MACROECONOMETRIC INPUT-OUTPUT MODEL FOR TRANSPORT SECTOR ANALYSIS

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KEYWORDS

Econometric model, input-output model, transport sector, transport policy development

ABSTRACT

Effective government transport policy can be based only on realistic data, sophisticated and detailed transport sector analysis, and productive modelling. The aim of the paper is to demonstrate the main elements used to develop a relatively small macro-economic input-output model with the emphasis on transport for one European Union (EU) country. Transport sector faces similar problems in various countries linked with emissions, transport flows, road accidents and other issues hence appropriate modelling tool should be selected. The model presented in this article consists of econometric and input-output relations. The research analyses and examines three scenarios and stresses the importance of the transport investment not only for development of the transport sector, but also for the economic development in general. The scenarios imply zero, 9 million and 6.7 million additional investment in transport sector eligible to the EU funding. As the result of additional investment, GDP recovers faster leading to 0.3-1.7%points faster growth rates as compared to the base scenario with no additional investment leading to faster cohesion with the average EU level, as well as higher number and turnover of passengers in the public and commercial transport, while the number of passenger cars is lower. The model can also be applied to study regional development, if it is possible to distinguish, which regions will benefit from the investment, as well as influence on fuel consumption and CO2 emissions, if the investments are targeted to specific means of transport.

INTRODUCTION

Policy making in the transport sector is a sophisticated task managed by the Ministry of Transport or other institution with the respective functions. It relies on information provided by the interested parties like road administrations, railway administrators, local municipalities and many others. Also for the EU countries, different EU policies and available funding has to be considered (Jankova, Jurgelane, and Auzina 2016). Moreover, nowadays emphasis has to be made also on the environmental issues, for example, CO_2 emissions (Joint Transport Research Centre 2008). Therefore, the use of different models is not only useful, but it is necessary. Such models are developed not only on a single country bases, but also as global models (Van der Zwaan, Keppo, and Johnsson 2013).

Input-output analysis is widely applied in many countries regrading transport and transportation, for example, to evaluate French maritime transport impact on air pollution (Bagoulla and Guillotreau 2020), investigate the structural emission reduction of transportation in China (Yu et al. 2021), examine economic effect of a port in Italy (Danielis and Gregori 2013).

Depending on the scope and use of the models, general framework of these models also differs. For general analysis of the impact of economic development on transport system, input-output models (Auzina-Emsina, Ozolina, and Jurgelane-Kaldava 2020; Bagoulla and Guillotreau 2020; Danielis and Gregori 2013; Yu et al. 2021) and econometric models (Auzina-Emsina, Ozolina, and Pocs 2018) can be used. In case specific aspects of the transport system are analysed using data on several countries, panel data approach can be used (Lin and Omoju 2017). Computable General Equilibrium models can be used for broader research, including global and regional aspects (Charalampidis, Karkatsoulis, and Capros 2019).

The use of models can sometimes be hindered by the lack of knowledge, as the clerks involved in the policy-making process may not have a strong background in modelling. Also time spent for development of models should be considered, as complex models tend to be very time-consuming (Skribans and Balodis 2016). Therefore, in the policy development process not only highly detailed and sophisticated models, but also relatively simple ones should be used.

The aim of the paper is to demonstrate the main elements used to develop a relatively small macro-economic input-output model with the emphasis on transport for one EU country – Latvia. Such a model can be applied in other countries, there are no limitations or specific characteristics in the modelled country (Latvia) that limit application.

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METHODOLOGY AND DATA

In order to estimate the model, publicly available data, mostly data of the national statistical office - Central Statistical Bureau (CSB) of the Republic of Latvia - were used. For indicators related to the EU, Eurostat data were used. The data period used for the model was mostly 1995-2019, however, for some indicators shorter time-period was used due to the unavailability of older data. The use of the selected databases ensures data comparability and reliability.

It should be noted that when re-estimating the model, careful analysis has to be made regarding the COVID crisis period, which began in 2020. At first, this period should be avoided, because it involves a lot of restrictions and not the conscious choice of passengers to change their mobility preferences. However, later this period can be treated similarly as the previous crises using the dummy variables in econometric equations, if necessary.

The model approach implies the use of input-output linkages and econometric equations. At present, the input-output part is static implying that it cannot be used for long-term analysis, as technologies tend to change. However, by analysing input-output tables of several years, it is possible to establish certain trends in the values of coefficients thus enhancing the applicability of the model for longer-term analysis, which is essential in case of transport projects.

Econometric equations of the model were estimated using *EViews* software, ensuring that they do not contain autocorrelation or heteroscedasticity problems (serial correlation LM test and White test without cross terms were used as the main tests to confirm that), and that all the coefficients are statistically significant.

The model itself was developed in *MS Excel*, ensuring that it can be widely used without the restrictions of specific software. This model is built to be used by the policy elaborators and clerks that have limited modelling skills. This imposes some limitations to the structure and application of the model. These limitations can at least be partly avoided during the scenario development process.

As the model is intended to be in a sense a sub-model in the context of overall economic modelling system of the government, it relies on the economic forecasts elaborated by the Ministry of Economics and the Ministry of Finance for budget planning purposes. However, it is possible also to consider other assumptions regarding the gross domestic product (GDP) growth and other important general economic indicators thus ensuring more flexible use of the model.

The current version of the model consists of the following blocks:

1. Population block, which includes the main indicators characterizing population in general and economically active population in particular, as well as the main age groups (before working age, working age and after working age).
2. GDP formation block, which includes estimates of GDP use elements and respective price indexes.
3. Input-output calculations with the Leontief function enable obtaining the values of real output and value added by industries. Currently the model disaggregrates the national economy into 8 industries – the model calculates indicators for agriculture (A according to NACE classification 2nd revision), industry (BDE), manufacturing (C), construction (F), trade and accommodation (GI), transport (H), government services (O, P, Q) and other services.
4. Employment and productivity calculations by industries.
5. Transport indicators block, which includes calculations of different transport flows, road quality and road accidents.
6. Fuel consumption and emissions, which includes calculations of consumption of the main fuels used in transport, as well as the main groups of emissions.
7. Key performance indicators (KPI) block includes calculation of several policy indicators to keep track on the broad aims of the government and their level of fulfilment. The main KPI are nominal labour productivity as % of the EU-27 respective indicator, GDP per capita as % of the EU-27 average and the decrease of the fatal road accidents.

All above-mentioned blocks are linked and ensure that development processes described within the model are coherent. Additional blocks can be added if certain modelling enquiry demands it.

Transport indicators block

The most important group of equations in the transport indicators block is related to the passenger flows therefore it will be discussed in more detail in this article.

There are many factors influencing these flows like GDP, average wages, level of automobilization, domestic income and expenditures, demographical indicators, changes on urban territories, economic changes, crisis and others (Griskeviciene, Griskevicius, and Griskeviciute-Geciene 2011). As it is not possible to even check all of those factors given that only 25 observations are available for the estimation of the equations, the main factors have to be distinguished. Moreover, distinction has to be made among the factors that influence the necessity to travel as such (the number of passengers) and the amount of travel done (passenger kilometres).

Table 1 summarises the results of specified equations for the number of passengers by the main means of transport in Latvia in the form of the elasticity coefficients as the respective equations are estimated in log-log form. It is evident that the number of passengers in transport means available only in the big cities (trolley busses and trams) is more affected by the number of population than more long-distance solutions as trains and busses. It can also be noted that the number of passengers in busses reacts slower to GDP changes, because busses are essential in intra-city, intra-regional and multi-regional traffic, while other means of the transport cover only specific areas. It can also be noted that in case of continuous decrease in population, it is expected that the investments will be more targeted at the quality improvements in the transport system rather than the quantitative ones as larger number of vehicles per se.

Table 1: Elasticity Coefficients in Equations for the Number of Passengers by the Means of Transport

Means of Transport	Factor	
	Population	GDP
Train	3.6	1.0
Bus	2.9	0.7
Trolley bus	6.5	0.9
Tram	7.1	1.0

Other factors are included in the scenario analysis indirectly via the coefficients of the distance per passenger (DISTANCE) in railway and road transport, which relate the number of passengers (PASSENGERS) and passenger kilometres (PKM) as Equation (1) shows. These coefficients can also be used to show the modal shift between the rail and road transport.

$$PKM = PASSENGERS * DISTANCE \qquad (1)$$

Alternative to the public transport is the use of the private vehicles. Therefore the model includes also the calculation of the number of private cars (CARS) as shown in Equation (2).

$$LN(CARS) = 0.8*LN(GDP) - 1.55 \qquad (2)$$

The coefficient of elasticity of private transport to GDP is similar as that of busses, only slightly higher. It may indicate that people in rural areas tend to use more private cars as the economy develops in contrast of using public transport more often. Further the structure of vehicles by the motor type is used to model the fuel consumption and analyse the impact of changes in the structure on fuel consumption.

SCENARIOS

Three scenarios were developed to show the influence of the transport projects on the economic development of Latvia. The base scenario implies no extra investments in the transport sector. Other two scenarios include the implementation of particular transport projects attracting additional investments. These projects are selected by the Ministry of Transport and are eligible to the EU financing.

The first scenario includes a set of projects with investments of 9 billion EUR, which are evenly distributed in 2021-2027 as there was no information available on when it is intended to implement each of those projects. The second scenario includes a set of projects with investments of 6.7 million EUR. In each of the sets of projects 1.5 million EUR are the private investments. Both scenarios imply that additional government consumption expenditures are not necessary.

It is assumed that the increase in the quality of transport infrastructure allows to increase the productivity in transport sector as well. In the first scenario it is assumed that the productivity increase will be 1%point higher than in the base scenario, and in the second scenario it is assumed to be 0.8%points higher.

The first scenario implies that there will be a modal shift from road transport to railway transport, especially in international traffic. Also the use of the public transport will increase. This shift is incorporated in the coefficients of distance per passenger.

Both scenarios ensure that passenger kilometres in road transport in 2030 will increase by 8.2% compared to 2019, but the number of passenger cars will decrease by 5.6% in the same period. In the meanwhile the passenger turnover in railways will be by 3.6% higher in the first scenario and by 2.3% higher in the second scenario.

As one of the projects included in the scenarios implies the adjustment of 200 busses for the use of alternative fuel and several more projects are dealing with the infrastructure for electric vehicles, the structure of the cars by the fuel type is changed and the share of busses run on alternative fuels is increased by 7%points, but the share of private cars run on electricity is increased by 0.5%.

RESUTS AND DISCUSSION

When analysing the results, we have to consider the COVID crisis, which is not yet thoroughly investigated and it is not clear, how exactly it will influence all the relationships included in the model. Therefore, comparison of the scenarios is more important here rather than the forecasts as such.

According to the assumptions regarding the general trends of economic development in Latvia, real GDP in the base scenario is estimated to decrease by 7.3% in 2020 followed by slight slowdown by 0.1% in 2021 and afterwards it would increase by 2.0-2.4% annually (see Figure 1). Due to additional investments in transport sector, the recovery of Latvia after the COVID-19 crisis would be much faster at around 2.3-4.1%.

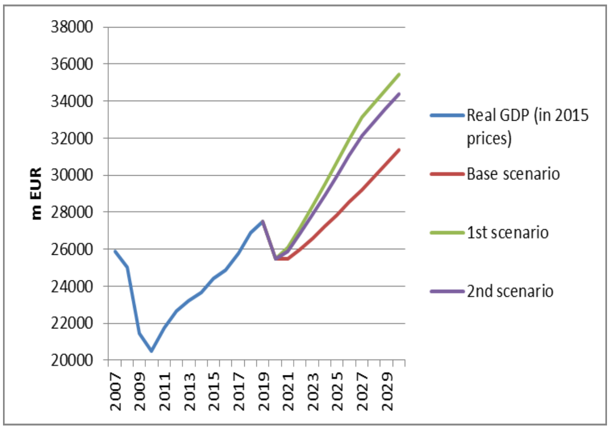

Figure 1: Real GDP of Latvia, m EUR

As it was already mentioned, transport projects included in the 1st and 2nd scenario would help to increase the productivity in transport industry. Figure 2 shows that it would help to sustain the level of productivity in transport sector against the EU-27 level, while in the base scenario the productivity in Latvia would become comparatively lower.

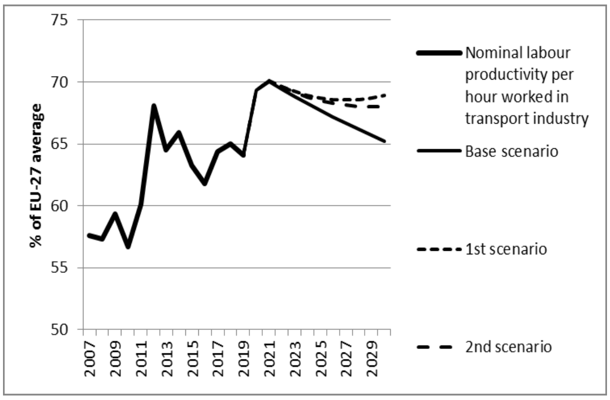

Figure 2: Nominal Labour Productivity per Hour Worked in Transport Industry in Latvia, % of the EU-27 average

In line with the assumptions made regarding the economic development, price levels and demographic situation, GDP per capita (PPP) relative to the EU-27 average would continue to increase. The increase would be even faster, if any of the additional investment packages would be implemented as it is evident from Figure 3. By year 2029 GDP per capita would reach only 75% of the average EU level, while in case of the 1st and 2nd scenario these values would be 85% and 83% respectively.

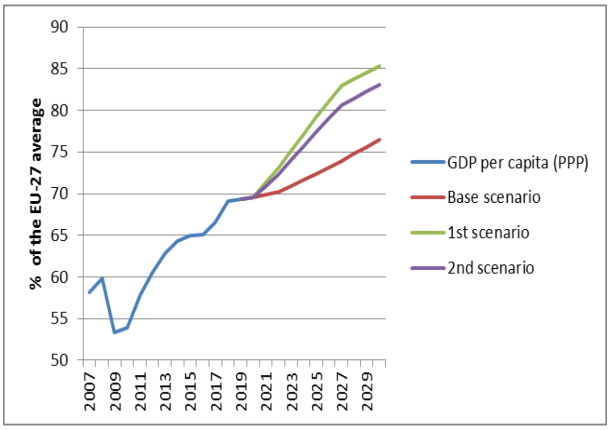

Figure 3: GDP per Capita (PPP) in Latvia, % of the EU-27 average

In case of more rapid economic development, also the number of passengers would increase, as Figure 4 shows. However, after the rapid decrease in 2020, the number of passenger would not recover, in comparison with 2019 during the next 10 years.

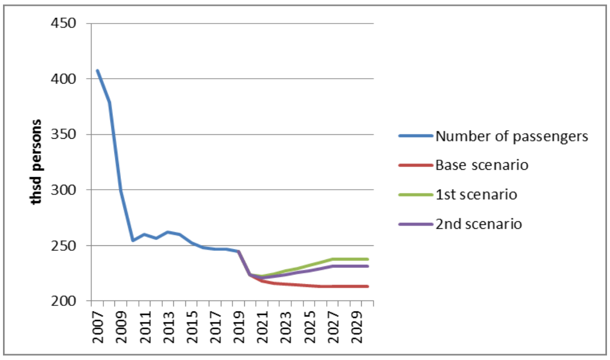

Figure 4: Number of Passengers in Public Transport in Latvia, thsd persons

Although other forecasts seem quite plausible, the forecasted passenger turnover seems a bit too optimistic (see Figure 5). Thus this aspect has to be analysed further more thoroughly also in the context of changes in people behaviour after the COVID-19 restrictions will end.

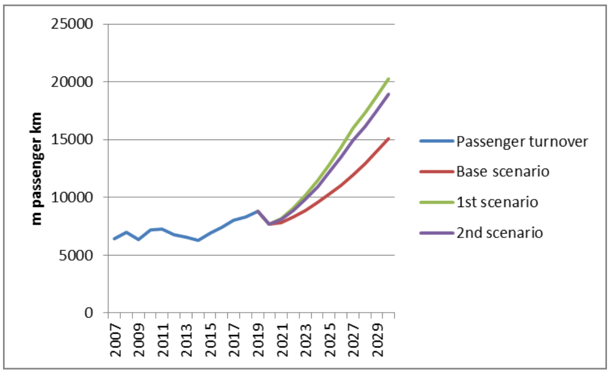

Figure 5: Passenger Turnover in Latvia, m passenger km

Future prospects of the number of registered passenger cars are similar in all the scenarios (see Figure 6). Only at the end of the forecast period the number of cars decreases in the 1st and the 2nd scenario as compared to the base scenario due to the implemented projects.

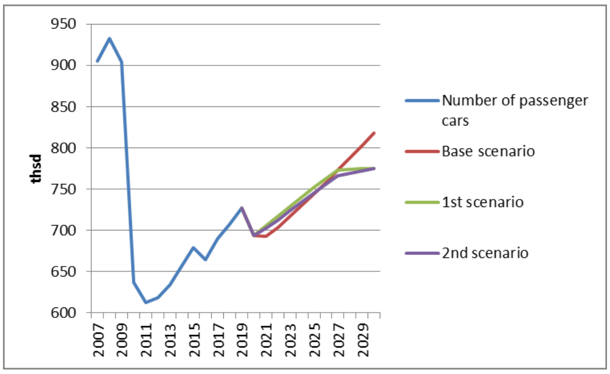

Figure 6: Number of Registered Passenger Cars, thsd.

The elaborated model has proved to be relatively easy used for policy analysis by providing additional information on the impact of transport projects on the economic development.

In case it is possible to distinguish, which regions of the country will benefit from the investment, it is possible to evaluate differences of the regional GDP and the number of population as well as other indicators available in regional detail.

Other application of the model is related to the fuel consumption. If some investment projects imply replacement of fosil fues vehicles by alternative energy vehicles, it is possible to evaluate the effects on the vehicle structure by fuel types and CO_2 emissions.

CONCLUSIONS

The main findings show that indeed transport processes are closely related to the economic and demographic development and these relations can be modelled in a relatively simple manner. However, it also implies thorough analysis during the scenario elaboration process as some of the variables included in the model can be highly sensitive to the future estimates of their values.

Future research in this field should be done both by updating and improving the equations already included in the model, but also by introducing the regional aspect to the model as transport projects are in many cases associated to the particular regions of the country and not the country in general.

In order to use the model for long-term analysis, it is necessary to use several input-output tables and analyse trends in the input-output coefficients in order to model changes in the technologies.

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