to the highest value markets, implying higher profit (according to some estimates (e.g. Gassco, 2014), the LNG flexibility may be up to 10% of the market price of the pipeline gas).

On the other hand, there is an option of a pipeline solution, connecting the Barents Sea with the existing transport network. The pipeline solution requires higher initial investments, lacks destination flexibility, but implies considerably lower than the LNG operating costs. Another benefit of the pipeline solution is the utilization of the transport capacity in the existing pipeline network, which may become spare in the near future. Maintenance costs for these transport facilities will be shared between larger volumes of transported gas, reducing the total unit costs. The most important advantage of the pipeline solution is a significant economy of scale in investments, which enables over-dimensioning. There is a low additional cost to establish a capacity above the committed volumes, with regard to future discoveries and corresponding tie-ins. Available spare pipeline capacity in the transport system provides incentives for exploration in the region and reduces the cost threshold for development of deposits along the pipeline. There are two perspectives of evaluation of infrastructure projects. The first perspective represents interests of a commercial company, which is willing to establish a transport solution for a certain field, and focuses on short-term cost minimization. The second perspective evaluates the solution from the point of view of a public decision-maker, which aims to maximize value creation on the NCS in the long run. The first perspective emphasizes market flexibility of LNG solutions and the related benefits, the second perspective emphasizes the benefits created by the economy of scale in investment of pipeline solutions and opportunities provided by that.

According to the study conducted by the operator of the gas infrastructure network on the NCS in 2014, existing fields and discoveries are not sufficient to justify an investment in new gas infrastructure from the Barents Sea (Gassco, 2014). While the pre-tax NPV (at 7 percent real discount rate) is similar for a new 32” pipeline and the LNG solution, the expansion of the LNG train is better when measured by the real IRR on investments. When the potential outcome of near-term (3 years) exploration activities in the Barents Sea are taken into consideration, a 42” pipeline gives a higher NPV in four out of five exploration scenarios, and a marginally lower NPV in one scenario. An analysis of the long-term resource scenarios also proves robustness of the pipeline solution with excess capacity.

From the NCS perspective, the excess pipeline capacity has a certain value, because it creates a possibility to connect new fields in the future at a low cost if there are new discoveries. From the project-economic perspective, investments in the excess pipeline capacity represent a capital tied-up in unprofitable investments. Therefore, the costs of excess capacity should be justified analytically. However, the currently used evaluation approach does not directly quantify the benefits of the flexibility provided by the excess capacity (e.g. Barents Sea Gas Infrastructure (BSGI), 2014, NCS2020-study, 2012). The Real Options Analysis (ROA) provides a means to estimate the monetary value of flexibility in investments, which is the ability to alter the course of the project so that expected returns are maximized or expected losses are minimized (Brandão et al., 2005). Copeland and Antikarov (2003) define a real option as the right, but not the obligation, to take an action (e.g., deferring, expanding, contracting of abandoning) at a predetermined cost, called exercise price, for a predetermined period of time – the life of the option. Real option valuation techniques are conceptually different from traditional discounted cash flow tools, as they directly value managerial flexibility. Examples of project flexibilities include deferring investment until new information arrives, expanding operations if market conditions are favorable, abandoning a project, suspending operations temporarily, switching inputs or outputs. According to Sarkar (2009), excess capacity can be regarded as an option to expand the production. The objective of this paper is to consider how real options thinking can be applied to estimate the monetary value of the flexibility provided by excess capacity in gas transport pipeline investments.

The paper is organized as follows. A review of the relevant research is presented in Section 2. Section 3 describes the chosen approach for a real options valuation. The application of this approach to the valuation of the flexibility provided by excess pipeline capacity is demonstrated in Section 4. The implications of such valuations on the investment appraisal and decision system in the Norwegian gas transport sector is discussed in Section 5. Section 6 concludes.

2 Literature Review

Petroleum investments have been among the earliest applications of the real options valuations. A license for petroleum reserve exploration and operation, obtained by a petroleum firm, can be considered as an option to invest into development of oil fields if the market conditions are favorable. Examples of ROA of investment in petroleum reserves can be found in the classical books by Dixit and Pindyck (1994) and Trigeorgis (1996), and in number of research articles. Smith and McCardle (1999) consider the application of the options approach to oil and gas investment valuation and discuss the benefits of real options analysis over the traditional decision analysis techniques. Lund (2000) considers the value of flexibility in offshore oil fields development on the coast of Norway, using stochastic dynamic programming to model market risk and reservoir uncertainty. Miltersen (2000) allows for a stochastic interest rate and convenience yields in real option valuation of petroleum deposit investment. Chorn and Shokhor (2006) combine Bellman's equation with a real options valuation algorithm to represent sequential investment decisions in petroleum field development. Johnson et al. (2006) examine the application of system dynamics to real options analysis in the oil and gas industry. Enders et al. (2010) apply stochastic dynamic programming to analyze the interaction between two types of real options arising in natural gas production: the option to scale the production level and to scale the extraction rate by pausing production. These studies are related to investment decisions in the upstream, or production, segment of the gas value chain.

A more recent stream of research is applications of ROA dealing with distribution, or the downstream, part of natural gas value chain (e.g., investments into natural gas power plants or LNG plants). Näsäkkälä and Fleten (2005) valuate the flexibility in the choice of technology regarding investments in gas-fired power plants, modelling the spark spread, and estimate investment thresholds for optimal decisions. Abadie and Chamorro (2009) present a valuation of investment options into a NGCC power plant and an LNG facility following a least squares Monte Carlo approach. Another application of RO analysis in the distribution segment is storage valuation: Arvesen et al. (2012) study the value of using the pipeline linepack as a short-term gas storage.

What is common for these two fields of research is that in the investment analysis of a field development or a power plant construction, the gas transport capacity is treated as an exogenous constraint. A common approach to dealing with gas transport infrastructure investments, both in the research and practice, is to apply optimization techniques, where existing infrastructure and potential projects are included in the model and the optimal design is defined with the focus on the properties of the network (e.g. Rømo et al., 2009, Hellemo et al. 2012). When the optimal design of transport network is defined, the investment analysis focuses on the activities “on the nodes” of transport infrastructure: gas production and distribution. This paper represents an attempt to expand the scope of ROA applications to the investment valuations of gas transport infrastructure projects.

3 Methodology

3.1 Real Options Valuation Approaches

Since the term “real option” was introduced by Myers in 1977, the ROA attracted the attention of researches and practitioners, and various approaches of real options valuations have been proposed (for a critical review see e.g. Borison, 2005). The so-called “classic approach” (e.g. Amram and Kutilaka, 1999) is based on the theory of financial option pricing introduced by Black and Scholes (1973). This theory presumes that markets are complete, all risks are liquidly traded on the financial market, and can be hedged through constructing a portfolio of financial instruments which provide the exact same payoff as the project itself in any state and at any point in time. This assumption rarely holds for real world projects, since there are many non-tradable, or private, risks, which cannot be hedged away. In response, researchers (e.g. Dixit and Pindyck, 1994) suggested to use finance-based real options approach to valuations of project where market risks are dominating, and to apply decision analysis techniques (as decision trees) to projects with primarily private risks. However, there are approaches which allow evaluating of projects where both types of risks are present and significant. Smith and Nau (1995) proposed an integrated approach, where both market and private risks are identified explicitly. According to this approach, market risks can be modelled using the traditional financial option pricing techniques (the replicating portfolio approach), while private risks are modelled through subjective beliefs and preferences of stakeholders expressed as utility functions. Another approach to dealing with incomplete markets in real options valuations has been proposed by Copeland and Antikarov (2001). This approach does not explicitly rely on the existence of a traded replicating portfolio that can serve as a basis for valuation of the project market value. Instead, it is assumed that the present value of the project without options (evaluated with traditional discounted cash flow technique) is the best unbiased estimator of the market value of the project (the Market Asser Disclaimer (MAD) assumption). The market value of the project is then assumed to vary over time according to a random walk stochastic process (Geometric Brownian Motion, GBM), and the options can be valued with traditional option pricing methods. The assumption that the project value follows the GBM is based on the Samuelson's proof (1965) that properly anticipated prices fluctuate randomly, meaning that multiple uncertainties affecting project's cash flows, which can follow different stochastic processes (e.g. mean-reverting), can be reduced to a single uncertainty, which follows a GMB.

There are numerous sources of uncertainty affecting the volatility of project returns in the gas transport sector. The main two are the rate of exploration success and the dynamics of gas prices. Certainly, these two factors are not sole, there is also uncertainty over the investment costs, which may change significantly during the planning and construction period. The long-term valuations may also be affected by the development of new technologies that influence investment and operating costs. The dynamics of gas prices and investment costs are the market uncertainties, the rate of exploration success and technological developments are the project-specific, or private, uncertainties. The approach to real options valuations in the gas transport projects needs to be able to incorporate both types of uncertainties. Therefore, the relevant methodologies are the integrated approach of Smith and Nau and the approach proposed by Copeland and Antikarov (henceforth the CA approach). The latter one is adopted to the purpose of this paper, as this approach can be relatively easily applied in practice of project evaluations by a public decision-maker.

There are two main ways for option pricing: a continuous model developed by Black and Scholes (1973) and a discrete approach of the binomial model, see Cox, Ross, and Rubinstein, 1979. The binomial model is adopted in the CA approach. Besides being mathematically less demanding, the binomial model has advantages over the continuous model for real option valuations (c.f. Copeland and Antikarov, 2003).

In the binomial model, the price of the underlying asset follows a multiplicative binomial process: the price can either move up by a fixed value u or down by a fixed value d. If the value of the project follows the Geometric Brownian Motion, this value at any point in time has a lognormal distribution. By equating the first and second moments of a binomial and lognormal distribution, we derive that $u = e^{\sigma\sqrt{t}}$ (t is a length of the binomial period, σ is volatility), under the assumption that $u = 1/d$. This procedure ensures that the discrete distribution approximates the continuous distribution in the limit. Applying this technique, we get a recombining (event) tree representing the development of the asset value S_{ij} (i is index for time, j is index for state at time i).

In order to derive the value of the American call option, a decision tree is built. The tree is solved recursively. At the expiration date, the option value is equal to (zero value if not exercised):

$$C_{ij} = \max(S_{ij} - E, 0) \tag{1}$$

where E is the exercise price of the option. Before the expiration, the values on the nodes of the decision tree is defined using the risk-neutral probability approach (maximum between the value of the exercised option and the "alive" option):

$$C_{ij} = \max\left(S_{ij} - E, \frac{(pC_{i+1,j} + (1-p)C_{i+1,j+1})}{1 + r}\right) \tag{2}$$

where r is a risk-free rate. The risk-neutral probability $p = (e^{rt} - d)/(u - d)$ is constant and is applied throughout the tree. Solving the tree backwards, we obtain the value of the project at time 0.

3.2 Valuation of an Option to Expand

The option to expand can be valued as follows. The underlying risky asset is the value of the project V, which follows a binomial stochastic process. The values of the up and down movements, u and d, are estimated based on the volatility of the project value. The expiration time is limited by the life-time of the project. Additional investment needed to expand the project is the exercise price E. If the option to expand is exercised, the scale of the project is increased to a factor k. To find the values on the nodes of the decision tree, we start at the end node. If the increase of the project value due to the expansion exceeds the cost of expansion ($kV_{ij} - E > 0$), the option is exercised. At the expiration date t, the payoff is defined as:

$$C_{tj} = \max\big(V_{tj}, (1 + k)V_{tj} - E\big) \tag{3}$$

Before the expiration, if the option is exercised, the payoff is $(1 + k)V_{tj} - E$; if the option is kept “alive”, the payoff is defined using the risk-neutral probability approach. The decision rule is:

$$C_{ij} = \max\left(\frac{\big(pC_{i+1,j} + (1-p)C_{i+1,j+1}\big)}{1 + r}, (1 + k)V_{ij} - E\right) \tag{4}$$

The value of the flexibility is the difference between the value of the project with the option to expand (C_0) and the value without the option (V_0).
The described approach of the option to expand valuation can be adapted to gas infrastructure investments in the following way. The investment cost for excess pipeline capacity is the price that the investors pay to get the option to expand the system by tying-in new transport facilities and connecting new fields at a later point in time. The value of this option depends on the uncertainty over the project value. The project valuation includes all parts of the value chain, from the subsurface to the market, incorporating cost estimates from field developments, offshore and onshore processing facilities, and transport of gas to the relevant market.

To approximate the stochastic process followed by the project value, three parameters are needed: the estimate of the current value of the project, the volatility of returns, and the risk-free rate. The risk-free rate over the life of the option is constant; the one determined by the Government bonds can be used. The initial project value V_0 can be estimated as a traditional net present value (NPV), calculated based on the risk-free discount rate. The volatility of project the value σ is to be approximated by Monte Carlo simulation, which includes different price and resource scenarios. The upscaling potential k is limited by the available excess capacity. The exercise price of the option is the additional investments, required for upgrading the pipeline with new compressors, and for the development of new fields, that come on-stream if the market conditions are favorable. The option to expand may be exercised at any time in the future, limited by the lifetime of the pipeline in question (30-40 years).

4 Example of Option Valuation

In order to demonstrate how the described technique can be applied for a valuation of value of flexibility provided by excess capacity, a simulated example, similar to the Barents Sea Gas Infrastructure project, is considered. There is a transport solution, which assumes a pipeline of 32″, suggested based on a medium resource scenario. The expected pre-tax NPV of the whole project is 50 billion NOK, estimated by the traditional technique, using a risk-free rate 2%. It is assumed, the option to expand can be exercised during the first 20 years of the pipeline operation.

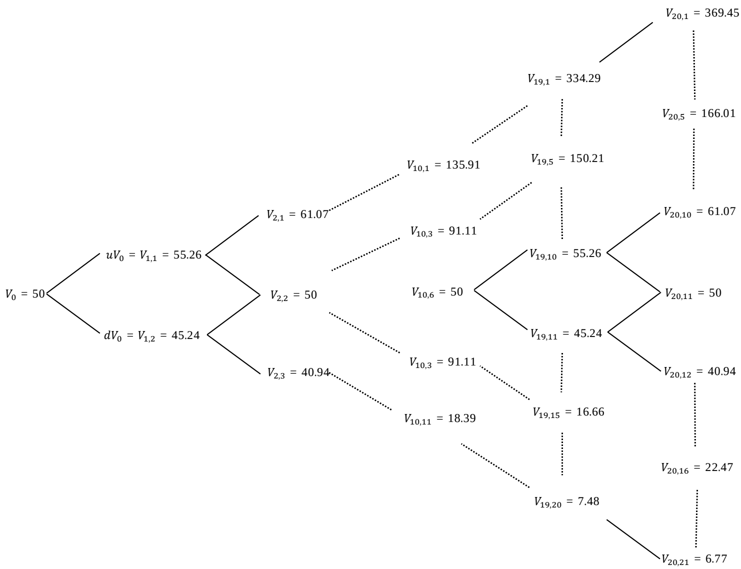

Figure 1 Event tree: value of the underlying asset

Assuming volatility equal to 10% a year ($u = e^{\sigma\sqrt{t}}$= 1.105, $d = {}^{1}/_{u} = 0.905$), an event tree representing the dynamics of the project value over the 20 year period (21 different outcomes) is generated (see Figure 1).

For an additional 5 billion NOK, the initial pipeline dimension can be increased to 42″. It gives the option to expand the gas production by 50%, if rate of exploration success is high and market conditions are favorable. This option can be exercised for 25 billion NOK investment in the pipeline and processing facilities upgrading and associated fields development.

The decision tree (see Figure 2) is solved backwards to find the value of the project with flexibility.

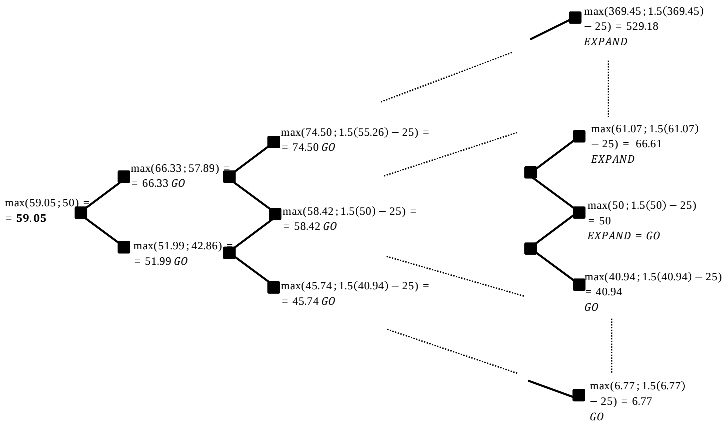

Figure 2 Decision tree for the option to expand

The calculated risk-neutral probability is $p = \frac{e^{rt} - d}{u - d} = 0.575.$

The value of the flexibility provided by the excess pipeline capacity is the difference between the initially estimated NPV and the value of the project obtained after solving the decision tree. In the example, the value of the flexibility provided by pre-investment of 5 billion NOK is 9.05 billion NOK, meaning that the investments in excess pipeline capacity are reasonable. The value of flexibility gets higher if the volatility increases. In the example, with σ equal to 0.2, the value of flexibility is 12.85 billion NOK. The size of a potential expansion also positively affects the value of flexibility: it increases up to 13.61 billion NOK, if the project can be scaled up to 60%. With a higher exercise price, the expansion gets less attractive and the value of flexibility reduces: cost of expansion of 30 billion, gives the value of flexibility equal to 6.77 billion NOK.

5 Value of Flexibility in Project Appraisal

There is a growing number of studies showing the importance of the use of ROA in the public decision-making. Livermore (2013) discusses the issue of the real options theory use for public decision-making in petroleum industry. He argues that consideration of real options is necessary to maximize economic returns from non-renewable natural resource extraction, using the example of offshore oil drilling in the USA as a case study. The author claims that the cost-benefit analysis of economic consequences of leasing of offshore lands performed by the responsible authority and the existing bidding system fail to account for real option value, therefore, failing to maximize the net benefits generated by this public resource. He states: “Ultimately, planning and leasing decisions are being made without estimations of option value, and private market actors do not have incentives to adequately consider several of the central uncertainties that are relevant to society in general (Livermore, 2013, p.637)”.

The flexibility provided by excess pipeline capacity has a high value for the NCS in the long run and, hence, for the Norwegian society. The private companies do not have incentives to consider such long-term development in their project appraisal. Consideration of the prospects for the further development of the transportation network is the task of the independent system operator and public authorities, which approve the infrastructure development plans. While the project economic perspective comprises only the costs and revenues that occur to the parties directly involved in the project: the producer from the existing fields (or shippers) and investors (which are often the same companies); a public decision-maker should also consider the effects on shippers and owners of the existing infrastructure. These differences between the project-economic perspective and the perspective of the NCS is demonstrated on the simulated example that follows. The example considered in Table 1 represents a case similar to the Barents Sea Infrastructure Project: there is an LNG facility of a capacity exactly needed to transport the gas from the existing discoveries (there is no economy of scale in investments, hence, no reason for pre-investments), and a pipeline solution with a capacity 50% higher with regard to possible future tie-ins. At the initial stage of the analysis, only the existing fields and discoveries are included, giving the expected revenue from selling the pipeline gas 70 billion NOK (9 NOK is approximately 1 €), excluding the production costs. The expected revenue for the LNG alternative is 5% higher due to the destination flexibility (the option premium). The LNG solution requires 14 billion NOK of initial investments (CAPEX), the costs of the sea shipping counts for additions 14 billion NOK (OPEX). The pipeline solution requires a higher initial investments, 25 billion NOK. The tariffs in the new facility and in the downstream network include the capital element and the operating cost (the Tariff Regulations, 2002). The operating element is calculated annually, and covers the operating cost of running a facility. The capital element should cover the investment cost with a ‘reasonable’ return on the capital invested during the lifetime of a license (historically, 7% before tax). The capital element represents the revenue for the investors/owners of the infrastructure. The total tariff paid by the shippers for the transportation in the new pipeline is 27 billion NOK (25 billion as the capital element and 2 billion as the operating element). The shipper will as well use the existing network downstream, the total tariff paid is 4 billion NOK. Comparing the NPV (7% discount rate) of the alternatives from the project-economic perspective, the LNG solution is better: 45.5 billion NOK vs. 39 billion NOK.

Expanding the evaluation framework, the planner should include the effects on the rest of the transportation network. The inflow of gas from the new pipeline into the existing downstream network brings additional income to its owners (the capital element of the tariff paid by shippers, 3 billion NOK) and reduces operating element of the tariff for the shippers (1 billion NOK of savings). The prospects for future tie-ins are included in the analysis as option value of flexibility provided by excess capacity (9 billion NOK). From the perspective of the Shelf, the NPV of the pipeline solution is higher than of the LNG solution: 45.5 billion NOK vs. 52 billion NOK.

Table 1 Example of a project valuation with simulated numbers (Million NOK, 7% discount rate)

Cash Flows	LNG solution	Pipeline solution
Shippers in the new infrastructure		
Revenue (excl. production costs)	70000	70000
Value of destination flexibility	3500	0
Tariff in the new infrastructure	0	- 27000

Cash Flows	LNG solution	Pipeline solution
Tariff in the downstream network	0	- 4000
Cost of shipping	- 14000	0
Investors in the new infrastructure		
Investment costs	- 14000	- 25000
Tariff revenue	0	25000
TOTAL FOR THE PROJECT	45500	39000
Shippers in the existing infrastructure	0	1000
Owners of the existing infrastructure	0	3000
Option value of flexibility	0	9000
TOTAL FOR THE SHELF	45500	52000

Though this aspect is not covered in this paper, it should be noted that infrastructure projects in the gas sector may have significant externalities, such as environmental impacts, impacts on fisheries and shipping, which should be as well taken into consideration in the socioeconomic evaluations of a project (for a relevant discussion, see e.g. Shaton, 2015).

This example shows that the evaluations of a project from the project-economic and NCS perspective may lead to opposite decisions. The participation of the independent system operator in the infrastructure planning on the NCS ensures that the effects on the existing network are taken into account, however, the value of flexibility in the pipeline investments has not been directly quantified and included in the analyses so far. The presented example shows that this value can be estimated and used in the project appraisal.

6 Conclusion

Real options theory is a means to structure and value flexible strategies to address uncertainty. Real options is particularly appealing concept when capital intensive investments must be undertaken under great uncertainty. In the case of gas transport infrastructure projects, multi-billion investment decisions should be made under the uncertainty over gas prices and highly inexact knowledge of the long-term resource base. Infrastructure developments on the NCS are financed by petroleum companies, which need transport solutions for their gas fields. However, the development of the transportation network is coordinated by an independent system operator, in order to ensure that effects of the new infrastructure development on the existing transportation system and overall value creation on the Shelf are taken into account. According to its architect role, the system operator can give recommendations regarding the landing points, connections, and the capacity of pipelines. Investments in excess pipeline capacity gives possibilities for efficient connections in the future. When an LNG and a pipeline solutions are considered, there arises a trade-off between the destination flexibility of LNG and strategic flexibility provided by excess pipeline capacity. The destination flexibility of LNG can be easily included in the project evaluation as a price premium for the unit of sold gas. The task of estimation of the monetary value of flexibility provided by excess capacity is not straightforward. This paper discusses how the real options analysis can be applied to estimate the value of flexibility in gas pipeline investments, and how this value can be used in the project evaluations by the system operator.

The infrastructure development decisions taken so far on the shelf of Norway prove to be very efficient. However, the decision system in the sector still has a room for improvement. In the study of possible infrastructure solutions in the Barents Sea, the system operator Gassco states the following: "Identification of possible measures to bridge the gap between socioeconomic and project economic perspectives should be a focus area in near-term" (Gassco, 2014, p.36). Real options analysis applied to the valuations of the flexibility provided by excess capacity can be one of the analytical tools to bridge the gap between the two evaluation perspectives. The main implication of such valuations is a more robust and transparent analytical platform for the decision-making in the gas transport infrastructure development.

The approach presented in this paper can be extended to incorporate multiple options. In the preformed calculations, only the option to expand the system up to the full capacity of the pipeline in question is considered. While in practice, there are possibilities to expand the system step-wise by new tie-ins of different size. It can be modelled as a compound option, using the proposed framework.

The consideration of the investments in excess pipeline capacity though the lenses of the ROA has some limitations, as it cannot incorporate such effects as increased value creation onshore due to expansion of petroleum activities. However, the real option value can serve as a good proxy of the value of the excess pipeline capacity and play an important role in project evaluations.

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Evaluating Investments in Emerging Automation Solutions for Logistics

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According to a recent survey the great majority of players in logistics are planning to adopt one or more robotic solutions until 2019. Technical solutions for automation of processes in logistics are often available as a market-ready product, but the lack of standardization and skepticism towards long term investments are often the reasons why these solutions are not implemented on a large scale. This paper is set to bridge the gap between the world of technologies and the one of applications in order to help investors, robot producers and system integrators to decide on which branch of logistics to set their focus. The three main branches Courier Express Parcel (CEP), contract logistics and production logistics are briefly defined and distinguished through their characteristic factors and parameters. Then a method based on the analysis of three parameters (operative costs, required performance and flexibility) in the three branches is set to identify the most convenient branch of logistics for investing in new technologies, namely the one in which the risk of investment is lower, the return is higher and faster. The conclusion of the method shows that higher labor costs, strict regulations and higher standardization make the production logistics the most suitable branch for investments in emerging automation solutions.

Keywords: Automation, Investment, Production logistics, Emerging Technology

1 Introduction

A recent study of the Bremer Institute for Production and Logistic Ltd. stresses the need for automation in the logistics field. In particular, the study refers to robotic solutions for the optimization of the internal material flows and processes. The trend shows that the use of robotic solutions in the logistics area is increasing, with cost efficiency of material flow and higher competitiveness being the main drivers for investing in these technologies. In 2007, 41% of the participants of the study had used robotic solutions, while seven years later the number has increased to 67% and an additional 68 % of the participants see a need for investing in robotic solutions in the next five years (BIBA, 2015).

Companies are therefore keen to evaluate investments in robotic solutions for logistic tasks, but the challenge is to set the right focus, understanding in which scenarios such investments will create the best return minimizing the risks. This paper is set to help investors, robot producers and system integrators to focus on the right scenario for the investment. In the remaining part of this section a taxonomy of the branches of logistics is introduced, which will be used later in the paper to identify the logistic scenario with the best return and minimum risk. In section 2 of the paper the relevant parameters (operative costs, required performance and flexibility) for automation in the logistic field are explained and divided in factors; in section 3 the branches of logistics are described again through the factors (and parameters) of section 2 and a qualitative impact of each factor on the return of investment in automation is given. In section 4 a method is presented that qualitatively evaluates the suitability of each branch for long term investments in automation technology. Result are then discussed in section 5 and conclusions are drawn.

In the following taxonomy logistics is divided into four main branches: Courier Express Parcels (CEP), wholesaling/retailing, contract logistics and production logistics. This taxonomy is then simplified by merging the wholesaling/retailing into the contract logistics and for the rest of the paper the focus is put on three logistic branches: CEP, contract logistics and production logistics.

1.1 An Automation-oriented Taxonomy for Logistics

In this section a taxonomy for logistics is introduced, which divides the field in branches representing different scenarios for the investment in automation.

1.1.1 Courier Express Parcel

The CEP service sector has been ever growing over the last 40 years. Beginning in the mid of 1970s, pioneers of the express market, such as FedEx or DHL expanded at a rapid pace. Because of their unique position these integrators achieved in service and prices sufficient revenue in order to establish international networks including in their offer also courier and parcel services. On the one hand the standardization of the transport processes and on the other hand the economic development of the share of high value goods encouraged the growth of the traffic of high value and light weight packages. New requirements of fast, reliable and punctual deliveries became more and more important with the development of strategies for increasing the efficiency of the processes, as for instance the lean production based on the Just in Time (JIT) principle. The growing demand was also fostered by the Schengen Agreement, the economic unification of Europe and the rising of online market places for both business and private commerce (Helmke, 2005). In 2012 the turnover of the European B2C E-Commerce market was € 112 billion and according to the study it will reach € 191 billion in 2017. This underlines the rapid growth of the CEP branch (Stallmann and Wegner, 2015, p.86). A different study from the German Federal Association E-Commerce and Mail Order Business (BEVH) also indicates a notable growth of the B2C E-Commerce business and points out that the increased volume of parcel shipments leads to a higher significance of the CEP branch (Manner-Romberg, et al., 2014, pp.4-7). The CEP branch includes mainly parcel shipments with a low weight (2 kg until 31.5 kg), limited volume and a shipment often consists of only one unit. The reason for the weight regulations of parcels is that the parcels are mostly handled by people (Kille, 2012). The CEP system, in countries where the e-Commerce is strong and in growth such as Germany, seems to have reached the boundaries of its technological capacity; if the throughput can be increased by using new and more powerful sorting technologies (such as rubber cross-belts), still remains the bottleneck of the loading and unloading of swap bodies, trailers and containers. In the past this problem was solved by increasing the number of loading and unloading docks, but this is in trade-off with the costs generated by the necessary additional surface and the necessary additional conveying technology needed to cover the larger distances. DHL is searching a solution for loading and unloading, which could increase the throughput in each unloading/loading dock to 3.000 parcels per hour, hence more than 4-5 times the current manual rate.

1.1.2 Wholesaling and Retailing

The retailing branch of logistics refers to those companies selling products or services directly to final consumers for their personal, non-business use. Example of this category are: Tschibo, Aldi, Amazon and H&M. Wholesaling, on the other hand, relates to those companies, such as Metro, selling goods and services to those buying for resale or business use.

1.1.3 Contract Logistics

Contract logistics companies take over comprehensive logistic services for the whole supply chain, such as the central warehousing for the procurement and distribution, internal and external tasks of the production logistics and wholesaling/retailing or the collection and distribution of shipments. These providers are also defined as Third Party Logistic Service Providers (3PL). An additional characteristic of the contract logistics is short term (usually 2-4 years) contractual commitment between the company and the service provider, where the upper boundary is usually touched when the service provider needs additional investments for the realization of the service (Gleißner and Femeling, 2008, p.85). Consequently a 3PL has to adapt to the business of its contract partner, which leads to constantly changing business environments and processes. Additionally, the defined contract between the two parties always starts with precise outline of process requirements, formalized in a document and presented by the party requiring services through a bidding process, to which each interested third party logistics company answers offering the required services for a specific price (specification of services). Often the process requirements are so rigid and non-negotiable, that there is little margin for the 3PL providers to influence the processes of their customers.

1.1.4 Production Logistics

The production logistics, which is in between the procurement and distribution logistics, can be defined as everything that is intralogistics and not outsourced to a contract logistics service provider. As soon as the processes are outsourced, they fall in the branch of contract logistics. Examples for these processes are: feeding of production lines, handling or stocking between different productions or assembly stations (of the same facility) and loading/unloading of containers. Production logistics represents a central function of the single logistics sections of a company. The main task is the planning and control of the material and information flow, which means starting from the raw material stock to the finish goods stock. The complex task shows the crucial importance of the production logistics in controlling the supply chain. Fulfilling the main goal of customer satisfaction is challenging in the production logistics as it faces increasing product variety and shorter delivery times (Pawellek, 2012, p. 466).

1.2 Simplifying the Taxonomy of Logistics

The branch of wholesaling and retailing is added to the taxonomy for the sake of completeness, but its parameters and factors (see section 2 of the paper) are not different than those of contract logistics. Core competences of companies operating in this branch are, for instance, warehousing, commissioning, cross-docking, milk-runs and delivery; the focus is set on logistics and handling, much like in contract logistics. The only point of difference between wholesaling/retailing and contract logistic is that in the first there are no short term contract limiting long term investments. However the relevant presence of on-line wholesaling and retailing (e.g. Amazon) makes this sector extremely dynamic and increases the need for flexibility necessary for the survival in the branch. This is true both for players who take active advantage of the e-business as for those who are passively subdued to the first category and need to react on its marketing decisions. As a consequence, with a relatively short notice, warehousing/commissioning facilities of wholesalers/retailers can be moved or their purpose (type of stocked goods, customization, re-branding, re-packaging etc.) can be changed. As a result, long term investments in this branch preserve the high risk character that, for different reasons, characterizes also the contract logistics branch. For this reason hereinafter in this paper, this branch will be treated as merged with the contract logistics, and every conclusion drawn for contract logistics applies, in the authors' opinion, also to the wholesaling and retailing business.

For this reason the taxonomy of branches analyzed in the remaining part of the document is simplified to three branches: CEP, contract logistics and production logistics.

2 Relevant Parameters for Automating in Logistics

In this section the most relevant parameters for automating logistic processes will be described and deployed into factors. This is functional to the detailed description, in section 3, of the three main branches mentioned in section 1.

The automation of logistic processes is a serious challenge, not only because the complexity of technologies is increasing in order to cope with a larger variety of unconstrained scenarios that logistics presents, but also because processes often need to be slightly modified in order to fully exploit the new available technologies. Every logistic process can be described through three main parameters: cost, performance and flexibility (Bonini et al., 2015). Unfortunately these parameters are often in trade-off and it is not always immediate to find the right balance among them in order to take advantage of automation. This trade-off can be seen from two different, but intimately related points of view: (1) from the point of view of the technology provider or (2) from the one of the investor. The technology provider (1) strictly relates these parameters to the technology, meaning that the cost represents the price of the system, the performance the handling rate and the flexibility the ability of the provided system to cope with different scenarios and situations. On the other hand, the investor (2) interprets the same three parameters in order to describe the current processes at his own facility; in this way the trade-off among parameters will steer the choice of the technology and influence the economic evaluation of the investment. Considering the point of view of an average investor assessing the possibility of automating a logistic process in order to fulfill emerging requirements, it makes sense to deploy the parameters into factors in order to better understand the characteristics of a scenario in which the investment in automation would be more convenient. The remainder of this section is dedicated to the interpretation of the three parameters (costs, performance and flexibility and their deployment in factors) from the point of view of a potential investor seeking to invest in his facility.

2.1 Cost

This parameter aims to describe the costs of the manual process. Two factors are considered to be have the highest influence, namely (1) the wage (company gross) of the operator directly involved in the manual process and (2) the operative time. The wage factor (1) has a high influence on the total costs in logistics, for instance, in Germany it is accounted for the 21.19% of the total costs (Statistisches Bundesamt, 2014, p. 10). Anyway it is strictly related to the context. Wages may be really different depending on the country, the region within the country, the qualification of the considered labor and other parameters. With operative time (2) is meant the time the company is operating. In general the higher the wage and the longer the operative time, the higher are the operative costs and the sooner the investment in automation will be paid back.

2.2 Performance

The performance of the manual process can be directly linked to the handling rate required by the process. It can be influenced and limited by the interface with neighbor processes, both up-hill and down-hill, in order to avoid bottlenecks and sub-optimal solutions. The implicit requirement of not damaging the good while performing the manual handling holds always true.

2.3 Flexibility

Flexibility is a complex parameter that represents the variety of scenarios that could be encountered while accomplishing the handling task and how often these scenarios are expected to change. Whereas it is relatively easy for a human operator to handle a large variety of items or move from one point to the other of the facility, those task are not trivial when it comes to automation. The higher the flexibility required by the process, the more complicate and expensive will be the new automated solution. The factors that define flexibility are mainly four (4) hereafter listed and briefly described.

2.3.1 Standardization

This factor describes the standardization level of the items to be handled. It is strictly related to the kind of material, the shape and the weight of the goods and depends on the numbers of different items, object of the handling, which are flowing through the facility. High standardization level implies a small variety of goods (even with large volumes). For instance in facility where 20 types of goods are handled standardization is lower than in facility that has to deal with only 5 types of goods.

2.3.2 Homogeneity of the Batch

It evaluates how often the kind of good changes in the process. A flexible system is able to cope with all the goods the business is dealing with, but it is also true that this has an impact on the efficiency. For this reason dedicated processes, not subjected to recurring changes, are highly desirable. For instance in the CEP branch no batch exists, as parcels, for instance, flowing on a sorter have most likely different origins and destinations. On the contrary in the production logistics, goods flowing on a conveyor belt are likely to flow in batches, reflecting the production series.

2.3.3 Continuity of the Flow

In order for the automation to be economically convenient the utilization of the automated solution must remain high and levelled. In other words the system should be always fed during the whole operative time. The stream of goods has to be wide enough to assure the continuous exploitation of the automation technology. This factor should be carefully evaluated especially in businesses affected by seasonal variation in demand or where the volume of traffic is hard to forecast.

2.3.4 Continuity of the Business

Investing in automation make sense only if the business is supposed to last long enough to fully exploit the benefits of the investment. For this reason the continuity of the business is a factor that must be taken into account. Usually in the logistic sector investors are evaluating the risk of investing through the indicator of the payback period. A shorter payback period means an investment with a lower risk and the threshold of acceptance is set between 2 and 3 years. This threshold can vary with the nature of the automation which is being evaluated: in case of new cutting-edge technology the rigid lower bound of the threshold is applied (2 years), because the

risk is supposed to be high. If an investment in some well-established equipment (such as an Automatic Storage and Retrieval System) is instead being evaluated, the cut-off could fall on the longer term (even more than 4 years), because the investment is deemed to be less risky. The timeframe in which the investment is not profitable could vary from case to case, but generally is much longer in scenarios which are adverse to automation.
In the next section the parameters and their factors will be used to describe the logistic branches introduced in section 1.

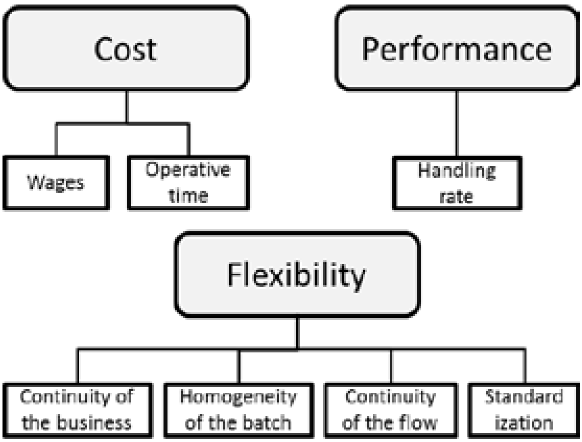

Figure 1 Relevant parameters and factors for automation in the logistic field

3 Comparing Logistic Branches through Automation-relevant Factors

In this section each one of the three major branches of logistics introduced with the taxonomy of section 1 will be analyzed through the parameters and factors that have been described in the previous section.

3.1 Courier Express Parcel

The CEP branch addresses the largest array of customers, ranging from the end (non-business) user who ships something from point A to point B (Customer2Customer service), to the company delivering products directly to the customers (B2C) or to other companies (B2B) using the existing infrastructure put in place by the CEP service providers. The increasing of the material flow due to the e-business, as explained in section 1.1.1 of this paper, creates new bottle-necks in the CEP branch, highlighting that existing systems are often under-dimensioned and overwhelmed by a continuous stream of goods. The short delivery requirement typical of the CEP branch makes things even more critical: pushed to the limit this requirement becomes the so called "same day delivery", offered by some providers. Because of the required short delivery time, CEP service providers are inclined on the one hand to extend the operative time to 24/7, on the other hand to reduce as much as possible the cycle time, namely the time one item remains in the system, optimizing the logistics processes in order to keep high performances, which is only possible by levelling all bottlenecks. Especially in environments characterized by a low level of standardization, the required flexibility is only achievable with high investment in advanced technologies, which often are not reliable and fast enough to cope efficiently with the variety of scenarios (Bonini et al., 2015). Whereas there are no doubts about the longevity of this business, which makes long term investments possible, the easy nature of the handling task enable the employment of low qualified cheap manpower; wages in the CEP branch for handling tasks are probably the lowest in logistics, hence the hardest to replace through automation. The required high flexibility is due to the lack of restrictions in terms of processed items; the only restrictions that contribute to the improvement of the standardization level are limitations on weight and dimension of the items (usually parcels). However, setting an upper limit to weight and dimensions reduces, but not completely removes the need of flexibility. There are no rules concerning the homogeneity of the items belonging to the same batch (in this case a batch can be considered a cargo, which is a rather different concept than a production batch) both considering inbound and outbound. This is due to the fact that items coming from different customers, having in common an intermediate destination, have different shapes and sizes, but they are nevertheless aggregated in the same container in order to exploit all the advantages related to cargo consolidation. In other words, observing a stream of good in a CEP facility, at the inbound, at the outbound or in each process in-between, the probability of finding two items in row having the same characteristics (weight, shape, quality and type of surface) are close to zero.

3.2 Contract Logistic

Since logistics is the core business of companies operating in this branch, processes are usually optimized in order to obtain high efficiency and handling rate. Peculiar characteristic of the contract logistics is the contractual commitment between customer and service provider, usually result of a bidding process won by the provider offering the best service for the lowest price. According to the customer requirements the service provider shapes his processes and develops, if necessary, customized solutions in order to profit, operating into the usually narrow margin that the contract allows and therefore seeking costs optimization. The standardization level varies with the customer, but normally goods, unit loads, packaging, homogeneity of the batches and the volumes are usually punctually described in the contract, hence known a priori. This means that, within the same contract, normally providers operate with a rather high degree of standardization and batches of products are homogeneous. Handling rates are rather high; manpower is low qualified, hence cheap and flexible short on-demand contract for personnel can be set-up in order to answer to peak seasons. Due to the shortening of the product life cycles, contractors tend to lower their risk pushing for relatively short time framed contracts of three or four years (Doll, et al., 2014, p. 26). For this reason the continuity of the business cannot be guaranteed on the long term, but only within the contract duration, which does not favor long term investments in new technologies.

3.3 Production Logistic

The main distinguishing characteristic of this branch is that the core business is not logistics, but production; logistic tasks are internally carried out, instead of being outsourced, mainly for the irrelevance that they cover in respect to the production processes. Some of the production companies do not outsource logistic tasks because they don't want third party workers looking around in the facility where they are producing novel products often not yet on the market. The first results of this choice are (1) the job rotation and (2) higher wages. In order to keep high focus and attention, in most companies the task of production workers is changed in regular intervals (few hours): in some of the production companies, which handle logistic processes (palletizing, de-palletizing, packaging, labelling, warehousing, commissioning), the (1) job rotation can include a mix of logistic and production tasks (such as assembly, quality check feeding of lines and similar tasks). In combination with regulation of trade unions, the job rotation makes it impossible to distinguish the salary of production task (traditionally higher, such as in the metal-mechanic sector) with those of logistic ones (traditionally lower as in the CEP and contract logistics). Considering a same task (e.g. palletizing), this creates considerable (2) higher wages in production logistics than in the other described logistic branches. A secondary effect of the job rotation is the low handling rate (performance) that is characteristic of production logistics; workers are often not specialized in one single task and are therefore less efficient. Nor the need of high handling performance is really relevant in the branch, being the rhythm of logistics a consequence of the mostly levelled production stream: for instance in case of a make-to-stock strategy, both the production and the connected logistics can be thoroughly planned in advanced. Production logistics not only acts with a continuous and levelled stream of goods, but, in general, also with a high level of standardization of items, a 24/7 operative time and homogeneous batches (compatibly with the productive mix and relative customizations). This is true for a stream of goods in output to a general production facility, for every stream in-between production processes and also (less trivial) for the inbound flow of goods (e.g. supplied parts to be assembled): a relatively high standardized and levelled inbound flow is a luxury that production companies can afford thanks to their normally long term contract and to the negotiation power against suppliers. In addition, the business of production logistics is as durable as the connected production business, with no time contractual restrictions, nor bidding processes.

All of these factors make the production logistics the most appealing candidate for long term investments in automation technology in logistics. In the next section all considerations leading to this conclusion are quantified and compared with the other two logistic branches.

4 Quantification of a Qualitative Comparison

In this section a method for quantifying the convenience of investing in each of the logistic branches introduced in section one is first exposed. Then the method is applied and the results are reported.

4.1 The Method

The introduced method is based on the technique of Multiple-Criteria Decision Analysis (Figueira, Greco and Ehrgott, 2005); in particular a decisional matrix is used as an instrument to define in which of the three main branches of logistics long term investments in automation technology are more appealing. The criteria evaluated for the decision are the factors of the three parameters (cost, performance and flexibility) described in section 2 and, because it is extremely hard to decide a priori which factor is more important, they are considered to have all the same weight for the decision (non-weighted multi-criteria decisional analysis). For each of the factors a question has been formulated to which four possible answers can be given; to each answer is associated a double plus (++), a plus (+), a minus (-) or a double minus (--), respectively when the answer is "almost always" (++), "sometimes" (+), "rarely" (-) or "nearly never" (--). The decisional matrix is then compiled for each factor and each branch; because of the non-weighted approach, the pluses and minuses are in the end simply counted for each branch and a score is assigned subtracting the total number of minuses to the total number of pluses. For graphical reasons first intermediate results grouped per parameters (costs, performance and flexibility) are reported in table 1, 2 and 3 and commented; then overall results are summarized in table 4. According to the method, the logistic branch with the highest score is the one in which long term investments in automation technology are most appealing.

4.2 Results Grouped per Parameters

In this section the results of the method are reported and commented grouped per parameter; partial scores are given to each parameter as a sum of pluses and minus evaluating the factors through the asked question. Questions have been qualitatively answered based on the considerations reported on section 3.

4.2.1 Costs

As reported in Table 1, it is clear that production logistics is the best branch for long term investment in automation technology from the point of view of the cost parameter. This is due to the mostly higher wages (job rotation and trade union regulations) that are applied in production logistics. The higher are wages, the higher are, in turn, operative costs; this effect multiplies for the operative time. This means that the higher are the operative time and the wages and the shorter is the return of investment in automation technology.

Table 1 Evaluation of branches through the factors of the cost parameter

Factor	Question	CEP	Contr. Log.	Prod. Log.
Wages	Is the salary higher than the salary of a low qualified worker in logistics?	-	-	++
Operative Time	Is the facility operating 24/7?	++	+	+
Score		+1	0	+3

Legend: ++ = almost always, + = sometimes, - = rarely, -- = nearly never

4.2.2 Performances

A high manual handling rate poses a challenge for the automation technology to match. On the other way around the lower the performance of the manual handling, the more operators can be replaced with the automation technology making the investment appealing. Traditionally high handling rates are to be found where logistics is the core business of the company (CEP and contract logistics), while performances are lower when the core business of the company is different than logistics; hence the question in Table 2 and the score of the performance parameter.

Table 2 Evaluation of branches through the factors of the performance

Factor	Question	CEP	Contr. Log.	Prod. Log.
Handling rate	Is the company core business different from logistics?	--	--	++
Score		-2	-2	+2

Legend: ++ = almost always, + = sometimes, - = rarely, -- = nearly never

4.2.3 Flexibility

The parameter flexibility is composed of several factors which are better analyzed one at the time.

Table 3 Evaluation of branches through the factors of the flexibility

Factor	Question	CEP	Contr. Log.	Prod. Log.
Standardization	Are the items standardized?	--	++	++
Homogeneity of the batch	Are there batches of homogenous items?	--	+	+
Continuity of material flow	Is the material flow levelled during the operative time?	++	-	+
Continuity of business	Is the business supposed to last more than 4 years?	++	-	++
Score		0	+1	+6

Legend: ++ = almost always, + = sometimes, - = rarely, -- = nearly never

The factor "standardization" and "homogeneity of the batch" naturally penalize the CEP branch, where any kind of item (dimension, weight and quality of box/envelope) can be found in the system and batches, when even existing, are made of a small amount of items having in common either the destination or the provenience, but rarely both. The penalty (--) is due to the clear disadvantage that this represents in terms of automation technology. On the other hand though, the CEP branch experiences a stream of goods mostly levelled in the operational time (with the exception of seasonality, such as the 2-3 weeks before Christmas) and an eventual automated solution would rarely remain idle (hence higher operative time), since the system is full and operating nearly 24/7. The same applies to production logistics, with a slight difference (one plus instead of two): although the production is levelled by nature, the consequent logistics could suffer of the elastic effect due to the change in the mix and the set-up time. Contract logistics stands in this regard a clear step behind; items can here be subjected to strong seasonality or trend, having a great impact on the process of warehousing and commissioning. Inbound and outbound processes (unloading, depalletizing, palletizing, loading, cross-docking, etc.) are mostly restricted, in the service contract, to specified time windows, often due to external constraints: this means that trucks can, for instance in a cross-docking process, arrive between 9 and 12 in the morning, while they have to be loaded and leave between 14 and 17, creating high traffic in specific hours with no hope to level the peaks due to the scarce negotiation power. As for the last factor, the continuity of the business, it has already been clearly explained how contact logistics is penalized; contracts have in most cases a short term (less than 4 years). On the contrary the business of

CEP is prosperous (capacity seems to be worldwide not enough due to the e-business) and the one of the production logistics is as durable as the connected production business.

Being overall production logistics the branch where flexibility is less required (hence the high score according to the posed questions), once again this branch appear to be the best for long term investments in automation technology.

4.3 Overall Results

Table 4 shows the partial results summarized and the final score of the three logistics branches with regard to the convenience of committing to long term investments in automation technology.

Table 4 Final results showing production logistics as the most convenient branch for long term investments in automation technology

Parameter	CEP	Contract Log.	Prod. Log.
Cost	+1	0	+3
Performance	-2	-2	+2
Flexibility	0	+1	+6
Total	-1	-1	+11

Overall the higher operative costs, due to the high cost of manpower, together with the generally lower handling performances and the lower required flexibility (in turn due to a high degree of standardization), make production logistics by far the branch in which it is more convenient to invest in long term automation technology.

5 Interpretation and Discussion of Results

In this section the results are discussed and an interpretation is given from two points of view, namely from the investor side (section 5.2) and from the technology provider side (section 5.3).

5.1 Validation of the Simplified Approach

In this paper assumptions and simplifications of complex factors have been made in order to ease the demonstration of the thesis. One instance of such simplification is to be mention in regards to the difference in average wages among the three branches, which plays a fundamental role in demonstrating the thesis of this paper. It could be argued that wages strongly depends on the country, the region and the specific arrangements with the unions; the statement presented in this paper (i.e. that wages in CEP and contract logistics are rather similar to each other and averagely lower than in production logistics) is indeed a simplification of the variety of wages that can be found in these branches. Even though wages may differ from country and region, hereafter the tendency of the wages in the three branches is reported with the example of West Germany (North Rhine-Westphalia).

Table 5 Comparison among wages in the three logistics branches in West Germany (North Rhine-Westphalia)

CEP	Contract Logistics	Production Logistics
11,31€/h (MAIS 2015)	11,31€/h (MAIS 2015)	14,83€/h (Metall NRW 2015, p.1)

As shown in table 5, wages of West Germany in the production logistics are 31.12% higher, for the same job, than in contract logistics or CEP.

Simplifications and generalizations like the one in the mentioned example are based on the experience of the group of writers concerning automation of processes in various logistic fields. They could be demonstrated in a context specific environment, but ultimately it is up to the reader to contextualize the results based upon his/hers specific experience and to deduct therefore their validity.

5.2 Interpretation of Results for Investors

The taxonomy proposed in section 1 of the paper is general and based upon simplifications and generalizations; the presented method for evaluation of the convenience of committing to long term investments for automation technology however can be applied independently on the universal validity of the taxonomy. The question of tables 1, 2 and 3 can be asked to every company dealing with logistic processes and, depending on the answer, a score (++, +, - or --) can be given for each factor. The higher the total score the more convenient can be long term investments in automation technology. In case the score is negative or low, generally long term investments in automation are discouraged; nevertheless some punctual specific task, regarding probably a part of the process or a sub-set of items, could still be effectively automated.

5.3 Interpretation of Results for Technology Providers

From the point of view of technology providers who seek in the results of this paper a guideline for the market segment where to focus their product, the interpretation of the findings is two-sided, indicated with (1) and (2) in the following text. In case the technology provider is evaluating the penetration on the market of a cutting edge technology (e.g. autonomous robots in logistics), the skepticism due to the novelty of the solution represents inevitably a strong barrier to those branches with a low score (CEP and contract logistics). In this case it is advised to (1) focus on a branch with high score (high convenience of committing long term investment in automation technology), hence production logistics. On the other hand the production logistics often requires a rather customer-specific approach: each automation technology sold is somehow customized to the specific requirements and the reproducibility of the specific conditions is improbable. Quite oppositely, if an automation technology is sold to a CEP customer, the volume of ordered systems is most probably going to be high enough to justify the costs of customized engineering. Especially in case of emerging automation technology, in order to win over the skepticism due to the novelty of the solution, a quick return of investment is of essence; in the CEP branch, where manpower has high performance standards and low costs, the only way to achieve a fast return on investment it to keep the price of the automation low. For this reason it makes sense to (2) develop technology with the target cost of the CEP branch, being this environment the most hostile for automation technology: if, thanks to the low price, the technology can penetrate the CEP branch, success in the other two more automation-favorable branches is guaranteed and the market potential for the developed automated solution results higher.

6 Conclusions

In this paper first an automation-oriented taxonomy for logistics has been given, which results in three main branches: CEP, contract logistics and production logistics. Then a method for evaluating the convenience of committing to long term investments in automation technology for logistic processes has been presented. The method is based on the identification of logistic-specific parameters (costs, performances and flexibility) having a strong impact on the convenience for automation; these parameters are then divided in factors (wages, operative time, handling rate, standardization, homogeneity of the batch, continuity of the flow and continuity of the business) that lead to the evaluation of the convenience depending on the logistic context. The method has been applied to the automation-oriented taxonomy for logistics; production logistics has been evaluated as the most convenient branch for committing to long term investments in automation technology. Results have then been discussed from the point of view of potential investors (users) and from the one of technology providers.

Financial Disclosure

Supported by the European Commission through the 7th Framework Programme for Research and Development, Grant Agreement n. 270350 – Project ID: RobLog.

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III.
Recent Approaches for Supply Chain Risk Management

Risk Identification for Outbound Road Freight Transportation Service

Thutchanan Sangwan and Jirapan Liangrokapart

The start of Asian Economic Community (AEC) at the end of 2015 will strengthen Thailand's position as a transportation hub for the Greater Mekong Sub region (GMS). It has increased Thailand's opportunities for cross-border trades and import-export shipments especially between Thailand and its four immediate neighbors - Myanmar, Malaysia, Laos, and Cambodia. The major mode of transportation among these countries is the road transportation. Fierce competition will occur as professional multinational logistics companies owned by foreigners will use their competitive advantage to get the major market shares and compete with local logistics providers. To survive the competition under the AEC, local logistics firms should identify the risks for their logistics services among the neighboring countries and find avenues to manage the risks. This paper studied relevant literatures and summarized the risks related to the Outbound Road Freight Transportation Service. The risks have been validated by industry experts, the effect of each risk on key performance indicator has been analyzed, and suggestions for mitigating the risks have been included.

Keywords: Risk Identification, Outbound Road Freight Transport,
ASEAN Economic Community (AEC), Logistics Service Provider

1 Introduction

Currently, globalization is becoming an important issue of world economy. The competition in world trading is very high and increasing. Hence, many countries in each region have to improve their abilities and try to collaborate in term of international integration to enhance benefit, increase bargaining power, and gain advantage of international trading, investment, and information technology. Furthermore, the integration also comprehends in liberalization within the region to facilitate logistics activities of local company, eliminate tariff-barrier, free flow of products and services, in order to attract external investor investment and stimulate demand.

ASEAN Economic Community (AEC) is the one of the international integration among between 10 ASEAN member countries for overall benefit and competitive advantage of members especially in international trade. AEC is going in the same direction as European Union (EU) has done.

The initiative of AEC integration was from the 9th annual meeting of ASEAN members in Indonesia in 2003. The idea of community comprises three elements include ASEAN Political-Security Community (ASPC), ASEAN Socio-Cultural Community (ASCC), and ASEAN Economic Community (AEC) under the slogan "One Vision, One Identity and One Community". Being singed in 2007, "AEC Blueprint" was designed to have the clear plan and framework, so that it will be fully implemented by the end of year 2015. The AEC Blueprint consists of four important characteristics including single market and production base, highly competitive economic region, region of equitable economic development, and region fully integrated into the global economic.

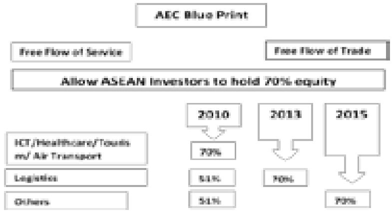

Figure 1 Timeline of Liberalization plan, adapted from AEC Blue Print (2008)

Figure 1 represents the timeline of liberalization plan in each sector before the official opening of AEC at the end of year 2015. Logistics are considered as the important sector which is also included in the Blueprint. The logistics free flow in ASEAN started in 2010.

1.1 Impact of AEC on Road Freight Transportation Service

The opening of AEC will have direct impact on most of industries in Thailand. The advantages of Thailand including central location, facilities, infrastructure, capability, and low production cost will strengthen Thailand to be the transportation hub for the Greater Mekong Sub-region. Hence, the opportunity for cross-border trade and export-import shipment will be increased, and it will benefit the four immediate neighbor countries namely Myanmar, Cambodia, Laos, and Malaysia. Due to the major mode of transportation in these GMS countries is road transportation, the opening of AEC will increase the demand in exports and import products and border trade. Hence, the demand for Road-freight transportation service will also increase. In order to support such demands, ASEAN Highway under Framework Agreement on the Facilitation of Goods in Transit (AFAFGIT) and ASEAN Agreement for the Facilitation of Inter-State-Transport (AFAFIST) have been issued for the members to prepare their transportation routes and infrastructure to facilitate goods in transit. According to the Master Plan on ASEAN Connectivity, six new routes have been constructed in Thailand to support the goods in transit associated to eight custom houses. The total distance of these routes is about 4,477 kilometers.

The increase of market demand, free flow of goods, services, trade, labor, capital, and investment is not only benefit Thailand and the Thai corporations but also create great opportunities for the multinational companies or investors to take the benefit of bigger market with less regulation. In logistics sector, foreigner logistics companies will enter the competition professionally and use their competitive advantage to gain more market share from local logistics providers. Hence, Thai logistics providers need to improve their service and efficiency in order to compete with the multinational companies, maintain the market share, and increase opportunity to attract new customers.

Hence, Thai companies need to reduce the risk which may occur and disrupt the company performance and have negative impact on the local companies. The focus of this study is limited to the outbound road freight transportation service in the land-link ASEAN countries namely Thailand, Laos, Cambodia, and Myanmar only. To mitigate the risks, there is a need of identifying the risk factors since they will negatively affect the company's performance.

Therefore, the objectives of this study are:

1. To identify risk factors for local logistics service providers (LSP) in respect of the opening of AEC.
2. To suggest the way to mitigate the risks and gain competitive advantages.

2 Literature Review

2.1 Definition of Logistics Service Provider

Lieb.et.al (1993) defined logistics and transportation service provider as an external company which offers service related to logistics activities for customers. Sorat (2008) stated that logistics service provider is an external organization which experts in logistics activities under contract in exchange with benefit. Transportation is one of the important logistics activities. Pathomsiri (2010) defined transportation as the process of moving people, goods, and service from one location to another location in order to meet the customer requirement and link logistics activities together. Therefore, transportation is an important factor contributing to sustain the economic growth and increase the competitiveness for the country. Komnamul (2007) also agreed that current action puts logistics more emphasis on transportation due to every logistics activities needs to link with each other by transportation. The logistics activities include transportation of raw materials that serve manufacturers for production and transportation of finished goods to distribute to customers. Road freight transportation service is a major part of LSP services which is the focus of this study.

2.2 Risk Management for LSPs

Jenkins et al., (2010) and Rao and Goldsby (2009) presented general risk management process as shown in Figure 2. The process starts from establishing the context including internal and external factors, objectives, and risks. Then the risk assessment should be performed via 4 steps: risk identification, risk analysis and risk evaluation, followed by the risk treatment. The process should be monitored, reviewed, communicated, and consulted continuously. It is expected that the implementation of risk treatment which is treated, shared, retained, and avoided will result in a better performance.

According to report from ABNAMRO in January 2015 on LSP industry, more than 90 percent of the LSPs and transport companies claim to be aware of their principal operational and strategic risks. However, only 61 percent of those have an alternative plan if there is a major breakdown in their operations. Just fewer than 50% of the companies express the business implications in monetary terms. This means that the Transportation and Logistics sector is on the right track; now they need to move to the next step and adopt a more mature risk management approach. Companies should systematically map out risks that might affect their business objectives and formalize their measurement control.

Figure 2 General Risk Management Process adapted from Jenkins et al., (2010) and Rao and Goldsby (2009)

Risk is defined as uncertainly of situation or event which can negatively affect the performance of organization, or event that has a few probability to happen but can harm the organization both in short term and long term sustainability, Tang and Musa (2010). Goh et al. (2007) stated that source of risk can be categorized into 2 groups namely internal instability in organization and external environment. In addition, Brenchley (2000) categorized loss into 6 groups: financial loss, performance loss, physical loss, psychological loss, social loss, and time loss. Jenkins et al. (2010) defined risk and harm as a probability of occurring the damage which is the consequence of loss in operations. Moreover, they divided risk management processes to 3 steps: risk assessment, risk control, and risk review.

From extended literature in respect of risk management in logistics service providers, a number of risk models have been found. Pujawan and Geraldin (2009) presented the "House of Risk" model to investigate risk based on case study of a fertilizer company in Indonesia. Berle et al. (2013) presented the risk assessment and flexibility of transportation sector for liquid natural gas (LNG) cargo. Caputo et al. (2011) proposed the impact of accident risk in road transportation in a hydrogen cargo. Yang (2011) presented risk management of Taiwan maritime supply chain security which is under the rule of container security initiative (CSI) according to 24-hour rule and use bowtie diagram to investigate risk management strategy. Tummala and Schoenherr (2011) presented the assessing and managing risk using the Supply Chain Risk Management Process (SCRMP). Harland et al. (2002) presented risks in supply chain network by defining loss, consequence, and probability of occurrence in each logistics activity. Liangrokapart (2012) studied Supply Chain Impact Analysis using a case study of hospital supply chain disruptions in Thailand.

In addition, Benchaley (2000) showed the risk in cargo transportation by illustrating risk event, consequence, business impairment, and magnitude of loss respectively. Chopra and Sodhi (2004) investigated risk management in supply chain in order to avoid or mitigate supply chain system breakdown by defining categories of risk, illustrating risk driven and suggesting risk strategy. Gaudenzi and Borghesi (2006) presented the use of AHP model to evaluate the supply chain risk focusing on customer requirement, on time delivery, order complete, order correctness, and damage free detection. Schroeder and Gomes (2014) investigated risk of international trade operations in order to support the entrepreneur in managing their risk. Peck et al. (2003), mentioned risk management of LSP whether the logistics operators still run and are aware of risks based on day by day assessment. However, there are just a few formal researches which consider risk management and figure out quantitative the probability of occurrence, severity as well as mitigation strategy to support decision making of logistics companies.

2.3 The Impact of the Risks

Performance measurement becomes an interesting issue over past 20 years. The well-known adage of performance measurement "if you can't measure it, you can't manage it" stated by Hamel and Prahalad (1994). The definition of performance measurement can be explained by understanding the action in each activity in order to lead organization to reach target objectives. Chan and Chan (2004) explained the definition of performance measurement in term of how to meet the goal by focusing on output efficiency.

To know the level of the risk impact on supply chain, appropriate key performance indicators (KPIs) should be developed. This study has reviewed supply chain and LSP performance measurement literatures focusing on the KPIs influencing customers to outsource their logistic activities. Pedersen and Gray (1998) defined key factors of transportation selection criteria as time, cost, and service quality correspond with experts' opinion. These represent the reliability of firms as in Figure 3.

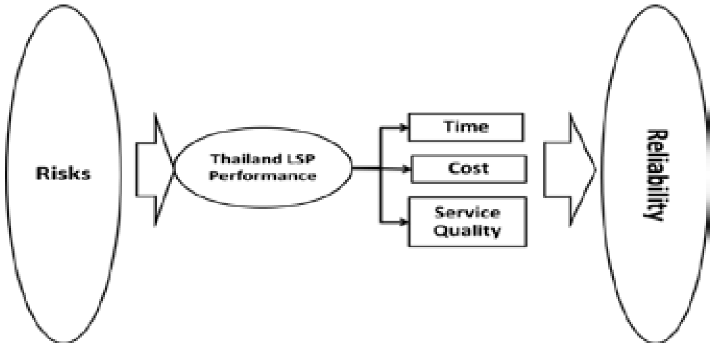

Figure 3 Risk impact on LSP performance indicator, adapted from Pedersen and Gray (1998)

3 Research Method

The research methodology used in this study starts from 1) identifying the problems in the logistic service industry, 2) summarizing risks in the industry and its impact on KPIs from previous literatures, then 3) asking experts to select the risks and define the risks levels based on the severity and the probability of occurrence, and finally 4) Proposing the avenues for mitigating the risks as shown in Figure 4. To identify the risk, the interview was conducted with three experts who have experienced in LSP industry as shown in Table 1. Experts have been interviewed in get the current problems and overview of working process. The risk factors were identified by extracting from relevant literature and coding from the expert interview when they answered the questions: what can go wrong in each process, what are the opportunities to occur and how much does it negatively affect the companies based on the KPIs.

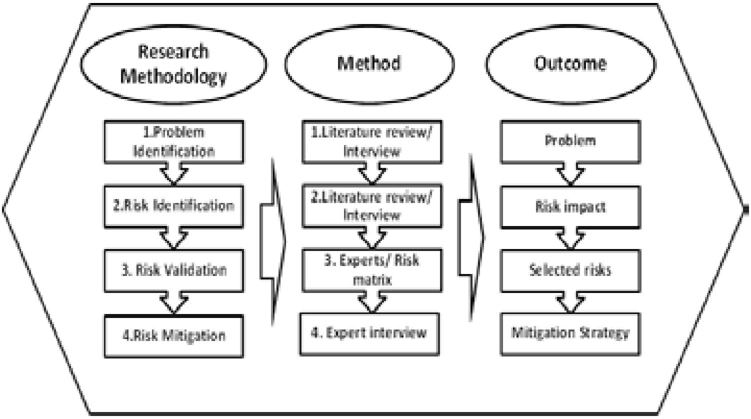

Figure 4 Research method

The research framework contains the risks occurring during the flow of goods and services from manufacturers through distributors, passing the outbound customs border, free zone goods in transit, inbound customs border, and at the end, to the customers.

Table 1 Overview of company representative interview

Company type	Interviewees	Nationality
LSP	Marketing and Sale Manager	Multinational
LSP	CEO	Thai
LSP	Managing Director	Multinational

The risks affecting the financial and information flow are also brought into consideration. From the research framework, there are 3 major research questions involved. They are:

1. What are the current problems or risks of road freight transportation and LSP associated with current working process and KPIs of firms?
2. What are the level of risks based on the probabilities to occur which lead to negative consequence to road freight transport and LSP and the severity of the impact to KPIs of companies?
3. How to manage each risk, if occurs?

4 Findings

4.1 Identifying the Problems in the Logistic Service Industry

The findings for this step are the answers to research question 1. Although the goal of AEC is going in the same line with the EU, but there are still many differences between AEC and EU. From SCB Research Analysis EIC (2012), the EU took 35 years to become real free trade area by completely implement of single market, free transportation, and no customs procedures. The current practice of the AEC cross border transportation still does not relax the laws on the cross border customs procedures. Trucks have to stop at border checkpoint in order to pass customs process. Moreover, the trucks have to transit goods in the free zone due to constraints of vehicle standard of each country and also the limited of quota permit of cross border trucks.

In addition, there are approximately 18,399 LSPs in Thailand and the growth rate is about 3.7 percent per year. Visondilok et al. (2012) stated that the LSPs provide transportation services to the customers mainly by truck transportation which is account for 82 percent of total freight transportation. This study focuses on the truck transportation and the problems occurred by the opening of AEC which affect the local LSPs' performance. The associated risks are identified in the next section.

4.1.1 Summarizing Risks in the Industry and its Impact on KPIs from Previous Literatures

In this step, the risk factors were identified from previous literatures and experts interview. After reviewing the literature, risk factors were identified in large amount and were selected only the necessary factors which relate to outbound road freight transportation base on experts' opinion. For example Kersten et al (2012) mentioned about the staff performance and responsibility, vehicle breakdown, technical defects of vehicle, and delay customs process in border area. Whereas Chopra and Sodhi (2004) mentioned about the risk factors namely seasonal factors, supplier bankrupt, and customs system failure. Pujawan and Geraldin (2009) referred to exchange rate fluctuation, and delay on time delivery both by supplier and non-supplier. Rogers et al. (2013) stated that the important problems supply chain is from low commitment with partner and lack of appropriate IT system. After risk factors were selected from previous literature, experts suggested to add more risk factors in general processes such as staff breach a safety rule, inadequate truck, strategy in term of truck investment plan and delay in document process. Moreover, experts also emphasis on the changing of government regulation from the opening of AEC which will attract foreign investors to gain the benefits and market share. Hence, the declination of customers and competitors increasing therefore becomes the critical point to concern. According to selected risks above, risk factors can be categorized into 7 groups: disruption, operations, financial, strategy, regulation, system, and marketing. And the definition of each category is in Table 2.

Table 2 Risk Categories

Categories	Description
Disruption	The event that is unable to plan may have seriously disrupt to operation of road freight transportation line
Operation	The error of truck, staff, and operation process which may make a loss to firms
Financial	The event that may make company loss in term of financial
Strategy	Risk from business implementation base on business strategy
Regulation	Risk related to the trade regulation
System	Risk from system failure
Marketing	Risk relate to the decrease of market value

4.1.2 Asking Experts to Select the Risks and Define the Level of Risks Based on the Severity and the Probability of Occurrence

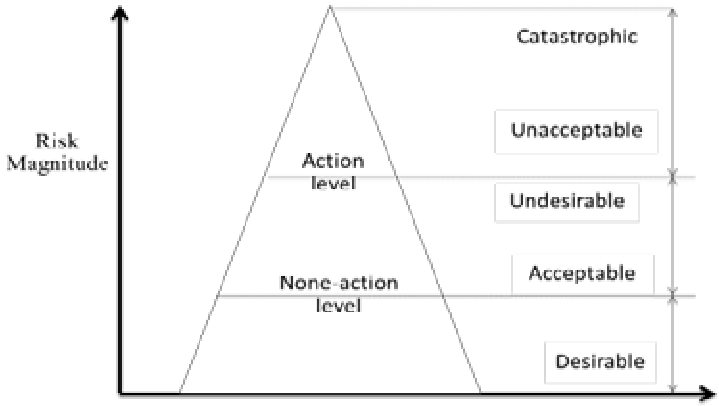

Figure 5 Risk Level, Adapted from Rao and Goldsby (2009)

In this step, the levels of risks were determined based on expert opinions. The experts were asked to define level of risk magnitude based on levels of each risk. The levels of each risk were categorized into 5 levels namely desirable, acceptable, undesirable, unacceptable, and Catastrophic as shown in Figure 5.Then, the outcome of this step answers research question 2 as shown in Table 3.

Table 3 The levels of risk base on experts opinion

Code	Risk Factors	Category	Risk Level
F1	Natural disaster	Disruption	Acceptable
F2	Staff breach a safety rule	Disruption	Undesirable
F3	Seasonality factor	Disruption	Undesirable
F4	Damage product from accident	Operation	Undesirable
F5	Staff performance and responsibility	Operation	Catastrophic
F6	Vehicle condition	Operation	Undesirable
F7	Blurring boundaries between buying and supplying companies in the chain	Operation	Undesirable
F8	Inadequate truck	Operation	Undesirable
F9	Delay customs process in border area	Operation	Catastrophic
F10	Delay on time delivery	Operation	Catastrophic
F11	Delay document process	Operation	Catastrophic

F12	Supplier bankrupt	Financial	Acceptable
F13	Exchange rate fluctuation	Financial	Acceptable
F14	Truck investment plan	Strategy	Undesirable
F15	Low commitment of partners	Strategy	Undesirable
F16	Government regulation	Regulation	Unaccepta-ble
F17	Lack of appropriate IT	System	Acceptable
F18	Breakdown custom system	System	Undesirable
F19	Increasing competitor	Marketing	Undesirable
F20	Customer decline	Marketing	Catastrophic

From above Table, there are 6 factors locating in catastrophic namely staff performance and responsibility, delay on time delivery and customs process and document, and customers decline level (due to these factors are high severity and almost certain to happen and should have immediate action to reduce these risks). One more significant risk is government regulation that will change after AEC is started. The company should manage this risk and be ready to encounter. The other risks that not locate in critical area do not require for immediate action but company should monitor the situation and prepare for emergency plan.

4.1.3 The Avenues for Mitigating the Risks are Proposed

Base on the theory of 4Ts of hazard response, Enyinda (2008), risk mitigation process requires the judgment from the experts. The 4Ts are the strategy to manage the significant risk by the common means to mitigate he risk. 4Ts stand for:

1. Treat: It is the actions which can be performance to control or reduce the probability and severity of risks, so that supply chain disruption can be prevented.
2. Take: It refers to the risk acceptance or the risk that cannot be treated or managed.
3. Transfer: It refers to the sharing of responsibility to another party if the risks occur. The risks can be shared by using insurance, or out-sourcing the operations of the organization to other parties such as supplier, sub-contractors.
4. Terminate: The risks can be eliminated by doing things differently, so that opportunities leading to the risk caused by particular activities can be avoided.

In this study, experts suggest means to mitigate each risk factor as shown in Table 4.

Table 4 Risk mitigation base on 4Ts strategy

Code	4Ts Strategies	Description
F1	Take	Follow the situation and prepare for emergency plan
F2	Treat	Strengthen safety policy and monitor staff behavior to follow the safety rule
F3	Treat	Apply information technology to enhance the accuracy of forecast
F4	Terminate	Train the staff to be aware and avoid behavior leading to probability to get damage
F5	Treat	Strengthen safety policy and responsibility and do not assign too much job to staff
F6	Terminate	Avoid the action that leads to vehicle breakdown, evaluate vehicle before start working, and train staff to be able to solve problem immediately
F7	Treat	Set a responsible clarity and task

Code	4Ts Strategies	Description
F8	Treat	Apply the tool to enhance the accuracy of demand forecasting and outsourcing supplier
F9	Terminate	Prepare accurate and completed customs document to reduce waste time
F10	Terminate	In case of supplier, check suppliers network before assigning the shipment appropriate shipment to suppliers. In case of non-supplier, check the route & condition before accept the shipment, avoid bad traffic and poor route, and check the accuracy of map to prevent driver from getting lost
F11	Treat	Define the appropriate lead time in each process, then assess and monitor
F12	Transfer	Use various suppliers to share responsibility and audit and monitor supplier performance

Code	4Ts Strategies	Description
F13	Transfer	Sign contract to fix exchange rate value and crop insurance for exchange rate fluctuation
F14	Transfer	Outsource the suppliers and compare each of them to offer the selection of the best alternative
F15	Treat	Set a responsible clarity and task
F16	Treat	Always be informed of government situation
F17	Take	Implement software at least appropriate with customers and customs system
F18	Take	Monitor the situation due to being unable to control
F19	Treat	Enhance customer relationship management to maintain customers base
F20	Treat	Enhance customer relationship management and improve service quality

After mitigation strategies were suggested, experts were asks to classify impact of each risk based on KPI which influences the customer to outsource LSP based on decision criteria of Pedersen and Gray (1998) namely time, cost, and quality. The levels of impact were classified into 3 levels by H = high level of impact, M = medium level of impact, L = low level of impact as shown in Table 5.

Tabe 5 Assessing impact of risks associate with each KPI

Code	Risk Factors	Time	Cost	Quality
F1	Natural disaster	N/A	N/A	N/A
F2	Staff breach a safety rule	M	M	M
F3	Seasonality factor	M	M	M
F4	Damage product from accident	H	H	H
F5	Staff performance and responsibility	M	M	H
F6	Vehicle condition	H	M	H
F7	Blurring boundaries between buying and supplying companies in the chain	M	L	L
F8	Inadequate truck	M	M	H

Code	Risk Factors	Time	Cost	Quality
F9	Delay customs process in border area	H	L	H
F10	Delay on time delivery	H	L	H
F11	Delay in document process	H	L	H
F12	Supplier bankrupt	L	L	H
F13	Exchange rate fluctuation	L	L	L
F14	Truck investment plan	L	H	M
F15	Low commitment of partners	M	L	H
F16	Government regulation	M	L	L
F17	Lack of appropriate IT	M	L	M
F18	Breakdown custom system	M	L	M
F19	Increasing competitor	M	M	M
F20	Customer decline	H	M	M

From above table, N/A means the effect of F1 does not include in performance measurement for customer consideration due to being unable to control. While F4 refers to the critical factor since it has highly effect on all criteria. If it is concerned separately, cost reduction should focus on the factors which have high level of impact on cost namely F4 and F 14. In term of service quality, F4, F5, F6, F8, F9, F10, F11, F12, and F15 should be mitigated if service quality is required to improve. For F4, F6, F9, F10, F11, and F20 impact on high level of time disruption. In daily working process of LSP, there are many risks affecting different levels of company performance which is the important criteria for customer consideration. Hence, to improve performance of firms, risk management is one of effective way for LSPs consideration.

5 Conclusion and further research

This research has revealed the risks for local LSPs in Thailand when the stronger Multinational LSPs have entered the ASEAN market and compete with the LSPs. The levels of risks have been determined in order to help local LSPs to survive and the strategy to manage the risks have been proposed. However, this study is just a preliminary research and the findings are limited only to the literature review and expert opinions. The scope of this study covers the risks related to the Outbound Road Freight Transportation Service. Extensively quantitative surveys in the future are recommended in order to gain more precise quality of the risks, the impacts, and the ways to effectively mitigate the risks. The expansion of the scope is also suggested as well as the detail of relationship between each risk in the study.

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Selection of Optimal Redundancy Strategies for a Supply Network

Abroon Qazi, John Quigley, Alex Dickson, Barbara Gaudenzi and Şule Önsel

Supply chains have become more vulnerable because of increased globalization and interdependency between network actors and risks. It is, therefore, extremely important to model interdependency between risks taking into account the supply network configuration. In this paper, we have followed the existing concept of modelling supply network as a Bayesian belief network capturing network configuration, probabilistic interdependency between risks and losses resulting from the realization of risks. We propose a new method for evaluating efficacy of different combinations of redundancy strategies. For each node of the network, we incorporated a strategy of adding redundant resource as a risk management approach that would disengage the particular node from its parent node(s). The model was solved against the bi-criteria objective of maximizing normalized expected utility for loss exposure and normalized utility for cost of redundancy strategies keeping into account different risk attitudes and criteria weights. The model also helped in identifying optimal combination of strategies for specific allocation of budget as there could be different combinations of allocating redundant resources across the network resulting in sup-optimal values of risk measures.

Keywords: Supply Network Configuration, Bayesian Belief Network, Redundancy Strategies, Risk Attitudes

1. Introduction

Supply chain risk is characterized by both the probability of an event and its severity given that an event occurs (Handfield et al., 2011). According to Jüttner et al. (2003), "Supply chain risk management (SCRM) aims to identify the potential sources of supply chain risk and implement appropriate actions to avoid or contain supply chain vulnerability". Vulnerability is defined as an exposure to serious disturbances from risks within the SC as well as risks external to the SC (Christopher and Peck, 2004). Risk management is an established field in some areas of organizational life like finance but it is still a developing theme within the realm of supply chain management (Khan and Burnes, 2007).

Because of the complexity of global supply chains, there is need of developing robust risk management techniques for capturing interdependent risks ranging across the entire network (Khan and Burnes, 2007, Ghadge et al., 2012, Olson and Wu, 2010, Rao and Goldsby, 2009, Vanany et al., 2009). It is important to realize that risk exists at various levels, inside the focal company and at the network level. Furthermore, risk evaluation depends on the stakeholder's perspective and therefore, the subjective judgement of a particular stakeholder determines what constitutes a risk and what level of risk is acceptable (Gaudenzi and Borghesi, 2006). Similarly, the risk attitude of the stakeholder will influence the extent to which a specific control strategy needs to be implemented for mitigating controllable risks.

Bayesian belief network (BBN) is a an acyclic directed graphical model comprising nodes representing uncertain variables and arcs indicating causal relationships between variables whereas the strength of dependency is represented by the conditional probability values (Sigurdsson et al., 2001). BBNs have the potential of capturing interdependency between supply chain risks (Garvey et al., 2015, Badurdeen et al., 2014). However, current studies have not covered all stages of supply chain risk management process through BBNs.

1.1 Research Problem and Contribution

In this paper, we present a new modelling approach of capturing interdependency between risks using BBNs. The model incorporates supply network configuration, probabilistic interdependency between risks, resulting losses, redundancy strategies and associated costs. Implementation of a redundancy strategy through disconnecting a node from its parent nodes is a unique idea for evaluating the benefits associated with different combinations of such strategies across the network. Furthermore, we also consider risk attitude of the decision maker in choosing the optimal combination of redundancy strategies. We demonstrate our modelling approach through a simple example.

1.2 Paper Outline

Review of the literature is briefly presented in Section 2 including discussion on the studies focusing on Bayesian network based modelling of Supply chain risks and their limitations. The proposed modelling approach, risk measures and mathematical representation of the problem are elaborated in Section 3. Simulation study is illustrated in Section 4 followed by the presentation of results and discussion in Section 5. Finally, conclusion and future research agenda are described in Section 6.

2 Literature Review

Dickson (1989) defines risk management as "the identification, analysis and control of those risks which can threaten the assets or earning capacity of an enterprise." Risk management is a continuous process which takes into account the past history of an organization in order to develop robust strategy for dealing with the present and future risk events. The actual process of risk management starts with assessment of two factors including likelihood of occurrence of a specific event and the resulting consequence (Cox and Townsend, 1998).

The Royal Society (1992) defines risk management as a process of making and implementing decisions pertaining to risks on the basis of risk estimation and evaluation in order to mitigate the impact of risk events through reduction of their likelihood and/or the impact of resulting consequence. Risk management does not need to be a highly sophisticated process rather it must be based on common sense and rationality (Smallman, 1996). According to White (1995), risk management process generally comprises following three stages:

1. Risk Identification. The first stage involves identification of hazards, potential failures and adverse consequences.
2. Risk Estimation. In the second stage of risk management process, probabilities of risk events are estimated and quantification of risks is performed.
3. Risk Evaluation. Risk evaluation involves estimating significance of risks, judging acceptability of risks and comparing risks against benefits.

According to Simon et al. (1997), all techniques related to the risk management process can be classified into following three groups:

1. Qualitative techniques. These are the techniques that seek to identify, describe, analyze and understand risks.
2. Quantitative techniques. These techniques incorporate modelling of risks for quantification.
3. Control techniques. These methods develop mitigating techniques in order to minimize the effect of risk events.

Manuj and Mentzer (2008) conducted an extensive literature review and a qualitative study comprising interviews and focus group meeting in order to develop a grounded theory for understanding global supply chain risks. According to them, "Global SCRM is the identification and evaluation of risks and consequent losses in the global supply chain, and implementation of appropriate strategies through a coordinated approach among supply chain members with the objective of reducing one or more of the following – losses, probability, speed of event, speed of losses, the time for detection of the events, frequency, or exposure – for supply chain outcomes that in turn lead to close matching of actual cost savings and profitability with those desired". It is important to consider that risk management is a continuous process and therefore, there is always a need for anticipating unforeseen risks and adapting the contingency plans.

According to Sodhi and Tang (2012), risks can be viewed with respect to three broad perspectives:

1. A 'butterfly' depiction of risk that separates underlying causes, actual events and ultimate consequences
2. Impact based perception in terms of disruptions and delays
3. Network perspective in terms of local-and-global causes and local-and-global effects

Sodhi et al. (2012) conducted a thorough study by carrying out direct observations of the researchers' output, gathering evidence through surveys of focus groups of researchers and seeking confirmation through a formal survey of a large group of researchers. They have identified following major gaps in the field of SCRM:

1. There is no clear consensus on the definition of SCRM
2. There is lack of research on the reactive strategies once the risk event has occurred
3. There is shortage of empirical research in the field

2.1 BBN based Models in SCRM

BBNs have started gaining the interest of researchers in modelling supply chain risks (Badurdeen et al., 2014). BBNs offer a unique feature of modelling uncertainty combining both the statistical data and subjective judgment in case of non-availability of data (Sigurdsson et al., 2001, Kelangath et al., 2011, Qazi et al., 2014). Lockamy (2011, 2014) and Lockamy and McCormack (2009, 2012) developed a model for benchmarking supplier risks involving risk events related to supplier network, internal operations and external factors and found BBNs to be a very useful tool in assessing

risk exposure of a company to its suppliers. Dogan and Aydin (2011) developed a supplier selection method combining BBNs and Total Cost of Ownership method and advocated the efficacy of BBNs in dealing with incomplete or uncertain information of buyers about their suppliers.
Dogan (2012) introduced a model for selection of an international manufacturing site using BBNs. The proposed method allows exploring judgment of managers by following a systematic approach while globally considering all the relations among factors and between factors and objectives. Badurdeen et al. (2014) developed supply chain risk taxonomy and a risk network map that captures interdependencies between risks. The model presents an effective tool to capture the interaction of risk factors and helps identifying key suppliers.

2.2 Limitations of the Existing BBN based Models

Many studies have focused on specific domain of SCRM like supplier selection, supplier evaluation and ranking. BBNs have not been fully explored for capturing the holistic view of supply network. Furthermore, it is not only important to consider the probabilistic interaction between risks but also take into account the resulting losses and costs and benefits associated with different control strategies. A comprehensive risk management modelling approach must be able to address all stages of risk management. Our study is supposed to bridge the mentioned research gap.
In a recent study conducted by Garvey et al. (2015), supply chain process and risks corresponding to various segments of the supply network are combined together and modelled as a BBN. New risk measures are also

proposed for identification of important elements within the supply network. The proposed model considers risk analysis under a given configuration whereas it is important to evaluate different risk mitigation strategies. Expected location risk contribution factor (ELRCF) is proposed as a measure for calculating the expected aggregated loss value including losses at the location and propagation of resulting losses across pure descendants corresponding to all possible scenarios at the specific location. Association of this measure with each element of the supply network rather than risk factor itself results in a major problem because for all different combinations of instantiation of risk factors corresponding to each element, propagation across the pure descendants only depends on the state of specific parent node that connects risks of that element to the rest of risk factors. Furthermore, in case of a large network, it will not be feasible to track the losses across pure descendants only. Instead of defining the measure for each element of supply network, it would be better to associate this measure with each risk factor. In that case, there would be no requirement of tracking various scenarios that increase exponentially with the increase in number of risk factors defined for each element of the supply network. Instead of relying on the pure descendants, entire Bayesian network can be easily monitored for change in the risk exposure.

Propagation ratio has been introduced as the total amount of propagation loss for all scenarios at a location divided by the total amount of loss for all scenarios. The main problem with this measure relates to the fact that it has not been normalized against a common denominator and therefore, it is not possible to compare different nodes on the basis of propagation ratio. A node having a propagation loss of 2 units against the total location specific loss of 1 unit will result in the propagation ratio of 2 whereas another node having a propagation loss of 1500 units against the total location specific loss of 1000 units will yield the ratio of 1.5.

3 Proposed Model

A discrete supply chain risk diagram $N = (X, G, P, L)$ is a four-tuple consisting of a directed acyclic graph (DAG), $G = (V, E)$, with nodes, V, representing discrete risk events, X_R, discrete redundancy strategies, X_S, and loss functions, L, and directed links, E, encoding dependence relations, a set of conditional probability distributions, P, containing a distribution, $P(X_R|X_{pa(R)})$, for each risk event, X_R, a set of loss functions, L, containing one loss function, $l(X_{pa(V)})$, for each node v in the subset $V_l \in V$ of loss nodes. Network expected loss, $EL(X)$, is calculated as follows:

$$EL(X) = \prod_{X_v \in X_R} P(X_v|X_{pa(v)}) \sum_{w \in V_L} l(X_{pa(w)}) \tag{1}$$

Supply network is considered to be in its standard configuration (SC) when all the redundancy strategies selected in the Bayesian network reflect real-time profile of these strategies in the supply network whereas supply network is considered to be in its contingency configuration (CC) when all the redundancy strategies in the Bayesian network are selected against the multi-criteria decision making of maximizing weighted summation of expected utility for loss exposure and utility of redundancy cost.

3.1 Risk Measures

We introduce two risk measures in order to evaluate the importance of risk factors in terms of their contribution towards the loss propagation across entire network.

3.1.1 Loss Propagation Containment Measure (LPCM)

Loss propagation containment measure is the ratio between relative improvement in the network expected loss corresponding to complete mitigation of the risk factor and network expected loss for the standard configuration.

$$LPCM_{X_{R_i}} = \frac{EL(X) - EL(X|X_{R_i} = false)}{EL(X)_{SC}} \tag{2}$$

$$Average\ LPCM\ (\overline{LPCM}) = 1/n \sum_{1}^{n} LPCM_{X_{R_i}} \tag{3}$$

3.1.2 Loss Propagation Spread Measure (LPSM)

Loss propagation spread measure is the ratio between range of network expected loss corresponding to the two extreme states of the risk factor and network expected loss for the standard configuration.

$$ELPSM_{X_{R_i}} = \frac{EL(X|X_{R_i} = true) - EL(X|X_{R_i} = false)}{EL(X)_{SC}} \tag{4}$$

$$Average\ LPSM\ (\overline{LPSM}) = 1/n \sum_{1}^{n} LPSM_{X_{R_i}} \tag{5}$$

3.2 Problem Statement

Given different levels of redundancy strategies and associated costs available at different nodes of the supply network, what is the optimal combination of these redundancy strategies yielding maximum utility for the decision maker?

3.2.1 Objective Function

The objective function is to maximize the weighted sum of normalized expected utility for network loss and normalized utility for cost of redundancy strategies.

$$\max_{\gamma_{x_S} \in \gamma_{X_S}} w * \overline{EU}\left(X_{\gamma_{x_s}}\right) + (1-w) * \bar{U}(C_{\gamma_{x_s}}) \tag{6}$$

$$EU(X) = \prod_{X_v \in X_R} P(X_v | X_{pa(v)}) \sum_{w \in V_U} u\big(X_{pa(w)}\big) \tag{7}$$

where γ_{X_s} is a set of all possible orderings of different states of n redundancy strategies $(x_{s_1} \times x_{s_2} \times \ldots \times x_{s_n})$

w is the relative importance of utility for loss exposure

$\overline{EU}(X)$ is normalized expected utility of the decision maker for loss

$C_{\gamma_{x_s}}$ is cost of implementing γ_{X_s} combination of redundancy strategies

$\bar{U}(C)$ is normalized utility of cost related to implementing redundancy strategies

4 An Illustrative Example

In order to demonstrate the application of our modelling approach, we make use of the supply network model presented by Garvey et al. (2015). However, our model is not the same as we aim to consider the evaluation of different redundancy strategies. The hypothetical supply network comprises raw material source (RM), two manufacturers (M1, M2), warehouse (W) and retailer (R). Each of the mentioned locations is termed as a risk element. In addition, there is another risk element ‘W-R’ which is the transportation link between the warehouse and retailer. Each risk element consists of risk factor(s) that can affect the respective element. Risk factors have been described in Table 1 with corresponding risk number and the risk element. The supply network is modelled in GeNIe as shown in Figure 1. All risk factors are represented by oval shaped nodes. Diamond shaped nodes represent loss values resulting from the realization of risks whereas rectangular shaped nodes denote redundancy strategies having binary states of ‘Yes’ and ‘No’. Assumed (conditional) probability and loss values for the model are shown in Table 2.

Table 1 Description of risk factors

Risk No	Risk Factor	Risk Element
R1	Contamination	Raw material source
R2	Delay in shipment	Raw material source
R3	Machine failure	Manufacturer No. 2
R4	Machine failure	Manufacturer No. 1
R5	Delay in shipment	Manufacturer No. 1
R6	Delay in shipment	Manufacturer No. 2
R7	Overburdened employee	Warehouse
R8	Damage to inventory	Warehouse
R9	Delay in shipment	Warehouse
R10	Truck accident	Warehouse-Retailer
R11	Inventory shortage	Retailer
R12	Flood	Warehouse

Table 2 (Conditional) probability and loss values

$[P(risk = F|parents) = 1 - P(risk = T|parents)]$

Parents				$P(risk\|parents)$					
				R1	R2	R3	R4	R5	R6
R1	R2	R3	R4	T	T	T	T	T	T
				0.4					
T					0.8				
F					0.3				
						0.2			
							0.3		
	T		T					0.7	
	T		F					0.4	
	F		T					0.6	
	F		F					0.1	
	T	T							0.9
	T	F							0.6
	F	T							0.5
	F	F							0.2
Loss				600	500	200	340	100	220

Parents							$P(risk\|parents)$					
							R7	R8	R9	R10	R11	R12
R5	R6	R7	R8	R9	R10	R12	T	T	T	T	T	T
							0.4					
		T				T		0.8				
		T				F		0.3				
		F				T		0.6				
		F				F		0.2				
T	T		T						0.9			
T	T		F						0.5			
T	F		T						0.6			
T	F		F						0.3			
F	T		T						0.4			
F	T		F						0.3			
F	F		T						0.3			
F	F		F						0.2			
										0.4		
				T	T						0.9	
				T	F						0.7	
				F	T						0.6	
				F	F						0.2	
												0.2
Loss							40	500	940	340	30	200

Conditional probability values of each risk factor given the implementation of respective redundancy strategy are given as Equations (8) and (9). Assumed utility functions and the value of criterion weighting 'w' are shown in Table 3. It is assumed that there is no redundancy strategy selected at any node under standard configuration.

$$P(risk = T|redundancy = Yes) = 0.0001 \tag{8}$$

$$P(risk = F|redundancy = No) = 0.9999 \tag{9}$$

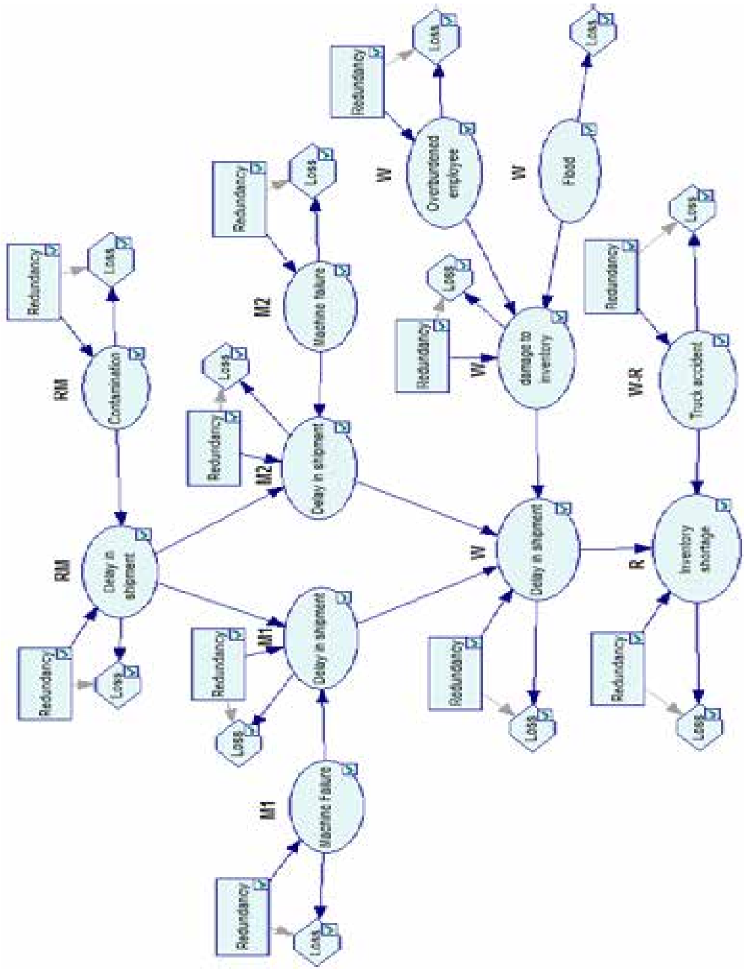

Figure 1 Supply network modelled as a Bayesian belief network in GeNIe

Table 3 Assumed parameters

Parameter	Assumption
w	0.5
$u(x)\ for\ risk\ neutral$	x
$u(x)\ for\ risk\ taking$	x^2
$u(x)\ for\ risk\ averse$	$\sqrt{x}$
$U(C)$	$1 - cost/max\ cost$

5 Results and Discussion

Three models were developed in GeNIe according to the utility functions representing different risk attitudes of the decision maker as given in Table 3. For each model, results of GeNIe were exported to Microsoft Excel for evaluating the risk measures and utility values. Objective function given as Equation (6) was solved for the three types of decision makers. Optimal combination of redundancy strategies for the risk-neutral decision maker is shown in Table 4. Redundancy number corresponds to the respective risk factor number and implementation state of 'Yes' represents adding redundancy at that node. Optimal combination resulted in achieving weighted utility sum of 0.61 at the total redundancy cost of 880 units.

Table 4 Optimal combination of redundancy strategies (risk-neutral decision maker)

Redundancy No	Cost	Implement
1	350	Yes
2	300	No
3	100	No
4	200	No
5	50	Yes
6	140	Yes
7	30	No
8	200	Yes
9	500	No
10	140	Yes
11	20	No

Risk measures were evaluated for the optimal combination of redundancy strategies as shown in Figure 2. LPCM values of 0 for the risk factors R1, R5, R6, R8 and R10 relate to the fact that redundancy has been added at the mentioned nodes and therefore, the specific risk factors are disconnected from the influence of parent nodes. It is interesting to note that R9 is the

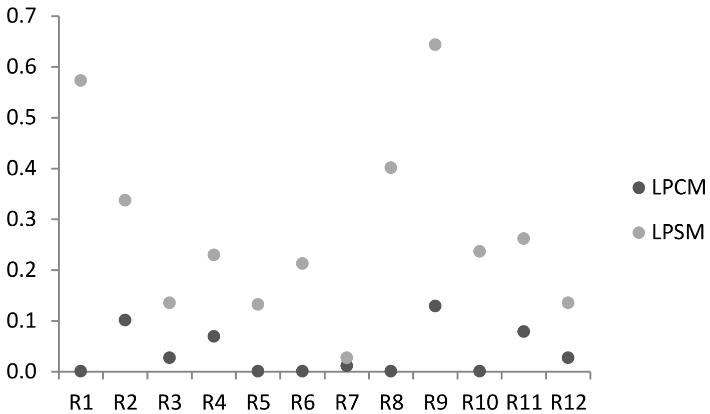

Figure 2 Risk measures of the supply network under contingency configuration (risk-neutral decision maker)

most important risk factor but the optimal combination of strategies does not necessitate implementation of redundancy strategy at the node.

Network expected loss is an important parameter that serves the central role in evaluation of our proposed risk measures. Network expected loss was evaluated for all combinations of redundancy strategies as shown in Figure 3. It can be observed that the rate of decrease in expected loss decreases gradually with the increase in redundancy cost. Furthermore, corresponding to each value of redundancy cost except the minimum and maximum costs, there are a number of possible combinations of strategies. All such combinations except the dark-shaded points result in inefficient solutions. Therefore, in case of a limited budget, the model can be used for selection of optimal mix of redundancy strategies for achieving the minimum value of network expected loss.

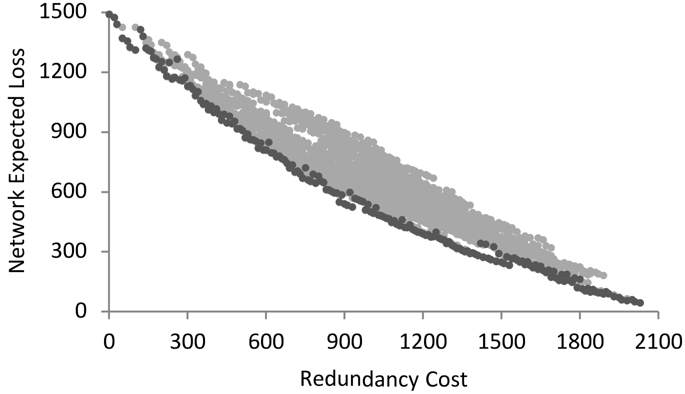

Figure 3 Variation of network expected loss with all possible combinations of redundancy strategies

Average LPCM represents the average value of LPCM for all the risk factors. Variation of this important measure is shown in Figure 4 with respect to all possible combinations of available redundancy strategies. As there are 11 redundancy strategies available across the supply network with each strategy having two states, there are a total of 2048 different combinations of redundancy strategies. The graph represents average LPCM values for all these 2048 strategies. Corresponding to a specific budget allocation for implementing redundancy strategies, there is a unique optimal combination of resource allocation across the network in order to achieve the minimum value of average LPCM. All such points are shown in dark shade representing the minimum points against specific redundancy cost. It is also evident from the graph that the rate of decrease declines sharply with the increase in redundancy cost.

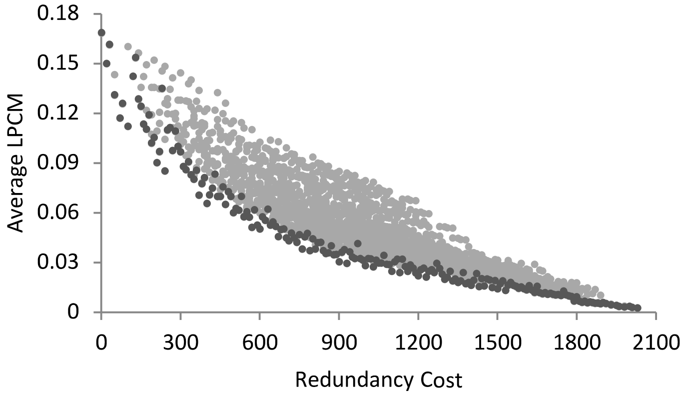

Figure 4 Variation of average LPCM with all possible combinations of redundancy strategies

Average LPSM represents the average value of LPSM for all the risk factors. Variation of this important measure is shown in Figure 5 with respect to all possible combinations of available redundancy strategies. Corresponding to a specific budget allocation for implementing a redundancy strategy, there is a unique optimal combination of resource allocation across the network in order to achieve the minimum value of average LPSM. All such points are shown in dark shade representing the minimum points against specific redundancy cost. It is also evident from the graph that the minimum average LPSM value remains unchanged after approximately 1300 units of redundancy cost.

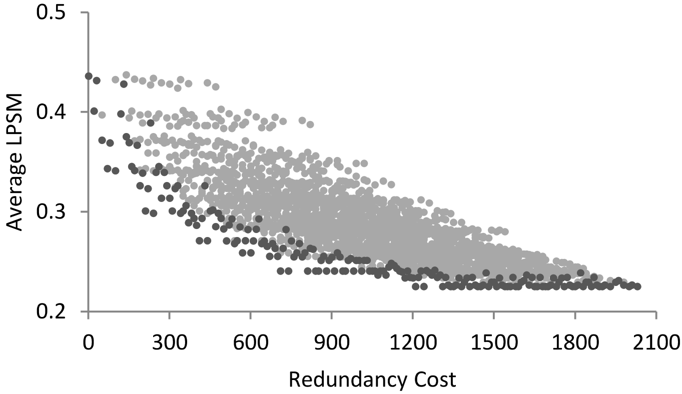

Figure 5 Variation of average LPSM with all possible combinations of redundancy strategies

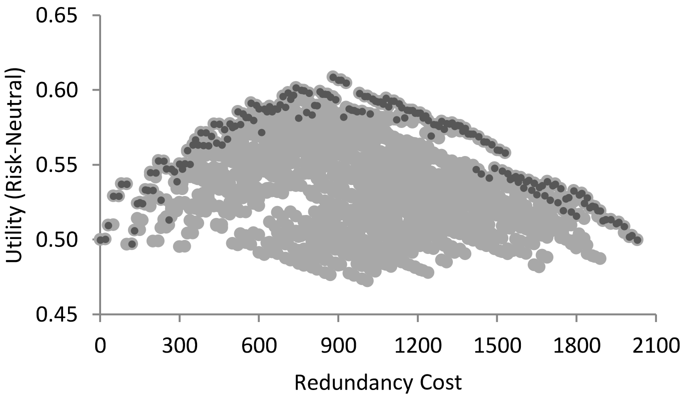

Figure 6 Variation of utility for risk-neutral decision maker with all possible combinations of redundancy strategies

Utility of the risk-neutral decision maker was calculated against all possible combinations of redundancy strategies as shown in Figure 6. There can be a number of combinations of redundancy strategies against specific budget allocation, however, only a unique combination results in maximizing the utility value. Dark shaded points represent all such combinations that maximize the utility values against specific redundancy cost. The maximum utility value is 0.61 corresponding to the total redundancy cost of 880 units. Utility of the risk-averse decision maker was calculated against all possible combinations of redundancy strategies as shown in Figure 7.
Dark shaded points represent all combinations of redundancy strategies that maximize the utility values against specific redundancy cost. The maximum utility value is 0.62 corresponding to the mitigation cost of 930 units.

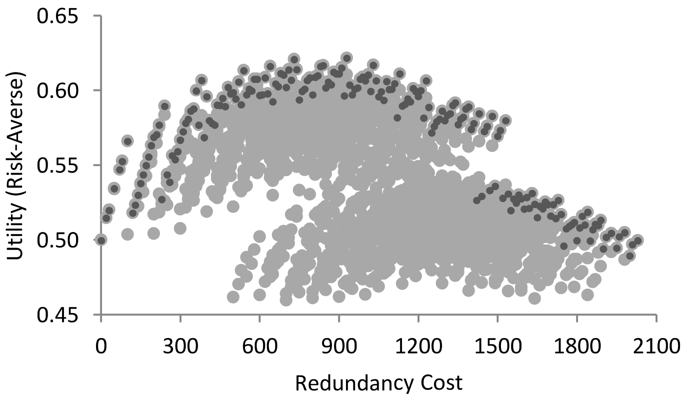

Figure 7 Variation of utility for risk-averse decision maker with all possible combinations of redundancy strategies

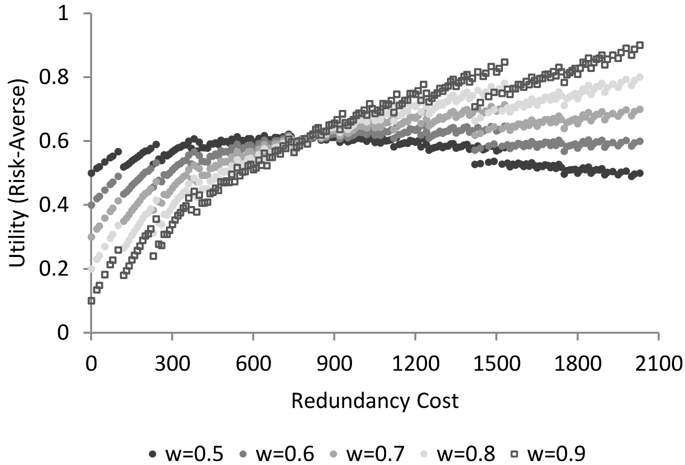

Figure 8 Variation of maximum utility for risk-averse decision maker with redundancy cost corresponding to different weighting schemes

It is important to consider that equal weightage was assigned to the two attributes of utility for cost and expected utility for loss exposure. Risk-averse decision makers might allocate higher weightage to the expected utility for loss and it might influence the results as shown in Figure 8. As more weightage is given to the expected utility for loss, the decision maker is less concerned with the disutility of redundancy cost and therefore, optimal solution is represented by a combination of strategies having higher redundancy cost. Utility of the risk-taking decision maker was calculated against all possible combinations of redundancy strategies as shown in Figure 9.

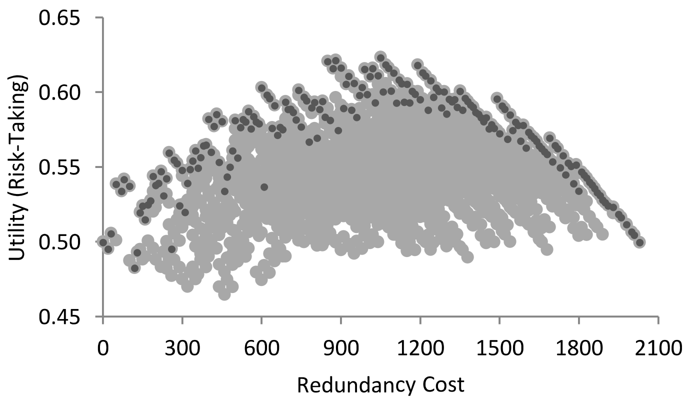

Figure 9 Variation of utility for risk-taking decision maker with all possible combinations of redundancy strategies

Dark shaded points represent all combinations of redundancy strategies that maximize the utility values against specific redundancy cost. The maximum utility value is 0.62 corresponding to the mitigation cost of 1050 units. Again, equal weightage was assigned to the two attributes of utility for cost and expected utility for loss exposure. Risk-averse decision makers might allocate lower weightage to the expected utility for loss and it might influence the results as shown in Figure 10. As lesser weightage is given to the expected utility for loss, the decision maker is more concerned with the disutility of redundancy cost and therefore, optimal solution is represented by a combination of strategies having lower redundancy cost.

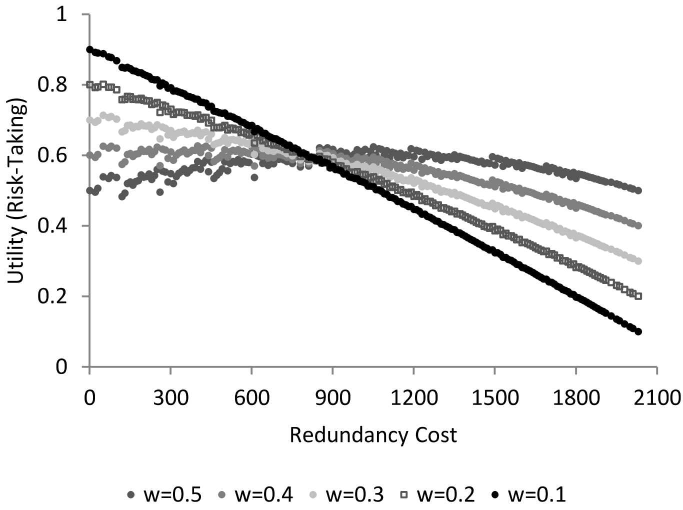

Figure 10 Variation of maximum utility for risk-taking decision maker with redundancy cost corresponding to different weighting schemes

Maximum utility values for all three risk attitudes of the decision maker were plotted against redundancy cost as shown in Figure 11. Equal weightage was assigned to both the criteria of the objective function. Initially, as the network expected loss decreased sharply with the increase in redundancy cost, risk-averse decision maker was more sensitive to this change in comparison with other types of decision maker. Afterwards, risk-taking decision maker was achieving higher utility values because of the reversal of the mentioned phenomenon.

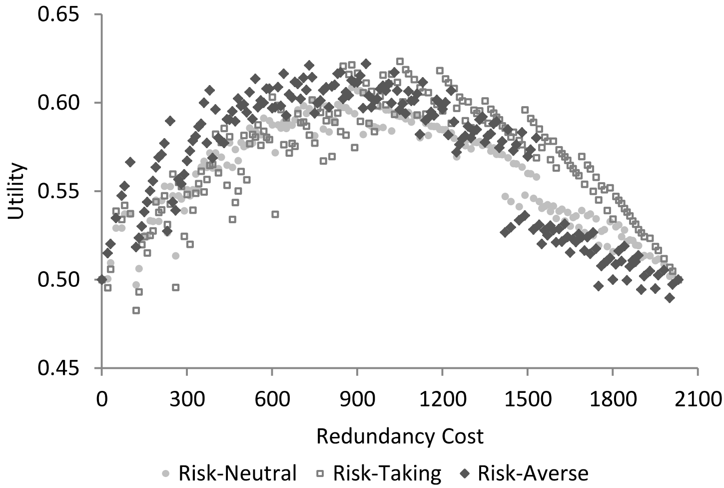

Figure 11 Variation of maximum utility values with redundancy cost for three different risk attitudes

It is also important to consider the variation of maximum expected utility values for loss and utility for cost with redundancy cost corresponding to three different risk attitudes as shown in Figure 12. Utility function of cost was assumed as linear. For risk-neutral decision maker, the graph of expected utility for loss is the mirror reflection of graph for expected loss.

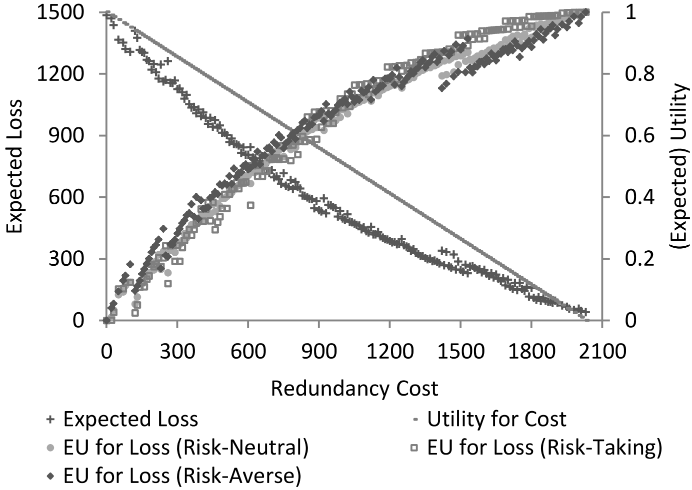

Figure 12 Variation of maximum expected utility values for loss and utility for cost corresponding to three different risk attitudes with redundancy cost

6 Conclusion

Supply chain risk management is an active area of research demanding development of effective techniques for capturing the interdependency between risks. Bayesian networks can be used for modelling the complex nature of interacting risks; however, current studies have not fully utilized the strength of this modelling technique. We have proposed a new approach of modelling the supply network configuration, probabilistic interdependency between risks, resulting losses and redundancy strategies that not only captures the dynamics across supply chain risks but also covers all aspects of risk management process. New risk measures have been introduced for evaluating the relative contribution of each risk factor towards the network expected loss. The proposed method was demonstrated through a simple example taking into account the risk attitude of a decision maker. Redundancy strategy at a node was incorporated through disconnecting the node from its parent node(s). Therefore, in case of a redundancy strategy at a node, the probability of risk occurring at the node would be extremely low. Furthermore, given a certain budget allocation, it was shown that there would be a number of ineffective allocations of redundancy strategies across the network and the optimal combination could only be selected through the proposed method.

Risk attitude of the decision maker can highly influence the final outcome and therefore, it is important to consider the relative importance of expected utility for loss exposure with respect to the utility for redundancy cost. The proposed method is considered as an important contribution to the literature in terms of introducing a new approach of capturing the interdependency between risks and covering all stages of risk management process. In future, research may focus on the application of proposed method in different industries.

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Inland Transportation and Lead Time of Apparel Exports

Anupama Gupta, Pinaki Dasgupta and Mridula S. Mishra

The purpose of this research was to study the relationship of severity levels of road and rail transportation activities and related issues and challenges in terms of their effect on delivery lead time of Indian apparel exports. The research was conducted in India and 157 managers handling ocean freight operations of apparel export shipments participated. It was found that lack of professionalism/skill levels of truck drivers and bad quality/condition of roads are the two most significant logistics challenges in road transportation that affect delivery lead of Indian apparel exports. The next significant issues and challenges explaining the severity level of road transportation were found as delay involved in interstate regulatory check points and inefficient /older technology inbuilt in trucks /trailers. Lack of planning and coordination in cargo rail services and lack of frequency of container rail services due to evacuation constraints were identified as two most significant logistics challenges in rail transportation that affect delivery lead of Indian apparel exports. The next significant issues and challenges explaining the severity level of rail transportation were found to as non availability of rakes/wagons and less number of dedicated tracks for container rail.

Keywords: Apparel Exports, Delivery Lead Time, Road Transportation, Rail Transportation

1 Introduction

The apparel industry is a classic example of global sourcing and is one of the oldest and largest export industries. It is also one of the most global industries because most nations produce for the international textile and apparel market (Stengg, 2001; Gereffi and Frederick, 2010). International sourcing involves longer lead time than domestic sourcing and is affected by international logistics activities resulting in delayed delivery (Cho and Kang, 2001; Yu, 2011; Yu and Lindsay, 2011). In the context of international purchasing, the key variable underlying logistics factors are lead-time (Lucero, 2008). Lead time is one of the most critical factors in sourcing fashion apparel products (Froza and Vinelli, 2000; Christopher and Towill, 2002; Kam et al, 2011; Candace et al, 2011). The delivery date of apparel export shipments are often not met due to issues and challenges involved in logistics activities (Ahsan and Azeem, 2010). Therefore, the focus of the present research was to study logistics issues and challenges and their severity levels in terms of affecting delivery lead time of apparel exports.

2.1. Apparel supply chain and sourcing complexities

Apparel supply chain is complex and characterised by short product life cycles, tremendous product variety, volatile and unpredictable demand, long and inflexible supply processes (Lam and Postle, 2006; Sen, 2008). The supply network includes different kinds of retailers, agents, garment manufacturers, yarn/fabric producers, trims/embellishment producers, freight forwarding and warehousing companies, etc. Every stakeholder in the apparel supply chain has separate set of challenges which are interlinked. Maintaining delivery lead time is primarily the responsibility of apparel export manufacturing units which face intense competition (Lim and Lam, 2007;

Watchravesringkan et al, 2009) and are always under pressure of low cost production (Lim and Lam, 2007) in less time (Gereffi and Frederick, 2010, Ahsan and Azeem, 2010). Apparel export supply chain has various kind of logistics related complexities like underdeveloped domestic infrastructure, inter modal transportation related issues and challenges (Kalegama, 2009; Watchravesringkan et al, 2009, etc).

2 Apparel Supply Chain and Sourcing Complexities

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2.1 Role of Freight Forwarders in Apparel Export Supply Chain

Apparel exporters normally outsource their logistics activities to third party who are freight forwarders. The selection of freight forwarders and carriers is generally based on the buyer's choice or requirement (Yu and Lindsay, 2011). Freight forwarders are international trade specialist who can manage variety of logistics related function to facilitate the movements of cross border shipments. Some of the logistics functions are booking vessel space, preparing relevant documentation, paying freight charges on behalf of shipper/buyer, arranging inland transportation services, many value added services, etc. (Murphy and Daley, 2000; Costes et al, 2009).

2.2 Indian Apparel Exports

The textiles and clothing industry is one of the mainstays of the Indian national economy. The textiles industry accounts for 14% of industrial production, which is 4% of GDP and employs approximately 45 million. Readymade garments account for almost 39% of the total textiles exports (Annual Report, Ministry of Textiles 2012-13). Buyers work with Indian suppliers because of category expertise, a high level of convenience, functional capabilities, effective pricing structures, and good service (Singh, 2008).

2.3 Challenges of Indian Apparel Industry

It was estimated that India's share in world trade could quadruple from about 4 % to 15 % after the removal of Multi Fibre Agreement (Nordås, 2004) but India could not ever cross even 4 % share of world apparel exports (ITS statistics, WTO, 2003-2013). China was the clear winner along with Bangladesh, Vietnam and Cambodia performing very well but India's performance was disappointing (Thoburn, 2010).

The reasons for India not reaching to its predicted potential performance are many. Indian apparel industry suffers from technological obsolescence, fragmented capacities, low scales of operation, rigid labour laws, less competitive pricing, product quality, business culture issues, poor logistic support, etc. (Tewari, 2005; Singh, 2008). Few research studies have mentioned about logistics challenges affecting Indian apparel exports industry like port infrastructure, customs regulation, cumbersome inspection, poor rail and road infrastructure, poor quality of inland roads, large number of octroi posts, lack of available space, slow clearance time, no link facility at ports and airports (Ramachandran, 2001; Shetty, 2001 ; Verma, 2002).

2.4 Business Process of Apparel Exports and Outbound Logistics Activities

The business process analysis of outbound logistics process of apparel exports can be explained in nine steps: arrange transport, arrange for inspection, obtain cargo insurance, collect empty container from yard, stuff the container, transportation to port of departure, customs inspection and clearance, container handling and prepare documents for importer (Ramasamy, 2011). The steps of arranging transport and transportation to port of departure can be categorised under inland transportation. The focus of the present study is to cover inland transportation activities under road and rail transportation.

2.5 Road Transportation Activity

India's road network is second largest in the world. Roads carry about 65% of the freight and 80% of the passenger traffic. National highways constitute 1.7% of all roads and carry 40% of the road traffic. It is evident from these data that road transit is most important mode of freight transportation in India. Irrespective of continuous efforts through projects and regular work by the authorities, still there are many issues and challenges.

2.6 Issues and Challenges in Road Transportation

1) Delay at regulatory check points: During road transit of cargo from factory premises to gateway seaport; it has to cross many state borders. All of these state borders have several regulatory check points to inspect export and transport documents and physical check of cargo, if required (Mitra, 2011; Gupta et al, 2010). 2) Time bound vehicle entry restrictions in cities: Many highways pass through the small and big cities. These cities put entry restrictions for the cargo trucks to enter and cross the city during day time to avoid inconvenience (Subramanian and Arnold, 2001; Planning Commission Report, Government of India, 2007; Gupta et al, 2010). 3) Unavailability of trucks/trailers: Availability issue of trucks and trailers may not be there in all areas. But in few areas, shippers face this challenge (Horst and Langen, 2008). 4) Technology level of existing vehicles: Most of the cargo trucks do not have inbuilt tracking technology through GPS which makes it difficult to have real time and correct information. The trucks are also ill maintained which leads to breakdown of vehicles. (Hsu et al, 2009; Gupta et al, 2010; Shi et al, 2011; Kemp et al, 2013). 5) Professionalism/skill level of drivers: This is big area of concern as drivers become the sole caretakers

of the cargo during transit. The maintenance of vehicle during transit, safeguarding of vehicle from any breakdown/damage/accident and safeguarding of cargo from damage/theft/pilferage is very crucial issue for road transportation (Fugate et al, 2009; Kemp et al, 2013). 6) Inadequate road networks: Although India has second largest road network in the world but still inadequacy of road network is felt in case of freight transportation (Peters, 1990; Mitra, 2011). 7) Poor quality/condition of roads: It has been observed that roads are narrow and made of substandard quality materials. Moreover, the maintenance and repair work of roads are not as per standard. Many road accidents and traffic congestions are also due to poor quality and conditions of roads (Sahay and Mohan, 2006; Planning Commission Report, Government of India, 2007).

3 Indian Apparel Clusters under the Study

Indian apparel clusters (AEPC, 2010) were considered for the study. The seven clusters, Tirupur, Ludhiana, Gurgaon, Bangalore, Noida, Okhla and Jaipur were selected for the study. All selected clusters are located in landlocked regions and require inland transportation to reach gateway seaport.

3.1 Hypotheses Statements

Within the purview of the present research objective about measurement of severity level of key issues and challenges and outbound logistics activities that affect delivery lead time of apparel exports in consideration, following hypotheses statements were made basis the literature review.

Literature review for the present study explained that road transportation activity has many issues and challenges. Bad quality/condition of roads, time bound vehicle entry restriction in cities, unavailability of trucks/trailers, delay at regulatory check points, older technology level of existing vehicles, lack of professionalism/skill levels of drivers, inadequate road networks, traffic congestion, and unfavourable weather conditions are problem areas.

Therefore the hypothesis statements related to road transportation activity are:

H_{01}: There is no significant relation between severity levels of road transportation activity and its issues and challenges that affect delivery lead time of apparel exports.

H_{a1}: There is a significant relation between severity levels of road transportation activity and its issues and challenges that affect delivery lead time of apparel exports.

Literature review highlighted that rail transportation faces various issues and challenges like coordination/planning issues, absence of dedicated and good quality tracks, availability of rakes/wagons, low priority to cargo trains over passenger trains and unfavourable weather conditions.

Therefore the hypothesis statements related to rail transportation activity are:

H_{02}: There is no significant relation between severity levels of rail transportation activity and its issues and challenges that affect delivery lead time of apparel exports.

H_{a2}: There is a significant relation between severity levels of rail transportation activity and its issues and challenges that affect delivery lead time of apparel exports.

4 Research Approach and Design

The study was divided in two stages. Descriptive cross-sectional research design was adopted for the study. In the first stage pilot study was conducted with the help of Delphi technique and at the second stage survey was undertaken through structured questionnaire.

4.1 First Stage: Pilot Study

Pilot study was conducted to with the purpose of validation of issues and challenges involved in road and rail transportation activities of apparel exports and identification of any other issues and challenges beyond available literature.

16 experts holding post in senior management and having experience of more than 20 years in handling logistics of apparel export shipments participated in pilot study (Stakeholders covered: Manufacturer exporters, Freight Forwarders).

In the first stage questionnaire 12 logistics issues and challenges under road and rail transportation activities were mentioned for validation. All experts were not in agreement for availability of trucks/trailers being a challenge in present Indian scenario. In second round all experts agreed that the same issue may not be considered in present context. Experts validated rest all issues and challenges for Indian apparel exports.

The detail of identified issues and challenges under road and rail transportation activities in context of Indian apparel exports are listed below,

Road Transportation:

1. Bad quality /condition of roads
2. Inefficiency /older technology (GPS, etc.) inbuilt in trucks /trailers
3. Lack of expansion of road network
4. Lack of professionalism/skills of truck driver
5. Delay involved in interstate regulatory check points
6. Waiting time due to vehicle entry restrictions in cities

Rail Transportation:

1. Lack of availability of rakes/wagons for rail transportation
2. Lack of number of dedicated tracks for container rail transportation
3. Lack of regular frequency of container rail services due to evacuation constraints
4. Lack of planning and coordination in cargo rail services
5. Lack of priority to passenger trains over container trains

4.2 Second Stage: Survey

The objective of survey was to measure severity levels and analyse relationship between severity levels of existing challenges and road/rail activities through quantitative research. The research studies having similar kind of focus were identified to decide on the measurement scale selection for the study. Razzaque (1996) employed 5 point Likert scale to rate the variables which were viewed as challenges in the development of logistics in Bangladesh. Carter et al (1997) used 5 point Likert scale to measure the severity of the logistics barriers in China. Ta et al (2000) employed 7 point Likert Scale to rate the degree of seriousness for various transportation problems. Ozdemir (2010) used 5 point Likert to measure variables indicating weaknesses of Istanbul as a regional logistics centre.

Considering above, Likert scale was chosen for this part of study. One participant each from all five target apparel clusters were chosen for scale evaluation and personal interview was conducted. Content validity was done to check the coverage of construct to be measured. Participants agreed on the applicability of the scale for the study and also commented positively on the scale's relevance for the landlocked apparel clusters sending export shipments through sea mode.

Three questions on five point Likert were prepared keeping the objective in consideration. The first question was designed to rate road and rail transportation activities of Indian apparel exports in terms of their severity level of affecting delivery lead time. Rest two questions were designed to rate respective issues and challenges of road and rail transportation activities in terms of their severity level of affecting delivery lead time. All questions were deigned on 5 point rating scale in which 1 was indicated as "least severe" and 5 being "most severe". Pretesting of questionnaire was done through electronic mode and personal telephonic interviews. 15 respondents (3 each from 5 apparel clusters) participated for pretesting and debriefing method was adopted. Two participants gave feedback in terms of language modification which was incorporated.

4.2.1 Sampling Design for the Survey

Freight forwarders handling apparel export shipments in the selected area of study (all 5 apparel clusters) were targeted for this stage of study. Managers handling ocean freight operations of apparel export shipments were requested to participate in this survey. Since there was no database available of the freight forwarding organisations that handle apparel export shipments hence, snowball sampling technique was chosen for the study. In total 36 freight forwarders were approached. All branch offices of freight forwarders located in selected apparel clusters were contacted. In response, 157 managers handling ocean freight operations of apparel export shipments participated in the survey. Data was collected through online method. Four rounds of reminder e-mails and follow up calls were made in the time span of 65 days. It took 70 days to get the response from 157 managers.

4.2.2 Data Analysis

Considering the objective of study and developed scale, principle component factor analysis and multiple regression analysis were chosen as data analysis tools. Component analysis was used to check the grouping of considered items in the scale. Version 16.0 of SPSS software package was used for statistical analysis.

The KMO measure of sampling adequacy value was 0.867 which is interpreted as meritorious (Hair et al, 2006). The result of Bartlett's test of sphericity was also significant. The two factors accounted for 72.23% of total variance.

Table 1 Rotated Component Matrix

	Factor 1	Factor 2
Lack of number of dedicated tracks for container rail transportation		0.8207
Lack of frequency of cargo rail services due to evacuation constraints		0.8677
Lack of planning and coordination in cargo rail services		0.8976
Lack of availability of rakes/wagons for rail transportation		0.8794
Lack of priority to passenger trains over container trains		0.7433
Bad quality /condition of roads	0.8700	
Inefficiency /older technology inbuilt in trucks /trailers for road transit	0.7830	
Lack of expansion of road network	0.8076	
Lack of professionalism/skills of truck driver	0.8329	
Waiting time due to vehicle entry restrictions in cities	0.7808	
Delay involved in interstate regulatory check points	0.8144	

As per table 1, factor 1 comprises of all items considered in scale under road transportation activity and factor 2 comprises of all items under rail transportation activity. Reliability test was done for both these factors. The Cronbach's alpha value for both road transportation and rail transportation activity factors was 0.913.

The purpose of employing multiple regression analysis was to study the relationship of severity levels of road and rail transportation activities and their related issues and challenges in term of their effect on delivery lead time of Indian apparel exports.

Road Transportation Activity: For the factor representing road transportation activity the following issues and challenges were loaded: Lack of professionalism/skills of truck driver (X_1), Bad quality /condition of roads (X_2), Delay involved in interstate regulatory check points (X_3), Level of inefficiency /older technology inbuilt in trucks /trailers (X_4), Lack of expansion of road network (X_5), Waiting time due to vehicle entry restrictions in cities (X_6).

All six issues and challenges were considered as independent variables and road transportation activity was considered as dependent variable (Y_1). Following represents the model summary of stepwise multiple regression done.

Table 2 Model Summary of Stepwise Multiple Regression (Road Transportation)

Overall Model Fit					
Model	R	R^2	Adjusted R^2	Std. Error of the Estimate	
Step 4	0.878	0.771	0.765	0.490	
R^2 Change Statistics					
Model	R^2 Change	F Change	df1	df2	Sig. F Change
Step 4	0.017	11.428	1.000	152.000	0.001

Model 4- Predictors: (Constant), X_1, X_2, X_3, X_4, Dependent Variable: Y_1

Model 4 is the final multiple regression model and the value of multiple R and R^2 was 0.878 and 0.771 respectively. The value of adjusted R^2 was 0.765 which indicated the final model was able to explain 76.5% of the variance. The standard error of the model which measures the variation around the regression line decreased to 0.49 showed good overall model fit. The F value in final model was 128.77 which is more than the corresponding critical F value of 4.39. The significance value showed that the regression model is significant.

Following table shows the coefficient value of final model. The four regression coefficients plus the constant, were significant both at .05 and .01 level. The t values for all were more than corresponding critical t value of

1.976. The collinearity statistics was studied it was found that the tolerance values for the variables in the equation ranged from 0.552 to 0.357. All values were well above the cut off value of 0.1 (Hair et al, 2006). The VIF value ranged from 1.812 to 2.8 which is less than cut off value of 10 (Hair et al, 2006).

Table 3 Table of Coefficients for final model of Regression (Road Transportation)

Coefficients of Final Model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
4	Const.	0.609	0.140		4.348	0.000
	X_1	0.239	0.046	0.314	5.192	0.000
	X_2	0.220	0.051	0.282	4.347	0.000
	X_3	0.173	0.042	0.216	4.138	0.000
	X_4	0.167	0.049	0.213	3.381	0.001

The predictive equation based on four independent variables is:

$$Y_1 = 0.609 + 0.239\,X_1 + 0.220\,X_2 + 0.173\,X_3 + 0.167\,X_4 \qquad (1)$$

Therefore the severity level of road transportation can be explained through severity levels of following four issues and challenges:

Severity levels of road transportation = 0.609 + 0.239 (Severity Level of lack of professionalism/skills of truck driver) + 0.220 (Severity Level of bad quality/condition of roads) + 0.173 (Severity level of delay involved in interstate regulatory check points) + 0.167 (Severity level of inefficiency/older technology inbuilt in trucks/trailers)

With the help of regression beta coefficients the relative importance of issues and challenges in the regression variate was analysed. Lack of professionalism/skills of truck driver and bad quality /condition of roads were most crucial followed by delay involved in interstate regulatory check points and inefficiency/older technology inbuilt in trucks /trailers.

Thus the alternate hypothesis, H_{a1} that there is a significant relation between severity levels of road transportation activity and its issues and challenges that affect delivery lead time of apparel exports was accepted.

Rail Transportation Activity: For the factor representing rail transportation activity the following issues and challenges were loaded:

Lack of frequency of container rail services due to evacuation constraints (X_7), Lack of planning and coordination in cargo rail services (X_8), Non availability of rakes/wagons for rail transportation (X_9), less number of dedicated tracks for container rail transportation (X_{10}), Lack of priority to passenger trains over container trains (X_{11}).

All five issues and challenges were considered as independent variables and rail transportation activity was considered as dependent variable (Y_2).

Following table represents the model summary of stepwise multiple regression done.

Table 4 Model Summary of Stepwise Multiple Regression (Rail Transportation)

Overall Model Fit					
Model	R	R^2	Adjusted R^2	Std. Error of the Estimate	
Step 4	0.928	0.861	0.858	0.412	
R^2 Change Statistics					
Model	R^2 Change	F Change	df1	df2	Sig. F Change
Step 4	0.016	17.267	1.000	152.000	0.000

Model 4- Predictors: (Constant), X_7, X_8, X_9, X_{10}, Dependent Variable: Y_2

Model 4 is the final multiple regression model and the value of multiple R and R^2 was 0.928 and 0.861 respectively. The value of adjusted R^2 was 0.858 which indicated the final model was able to explain 85.8% of the variance. The standard error of the model which measures the variation around the regression line decreased to 0.412 showed good overall model fit. The F value in the final model was 236.05 which is more than the corresponding critical F value of 4.39. The significance value showed that the regression model was significant.

Table 5 shows the coefficient value of final model. The four regression co-efficients plus the constant, were significant both at .05 and .01 level. The t values for all are more than corresponding critical t value of 1.976.

The collinearity statistics shown that the tolerance values for the variables in the equation ranged from 0.275 to 0.388 which are not below the cut off value of 0.1 (Hair et al, 2006). The VIF value ranged from 2.574 to 3.631 which is less than cut off value of 10 (Hair et al, 2006).

Therefore the severity level of rail transportation can be explained through severity levels of following four issues and challenges,

Severity levels of rail transportation = 0.467 + 0.215 (Severity Level of lack of frequency of container rail services due to evacuation constraints) + 0.230 (Severity Level of lack of planning and coordination in cargo rail services) + 0.207 (Severity level of non availability of rakes/wagons for rail transportation) + 0.173 (Severity level of less number of dedicated tracks for container rail transportation).

Table 5 Table of Coefficients for final model of Regression (Rail Transportation)

Coefficients of Final Model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
4	Const.	0.467	0.091		5.152	0.000
	X_7	0.215	0.046	0.270	4.693	0.000
	X_8	0.230	0.044	0.290	5.288	0.000
	X_9	0.207	0.039	0.259	5.336	0.000
	X_{10}	0.173	0.042	0.217	4.155	0.000

The predictive equation based on four independent variables is:

$$Y_2 = 0.467 + 0.215\,X_7 + 0.230\,X_8 + 0.207\,X_9 + 0.173\,X_{10} \tag{2}$$

With the help of regression beta coefficients the relative importance of issues and challenges in the regression variate was analysed. Lack of planning and coordination in cargo rail services, lack of frequency of container rail services due to evacuation constraints and non-availability of rakes/wagons for rail transportation most crucial followed by less number of dedicated tracks for container rail transportation. Thus the alternate hypothesis H_{a2} that there is a significant relation between severity levels of rail transportation activity and its issues and challenges that affect delivery lead time of apparel exports was accepted.

5 Findings of the Study

The major findings of the study are analysis of relationship between the road and rail logistics activities and their issues and challenges in the current Indian scenario. Out of six key issues and challenges related to road transportation activity, severity level of four issues and challenges were able to explain the 76.5 % of variance of severity level of road transportation in terms of affecting delivery lead time of Indian apparel exports. Lack of professionalism/skill levels of truck driver and bad quality/condition of roads emerged as two most significant logistics hindrances in road transportation that affect delivery lead of Indian apparel exports. The next significant issues and challenges explaining the severity level of road transportation were found to as delay involved in interstate regulatory check points and inefficient /older technology inbuilt in trucks /trailers.

Out of five key issues and challenges related to rail transportation activity, severity level of four issues and challenges were able to explain the 85.8 %

of variance of severity level of rail transportation in terms of affecting delivery lead time of Indian apparel exports. Lack of planning and coordination in cargo rail services and lack of frequency of container rail services due to evacuation constraints were identified as two most significant logistics hindrances in rail transportation that affect delivery lead of Indian apparel exports. The next significant issues and challenges explaining the severity level of rail transportation were found to as non availability of rakes/wagons for rail transportation and less number of dedicated tracks for container rail transportation.

6 Significance of the Study

In post MFA phase, the study holds significance because of changing pattern of the business of shorter fashion seasons/business cycles. This is in addition to the ever demanding buyers who look for shorter procurement lead time. In the post MFA scenario, combating sourcing challenges has become very crucial for apparel exporting countries to remain and grow in the global trade. In this regard, challenge of managing delivery lead time has become an important aspect for apparel trade. As a part of this, identifying and managing outbound logistics challenges have become critical in the process. The research has been able to adequately cover the perspectives of freight forwarders who analyzed micro level logistics issues and challenges in inland transportation activities with specific focus to apparel exports business from landlocked areas till gateway seaports. The study has been able to clearly identify the micro level issues and challenges that affect delivery lead time of apparel trade. Most of the studies, so far, aimed at identification of micro level issues, were either not sector driven or lacked export focus. From that context the study has been clearly been able to identify the micro level issues specific to apparel trade for inland transportation logistics activities.

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Identification of Design Variables for a Supply Chain Risk Management Audit

Meike Schröder, Johannes Beck and Wolfgang Kersten

Due to an increasing vulnerability in today´s supply chains a supply chain risk management (SCRM) system is strongly recommended, especially for companies with a high degree of dependence on supply chain partners. However, as a permanent and effective use of the SCRM system is not only ensured by a successful implementation, an appropriate control mechanism needs to be implemented. Auditing the SCRM system can be such a solution. The main objective of this study is the identification of variables and their possible design related to SCRM systems. Based on an extensive literature review aiming to identify those variables, an empirical study with experts in the field of auditing is carried out. The transmission of the results to the concept of SCRM leads to possible configurations of the variables, both for a general internal SCRM self-audit and an audit focused on small and medium sized enterprises (SME).

Keywords: Supply Chain Risk Management, Supply Chain Management, Auditing, SME

1 Introduction

Today´s enterprises are faced with an ever-stronger competition, increased customer requirements and shorter product lifecycles (Simchi-Levi et al., 2004). Along with an also increasing focus on core competencies, leading to outsourcing of specific operations, supply chains become more and more complex (Christopher, 2011) and result in global supply networks (Christopher and Peck, 2004). These networks and the close collaboration between the supply chain partners not only increase the dependence on each other, but also the vulnerability to risks (Christopher and Peck, 2004; Giunipero and Eltantawy, 2004). Occurring risks may spread throughout the entire supply chain (Jüttner et al., 2003). Especially in the recent past supply chain risks have amplified. Hence, more and more companies focus on handling these risks with an appropriate SCRM system. Nonetheless, implementing and operating such systems is yet not sufficient. To secure the sustainable success of a SCRM system it is advisable to introduce a control mechanism such as an audit.

2 Theoretical Background

In this chapter, the necessary theoretical foundations will be discussed. Apart from a brief introduction to SCRM this chapter focuses also on auditing in general.

2.1 Supply Chain Risk Management

Time has changed and companies are not standalone and independent business units anymore. Instead these companies focus progressively on their core competencies and become part of a global acting and complex supply chain (Christopher, 2005; Christopher, 2011). Christopher (2011, p. 4) defines a supply chain as “a network of connected and interdependent organizations mutually and co-operatively working together to control, manage and improve the flow of materials and information from suppliers to end users”. Figure 1 illustrates such a supply chain from the perspective of the focal company.

Increasing resilience in the supply chain results in two factors. First, no longer individual companies but entire supply chains compete with each other. Second, but not less important, that consequently induce to the situation that the individual success depends extremely on the cooperation with the supply chain partners (Christopher and Jüttner, 2000; Lambert, 2008; Christopher, 1998). Due to this changed circumstances companies

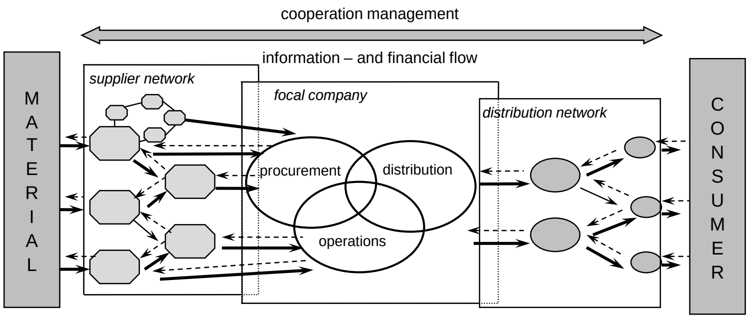

Figure 1 Supply chain structure (Bowersox, 2002)

are no longer only faced with risks from their own business activities but also exposed to risks from the close cooperation with companies in the supply chain. These so-called supply chain risks are described by Kersten et al. (2007) as damage, linked to a probability of occurrence, and concerns several companies at the same time. The reason for that damage could be found within the company, inside the supply chain or the environment.
According to Christopher and Peck (2004) figure 2 illustrates a classification of such supply chain risks. Thus, the source of a supply chain risk might be within the focal company itself, in a company that is part of the supply chain or in the environment with a resulting effect on any supply chain partner.

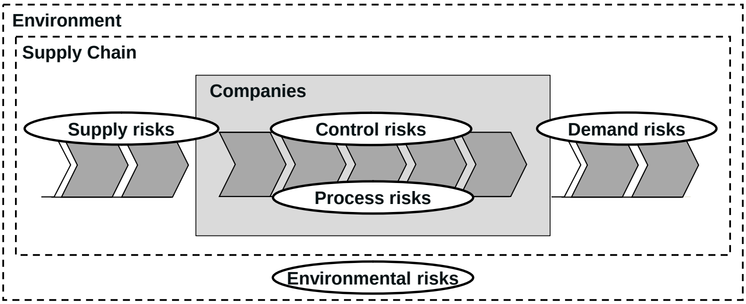

Figure 2 Sources of supply chain risks (modeled after Christopher and Peck, 2004)

2.2 Auditing

Initially the concept of auditing was used in the field of business and finance to assess the performance level of a specific object. Later on it was transferred to various others sectors. For a long time an audit used to be only a target-actual comparison, in which the current state of the object is checked against the respective specifications and requirements (Schwarz, 2010). Meanwhile, a more dynamic approach was established as well, which goes beyond the static target-actual comparison but also aims to improve the audited object (Gietl and Lobinger, 2004). Today the most common audit is probably the quality audit which has changed the quality management significantly in the recent years (Wildemann, 2002). Regardless of the field of application audits can be categorized based on two features. Initially the position of the auditor distinguish between an internal audit (auditor is employed by the audited company) and an external audit (auditor is not employed by the autited company) (DGQ, 2008). In addition the objective of investigation can differ significantly. A process audit aims to investigate a specific process whereas a system audit concentrates on a whole system (e.g. quality system).

According to Neumann (2012) all audits share a common structure and consist of three phases: (1) preparation, (2) realization and (3) tracking.

3 Identification of Design Variables

The identification of the design variables follows a three-step process. First, relevant literature was reviewed and identified variables and corresponding characteristics were studied. The second step contains an empirical study with experts in the field of auditing. Third, in a consolidation the results of the research are summed up and therefore enable a transmission to a possible SCRM audit.

3.1 Literature Review

An extensive literature review provides the basis for further steps. Standards and guidelines for auditing and risk management are considered as an important source for the identification of relevant variables. Furthermore, SCRM concepts are reviewed. The main goal during the literature review was the identification of the variables, not their specific design. More than 30 sources were analyzed and a total of 16 variables were identified. The theory-based variables can be assigned to – analogously to ISO (2011) – the three phases of an audit: (1) preparation, (2) realization and (3) tracking. Furthermore, they can be classified within the phases based on their content either in organizational, personnel or information and technology (IT) category, as illustrated in table 1.

The variables characterize the development of an audit significantly. E.g. the question concerning the main responsibility for the audit determines the organizational structure of the audit strongly. All other variables are shown and explained in table 2.

Table 1 Theory-based variables assigned to three audit phases

Audit Phase	Organization	Personnel	IT
Preparation	main responsibility	audit responsibility	reporting
	audit organization	audit team	
	audit objective		
	audit policy		
Realization	joint audit vs. single audit		documenta-tion
	audit configuration		I&C technology
	audit criteria		
	audit methods		
Tracking	interface for improvements	performance evaluation of auditors	
	audit scores		

Table 2 Short description of the design variables

Design variable	Description
Main responsibility	Most sources adjudge the main responsibility for the audit to the top management.
Audit organization	Independence and objectivity are essential prerequisites. For that reason it is recommended to establish the audit at an independent unit in the company.
Audit objective	The objective can be diverse: Assessment of compliance with standards or the effectiveness and efficiency. Furthermore the objective may be the finding of potential improvements.
Audit policy	The audit policy defines whether audits are performed regularly or only when necessary.
Joint audit vs. single audit	There is a need to make a decision either the audit should be performed individually as a single audit or together with another audit e.g. quality audit.
Audit configuration	Frequency, scope and focus of the audit need to be clarified.
Audit criteria	The reference base needs to be defined to enable a comparison with the audited object.
Audit methods	Suitable methods regarding other variables must be selected.

Design variable	Description
Interface for improvements	An interface between the results and the object needs to be established to ensure effective improvement.
Audit scores	The audit itself needs to be reviewed to achieve continuous improvement.
Audit responsibility Audit team	The decision who will be the auditor (operational audit responsibility) is closely related to the decision if an audit team might make sense. Objectivity and independence are of great importance. Hence, an audit team can fulfill these prerequisites more easy.
Performance evaluation of auditors	To ensure the audit quality a performance evaluation of the auditor(s) is recommendable.
Reporting	An appropriate reporting is essential for the preparation phase.
Documentation	In addition to the results, also roles and responsibilities need to be communicated and documented in an appropriate way.
I&C technology	Necessary Information & Communication technology should be provided to ensure full and confidential communication to all involved parties.

3.2 Expert Study

In order to develop a deeper understanding of the practical relevance and the design of the theoretically identified variables a qualitative research design was chosen. This study focuses on the exploration of the relevant variables of an audit and their design in different fields. In particular, obtaining a detailed understanding of the design of these variables aims at enabling a transfer to the SCRM audit. A structured qualitative content analysis is applied which involves the preliminary work from the literature analysis.

3.2.1 Approach

The main goal of a qualitative content analysis is to edit and analyze communication material systematically and being able to draw conclusions regarding specific features (Mayring, 2010). In this study the collection of the communication material is part of the research process. By means of semi-structured interviews several experts from different fields were consulted. The selection of the interview partners follows an approach to maximize the contrast by that is ensured a substantiated transfer to the diversified concept of SCRM. Table 3 illustrates the different characteristics of the consulted experts.

Table 3 Characteristics of the consulted experts

Industry	Position	Company size (EE)	Audit field	Type of audit
Rail vehicle construction	Manager strategic sourcing	~ 2700	Quality & supplier	Internal & External
Aviation	Supply chain manager	~ 70000	Quality	Internal & External
Wind energy	Head of quality management	~ 250	Work safety, quality and environment	Internal & External
Consulting	Management consultant	~ 2500	Quality, environment & supplier	Internal & External
Auditing company	Auditor	~ 150	Financial auditing	External

3.2.2 Results

The interviews were conducted in September and October 2014 either face-to-face or via telephone with a length between 30 and 60 minutes and transcribed afterwards.

The qualitative content analysis follows the approach of Kuckartz (2014) and consists of 7 phases. During phase 1 the material needs to be read,

marked and commented preliminary for the following steps. Phase 2 aims to develop the main categories, however due to the preliminary work during the literature review most main categories were already identified. Coding starts in phase 3 where text is assigned to the main categories. Phase 4 and 5 includes the consolidation of the coded text by the main categories and if necessary a further diversification or the addition of another main category. The category system is the basis for another complete coding process in phase 6. The material is coded and assigned again and the result is an appropriate matrix and the basis for phase 7 in which the material is analyzed and evaluated. The analysis is category-based and the main focus is to find out which variable has a high practical significance and the different designs of the variables. Based on this information an adaption to the concept of SCRM seems legitimate.
According to the interview results, all relevant design variables were identified in the preliminary work. Nevertheless the consulted experts noted that the variable I&C Technology is relevant not only for the realization phase but also for the other phases.
Due to a limited amount of space it will be renounced to illustrate every single design of the variables. Instead the most relevant ones will be described briefly. All other design variables are listed in the following tables. There was a general agreement on the design about the variable Responsibility for auditing. All experts have emphasized that the auditor needs to have an overall competence without being able to specify precisely. According to the interviews it is possible to organize the audit very differently.

Table 4 Organizational characteristics during the preparation phase

Phase	Structure	Variable	Characteristics in practice			
		Organizational location (Audit organization)	Auditing as a professional activity	Audit committee	Audit department	Auditing company
Preparation	Organizational	Primary responsibility	Management bears responsibility		Management delegates responsibility	
		Audit policy	Audit program & ad-hoc-audit			
		Audit objective	Target-Actual comparison		Improvement objectives	

Table 5 Personnel and informational characteristics during the preparation phase

Phase	Structure	Variable	Characteristics in practice			
Preparation	Personnel	Responsibility for auditing (Auditor)	Overall competence			
		Audit team	No audit team	Audit team "competencies"	Audit team "complexity"	Audit team "always"
	Informational	Reporting	IT-supported		Personally, verbally	

There was extensive agreement about the audit configuration, too. All experts reported about the need to configure the audit individually. In some cases there might be regulations that influence the configurations but usually the company needs to clarify configuration elements as frequency, scope or focus individually. Furthermore, the interviews showed the broad field of audit criteria. Besides legal regulations, standards, norms or contracts can give clear guidance about criteria. However, in absence of guidelines internal company requirements are the basis for the audit criteria.

Table 6 Characteristics during the realization phase

Phase	Structure	Variable	Characteristics in practice		
Realization	Organizational	Audit configuration	Individual audit configuration		
		Audit criteria	Legal regulations	Standards, Norms, Contracts	Internal company requirements
		Audit methodology	On-site-methods	Remote audit methods	
	Informational	Documentary report	Audit results	Audit report	Plan of action

As mentioned before the interviews demonstrated that it is recommendable and state of the art to use I&C technology across all phases. Not only will this encourage the acceptance of the audit in the company, it will also support the improvement process.

Table 7 Characteristics during the tracking and cross phase

Phase	Structure	Variable	Characteristics in practice		
Tracking	Organizational	Interface for improvements	Person mainly responsible	Chief of department	Auditee process
	Personnel	Performance evaluative of auditors	Feedback	Evaluation Grading	
Cross Phase	Informational	I&C technology	Preliminary information exchange	During auditing	Documentary report

To sum up, it can be concluded that the interviews have examined the broad field of auditing.

3.3 Transmission of Results

The literature review and the results from the qualitative content analysis enable a transfer to the concept of SCRM. Nevertheless special features with a direct influence to audit need to be considered. Especially a lack of standards and legal requirements affect the auditing of a SCRM system. As a result, a range of individual developed SCRM projects and systems need to be taken into consideration. Basically companies set up their own system and specify their dealing with risks based on their overall business objectives. For this reason, the design of the variables should be seen as a recommendation, but not as rule.

Table 7 Transferred characteristics to SCRM

Variable	SCRM-Audit	SCRM-Audit in SME
Primary responsibility	Management bears or delegates responsibility	Management bears responsibility
Audit objective	Target-Actual comparison and improvement objectives	
Audit policy	Audit program, ad-hoc-audit	
Audit configuration	Individual configuration of audit	
Audit criteria	Internal company requirements	
Organizational location (Audit organization)	Audit department	Audit committee
Responsible for auditing (Auditor)	Overall process	
Audit team	Expertise, complexity	Expertise, complexity, always

Variable	SCRM-Audit	SCRM-Audit in SME
Audit methodology	On-site-methods	
Documentary report	Audit results, audit report, plan of action	Audit results, plan of action
Reporting	IT-supported, personally, verbally	
Interface for improvements	Person mainly responsible, chief of department	
Performance evaluation of auditors	Feedback	
Information and communication technologies	Preliminary information exchange, during auditing, documentary report	Preliminary information exchange, documentary report

The study with the experts as well as the literature review has shown that the main responsibility for the audit should lie with the executive management. This is, among other reasons, due to the fact that the SCRM follows the objective to secure the company's continued existence. Nevertheless, it is also conceivable to delegate the operational control, e.g. to an existing internal audit function.

The audit objective depends directly and indirectly on several factors. Basically it can be distinguished between a target-actual comparison and an improvement objective. A target-actual comparison requires a desired status, e.g. rules or process procedures. In case of an improvement objective especially well-funded specialist know-how in the field of SCRM is of great importance. Overall, an individualized audit objective taking into account the circumstances of the company is expedient.

The audit policy distinguishes between an audit program, in which timing and extend of the audit is determined, and ad-hoc audits which are scheduled when required. In general, both forms are useful, cause however possible interactions with other variables. For instance if the main audit objective is an improvement of the SCRM system the integration into an audit program is preferred due to its regularity.

Analyzing the interviews reveals a broad diversification of possible audit criteria. However, the literature review points out the lack of legal requirements or standards in the field of SCRM. Internal company requirements define the desired status and serve as criteria for the SCRM audit.

From the organizational perspective the audit needs to be established either in an auditing division or in an audit committee. This depends very much on the structures in the company. However, independence to the audit object must be retained. An auditing committee which consists of several individuals from different divisions solves the problem of dependence.

The selection of the auditor is of great importance. A lack of specialized knowledge in the field of SCRM often prevents a successful implementation. For that reason the auditor should provide specific knowledge in the field of SCRM in order to review a running system. Furthermore, the auditor has to meet the requirements of an overall competence. In circumstances such as none of the employees meet all requirements a compromise has to be made. An audit team ensures more independence to the area and processes to be audited and would solve to the previously mentioned problem.

Another essential factor for success of the audit is an expedient documentation. It is recommendable to not only document the results of the audit but also to carry out a report and a plan for further improvements. This prevents misunderstandings and strengthens both the transparency and the accountability of the audit. The documentation is closely related to the reporting which has a great impact on the audit as well. Especially due to the company-wide influence the reporting should include both personal and electronic reporting. This ensures appropriate feedback on a personal level with a direct link to the audit and the SCRM system itself, but does not exclude any other employees.

The definition of interfaces for improvements is crucial for a long-term success. Besides the person with the main responsibility for the audit it is necessary to involve all SCRM-responsible employees and the department heads.

The interviews as well as the literature review showed that the performance evaluation of auditors is usually organized in the course of feedback sessions. Especially in SMEs it is recommended to carry out a final meeting to provide feedback in order to facilitate further developments.

Information and communication technologies are used in varies ways in the field of auditing. Especially systems for information exchange, e.g. SAP, are applied before, while and after auditing. Various information needs to be exchanged between the auditor and the audited persons or divisions, for instance the audit plan or the audit goal. The use of the information systems has the double benefit to track the implementation of improvement activities as well as providing relevant results automatically and company-wide. Since SMEs sometimes lack the use of modern communication and information technologies the experts pointed out that the use of standard office software or the intranet is expedient as well.

4 Conclusions and Opportunities for Further Research

As mentioned before, SCRM is increasingly important nowadays. Equally to all management systems an effective application is not ensured simply by the implementation, but should be supported by appropriate control mechanisms. An audit is such a control mechanism and by identifying the design variables and their transmission to a SCRM system this work contributes to the development of a standardized approach for a SCRM audit. However, the transfer of the design variables and their configurations are occupied not directly empirically on SCRM. An empirical validation of the transferred configurations on the SCRM audit could therefore represent a next research step.

Acknowledgements

Funding Reference:
The interviews described in this paper were conducted within the IGF-project 18138N of the 'Forschungsvereinigung Bundesvereinigung Logistik e.V.', funded by the German Federal Ministry of Economics and Technology via the Industrial Community of Research and Development (IGF).

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Service Supply Chain Risk Management: Distinctions from Manufacturing

Thi Huong Tran and Sebastian Kummer

In recent decades, service sector has become a main driver of most economies. This sector has unique characteristics entailing many distinctions in operations management and supply chain management compared with manufacturing. However, from academic and practical standpoints, the focus in supply chain management has been strongly leaned toward the goods-dominant logic. So far, the conceptual as well as empirical research on service supply chain risk management (SSCRM) has been scarce. This paper, therefore, attempts to investigate SSCRM with focus on its distinctions from manufacturing through two steps. At the first step, authors review prior research to explore the distinctive features of service supply chain and identify typical supply chain risk management (SCRM) strategies which are effectively applied to manufacturing industry. As a second step, we conduct a case study research of four service providers in telecom and logistics industry in Austria in order to investigate influences of these different features on SSCRM. Findings present distinctive risks arising in service supply chain, features of SSCRM, and efficiency extent of implementing manufacturing SCRM strategies to SSCRM.

Keywords: Risk Management, Service Supply Chain, Manufacturing Supply Chain, Distinctive Attributes

1 Introduction

In line with the increase of global dangers, SCRM plays an increasingly important role in contemporary enterprises and becomes an essential part of a holistic supply chain design (Christopher and Lee, 2004; Ghadge, Dani and Kalawsky, 2012). As a result, SCRM has been a salient topic in recent supply chain management research (Wieland, 2013) with a significant growth in number of published scientific papers and books.

In discipline of operations management, distinction of services from manufacturing/goods began to be considered the first time in the book "The wealth of nations" of Adam Smith in 1776 and has been intensively researched since 1970s (Nie and Kellogg, 1999; Moeller, 2010; Parry, Newnes and Huang, 2011). Services has unique characteristics including high level of customer’s involvement and influence, simultaneity of production and consumption, intangibility, non-storability, perishability, and labor intensity (Nie and Kellogg, 1999). These distinctions result in differences in operations management as well as supply chain risk management between manufacturing and service supply chain. For instance, while finished goods inventory can be seen as a buffer against demand fluctuation in manufacturing supply chain (Anderson and Morrice, 2000), it is impossible to put services in storage.

However, from academic and practical standpoints, the emphasis in supply chain management, including SCRM, has been strongly leaned toward the manufacturing sector (Boonitt and Chanida, 2011; Ellram, Tate and Billington, 2004). So far, research about the special features of SSCRM has been scarce (Vilko and Ritala, 2014).

Therefore, this paper attempts to investigate unique characteristics of services and service supply chain, then identify their influence to SSCRM and point out lessons which service providers can learn from manufacturers in term of SCRM.

To this end, the following research questions are proposed:

1. What are unique characteristics of services and service supply chain?
2. How do these characteristics lead to distinctive risks which affect service supply chain in comparison with manufacturing?
3. What are the similarities and differences between service and manufacturing supply chain in term of risk and risk management?
4. In what extend lessons/original risk management strategies in traditional/manufacturing supply chain can be directly extrapolated to service supply chain?

These questions are answered through two steps. Firstly, authors conduct a literature review to explore the distinctive features of service supply chain and identify typical SCRM strategies which are effectively applied to manufacturing industry. Secondly, we conduct a case study research of four service companies in Austria in order to investigate influences of these different features on SSCRM

The rest of this paper is organized as follows. Section 2 presents literature review on service, service supply chain, and SSCRM. Section 3 describes case study research methodology. Findings from empirical research are presented in section 4. Finally, we provides discussion, conclusion, and an outlook on future work in section 5.

2 Literature Review

2.1 Service Supply Chain

Service supply chain is defined as a network of interactive service processes (Sampson and Spring, 2012a). Baltacioglu et al., (2007, p.112) clarified more detail that "service supply chain is a network of suppliers, service providers, consumers and other supporting units that performs the functions of transaction of resources required to produce services; transformation of these resources into supporting and core services; and the delivery of these services to customers".

In a service supply chain, there are six major processes, namely plan, source, develop, adapt, operate, and recover (Giannakis, 2011). Based on "product" of supply chain, Wang, Wallace, Shen and Choi (2015) categorized service supply chain into Service Only Supply Chains (SOSCs) and Product Service Supply Chains (PSSCs). They defined that in SOSCs, the "products" are pure services and physical products do not play a role. Whereas, PSSCs manage physical products together with significant service considerations.

In recent years, researchers have conducted studies to gain insight into: understanding, concepts, and characteristics of service supply chain (Ellram, Tate and Billington, 2004; Voudouris, Owusu, Dorne and Lesaint, 2008; Voudouris, 2008); amplification in service supply chain (Akkermans and Vos, 2003); differences between service and manufacturing supply chain performance (Sengupta, Heiser and Cook, 2006); customer roles (Sampson and Spring, 2012a); process and operational models (Maull, Smart and Liang, 2014; Wang et al., 2015); contract and risk sharing in service supply chain

(Selviaridis and Norrman, 2014). However, according to Breidbach, Reefke and Lincoln (2015), service supply chain formation and governance, which provide a strategic advantage to service providers, still remain an unfamiliar challenge to many practitioners.

2.2 Distinctions between Service and Manufacturing Supply Chain

2.2.1 Distinctive Characteristics of Services

Two hundred years ago, services started to be distinguished from goods by Adam Smith. It is a product which perishes in the very instant of its performance, a result of unproductive labor (Smith, 1776) or an "immaterial" product (Say, 1836).

Through reviewing of research papers from 1963 to 1983, Zeithaml, Parasuraman and Berry (1985) found that the most frequently cited characteristics of services are IHIP, including Intangibility, Heterogeneity (or non-standardization), Inseparability (of production and consumption), and Perishability (or exclusion from the inventory). This IHIP framework has become a sound foundation in most of the marketing research (Parry, Newnes and Huang, 2011) and other fields such as service marketing, service quality, service management, service factory, and service value chain. Lovelock and Gummesson (2004) argued against the IHIP characteristics and tentatively proposed a “rental/access paradigm” instead. However, this paradigm has not been widely accepted (Edvardsson, Gustafsson and Roos, 2005).

According to Edvardsson, Gustafsson and Roos (2005), the IHIP characteristics have most often been discussed through the view of the service provider, instead of the view of the customers. The Unified Service Theory (UST) of Sampson and Froehle (2006), refined prior service perspectives and proposed five characteristics of service, including intangibility, heterogeneity, inseparability, perishability, and customer participation.

In the SCRM context, we adapted UST framework which views service characteristics under both lens of service providers and customers. Furthermore, labor intensity is also one common distinctive feature of service supply chain (Nie and Kellogg, 1999; Akkermans and Vos, 2003).

In brief, this paper proposes a research plan according to six salient distinctive characteristics: Intangibility, Heterogeneity, Inseparability, Perishability, Customer participation, and Labor intensity.

2.2.2 Differences in Supply Chain Structure

The differences in structure of a service supply chain derive from the unique characteristics of services, which distinguish them from goods (Baltacioglu et al., 2007).

Maull, Smart and Liang (2014) asserted that most traditional manufacturing supply chains are represented linearly, like "one-way traffic", with products flowing from ''upstream'' entities to ''downstream'' entities. However, service supply chains are different with a bidirectional traffic, in which products/services flows go both directions (Sampson, 2000, 2012). For instance, as described in figure 1, service providers receive inputs from service

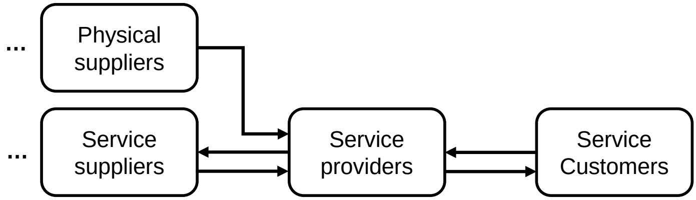

Figure 1 Service supply chain structure

customers then continue to provide inputs to their downstream service suppliers who in turn provide outputs to the initial service providers and subsequently back to customers (Maull, Smart and Liang, 2014).

The figure 1 shows that there are both physical goods suppliers and service suppliers in service supply chain. This feature leads to mixture and complexity of service supply chain structure. This issues will be discussed in the next sections.

2.2.3 Role of Customer in Supply Chain

One of the most distinctive features of service supply chains is the breadth of customer involvement (Nie and Kellogg, 1999). In the bidirectional service supply chain, customers play many roles including co-suppliers and co-producers through providing process components and labors, helping design and deliver services, and monitoring quality service (Sampson and Spring, 2012b; Selviaridis and Norrman, 2014).

2.2.4 Focus of Supply Chain Management

Beside some similarities in general demand management, customer relationship management, and supplier relationship management which are critical factors in both manufacturing and service supply chain, there does exist different aspects required to examination of service supply chain (Sengupta, Heiser and Cook, 2006). For instance, 'delivery' is central to service, whereas 'make' is central to manufacturing (Maull, Smart and Liang, 2014). Furthermore, in service supply chains, human labor is the most significant component of the value delivery process while physical handling of a product plays the most centralized role in manufacturing supply chains (Sengupta, Heiser and Cook, 2006; Breidbach, Reefke and Lincoln, 2015).

2.3 Service and Manufacturing Supply Chain Risk Management

2.3.1 Supply Chain Risk Management

SCRM is the implementing strategies to manage both daily and exceptional risks along the supply chain based on continuous risk assessment in order to reduce vulnerability and ensure business continuity (Wieland and Marcus Wallenburg, 2012). A variety of SCRM frameworks have been developed in both of proactive as well as reactive approach and focused on upstream or downstream. So far, SCRM methodologies have been diversified from conceptual framework, modelling, and simulation to empirical research through case study, survey or expert interview.

Supply chain risk is like an iceberg. Many attempts in defining supply chain risk are often too broad or too narrow. Therefore, risk identification is the first and the most important task in SCRM process. In risk identification stage, characteristics of supply chain must be deeply investigated and considered from different aspects to obtain insights into uncertainties, vulnerabilities, risk sources, and risk drivers. The following steps, risk evaluation and risk mitigation, also depend on features of supply chain and the focal company.

2.3.2 Supply Chain Risk Management Strategies

Through a review of 140 quality papers in SCRM literature, Ghadge, Dani and Kalawsky (2012) presented a list of supply chain risk management strategies classified into two approaches as proactive and reactive (cf. table 1).

Table 1 SCRM strategies (Ghadge, Dani and Kalawsky, 2012)

Proactive SCRM strategy	Reactive SCRM strategy
Supplier management: risk sharing by contract manufacturing, contractual governance, dual/multi-sourcing. VMI/buffer stock. Product/process management: product diversification, postponement, product design and delivery management. Supplier collaboration through improved confidence, cultural adaptation, information sharing.	Contingency planning: strategic event management plan, enhanced flexibility in options. Disaster management: robust recovery, rebuilding of supply chain, resource utilization/management, scenario analysis for future disruptions. Demand management: operational rerouting, shifting customer demand, dynamic pricing.

These strategies have been effective for typical/manufacturing supply chain risk management. In this research, through semi-structure interview with service supply chain managers, we will exam adoption of the identified strategies in SSCRM.

2.3.3 Supply Chain Risk Management in Service Sector in Comparison with Manufacturing

Researchers asserted that service supply chains should be managed differently from manufacturing due to their distinctive characteristics (Akkermans and Vos, 2003; Sampson, 2012; Sampson and Spring, 2012b; Sengupta et al., 2006; Kathawala and Abdou, 2003; Baltacioglu et al., 2007). SSCRM is no exception. However, the understanding of risk management in service supply chains is still in its infancy (Vilko and Ritala, 2014). So far, there has been quite few of research about service supply chain risk management. Research of Vilko and Ritala (2014) mostly is one of the first studies in generating a framework in service supply chain risk management. Their research described distinctive IHIP attributes of service, demonstrated the contrasting traditional supply chain and service supply chain (table 2), and proposed a conceptual framework of service supply chain in terms of risk management at different levels (process, offering, and system).

However, supply chain risk management in service sector in compared with manufacturing still lacks of empirical studies (Vilko and Ritala, 2014). Therefore, this paper conducts to do a step further in order to capture instances of the practitioners' views on service supply chain risk management through an empirical case study research.

Table 2 Contrast between traditional supply chain and service supply-chains (Vilko and Ritala, 2014)

	Traditional supply chain	Service supply chain
Risk management emphasis	Tangible, potentially separable supply chains; emphasis on pre-risk-event activities	Intangible, high interdependent, multi-actor supply chains; emphasis on real-time and activities
Key risk management inputs	Information; systematic process understanding	Knowledge; systemic process understanding
Key risk management activities	Hierarchical, statistical approach to risk identification, analysis and control	Intuitive and proactive approach to risk identification, analysis and control

3 Empirical Research Methodology

3.1 Case Study Research

Case study research is widely used in organizational studies and across the social sciences (Kohlbacher, 2006). This method enables researchers to answer "how" and "why" questions, while taking into account how a phenomenon is influenced by the context within which it is situated. Stuart et al. (2002) suggested that case study is an appropriate research methodology to map the field of supply chain management. According to Halldórsson and Arlbjørn (2005), the actual use of the case study methodology may facilitate current research on supply chain management, in particular for building theories, providing detailed explanations of best practices, and making more understanding of collected data. In supply chain management literature, conceptual framework and empirical research along with the case study approach are commonly used (Ghadge et al., 2013).
Multiple case studies provide a more rigorous and complete approach than single case study research because of the triangulation of evidence (Bonoma, 1985). Therefore, our selection of four cases falls within the mentioned recommendations.

3.2 Case Selection

Authors selected one telecom company (named as company A) and three logistics service providers (named as company B, C, and D) to implement this empirical research. These four service providers in Austria range from medium to large size; cover both B2B and B2C services; and include SOSC (telecom) and PSSC (logistics service providers). All four service companies are doing business in global environment and seriously pay attention to supply chain risk management.

The logistics service provider was proved as an appropriate empirical example to study research in SSCRM (Selviaridis and Norrman, 2014). Telecom industry also is a proper sample in research of Akkermans and Vos (2003) about amplification in service supply chain.

3.3 Data Collection

The data were collected through semi-structured interviews and published documents.

Interviewees are senior managers of supply chain and risk management departments of four service companies. Questionnaires were sent to the respondents in advance. We conducted personal interviews with notes taken in February and March, 2015. Each interview lasted about 45 to 90 minutes. Complementary documents includes company website, company profile, risk management report, and annual reports. These materials are used to cross-check for triangulation purpose together with cross case analysis.

The content of questionnaire is as follows:

Question 1:

Do the distinctive features of services (intangibility, heterogeneity, inseparability, perishability, labor intensity, and customer participation) result in distinctive risks of service supply chain in compared with manufacturing? How does your supply chain deal with these risks?

Question 2:

In what extent the SCRM strategies in table 1 in traditional supply chain have efficiency to service supply chain risk management?

Question 3:
What are the most significant risks in your service supply chain from the following points of view: process, resources, and environment?
Question 4:
How differently does your company manage the relationships with your physical goods and service suppliers?
Question 5:
Is there any problem arising in SCRM (Risk identification, assessment and mitigation) of your service supply chain?

3.4 Data Analysis

Data analysis is the process of categorizing, tabulating, testing, recombining both quantitative and qualitative evidence to address the initial propositions from literature review (Yin, 2003). In this phase, evidences including transcripts from expert interviews and complementary documents, were analyzed, synthesized, and combined to answer research questions.

4 Case Study Analysis

4.1 Research Context

This research investigated four service providers in two service supply chains (telecom and logistics) which are described as follows:

4.1.1 Supply Chain of Telecom Service Provider (Company A)

Company A is a large size corporation in telecom industry. As a leading telecom provider, this company serves almost 20 million customers in seven countries across Central and Eastern Europe and earned about €4 billion in 2014. Figure 2 represents services and service supply chain of this company.

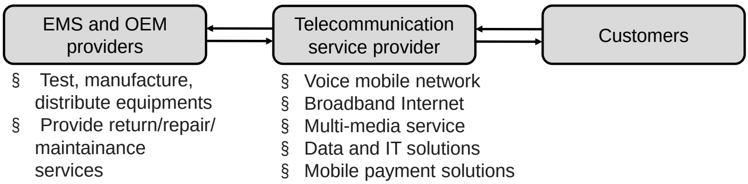

Figure 2 Telecom service supply chain

4.1.2 Supply Chain of Logistics Service Providers - LSPs (Company B, C, and D)

Company B is a large size logistics company with turnover more than one billion euros in 2014. This company employs over 5000 staffs, and operates over 3000 trucks on road per day in about 30 countries in Europe and Asia.

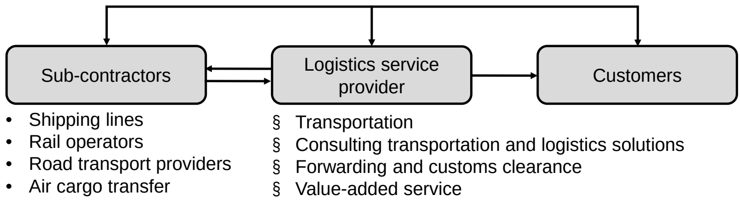

Figure 3 Logistics service supply chain

Company C is a medium size logistics company, with turnover approximately €500 million euros in 2014, having more than 2000 staffs, and doing business in about 90 locations in 20 countries. Company D is a subsidiary company in Austria of a worldwide logistics group. Last year, this company earned more than 1.5 billion euros in revenue figure which created by over 5000 employees. Figure 3 illustrates supply chain of these companies.

4.2 Characteristics of Services- Source of Distinctive Risks Exposed to Service Supply Chain

Figure 4 presents cross-case analysis findings on distinctive risks of service supply chain, which stem from the six identified characteristics. The next sub-sections will detail these findings.

4.2.1 Intangibility

As described in figure 4, this attribute results in five typical distinctive risks appearing in service supply chain as follows:

Unique characteristics of service	Distinctive risks in Service supply chain		
	Service suppliers	Service providers	Service customers
Intangibility	§ Traceability risk	§ Design risk § Quality risk § Traceability risk	§ Vague demand § Subjective quality assessment
Heterogeneity	§ Punctuality risk	§ Punctuality risk § Reliability risk § Reputation risk	*No findings*
Inseparability	§ Just-in- time risk	§ Just-in- time risk	§ High customization risk
Perishability	*No findings*	§ Capacity risk § Real-time risk § Loss of defect	*No findings*
Labor intensity	*No findings*	§ Standardizing risk § Knowledge, skill and cultural risk	*No findings*
Customer participation	*No findings*	§ Traceability risks § Information sharing risk	§Co-producer & co-supplier complexity §High customization

Figure 4 Distinctive risks exposed to service supply chain

Vague demand and design risk: Intangibility refers to the ambiguous specifications of stakeholders in general and customers in particular. This feature hinders service providers from perceiving clearly and exactly their customers' expectation. This issue results in risks in design stage and entails ineffective service control.

Quality control risk: In addition, service managers also cannot directly observe and control quality of process. For instance, whereas manufacturing managers can supervise their production line, the managers of LSPs said that it is really hard to follow truck drivers and see how they behave with customers, and how they handle goods. Company C asserted that the most vulnerable problems happen "on the road". The quality control risk in service supply chain is typically much more significant in compared with manufacturing industry.

Traceability risk: Service supply chains relate to the sourcing and delivery of intangibles. This fact results in traceability risks happening in both supply side and focal service company. As LSPs' key informants described about their logistics consulting service that in order to give advices and solutions to business partners, the consultants have gained knowledge, skill and information from various sources, both of tangibles and intangibles. That leads to the difficulty to identify suppliers of intangibles' failures.

Risk arising from subjective service quality assessment: Due to the vague nature of services, this risk arises in qualifying of service quality and performance because of the bias and subjective attitude of customers. For example, in manufacturing sector, products can be physical evidence to proof quality and performance, but in service sector, managers "apply standards, try to provide the best service in the best manner and by the best people, however the final judgement belongs to customer experience" (interviewee of company B).

4.2.2 Heterogeneity

Services is not consistent like physical products. It tends to be heterogeneous because customers and service suppliers present heterogeneous inputs. According to key informant of company A, "Rules can apply to machine but it is difficult to totally apply to people".

In fact, it is very difficult to standardize entire of service process and implement a mass service production. As a result, punctuality rate of service fluctuates continuously at the stages of pre-hold, loading, unloading, and delivery (as company C's informant said). In addition, company D also asserted that punctuality is a significant worry when they make use of service sub-contractors. Consequently, punctuality risk entails reliability risk when customers cannot receive services as their expectations, previous experience, or as other customers' receiving. More importantly, service providers can lose their loyal customers and even their reputation due to consistence break.

4.2.3 Inseparability

Due to simultaneity in production and consumption feature, service supply chains have to face with two significant risks: Just-in-time and high customization risks.

Logistics companies cannot transport goods until order from customer arrives; telecom firm also will not consult or install service to consumers who do not have demand. Therefore, in service, just-in-time (JIT) delivery is a requirement, not a choice. Consequently, a service provider may take the double JIT risk when they need participation of other service suppliers to fulfil customer's demand.

Furthermore, when consumption and service process take place in the same time, customers have more opportunity to customize their requirements. On the one hand, high customization can lead to higher satisfaction of customer. However, on the other hand, this customization is not easy to "modify routing schedules which are optimized in advance" (company C) as in logistics company.

4.2.4 Perishability

Perishability feature entails risks of real time management, loss of defect, and capacity management in service supply chain.

In services, any unutilized time or services cannot be stored or reused to later customers. Therefore, perishability characteristic creates real-time management risk and enormous loss when failures happen since "loss of time is loss of revenue, even loss of customer" company B's respondent emphasized.

In addition, this characteristics cause capacity risks at seasonal peak. Service providers must face to trade off problem between redundant cost for back-up capacity and satisfaction customer demand. Like a respondent said, they have to back-up staffs, trucks, containers, and sub-contractors to fulfil orders at Christmas time in Europe and Lunar New Year in Asia market. The similar phenomenon is also seen in telecom company at the time of Christmas and new school years.

4.2.5 Labor Intensity

In service sector, human factor is the most significant component. The direct workers as truck drivers, telecom installer, telecom service consultant, and customer service staff are the most important representative of service companies. Their skills, knowledge, attitude, and behaviors are the key to assess service performance. Only a small mistake happens, the reputation of service providers can be damaged. Therefore, all informants asserted that risk in knowledge, skills, and cultural of labor is the most challenge with them.

Besides that, the implementation of standards to service operations also contains risks. It is necessary to cite again the saying of company A, “Rules can apply to machine but it is difficult to totally apply to people”.

4.2.6 Customer Participation

Customers may have many roles in the bidirectional service supply chain. For instance, LSPs' customers can provide products and order logistics companies to pack, transport to their customers. In this case, customers are also suppliers. In another example, as companies B and D explained about their logistics consulting service, customers describe their problems and requirements, then discuss as well as brainstorm with consultants to find out the best solution. In brief, customers can be co-supplier, co-producer in service supply chain.

Multiple roles of customers lead to risks in traceability when problem raises from customer side. This feature, furthermore, results in the complexity in information sharing and operations management with co-producers and co-suppliers, and high specifications’ customization.

4.3 The Most Vulnerability in Service Supply Chain

4.3.1 Process Point of View

As defined in figure 4, most distinctive risks arising from service providers due to nature of services. Specifically, LSPs stated that, “on the road”- operation stage is the most significant risk in process point of view. Similarly, the customer-contact moment in telecom service supply chain is the most vulnerable process.

4.3.2 Resource Point of View

People are the most vulnerable resource in service supply chain. Because production lines can operate automatically and produce massively. However, labor in service system varies in skills, knowledge, behavior, attitude, and even cost (LSPs' key informants).

4.4 Supplier Risk Management in Service Supply Chain

In service supply chain, a service provider may include physical goods suppliers and other service suppliers. Supplier risk management strategies in traditional supply chain have been explored and widely applied. There is a question arising that is there any differences in supplier risk management strategies between service suppliers and physical goods suppliers?

4.4.1 Physical Goods Suppliers

To manage physical goods providers, a service company can apply supplier risk management strategies as in manufacturing supply chain such as incoming inspection, dual/multi sourcing, VMI, buffer stock, collaboration, and risk sharing contracts. As company A responded, the original equipment manufacturers supply one of the most important physical inputs to provide telecom service. In order to manage these suppliers, company A applied strategies such as incoming inspection and collaboration in storage, inventory, and capacity adjustments.

4.4.2 Service Suppliers

Service suppliers need to be managed differently because they have unique characteristics and distinctive risks to the focal service providers. As companies B, C, and D described the management to their freight forwarding sub-contractors that they have to share the same understanding of quality, work with uniform systems, and live in a similar corporate culture. In this way they can ensure that the customers are provided with homogeneous services.

4.5 Efficiency of Traditional Supply Chain Risk Management Strategies in Service Sector

Both of traditional manufacturing and service supply chains operate in the same business environment and base on the general supply chain principles. Therefore, service and manufacturing supply chains have to face quite a few similar risks from external environment and deal with problems from suppliers, outsource partners, competitors, and customers. However, there are also many different risks as mentioned in the above sections. This section investigates whether typical risk management strategies in traditional supply chains (table 1) can be directly extrapolated to service supply chains.

Resulting from the need of uniform services, strategies such as collaboration and information sharing show high effectiveness in service supply chain. All experts asserted that, when internal members are too familiar with business activities and environment, it is the difficulties to identify potential risks. As a result, collaboration and sharing information with supply chain partners can help service providers detect supply chain risks more comprehensively.

Product/service diversification strategy is also highly appreciated by all experts, especially in telecom company with various value added-services. In fact, customers can join service production process and order their requirements. Therefore, service supply chain should proactively give customers opportunities in customizing service although this action can bring risks to service providers.

Dual/multi sourcing in physical goods or service suppliers are taken advance in service supply chain. For example, logistics company B assesses and selects their trust sub-contractors to face capacity shortages in seasonal peaks.

In contrast, risk sharing contract is mostly not applied in service supply chain except for the long-term contract which helps service providers to hedge out the risk of price changes. To control the severity of risk, stocking an excess buffer and safety stocks are also a common measures in manufacturing. However, these strategies mostly do not work in service supply chain except for tangibles resources.

5 Discussion and Conclusion

In this paper, we investigated distinctions of service, service supply chain, and service supply chain risk management. Through reviewing SCRM and service field literature, authors proposed six unique characteristics which distinguish service and manufacturing supply chain, including intangibility, heterogeneity, inseparability, perishability, labor intensity, and customer participation. We furthermore investigated influences of these features in service supply chain in term of risks, supply risk management and SCRM strategies. Findings also showed some typical SCRM strategies in traditional supply chain can be extrapolated to service supply chain.

When it comes to managerial insight, the responses from expert interviews suggested that establishing a quality cultural throughout supply chain is a sustainable risk management strategy in order to supply a uniform service to customers. The higher intangible level requires the more efforts in collaboration with supply chain partners. The more customer involvement, the more information sharing needed.

In this study, authors attempted to ensure a reliable and valid research design through coherent literature review and multi-case together with multi-evidence investigation. However, there are several limitations. Firstly, four selected cases in telecom and logistics industry did not cover a various range of service sector although these cases can have all six unique characteristics of a service supply chain. Secondly, supply chain partners of service providers were not interviewed in this empirical study. Finally, measuring efficiency of traditional SCRM strategies in service supply chain was conducted qualitatively with a small sample size containing four cases.

To overcome these shortcomings, in future research, researchers can conduct empirical investigations in other service sectors, or quantitative examinations of the analyzed distinctions, as well as establishment specific SCRM framework in service supply chain.

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A Simulation-based Analysis of Supply Chain Resilience

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The increased interest in supply chain risk management (SCRM) is not only a consequence of recent natural disasters, but moreover the recognition that even small incidents can have a severe impact on the entire supply chain (SC). Instead of making high investments in eliminating every potential risk, it is much more appreciated to incorporate the concept of resilience in supply chain design and operations that provides the ability to reduce the consequences of disruptions and to reduce the time to recover normal performance. However, as resilience significantly increases the ability to adapt quickly and efficiently to changes in the environment, it comes along with an increase in costs in most cases. Moreover, achieving resilience in supply chains and agile response requires a holistic approach, which contributes to the complexity of decision making processes in supply chains. Since most of the researches has been discussed the resilience of supply chains from a qualitative point of view in the literature, there is a lack of research concerning the resilience from a quantitative perspective. In this context, the main purpose of this paper is to provide a simulation-based decision support framework for assessing supply chain resilience and evaluating the cost and resilience trade-off with different mitigation strategies in an uncertain environment. The decision framework incorporates the supply chain resilience metrics and argues their relationship to the impacts of those disruptions on the performance and to the time required for recovery.

Keywords: Supply Chain Resiliency, Simulation, Flexibility, Supply Contract

1 Introduction

Companies operating in today's business environment face various uncertainties that make it difficult to operate successfully as supply chain disruptions are occurring regularly (Glendon and Bird 2013). With the advancement in communication and transport technology enabling an international alignment, global supply chains were found to be a competitive advantage. As companies have been focusing on the reduction of costs and a fundamental growth, the access of cheap labor and raw materials, better financing opportunities, larger product markets, arbitrage opportunities and the attraction of foreign capital are a key to success (Manuj and Mentzer 2008). Likewise, the increased use of outsourcing of manufacturing and services to foreign suppliers intends to create cost advantages and enables the companies to focus on their core-competency (Norman and Jansson 2004).

The opportunities created by the globalization of supply chains are often accompanied by new supply chain challenges. Longer transport distances and lead times have been accepted to benefit from lower labor costs. The disadvantage of global supply chains is therefore the exposure to intercontinental risks and disruptions. As the network extends over the entire globe, the amount of links interconnecting a wide network of companies is growing numerously. The links are prone to disruptions, bankruptcies, breakdowns, and disasters, increasing the possibility for an unplanned event (Manuj and Mentzer 2008). More partnerships, as occurring in supplier of supplier relationships, can also lead to a loss of visibility, higher complexity, and less control for the focal firm in cases of disruption (Christopher

2011). Furthermore, as supply chains become more global, they are becoming more vulnerable to business disruptions and hence, they are usually slow to respond to changes (Tang and Tomlin 2008).

Between 2009 and 2011 the number of supply chain disruptions has risen by 465%, interrupting the flow of merchandise and leading to costs of $350 billion (Langley 2012). An excellent example that shows how an enterprise suffers from a significant disruption is Ericsson's crisis in 2000: a fire broke out at Ericsson chip supplier plant leading to a production standstill of 2 weeks that finally caused an estimated loss of 400 Million Dollars because Ericsson had no backup sources. Similarly, Toyota was forced to shut down 18 plants for almost two weeks because of the fire in 1997 at Toyota's brake valve supplier. The costs caused by the disruption were an estimated $40 million per day (Norrman and Jansson 2004).

The examples mentioned above show that even small incidents can have a severe impact on the whole supply chain. The challenge in risk management today is to avoid such incidents or reduce their negative impacts. Instead of making high investments in eliminating every potential threat, it is much more appreciated to increase the resilience of the supply chain to adapt quickly and efficiently to changes in the environment. Building a resilient supply chain is related to development of responsiveness capabilities through flexibility and redundancy (Rice and Caniato 2003). Recent studies found out that organizations with higher levels of flexibility are more capable of responding to unexpected events compared to inflexible supply chains (Swafford et. al. 2006). However flexibility comes along with an increase in costs in most cases as it increases the ability to adapt to changes. Thus, a match between flexibility and environment uncertainty has to be found in order to create a cost-effective flexibility configuration (Merschmann and Thonemann 2009). This match is difficult to find in the first place as companies are struggling to determine the consequences of uncertainty and therefore the required degree of flexibility. As a result, there is a need for an approach to be capable of assessing risk exposure in order to implement the suitable extent of resilience, so that organizations can survive in a competitive business environment and succeed their strategies under uncertainty. This paper presents a simulation-based quantitative approach for assessing supply chain risks and evaluating the cost and resilience trade-off with different mitigation strategies in an uncertain environment. To be able to develop a decision support system, we propose a simulation-based framework that incorporates concepts of resilience into the process of supply chain risk management and design. In this context, resilience is defined as the ability of a supply chain system to reduce the time to recover normal performance under disruptions. To illustrate how the developed simulation model can be utilized to determine the resilience in the supply, a case study is presented.

2 Supply Chain Resilience

The high number of sources of complexity exposes the network to an increasing level of uncertainty, and the uncertainty level exposes the network to numerous kinds of events that may disrupt the course of their business. These events are usually random and have a probability of occurrence. They are disruptive, have a relevant impact on the performance and they are sometimes difficult to anticipate. Hence, risk is defined as an uncertain event or a set of circumstances which, should it occur, will have an effect on the achievement of one or more objectives (Tuncel and Alpan 2009). Uncertainty can also be declared as the risk causing factor, which forms a changing environment, in which risky events may occur. Any risky event is defined as an event that is not known for sure ahead of time, but the risk itself is defined as the potential harm that may arise in future due to some present processes or some future events (Klimov and Merkuryev 2008). In particular, resilience has been used as an important characteristic to handle uncertainties in a supply chain and to respond to such major supply chain disruptions. In the literature, several terms are linked with resilience, such as, agility, flexibility, and robustness. According to Ponomarov and Holcomb (2009), resilience is "the adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at desired levels of connectedness and control over structure and function". In contrast, robustness refers to the ability to endure changes in the environment without adapting (Asbjornslett 2008). Asbjornslett states that a robust system has the ability to absorb a disturbance while retaining the same previous state whereas a resilient system has the ability to adapt and achieve a new stable state. According to Swafford et al. (2006), agility refers "the supply chain's capability to adapt or respond in a speedy manner to a changing marketplace environment". Agility is unplanned and unscheduled adaption to unforeseen and unexpected external circumstances (Goranson 1999). In contrary, flexibility is scheduled or planned adaption to unforeseen and expected external circumstances. The concepts of flexibility and agility are therefore tightly coupled with supply chain resilience. Wieland and Wallenburg

(2013) for example divide suppy chain resilience into agility, resulting from visibility and speed, and robustness, resulting from anticipation and preparedness. Christopher and Peck (2004) define agility as the third element of supply chain resilience. According to Longo and Ören (2008), the most important elements affecting supply chain resilience are: flexibility, agility, velocity, visibility and redundancy. Based on the literature review, Lotfi et al. (2013) illustrate some overlapping and non-overlapping practices/initiatives across robustness, agility and resilience.

Consequently, resilience can be achieved through robustness, flexibility and agility. In the context of robustness redundant capacity that may or may not be used is installed. It is additional capacity that would be used to replace the capacity loss caused by a disruption. In this regard, flexibility entails redeploying previously committed capacity (Rice and Caniato 2003). Moreover, instead of raising the claim of being prepared for every situation by creating a robust supply chain through comprehensive planning, it is much more appreciated to increase the flexibility of the supply chain to adapt quickly and efficiently to changes in the environment, because frequent plan adjustments in the analysis would be necessary in times of increasing environmental dynamics (Bretzke 2010). Sheffi and Rice (2005) claim that enterprises can increase their resilience by developing flexibility in supply and procurement. In other word, supply flexibility plays a critical role in supply chain resilience.

As the future performance of the entire supply chain depends significantly on the selected sourcing strategy and supplier management (Klug 2010), flexible supply contracts are presented next as a mitigation strategy in order to create a resilient supply chain. Supply contracts coordinate materials and information flows between a supplier and a buyer. Different and often conflicting objectives can be accommodated through associating them with the right incentives (Tsay and Lovejoy 1999). In general, pricing, minimum purchase commitments, quantity flexibility, buy backs or return policies, allocation rules, lead time and quality can be issued in such contracts (Hennet and Arda 2008). Quantity flexibility can be specified in a supply chain contract that allows the buyer to adjust its order quantities after the initial order is placed. A buy-back contract (return policy) is a commitment by the supplier to buy back unsold inventory of the goods at the end of the selling season so as to induce the buyer to order more from the supplier (Hou et. al. 2010). Another form of flexibility in supply contracts includes capacity reservation, when the supplier is obligated to cover any request that remains within the upside limits (Cheng 2003). For undertaking the risk of guaranteeing to deliver any order amount desired by the buyer up to a reserved fixed capacity, the buyer offers guaranteed payment by making an obligation to buy a certain unit of capacity every day. Even if the buyer does not fully utilize the reserved capacity, he will pay for it (Xu 2006). Another proposed resilience strategy o mitigate disruption is multiple sourcing and safety stock (Iakovou et al. 2007). However, these strategies have not simulated or implemented under disruptions.

One challenge question in supply chain management is how to assess the resilience. A significant disruption initiated by a triggering event influences the company's performance in many ways. The process of a disruption can be categorized in different phases as it is illustrated in Figure 1. The impact

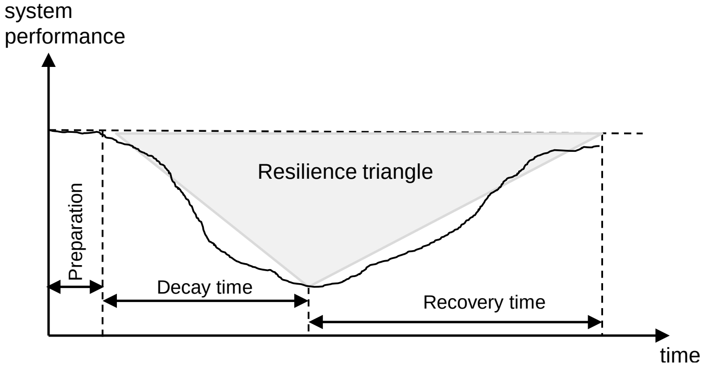

Figure 1 The stages of a disruption

is caused by a disruptive event, for instance the start of a labour strike or the explosion of a facility.

The normal operations are affected immediately, as contingency plans are implemented in the first place to prevent further damage. While some impacts are propagating through the value chain, the full impact is revealed by a short delay. During this time preparations for recovery typically start parallel in order to continue production and resume operations as soon as possible (Sheffi and Rice 2005).

3 Risk Assessment in Supply Chains by Using Simulation

A typical process of risk management is divided into four steps: risk identification, risk assessment, risk treatment and risk monitoring (Hallikas et. al. 2004). The aim of risk identification is to recognize the future uncertainties and the potential risks surrounding the supply chain (Güller et al. 2015). The risk assessment stage defines the consequences of these risk events defined in the first step in order to give a clear view of all risks.

In the third stage, the most suitable mitigation options are to be implemented to reduce either the occurrence probability or the degree of severity of the pre-identified risks' consequences. The last stage of the process is the risk monitoring where risks are monitored to define variations in their probability or consequences (Hallikas et. al. 2004). Besides the definition and scope of risk management, it is also important to identify the measurement technique used in evaluating and assessing risk issues (Güller et al. 2015). In the literature, risks are measured based on qualitative and quantitative techniques. Measuring risk in a qualitative way is the most commonly used approach and only a quarter of the researches apply a quantitative method (Ghadga et. al. 2010). It is obvious that there is a lack of simulation-based quantitative approaches for assessing supply chain risks and analyzing supply chain resilience (Güller et al. 2015).

In the risk treatment phase, the improvement through reconfiguration of the supply chain cannot be examined with the common risk management methods, because a feasibility check is missing in the first place. In other words, the effect of possible mitigation strategies cannot be measured until they are selected during risk treatment and implemented in the real system. By estimating the potential costs and integrating them via the HTP-method, an approximate performance audit is feasible, when comparing them with the estimated impact of the risks. What remains characteristic for the qualitative methods are the vague results in the end as they are all based on subjective estimations instead of quantitative data. That is also the main problem in risk monitoring and the reason why the requirement of control is not met at all. After the selected mitigation strategy is implemented, it is impossible to assess if the risk has been eliminated, because it remains unknown how the changed system will react to a risk event that has not occurred yet.

Discrete-event simulation exactly begins at this point where common qualitative methods struggle the most. It addresses the problem of quantitative data and also offers the opportunity to perform what-if analysis on the basis of a model of the real system. Therefore the findings of the observed behavior of the model can be transferred on the real system. This includes the assessment of the risk level, which can be measured precisely in terms of cost and performance data by simply implementing the risk event in the model. Besides, different mitigation strategies worked out by the operator can be implemented in the model as scenarios, supporting the operator with making a decision as the scenario with the best results in performance can be selected afterwards. By experimenting with different configurations of the supply chain in order to find the optimal mitigation strategy, the feasibility of different strategies also becomes apparent. Bottleneck analysis is particularly interesting in this context, because it indicates where work-in-process, information, materials etc. are being excessively delayed, causing an unstable environment. In summary, simulation as a quantitative method can particularly support the SCRM in the fields of risk assessment and risk treatment. The risk events and disturbances can be simulated virtually in a model environment in order to be able to compare the cost and performance data with and without mitigation strategies.

4 Simulation-based Decision Support Framework for Supply Chain Risk Management

The aim of this section is to build an approach that is capable of ensuring the correct solution in risk treatment based on a quantitative risk assessment. As discrete-event simulation does not support the entire SCRM process, methods in the field of risk identification and risk monitoring should be combined with simulation. Therefore, in order to guarantee the goals of SCRM throughout the simulation study, the very same process should be implemented in the simulation study process.

Risk identification is integrated in the first phase preparation of the simulation study. Both phases show similarities and harmonize well as it is important to first limit the scope of the system that is to be modeled. Furthermore, the critical parts of the supply chain are determined with the help of a portfolio in order to clarify the initial situation as it is important that the problem has been clearly understood. Now that the content of the future simulation model is known, cost and performance data is defined as the target system of the simulation study. Furthermore the goals of the simulation study are formulated and the questions that are to be answered as well as the data requirements are determined. Additionally to the common input, the probabilities, duration and manifestation of the risks have to be defined. Once the data is collected, analyzed and the random variables are determined as well as the distribution functions are fit and the constants are selected, the simulation model can be developed based on the supply chain map that was defined in the beginning.

With the completion of the simulation model, the actual simulation study can begin by defining a test plan. As the study is divided up into the two parts assessment and treatment, the test plan also consists of the two parts that are defined separately. The research questions formulated in the preparation phase are usually investigated in the second part. In risk assessment, every risk is examined individually and if more than one risk factor exists, they should be studied individually as well. This is important as risk assessment is about determining the risk level of each individual risk in order to enable outright prioritization without interdependencies, so that conclusions can be drawn for risk treatment.

Risk assessment is about getting a feeling of how the real system currently reacts to certain planned events in different kind of ways. It is not about improving the system, but about determining the actual status as a preparation for the development of mitigation strategies. This is why the collected results should be evaluated with the help of graphical representations after the simulation runs have been carried out and before risk treatment takes place. That way, the simulation analyst gets a good overview on the different risks and it is easier to make comparisons. The most common graphical editing is to display the disruption curve with the help of the β-service level in a line graph, which is most suitable to illustrate the extent on the customer. Once the risks have been evaluated individually, whatever risks cause the longest delay, the worst service level or the most costs for example, are selected for risk treatment.

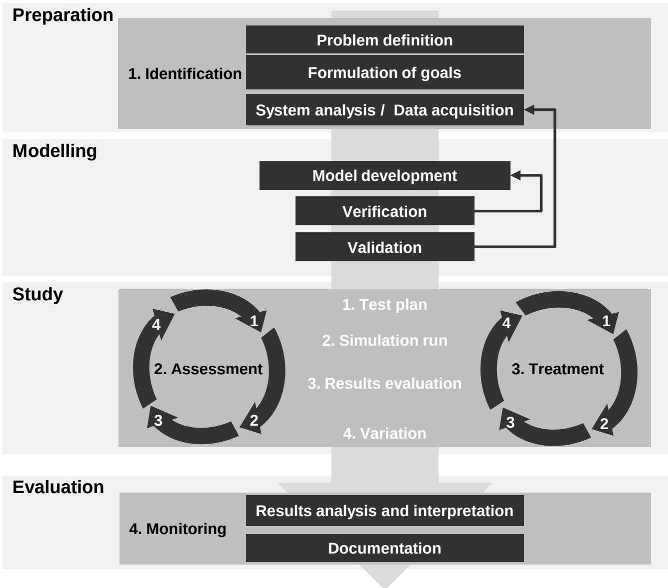

Figure 2 New SCRM simulation study approach

The goal of risk treatment is to find an overall optimum configuration of the supply chain in order to be able to handle the different risks in the best way. Similarly to risk assessment, it is recommended to also simulate the risk categories separately, but with all risk factors turned on. Additionally to these scenarios, the risk probability and duration should be varied, so that the effectiveness of the mitigation strategies can be fully assessed. More than in risk assessment, risk treatment is an iterative loop, because simulation is not a decision-making tool, but a decision support tool, which means that in order to find the optimal configuration, a loop has to be built as described in Figure 2. Instead of the graphical analysis in risk management, it is advisable to evaluate the results with the help of total costs in order to find a global optimum, because nearly every KPI can be included. This is done with the help of penalty costs. As every scenario consists of different risks, this is done for all the scenarios defined in the test plan. As soon as a decision has been made for one solution in each scenario, risk treatment and the simulation study are over and the last phases evaluation and risk control begin.

In evaluation, the analysis and interpretation of every simulation result takes place. The result for every scenario or in the other words, the output data for every risk is analyzed. By comparing the results of the different risks, especially with regards to a scenario with the combined risks, conclusions are drawn with regards to the mitigation strategies and compressed statements are made. Hence, the interpretation is based on the detailed analysis of the varied parameter of the simulation model. The outcome is the determined configuration of the modeled supply chain that can be transferred to the real system.

In contrast to the qualitative methods, specific basic data can be stated like total costs, the required extent (e.g. number of supplier and quantity per supplier), savings and performance data (e.g. service-level, cycle time etc.) The acquired data also changes the purpose of the risk monitoring phase compared to the common approach, if the modeling of the simulation and the experimentation with the model has been done correctly up to here. Corrective actions will not be necessary as long as the simulation model operates in the scope of the real system, since the mitigation strategies have already been tested when experimenting with the model.

5 Case Study and Simulation Results

In the following, disruption curves due to supplier failure and demand volatility will be investigated exemplary. As a case study, the supply chain of an original equipment manufacturer (OEM) from the automotive industry in Germany is selected. The suppliers of the factory are spread all over the world. In the test plan, the scenarios are made up of different strategies such as JIT-Concept, inventory, multiple sourcing and flexible supply contracts. The JIT-concept is the base case of the model as waste is avoided through single sourcing and no inventory. The processes are efficient in order to cut down costs. The other configurations build in reserves in terms of inventory, multiple sourcing or standby suppliers (flexible supply contract). The flexible supply contract means that a certain amount of capacity is reserved each day, which can be used in case of a disruption, but that is paid for every day. First, the impact of demand volatility is shown. The total standard deviation was increased tenfold resulting in a higher number of extreme situations like days with almost no demand, or days on which demand is almost doubled with an overall average demand that stays virtually the same. In the base case JIT-deliveries, this does not lead to a significant drop in the service level as long as it does not happen several times in a row. But once the service level has dropped to zero, it will take time until the system has recovered itself depending on how much demand has to be covered at the bottom.

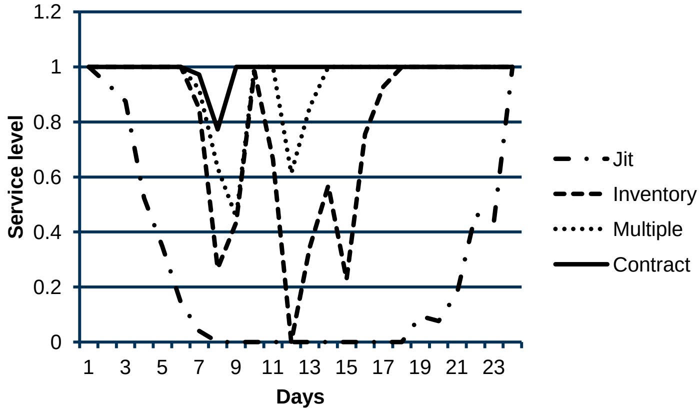

Figure 3 Disruption curves due to demand volatility

Figure 3 shows one of two longer disruption curves that occurred during the simulation run. This one occurred, because a very high demand had to be served in the beginning of the curve leading to eleven days with service level zero, because none of the products can be supplied on time. Unlike a disrupting event, the recovery phase depends on whether there will be additional days with very high unusual demand. As this is not the case during the last ten days of the curve, recovery can take place. With one day of inventory on hand, the disruption can be delayed until the seventh day.

The spikes in the other curves come from peaks in the daily demand that were not visible during JIT-delivery, because the service level already dropped to zero. As the demand can be distributed on more than one

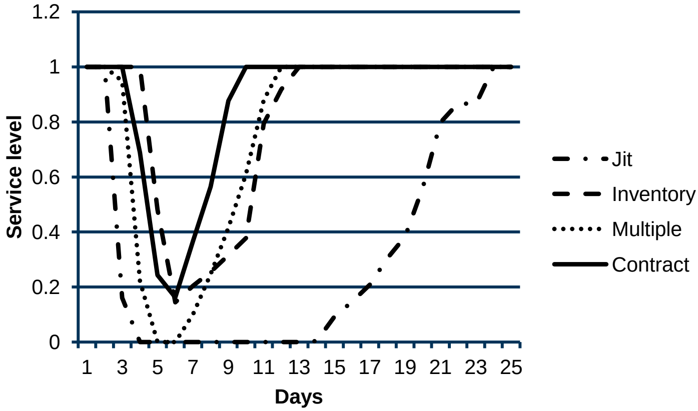

Figure 4 Disruption curves triggered by diminished capacity

supplier, the spikes in the service level are not as big, because additional capacity is available each day. The smallest drop in the service level is achieved through the flexible supply contracts. The impact of peaks in the daily demand is lessened through the flexible allocation of the backorders from the previous day on the standby supplier instead of maintaining the boundaries of common multiple sourcing, where backorders are not transferred from one supplier to another.

Figure 4 displays the different disruption curves according to the service level, when the capacity of a supplier for the steering columns is reduced by 50% for five days. The disruption happens on the second day of the curves resulting in an immediate drop to 20% service level in the base case on the next day. As there is 50% of the capacity left, the customer orders of the day of the disruption can be fulfilled the next day, so that they are still on time. All the other curves are shifted to the right and can recover faster.

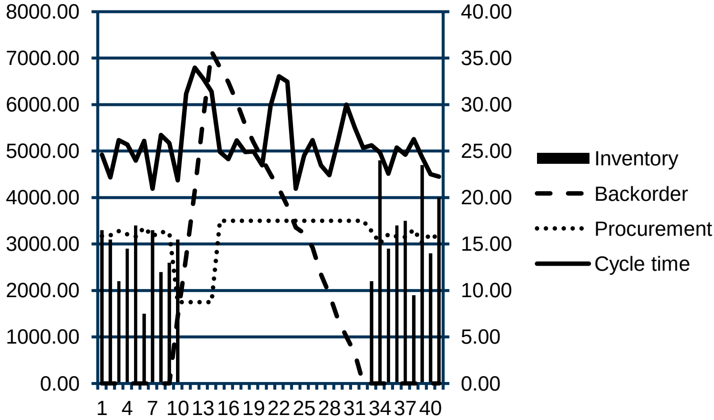

Figure 5 Performance data of a customer and supplier

With one day of inventory, the disruption can be absorbed for three days. Only the last two days make an impact resulting in a drop to 14%.

An explanation can be given by Figure 5 that describes causal relations of the individual performance data. It displays the level of inventory, the amount of backorders and the procurement volume of the disrupted supplier (all primary axis) and an exemplary cycle time for a customer (secondary axis). With the help of inventory, day one and two can be served completely as the supplier is able to supply one day of demand while the inventory is used up. On day three, only half of the demand can be satisfied, leading to a series of longer waiting times. As the modules supplied on the next day are used for the rest of the orders from last day, all customer orders are late from now on, because the backorders are building up until the capacity of the supplier resumes back to 100%.

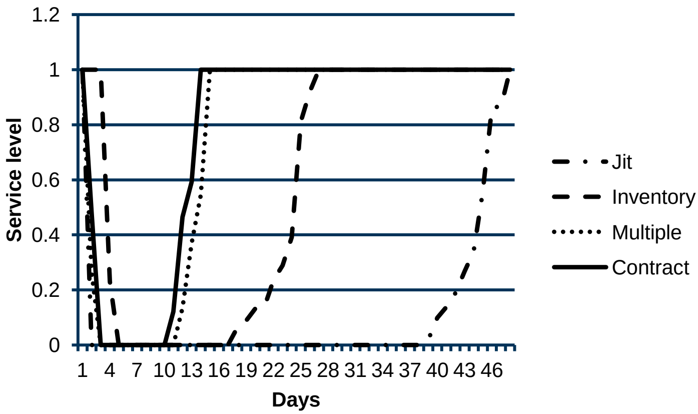

Figure 6 Disruption curves due to complete supplier failure

Since the supplier can only use the rest of the capacity that is not needed for new customer orders for the reduction of back orders, the curve only comes down slowly while maximum order quantity is ordered continuously for 16 days in a row. As this means that not enough modules are supplied (backorders still exist), it results in additional peaks in cycle time depending on which customer order has to wait for the modules. Only once the backorders are back to zero, the system returns to a normal state as inventory is building up again and the procurement volume only includes the daily demand. The effect is intensified in case of complete supplier failure, because there is no capacity available at all for five days (Figure 6). The configuration of the supply chain differs slightly compared to the diminished capacity in order to be able to cope with the increased impact. As only half of the capacity is disturbed in the first one, 10% are distributed to the continuing 2nd supplier compared to 25% in case of complete supplier failure.

Same goes for the flexible supply contract with 500 and 1000 reserved modules per day. This is the reason, why compared to the base case, the service level does not go down to 0% immediately on the day of the disturbance as some remaining capacity is left due to the second supplier to at least fulfill part of the customer orders on the second day. The additional capacity also helps the system to recover more quickly, because less back orders have to be caught up with. It is not sufficient though to keep up a low service level as the orders are processed later and later the longer the disturbance continues. Furthermore, the flexible supply contract has the advantage of fully distributing the demand flexibly on the available capacity. The two days of inventory help to absorb the impact as described before, but the recovery takes just as long as in the base case, because there is no additional capacity available. This also explains why five days of no capacity lead to 37 days with a service level of zero, as 46 days are needed to equalize the number of back orders, because new demand is continuously generated and no additional capacity is available.

6 Conclusion

The negative consequences which a company is confronted with in the course of an incoming supply chain risk depend on the features of the risk event on the one hand and on the design of the supply chain on the other hand. Both parameters have a significant impact on the vulnerability of a supply chain, which depends on numerous factors. Therefore, resilience is becoming an ever more important feature of supply chains to overcome their vulnerabilities and to react effectively to negative effects of risks.

Qualitative methods are not adequate, because they require an aggregation level that today's complex structures do not fit in. As a result, today's complex system has to be mapped in a simulation model in order to be able to perform a sufficient risk and resilience assessment.
As most of companies are struggling to perform simulation studies in practice due to the uniqueness and individuality of simulation technique, a new approach was specifically developed for SCRM. Simulation has been proven to be a suitable tool to analyze supply chain resilience to different strategies. Simulation is anticipating how the newly configured system will react to certain risk events within an experimental environment, which is the only alternative to an implementation in the real system and measuring the impact in the operative business. Herby, the difference of ignoring the risk and investing in mitigation strategies becomes apparent, which is not achievable in practice. If everything goes smoothly, the implication of risk will be absorbed by mitigation strategies and the benefits remain unclear. This is very useful as it enables performance audits and feasibility studies, which can be used in order to find a perfect match between resilience and uncertainty.

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Supply Chain Risk Management: A Case Study in Thailand

Chatchai Raka and Jirapan Liangrokapart

While the increasing of globalization trades, the supply chain has been confronted with complexity and insecurity. Supply chain risk management has become an important tool for managing the risks in the supply chain. Thus the objective of this paper is to study the supply chain risk management by using a fresh produce supply chain in Thailand as a case. Targeted supply chain's stakeholders were interviewed including growers, collectors, wholesalers, processors, retail stores and consumers. The risk events were identified and evaluate into 9 categories. They are Climate risk, Demand risk, Financial risk, Information risk, Operational risk, Policy risk, Price risk, Regulatory risk, and Supply risk. The details of these risks have been clarified and some of risk management guidelines are introduced in order to mitigate them. As a result, the current fresh produce supply chain structure in Thailand has been draw up additionally.

Keywords: Supply Chain Risk Management, Risk Identification, Risk Assessment, Risk Control

1 Introduction

Thailand is an agricultural country. The Office of Agricultural Economic, Ministry of Agricultural stated that in 2011, Thailand total export amounts are 6,882,642 million Baht (or USD 229,421 millions) with 1,447,716 million Baht (or USD 48,257 millions) for agricultural products. Because of a globalization trade of agricultural products is increasing, its supply chain is more complicated accordingly. Ineffective supply chain management will make its chain risky and vulnerability. These will lead decreasing of supply chain's performance. To mitigate the risks which might be occurred in the chain, risk management strategies play an important role for risk reduction. To integrate risk management concept into supply chain activities, supply chain risk management (SCRM) can be defined as "the management of supply chain risks through coordination or collaboration among the supply chain partners so as to ensure profitability and continuity" (Christopher 2006, p.453). The typical risk management steps start from risk identification, risk assessment, risk management, risk control and monitoring. The aim of this paper is to study supply chain risk management by using a fresh produce supply chain in Thailand as a case. A fresh produce supply chain is a dynamic operation, their products are easily to perish and there are many factors influencing while moving along the chain. Hence, this research will study the obstacles or risk factors in a fresh produce supply chain and to acquire the guidance for risk mitigation based on risk management process as mentioned above.

2 Literature Review

2.1 Definitions of Risk

There are a number of research papers defining the concept of risk and uncertainty. The study of risk started in seventeenth century and the probability theory which is the important method to study risk management nowadays was developed. The definitions of risk were addressed by many studies. Manuj and Mentzer (2008) defined uncertainty as the event which is difficult to predict the possible outcome, whereas risk is consisted of three components; they are the possibility of losses, the probability of those losses which might be happened and the importance of the losses' result. Khan and Burnes (2007) have compared the definition of risk and uncertainty that risk can be measured and estimated the probability of the outcome while uncertainty cannot be quantified and estimated. Norrman and Jansson (2004) stated that risk can be quantified the probability of the occurrence of the primary event and measured the consequence of that event. Then Tang and Musa (2010) believed that risk's impact outcome and risk's sources expectation are among the important topics to be studied and discussed. Merna and Al-Thani (2008) explained the risk and uncertainty as the decision about risk will be made if the outcome can be estimated for both possibility and probability, while uncertainty is defined if there are a number of possible outcome but the probability of individual outcome cannot be estimated. Manuj and Mentzer (2008) refined the concept of risk from their research about "Global supply chain risk management strategies" as the potential losses are the significant losses if risk happened and the likelihood is the probability of the emergent event that leads to those risks become realization.

Therefore, the definition of risk for this research is defined as risk is the potential of losses which can be estimated their likelihood and the significant of the outcome should be evaluated for risk mitigation further.

2.2 Supply Chain Risk Management

Risk management can be defined as any actions taken by organizations in order to mitigate the risk arising within their businesses. The risk management involves risk identification, estimation of the probability and the severity of that occurrence, decision to mitigate the risks and implementation of the decided actions. Tang (2006) portrayed four basic approaches which organizations could implement during coordination in their supply chains. The four basic approaches are supply management, demand management, product management and information management. Considering the whole supply chain originating from supply until products' delivering to meet end customers' demand, there are a number of risks along the chains. The major risk factors occurred in both internal and external supply chain are supply risk, operational risk, financial risk, demand risk, information risk, economic crises, change of government rules and regulations, labor issue, natural and man-made disasters and any others.

Many studies involve the risk evaluation and the impact of the risks in difference supply chains. Liangrokapart (2012) studied the case of hospital supply chain disruptions in Thailand. Raka and Liangrokapart (2013) described the risks in pharmaceutical supply chain. While Blos et al. (2009)

who studied SCRM on the automotive and electronic industries in Brazil stated four vulnerabilities in the supply chains; they are financial vulnerability, strategic vulnerability, hazard vulnerability and operations vulnerability.

Vilko and Hallikas (2012) grouped risks into six categories: supply risks, operational risks, security risks, macro risks, policy risks and environmental risks. Manuj and Mentzer (2008) defined risks into eight groups: supply risks, operational risks, demand risks, security risks, macro risks, policy risks, competitive risks and resource risks but the first four are exactly assort with supply chains. Olson and Wu (2010) categorized risk from the literatures into 2 groups, internal and external. Internal risks consist of nature, political system, competitor and market, whereas external risks include available capacity, internal operations and information system. Ritchie and Brindley (2007) described supply chain risk management framework. Risks in the supply chain are originated from particular variables – environmental, industrial, organizational, problem specific and decision-maker related variables. These variables are not only affect risk in terms of systematic and unsystematic, but also affect potential performance.

2.3 A Fresh Produce Supply Chain

The fresh produce industry in Thailand flows from farmers or growers who plant the varieties of products, then harvest and pack in many types of packaging and sell to the district or regional wholesale markets. Most of products are sold through middlemen or collectors and transported to wholesale markets and processing plant. Then processed products are delivered to local retail stores and oversea. Lertrat et al. (2008) has studied the supply chain management for fresh vegetable in Nakornprathom province, Thailand and stated that the stakeholders in this chain from upstream through downstream consisted of farmers or growers (upstream), collectors (middle stream), processors and exporters (downstream) and final delivered to consumers for both domestic and oversea markets. Moreover, Bourlakis and Weightman (2004) said that the food supply is very important for all countries. The general food chain in UK consists of farmers, food manufacturing, wholesaler, retailer, catering or food service, and then delivered to the consumer.

From the literatures and preliminary study, the fresh produce supply chain in Thailand is not much different from vegetable supply chain and food supply chain mentioned above. Fresh produce are perishable products include fruits, vegetables, foods, flowers, meats and etc. Hence, the fresh produce supply chain can be drawn as shown in Figure 1 below;

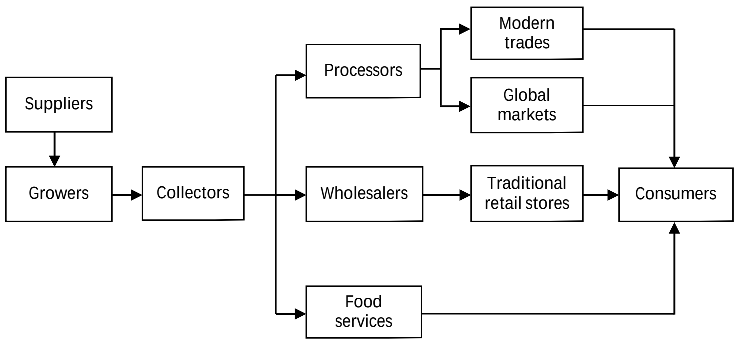

Figure 1 Thailand fresh produce supply chain (Authors)

There are a number of stakeholders in a fresh produce supply chain in Thailand as shown in Figure 3. This research focused on the major stakeholders including growers, collectors, wholesalers, processors, traditional retail stores and domestic consumers for data collection.

3 Research Methodology

After studied a fresh produce supply chain context, then risk assessment in supply chain risk management (SCRM) process has been proceeded. The risks were identified, analyzed and evaluated respectively. A qualitative technique has been applied to this study. An in-depth interview was used to identify the risks in a fresh produce supply chain in Thailand. The samples consist of growers, collectors, wholesalers, processors, traditional retail stores and domestic consumers were selected based on the purposive sampling theory. The risk events in the supply chain have been identified and categorized. Then risk ranking and filtering technique has been applied for risk evaluation. Some of risk control strategies have been suggested consequently in order to minimize the significant risks. The research framework has shown in Figure 2.

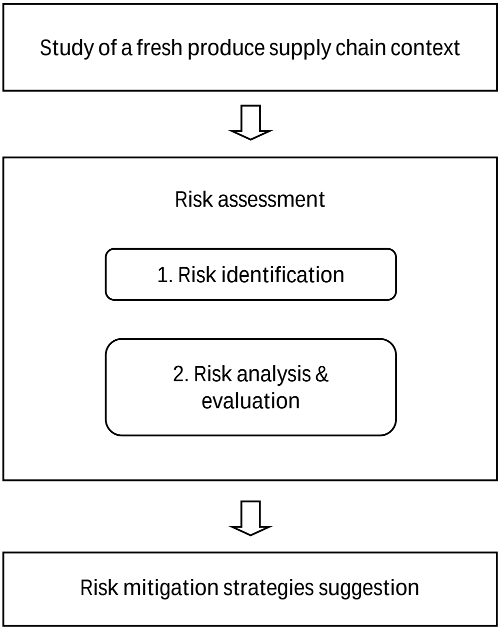

Figure 2 Research framework

4 Findings

After interview, a total of 33 risk events in the fresh produce supply chain were identified. The risk events have been grouped based on its individual relevant to each stakeholder and categorized into climate risk, demand risk, financial risk, information risk, operational risk, policy risk, price risk, regulatory risk, and supply risk. The source of these risk events are classified into two major categories: internal and external. Numerous obstacles during supply chain activities, both internal and external. From farm to fork, the stages of fresh produce; harvesting, collecting, processing, delivering and consumption, encounter many difficulties e.g. price fluctuation, environmental disaster, lack of knowledge, insufficient resources, demand fluctuation, regulatory problems, short shelf-life and etc. These risks are shown in Table 1.

Table 1 The risk events in the fresh produce supply chain

Risk events	Code	Risk sources	Category
Growers			
1. The products' price are lower than cost.	E1	External	Price risk
2. Climate change.	E2	External	Climate risk
3. Lack of knowledge in agricultural technology.	E3	Internal	Information risk
4. Agricultural pest problem.	E4	Internal	Operation risk
5. Lack of labor.	E5	Internal	Operational risk
6. Seeds, fertilizers and pesticides shortage.	E6	External	Supply risk

Risk events	Code	Risk sources	Category
7. Uncertainty government policies.	E7	External	Policy risk
8. Cash flow problem.	E8	Internal	Financial risk
Collectors			
9. Trust between growers and collectors, not strict to the commitment (if benefit involved).	E9	External	Price risk
10. Cash flow problem.	E10	Internal	Financial risk
11. Uncertainty purchase order from buyers.	E11	External	Demand risk
12. Responsible for perished products.	E12	Internal	Operational risk
Wholesalers			
13. Cash flow problem.	E13	Internal	Financial risk

Risk events	Code	Risk sources	Category
14. Responsible for perished products.	E14	Internal	Operational risk
15. Short shelf-life products.	E15	Internal	Operational risk
Processors			
16. Raw materials' price fluctuation.	E16	External	Price risk
17. Short shelf-life products.	E17	Internal	Operational risk
18. Production planning difficulty.	E18	Internal	Operational risk
19. Strictly regulations from regulators, both domestic and overseas.	E19	External	Regulatory risk
20. Highly cost for quality systems.	E20	Internal	Financial risk
21. Labor cost problem.	E21	Internal	Financial risk

Risk events	Code	Risk sources	Category
22. Lack of labor skills.	E22	Internal	Information risk
23. Lack of workforces.	E23	Internal	Operational risk
24. Selling price problem, especially for modern trades.	E24	External	Price risk
25. New competitors can enter easily.	E25	External	Demand risk
Retail stores			
26. Short shelf-life products.	E26	Internal	Operational risk
27. Products shortage due to farming problems.	E27	External	Supply risk
28. Strictly regulations from regulators, such as pesticide residue test, will make unsatisfactory from consumers.	E28	External	Regulatory risk
29. Increasing of new competitors.	E29	External	Policy risk

Risk events	Code	Risk sources	Category
30. High cost.	E30	Internal	Financial risk
Consumers			
31. Products quality problem.	E31	External	Supply risk
32. Higher price if buy from modern trades but the quality might be equal to other fresh food markets.	E32	External	Price risk
33. Consumer confidence in terms of products traceability.	E33	External	Supply risk

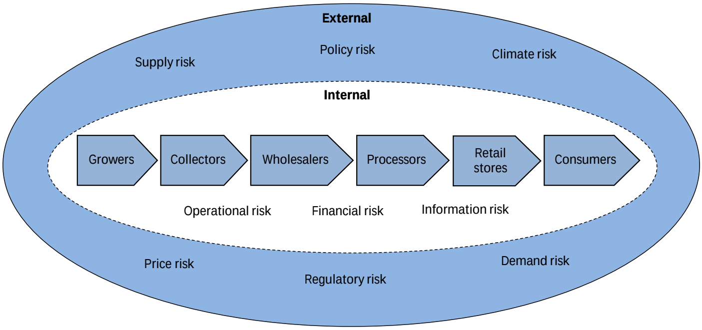

Figure 3 External and internal risks in the fresh produce supply chain

The risk events which happened in each major stakeholder in the fresh produce supply chain have been categorized into 9 categories as explained above then merged into the supply chain as shown in Figure 3. The internal risk sources which occurred within their organizations are including financial risk, information risk and operational risk, respectively. And the remaining; climate risk, demand risk, policy risk, price risk, regulatory risk and supply risk are under the external risk sources as they are the circumstances outside which effect to the chain.

These risks have been evaluated by risk ranking method to quantify the probability and consequence with a two-dimensional diagram, a basic evaluation model. The scores are assigned as high (3), medium (2) and low (1) for both probability of occurrence and severity of consequences. The risk score (R_n, a risk event n) is given by the multiple of probability (P_n, a probability of occurrence n) and severity (S_n, a severity of consequence n) as shown in formula (1).

Probability of occurrence

High (certainly occurred)	Medium risk (3)	High risk (6)	High risk (9)
Medium (probable occurred)	Low risk (2)	Medium risk (4)	High risk (6)
Low (hardly occurred)	Low risk (1)	Low risk (2)	Medium risk (3)
	Low potential impact	Medium potential impact	High potential impact

Severity of consequences

Figure 4 Two-dimensional diagram risk ranking matrix (adapted from The Chartered Quality Institute, UK, 2010)

The risk ranking and evaluation has been presented in Table 2, these results were evaluated by 3 experts who are senior managers in a fresh produce supply chain. Two-dimensional diagram risk ranking matrix has been illustrated in Figure 4 below;

$$\boldsymbol{R_n} = \boldsymbol{P_n} \times \boldsymbol{S_n} \tag{1}$$

Table 2 The risk ranking and evaluation

Risk events	Category	P_n	S_n	R_n
E1	Price risk	3	3	9
E2	Climate risk	2	3	6
E3	Information risk	3	1	3

Risk events	Category	P_n	S_n	R_n
E4	Operation risk	2	2	4
E5	Operational risk	2	2	4
E6	Supply risk	2	3	6
E7	Policy risk	2	1	2
E8	Financial risk	3	3	9
E9	Price risk	2	3	6
E10	Financial risk	3	3	9
E11	Demand risk	2	2	4
E12	Operational risk	2	2	4
E13	Financial risk	3	3	9
E14	Operational risk	2	2	4
E15	Operational risk	2	2	4
E16	Price risk	3	3	9
E17	Operational risk	2	2	4

Risk events	Category	P_n	S_n	R_n
E18	Operational risk	2	2	4
E19	Regulatory risk	2	1	2
E20	Financial risk	2	3	6
E21	Financial risk	3	3	9
E22	Information risk	2	2	4
E23	Operational risk	2	2	4
E24	Price risk	3	3	9
E25	Demand risk	2	2	4
E26	Operational risk	2	2	4
E27	Supply risk	2	3	6
E28	Regulatory risk	2	1	2
E29	Policy risk	2	1	2
E30	Financial risk	2	3	6
E31	Supply risk	2	3	6

Risk events	Category	P_n	S_n	R_n
E32	Price risk	2	3	6
E33	Supply risk	2	3	6

The risk events which revealed 6, 9 points are high risks. The scores of 3, 4 are medium risks. Then the scores of 1, 2 are low risks. Therefore, the risk score can be summarized into 3 levels; high, medium and low. From the result in Table 2 above, climate risk, financial risk, price risk and supply risk resulted in 6 and 9 scores which located in the high risk area. These risks are the most priority for growers and most significant for collectors, processors and consumers as well. The cash flow problem, raw materials' price, raw materials supply, climate change, operational cost, labor cost and selling price are the most critical for them. While, demand risk, information risk and operational risk resulted in 3 and 4 scores, moderate risk level. Lack of information, operational difficulty, labor shortage and demand uncertainty are medium potential impact to the chain. At last, policy risk and regulatory risk are lowest priority for risk mitigation as resulted in 1 and 2 scores.

The experts also recommended some suggestions which are useful to reduce risk impact. These suggestions were merged into 4Ts strategy by the authors. The Chartered Quality Institute, UK (2010) explained risk mitigation strategy based on 4Ts (treat, transfer, terminate and tolerate), a beneficial method for risk control. The risks will be treated to reduce their severity of consequences and prevent their probability of occurrence, transferred to the third party such as consider to buy the insurance, terminated by stop implementing the risks' activities and tolerated them by accept the insignificant risks or do not perform any actions. The risk control guidelines are concluded in Table 3.

Table 3 The level of risk and risk control guidelines

Risk categories	The level of risk	Risk control guidelines	4Ts Strategy
Climate risk	High	- Crop insurance.	Transfer
		- Avoid planting if climate forecast detected any problems.	Terminate
Financial risk	High	- Low interest loan from agricultural bank or the government financial institute.	Transfer
		- Cost control.	Treat
		- Attend some financial or accounting courses.	Treat
		- Avoid investment without appropriate plan.	Terminate
Price risk	High	- Price guarantee from the government.	Transfer

Risk categories	The level of risk	Risk control guidelines	4Ts Strategy
		- Avoid unreliable partners.	Terminate
		- Multiple sources.	Treat
Supply risk	High	- Multiple sources. Treat	Treat
		- Implement contract farming.	Treat
Demand risk	Medium	- Implement customer relationship management.	Treat
		- Using information technology e.g. forecasting model.	Treat
Information risk	Medium	- Attend training courses concerning agricultural technology.	Treat
		- Using information technology e.g. internet.	Treat
Operational risk	Medium	- Provide in-house or outside training courses concerning operation / quality control.	Treat

Risk categories	The level of risk	Risk control guidelines	4Ts Strategy
		- Implement human resource management program in order to maximize employees' performance.	Treat
Policy risk	Low	- Accept the policies as launched by the government.	Tolerate
Regulatory risk	Low	- Accept the regulations to comply with the government's orders.	Tolerate

5 Conclusion

In this study, risk events in the fresh produce supply chain in Thailand have been identified and evaluated. These risk events have been classified into 9 categories. They are climate risk, demand risk, financial risk, information risk, operational risk, policy risk, price risk, regulatory risk and supply risk. Climate risk, financial risk, price risk and supply risk have the strongest impact to the fresh produce supply chain whereas demand risk, information risk and operational risk are in average effect. Policy risk and regulatory risk are insignificant to the chain as per the experts' perspectives. Furthermore, the risk mitigation strategies for risk control have been suggested regarding 4Ts strategies (treat, transfer, terminate and tolerate) in order to reduce the probability and severity of these risks, especially the most impact categories. In addition, the current fresh produce supply chain structure in conjunction with internal and external risks has been drawn as well.

Finally, other stakeholders in a whole chain would be considered for further study in order to ensure the risk categories. Other research methodologies e.g. Analytical Hierarchy Process (AHP) might be applied to select the most appropriate risk mitigation strategies.

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Since 2006 the annual conference Hamburg International Conference of Logistics (HICL) at Hamburg University of Technology (TUHH) is dedicated to facilitate the exchange of ideas and contribute to the improved understanding and practice of Logistics and Supply Chain Management. HICL provides a creative environment, which attracts researchers and practitioners from all over the world.

This volume contains research contributions by an international group of authors addressing innovative and technology-based approaches for logistics and supply chains. They present business models and investment options for enhanced strategic decision making as well as recent approaches for supply chain risk management.

This volume, edited by Wolfgang Kersten, Thorsten Blecker and Christian Ringle, provides valuable insights into:

- Innovative and Technology-based Approaches for Logistics and Supply Chains
- Business Models and Investment Options for Strategic Decision Making
- Recent Approaches for Supply Chain Risk Management

ISBN (Print) : 978-3-7375-4057-5
ISBN (Online) : 978-3-7375-4059-9
ISSN (Print) : 2635-4430
ISSN (Online) : 2365-5070