# Analysis of road freight transport in the Czech Republic

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## Abstract

Road transport in the Czech Republic is an important part of the economy. Transport performance is closely related to the development of GDP. The operation of road freight transport is connected with the commitment of the EU and the Czech government to reduce emissions. The share of road transport should be reduced by 30 % by 2030 and allow for a modal shift. Due to significant energy efficiency, the goals in this area are focused on a sustainable transport system. In the Czech Republic, especially with regard to its geographical location, it is a shift to rail transport. The aim of the paper is to analyse the course of reducing the share of road transport in the Czech Republic. Whether this goal is met is analysed using correlation and regression analysis. The obtained models for the export and import of goods explain the study and show a gradual decrease in the share of road transport.

## Keywords

Road freight transport, intermodal transport, sustainability, emission allowances, correlation analysis

## Clasification JEL

R42

## Introduction

Road freight transport is still the most profitable mode of transport. The efficiency of this transport is an integral part of the modern economy. This is mainly transported over short distances. It serves as a form of transport of goods from the place of departure to the place designated. A big trend is its functional connection to other multi-capacity modes of transport, the so-called Intermodal or Combined Transport. A number of studies have dealt with optimization in a combined form. For example, Arnold (2004) or Baykasoğlu and Subulan (2016).

One of the EU's climate and energy frameworks contains a target to reduce greenhouse gas emissions by at least 40 % by 2030. All sectors must be involved in this goal. According to Regulation (2018) of the European Parliament and of the Council, emissions from heavy

vehicles represent 6 % of total EU emissions. At present, these emissions are not regulated within the EU. The Czech Republic has committed itself to a 30 % reduction in the share of road freight transport. The aim of the paper is to find out whether this obligation is being fulfilled.

According to one of the studies (First, 2014), the energy intensity of individual types of transport with regard to the environment is understood as a fundamental factor. Motor vehicles emit emissions into the air that are undesirable. More than 1000 components of pollutants emitted by the engine are specified, but we only legislatively monitor and limit a few.

Each operator of fixed assets that produce $CO_2$ emissions will receive a certain amount of allowances according to the National Allocation Plan, which is always processed for one allocation period. Allowances can be bought, sold or transferred to other people. From an international point of view, there is no uniform legislation in the field of accounting or taxation (Hanková, 2009). Road transport has still not been included in the EU ETS and the issue of regulation of its emissions is addressed in other forms - pressure on engine modifications and their management (act. EURO6 standard, planned EURO7), construction of low-emission zones, bypasses, etc.

The current expansion in the field of freight transport brings with it innumerable problems. These include the increase in vehicle numbers, energy consumption, air pollution, noise pollution, traffic congestion, etc., as stated (Sabyasachi, et al., 2018) in his study. Regulation of emission allowance prices is one of the ways to accelerate the intention to reduce the consumption of fossil fuels.

The Czech economy is significantly dependent on the consumption of fossil fuels. However, the burning of fossil fuels also leads to emissions of greenhouse gases and pollutants, which contribute to climate change or worsen human health. Apart from brown coal, fossil fuels are not predominantly of domestic origin, implying the economy's dependence on imports, as reported in the study (Řečka, et al., 2016).

The transition from today's use of fossil fuels to renewable energy sources is a frequently discussed issue. This need depends not only on issues of improving the environment but also on the position of the state. We are currently one of many countries dependent on oil supplies. Due to the global effort to increase the use of renewable resources and break away from dependence on the global power of oil-exporting countries, it is possible in the future to establish relations with other countries that will have a similar environmental policy. It can also be predicted with certainty that states that are already trying to transform the use of fossil fuels to a large extent today will have a great advantage in the form of decentralized power.

Renewable resources are available to varying degrees in most countries. Renewable energy can thus be easily produced and consumed in a decentralized manner.

The negative effect of CO2 emissions is a frequently discussed issue around the world. Many countries, including the European Union, are trying to legislate on the number of emissions into the air. A significant improvement is a fact that countries with large population expansion and developed industries, such as India or China, are increasingly addressing this issue.

However, legislative support for reducing emissions also has a downside. Industrial companies, which are not enough to adjust their operation to a "cleaner" variant, will not have enough emission allowances for their operation, which will reduce production or, in the worst case, the demise of companies. This will affect the export of products and the value of GDP. So, we can only hope that the performance of the state's economy will not decrease.

# 1     Metodology

## 1.1   Regression analysis

The regression analysis establishes the relationship between a so-called dependent variable, which is also called regressand and is referred to as *Y* and several others called independent variables, or regressors, which are referred to as *X*. The relationship between these variables is called the regression function. "The aim of the regression analysis is to bring the empirical regression function as close as possible to the hypothetical regression function." If the course of dependence is found to be 'relatively best', then the strength of dependence, or the closeness of dependence, is subsequently determined, as Hendl (2012) suggests.

The simplest type of regression function is linear regression. In this post, taking into account data fluctuations, the function loses in linearity and best suits polynomial flow in the form (1):

$$y_i = \beta_0 \cdot x_i^2 + \beta_1 \cdot x_i + \varepsilon_i \qquad (1)$$

Where:

$\beta_0$ ... absolute member

$\beta_1$ ... slope of the regression line

$\varepsilon_i$ ... random folder

The determination of the value of the coefficient of determination is also part of the analysis. This value describes what proportion of the total variability in the variable dependent was explained by the selected model that captures the issue with its function. So, it shows how successful the regression analysis was. The coefficient is $R^2$ and calculate it using the relationship (2) according to Hendl (2012):

$$R^2 = \frac{\sum(\hat{y}_i - \bar{y})^2}{\sum(y_i - \bar{y})^2} \qquad (2)$$

## 1.2 Correlation analysis

Correlation analysis looks at interdependencies (mostly linear) where the emphasis is placed primarily on the intensity (strength) of the relationship rather than on examining quantities in the direction of cause-effect. When establishing functional dependency, Bluman (2017) work with random selection $(X_1, Y_1), (X_2, Y_2), \ldots, (X_n, Y_n)$ from some two-dimensional distribution.

The strength of linear dependency between two variables can be quantified by Bluman (2017) using the Pearson correlation coefficient (3):

$$r_{yx} = r_{xy} = \frac{n\sum_{i=1}^{n} x_i y_i - \sum_{i=1}^{n} x_i \sum_{i=1}^{n} y_i}{\sqrt{n\sum_{i=1}^{n} x_i^2 - \left(\sum_{i=1}^{n} x_i\right)^2}\sqrt{n\sum_{i=1}^{n} y_i^2 - \left(\sum_{i=1}^{n} y_i\right)^2}} \qquad (3)$$

$x_i, yi$ … are the actual values of different statistical characteristics (random variables $X$ and $Y$) expressing sampling variances.

This coefficient $r$ obtains values from an interval of -1 to 1. Negative values mean indirect linear relationship, positive values mean direct linear relationship, and 0 means linear independence.

## 1.3 Spearman´s rank correlation coefficient

If we have several of the same values, then we assign them an average order. Obviously, if $Y_i$ grows as $X_i$ grows, then the same relationship will apply to their ranking. If $Y_i$ tends to decrease when $X_i$ decreases, then the same relationship will apply to their ranking. Let $R_1, R_2, \ldots, R_n$ denote the rank $X_1, X_2, \ldots, X_n$ and $Q_1, Q_2, \ldots Q_n$ denote the rank $Y_1, Y_2, \ldots, Y_n$. If the variables $X$ and $Y$ are independent, then their order values will also be randomly tossed Bluman (2017). Spearman's correlation coefficient $r_S$ is defined by the relationship (4):

$$r_S = 1 - \frac{6}{n(n^2-1)} \sum_{i=1}^{n}(R_i - Q_i)^2 \qquad (4)$$

The Spearman´s rank coefficient also takes its values from the interval $\langle -1;1\rangle$. In the case of identical rank, the value of the Spearman's rank correlation coefficient is 1. In the case of the opposite rank, its value is -1. In the case of the independence of both variables X and Y, its value is 0.

## 2    Results and discussion

The majority of road freight transport is made up of domestic freight transport. Approximately one-tenth of the transported goods remain for international transport.

Data from the Czech Statistical Office (CSO) in the period 2010 to 2018 were used for statistical analysis, shown in Table 1. According to calculations, exports and imports in road transport are statistically dependent.

**Table no. 1: Goods Transport flows from and into the Czech Republic – Road Transport (thous. tonnes)**

| Year | Export | Import | Net exports |
|------|--------|--------|-------------|
| 2010 | 21019  | 18705  | 2314        |
| 2011 | 23083  | 19802  | 3281        |
| 2012 | 22116  | 18436  | 3680        |
| 2013 | 25030  | 20028  | 5002        |
| 2014 | 26132  | 19923  | 6209        |
| 2015 | 27116  | 22282  | 4834        |
| 2016 | 23151  | 17218  | 5933        |
| 2017 | 20601  | 14282  | 6319        |
| 2018 | 17077  | 12561  | 4516        |

Source: Custom processing based on data CSO (2020).

From the outcome of the correlation analysis, see Table 2, it is possible to determine net exports from a macroeconomic perspective. Exports and imports in road transport are interdependent. The assumption is that the higher the export, the higher the import. In road transport, exports predominate. A positive value of net exports increases the economic performance of the state.

**Table no. 2: Correlation Analysis in Road Transport**

|        | Export  | Import |
|--------|---------|--------|
| Export | 1       |        |
| Import | 0,89811 | 1      |

Source: Custom processing based.

Based on the index of determinations, it suits the polynomial course in both cases, see Figure 1 and 2. For illustration, the equation of the regression line and the index of determination is inserted into the graphs.

**Figure no. 1: (a) Goods Transport flows into the Czech Republic – Road Transport (thous. tonnes)**



$y = -312,69x^2 + 2438,3x + 15848$
$R^2 = 0,7922$
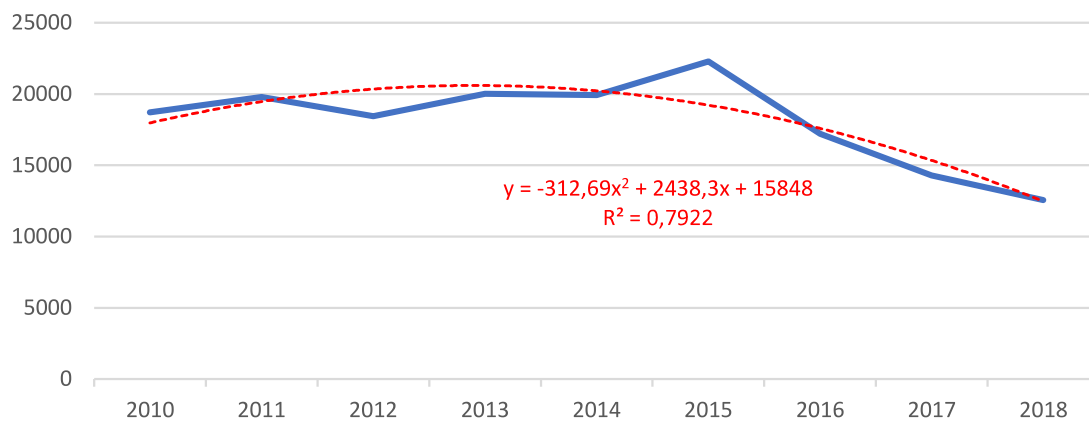
Source: Custom processing based on data CSO (2020).

As can be seen from both figures, in 2015 there was a significant increase, compared to 2014 by up to 11,7 %. A similar development can also be observed in transport performance.

**Figure no. 2: Goods Transport flows from the Czech Republic – Road Transport (thous. tonnes)**



$y = -431,58x^2 + 3998,2x + 16490$
$R^2 = 0,8331$
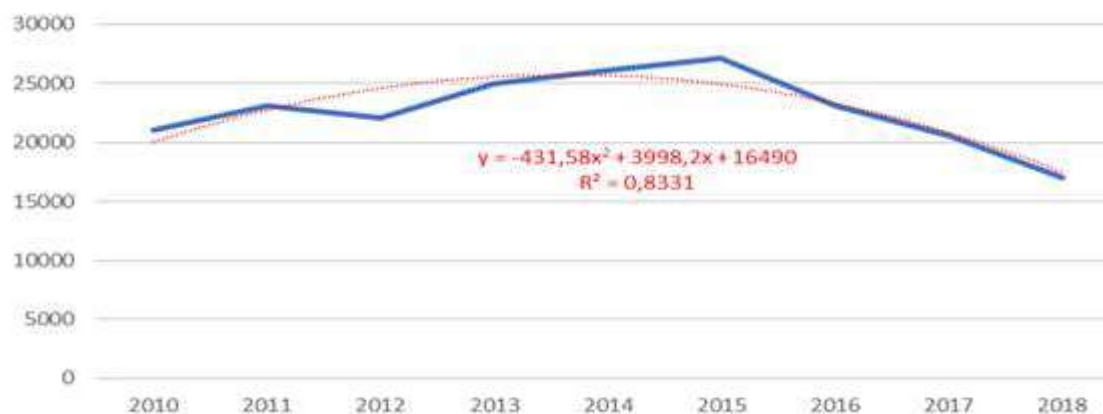
Source: Custom processing based on data CSO (2020).

Both models show unsystematic components (residues, chaos) of 20,78 % and 16,69 %. These are mainly due to a large increase in 2015.

To support the trend and indicate a decrease in the volume of transported goods, it is also appropriate to mention the proportional change in other modes of transport. In the case of the

Czech Republic, with regard to its geographical location, rail transport is offered in particular. Data from the Czech Statistical Office (CSO) in the period 2010 to 2018 were used for statistical analysis. Based on the index of determinations, it suits the polynomial course in both cases. For illustration, the equation of the regression line and the index of determination is inserted into the graphs. Rail freight fell sharply between 1998 and 2012. Figure 3 below shows rail imports (a) and exports (b) from 2010 to 2018.

**Figure no. 3. (a) Goods Transport flows into the Czech Republic – Rail Transport (thous. tonnes); (b) Goods Transport flows from the Czech Republic – Rail Transport (thous. tonnes)**
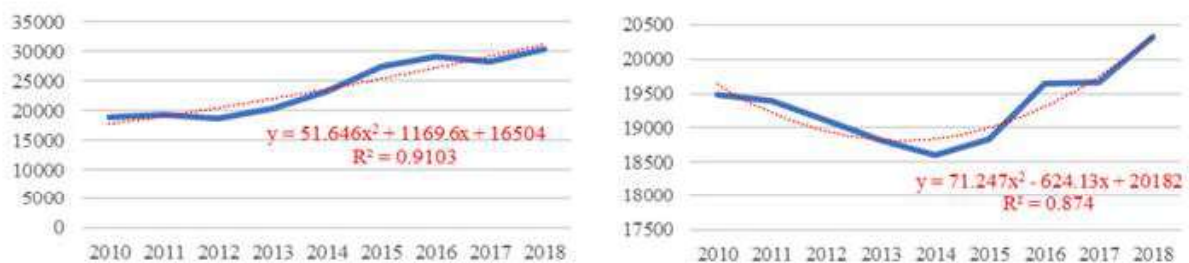


Source: Papoušková (2020).

International transport accounted for more than half of both freight transported and transport performance. Its decrease was more moderate in the two indicators observed compared to national rail freight. National transport performance (in tkm) decreased by 28.8 % according to CSO (2020), international transport by 19.8 %. Under international rail freight, exports fall more than imports. The decline in both exports and imports in 2012 was more pronounced in the evaluation of the transport performance indicator (in tkm) than in the evaluation of the sheer weight of goods transported. Since 2014, we can talk about increasing the volume of goods transported by rail. From an economic point of view, the key parameter is export (Papoušková, 2020).

## Conclusion

Road transport in the Czech Republic is an integral part of the economy. Transport performance is closely related to the development of GDP. The former orientation of the Czech economy towards the extraction of raw materials and industry gradually changed to a market economy with a high share of international trade. These changes meant a decline in rail transport. In connection with this change, the transport performance of road freight transport grew very

rapidly. This development has resulted in a sharp increase in the number of lorries and the associated deterioration of roads and motorways, an increase in accidents and, as a result of noise and emissions, a deterioration in the environment.

Due to significant energy efficiency, the goals in this area are focused on a sustainable transport system. By the year 2030, 30 % of road freight transport should be shifted to rail or waterborne transport. Due to the geographical location of the Czech Republic, this is a change mainly to rail transport. Should this target be changed, this represents an increase of almost 70% in rail freight. However, this goal cannot be achieved without effective technologies. For transports of smaller volumes, a move to multimodal transport is envisaged.

Rail transport has a number of advantages. The most important are low external costs, high transport capability especially over long distances, high transport speeds and environmental friendliness compared to road transport. It is an integral part of a well-functioning intermodal transport system. In terms of sustainability, rail transport is a desirable product (Papoušková, 2020).

The condition for involvement in multimodal transport is the support and popularization of combined transport between carriers. Combined transport must be supported by legislation. Last but not least, it is necessary to define the neutrality of combined transport terminals. The deteriorating environment is gradually affecting all macroeconomic identities. It is therefore a priority to focus on improving it. The cooperation of the state in the form of investments in transport infrastructure must be a matter of course.

The aim of the paper was to prove the gradual fulfillment of the commitment promised by the Czech Republic. The proposed models show certain unsystematic components, although we can state that the models explain the case study and a gradual reduction in the share of road traffic is ensured.

# Reference

[1]    ARNOLD, P., D. PEETERS and I. THOMAS. Modelling a rail/road intermodal transportation system. *Transportation Research Part E: Logistics and Transportation Review*. 2014, 255-270.

[2]    BAYKASOĞLU, A. and K. SUBULAN. A multi-objective sustainable load planning model for intermodal transportation networks with a real-life application. *Transportation Research Part E: Logistics and Transportation Review*. 2016, 207-247.

[3]    BLUMAN, A. G. *Elementary Statistics: A Step By Step Approach*. In: McGraw-Hill, New York, 2017.

[4]    CSO, 2019. *Statistical Yearbook 2019*, Prag, Sept. 2020.

[5]     EUROPEAN COMMISSION. *Setting an emission standard for new heavy-duty vehicles*. [online] 20. 6. 2019 [cit. 1. 10. 2020]. Dostupné z: https://eur-lex.europa.eu/legal-content/CS/TXT/HTML/?uri=CELEX:52018PC0284&from=EN

[6]     FIRST, J. *Energetická analýza pozemní dopravy*. [online] 2014 [cit. 20. 9. 2020]. Dostupné                                                                                z: http://k616.fd.cvut.cz/download/first_energeticka_analyza_pozemni_dopravy.pdf

[7]     HANKOVÁ, J. Emisní povolenky z daňového hlediska. *APOGEO*. [online] 2009 [cit. 21. 9. 2020]. Dostupné z: https://www.apogeo.cz/novinky/emisni-povolenky-z-danoveho-hlediska-415/?p=43

[8]     HEINOLD, A. and F. MEISEL. Emission limits and emission allocation schemes in intermodal freight transportation. *Transportation Research Part E: Logistics and Transportation Review*. 2020, vol. 141, issue C.

[9]     HENDL, J., 2012. Přehled statistických metod: Analýza a metaanalýza dat (Overview of Statistical Methods: Data Analysis and Metaanalysis). 4th extended edition. In: Portál, Prague.

[10]    PAPOUŠKOVÁ, K. The Concept of Railway Transport in the Czech Republic. *Horizons of Railway Transports 2020*. Paper in conference proceedings at University of Žilina. Forthcoming.

[11]    SABYASACHI, T. and K. SHUPINDER. Do negative externalities have any impact on populations agglomerations? Evidence from urban India. *Theoretical & Empirical Researches in Urban Management*. 2018, sv. 13, 3, s. 5-24.

[12]    ŘEČKA, L. a M. ŠČASNÝ. *80% snížení emisí skleníkových plynů: analýza vývoje energetiky České republiky do roku 2050*. Praha: Národohospodářský ústav AV ČR, 2016.

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