Proceedings of the 2016 International Conference "ECONOMIC SCIENCE FOR RURAL DEVELOPMENT" No 42
Jelgava, LLU ESAF, 21-22 April 2016, pp. 171-178

FORECASTING ROAD FREIGHT TRANSPORT ALTERNATIVES FOR SUSTAINABLE REGIONAL DEVELOPMENT IN ESTONIA

Aevar Valdas[1], MA; **Raivo Ruus**[2]; **Reet Põldaru**[3], Dr. rer. oec.; **Jüri Roots**[4] PhD

[1, 2, 3, 4] Institute of Economics and Social Sciences,
Estonian University of Life Sciences

Abstract. Transportation has always been one of the main driving forces of any country's economic development, and Estonia is no exception. Transport influences other economic sectors and the service sector, and these sectors in turn have a strong influence over the transport sector. Road transport plays an important role in the regional and sustainable development of economy. Road transport, however, is the main source of greenhouse gas (GHG) emissions. Therefore, it is important to be aware of the factors which affect both road freight and the amount of greenhouse gases emissions by road freight transport. One way to acquire information about the future is by using econometric models which, in addition to forecasts, illustrate interconnections between different factors. This study looks at the use of the econometric simultaneous equations model for forecasting the effect and the negative impact that road freight transport has on environment. Forecasts are made in three different variants, considering different growth rates of Gross Domestic Product (GDP) per capita. The analysis showed that the most important factors in forecasting both freight volumes and GHG emissions were GDP per capita and the number of inhabitants in Estonia.

Key words: econometric model, road freight transport, GHG emissions

JEL code: C3, R4, Q01

Introduction

The European Commission is planning to reshape the European transport system, and according to the Transport 2050 Roadmap to a Single European Transport Area, there is a need to significantly reduce Europe's dependence on imported oil, and to reduce transport-related CO2 emissions by 60% compared to the 1990 level. According to the Roadmap, 30% of road freight over 300 km should shift to rail or waterborne transport by 2030, and more than 50% by 2050 (Transport 2050, 2011).

Road freight transport is an important factor in the development of a national economy but on the one hand, road freight transport has a negative impact on the environment and on people's health. For a long time, the main criterion of planning road freight transport was the minimisation of expenses (Crainic T.G., 2000; Forkenbrock D.J., 2001). A classic example of minimising freight costs is using a linear transport problem to define optimal transport routes (Taha H.A., 2003). The situation today is different. Increased global attention to climate problems and environmental protection has encouraged logistics experts and representatives of road freight transport companies to pay more attention to the downsides of their activities. The main negative impacts are the generation of pollutants, road traffic accidents, noise pollution, land use deterioration etc. but the main focus is on limiting the increase of GHG emissions (Demir E. et al., 2014; Lin C. et al., 2013; van Veen-Groot D.B., Nijkamp P., 1999).

At local and regional levels, lorries, though being a significant cause of pollutants, are the main means of freight transport. Although the technology of lorry production is being continuously improved and the quality of fuel is improving, lorries will remain the main cause of pollution in the near future. In the context where the effect of greenhouse gases must be taken into account, a new road transport development trend – green road freight transport – has appeared (Lin C. et al., 2013).

At the level of individual countries and areas, the volume of road freight transport, turnover and GHG emissions have been addressed in various articles (Brizga J. et al., 2014; Ofei-Mensah A., Bennett J., 2013; O'Mahony T. et al., 2013; Piaggio M. et al., 2015; Singh B. et al., 2015; Sobrino N., Monzon A., 2014; Streimikiene D., 2015; Yan X., Crookes R.J., 2009).

At the global level, the increasing GHG levels in the atmosphere cause the increase of the Earth's temperature. In the road transport sector, the main component of GHG is CO2, which is created when motor fuel burns. GHG is thus directly dependent on the amount of fuel used by a vehicle.

Estonia's low population density has caused road freight transport to have the leading role in providing nationwide services in the transport of goods, as well as ensuring mobility. In terms of domestic freight

[1] Corresponding author. Tel.: + 372 50 33 784 E-mail address: aevar.valdas@emu.ee

transport, local businesses and competitiveness, road freight transport is irreplaceable. Economic growth leads to the society's increased welfare, whereas adverse effects caused by road freight transport reduce welfare.

The objective of this study is to forecast the key indicators of road freight transport (freight volumes, freight turnover), and the amount of GHG emissions (CO_2 equivalent) caused by the transport sector.

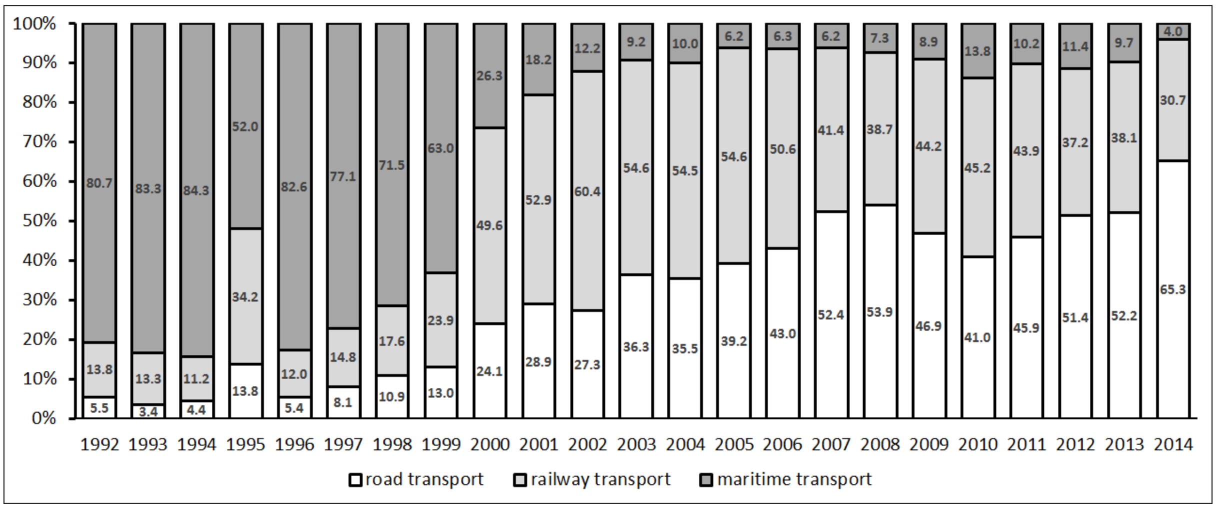
The following problems must be solved in order to meet this objective:

1) building an econometric model and forecasting the freight volumes of road freight transport and the size of the adverse impact (emission of greenhouse gases) that road freight transport would cause to the environment during the period from 2015 to 2030;
2) analysing the modelling results and defining the factors whose modification would allow road freight transport to reduce the emission of greenhouse gases, or, at least, reduce their increase rate.

Research results and discussion
1. Overview of transport sector in Estonia

In Estonia, the main types of transport are road, rail, maritime and air transport. The share of air transport in freight transport is unremarkable and is not used in further analysis. Freight volumes are best characterised by freight turnover, since it comprises two components: the amount of goods transported, and transport distance. Freight turnover is measured in tonne kilometres (tkm). One tonne kilometre equals transporting one tonne of goods to the distance of one kilometre (Statistics Estonia, 2015).

In the 1990s, after Estonia had regained its independence, the main type of transport was maritime transport but since 2000, the proportion of maritime transport in freight turnover has significantly decreased, and only made up 4% in 2014, whereas the proportion of both rail and road transport has increased (Figure 1) (Statistics Estonia, 2015).



Source: authors' construction based on Statistics Estonia

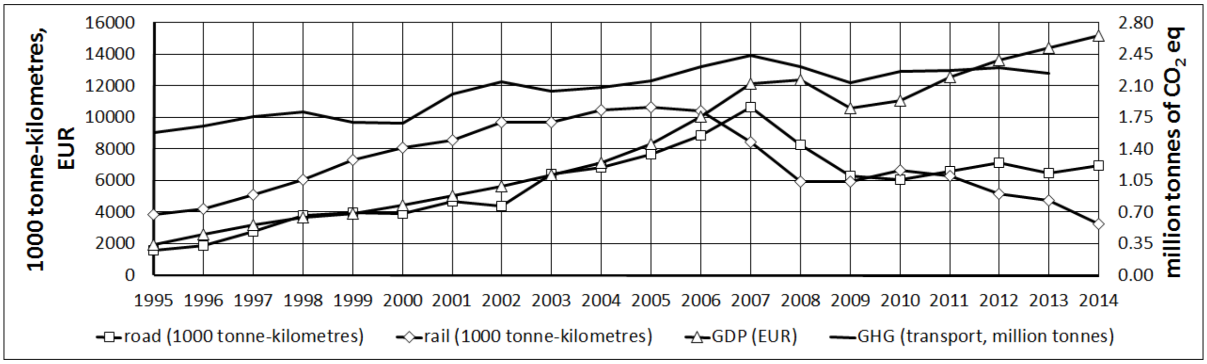
Fig. 1. **The proportions (%) of main types of transport out of freight turnover from 1992 to 2014**

During the years 2000-2006, rail transport constituted the largest proportion. Since the economic recession in 2007, road freight transport has grown rapidly, making up 65.3% of the total freight turnover in 2014, and the proportion of rail transport has decreased (30.7%) (Figures 1 and 2) (Statistics Estonia, 2015). The decline in rail freight transport is caused by the fact that oil transportation is decreasing and shifting to Russian ports. This is a positive development in terms of reducing environmental risks but also shows that Estonia has not been successful at impeding the growth of road freight transport and shifting it to railways.

In recent years, freight turnover on roads and railways has been smaller than economic growth (Figure 2). In Estonia, 21.8 million tonnes of CO_2 equivalent were emitted in 2013, 10.3% of which was transport-related (Eurostat, 2015). CO_2 (carbon dioxide) equivalent (CO_2 eq) is a metric measure used to compare the emissions from various greenhouse gases on the basis of their global-warming potential (GWP), by converting amounts of other gases to the

[1,]Corresponding author. Tel.: + 372 50 33 784 E-mail address: aevar.valdas@emu.ee

equivalent amount of carbon dioxide with the same global warming potential (Eurostat, 2016).



Source: authors' construction based on Statistics Estonia and Eurostat

Fig. 2. **Freight turnover (tkm) on roads and railways, GDP per capita (EUR) and the amount of GHG emissions by transport (million tonnes of CO_2 equivalent)**

2. Model description

In order to meet the objective, an econometric simultaneous equations model was built, which allows modelling the studied processes using several equations that have a simultaneous effect (Greene W.H., 2008). The model includes stochastic, i.e. structural equations, and identities. The exogenous variables of the model are external variables, which are presented as given values from the perspective of the model. Endogenous variables are variables with values set by the model, i.e. each endogenous variable has a separate equation (a stochastic equation or identities), thanks to which there is an equal number of equations and endogenous variables in the model.

The parameters of the model were estimated using the data collected by Statistics Estonia and Eurostat on road freight transport freight volumes, CO_2 emissions, and macroeconomic indicators characterising Estonian national economy during the period from 1992 to 2014.

Freight transport and CO_2 emissions are modelled using a model with 7 exogenous variables. Exogenous variables and their main statistics are reported in Table 1.

Table 1

Exogenous variables of the econometric model, and their main statistics

Symbol	Exogenous variable	Statistics			
		Average	Max	Min	Standard deviation
X1	Trend	1.50	13.0	-10.00	7.07
X2	GDP per capita (thousand)	7.03	10.3	3.98	2.35
X3	Estonian average monthly salary (EUR)	468.6	1006	35.0	314.1
X4	Consumer price index (CPI)	1.173	1.90	0.98	0.275
X5	Recession dummy variable	0.167	1.00	0.00	0.38
X6	Estonia's population (thousand)	1365	1533	1282	78.1
X7	Total GDP (billion EUR)	9.44	13.2	5.72	2.74

Source: authors' calculations based on Statistics Estonia

The model has 10 endogenous variables. The descriptive statistics of the data used for the model parameter estimation are reported in Table 2.

[1,]Corresponding author. Tel.: + 372 50 33 784 E-mail address: aevar.valdas@emu.ee

Table 2

Endogenous variables of the econometric model, and their main statistics

Symbol	Endogenous variables	Statistics			
		Average	Max	Min	Standard deviation
Y1	Road freight transport freight volume (million tonnes)	24.57	52.4	9.6	11.6
Y2	Road freight transport freight turnover (million tkm)	4183.7	7026.0	1056.0	1876.4
Y3	Total CO_2 emissions (million tonnes of CO_2 eq)	20.695	37.560	16.290	4.374
Y4	CO_2 emissions caused by the transport sector in Estonia (million tonnes)	1.972	2.420	1.160	0.353
Y5	CO_2 emissions caused by road freight transport in Estonia (million tonnes)	1.787	2.230	1.010	0.343
Y6	Proportion of CO_2 emissions caused by the transport sector of total CO_2 emissions	0.098	0.131	0.042	0.0232
Y7	CO_2 emissions caused by the transport sector per one transported tonne	0.087	0.147	0.030	0.0341
Y8	Freight turnover per one euro of GDP (tkm/EUR)	0.423	0.554	0.167	0.1131
Y9	CO_2 emissions caused by the transport sector per one euro of GDP (kg CO_2 eq/EUR)	0.218	0.345	0.176	0.0425
Y10	CO_2 emissions caused by the transport sector per one tkm (kg CO_2 eq/tkm)	0.528	1.220	0.304	0.2696

Source: authors' calculations based on Statistics Estonia and Eurostat

The parameters of the stochastic equations of the econometric model were estimated using the FP programme package (Fair R.C., Parke W.R., 2012). Three different methods were used for the estimation of the parameters: 2SLS – two-stage least squares, 3SLS – three-stage least squares, and FIML – full information maximum likelihood.

3. Forecasts up to the year 2030

Forecasts are made in three different variants, considering different growth rates of the exogenous variable X2 (GDP per capita). The values of exogenous variables X1, X3, and X6 are forecasted based on possible developments. The values of other exogenous variables remain the same in each forecast.

The amount of goods in tonnes (Y1) and freight turnover in tonne kilometres (Y2) are used to estimate the parameters of road transport freight volumes (Figures 3, 4). Freight volumes are modelled based on the following equation: Y1 = F(X1 – trend, X2 – GDP per capita, X3 – Estonian average monthly salary, X5 – recession dummy variable).

Forecast curves (Figure 3) show that the pre-recession level of road freight transport (38.5 million tonnes in 2007) could not be reached until 2030, even when using the most optimistic estimation (GDP growth rate of 2.2% per year). If the annual average growth of GDP will be 1.3% (GDP1.013) or 1.5% (GDP1.015), freight volumes would decrease, since the multiplier of the trend variable is negative. As a result, negative influence would gradually increase with the passing of time.

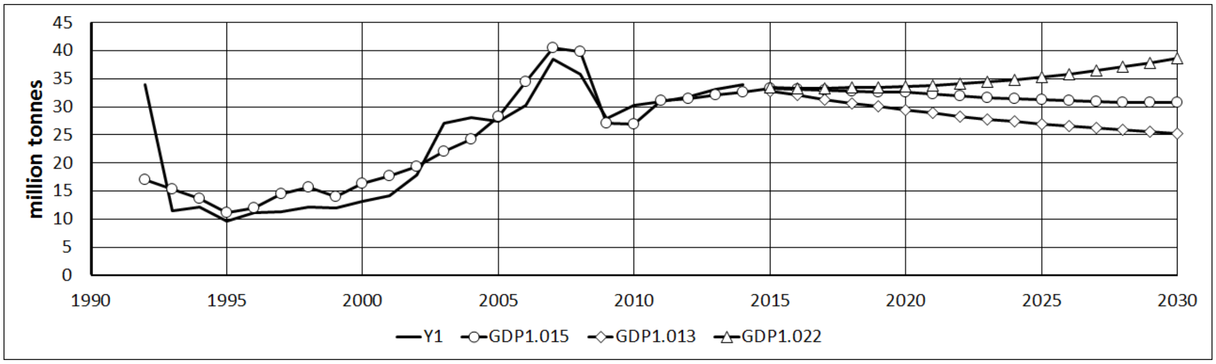
The following equation is used in modelling freight turnover: Y2 = F(Y6 – proportion of CO_2 emissions caused by the transport sector of total CO_2 emissions, X2 – GDP per capita, X4 – consumer price index, X5 – recession dummy variable).

Figure 4 shows that in case of 0.6% annual GDP growth rate, the pre-recession level (7026 million tkm) would not be reached until 2028. If GDP increased by 1.4% per year, the pre-recession level would be achieved by 2020 according to the forecast, and by 2018, if GDP increased by 2.2% annually.

The analysis of Figures 3 and 4 demonstrates that economic recession has affected the growth of freight volumes more than it has affected the growth of freight turnover (the pre-recession level will be reached later).

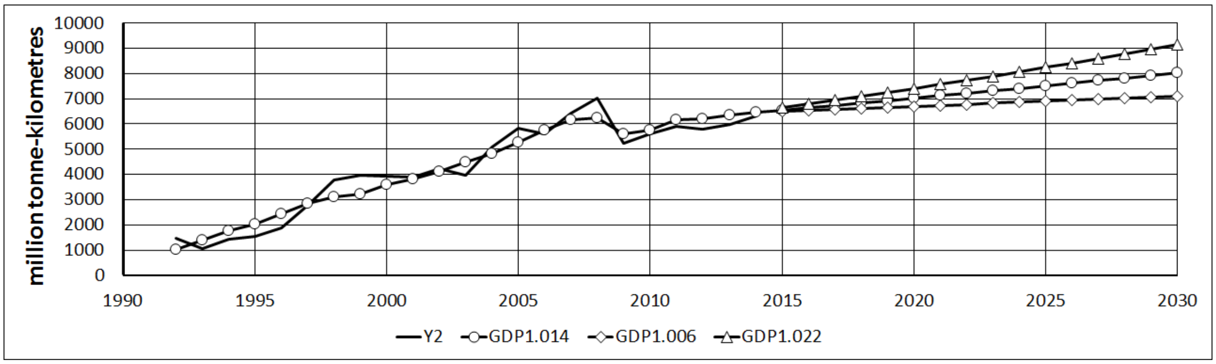
The endogenous variables that harm the environment are the total CO_2 emissions (Y3), CO_2 emissions caused by the transport sector (Y4), and the amount of CO_2 emissions caused by road freight transport (Y5).

[1,] Corresponding author. Tel.: + 372 50 33 784 E-mail address: aevar.valdas@emu.ee



Source: authors' construction based on the econometric model

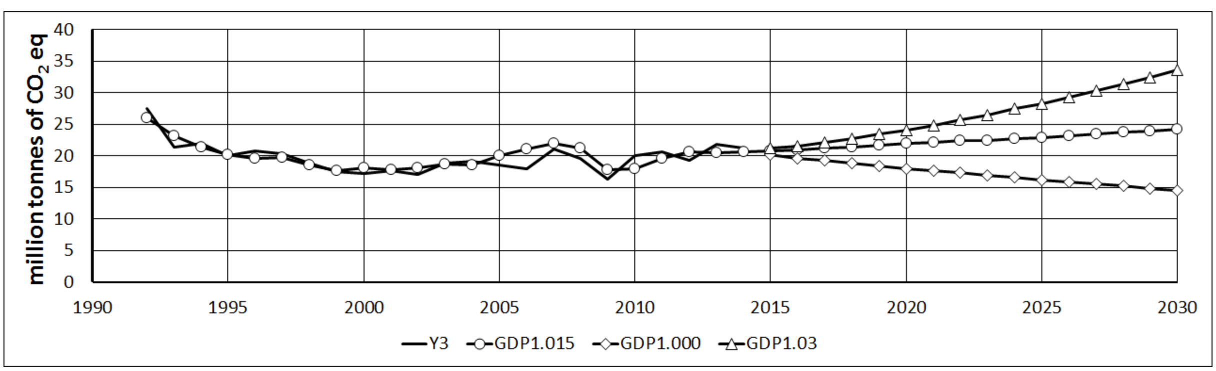
Fig. 3. **Road freight transport freight volumes in Estonia from 1992 to 2014, and freight volume forecasts for 2015 to 2030 considering different GDP per capita growth rates**



Source: authors' construction based on the econometric model

Fig. 4. **Road freight transport freight turnover in Estonia from 1992 to 2014, and freight turnover forecasts for 2015 to 2030, considering different GDP per capita growth rates**

The total CO_2 emissions were modelled using the equation Y3 = F(Y10, X2, X4, X5, X6). Total CO_2 emissions are largely defined by two exogenous variables: GDP per capita, and population. If GDP per capita remains unchanged (grows by 0.0% per year), the total CO_2 emissions decrease due to the forecasted decline in population (Figure 5). According to forecasts, total CO_2 emissions will fall from the 20.2 million tonnes forecasted for 2014, to 14.6 million tonnes, i.e. by 28.0%, meaning that total CO_2 emissions would decrease on average by 2.2% per year.



Source: authors' construction based on the econometric model

Fig. 5. **Total CO_2 emissions in Estonia from 1992 to 2014, and total CO_2 emissions forecasts in Estonia for 2015 to 2030, considering different growth rates of GDP per capita**

Forecasts show that if GDP increased by 1.5% per year, the pre-recession level (21.1 million tonnes) could be reached by 2017. If, however, GDP grew by 3% per year, the pre-recession level could be reached by 2015. The increase of total CO_2 emissions is caused by the increase of GDP (per capita), but the negative effect of the population size will remain.

CO_2 emissions caused by road freight transport are modelled using the following equation: Y5 = F(X2, X3, X5, X6). CO_2 emissions caused by road freight transport are forecasted to increase in the coming

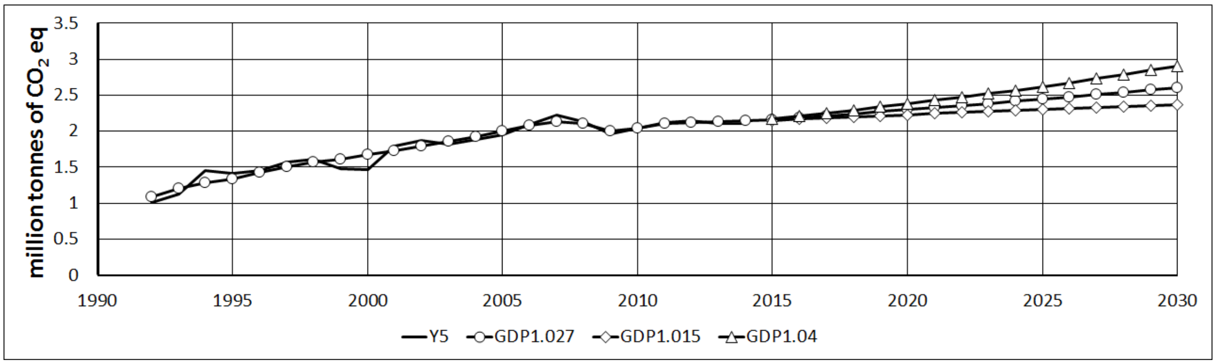
[1,]Corresponding author. Tel.: + 372 50 33 784 E-mail address: aevar.valdas@emu.ee

years (Figure 6). Such situation is caused by the fact that in addition to the variable X2 (GDP per capita), CO_2 emission is also affected by X6 (the population size), which is expected to decrease during the forecast period, and X3 (average salary), which is expected to increase during the forecast period. These two variables balance each other out in such way that their total impact will be negligible during the forecast period.

The forecasts show that if GDP increased by 2.7% per year, the pre-recession level (2.23 million tonnes) could not be achieved until 2019, whereas if GDP increased by 4.0% per year, the pre-recession level could be achieved in 2016.

If GDP per capita increased by 4.0% per year, CO_2 emissions caused by road freight transport would rise from 2.15 million tonnes to 2.90 million tonnes by 2030, which would mean an average 1.97% annual growth of CO_2 emissions caused by the transport sector.

This analysis demonstrates that the growth of CO_2 emissions caused by road freight transport is significantly smaller than the average increase of economic growth. Therefore, the development of road freight transport is sustainable.

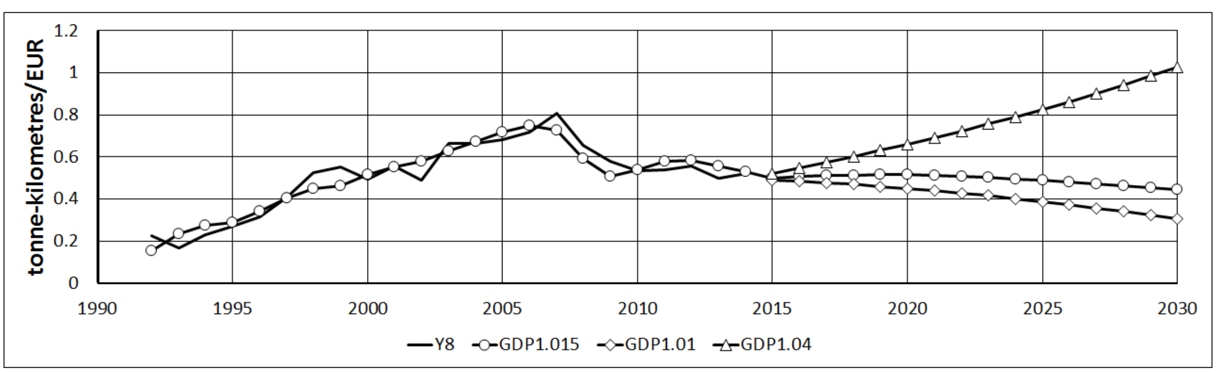


Source: authors' construction based on the econometric model

Fig. 6. **CO_2 emissions caused by road freight transport from 1992 to 2014, and forecasted CO_2 emissions caused by road freight transport from 2015 to 2030, considering different growth rates of GDP per capita**

The economic efficiency of the transport sector is modelled using three variables: freight turnover per one euro of GDP (Y8), CO_2 emissions caused by the transport sector per one euro of GDP (Y9), CO_2 emissions caused by the transport sector per one tkm (Y10).

Freight turnover per one euro of GDP (Y8) is modelled using the following equation: Y8 = F(Y6, X2, X3, X6). Freight turnover per one euro of GDP increased at a relatively stable rate from 1992 to 2007 (Figure 7). Following that, freight turnover per one euro of GDP decreased during the economic recession, and stabilised at the level of 0.6 by 2010, remaining unchanged until 2014.



Source: authors' construction based on the econometric model

Fig. 7. **Freight turnover per one euro of GDP in Estonia from 1992 to 2014, and forecasts of freight turnover per one euro of GDP in Estonia for 2015 to 2030, considering different growth rates of GDP per capita**

[1,]Corresponding author. Tel.: + 372 50 33 784 E-mail address: aevar.valdas@emu.ee

Freight turnover per one euro of GDP is highly dependent on GDP per capita (X2). If GDP per capita grew by 4.0% per year, freight turnover per one euro of GDP would start to increase significantly, and reach its peak by the end of the period. By 2030, freight turnover per one euro of GDP would have risen from 0.519 to 1,027, i.e. a 0.508 (tkm/EUR) growth, meaning that freight turnover per one euro of GDP would increase by an average of 4.63% per year.

If GDP per capita changes little (approximately by 1.0% per year) – GDP1.01, then freight turnover per one euro of GDP declines by an average of 3.1% per year due to the decrease of the population. Such relatively significant decrease of freight turnover per one euro of GDP (Y8) is caused by the fact that the growth of variable X2 (GDP per capita) does not outweigh the negative impact of variable X6 (the population size) yet.

If GDP per capita increased by 1.5% per year, freight turnover per one euro of GDP would start to grow, reach a peak in 2020 (0.519 tkm/EUR), and then start to decline. By 2030, freight turnover per one euro of GDP in Estonia would thus have fallen from 0.519 to 0.443, i.e. a 0.076 (tkm/EUR) decrease, meaning that freight turnover per one euro of GDP would decrease by an average of 0.82% per year.

Conclusions

1) A simultaneous equations model was constructed and used to forecast the freight volumes and freight turnover of road freight transport, the adverse impacts that road freight transport has on the environment (greenhouse gas emissions), and the economic efficiency of the transport sector for the period of 2015-2030.

2) The most important exogenous variables turned out to be X2 (GDP per capita) and X6 (the population size). In most cases, the growth of GDP also increased the value of the endogenous variable, i.e. X2 has a positive (enhancing) effect in the model. X6 (Estonia's population size), on the one hand, is an exogenous variable that diminishes the endogenous variable, since the population is forecasted to decrease during the period of 2015 to 2030.

3) The economic recession has affected the growth of freight volumes more than it has affected the increase of freight turnover (the pre-recession level will be reached later). According to the most optimistic estimation (GDP growth rate of 2.2% per year), the pre-recession level of freight volumes will be achieved in 2030 at the earliest. Freight volumes will decrease if the annual average growth of GDP is 1.5%. The pre-recession level of freight turnover would be achieved by 2020 if GDP increased by 1.4% per year, and by 2018, if GDP increased by 2.2% annually.

4) The average growth of CO_2 emissions caused by road freight transport is significantly smaller than the average increase of economic growth. If GDP per capita increased by 4.0% per year, CO_2 emissions caused by road freight transport would rise from 2.15 million tonnes to 2.90 million tonnes by 2030, which would mean an average 1.97% annual growth of CO_2 emissions caused by the transport sector. Hence, currently prevailing development trends in the field of road freight transport will ensure sustainable regional growth.

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[1]Corresponding author. Tel.: + 372 50 33 784 E-mail address: aevar.valdas@emu.ee