

STATISTICAL DEVELOPMENT OF TRANSPORT WHICH REFLECTS THE NEED FOR CATALYSTS

Peter Kačmár

Technical University of Košice, Faculty BERG, Park Komenského 14, 04001 Košice, Slovakia, EU,
peter.kacmary@tuke.sk

Martin Straka

Technical University of Košice, Faculty BERG, Park Komenského 14, 04001 Košice, Slovakia, EU,
martin.straka@tuke.sk (corresponding author)

Keywords: freight transport, transport forecast, PGMs, catalyst, resources

Abstract: This paper deals with the analysis and expected development of freight transport and especially road freight transport in Slovakia and in the European Union. Transport, which ensures the movement of goods, animals and people in all countries around the world, has a significant influence on the development of the national economy. However, this development of transport has a negative impact on the global ecological situation, and therefore devices, that eliminate this impact, are still developing at the same time. These devices include catalytic converters (catalysts) for exhaust systems fitted to all modern propulsion systems of road, rail and water vehicles that use burning petrol or diesel. Based on the development of transport, the need for catalysts is derived, which still use elements of the PGMs (Platinum Group Metals). The result of the article is an analysis and expected predicted development of freight transport and road freight transport in both cases - in Slovakia and in the EU, which will affect the future demand for PGMs.

1 Introduction

Transport is characterised among the oldest and most important human activities, which is extremely important for the development of society. Freight transport is an important factor in the economy as a part of material production and logistics. By providing a link among the areas of production, circulation and consumption, it unites geographically separate areas of production and consumption. In the field of freight transport, in terms of transport demands, the mutual relationship of the individual components of the production chain can be considered: a source of raw materials - a source of necessary energy - a manufacturing company - a market, is essential in the production process. Transport is an integral part of almost every technological process. The technical level of transport should correspond to the technical level of other machinery and equipment so that a situation of slowing down the technological process does not arise. Transport processes can clearly and directly affect the performance and economic results of the manufacturing process in a production organization [1].

There are different types of used means of transport [2]:

- Road and urban public transport.
- Railway.
- Air.
- Water.
- Combined.

The road transport, together with the rail transport, forms the basis of the transport system in the EU as well as in Slovakia. Just the road freight transport is targeted by this paper, because it plays an important role in the

development, production of catalysts for HDV (Heavy-Duty Vehicles) and consumption of PGMs (Platinum Group Metals) [2].

The road freight transport transports the most goods in tonnes and achieves the highest degree of transport performance in tonne-kilometres. It allows the widest market coverage, its flexibility is influenced by the density of the road network. Due to its versatility, it best meets customer requirements. The road transport is irreplaceable in flexibility, efficiency and time savings. It is the most often used to transport building materials, parcels, cereals, animals, solid fuels and other shipments. It is one of the most important transport modes within the logistics [3].

The railway transport is the second important mode of transport and it is suitable medium and long distances, especially for bulk and extensive deliveries in complete trains. The most frequently transported goods are fuels, ore, wood, building materials and other types of goods that do not matter the speed of transport. Rail transport must be combined with other modes of transport, mostly with the road transport. Among the disadvantages of railway transport, it is included a high demand for investment funds in the transport route, security equipment, locomotives, wagons, loading stations, etc. [4].

2 Methodology

The aim is to achieve a hypothesis about the future situation of transport development, which is based and focused on methods associated with forecasting. It can be said with certainty that forecasting is a regular examination of the future and the formulation of scientific claims about possible versions of future developments. In practice,

STATISTICAL DEVELOPMENT OF TRANSPORT WHICH REFLECTS THE NEED FOR CATALYSTS

Peter Kačmár; Martin Straka

forecasting becomes a part of the management and planning process. New knowledge is gained about future facts and processes by the forecasting. It facilitates communication among the representatives from different fields, such as e.g. administration, science, civic movement and governance through an illustrative form for a user. It also includes the promotion of results in prognostic practice [5].

2.1 Transport forecasting

The basis of the transport forecasting is the specification of requirements for the transport infrastructure and the entire transport system. It is the most complex part of the transport forecasting process and must cover all aspects of development, all traffic modes and the possibilities of multimodality and intermodality. Traffic forecasts are divided into four groups according to time horizons:

- Short-term up to 5 years.
- Middle-term from 5 to 10 years.
- Long-term from 10 to 25 years.
- Extra long-term forecasts over 25 years, normally up to 30 years in accordance with the provisions of STN standardisation.

Sophisticated mathematical procedures are used for transport forecasts, but the personality of the prognosticator and his experience plays important roles in their quality. In terms of accuracy, forecasts over 10 years are very strongly dependent on the amount and quality of input data and also on the stability of the economic situation. Forecasts over 25 years can be considered as indicative [6,7].

2.2 Methods of forecasting

Regression analysis: Regression analysis examines the relationship between two or more random variables. It most often examines the dependence between two quantities, when X is called an independent variable and Y is a dependent variable. This dependency (1) can be write as:

$$y = \varphi(x), \quad (1)$$

where $\varphi(x)$ indicates a function that describes a given dependency.

In most cases, this function cannot be expressed by any description, so a function is sought that best describes the dependency. If this dependence is found, then it is possible to estimate the value of the dependent quantity Y by any independent quantity X .

The dependence between the quantities is influenced by various random influences, which are called noise. In some cases, the magnitude of the noise may be large, and in other examples it may be very small. The mean noise value is assumed to be zero [7,8].

Exponential smoothing: Exponential smoothing (2) is a method of intuitive prediction that weighs the observed time series unevenly. Recent observations have higher weight than older ones. Uneven weighing is performed using one or more parameters that determine the severity of each observation.

$$F_{N+1} = \alpha Y_N + (1 - \alpha)F_N \quad (2)$$

Exponential smoothing models are widely used methods in time series analysis. This popularity can be attributed to their simplicity, computational efficiency, accuracy, and ability to adapt to changes in the prediction process. In general, exponential smoothing is a simple technique that gives a good forecast in a wide range of applications. In addition, the requirements for data storage and computing are minimal [8].

Holt method: Holt linear exponential smoothing is a modification of simple exponential smoothing in which two smoothing constants are used:

- To create the level of a given series of smoothing constants (α);
- For the direction compensation constant (β).

Due to the different trends in individual data, simple exponential smoothing is able to process some interesting and important non-stationary processes in these trends. E. S. Gardier explains as C. C. Holt, whose model also includes trends in time series. The final formula (3) for the prediction contains the mean coefficient and the trend coefficient together with the functional error (ε):

$$F_{N+p} = L_N + pT_N + \varepsilon \quad (3)$$

This formula consists of two sub-equations for smoothing of two parameters of the equation, namely the mean (level) coefficient L_t (4) and the trend coefficient T_t (5). The current equation for the middle level of the equation is a version of simple exponential smoothing. As the trend coefficient has been added to the previous interruption for component formulation, it will get an exponential decrease in the impact of the current observation. The process has been extended one step backwards along the timeline [8].

Mean (level) coefficient:

$$L_N = \alpha \cdot Y_N + (1 - \alpha)(L_{N-1} + T_{N-1}) \quad (4)$$

Trend coefficient:

$$T_N = \beta(L_N - L_{N-1}) + (1 - \beta)T_{N-1} \quad (5)$$

3 Results

In the following section, this paper provides an analysis of the development of transport, which is focused on road transport, because this type of transport has the significant

STATISTICAL DEVELOPMENT OF TRANSPORT WHICH REFLECTS THE NEED FOR CATALYSTS

Peter Kačmár; Martin Straka

impact on the production of catalysts and the consumption of PGMs, as the basic natural resources.

The development of road transport is reflected by amount of transported goods. In this way, the data that forms the time series are recorded. In the first case, the forecast is devoted to developments in Slovakia and in the second case is the forecast of developments in the European Union. Due to the comparison of individual results for Slovakia and EU, the main indicator of traffic intensity is the selected traffic performance in units of tkm (tonne-kilometres).

3.1 Development of the road transport in Slovakia

In Slovakia, as well as in other EU countries but also in all countries around the world, the road freight transport forms the main freight transport. Although many activities are being taken to reduce road freight transport and subsequently shift it to another mode of transport, the constant increase in demand for the transport of goods does not reduce this trend much in reality. The subsequent overview of the development of transport and the forecast in Slovakia is the proof of this fact - Table 1 and Figure 1. The forecast is made for the next 5 years and to increase objectivity, the forecast is made by two traditional methods and their results are combined as follows: 50% Holt + 50% Linear regression.

Table 1 Development of transport in Slovakia

Source: <https://slovak.statistics.sk>

Year	Total freight transport	Road freight transport	Forecasts		
	millions tkm	millions tkm	Holt millions tkm	Regression millions tkm	Combination millions tkm
2009	35678	27484			
2010	37682	27411			
2011	38029	29045			
2012	38173	29504			
2013	39245	30005			
2014	40849	31304			
2015	42745	33525			
2016	46075	36106			
2017	44724	35362			
2018	44873	35590			
2019	43318	33888			
2020			34995	37225	36110
2021			34805	38137	36471
2022			34615	39050	36833
2023			34425	39963	37194
2024			34235	40876	37555

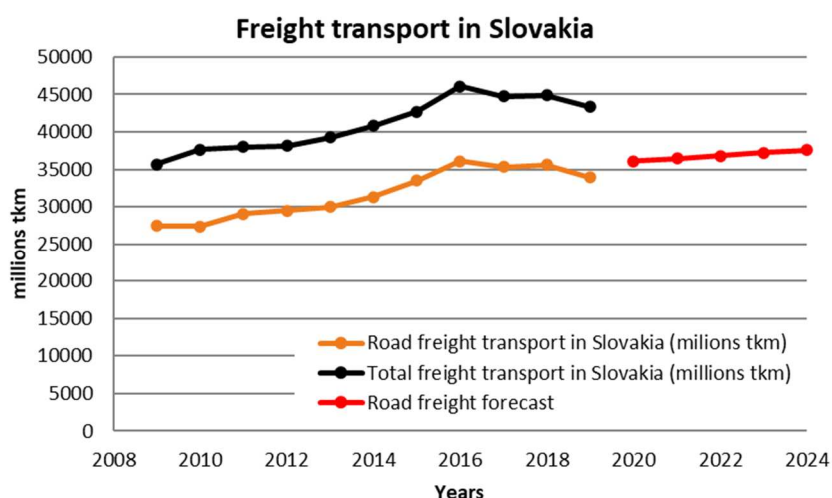


Figure 1 Graphic overview of the development of transport in Slovakia

STATISTICAL DEVELOPMENT OF TRANSPORT WHICH REFLECTS THE NEED FOR CATALYSTS

Peter Kačmár; Martin Straka

3.2 Development of the road transport in EU

The development of the freight transport in the EU is similar as in Slovakia. The subsequent overview of the development of transport and the forecast in Slovakia is the

proof of this - Table 2 and Figure 2. And again the forecast is made for the next 5 years and to increase objectivity, the forecast is made by two traditional methods and their results are combined as follows: 50% Holt + 50% Linear regression.

Table 2 Development of transport in the EU

Source: European Commission (2019). EU transport figures. Statistical pocketbook 2019, Luxembourg: Publications Office of the European Union

Year	Total freight transport	Road freight transport	Forecasts		
	billions tkm	billions tkm	Holt	Regression	Combination
	billions tkm	billions tkm	billions tkm	billions tkm	billions tkm
2009	3292	1607,3			
2010	3462	1709,9			
2011	3488	1699,1			
2012	3394	1645,3			
2013	3434	1670,8			
2014	3480	1677,0			
2015	3504	1713,7			
2016	3661	1803,5			
2017	3745	1848,6			
2018	3883	1798,7			
2019	3953	1816,6			
2020			1848,2	1846,9	1847,6
2021			1862,3	1867,0	1864,7
2022			1876,4	1887,1	1881,7
2023			1890,4	1907,2	1898,8
2024			1904,5	1927,3	1915,9

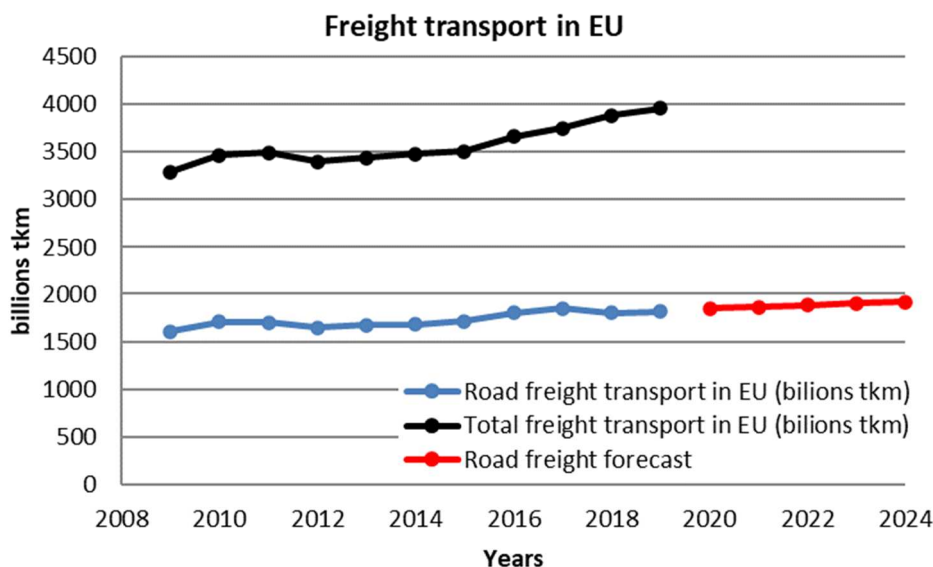


Figure 2 Graphic overview of the development of transport in the EU

4 Conclusion

Forecasts in both cases show a positive trend in the development of transport not only in Slovakia but also the EU. The forecasts do not include the current impact of the pandemic situation caused by COVID-19, which was spread out worldwide in 2020. It is expected that the

declination in traffic and thus its performance will fall by about 6%. This declination is caused mainly by the shutdown of industry and thus the economies in the first wave of the pandemic crisis. In the second and in some other waves, this declination is minimal, because although lockdowns have been introduced again in many countries, the industries have not been shut down and the main

STATISTICAL DEVELOPMENT OF TRANSPORT WHICH REFLECTS THE NEED FOR CATALYSTS

Peter Kačmáry; Martin Straka

engines of the economies have not been greatly weakened. In any case, even after the end of this COVID-19 crisis, the demand for freight and thus also road transport is expected to increase even more. This directly means an increase in demand for minerals, especially PGM's for the production of catalysts. Therefore, current research in the world is focused not only on the recycling of these PGM elements but also on the development of technologies that could replace these elements in the future in order to minimize costs and environmental impacts.

Acknowledgement

The submitted paper is a part of EIT RM KAVA 18344 – INNOCAT project “Innovative CRM substitutions technology for public authorities’ vehicle catalysts.”

References

- [1] ONDERIŠINOVÁ, A.: *Porovnanie a predpokladaný vývoj vybraných ukazovateľov priemyslu a ich dopady na dopravnú logistiku na Slovensku*, Diploma thesis, Technical University of Košice, Košice, 2020. (Original in Slovak)
- [2] SHIGAPOV, A., DUBKOV, A., UKROPEC, R., CARBERRY, B., GRAHAM, G., CHUN, W., McCABE, R.: Development of PGM-free catalysts for automotive applications, *Kinetics and Catalysis*, Vol. 49, No. 5, pp. 756-764, 2008. doi:10.1134/S0023158408050224
- [3] SCHULTE, Ch.: *Logistika*, Victoria Publishing, Praha, 1994. (Original in Slovak)
- [4] SIXTA, J., MAČÁT, V.: *Logistika – teorie a praxe*, 1st ed., CPBooks, Brno, 2005. (Original in Czech)
- [5] CHAJDIK, J., KOMRNÍKOVÁ, M., IŠTVÁNIKOVÁ, A.: *Metódy prognózovania*, Stais, Bratislava, 1998. (Original in Slovak)
- [6] CHAJDIK, J., MEDVEĎOVÁ, E.: *Prognózovanie časových radov*, Stais Bratislava, 1995. (Original in Slovak)
- [7] BUŘITA, L.: Prognostické metody a jejich využití v resortu obrany, *Obrana a strategie*. Vol. 3, No. 1, pp. 47-60, 2003. (Original in Czech)
- [8] KAČMÁRY, P., MALINDŽÁK, D.: *The Forecast Methods of Sale and Production in Dynamically Changing Market Economy*, VŠB Ostrava, Ostrava, 2013.

Review process

Single-blind peer review process.