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**PRODUCTIVITY IN ESTONIAN ROAD
FREIGHT TRANSPORTATION**

Master thesis

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Name and signature of supervisor

Allowed on defense

(Date)

I have written this master's thesis independently. All viewpoints of other authors, literary sources and data from elsewhere used for writing this paper have been referenced.

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Abstract

The research paper aims to explore productivity and its determinants in Estonian road freight transportation sector at national, company and governmental level. This article utilizes combined methodology, which addresses the issue of productivity and added value both on the national, company level and governmental level. At national level, productivity data for Estonian road freight transportation sector is analyzed. At company level, an illustrative case study of one road freight transportation company is conducted. At governmental level interviews are utilized in the study. The productivity in Estonian road freight transportation sector has decreased especially for smaller companies. Innovation in road freight transportation is mostly process innovation. The main ways for increasing productivity are investment into new production technology, applying the production technology more efficiently, downsizing sales and administrative processes. Governmental regulation is mostly productivity-decreasing for road freight transportation. The sector is relatively heavily taxed and weight restrictions hinder application of larger and more efficient vehicles. Some of these restrictions may be eased in the future.

Keywords: productivity, innovation, regulation, case study, road freight, transportation

Introduction

In European Union, road freight has the 72% modal share in inland freight transport activity (European Commission, 2017). As road freight transportation is a production input for many sectors, then its productivity affects transportation costs for many companies and sectors as well as the speed and quality of logistics operations (Aylward, and O'Toole, 2007). In Estonia, road freight transportation sector is through value chains most directly related to other logistics operations, wholesale and retail trade, food and metal industries (Unt *et al.*, 2018). Advances in road freight productivity may have broad efficiency and productivity effect of on economy. For example, they may lead to better availability of goods and services to consumers, more efficient production and thus to increased competitiveness of national economy (Weisbrod *et al.*, 2014). In addition, road freight creates jobs and is vital for achieving economic growth (European Commission, 2011). Thus, achieving higher productivity in road freight transportation has clear aggregate economic benefits.

In addition, road freight transportation accounts for a large proportion of environmental costs, especially those being tied with the carbon dioxide equivalent emissions (Demir *et al.*, 2014). Therefore, increasing productivity in transportation sector may have environmental benefits as it could lead to lower mileage for heavy trucks, more efficient use of fossil fuel and lower emissions, although it is possible that due to rebound effects the total fuel consumption may increase if the fuel efficiency of heavy trucks increases (Gossart, 2015).

Road freight sector is described by intense competition and low profit margins. In addition to competition between road freight companies, road freight is also subject to intermodal competition, for example with rail transportation (Woxenius and Bärthel, 2008). Many of the smaller companies are under constant competitive pressure (Riedl *et al.*, 2018) and with the possible further liberalization of road freight transportation in EU (Borgström *et al.*, 2016), the competition may become even more intense. By increasing productivity, the transportation companies may improve their competitive position.

Productivity gains in road freight transportation can be achieved by application of more efficient vehicles (Thompson and Hassall, 2014), more efficient vehicles routing (Aylward, and O'Toole, 2007) or automating and digitizing processes (Riedl *et al.*, 2018). Achieving these gains calls for innovation and investment from road freight companies. Although Dutz (2005) has found a positive relationship between competition intensity and innovation in road freight logistics, it is possible that barriers to innovation, such as financial constraints, risk or focus on short term view (Caniëls *et al.*, 2008), will prevent companies from investing in innovative solutions. Therefore, it is possible that road freight companies in some countries will lag in productivity due to these barriers to innovation.

So far, there is little known about the recent productivity increases and productivity-augmenting investment and innovation in Estonian road freight sector. Therefore, research is needed for studying, how the road freight companies in general apply innovative solutions for increasing their productivity.

Current research paper aims to explore productivity and its determinants in Estonian road freight transportation sector at national, company and governmental level.

This article utilizes combined methodology, which addresses the issue of productivity and added value both on the national, company level and governmental level. At national level, productivity data for Estonian road freight transportation sector is analyzed. At company level, an illustrative case study of one road freight transportation company is conducted. At governmental level interviews are utilized in the study.

The article is structured as follows. First, there will be given a literature overview. It is followed by the description of research methodology. Next, productivity of Estonian road freight transportation sector is analyzed at macro level. This is followed by the presentation of case study results and governmental approach. Finally, the results of the study are to be discussed and conclusion are drawn.

1. Literature review

1.1. Productivity

Productivity describes the efficiency of production and it is expressed by the ratio of output to input (Syverson, 2011). While several measures for productivity can be applied, all of them quantify output and input and relate them to each other (Hall, 2011). Thus, increases in productivity mean that companies are able to produce more goods or services with the given output.

Productivity can be described by partial or total productivity measures. Partial productivity describes the ratio of single input to output. Probably the most common form of partial productivity is labour productivity, which expresses the ratio of output to labour input (number of employees, hours worked). Partial productivities can be also calculated for capital (real value of capital stock), fuel, energy or other inputs. Due to the importance of environmental sustainability, the measuring of energy productivity has gained an interest. (Matos and Silva, 2011) Partial productivities are easy to calculate and interpret and therefore, in most cases partial productivities are applied in practical calculations. However, partial productivity measures do not reflect the trade-offs between different production factors. (Hannula, 2002). For example, if labor productivity increases, it does not give any information, if it is caused by technological progress or increased capital input (McKellips and Calver, 2016).

Total productivity is a multi-factor measure, which takes all the production inputs into account. Frequently, this is referred as Total Factor Productivity (TFP). For calculating TFP, a weight set of all inputs of production process has to be accounted for (Syverson, 2011). Calculating TFP needs making assumptions about weights of different production inputs. It is possible to apply shared of revenues (Hall, 2011) or production costs as weights (McKellips and Calver, 2016). It is also possible to include greenhouse gas emissions as an input in TFP in order to capture the environmental effects of production (Zhang *et al.*, 2015).

Productivity can be expressed in physical or monetary terms (Syverson, 2011). In case of monetary productivity, the outputs are measured in their monetary value. If productivity is measured in monetary terms and data from different time periods are compared, then

issues of price changes arise (McKellips and Calver, 2016). In order to express productivity in real terms, price deflators need to be applied (Rogers, 1998). In physical terms, output is measured in physical units (McKellips and Calver, 2016). For example, in transportation, output can be measured by ton-kilometers, which is often used in empirical studies (Table 1).

Productivity measures can be based on gross output or value added. While gross output takes into account all the goods and services produced, value added-based output considers only contribution of labor and capital inputs to output (Hall, 2011). At macro level, accounting for value-added output makes sense as it subtracts the intermediaries from output and avoid double counting them. Value-added output is also a standard choice for sectoral productivity analysis (McKellips and Calver, 2016). However, value-added approach cannot be applied when expressing productivity in physical terms such as ton-kilometers as intermediaries can be usually expressed only in monetary terms.

Table 1. List of productivity measures applied in previous studies of road freight transportation productivity.

Measure	Type	Sources
Value added per employee	Monetary, value added, partial	European Commission (2009), Rashidi and Samimi (2012)
Value added TFP	Monetary, value added, total	Zhang <i>et al.</i> (2015)
Ton-kilometers per employee	Physical, gross output, partial	Aylward, and O'Toole (2007)
Ton-kilometers per vehicle	Physical, gross output, partial	Mitchell (2010), McKinnon (2015)
Ton-kilometers per megajoule	Physical, gross output, partial	Ramsay and Alford (2009)

Source: compiled by the author, based on the literature.

In some studies (e.g., McKinnon, 2010) output measures such as ton-kilometers per year are referred as productivity. However, these measures do not correspond to the concept of productivity as they do not take the production inputs into account.

According to OECD (2001), measuring of productivity has five objectives: (1) measuring technical change, (2) measuring efficiency improvements, (3) measuring real cost savings, (4) measuring improvement in living standards and (5) benchmarking production. Although productivity change is often applied as a proxy for technological progress, increases in productivity can be in cases caused by increased efficiency of

utilizing the existent technological solutions (Rogers, 1998). Hence, productivity gains do not always have direct relationship with technological progress.

In this paper, measuring productivity in Estonian freight sector is motivated by the first three of OECD (2011) objectives. Productivity analysis for the road freight transportation will give the information about the technological progress and innovation in the sector, e.g., how efficiently road freight companies utilize new technologies and how it can lead to lower costs for these companies.

1.2. Sources of productivity growth in road freight transportation

Productivity growth may be the result of various factors. Advances of managerial practices, implementation of higher-quality capital and labour inputs, acquiring knowledge by learning and doing and implementation of new technologies may all lead to productivity increases (Syverson, 2011). During the recent decades, much of the productivity growth has been achieved by efficient application of information technology (Bloom *et al.*, 2012). Productivity may be increased by product or process innovation, which offer more value to customers or make production more efficient (Griffith *et al.*, 2006). Traditionally, product innovation has not been very widespread in transportation sector (compared to manufacturing or knowledge-intensive services). Instead of that, innovation in transport is more related to application of more efficient vehicles, informational technology and development of new business processes (Wagner, 2008). So innovation in road freight transportation is usually process-innovation as new technology and vehicles increase the efficiency of business processes.

Much of the recent advances of road freight productivity are related to application of more efficient trucks. For example, there has been an increase in trucks' length and capacity (McKellips and Calver, 2016). Also, there have been developed vehicles, which exceed 30 m in length and 60 t in carrying capacity and empirical analysis has shown that longer and heavier vehicles are more productive as they consume less fuel per unit transported freight (Glaeser and Ritzinger, 2012). As in this case, innovation leads to an increase in carrying capacity of the vehicles, which is referred to as the carrying capacity effect (Aylward and O'Toole, 2007).

Productivity gains in road freight are related to increases in energy efficiency, as energy is one of the most important production inputs in road freight transportation (Liimatainen *et al.*, 2012). Newer trucks are more fuel efficient, which leads to increased output per fuel consumed, as well as environmental benefits. Fuel-efficiency is related by advancement in engine technologies (McKellips and Calver, 2016) and aerodynamic improvements (Liimatainen *et al.*, 2012). To smaller extent fuel efficiency can be increased by application of fuel efficient tyres, synthetic engine oil and reduction of the tare weight of the vehicle (Liimatainen *et al.*, 2014). Some driver aids, such as gear-shift indicators or speed profile recommendation will assist the driver to adopt more fuel-efficient driving style (Klunder *et al.*, 2009).

Energy efficiency can be improved by introducing alternatives to diesel fuel. Liquid natural gas (LNG) is a potential alternative as LNG-truck have often better fuel efficiency than modern diesel trucks (Osorio-Tejada *et al.*, 2017). Besides LNG, compressed natural gas (CNG) may be the next alternative to diesel fuel. Hybrid vehicles combining electric and combustion power will decrease significantly consumption of fossil fuel. The next step from hybrid vehicles could be full electrical or hydrogen powered and fuel cell vehicles (Litschke and Knitschky, 2012), which are currently impractical to operate due to lack of refueling infrastructure (Lee *et al.*, 2018).

To some extent energy efficiency may be achieved by increase awareness and changes in practices of hauliers. For example, even basic vehicle maintenance, such as regularly checking tyre pressures, will improve fuel efficiency. Avoiding vehicle idling and adoption of fuel saving driving style will decrease fuel consumption further (Liimatainen *et al.*, 2012). Limiting the speed and avoiding unnecessary acceleration and deceleration will decrease fuel consumption. For heavy trucks, the minimal fuel consumption is achieved at about 55 km/h (Demir *et al.*, 2011). The differences between the best and worst driver in a single road freight company in terms of fuel consumption can be around 25% (Demir *et al.*, 2014). Therefore, eco-driving training has great potential in making corrections to truck drivers' driving style and thus contributing to fuel efficiency (Klunder *et al.*, 2009).

Many new innovations in road freight industry are related to the implementation of information technology. For example, it can be applied for analyzing and optimizing

transportation operations efficiency. Informational technology can be used for tracking vehicles and monitoring their performance, such as speed or fuel consumption. Technology allows location-tracking and real-time communication between drivers and dispatchers, which may lead to optimized dispatching and routing (McKellips and Calver, 2016). GPS-based solutions may be used for determined both the location and speed of vehicles: These systems can be used for monitoring transportation operations, keeping track of drivers' performance and for security reasons (Jarašūnienė and Greičiūnė, 2013). These measures could lead to faster deliveries, decreased fuel consumption and accident rates (Stefansson and Woxenius, 2007).

Road freight companies may use software, which allows web-based fleet management (Jarašūnienė and Greičiūnė, 2013). This allows better vehicle routing and vehicle management optimization, especially re-routing vehicles in case of changes in deliveries (Aylward and O'Toole, 2007). Better vehicle routing leads to less time lost in congestion, which also decreases fuel consumption (Demir *et al.*, 2014). Therefore, traffic forecasting is vital for predicting congestions (Aschauer and Starkl, 2010). Fleet management includes selection of right types of vehicles for the specific journey. Larger trucks have higher fuel consumption, but also higher carrying capacity. Therefore, larger trucks should only be applied to hauls, in which they could be sufficiently loaded (Demir *et al.*, 2011).

Modern trucks have onboard-computers, which make billing and other paperwork related processes faster and easier, decreasing the labor input from administrative personnel (McKellips and Calver, 2016). Similarly, integrated company-wide informational systems integrate all company's business processes, which make the order-processing and billing faster and more efficient (Wang *et al.*, 2015). Thus, implementation of IT may increase productivity of the administrative processes of road freight companies.

Productivity in road freight depends on vehicle capacity utilization. Productivity may be increased by achieving high load factors and minimizing empty runs (Abate, 2014). IT utilization may lead to higher vehicle capacity utilization. For example, Barla *et al.* (2010) have found that application of electronic vehicle management systems leads to 6,3% productivity increase in ton-kilometers and 5% increase in fuel efficiency. The biggest gains in vehicle capacity utilization are achieved in backhaul operations. It is possible that

increased capacity utilization in backhaul operations allows hauliers to accept fronthaul operations with lower load factor leading to decrease of capacity utilization in fronthaul operations. According to McKinnon (2015) empty running on backhaul operations is to a certain extent caused by informational problems, as the hauliers lack of knowledge about the available backloads. Riedl *et al.* (2018) point out that digitalization and emergence of web-based marketplaces matching the supply and demand for road freight transportation are going to increase vehicle capacity utilization. Besides, bringing shippers and carriers together, new IT solutions help carrier to co-operate and exchange truck capacity and loads.

Capacity utilization may be increased by more efficient loading of the vehicles achieving better space utilization of trucks. Usually, the space wasted in vertical dimension. Both IT solutions for planning truck space utilization and advances in packaging design of low-density products may increase capacity utilization and productivity (McKinnon, 2010).

Productivity in road freight may be increased by increasing capital efficiency. Besides achieving higher load factors, making more journeys per week or longer hauls will lead to higher productivity (Aylward and O'Toole, 2007). Increasing vehicle utilization may be achieved by virtual forwarders, start-up companies, which function as intermediaries and purchase capacity from road freight companies (Riedl *et al.*, 2018). Increased capital efficiency results in more distance driven in a given time period and if there is no decrease in load factor, the number of ton-kilometers in a given time period will be higher (Aylward and O'Toole, 2007). It is referred as better vehicle time utilization, resulting from vehicles running more time on a road per given time period (McKinnon, 2009).

Increases in energy efficiency resulting from advances in both vehicle and IT technology may have positive environmental effects reducing the environmental costs of road freight transportation. Still, rebound effects must be accounted for and it is possible that higher fuel efficiency increases the output of road freight significantly and therefore the overall amount of fuel consumed in the sector will increase (Gossart, 2015). Increased fuel efficiency may increase the supply in road freight transportation by making it more profitable for the new firms to enter the market or by giving road freight a competitive advantage over other transportation modes, for example rail transportation (Leard *et al.*, 2015).

IT solutions may contribute to integration of road freight to other transportation modes, which generates new possibilities for improved freight forwarding (Jarašūnienė and Greičiūnė, 2013). It will allow application of road freight transportation for hauls, in which it is most productive and connecting it with other transportation modes in cases road freight is inefficient (Wang *et al.*, 2015).

Newer vehicles have more driver aids and onboard monitoring systems, which lead to increased safety and lower rates of traffic accidents. Driver aids, which warn drivers from lane departures and forward collisions, reduce accidents by approximately 20-30% (Pitera *et al.*, 2013). Roll stability control systems, which prevent trucks and trailers from rolling over, reduce accidents further (Cheng and Cebon, 2008). Monitoring systems reduce the hours of service (HOS) violations, which prevent driver fatigue and decrease accident rates (Pitera *et al.*, 2013). These innovations are likely to decrease losses from traffic accidents and penalties to the road freight companies and act as additional potential sources for the increase in productivity.

Road freight sector as many other sectors may be affected by emergences of disruptive innovations or business models, which could change the industry tremendously (ITF, 2018). For example, automation in road freight may lead to application of smart cargo, which can communicate with environment, store data and make decision about its routing (Csiszár and Földes, 2018). To some extent, road freight may be substituted by application of drones or pipeline supply networks or even 3D printing (ITF, 2018). All these innovations could lead to productivity gains.

Increasing production often calls for investment from road freight companies as buying newer vehicles, developing IT solutions and automated systems, require substantial amounts of capital. Barriers to innovation may hinder investments in these solutions. Financial constraints are one of the main obstacles to innovation in road freight, which is to some extent related to the small average firm size in road freight (Caniëls *et al.*, 2008). Many companies in road freight sector have focused on short-term cost optimization. Thus, if the investment in innovation will benefit the companies in more distant of the future, then these companies may not be interested in investment (Evangelista, 2014). In some cases, an intense competition may be hindered by the investment into the innovative solutions, as the companies have to fight for their survival. Some companies are

competing mostly on price and therefore, if innovations do not allow them follow low price strategy, they are not conducted (Oberhofer and Dieplinger, 2014).

Besides financial constraints, a lack of awareness may act as a barrier to investing in productivity-augmenting solutions (Liimatainen *et al.*, 2012). A lack of the awareness may be related to the management and employee insufficient knowledge or low innovation orientation, which could be related to high risk aversion (Caniëls *et al.*, 2008). Therefore, many freight companies are taking the “wait and see” approach to innovation (Evangelista, 2014). To some point, financial and informational constraints of innovation can be overcome by governmental support to innovation (Lin, 2007).

1.3. Public policy effects on productivity in road freight transportation

According to McKellips and Calver (2016), the deregulation of road freight transportation sector is likely to increase competition, which in turn creates incentives for productivity-augmenting investment. Additionally, increased competition may lead to more efficient practices from freight companies such as subcontracting or hiring foreign workers. Competition may also force companies to drop unproductive activities and work processes, which may also increase productivity (Schmitz, 2005).

In case of the European Union, creation of single market and the accession of new member states, has led to the application of labor from new member states with lower wages and social guarantees (Hilal, 2008). In addition, the regulations in the EU allow employing drivers from non-member states, for instance Ukraine or Macedonia, who are willing to work on even lower wages (Sternberg and Hofmann, 2018).

One of the biggest obstacles to competition is cabotage registration. In the European Union, there are strict restrictions on cabotage operations, which limits the cross-border competition between road freight companies from different member states (Kummer *et al.*, 2014). Although, further liberalization of cabotage rules is expected in the future, there is stubborn resistance to lifting cabotage restrictions from some member states (Ponti *et al.*, 2013). In addition to cabotage, international transport operations between European Conference of Ministers of Transport (ECMT) states require ECMT permits, which are distributed on a quota basis to ECMT member states (Medar *et al.*, 2014).

Productivity in road freight sector is affected by traffic and labor regulation. Minimum wages, restrictions of working hours and HOS, will limit the road freight companies the options of using the labor inputs. In some cases, haulers violate these restrictions for achieving greater efficiency (Hilal, 2008).

As productivity gains are related to the application of larger vehicles, then legal restrictions to trucks' dimensions and weight will hinder productivity. Therefore, allowing bigger vehicles to roads is likely to have positive productivity effects (Glaeser and Ritzinger, 2012). Increasing the maximum lengths of heavy trucks by 1 meter has been estimated to increase productivity by 14% and increasing the weight limit by 1 ton, will increase productivity by 10% (Thompson and Hassall, 2014). In case of Estonia, truck weight restrictions are an acute problem for the forestry sector as they increase transportation costs. For example, the maximum weight limits for heavy trucks in Estonia are lower than in Scandinavia countries (Lukason et al., 2011), which is likely to decrease productivity of Estonian road freight sector. While the main concerns for larger trucks are road wear and safety, then some countries such as Australia have implemented performance-based standards for trucks, which allow developing trucks exceeding dimension and weight restrictions, if they achieve required standards in terms of safety and road infrastructure protection (Thompson and Hassall, 2014). Thus, if truck manufactures are able to prove that larger trucks, which exceed size restrictions, are safe and do not cause excessive road wear, these trucks are allowed to the roads.

Public sector may contribute to road freight transportation productivity through the road construction. Larger highways and denser road network will allow delivering cargo faster (Klunder *et al.*, 2009). Improved road design may allow higher vehicle speed especially increasing average speeds by reducing congestions and avoiding bottlenecks. Adding highway lines or creating bypass roads will allow long-distance traffic to avoid local bottlenecks (Weisbrod *et al.*, 2014). Easy access and avoiding bottlenecks to major ports and railway stations are especially important for recusing time lost in congestions (Aylward and O'Toole, 2007). Intelligent and dynamic traffic light synchronization systems will make the traffic flow smoother and decrease stoppages at the traffic lights (Klunder *et al.*, 2009). In addition, maintenance of the existent road network plays also an important role as poor road surface may lead to lower speed, damage to vehicles and

cargo, higher fuel consumption, which all have negative effect on productivity (Steyn *et al.*, 2012).

Public sector may contribute to faster introduction of alternative fuels. Both for LNG and electric vehicles low spatial density of loading stations is a serious problem, which limit the possibilities for implementation of these types of vehicles (Taefi *et al.*, 2016; Osorio-Tejada *et al.*, 2017). By developing a charging network, public sector could support transfer to electrical freight trucks. In addition, government could offer tax incentives, purchase subsidies, access to bus lanes, privileged loading zones in urban areas, free parking or other support measures for freight companies utilizing electrical vehicles (Taefi *et al.*, 2016).

Road freight transportation companies are affected by specific taxes. Besides the fact, that fossil fuels are subject to excise taxes, road freight companies in EU have to pay heavy goods vehicle taxes and road-user charges (European Environment Agency, 2013). These taxes increase the operating costs for road freight companies, which have a negative effect on productivity.

Heavy vehicle charging can be applied to gather funds for road construction and maintenance (Harvey, 2015). Therefore, higher taxes may result in an improved road infrastructure. This in turn is likely to increase road freight productivity, which makes the total effect of heavy vehicle taxes on productivity could be ambiguous.

The summary of various factor affecting productivity in road freight transportation is presented in Appendix 1. According to the literature, it can be concluded, that the most important factors increasing productivity are application of more efficient trucks, more efficient vehicle utilization, application of IT and increased capacity utilization. The main barriers to productivity growth are financial constraints and lack of awareness. While governmental regulation such as weigh restrictions may decrease productivity, public sector subsidies and road construction have a positive effect on productivity. The effect of taxes and competition of road freight productivity is ambiguous.

2. Methodology

This article applies combined methodology, which addresses the issue of road freight productivity and value added both on the national and company level. Additionally, the viewpoint from governmental level is presented in order to discuss, how the productivity can be affected by the regulations.

At national level, productivity data for Estonian road freight transportation sector is analyzed. The data is acquired from Statistics Estonia and it covers period from 2005 to 2017, which is the most recent data available. Productivity is here analyzed both in terms of gross output and value-added terms. Therefore, overall trends in gross output and value added will be presented. These two are not productivity measures by itself, but they reflect the volume of output in the sector and act as the basis for productivity. Statistics Estonia calculates gross output and value added by the following formulas 1 and 2:

- (1) gross output = turnover + operating subsidies
- (2) value added = turnover + change in stocks of work-in-progress and finished goods
+ capitalized self-constructed assets + other revenue – other expenses
– costs of merchandise, materials, supplies, intermediate goods,
electricity, fuel, power, laid-out work – duties and taxes linked to
production – taxes on products

Next, gross output and value-added based productivities are presented. For both of these measures, labor productivity measures are calculated per employee and per hour. General trends in productivity will be illustrated by growth rates. In order to compare the level and trend of productivity in road freight transportation to the economy as a whole, it is compared to the national averages of Estonian economy. The productivity measures will be also presented by the number of employees, which allows comparison by firm size. Productivity by number of employees and per hour data is available from Statistics Estonia up to 2017.

In addition, productivity in physical terms will be presented at national level. Cargo turnover in ton-kilometers per hour and per employees are applied as productivity

measures in this case. The data is acquired from Statistics Estonia and it covers years from 2005 to 2017.

At company level, an illustrative case study of one road freight transportation company is conducted. The company was selected as a case-company as it serves as a typical example of Estonian international road freight transportation business. The company was established more than 20 years ago. It operates mostly on routes between Estonia and Italy and Estonia and Russia. It transports miscellaneous cargo, which can be handled on ordinary tent-trailers. Saw material, metal and paper products, peat, plumbing products and household goods are the most common types of cargo transported. The company has established long-term relationship with customers.

Various data sources about the company are utilized in the case study. The author conducted an interview with the CEO (Appendix 2). Annual financial reports, truck and fuel consumption data were also utilized. Output and value-added based productivities are calculated for the company from 2005 to 2018 according to formulas 1 and 2. Fuel consumption of different trucks is analyzed. Technology used in the company, main determinants of productivity and possible effects of external factors including governmental regulation are studied.

As productivity in road freight transportation sector is affected by governmental regulation, then there was conducted an interview with a transportation expert from the Ministry of Economic Affairs and Communications in Estonia (Appendix 3). It will add the viewpoint of a public sector representative to the study and allows comparing the views from company level.

3. Results

3.1. National level

At national level, it can be stated that both gross output and value added for Estonian road freight sector have increased from 2005 to 2017 (see e.g., Figure 1). Both measures have followed generally similar trends, but value added has been more stable. Output and value added in road freight transportation have been negatively affected by the Great Recession as they have declined sharply in 2009. There has been also a downward trend between

2013 and 2015, and a relatively fast recovery from it in 2017. Over the 12 year-period, gross output has increased by 91% and value added by 111%, which makes 5.6% and 6.4% growth on a yearly basis.

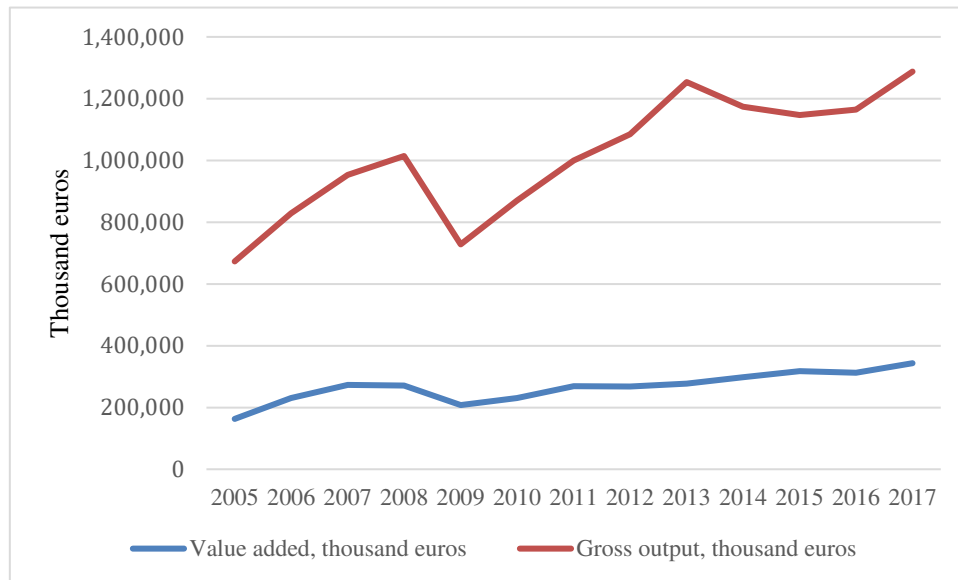


Figure 1. Gross output and value added in Estonian road freight transportation 2005-2017.
Source: Statistics Estonia.

The dynamics of gross output per employee and per hours are almost identical, which indicates that the number of hours per employees has been relatively constant at Estonian road freight sector between 2005 to 2017. The notable exception is 2009, when gross output per hour is relatively high (Figure 2). This is due to the low number of working hours in 2009, which was likely caused by the recession as some drivers were underemployed. To a lesser extent, there has been a decline in average hours in 2016 and 2017.

Gross output per employee has increased by 51% from 2005 to 2017, while gross output per hour has increased by 59% during the same period. It makes 3.5% and 3.9% growth per year. During the same period, gross output per employee has increased by 79% and gross output per hour has increased by 89% for the Estonian economy as a whole. It means, that gross output-based productivity growth in road freight transportation has been lower than the average growth in other sectors of Estonian economy.

At the same time, it can be noticed, that gross output has increased more than gross output per employee and per hour in road freight transportation sector between 2005 to 2017. It means that the employment in road freight transportation sector must have increased during that period.

The level of gross output per employee in road freight transportation is lower than the national average. As the labor productivity growth in road freight transportation has been lower than in the national economy on the average then relative gross output per employee to national average decreased. In 2005, it was 73% of the national average, while in 2017, it was only 61%.

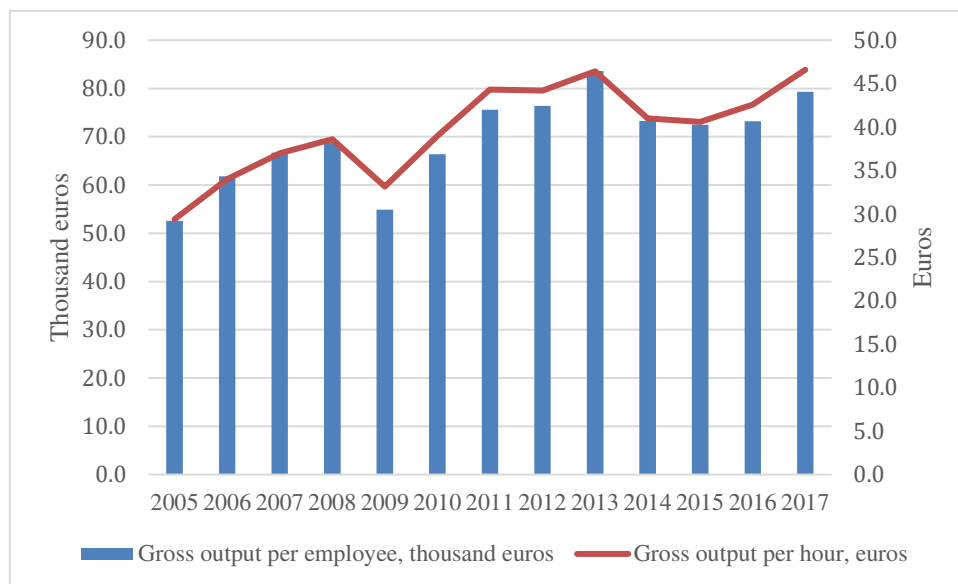


Figure 2. Gross output per employee and per hour in Estonian road freight transportation 2005-2017.
Source: Statistics Estonia.

Thus, in terms of gross output productivity, road freight transportation sector is lagging more and more to the other sectors as its productivity is growing slower than in the Estonian economy on the average. In fact, gross output productivity in that sector has declined during the last four years as the level of gross output per employee in 2017 is lower than 2013. The decrease in productivity from 2014 may be related to the decline on the Russian market due to the economic sanctions imposed to Russia after the annexation of Crimea. When many of the Estonian road freight company transferred their operations from Russian routes to the EU markets, the productivity started to recover.

The situation does not look better for road freight sector, in case the productivity is measured by value added. Value added per employee has increased by 72% and value added per hour has increased by 80% between 2005 and 2017. It makes 4.6% and 5.0% growth on a yearly basis. At the same time, national average of value added per employee has risen by 95%, while value added per hour has increased by 107%. The level of value added per employee in road freight transportation was 80% of national average in 2005 and 74% of national average in 2015. So, in terms of value added, productivity in road freight transportation is lower than in the Estonian economy on the average and the situation has even worsened for road freight transportation.

Productivity in terms of value added follows similar trends as gross output productivity and it generally corresponds to the cyclical fluctuations in the economy (Figure 3). Before the Great Recession, there was a rapid growth in productivity, which is followed by a decline in 2009. Over the following year the productivity has increased, but in 2012 and 2013 there was a second decline. However, from 2014 productivity has increased, with especially rapid growth in 2017.

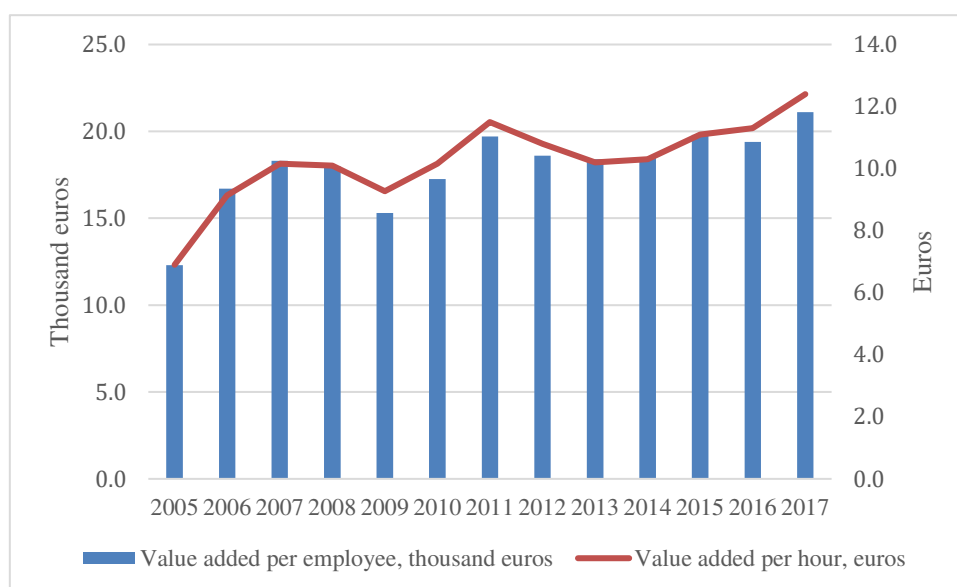


Figure 3. Value added per employee and per hour in Estonian road freight transportation 2005-2017.

Source: Statistics Estonia.

A fact that the productivity in terms of value added has increased more than in terms of gross output means that road freight transportation in Estonia was using less intermediary

inputs in 2015 than in 2005. It could be related to the wage growth and relative increase of labor costs or increased profit margins.

If we look at the cargo turnover in Estonian road freight transportation, a remarkable decline in 2008 has to be noticed. Over the following years cargo turnover has increased, but it is still 12% lower in 2017 compared to 2008 (Figure 4).

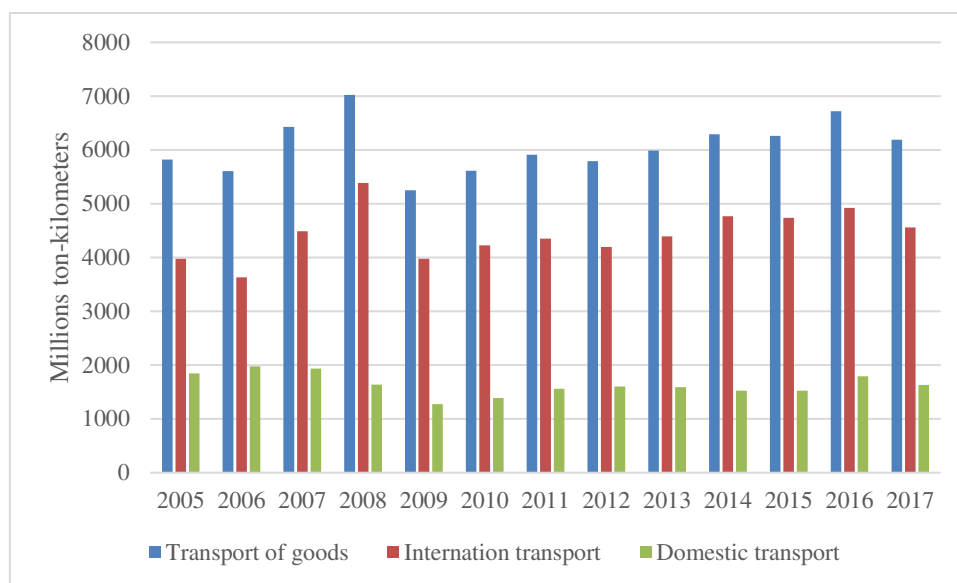


Figure 4. Cargo turnover in Estonian road freight transportation 2005-2017.
Source: Statistics Estonia.

Figure 4 also depicts that most of the Estonian road freight transportation cargo turnover comes from international operations; the share of domestic operations is about 25%. Over the years, domestic operations have been more stable, while there has been a relatively larger decrease in international operations. This can be explained by more intense competition for foreign operations, while the domestic market is protected by cabotage restrictions.

The physical productivity, measured in cargo turnover per employee or per hour has been declining since 2009, which the slight increase in 2016. Cargo turnover per employee is about 18% lower in 2017 compared to 2008 (Figure 5). The decrease in productivity is larger than cargo turnover as the employment in road freight transportation has slightly increased.

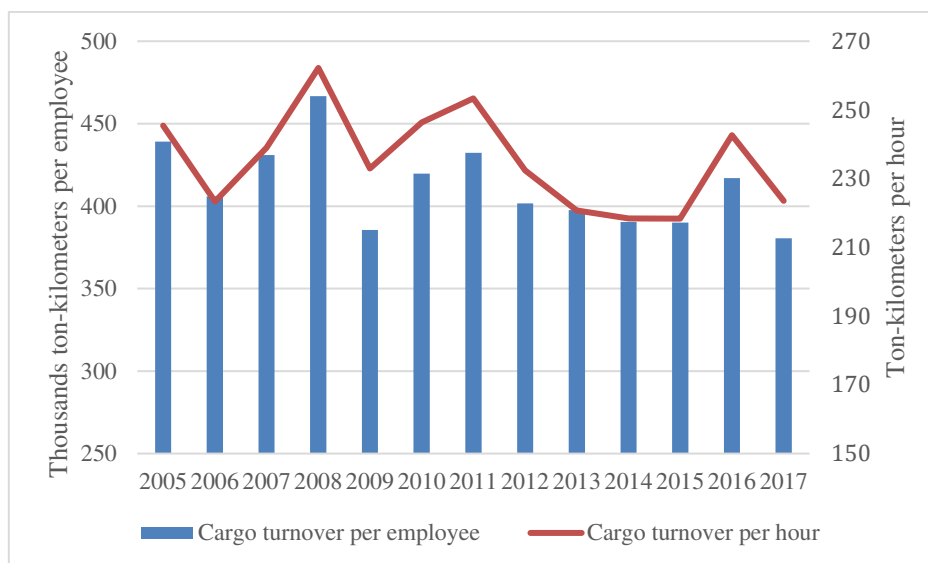


Figure 5. Cargo turnover per employee and per hour in Estonian road freight transportation 2005-2017.

Source: elaborated by the author, based on Statistics Estonia data.

There are remarkable differences in productivity by firm size in road freight transportation (Table 2). The largest firms with 100 and more employees are the most productive. Statistics Estonia do not present data about firms with 250 and more employees, due to small sample size for road freight transportation sector. The smallest firms are the least productive as in 2015 value added per employee for smallest firms was only 60% of the productivity for firms with 100 and more employees. The smallest firms have 30% lower productivity than then next size group (10-19 employees). The smallest firms make up 87% of businesses in Estonian road freight transportation sector in 2015. Therefore, it could be concluded that the sector consists of an overwhelming majority of small and medium-sized (SMEs) companies with relatively low productivity.

Table 2. Value added per employee and per hour in Estonian road freight transportation 2012-2015 by number of employees

Number of employees	Value added per employee, thousand euros				Value added per hour, euros			
	2012	2013	2014	2015	2012	2013	2014	2015
1-9	15,9	15,3	15,8	15,6	9,7	8,9	9,3	9,1
10-19	21,0	19,8	18,6	22,2	12,1	10,7	9,9	12,0
20-49	20,7	22,5	21,5	23,4	11,3	12,0	11,7	12,7
50-99	19,3	19,6	19,9	21,4	10,7	10,5	10,9	11,9
100-249	20,7	20,7	25,0	25,9	10,9	10,9	13,3	14,0

Source: Statistics Estonia.

If we look at the trends in productivity by firm size in the period between 2012 to 2015 then we see that productivity for the smallest firms have declined slightly, while it has increased for all the other size groups. Therefore, the differences in productivity between small and large firms have increased. Unfortunately, most of the companies belong to the smallest group, which means that although the productivity in road freight transportation sector as a whole has increased, then for most of the firms, it has decreased.

An expert from Ministry of Economic Affairs and Communications states that current situation for Estonian road freight transportation companies is good and they have expanded their operations. The number of trucks with international freight transportation licenses has increased steadily from 2010 to 2018. At the same time, the competitiveness of Estonian road freight transportation companies has decreased. This has resulted in decreasing profits, while revenues and employment in the sector have increased. This is to greatest extent caused by the accession of Bulgaria and Romania to the EU since 2007. Transportation companies from these countries operate on very low wage levels and therefore have significant cost advantages. Bulgaria and Romania have also large sectors of shadow economy and suspiciously, some of the road freight transportation companies from these countries belong to it. The competitive situation is more favorable for the transportation companies operating on the domestic market, as they are not subject to so intense competition.

According to the government expert, the main strengths for Estonian road freight transportation companies are long-term relationships and relatively new fleet, although majority of the trucks are more than 8 years old. The latter allows higher fuel efficiency. At the same time, the wage level in Estonia for truck drivers is higher than in several EU countries and it decreases the competitiveness. However, relatively good command of foreign languages by Estonian drivers can be seen as the strengths of Estonian road freight transportation sector.

The level of productivity in Estonian road freight sector was regarded satisfactory by the expert, regarding that many companies are actively seeking ways to increase productivity. According to his viewpoint, the most important drivers of productivity are investment in newer and more efficient vehicles. The companies optimize their fixed costs by personnel management. Optimization of work and rest time minimizes help to keep vehicles driving

for most of the time. The companies also apply new software solutions, for route optimization.

3.2. Company level

At a company level, productivity and its determinants are studied, based on an example of one typical Estonian road freight transportation company, which operates on an international transport routes. The revenue for the company was 1.5 million euros in 2018 and the company earned about 135,000 euros of profit. The revenue and profit have decreased slightly in comparison the previous year. About 50% of the revenue comes from Estonian customers, while the company has also customers in Latvia, Lithuania, Italy, Russian and other countries. The company has 17 employees, which makes it a bit larger than most of the Estonian road freight transportation companies. 13 of the employees are truck drivers. The company was established in 2004, thus it has been operation in road freight transportation sector for more than 20 years.

The technology used in the company consist mainly of trucks and trailers and software for monitoring vehicles. Most of the investment conducted by the company is related to purchasing new trucks and trailers.

The company operates 13 4×2 trucks and 13 three-axle tent-trailers. The load capacity of the trucks is up to 42 tons. The trucks are from 2011 to 2019 and all of them have been acquired as new. All the trucks are manufactured by Volvo. Most of the trucks have 500 bhp engines, some are with 460 bhp. Fuel tanks for most of the trucks have 1,000 liters capacity. Tent-trailers are from 2013 to 2018 and all of them have been acquired as new.

The company applies Dynafleet software for vehicle monitoring. It allows monitoring fuel consumption and tracking driver performance as well as vehicle positioning by GPS. Dynafleet software is developed by the car manufacturer. The company does not use any software for vehicle routing. All the routes are the planned by company's transport manager in co-operation with customers (freight forwarders).

Next, the productivity measures for the company are presented from 2005 to 2018. As it can be seen, that gross output for the company increased sharply from 2005 to 2013, which can be related to the economic boom as well as the expansion of the company. It

is notable, that the growth in gross output was not hampered by the Great Recession. From 2014, the gross output of the company has been declining, which is partly related to the decline in the Russian market after the imposition of economic sanctions on Russia (Figure 6).

The gross output productivity for the company increased from 2005 to 2013, with a decline in 2009 to due worsening of the economic climate. The growth in productivity has been slower than for gross output as the number of employees in the company has increased. From 2014 to 2018, the gross output-based productivity has been decreasing in the company. Gross output per employee has been above the national average for the case-company from 2008 to 2018 and during the last decade it has followed similar trends to the national average.

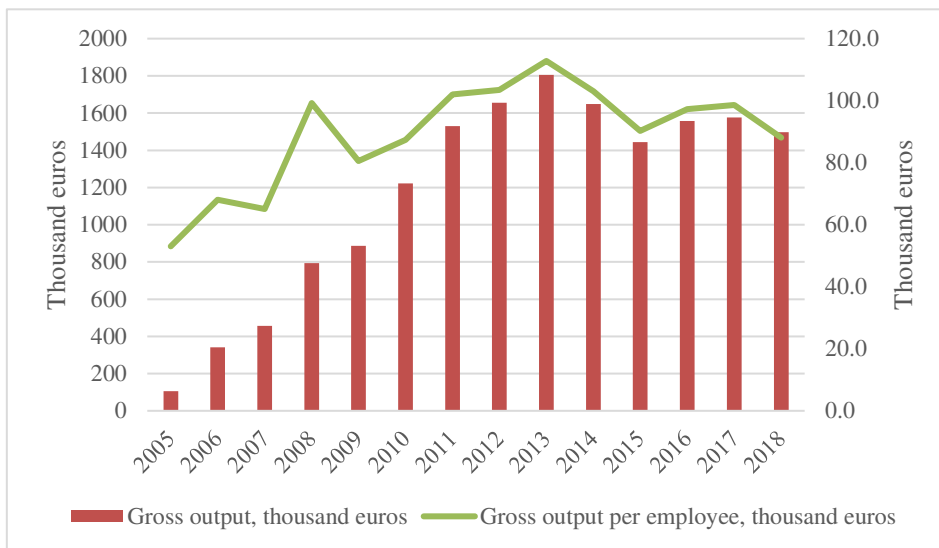


Figure 6. Gross output and productivity in the case-company 2005-2018.
Source: Case-company data.

Value added in the case company increased sharply from 2006 to 2008, but it remained stable for the next year. There was a sharp decline in value added in 2014, but in 2016 the value added achieved an all-time high for the company. During the recent year value added has been declining in the case-company (Figure 7). The fluctuations in value added are to the greatest extent related to changes in profits as the labor costs have been increasing steadily over the entire period.



Figure 7. Value added and productivity in the case-company 2005-2018.
Source: Case-company data.

Value added per employee achieved its highest level in 2013, but it has decreased more than two times since. It has been related to the decrease in profits. It has led to the situation in which the value-added productivity for the case-company is lower than the national average of the companies of similar size in the road freight transportation sector. However, before 2016 the productivity for the case-company was higher than the national average.

As the company has established long-term relationships with its customers, it has quite stable demand for the provided services. If there is a temporary decrease in demand from regular customers, then the company gets additional hauls on transportation portals such as cargo.lt or trans.eu. The competition on these portals is price-based although the carrier has to fulfill the criteria set by the freight forwarder. Therefore, the company is more focused on satisfying the needs of regular customers and is rather increasing its operational efficiency than acquiring new customers. Thus, the applied innovation within the analyzed case-study company can be regarded mostly as process innovation, in order to run the processes more efficient and to lower the production costs.

The company considers vehicle capacity utilization as the most important factor affecting productivity. Thus, the company always attempts to maximize load factor and avoid empty-running. This is achieved by route planning and co-operation with freight

forwarders. If there is unused capacity, the additional cargo can be found from transportation portals. Obtaining hauls with high load factors is according to the CEO result of negotiations and long-term co-operation freight forwarders. The main aim for the company is to make only hauls with high load factors. If the load factor is low or there is risk of empty running, the hauls will be rescheduled in order to increase load factor.

There is a clear tendency that newer trucks have lower fuel consumption. The trendline on figure 8 indicates that newest trucks have by the average approximately 10% lower fuel consumption. This is a general approximation and it has not been accounted that the trucks operate on different routes and may carry different cargo and loads, which will affect the fuel consumption. Still, it is obvious, that replacing older trucks with newer models will generally lead to lower fuel consumption. Lower fuel consumption of newer vehicles from advances in vehicle design lead to lower fuel efficiency as well as their better technical condition. Due to wear and tear, fuel consumption for trucks slightly increases over the course of many years.

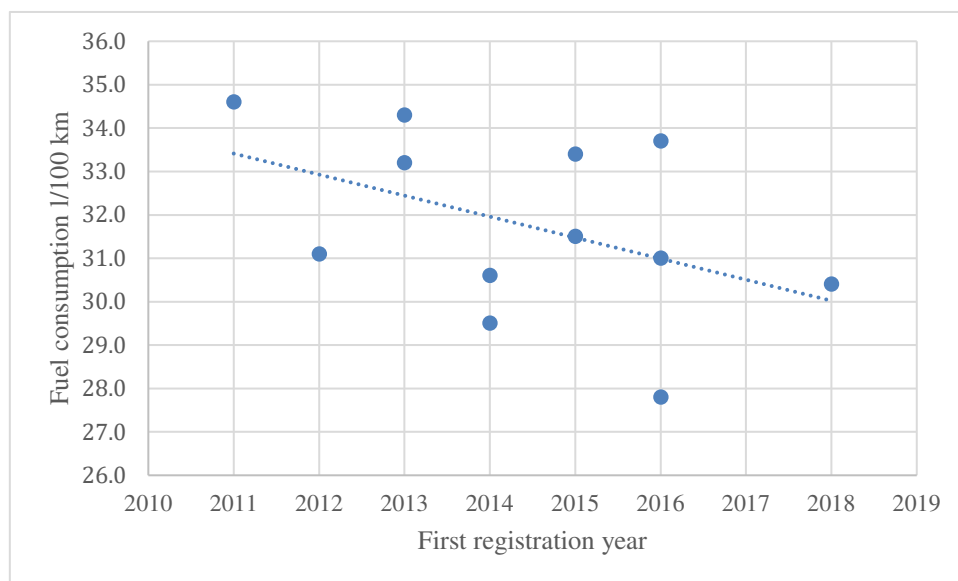


Figure 8. An average fuel consumption of trucks by the first registration year, 2017-2018 average

Source: elaborated by the author, based on the case-company data.

For monitoring fuel consumption, all the trucks have Dynafleet software, which allows monitoring of driving style and GPS tracking. It is possible to determine, which drivers are the most fuel-efficient and the driver performance is automatically rated in four areas: anticipating and braking, engine and gear utilization, speed adaptation and standstill. The

software allows ranking drivers and trucks by performance and analyzing trends in their long-term performance.

The company attempts to select routes and schedules in order to avoid congestions and roads with poor quality. It allows trucks to drive most of the time at constant speed, which reduces fuel consumption.

In addition to increasing fuel consumption, increasing maintenance costs and idle time due to vehicle breakdowns are even bigger problem for the older trucks. Therefore, the company has a policy that truck will be replaced after 7-8 years in operation. It keeps the maintenance costs at reasonable level and vehicle can be easily sold with a fairly good price. 20% depreciation rate is employed for truck value in accounting.

The company has considered increasing the load capacity of new vehicles. As the company has to comply restrictions on truck weight, load capacity can increase, if the tare weight of the truck or trailer is lower. Some new truck models satisfy that criteria.

The company uses only Volvo services for truck maintenance and repair in order to ensure vehicle reliability and avoid productivity losses from breakdowns. All trucks have maintenance contracts with services, which allow price reductions for spare parts.

The company does not use any special software for route planning. Still, Dynafleet gives GPS-positioned data about vehicle location and calculates estimated arrival time. It provides useful information; e.g., if the trucks are late, then the customers will be informed about that. The main reason, why route planning tasks are done manually, is that many of the hauls are between Estonia and Russia. It is very difficult to estimate, how much times it takes to cross the border. Thus, the company finds that IT-solutions has not much use in these situations. The results of the interview with the CEO indicate that application of IT-solutions are not considered as the major source of productivity gains.

Personnel development training is seen as the third most important option for increasing productivity, besides capacity utilization and investment in more efficient trucks. The company offers eco-driving training for the drivers in order to decrease fuel consumption. As the fuel consumption of the drivers is constantly monitored, drivers with higher fuel

consumption can be noted and recommendations about improving their driving style can be given. The company has monetary rewards for drivers with low fuel consumption, which provides the motivation to adapt eco-driving style.

The company constantly finds the ways to optimize loading processes. There is an active co-operation with local and international transportation terminals in order to improve loading efficiency and decrease load times. To some extent, getting hauls from transportation portals contributes to loading efficiency.

The long-term co-operation with regular customers allows optimization of sales and logistics management personnel. As there is stable demand from regular customers, there is less need for sales operations. Over the last year, the company has strengthened relations with freight forwarders, which has allowed downsizing sales personnel.

Intense competition was pointed out by the CEO as a barrier to productivity as it decreases the price level on the market. Especially, road freight transportation companies from Latvia, Lithuania and Poland operate on low costs due to their lower wage levels and are able to offer lower prices. The CEO does not consider intermodal competition to be a big issue. To some extent, competition from maritime transportation affects the market and there have been cases in which some of the company's customers have switch to maritime transportation instead of road freight. But, as maritime transportation is slower, then it is not that competitive. Flight and rail transportation do not offer much competition either. They are optimal for different types of cargo and therefore do not compete for the same hauls. According to the CEO, it is difficult to say, how the erection of the Rail Baltica in the future will affect the road freight market, as quite a lot depends on what freight rates will it offer to the customers.

The CEO pointed out that the productivity in road freight sector is also affected by the road conditions and traffic regulation. If the roads are in good conditions and traffic regulation ensures smooth flow of traffic, then it will allow hauls to be completed in shorter time, which offers more value to customers and gives better possibilities for optimization of load process. It will also increase productivity due to lower fuel consumption.

3.3. Governmental level

Within this paper, the legal environment is perceived by both the government expert and the CEO, as decreasing the general level of productivity of road freight transportation companies in Estonia. According to the CEO, the main problem is related to taxation, which increases costs and decreases productivity. The main problems are high level of labor taxes, increasing taxes on fuel, heavy goods vehicle taxes and road-user charges. Productivity could be improved by the reductions in fuel excise taxes and road-user charges. As the company operates internationally, the situation can be significantly improved only if taxation is decreased in many European countries, which likely calls to agreements on it at the EU level. In a similar way, the company will benefit from easing truck weight restrictions if it is done at the European level. As the company does not engage in cabotage operations, then lifting cabotage restrictions will not affect the company.

The company sees the limited availability of ECMT permits as a barrier to productivity. These permits are issued by Estonian International Road Association. The CEO of the company sees that the quota for EMCT is too low, as not all of the company's vehicles have obtained these permits. Therefore, not all of trucks can make hauls between two foreign states, i.e., from Italy to Austria. It will decrease the options for route planning and avoiding empty-running.

The government expert points out that the role of the state is foremost to ensure equal conditions for all actors on the market. International road freight operations are to great extent regulated at the EU level and the Estonian government does not have much power in this case. According to the expert opinion, lowering tax rates and allowing larger trucks to the roads could be the changes in regulations, what Estonian government could adopt, in order to increase the level of productivity in Estonian road freight sector.

Estonian government is considering some measures, which could increase productivity in road freight transportation. The government is co-operating with road freight companies in order to analyze the possibilities of easing truck weight restrictions. It is clear, that longer and heavier truck are more productive, but they cause more road wear and they could also cause disturbances to traffic. These studies have to provide an answer if and to

what extent larger trucks are allowed to Estonian roads. The results of a study conducted by Olep and Grünberg (2018) pointed out that the impact of truck on road pavement does not depend only on the gross weight of the truck, but also the number of axles, width of tyres and distance between axles. It was recommended that weight limits to trucks could be increased up to 52 tons without special permits, if the truck has seven axles and double wheels or single wheels exceeding 490 mm tyre width (Olep and Grünberg, 2018).

The government has considered offering subsidies to companies, who will purchase alternative fuel vehicles. As these vehicles are substantially more expensive from diesel trucks, the lack of capital is an obstacle in acquiring these innovative vehicles.

The government could lower the administrative burden for road freight transportation companies. The main emphasis would be to reduce paperwork and to allow exchanging any kind of information electronically. Estonia could co-operate with other EU members states in order to accept roadworthiness tests conducted in other member states. In that case, trucks operating in other countries do not need to travel back to Estonia for this test.

The potential effect of the Rail Baltica to Estonian road freight transportation sector is difficult to estimate according to the expert. Still, it has to be considered that Rail Baltica infrastructure will have high maintenance costs. To cover these costs, state could have an interest in ensuring a sufficient level on transportation operations on Rail Baltica. Therefore, hypothetically it would be possible that the government could apply measures, which decrease the competitiveness of road freight transportation in relation to railway transportation.

4. Discussion

The productivity in Estonian road freight transportation sector in monetary terms has increased over the last 12 years, but it is relatively low in comparison to the other sectors and in relation to the other sectors, the situation has become worse. The productivity measured in physical units (ton-kilometers) has been in decline since 2008. There are remarkable productivity differences by the size of the companies, as the smallest firms, which make up the majority of businesses in the sector, have substantially lower productivity. Furthermore, the data suggest that the productivity has decreased among the

smallest companies. Thus, the only productivity gains in Estonian road freight transportation sector come from larger companies, while the smaller ones are struggling in terms of the productivity growth issues. The situation of the case-company reflects the general trend of the sector, while over the recent years its productivity has relatively more in comparison to the other companies in road freight sector.

The productivity problems can be related to increasing competition in international road freight transportation market. The competition is to a great extent price-based service and Estonian companies have to compete with the companies from countries with lower wage levels, such as Latvia, Lithuania, Poland, Bulgaria and Romania.

It can be concluded that innovation in road freight transportation is mostly seen as a process innovation, in order to make operations more efficient and lower production costs. As for product innovation, there were found no signs of it. The services offered by road freight transportation companies seem to be standardized in general and while service quality, reliability and speed of delivery may be important, they are not modified radically. Therefore, productivity increases are achieved by investment into new production technology (mainly newer vehicles), using the production technology more efficiently (increasing load factors) or downsizing sales and administrative processes.

Decreasing fuel consumption and increasing load factor seem to be the most important ways for increasing productivity. Besides, an investment into the newer vehicles, fuel consumption may be decreased by eco-driving training and incentives for drivers to apply eco-driving principles. In addition, IT can be implemented for decreasing fuel consumption as it allows monitoring vehicles and route planning. All these practices are common in other countries as well and they have been extensively reflected in the literature (Abate, 2014; Barla *et al.* 2010; Klunder *et al.*, 2009; McKellips and Calver, 2016). While increase in fuel efficiency can be also achieved by application of longer and bigger trucks (McKellips and Calver, 2016), this is currently not the case for Estonia due to its relatively strict regulations on truck weight.

Increased load factors are achieved in several ways. Better freight planning can be achieved by implementing various IT-solutions or it can be done manually. Co-operation and long-term partnerships with customers may generate stable demand, which makes

achieving high load factors easier. Finding additional loads from transport portals helps also to improve load factors. These portals can be seen as digital marketplaces of matching trucks and cargo (Riedl *et al.*, 2018) and therefore helping road freight companies to achieve higher load factors and productivity. As it has been proven by Barla *et al.* (2010), the application of IT-solutions (e.g., digitization etc.) leads to higher truck capacity utilization. However, the application of these systems should be recommended as it is not likely that manual planning, which is applied in studied case-company, could be more efficient.

Downsizing sales and administrative processes helps firms to cut back on labor costs, which is especially important if the companies have to compete against service providers from countries with lower wage levels. Still, decreasing sales personnel may decrease long-run growth potential for the firm, although it depends on how the firm acquires its customers. It is clear that without new customers, the growth potential is limited, although some companies may not aim at achieving high growth rates, as income from existent customers may be satisfactory. If the firms find new and more cost-efficient ways of finding new customers, then there is not so much need for sales personnel either. Labor input could be also decreased by application of IT solutions to administrative processes.

According to the literature, the two main barriers for increasing the productivity are: 1) financial constraints (Caniëls *et al.*, 2008) and 2) the lack of awareness (Liimatainen *et al.*, 2012). The current study does not directly point to either of them, but the fact that the selected case-company does not use IT-solutions for freight planning as it find them not useful, might be related to the lack of knowledge about the possibilities of latest software developments.

The results of the study point out that governmental regulation is in most cases productivity-decreasing for road freight transportation. The sector is relatively heavily taxed as it is affected by excise taxes on fuel, heavy goods vehicle taxes and road-user charges. Weight restrictions also are productivity decreasing by its nature. It seems to be that the role of Estonian government is foremost not to contribute to productivity, but to ensure level playing field for all participants on the market. Largely, international road freight transportation is regulated on the EU level. It must be taken into account that governmental regulation is to larger extent oriented in achieving environmental benefits,

although productivity increases may contribute to environmental sustainability due to the rebound effects the opposite is possible (Gossart, 2015).

Still, the Estonian government is considering some changes in regulation, that could increase productivity in road freight transportation. Probably, the most important of them is increasing the maximum weight limits on heavy trucks. One of the main issues is road wear, but there have been conducted tests, which show that on certain conditions (seven axles, double wheels or single wheels with wide tyres) heavier vehicles do not cause more impact on road and therefore they should be allowed to Estonian roads (Olep and Grünberg, 2018). Upon these results Estonia could consider performance-based weight restrictions for trucks (Thompson and Hassall, 2014). As new and even larger trucks can be developed in the future, these trucks should be tested on a similar way and decisions to allow them to Estonian road could be based on test results.

The Estonian government could also consider subsidies on alternative fuel trucks. Due to the high price, they may be unaffordable for the road freight transportation companies, but they could have higher fuel-efficiency (Osorio-Tejada *et al.*, 2017), which could lead to productivity growth. In addition, the environmental benefits of alternative fuel trucks should be also considered. As alternative fuel truck may need special infrastructure (fueling or charging stations) (Taefi *et al.*, 2016) then subsidizing these trucks might require some governmental support to develop that infrastructure. In case of international transportation, it requires, that similar infrastructure is developed across all countries in the transportation networks.

Road freight transportation in Estonia is not subject to heavy intermodal competition as in most cases different transportation modes are used for different types of cargo. There is some competition for maritime transportation, but the effect of railway transportation is considered as modest. It is possible that in the future Rail Baltica will change the situation, but its long-term effects on road freight sector are indeterminate. The study conducted in this paper does not reveal that currently the threat from Rail Baltica is considered as an important issue.

Conclusion

The research paper explored productivity and its determinants in Estonian road freight transportation sector at national, company and governmental level. A combined research methodology was applied, which included analysis of national level productivity data for Estonian road freight transportation sector, a case-study of one road freight transportation company and an interview with a transportation expert at the governmental level.

While the productivity in monetary terms has slightly increased for the Estonian road freight transportation sector, productivity growth has been slower than in the national economy on the average. At the same time, productivity in physical terms has declined and the productivity in monetary terms has also decreased for the smaller companies, which make up the majority of the industry. These productivity problems are related to the increasing international competition.

Innovation in road freight transportation is mostly process innovation, there was no product innovation in the case-company. The main ways for increasing productivity are investment into new production technology, applying the production technology more efficiently, downsizing sales and administrative processes. Decreasing fuel consumption and increasing load factor are the most important of these. Fuel saving is achieved by application of newer vehicles, eco-driving and IT solutions for vehicle monitoring and routing. Load factor is increased by better freight planning, co-operation with customers and additional loads from transport portals.

Governmental regulation is mostly productivity-decreasing for road freight transportation. The sector is relatively heavily taxed and weight restrictions hinder application of larger and more efficient vehicles. However, these restrictions may be eased in the future. Estonian government is considering some also some regulatory changes, which may support productivity by decreasing administrative burden on road freight transportation companies.

In the future work, comparative analysis of different types of road freight transportation companies could be implemented. It would be interesting to see how that productivity affecting factors are different for companies operating on the domestic and international

markets. Additionally, comparative analysis of road freight transportation companies with different size could be conducted.

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Appendix 1. Factors affecting productivity in road freight transportation

Factor	Effect on productivity	Sources
More efficient trucks (increased carrying capacity, increased fuel efficiency, alternative fuel)	+	Glaeser and Ritzinger (2012), Liimatainen <i>et al.</i> , (2012), Litschke and Knitschky, (2012), McKellips and Calver (2016), Osorio-Tejada <i>et al.</i> (2017)
More efficient vehicle operation (maintenance, fuel saving, eco-driving)	+	Klunder <i>et al.</i> (2009), Demir <i>et al.</i> (2011, 2014), Liimatainen <i>et al.</i> , (2012),
Informational technology (vehicle tracking, fleet management route planning, integration with other transport modes)	+	Aylward and O'Toole (2007), Aschauer and Starkl, (2010), Demir <i>et al.</i> (2011, 2014), Jarašūnienė and Greičiūnė (2013), McKellips and Calver (2016)
Capacity utilization (decreasing empty running, finding backhauls, increased loading efficiency)	+	Abate (2014), McKinnon (2010, 2016)
Increasing vehicle utilization (more journey per week, longer hauls)	+	Aylward and O'Toole (2007), McKinnon (2009), Riedl <i>et al.</i> (2018)
Decreased accident rate (safer vehicles, monitoring hours of service)	+	Cheng and Cebon (2008), Pitera <i>et al.</i> (2013),
Financial constraints (decrease investment)	-	Caniëls <i>et al.</i> (2008)
Competition (may decrease investment, but may lead to more efficient practices)	?	Oberhofer and Dieplinger (2014), McKellips and Calver (2016)
Lack of awareness (decrease investment and innovation)	-	Caniëls <i>et al.</i> (2008), Liimatainen <i>et al.</i> , (2012)
Weight restrictions (hinder application of more efficient vehicles)	-	Glaeser and Ritzinger (2012), Thompson and Hassall (2014)
Road maintenance and construction (faster deliveries)	+	Klunder <i>et al.</i> (2009), Weisbrod <i>et al.</i> , (2014)
Subsidies to new technology (faster adoption of more efficient and alternative fuel vehicles)	+	Taefi <i>et al.</i> (2016), Osorio-Tejada <i>et al.</i> (2017)
Taxation (decreases productivity, but tax returns may be use for productivity supporting policies)	?	European Environment Agency (2013), Harvey (2015)

Source: compiled by the author, based on the literature.

Appendix 2. Interview questions with the case-company

1. Which are the best options in road freight to increase productivity?
2. What has the company done in the recent years for increasing productivity?
3. What have been the biggest changes in business processes?
4. In which areas has the company invested during the recent years?
5. Which new equipment besides trucks has been taken into use during the recent years?
6. What does the company do in order to plan transportation operations better?
7. What does the company do in order use vehicles more efficiently?
8. What has the company done for decreasing empty running during the recent years?
9. Which measures does the company employ for decreasing fuel consumption?
10. What else is being done for decreasing costs related to the trucks?
11. What has the company done for increasing the efficiency of loading vehicles?
12. What are the most important barriers to increasing productivity?
13. How does the competition effect productivity and possibilities for increasing it?
14. How do you evaluate the effects of competition from other transportation modes to road freight?
15. How do you evaluate the effect of Rail Baltica to the productivity of your company?
16. How does the legislation affect the company's operations and productivity?
17. Which changes could be done in legislations in order to increase productivity in road freight transportation?
18. To what extent easing the weight restrictions for heavy trucks would affect the company's productivity?
19. To what extent easing the cabotage restrictions would affect the company's productivity?
20. What is the effects of road conditions and traffic regulation on the company's productivity?

Appendix 3. Interview questions with transportation expert

1. How do you evaluate the situation of Estonian road freight transportation companies on the general?
2. Which are the main strengths and weaknesses for these companies?
3. How do you evaluate the productivity Estonian road freight transportation companies?
4. What are the most important actions from these companies for increasing productivity?
5. What does the Estonian government do for increasing productivity Estonian road freight transportation companies?
6. What can the government do better in this area?
7. How should the legislation change for increasing productivity Estonian road freight transportation companies?
8. According to your opinion, how will Rail Baltica affect Estonian road freight transportation companies and their productivity?

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