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Digitalized and Autonomous Transport – Challenges and Chances

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Purpose: European Logistics is characterized by a matured infrastructure. Nevertheless, industry has to catch up in terms of digitalized and autonomous transport. The awareness-rising of industrial companies in this area is still limited. Therefore, the paper includes a research in order to find out the reasons for hesitations of manufacturing industry.

Methodology: For this purpose, an overview of digitalized and autonomous transport based on a literature research is given and reflected at the beginning. The focus is on new concepts to demonstrate the potentials to handle actual challenges. Subsequently, an empirical study is conducted, on which 138 manufacturing companies have participated.

Findings: The empirical study shows that governmental institutions have to work out a legal framework. Manufacturing companies are still sceptical of trends in digitalized and autonomous transport logistics. Logistics Managers still see barriers in the fields of security and infrastructure. Actually they see low chances in the next years.

Originality: Current transport logistics trend analyses usually do not challenge the topic of digitalized and autonomous transport from the users point of view. Manufacturing companies have to face a variety of challenges in the field of transport. By conducting the research, the current state and hesitations of management can be outlined.

Keywords: Digital Supply Chain, Autonomous Driving, Freight Transport, Empirical Survey

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1 Digitalized and Autonomous Transport

Due to recent development of technology and prevalent logistics framework, the relevance of digitalized and autonomous transport is growing rapidly. Technical innovations enabled an impressive development of Information and Communication Technology (I&CT) in logistics. Nowadays these innovations allow to coordinate and control all processes along the supply chain to achieve fully transparency of orders and transports.

Driven by Industry 4.0 new technology like 3D printing, Cloud Computing and Big Data have a substantial impact on how logistics manager can steer global supply chains by using software for route and cost planning or real-time tracking of goods along the supply chain. There is a significant offer of solutions which rely on these technologies.

The utilization of these technologies is essential to control complex supply chain in context of international trade. The competitiveness of the European business location is obviously determined by an efficient logistics of goods. Especially in Germany, which is at the head of European export nations (World Trade Organization, 2018), logistics industry is the third largest economic sector of the country. Due to global megatrends, which have a significant impact on supply chains (Bischof, Tschandl, Brunner, 2018, p. 120), no stop in increasing of international trade is expected. (Enzweiler, Kind and Jetzke, 2018, p. 1).

Facing the future challenges freight transport can be supported by a unique key innovation. Autonomous driving is triggering social and economic benefits for all stakeholders in the supply chain. It is obvious that in the automotive sector, especially Original Equipment Manufacturers (OEM) are investing into research and development of autonomous driving (General

Motors, 2018). This development is particularly driven by government by a huge acceleration in investments in autonomous vehicle (AV) technology and the changing of policies to encourage AVs to opening public roads. AVs also have received attention of the European Commission strategic documents in the context of broader debates on European competitiveness, climate protection, energy, employment and education within the EU 2020 strategy (European Commission, 2010).

It is incontrovertible that AVs gain in importance for transport. Freight transport can be performed in different modes of transportation (Pfohl, 2010, p. 154). Beside AVs for road transport, OEMs are also working for solution on maritime roads (Pluta, 2018). In the area of freight transport, trucks will be equipped with driving robots, which take control of the vehicle, whereby a uniform definition of AVs is still missing (Maurer, et al. 2015, p. 2).

Table 5: Stages of Automation (Lemmer, 2016, p. 12)

Stage of Automation	Definition
0 (Driver Only)	The driver must take control of longitudinal and lateral guidance permanently.
1 (Assisted)	The driver must take control of longitudinal or lateral guidance permanently, while robotic performs the other driving guidance. The driver has to monitor the system permanently and must be ready to take over complete vehicle guidance.
2 (Partly Automated)	The robot takes control of longitudinal and lateral guidance in certain situations, while the driver has to monitor the system. The driver must be ready to take over complete guidance.
3 (Highly Automated)	The robot takes over control of longitudinal and lateral guidance for determined time, while the driver has not to monitor . The robot is able to hand over control to the driver considering a defined preparation time for driving tasks to get ready.
4 (Fully Automated)	Longitudinal and lateral guidance are taken over by the robot for a concrete application . The driver does not have to monitor within the application due to autonomous guidance of the robot as long as the vehicle does not leave the concrete application.
5 (Autonomous)	The robot takes control of full guidance and functions whereby the driver is not needed anymore.

To analyze the chances and challenges it is essential to specify the research subject by identifying capabilities of AVs which are essential to join public roads. Autonomous driving describes independent driving, which is already realized as concrete applications within a determined system like the subway in Copenhagen or the "Skytrain" at the Airport of Frankfurt (Wagner, 2017, p. 9f). To concretize the subject of autonomous driving, stages of automation are compiled to define the capability of vehicles explained in the Table above.

Starting in stage 3 the driver is able to fulfill other tasks during the ride, which is already realized. Based on expert's opinion Stage 4 will be attained in 2025, the final stage 5 in 2035 (Kossik, 2019). The final stage, which is the stage of autonomous transport is desired by industry to face the challenges of future logistics (Moring, Maiwald and Kewitz, 2018, p. 52) and offers new chances which will be presented in the upcoming chapters. This classification is based on a legislative proposal and serves as base for further law legislations (Bundesministerium für Verkehr und digitale Infrastruktur, 2015).

In 2017 law was changed to allow high or fully automated driving on German roads, as far as the system can be deactivated by humans at any time (Deutscher Bundestag, 2017). Fully autonomous driving is still not ratified in German law. In the area of freight transport legislative regulations have to be internationally valid.

Meanwhile OEMs like Daimler and Volvo have been already testing autonomous trucks on test tracks. Due to the enhancing improvement of technology, expert's opinions is that a limited amount of autonomous trucks could access public road until 2025 (Crandall and Formby, 2016, p. 29). The technological change will also affect the OEMs sustainably. This means that they

will have to increase their product portfolio by including new powertrains. In future they will have to focus on autonomous long-haul trucks, going away from making a home on wheels to self-driving containers (Nowak, Viereckl, Kauschke and Starke, 2018, p. 9).

To make AV, especially autonomous trucks for freight transport road capable several perspectives have to be considered to figure out chances and challenges for logistics. Therefore, in the following chapters the chances & challenges as well as new concepts will be described to get an inside-view into the complexity, but in particular into the perception of logistics manager in the industrial sector by applying an empirical study.

2 Chances and Challenges of Digitalized and Autonomous Transport

Logistics designs the value chain along the whole production life cycle concluding goods or services, information and financial flow and connects different businesses cost-efficiently. The advantages generated in these networks by logistics is gained higher than the economic value for the customer per se (Austrian Logistics, 2018).

As mentioned before German logistics is substantial for the country's economy. In Europe the total turnover of the logistics branch amount to 1.050 Billion Euro. Just under half of the total of logistics performance is visible and perceptible by the transfer of goods. The other half takes place in form of planning, controlling and realization within the companies (Grotebauer and Wagner, 2019, p. 70).

European road transport is under increasing criticism and afflicted with many problems. Beside the high pollutant emission, the increasing volume

of traffic on roads is enhancing the level of energy consumption, noise generation and road abrasion. As a result, toll costs, fuel and fuel taxes are increasing, while the EU eastward enlargement come along with a competitive distortion due to lower incidental wage costs (Kubenz, 2008, p. 234f). Therefore, autonomous transport is opening new opportunities and chances for logistics to meet the framework and handle challenges within the industry. The potentials of the technology are explained in the following subchapters.

2.1 Disruptions in Modern Transport Logistics

Autonomous transport is applicable in two different stages of external logistics. On the one hand manufacturing industry can use AVs for internal transport in plants, on the other hand autonomous trucks can be applied for external road utilization.

Within the factory site AVs could connect facilities like production and warehouses which are locally separated from each other. Otherwise AVs or so called Automated Guided Vehicles (AGV) can support transport processes at terminals. By applying the technology, transport routes can be shortened and empty trips avoided (Fläming, 2018, p. 372f).

Especially in the area of internal transport the potential of new technologies is already used by many companies. Electric driving systems are already applied in shuttle transport. Depending on the framework and the utilization of such applications they amortize within six years due to governmental subventions. The effect on public reputation and the decreasing of pollution is worth mentioning (Resch, 2018).

Emerging from the example above, not only automation and autonomy is disrupting European logistics. The principle of 3D-6Z is explaining three significant disruptions and thereof resulting zeroes in logistics in future, which are listed in the following Table.

Table 2: Principle of 3D-6Z (Rieck, 2018)

Disruptions	Zeroes
Electrification	Zero Emission
	Zero Energy
	Zero Congestion
Automation/Autonomy	Zero Accident
	Zero Empty
Connectivity	Zero Cost

The Initiative Connected Mobility (ICM) identified different benefits from autonomy in local transport. AVs can reduce noise and fine dust pollution, offers 24/7 application without taking time regulations into account, reduces transport costs by omission of drivers and employees for loading and unloading and optimization of these processes (Automotive Cluster, 2018). Due to the research subject of digitalized and autonomous transport, the following section is concentrating on the disruption of automation/autonomy and connectivity, which is the main idea of autonomous transport. Of course the disruption of electrification in transport is synonymous with those. New technologies enable to reduce emissions and energy consump-

tion and is an essential part of logistics in future. However, automation/autonomy and connectivity is also impacting the emission of pollutant as well as improving the energy consumption in transport due to optimized driving behavior.

Therefore, in the following subchapters the main focus is on the potentials concerning congestions and accidents as well as transport costs, which are seen as the zeroes with the highest impact on logistics. Emission and energy is seen within the issue of transport costs.

2.1.1 Congestion and Accidents

The "vision zero" refers to the goal of the European Commission to eliminating traffic fatalities and injuries by 2050 within the transport roadmap. In line with this goal, EU wants to halve road casualties by 2020 to become a world leader in safety of transport in all modes of transportation (European Commission, 2011, p. 10).

Nevertheless, by analyzing European strategies, the prioritization in the area of intelligent transport systems is based on the development of I&CT and does not explicitly talk about autonomy in transport so far (European Parliament, 2010).

Referring to the World Health Organization, in 2016 1.35 million road users were killed worldwide. In comparison to 2013 (1.25 million) this figure corresponds to an increase of 8% within 3 years, which doesn't comply with the desired development of the EU strategy 2020 (World Health Organization, 2018, p. 4). Based on the National Motor Vehicle Crash Causation Survey (NMVCCS) conducted from 2005 to 2007, 94% of all crashes are caused

by drivers themselves. The most common reasons are recognition, decision, performance and non-performance errors (e.g. sleep) of humans (92%) (U.S. Department of Transportation, 2015, p. 1f).

Removing the risk of human errors would reduce accidents and vehicle-related deaths. Despite this fact it is assumed further development in technology to improve safety of AVs. This fact is supported by the first death caused by testing AVs in Tempe, Arizona in 2018 (Bergen and Newcomer, 2018). However, autonomous transport could design road transport more safety and efficient due to less accidents and congestion. Affected by a lower risk for human caused accidents to reach the European Commission's goals until 2050.

Autonomous transport will have big impact on different industries. By reducing the amount of accidents and injuries especially the personal automotive insurance sector will be dramatically affected. Based on researches in the United States this sector could shrink by 40% within 25 years, while the number of accidents is estimated to drop around 80% (KPMG, 2015).

2.1.2 Transport Costs

A research by Morgan Stanley in 2013 shows the impressive cost reduction potential of autonomous vehicles. According to this, about \$1.3 trillion could be saved each year by using autonomous vehicles. By comparing this cost reduction with the gross domestic product of the United States, this amount is equivalent to approximately 7% (Morgan Stanley Research, 2013). This calculation includes savings in fuel, labor costs, injuries and fatalities, increase of productivity and less congestion, which are the main areas where autonomous driving takes effect. The research firstly shows the

impact of the technology even if it has to be considered that such calculations are based on assumptions due to missing field reports.

Due to the complex sensor technology and software which is required in AVs, the sales prices of series vehicles will increase. Therefore, driving robots will be found firstly in premium segments as well as in heavy utility vehicles and touring coaches before they will be comprehensively implemented in the market. Essential prerequisite is the customer's willingness to pay higher prices in order to meet the increased production costs (Kossik, 2019).

Other studies show that the new design of trucks influences the initial price of trucks enormously. Due to the drop of driver cabins, OEMs can reduce costs by approximately €30.000 per vehicle. The additional costs for technology is estimated about €23.000 per vehicle, which means that investment costs of trucks will decrease in average by 7% (Nowak, 2018).

Another important cost factor are labor costs. Driving jobs are a major source of employment in the European Union. 4.8 million people within 28 EU countries are employed as driver in the logistics industry (European Automobile Manufacturers Association ACEA, 2018). Implementing autonomous trucks will have positive as well as negative impact on economy. In this area the cost-benefit evaluation for European economy is not possible to execute due to missing facts.

3 Concepts concerning Autonomous Transport

In the following subchapters relevant concepts of autonomous transport are described to get an overview of the possibilities of technology and their impact on European freight transport.

3.1 Physical Internet

Autonomous transport is an approach of Logistics 4.0, which includes concepts and technologies for adaptable, efficient and sustainable logistics. The thematic focus is on the vertical and horizontal integration of the value chain through merging digital and physical technologies (cyber physics). In order to fulfill the requirements resulting from customer individualization and flexibility, approaches like autonomous transport as well as self-optimization and the Internet of Things (IoT) are used. In this context elements of Logistics 4.0 are included in the concept of the Physical Internet (Lueghammer, Schwarzbauer, et al., 2015).

The Physical Internet (PI) is an intermodal and open logistics network, which is characterized by standardization, modularity and real-time capacity by utilization of the IoT (Montreuil and Louchez, 2015). In 2011 the concept was introduced as a framework to improve the efficiency and sustainability of logistics networks by sending data packets through the IoT. Logistics objects, intelligent containers and trucks, will be connected to dynamically optimize the transport flows within this network. This development in logistics realizes new business models as well as new logistics processes. (Kasztler, Wagner, Wepner, 2017).

The European Technology Plattform ALICE (Alliance for Logistics Innovation through Cooperation in Europe) has set the PI as objective of efficient and sustainable logistics by 2050 (Treiblmaier, 2016, p. 2f). By taking into consideration that the PI will have a deep impact on European logistics, a concrete demand of information is given by the manufacturing industry to work on the objectives.

3.2 Platooning

Platooning is understood as the grouping of vehicles into platoons to increase the capacity of roads, especially on highways. Prerequisite for this is an automated highway system. The platoon consists at least out of two consecutive vehicles (Lehnertz, 2018) in order to reduce air resistance of the following vehicles. Due to short safety distance fuel consumption can be decreased, which leads to energy costs saving of 4 - 7% (Elger, 2014).

I&CT allows to interchange data in real-time and synchronize breaking operations of several vehicles in order to keep the safety distance. Vehicles are able to react based on the driving behavior of the leading vehicle in the front. This leads to the saving in employees, which is another cost driver in transport. The application of platooning allows to control several vehicles by a single driver, which leads to two important approaches in platooning (Lehnertz, 2018), shown in the following Table.

Table 3: Approaches of Platooning (Own Elaboration)

Cost savings based on reduction of driver	Cost savings based on reduction of transport time
The application of platooning allows to reduce the amount of drivers for the transport. In future, several vehicles can be controlled by the leading driver. This concept is only applicable on highways due to the lower complexity of traffic.	The application of platooning allows to skip rest times. While one driver can control at least two vehicles on the highways, the other driver is able to rest in the driver cab. This leads to a reduction of transport times and subsequently to optimization for all stakeholders.

Based on the current availability of drivers on the labor market, platooning could be an enabler for handling the lack of drivers in future's logistics. Whereby the approach of cost saving based on reduction of transport times is the solution more likely.

One main problem of platooning is the complexity of traffic. Whilst traffic in cities is characterized by high complexity due to a high number of influence factors (different road users, pedestrians, traffic lights, etc.), on highways the complexity is less complex. This leads to problems in the transition zone highways and cities or suburban areas, where platooning is not applicable (Automotive Cluster, 2018).

Benefits of platooning can be identified in the increasing of road safety by reducing human errors and the reduction of pollution by the optimization of fuel consumption.

Countries like Netherland, Belgium and Germany are already working together to establish platooning on major roads for logistics. This concept will get more important in spite of the fact that for instance in the United States the vehicle miles travelled per year (VMT) will reach 78 billion by 2040 to meet the demand resulting from increasing desire for same-day or same-hour delivery (KPMG, 2018, p. 11)

4 Empirical Study on Transport Trends

After analyzing the situation on autonomous transport on European roads, the conducted empirical study will be presented in the following chapter. Therefore, the research design, which contains the empirical sampling and

statistical analysis of the companies responding on the survey will be followed by an excerpt of the findings, related to the headed topic of this paper.

4.1 Research Design

The empirical study is based on data captured from manufacturing companies through executing a closed online survey. Objective of this survey is to research the actual state of transport logistics from the manufacturing company's point of view. The selection of study participants is done by a list-based sampling method. The focus of the empirical research is on manufacturing companies within Group C "Production of Goods" of the Austrian classification of economic activity ÖNACE (Wirtschaftskammer Österreich, 2017) with more than nine employees and a total turnover more than €2 million. The sampling is adjusted for Group C33 "Repair work & Installation" due to the fact that this group do not include manufacturing companies according to the survey's definition.

The survey was sent to 3.582 companies, whereof 194 participated in the empirical research (Response rate = 5,4%). 138 companies responded to all questions. To generate meaningful and representative findings, the survey was directed at managers within logistics-related departments with accountability for logistics tasks.

Table 4: Evaluation of dataset (Number of employees and turnover)

Number of	≤	≤	≤	≤	>
Employees	€ 2 Mio.	€ 10 Mio.	€ 49 Mio.	€ 100 Mio.	€ 100 Mio.
≤ 9	0	1	0	0	0
≤ 49	1	25	2	0	0
≤ 249	1	5	18	3	4
≤ 550	0	1	4	16	0
> 550	0	0	1	0	26

The majority of the companies participated at the survey are classified as small and medium-sized companies (SME). However, it is necessary to take account of the fact that due to incomplete data entries just 108 companies are considered in this statistic (Table 4).

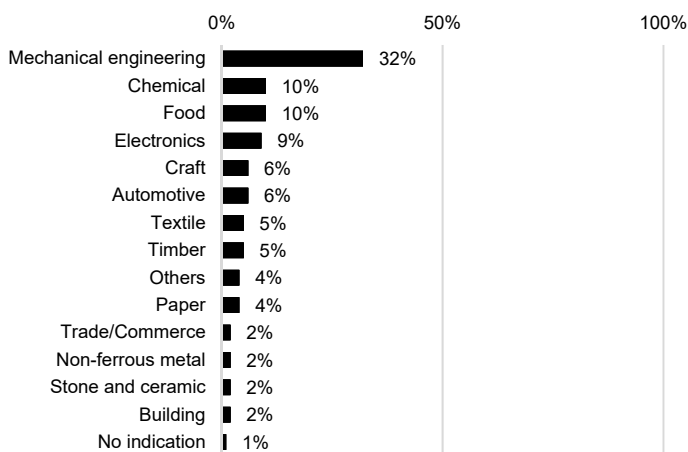


Figure 1: Industrial sectors addressed in the data set (n=138)

The Figure above shows the industry affiliation of the responding companies. The majority of the participants (32%) belong to the mechanical engineering industry. The second most frequently occurring industry is the chemical industry (10%) followed by the food industry (10%) and electronics industry (9%). "Other" includes those industries like pharmacy, synthetics, feed, consumer goods and biomass plants with 4% stake from the whole sampling.

4.2 Study on Modes of Transportation

137 out of 138 companies deliver frequently or more frequently to their customers by using European road infrastructure. The most important reason for its utilization is high flexibility and short delivery times as well as reliability of road transport. Deep sea shipping is a mode of transportation used by 27 companies frequently or more frequently due to low costs and transport risk. Especially the high mass capability is highlighted by the participants of the study. The Figure below shows that road transport is the most frequently used way of transport in manufacturing industry.

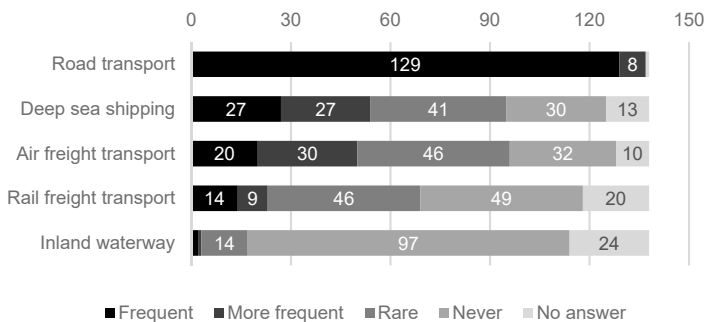


Figure 2: How frequently are modes of transportation used? (n=138)

Due to this fact, the importance of road transport for manufacturing is verified by the participants. This mode of transportation is used of companies for direct and indirect (combined or multi-level) transport.

Regarding the future development, road transport is seen as the mode of transportation with the highest increase in tonnage. Hand in hand with this development manufacturing companies see an increasing of tonnage in intermodal transport which means that road transport is going to be the key mode of transportation in future. The following Figure shows the estimation of the survey's participants in detail.

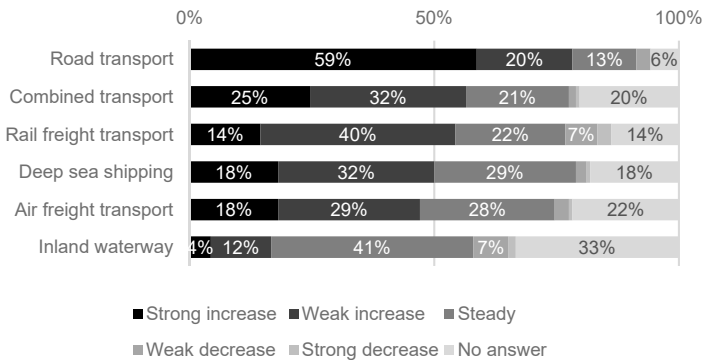


Figure 3: In the next five years, which changes in utilization of modes of transportations to you predict? (n=138)

The survey clearly points out the importance of road transport in future. The gaining in tonnage and increased utilization of the road infrastructure reinforces already existing challenges in freight transport. Therefore, the development of new concepts to face challenges and exploit opportunities like mentioned in the previous chapters will be essential to maintain and

develop the existing European logistics infrastructure and the whole business sector in a sustainable way.

In general, the logistics infrastructure is seen as highly sophisticated for the actual stage of development. Due to further Austrian researches in 2019 the technical infrastructure regarding the road and grid infrastructure is well-rated by 93% of the study's participants. 70% of Austrian manufacturing companies are located less than 50 kilometers away from the next freight terminal, which confirms the logistics manager's estimation concerning the growing in importance of intermodal transport in future (FH JOANNEUM - Institut Industrial Management, 2019).

Referring on this development new concepts are more vital than ever before. The concept of Industry 4.0 is seen as the most important enabler in this area. The survey shows that manufacturing companies still hesitant regarding new solutions in logistics. Whereby 56% of the participants are interested into the concept of Industry 4.0 in the context of logistics. The concept of the Physical Internet (PI) which is explained in chapter 3.1, is not well known. 23% indicated that there is a lack of information about the long-term effect of the Physical Internet.

4.3 Study on Autonomous Vehicles

The estimation of development in the area of autonomous transport is the core of these empirical research. Therefore, manufacturing companies were surveyed regarding their opinion, if autonomous trucks will be used on public roads in the next ten years. The findings are listed in the following Table.

Table 5: Evaluation of dataset (Number of Employees and turnover)

	Fully applies	Rather applies	Rather not applies	Not applies	No answer
Autonomous transport is just a hype!	11%	31%	23%	16%	18%
Autonomous trucks show a high potential. But there are too many barriers.	31%	31%	15%	6%	18%
Trucks will drive autonomously but drivers will have to attend.	25%	47%	8%	5%	15%
In 10 years autonomous trucks will be on roads.	0%	6%	21%	53%	20%
The progress cannot be evaluated.	32%	36%	8%	4%	20%

Just 6% of the participants think that autonomous trucks will be able to join public roads in the next ten years. Nevertheless, they see a high potential in AVs. These findings can be traced back to the barriers of technology, initial costs in investment as well as legal constraints and the missing legislation in road traffic regulations. Furthermore 72% of the participants think, that drivers cannot be replaced. This means, that the respondents count on fully automated vehicles of stage 4, which will be attended by drivers.

Especially the concept of platooning could be one realistic scenario in a pre-stage of autonomous driving from the industry's point of view. Worthwhile emphasizing is that in average 18% do not answered, which shows a high uncertainty of logistics managers in this topic. To find out more about the uncertainty the participants were asked about what barriers and challenges do they see regarding autonomous driving.

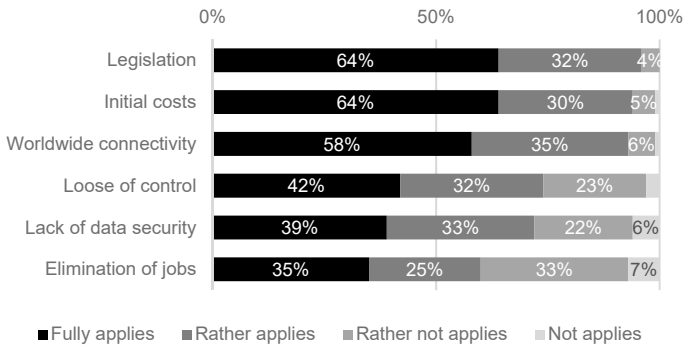


Figure 4: Which challenges/barriers are seen in utilization of autonomous trucks? (n=138)

As mentioned before, legislation is seen as the biggest barrier (see Figure 4). It appears that, that industry transferred this challenge into the area of responsibility of politics. Some countries already ratified laws for the utilization of autonomous vehicles, whereby this regulatory must be rolled put nationwide. The elimination of jobs is perceived as the lowest barrier for implementing autonomous transport. This is traced back to the lack of drivers in the logistics area. In relation to the initial costs of the investment in autonomous vehicles at the market entry, the participants rated investment costs with 64% as challenge.

By researching the advantages of autonomous trucks the rapid operational readiness is the highest rated aspect. Based on the connectivity of the fleet, participants see potentials in efficient route planning and reduction of operational costs (see Figure 5)

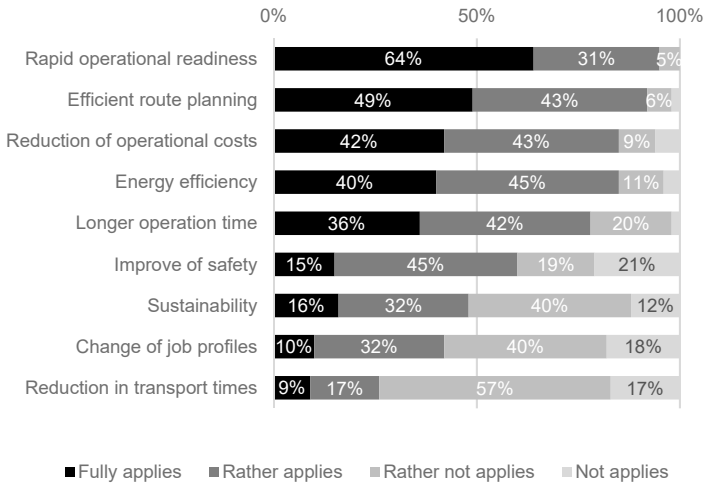


Figure 5: Which opportunities are seen in utilization of autonomous trucks? (n=138)

The results are not identical with the researches of chances. The participants are not convinced of the possibilities and chances that experts predict due to researches. Therefore, sustainability, short transport times and the change of job profiles for drivers is assessed poorly in this survey. All this could result out of the missing knowledge of manufacturing companies as well as the test results in stage 5, which just can be estimated by extrapolation on studies.

5 Concluding Remarks

The reflection of the research topics clearly shows the progressive development of I&CT. Based on this fact, autonomous driving is more than a vision of the future. Researchers expect a fast development of essential technology to enable the entry to public roads soon.

The logistics sector has to deal with many problems. Especially the lack of drivers is one of the most discussed problems. Due to the situation on the labor market, the situation will not ease up soon. On the contrary, the situation is more critical by increasing transport costs due to fuel taxes and toll costs. Moreover, environmental and noise pollution is influencing the reputation of European freight logistics and make the situation for logistics accountable more critical.

Autonomous transport could be an enabler to handle these challenges of modern logistics. The potential of this technology is highly evaluated by experts and researchers. Nevertheless, the participants of the conducted survey do not think that autonomous trucks will be approved for public roads in the next ten years.

Furthermore, the utilization of autonomous trucks will not replace the driver's job. While experts think that autonomous trucks will not need an attendant, logistics accountants of manufacturing companies do not see the solution for the lack of drivers. They think that drivers have to join the transport as attendant, from which job profiles will change in future.

The digitalization in industry will have far-reaching consequences, also in the education of logistics employees. The education with respect to digital technology is one priority issue which has to be strengthened in future.

Finally, all these concepts do not support in handling challenges of today and tomorrow, if the public and industrial perception of these technologies will not be enhanced. The survey clearly shows, the lack of awareness and the uncertainty of logistics managers in manufacturing companies.

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