



## DECOMPOSITION ANALYSIS OF FACTORS INFLUENCING SELECTED TYPES OF VEHICLE TRANSPORT IN POLAND

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**ABSTRACT. Background:** The paper presents the correlation between selected types of cargo transport by vehicle transport in Poland in the period 2008-2017 and selected factors influencing the types of cargo transport. The aim of this paper is to determine the correlation between vehicle transport of food products and of palletized goods, vehicle transport in total and gross domestic product (GDP).

**Methods:** Decomposition was conducted using the LMDI method (Logarithmic Mean Divisia Index). Three indicators were used in the analysis. The first was related to the increase and decrease in the interest in vehicle transport of food products and palletized products, the second was related to vehicle transport in general, and the third was related to changes in gross domestic product (GDP).

**Results:** The yearly average increase in the transport of food products in the period 2008-2017 was approximately 3.31 billion tonne-km/year and palletized goods was approximately 8.02 billion tonne-km/year. Decomposition analysis proved that the reasons for these increases are related 50% and 54% respectively to the increase in GDP, in 33% and 35% respectively to the increase of whole vehicle cargo transport and only in 17% and 11% to the interest shown by enterprises in this specific type of cargo transport.

**Conclusions:** The results of the analysis show that the main reason for the high increase in the transport of palletized goods and food products is the increase in economic growth expressed in GDP. The increase in vehicle transport in total has a smaller input, and the interest of enterprises in this specific type of cargo transport is the third reason in terms of its importance.

**Key words:** road transport, transport of food products, vehicle transport of palletized goods, decomposition analysis.

### INTRODUCTION

The transport system is characterized by a set of indicators of a spatial, time, technical, organizational and economic scope, which are values that are measurable and also hard to measure (described sometimes as immeasurable ones). Transport processes can be categorized in the same way [Ide et al. 2015]. To analyse the transport system it is necessary to assign appropriate indicators to measure the quantities and values of inputs and outputs from the system [Ortuzar et al. 2011].

The transport systems, both domestic and international, determine effective and efficient

goods flow and the close connection of processes between business partners on the market. The dominant position is occupied by road (vehicle) transport due to the volumes of goods transported (app. 90%) and the size of transport work (app. 80%). The organization of the transport system and the transport infrastructure in Poland and in Europe has a significant influence on many cross-sectional market, financial and operational results of cooperating enterprises, including costs, productivity, efficiency and the speed of operations, the use of resources, punctuality and the reliability of business activities [Speranza 2018].

Efficient transport is important for the development of the Polish economy due to the fact that it provides approximately 6% of GDP yearly.

A total value of 1737.3 million tons of cargo was transported by vehicles in 2017 year, which is 13% than the previous year. The load transported by vehicle transport was 348.6 tonne-km and was 14.8% higher than in 2016. The share of food products and beverages in the total structure of domestic vehicle transport was 52.4 billion tonne-km in 2017, which means an increase of 23.3% on 2016. On the other hand, the transport of palletized goods was 131.7 billion tonne-km, indicating a rise of 13.7% on 2016 [Roczniki statystyczne GUS 2008-2017, Fechner et al. 2017].

In this paper an analysis of changes in cargo volumes by vehicle transport in Poland described by selected indicators was conducted for the following groups:

- transport of food products,
- transport of palletized products.

The selection of transport of food products for decomposition analysis was dictated by the importance of food production for Polish economy, which results in its relatively high share in total vehicle transport. On the other hand, the volume of palletized goods transport significantly influences the efficiency of the total supply chain (efficiency of logistics operations).

The aim of this paper is to determine the influence of selected factors, in terms of volume, on changes in the transport volume of food products and palletized products in the period 2008-2017.

## METHODOLOGY

Decomposition analysis using the Logarithmic Mean Divisia Index method was implemented to investigate the factors influencing the volumes of transport of food products and palletized products. The following equation was used for these calculations [Ang 2016]:

$$\Delta V = \sum_{i=1}^n \left[ \frac{V_n^t - V_n^{t-1}}{\ln\left(\frac{V_n^t}{V_n^{t-1}}\right)} \ln\left(\frac{x_i^t}{x_i^{t-1}}\right) \right]$$

where:

- $V$  is described by  $n$  factors ( $x_1, x_2 \dots$ ),
- $\Delta V$  is the sum of effects of all factors taking into account in time period  $[t-1, t]$ ,
- $t$  present year
- $t-1$  previous year

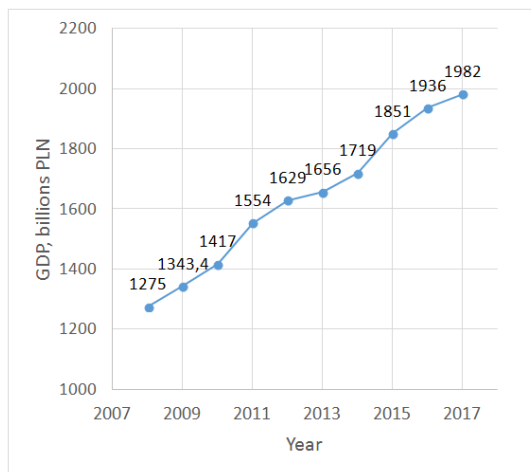
The decomposition analysis was conducted according to the methodology presented in the previous paper by the authors. The method is used mainly for research purposes, where the main aim is to determine factors that are the primary source of changes in energy consumption and environmental indicators over specific time periods [Ang 2004]. The other implementations of this method were shown in a study by [Fuji et al. 2016], where it was proposed for use in analysing innovations in green chemistry in Japan, as well as in papers related to tracking the added value of Chinese exports [Zhao 2018] or to analyse forces propelling the economy of this country [Wang 2017].

It seems that decomposition analysis consisting of analysing the changes in the volumes of transported food products and palletized products in relations to the changes of volumes of vehicle transport as well as of Polish GDP could be useful for identifying the driving forces behind the increase in the vehicle transport of palletized goods and food products.

The data for these calculations i.e. volumes of transport of food products by vehicle transport and volumes of transport of palletized goods by vehicle transport was taken from the report “Logistics in Poland” [Fechner et al. 2017]. Central Statistical Office was the source of the information concerning the vehicle transport in total and GDP [Roczniki statystyczne GUS 2008-2017].

## DISSCUSSION OF FINDINGS

The change in Polish GDP in the period from 2008 to 2017 is presented in Figure 1. The change in the volume of total vehicle transport, vehicle transport of palletized goods and vehicle transport of food products in the same period is presented in Figure 2.

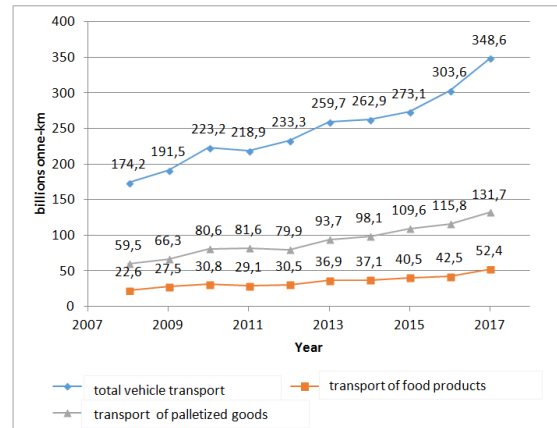


Source: own work based on GUS date

Fig. 1. GDP values in Poland in 2008-2017 years

It can be concluded from the data presented in Figures 1 and 2 that both the value of GDP and the volume of vehicle transport in this period increased significantly. Comparing the changes to 2008, it is clear that the highest

growth rate of 132% was recorded for the transport of food products and 121% for palletized goods. The growth in the remaining two indicators was lower, amounting to 100% for total vehicle transport and 55% for GDP.



Source: own work based on GUS date

Fig. 2. Vehicle transport of goods: total, palletized and food products in 2008-2017 years

The changes in the vehicle transport of food products against GDP values and total vehicle transport are presented in Table 1. The influence of GDP and total vehicle transport on the changes in the volumes of vehicle transport of food products determined by the use of logarithmic decomposition LMDI is presented in Figure 3.

Table 1. The changes in transport of food products against GDP and total vehicle transport

Year	Vehicle transport of food products	Total vehicle transport	GDP	Changes in transport of food products	Influence on change of		
					Transport of food products	Total vehicle transport	GDP
	billion tonne-km	billion tonne-km	bilion	billion tonne-km	billion tonne-km	billion tonne-km	billion
2008	22.6	174.22	1275	0	0.00	0.00	0.00
2009	27.5	191.48	1343	4.9	2.54	1.06	1.30
2010	30.8	223.17	1417	3.3	-1.16	2.90	1.56
2011	29.1	218.89	1554	-1.7	-1.12	-3.34	2.76
2012	30.5	233.31	1629	1.4	-0.50	0.50	1.40
2013	36.9	259.71	1656	6.4	2.80	3.05	0.55
2014	37.1	262.86	1719	0.2	-0.25	-0.94	1.38
2015	40.5	273.11	1851	3.4	1.92	-1.39	2.87
2016	42.5	303.56	1936	2	-2.39	2.52	1.86
2017	52.4	348.60	1982	9.9	3.36	5.43	1.11
Total	-	-	-	29.8	5.2	9.79	14.79

Source: own calculations based on GUS date

To determine precisely the factors influencing the increase in the vehicle transport of food products in the form of quantity correlation, LMDI decomposition analysis was used [Fujii, 2016]. Three indicators were used during this analysis. The first

(FoodTranspPrio) gives information about changes in the interest in enterprises' own and ordered transport of food products, the second one (RoadTransp) indicates the influence of the growth of total vehicle transport on the transport of food products, while the third one

(GDP) shows the influence of GDP on the transport of food products.

Decomposition analysis was conducted according to the following equation:

$$\begin{aligned} FoodTransp &= \left(\frac{FoodTransp}{RoadTransp}\right) \cdot \left(\frac{RoadTransp}{GDP}\right) \cdot GDP \\ &= FoodTransPRIO \cdot RoadTranspPRIO \cdot SCALE \end{aligned}$$

to compare the changes in various years:

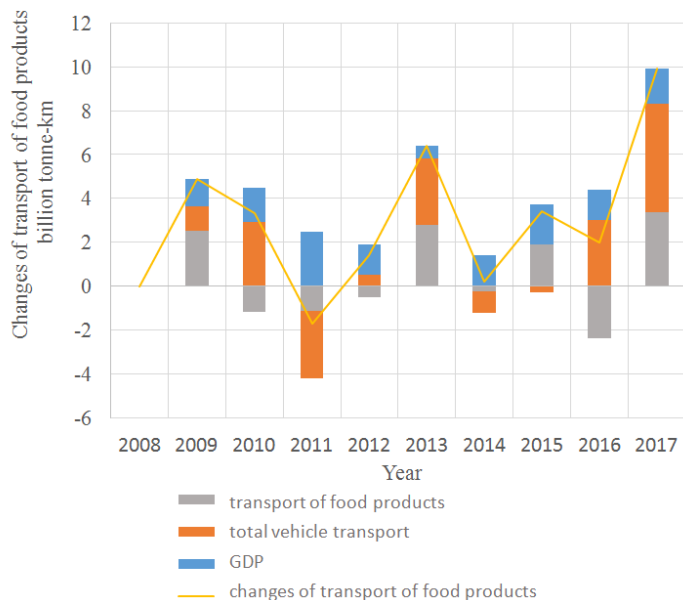
$$\frac{FoodTransp^t}{FoodTransp^{t-1}} = \frac{FoodTranspPRIO^t}{FoodTranspPRIO^{t-1}} \cdot \frac{RoadTranspPRIO^t}{RoadTranspPRIO^{t-1}} \cdot \frac{SCALE^t}{SCALE^{t-1}}$$

where:

t means present year and  
t-1 previous year

After finding the logarithm and multiplying by coefficient:

$$\omega^t = \frac{FoodTransp^t - FoodTransp^{t-1}}{\ln(FoodTransp^t) - \ln(FoodTransp^{t-1})}$$



Source: own calculations

Fig. 3. Impact of GDP and total vehicle transport on the changes in volumes of transport of food products

The accumulated impact during the period of nine years is at the level of 14.79 billion tonne-km, which constitutes 49.6% of the total impact on the changes in vehicle transport of

the following equation was obtained:

$$\begin{aligned} \Delta FoodTransp^{t,t-1} &= \omega^t \ln\left(\frac{FoodTranspPRIO^t}{FoodtranspPRIO^{t-1}}\right) \\ &+ \omega^t \ln\left(\frac{RoadTranspPRIO^t}{RoadTranspPRIO^{t-1}}\right) + \omega^t \ln\left(\frac{SCALE^t}{SCALE^{t-1}}\right) \end{aligned}$$

A similar method was used to analyse the vehicle transport of palletized goods. The influence of selected factors on the vehicle transport of food products and palletized goods was analysed on the basis of the data obtained.

## CORRELATION ANALYSIS OF VEHICLE TRANSPORT OF FOOD PRODUCTS

It can be concluded on the basis of data from Table 1 and Figure 3 that changes of GDP have the biggest and most positively stable influence on the changes in the transport of food products.

food products, estimated at the level of 29.8 billion tonne-km.

The influence of the volumes of total vehicle transport imitates the trend in changes

in the transport of food products and shows, especially a positive impact, but also a negative one, as a result of which the sum of values of influences is 9.79 billion tonne-km. Therefore the influence given in a percentage is relatively high, standing at 32.9%.

The calculated volumes of the influence of interest in transport of food products show low values and big changes and as a result give the low value of the influence indicator - 5.2 billion tonne-km - which is translated into 17.5% of influence on the increase in the transport of food products.

It can be concluded in general that the average yearly increase in the transport of food products in the 2008-2017 period is at the level of 29.8 billion tonne-km/9 years = 3.31 billion tonne-km/year. 50% of this increase is due to GDP growth, 33% of this increase is due to the growth in the total increase in

vehicle transport and only slightly more than 17% is due to the increase in the interest of enterprises in vehicle transport of food products.

## CORRELATION ANALYSIS OF VEHICLE TRANSPORT OF PALLETIZED GOODS

Analysing the reasons for the increase in the transport of palletized foods, a similarity can be observed with a previous case where the changes in GDP result in a stable increase in this type of transport of 39.19 billion tonne-km over the period of 9 years. This ensures the high impact on the increase of transport of palletized goods - 54.2%.

Table 2. The changes in transport of palletized goods against GDP and total vehicle transport

Year	Vehicle transport of palletized goods billion tonne-km	Total vehicle transport billion tonne-km	GDP billion	Change in vehicle transport of palletized good billion tonne-km	Influence on changes in		
					Transport of palletized goods billion tonne-km	Total vehicle transport billion tonne-km	GDP billion
2008	59.5	174.22	1275	0	0	0	0
2009	66.3	191.48	1343	6.8	0.86	2.67	3.27
2010	80.6	223.17	1417	14.3	3.09	7.28	3.93
2011	81.6	218.89	1554	1.0	2.57	-9.06	7.48
2012	79.9	233.31	1629	-1.7	-6.85	1.35	3.81
2013	93.7	259.71	1656	13.8	4.52	7.86	1.42
2014	98.1	262.86	1719	4.4	3.24	-2.42	3.58
2015	109.6	273.11	1851	11.5	7.53	-3.71	7.68
2016	115.8	303.56	1936	6.2	-5.71	6.85	5.06
2017	131.7	348.60	1982	15.9	-1.20	14.19	2.90
Total	-	-	-	72.2	8.05	25.01	39.13

Source: own calculations based on GUS date

The influence of total volumes of vehicle transport mirrors the same trend as the change in the transport of palletized goods and shows both a positive and negative impact in particular years. The total sum of the value of influences is 25.01 tonne-km, which gives a total increase in transport of 34.6%.

The volume of influences of interest of enterprises on transport of palletized goods that were calculated show a great yearly fluctuation around zero, which as a result has a low impact on the increase of transport of palletized goods of only 11,2%.

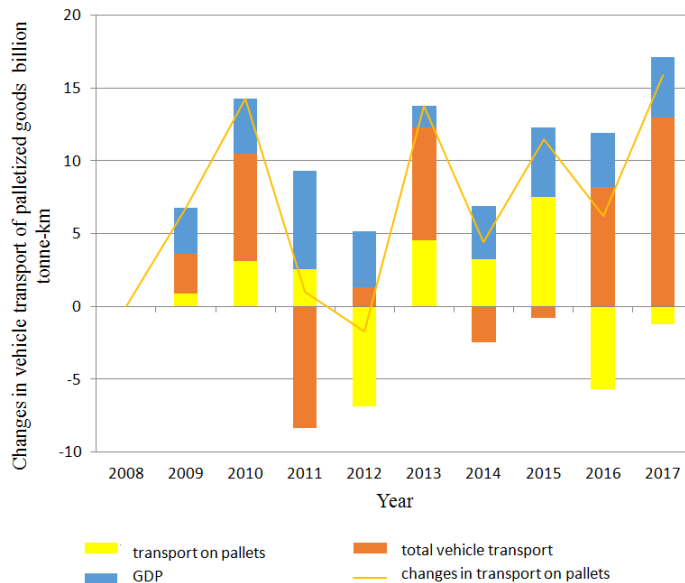
It can be concluded that the average yearly increases in the transport of palletized foods in

the period 2008-2017 are at the level of 72.2 billion tonne-km/9 years = 8.02 billion tonne-km/year. 54% of this increase is due to GDP growth, almost 35% of this increase is due to the growth in the total increase of vehicle transport and only a little above 11% is due to the increase in the interest of enterprises in vehicle transport of palletized goods.

These results of the analysis of factors influencing the increase in the transport of food products and also palletized foods enable this trend to be interpreted in a different way from the traditional one. These findings lead to the conclusion that the increase in GDP is the main factor in the increase in the transport of food products and palletized goods, the second

factor (of importance) is the increase in total vehicle transport, while the third most

important factor is the increase in interest in this type of transport.



Source: own calculations

Fig. 4. Impact of GDP and total vehicle transport on the changes in volumes of transport of palletized goods

## CONCLUSIONS

It can be concluded from the results of this analysis that the high values of indicators of the increase of transport of food products as well as for palletized foods from 2008-2017 are 50% due to the increase in economic development expressed in GDP and 33% due to the high speed of the increase of total vehicle transport. The third reason of significance is interest in this type of transport. This factor stood at 17% of all factors for foods products and 11% for palletized goods.

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## ANALIZA DEKOMPOZYCYJNA CZYNNIKÓW WPLYWAJĄCYCH NA WYBRANE RODZAJE PRZEWOZÓW ŁADUNKÓW TRANSPORTEM SAMOCHODOWYM W POLSCE

**STRESZCZENIE. Wstęp:** Artykuł analizuje korelacje pomiędzy wybranymi rodzajami przewozu ładunków transportem samochodowym w Polsce w latach 2008 – 2017, a określonymi czynnikami wpływającymi na rodzaje przewozów ładunkowych. Celem pracy jest określenie korelacji pomiędzy przewozami transportem samochodowym produktów spożywczych oraz spakowanych, transportem samochodowym ogółem i PKB (Produkt Krajowy Brutto) oraz korelacji pomiędzy tak dobranymi zmiennymi.

**Metody:** Dekompozycję wykonano metodą logarytmicznej średniej ważonej indeksu Divisia LMDI (Logarithmic Mean Divisia Index). W analizie wykorzystano trzy wskaźniki. Jeden odnosił się do wzrostu lub spadku zainteresowania transportem samochodowym w przewozie produktów spożywczych lub ładunków spakowanych, drugi odnosił się do transportu samochodowego ogółem, a trzeci do zmian PKB.

**Wyniki:** Średnio roczne przyrosty przewozów produktów spożywczych w latach 2008-17 kształtują się na poziomie 3,31 mld tkm/rok, a przewozów ładunków paletowych 8,02 mld tkm/rok. Analiza dekompozycyjna wskazuje, że przyrosty te wynikają odpowiednio w 50% i 54% ze wzrostu PKB, w 33% i 35% ze wzrostów przewozów samochodowych ładunków ogółem, a tylko w 17 % i 11% ze wzrostu zainteresowania przedsiębiorstw danym rodzajem gałęzi transportu w przewozach ładunków.

**Wnioski:** Wyniki przeprowadzonych analiz wykazują, że główną przyczyną wysokiego wzrostu przewozów produktów spożywczych oraz ładunków na paletach jest wzrost rozwoju gospodarczego wyrażonego w PKB. W mniejszym natomiast stopniu wpływa na to rozwój przewozów samochodowych ogółem, a dopiero trzecim czynnikiem rozwoju jest większe zainteresowanie przedsiębiorstw danym rodzajem przewozów.

**Słowa kluczowe:** transport samochodowy, przewozy produktów spożywczych, transport samochodowy ładunków na paletach, analiza dekompozycyjna

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