TRANSPORT SECTOR TECHNOLOGICAL SHIFTS AND INTERSECTORAL LINKAGES IN LATVIA

Astra Auzina-Emsina, Inguna Jurgelane-Kaldava, Agnese Batenko, Linda Kelle
Riga Technical University, Latvia
astra.auzina-emsina@rtu.lv, inguna.jurgelane-kaldava@rtu.lv, agnese.batenko@rtu.lv, linda.kelle@rtu.lv

Abstract. The rapid changes in the transport and logistics sector in connection with various major global events have shown the strengths and weaknesses of each country's economy. The study uses general scientific research methods (analysis, synthesis, induction and deduction). The paper is based on principles of generalization, concretization and abstraction. The input-output model together with other methods are applied to identify current and model future trends. Technological shifts in land transport (NACE H49) and warehousing and support services (H52) are examined and modelled, as well as the cross-sectoral impact and overall economic performance. The results argue that due to the replacement of technologies and external factors, land transport has increased value added per unit produced in 2010-2020. Findings justify the claim that land transport has the potential to apply more efficient technologies to increase wages and use additional profit for investments demanded by the EU Green Deal. However, the warehousing and support services have relatively lower value added per unit produced, and due to external shocks and global events, no notable improvements have been identified. Policymakers are recommended to elaborate more focused policy activities to ensure that sustainable solutions result in a competitive transport sector.

Keywords: transport sector, interdisciplinarity, economics.

Introduction

The recent studies on technological shifts in transport are more focused on search of new ecological and nature-friendly means of transport, highlighting that the leading trend is the electrification of all modes of transport and the promotion of a new consumer transport culture, which is based on an ecological mode of transportation, reducing the price and infrastructure dependence on fossil resources [1]. Hence there is little evidence on the transport industry and investigation as an inter-industry essential factor and its impact on other economic sectors in the regions. The generalisability of much published research on this issue is problematic.

An analysis of scientific literature shows the fragmentation in the research related to the technological changes in transport. The scientific literature could be divided into three directions: technological innovation such as blockchains, IoT; technological innovation as an enabler of climate change mitigation and technological change as a basis for economic growth. The study focuses on the third direction.

The historical development of digital technologies in logistics, technology and sustainable transport infrastructure is discussed by M. Acciaro, K. Renken and N. El. Khadiri [2], highlighting digital technologies such as automation, artificial intelligence and robotics as one of the key elements for the logistics industry development. Technological changes are considered as the facilitator in solving problems related to communication, high transportation costs and operational efficiency [3].

In addition, V. Brodskiy [4] research results should be pointed out, where the transport and technological system is defined as coordinated and consistent actions targeted to ensure the delivery process with minimal costs and maximum efficiency. On the contrary, technological innovation as a part of technological changes and facilitator of regional growth is discussed by various authors. E. Satrovic, A. Centidas, I. Akben and S. Damrah [5] focused on the technological innovation as the part of green investments and stimulator of economic growth. The limited number of research conducted with regard to the technological innovations and technological changes has been pointed out by M. Moughari and T. Daim [6], in their study they focus on technological innovations and technological changes between various sectors compiling changes and their impact on institutional, economic, political and technical level. Moreover, the researchers [7] discuss sustainable transport infrastructure and technological innovation policies as the facilitator for the regional growth emphasizing that transport technological changes and following regional development is a result of human ideas and knowledge.

Furthermore, studies reflect that transport technological changes impact regional development. As one of the examples could be mentioned the development of the mobility [8] through the transport technological development and changes in people habits - the idea that citizens should live in areas next to a city and are able to reach workplaces or places of entertainment through both private vehicles or public transportation. Additionally, T. Cohen and P. Jones [9] address the challenges of transport policy makers due to the rapid technological developments in the logistics field and increasing external influence. It is reflected that there are four areas of the technological development in the transport sector: mobility as a service, unmanned aerial vehicles (for example, drones), automated vehicles and telehealth. It was concluded that these technological development drivers rely on artificial intelligence or interconnectedness.

The study conducted by X. Fageda and C. Olivieri [10] defines a causal relation between transport and regional development, however, concludes that further research on the transport investment influence on regional development must be conducted. In the contrast, D. Bogart [11] focuses on the rejection of the transport developments in the framework of market integration and urbanization suggesting public and private partnership as a solution for regional transport development. Moreover, L. Yuan, M. Kleimann, H. Schmerer [12] assert that the effects from infrastructure provision on the regional development are visible in a five-year period. In addition, it should be emphasized that investments in transportation and its technological developments can improve the locational efficiency of the region and increase the amount of capital in the region shifting the economic activity to a lower productivity region or higher productivity region [13]. In contrast to the earlier findings, E. Cascetta and I. Henke [14] highlight that transport technological development has an impact on historical and economic development of regions. Those innovations include already mentioned autonomous vehicles and smart mobility services.

The aim is to identify current trends in the transport sector concerning the potential effects of technological shifts and intersectoral linkages on economic indicators.

Materials and methods

The present study employs the descriptive research design to identify and disclose the technological shifts in examined economic activities. The input-output analysis through three step analysis was adopted to gain detailed understanding of the technologies applied and the technological shifts, capturing the complexities of the gradual and non-gradual or leap technological shift phenomenon.

The data source is the Central Statistical Bureau of Latvia; symmetric product-by-product input-output tables of 2010, 2015, 2020, as published every 5 years. The latest available table is on 2020, published in late December 2023, NACE 2.rev. 2-digit disaggregation, 64*64 economic activities. The transport sector (H industry) consists of 5 economic activities: H49-H53. The main focus is on major economic elements: land transport and warehouse services; hence water transport, air transport and postal and courier service are covered only generally. The first step in this process was to analyse the final demand structure and shifts over time, then the second step is to estimate the value-added share and its changes over time, the third step is to compute direct input coefficients for analysing the technology and its shifts.

The indicators analysed (see formula (1), (2) and (3)). Total demand elements are according to national accounts system Private consumption (P31_S14_S15), Government expenditure (P3_S13), Gross capital formation (P5), Exports of goods and services (P6), Imports of goods and services (P7):

$$tu\_share_i = \frac{TD_i}{o_i}, \quad (1)$$

where tu_share_i – total use relative ratio, %;
TD_i – total demand element i, thsd. EUR;
O_i – output of activity i, thsd. EUR.

Value added per unit produced or the value-added share in the output value illustrates how high or low is value added in the activity and also the comparison over time identifies the shifts whether the

economic activity is producing services with higher value added per unit of output (value added relative ratio in% (computed like *tu_share$_i$)*) :

$$va\_share_{ij} = \frac{VA_{ij}}{o_i}, \quad (2)$$

where va_share_{ij} – coefficient of value added per unit produced;
VA_{ij} – value added of products *j* of activity *i*, thsd. EUR;
O_i – output of activity *i*, thsd. EUR.

Land transport and warehousing and support direct output coefficients a_{ij} are computed according to classic input-output equation:

$$a_{ij} = \frac{IC_{ij}}{o_i}, \quad (3)$$

where a_{ij} – direct input coefficient;
IC_{ij} – consumption of products *j* of activity *i*, thsd. EUR;
O_i – Output of activity *i*, thsd. EUR;

Land transport and warehousing and support services are two major economic activities in the transport industry (H industry), accounting for respectively – in total 91% of output and 100% of value added created in 2020. It is worth to be stressed that due to the COVID-19 pandemic and widespread travel and safety regulations and even restrictions, it resulted in negative value added in the air transport in 2020. This is a rare and specific case; it is outside the scope of this research.

Results and discussion

The transport sector economic activities regarding intersectoral linkages are diverse. In water transport services, warehousing services and postal and courier services and principally consumed by other industries, the ratio of intermediate consumption of these products to sectoral output is respectively –93%, 91% and 84% to sectoral output (see Table 1). In contrast, land transport and air transport services are mainly final demand products and exports account for 58% and 72% compared to the sectoral output.

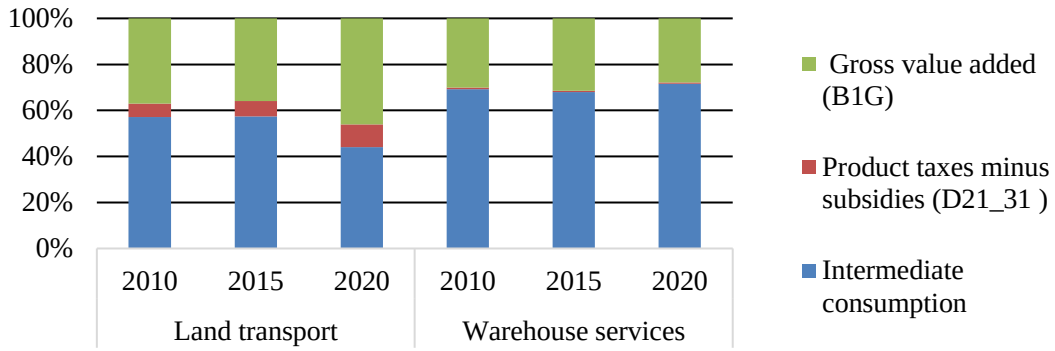
Table 1

Transport final use elements in transport (% to sectoral output) in 2020

Economic activity	Land transport	Water transport	Air transport	Warehousing services	Postal and courier services
CPA/ NACE code	H49	H50	H51	H52	H53
Private consumption (P31_S14_S15)	11%	7%	31%	1%	10%
Government expenditure (P3_S13)	10%	0%	0%	0%	0%
Gross capital formation (P5)	1%	0%	0%	0%	0%
Exports of goods and services (P6)	58%	0%	72%	13%	22%
Imports of goods and services (P7)	14%	0%	32%	4%	16%
Total final expenditure	66%	7%	70%	9%	16%
Total intermediate consumption	34%	93%	30%	91%	84%
Output (P1)	100%	100%	100%	100%	100%

Source: the authors' calculations

Land transport has gradually reduced the relative costs per unit produced on intermediate consumption (other manufactured items and services) and increased the value-added share from 37% in 2010 to 46% in 2020 (see Fig.1). In 2020, on average the value-added to output was 49.5%.



Source: the authors' calculations

Fig. 1. **Land transport and warehouse services technological shift in Latvia in 2010-2020**

However, warehousing services do not share the identified tendency as the value-added share fluctuated from 30% in 2010 to 32% in 2015 and then declined to 28% in 2020 (see Fig. 1). As warehousing services are mainly consumed by other economic activities domestically or abroad as intermediate consumption (see Table 1), then product taxes (minus subsidies) are insignificant.

Results of detailed intermediate consumption analysis of land transport claim that there are significantly more motor vehicles, trailers (C29) and construction services (F) in 2020 compared to 2010 (Table 2), however, land transport demands relatively less warehouse services (H52), rental and leasing services (N77) (see Table 2).

Table 2

Major intermediate consumption technological shift in land transport in 2010-2020

Category	2010	2015	2020	Change in 2020	
				compared to 2010	*compared to 2010, %*
C19 Coke and refined petroleum products	0.105	0.124	0.098	*-0.007*	*-7%*
H49 Land transport services	0.074	0.085	0.060	*-0.013*	*-18%*
H52 Warehousing and support services	0.205	0.090	0.045	*-0.159*	*-78%*
C29 Motor vehicles, trailers and semi-trailers	0.003	0.011	0.043	*0.040*	*1231%*
G46 Wholesale trade services	0.029	0.030	0.030	*0.001*	*2%*
G45 Wholesale and retail trade and repair services of motor vehicles	0.017	0.025	0.027	*0.009*	*54%*
N77 Rental and leasing services	0.036	0.043	0.026	*-0.010*	*-28%*
F Construction	0.001	0.047	0.021	*0.020*	*1986%*
G47 Retail trade services	0.003	0.008	0.011	*0.008*	*229%*
D35 Electricity, gas	0.006	0.010	0.010	*0.004*	*60%*

Source: the authors' calculations

The shares of costs spent on motor vehicles, trailers, and semi-trailers (C29) and also construction (F) products in land transport have notably increased. However, the coefficients were very low (below 0.01) in 2010, and even minor increases have resulted in large relative growth in 2020 compared to 2010.

Findings justify the claim that land transport has the potential to apply more efficient technologies to increase wages and use additional profit for investments in greener and low or zero-emission technologies demanded by the EU Green Deal. However, the warehousing and support services have relatively lower value added per unit produced, and due to external shocks and global events, no notable advancements have been identified. Further company-level data collection is recommended to determine factors that facilitate and inhibit technological change as the input-output data is published in a delay due to its complexity and resource intensity. Further modelling work will have to be conducted (as

concerning other major shocks [15]) in order to evaluate different development patterns and potential consequences to other industries, taking into account the on-going growing importance of data security in supply-chains [16], technological shifts and intersectoral linkages.

Conclusions

1. Land transport cost structure representing the technologies applied has notably changed in the past 10 years (2020 vs 2010). Land transport is consuming significantly fewer warehouse services (from 0.21 in 2010 to 0.05 in 2020). The input-output approach is valuable in identifying and analysing technological shifts, taking into account intersectoral linkages.
2. Warehouse services are mainly consumed by domestic companies for intermediate consumption. Any changes in technologies applied to other economic activities that demand warehouse services notably affect the warehouse services both in a positive and negative manner.
3. Based on the assessment of the theoretical literature and the main results of the applied input-output method, the identified technical shifts claim that the changes are expected to continue due to the introduction of digital solutions as drones and autonomous vehicles and following digital transformation of logistics processes as warehousing and land transport services.
4. Policymakers are recommended to elaborate more focused policy activities such as investment in technological innovations as well as infrastructure development to ensure that sustainable solutions result in a competitive transport sector corresponding to the requirements mentioned in the EU Green Deal.

Author contributions

Conceptualization, A.A-E.; methodology, A.A-E; validation, A.A-E; formal analysis, A.A-E, A.B., I.J.-K.a nd L.K.; investigation, A.A-E., L.K.; data curation, A.A-E, A.B., I.J.-K.a nd L.K.; writing – original draft preparation, A.A-E., A.B.; writing – review and editing, A.A-E., A.B., I.J.-K. and L.K.; visualization, A.A-E.; All authors have read and agreed to the published version of the manuscript.

References

[1] Zara A. World Automobile Industry in the Conditions of Transport Electrification: Concept Development and a New Production Center Formation. Економічний вісник НТУУ "Київський політехнічний інститут" No 24, 2022. (In Ukrainian). DOI: 10.20535/2307-5651.24.2022.274814
[2] Acciaro M., Renken K., El Khadiri N. Technological Change and Logistics Development in European Ports. European Port Cities in Transition. Cham: Springer, Cam, 2020, 345 p.
[3] Lagorio A., Zenezini G., Mangano G., Pinto R. A systematic literature review of innovative technologies adopted in logistics management. International Journal of Logistics Research and Applications, vol. 25, 2022, pp. 1043-1066.
[4] Brodskiy V. Improving transport and technological process to supply material resources for house construction. Transportation Research Procedia, vol. 63, 2022, pp. 639-647.
[5] Satrovic E., Centidas A., Akben I., Damrah S. Do natural resource dependence, economic growth and transport energy consumption accelerate ecological footprint in the most innovative countries? The moderating role of technological innovation. Gondwana Research, vol. 127, 2023, pp. 116-130.
[6] Moughari M. M., Daim T. U. Developing a model of technological innovation for export development in developing countries. Technology in Society, vol. 75, 2023, pp. 2-11.
[7] Acheampong A. O., Dzator J., Dzator M., Salim R. Unveiling the effect of transport infrastructure and technological innovation on economic growth, energy consumption and CO2 emissions. Technological Forecasting and Social Change, vol. 182, 2022, pp. 2-24.
[8] Lopatnikov D. Smart urban mobility from expert stakeholders' narratives. Proceedings of 2nd International Conference "Smart Cities, Smart-CT 2017", June 14-16, Malaga, Spain, pp. 137-141.
[9] Cohen T., Jones P. Technological advances relevant to transport – understanding what drives them. Transportation Research Part A: Policy and Practice, vol. 135, 2020, pp. 80-95.
[10] Fageda X., Olivieri C. Infrastructure Transport Investments, Economic Growth and Regional Convergence. International Encyclopedia of Transportation, vol. 5, 2021, pp. 2-5.

[11] Bogart D., Haupert M. Clio on Speed: A Survey of Economic History Research on Transport. Handbook of cliometrics. Second edition. Springer, 2019. 1768 p.
[12] Yuan L., Kleimann M., Schmerer H. Estimating causal effects of BRI infrastructure projects based on the synthetic control method. Asia Europe Journal, vol. 19, 2021, pp. 103-129.
[13] Larid J., Johnson D. The GDP Effects of Transport Investments: The Macroeconomic Approach. International Encyclopedia of Transportation, vol. 1, 2021, pp. 256-262.
[14] Cascetta E., Henke I. The seventh transport revolution and the new challenges for sustainable mobility. Journal of Urban Mobility, vol. 4, 2023, pp. 2-20.
[15] Auziņa-Emsiņa A., Ozoliņa V. Transportation, logistics and regional development in COVID-19 era: Modelling sectoral shocks caused by policy and safety measures. Research for Rural Development, vol. 36, 2021, pp.144-151.
[16] Jurgelāne-Kaldava I., Batenko A. Assessment of Data Security Implementation in the Supply Chain Enterprises in Latvia. WSB Journal of Business and Finance, vol. 57 (1), 2023, pp. 21-27