AIR-RAIL COMBINED TRANSPORT OF GOODS WITHIN EUROPEAN COUNTRIES

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Abstract

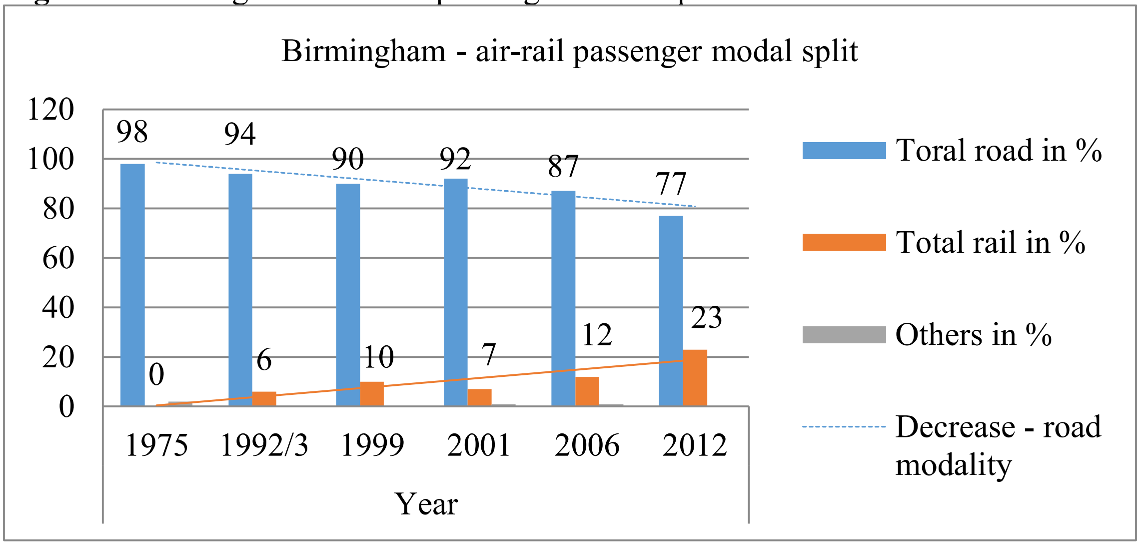
The main objective of this article is to evaluate and assess the possibilities of combined transport of goods with a special focus on non-traditional interconnection of air-rail transport modalities. The framework for this research is determined with two aspects - the aspect of environmentally friendly and sustainable transport and logistic solutions and the geographical aspect which focuses on the region of EU 27 (except of Malta) and the United Kingdom. Using the regression model, we attempt to confirm the dependence between the air transport performance in tonne-kilometres (Tkm) and the quality or availability of railway infrastructure (length of railways in km), the GDP per capita and the volumes of Intratrade import and export within the above geographical area. The existence of direct relationship between the length of the railways in km and the air transport performance in Tkm could confirm the complementary effect of these two transport modalities and it could be an evidence of the possibility of combined air-rail transport solutions. Thanks to the complementarity of the air transport with the rail transport modality, the aspect of environmentally friendly combined transport can also be emphasized since the rail transport is considered ecological. The very existence of this regression model also says that there is a kind of interconnection between these two modes of transport and it also could imply the feasibility of combined air-rail transport solutions. Further research will deal with the dynamics of changes in the interrelationship between air and rail transport over the period of several past years with implications for the future and with the purpose of trying to contribute to the possible development of air-rail combined transport within the EU countries.

Key words: Air Transport, Railways, Combined Transport of Goods, Aspect of Ecology

1. INTRODUCTION

The objective of our reseach of freight combined air-rail transport represents the added value of this article, because a great majority of research projects in this context are not focused on the freight transport (INTERREG, 2018), but they are focused on the passenger combined transport. An example is a statement of the International Air Rail Organization (IARO, 2015), which argues, that in the context of the air-rail combined transport, it is necessary to understand the geographic origins and destinations of passengers and to be able to forecast their movement. We assume that it is necessary to understand the geographic origins and destinations of transported goods and the forecast of their movements, too, to support the idea of air-rail combined freight transport. The idea of the air-rail combined passenger transport is not new, as rail-to-airport connections have been made in the relatively long past. Some examples are Birmingham or Frankfurt am Main airports.

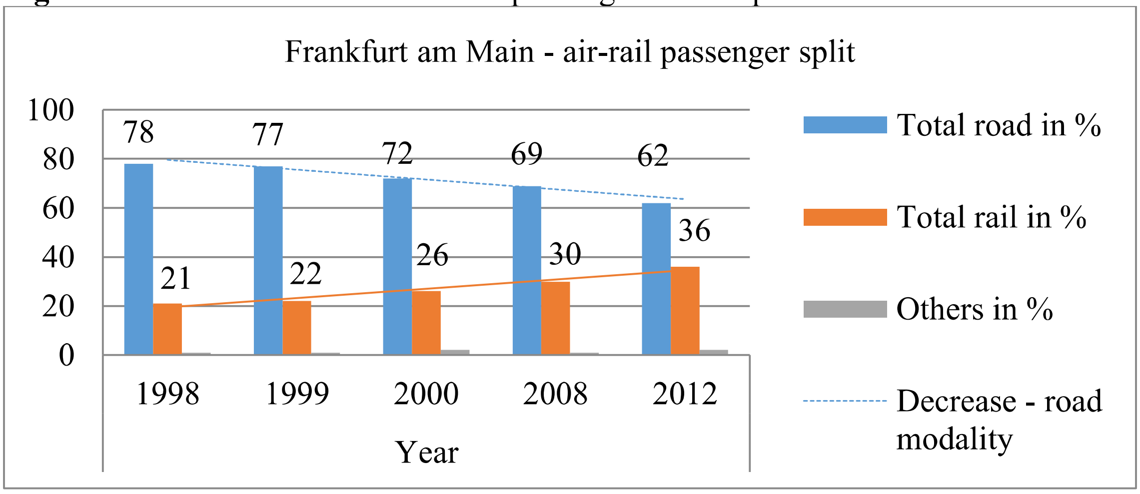
Figure 1. Birmingham – air-rail passenger modal split



Source: own processing based on data from IARO (2015)

From the fig. 1, it can be seen, that after the connections of the Birmingham airport to the railway were made (in 1976), there was a gradual decline in the importance of the road transport modality in favor of rail.

Figure 2. Frankfurt am Main – air-ral passenger modal split



Source: own processing based on data from IARO (2015)

The same trend is evident in the case of the airport in Frankfurt am Main (fig. 2). The connections of the Frankfurt am Main airport to the railway were made (in 1999), there was a gradual decline in the importance of the road transport modality in favor of rail, too.

There are many similar examples in the world. They all have one thing in common – the gradual decline in the importance of the road transport in favor of the rail transport. These examples inspired us in our research with the focus on the freight air-rail combined transport.

Combined maritime transport, together with road and rail, has a long tradition in the transport market, as evidenced by the fact that around 30 to 40 % of all freight transport anywhere in the world is realized by combining this transport modalities (Global Intermodal Freight Transportation Market 2015-2019, 2015). The nature of sustainable transport takes account of making best use of all modes and reducing reliance on carbon-based energy sources (Banister, 2018). The transport policies of each country have to diminish the environmental burden and damages on public health which are usually caused by road freight transport, by encouraging the transport modalities that are ecological such as railways and inland waterways. They can be integrated into the combined transport operations as the main transports-carriers (Široký, Schröder and Gašparík, 2017).

Table 1. Analysis of the strengths and weaknesses of air and rail transport modes

Air transport	
Strengths	*Weaknesses*
Fast - high speed	Load limitations
Accurate in delivery and reliable	Limited commodity structure
Low packaging costs	Highest prices
Simplified customs operations	Environmental problems
Low risk of damage of goods	Dependent on the weather
Railway transport	
Strengths	*Weaknesses*
Possible time and cost savings at medium and long distances	Lower flexibilty
More capacity and diverse fleet	Lower operability
Exact timetables	Problems with logistics
The possibility to achieve higher speeds	Problems with modern forms of business
Safe and relatively trouble-free	Lower price flexibility
Easy border crossing and transit	High investments
Joint responsibility of participating railways	
Environmental friendly	

Source: according to Hansenová (2007), Furdová and Hansenová (2013)

The analysis in tab. 1 is based on the strengths and weaknesses of transport modalities such as air and rail. The air transport is one of the most problematic with environmental problems which include mainly carbon footprint and CO_2 emissions (Hansenová, 2007 and Furdová and Hansenová, 2013).

The framework for the research presented in this article is determined with two aspects - the aspect of environmentally friendly and sustainable transport and logistics solutions, which are a factor of improving quality of life and business operations (Ceniga et all, 2019) and the geographical aspect, which focuses on the region of EU 27 (except of Malta) and the United Kingdom.

Air transportation service market has expanded and in fact become one large global market (Naletina et all, 2018). Air transport is also considered one of the key tools to advance economic development, but it is unclear if the economic development boosts the air transport performance or vice versa (Tolcha at all, 2020).

The article evaluates and assesses the possibilities of combined transport of goods with a special focus on air-rail transport modalities. This combination represents a non-traditional interconnection because it is not very common to combine these two madalities within Europe nowadays.

The United Nations Economic Commission for Europe (2020) defines the combined transport as *„intermodal transport where the major part of the European journey is by rail, inland waterways or sea and any initial and/or final legs carried out by road are as short as possible.“* IRU (2020) defines the combined transport as *„the carriage of goods from one place to another using different means of transport: road for the first and the last leg of the journey and rail or water for the rest.“* The European Union (2020) also regulates the combined transport through the Combined Transport (CT) Directive (Council Directive 92/106/EEC). The main aim of this regulation is to support and develop operations in combined transport through the authorisation procedures reduction and quantitative restrictions for the operations in combined transport and in a form of fiscal incentives, providing financial supports for these types of transport operations. In Europe, a combined transport is rapidly and dynamically developing and this development represents the main points of the EU´s transport and environmental strategy. This system for sustainable transportation of goods is strongly supported at the level of EU.

Combined transport is also used is the case of integrated logistics as well as tailor made solutions. The UIC (2020) considers the following aspects to be benefits of using of combined transport of goods: environmentally friendly (especially on those routes where transported volumes of goods and transport distances are appropriate), energy savings and lower CO2 emissions, society friendly (there is a decrease in accidents, road congestions and energy dependence), better use of existing transport capacity, a combination of flexibility of road transport and economies of railways in the case of long transport routes and large volumes of transported goods, integration of combined transport into logistics chains and last but not least its safety (there is a reduced risk of loss and damage to the goods during transport).

The internet web of Green Modal Transport (2019) also emphasizes some facts which are considered as advantages of a modal transfer: environmental, economic and social benefits, reduction of greenhouse gas emissions, sustainable development, reduction of negative impacts on sensitive ecological areas, lesser consumption of non-renewable resources, fuel costs and in general operating costs savings, lower impact of the road transport taxes mainly in Germany and France.

Freight air-rail combined transport systems have the potential to revolutionize the freight market. Given that this system is still used to a lesser extent compared to other types of combined transport, it is necessary to carry out a deeper analysis of the importance of a transport solution of this type. According to the website of Railway Technology (2020), air-rail transport has an advantageous position in the transport of time-sensitive goods, taking into account the aspect of sustainability. Tests have already been carried out in the real world to monitor the potential benefits of a transport system combining a high-speed freight train and an aircraft between Lyon-Saint-Exupéry Airport, Paris Charles de Gaulle Airport and St. Pancras International Railway Station in London. This test connection has proven to be positive in terms of efficiency, speed and ecology. Under the influence of the need to emphasize the environmental aspect (Zorkóciová, Palušková, 2019) of international freight transport a large number of logistics companies operating in a global environment are changing their transport policies towards multimodal transport solutions which, under certain conditions, have the potential to reduce transport costs and risks on one hand and to increase the speed and reliability of delivery of goods on the other hand.

Airports as well as ports are hubs of a number of multimodal operations such as transhipment, storage, transport of cargo by different modes of transport (Dávid et all, 2019). According to Railway Technology (2020), several feasibility studies have shown that a direct connection between the railway networks and the most important airport hubs is feasible, but further studies and research are needed in terms of their economic contribution to international freight transport.

Hubs of integrated air-rail or also road combined transport are commonly used in case of passenger transport, but in case of transport of goods, this combination was rather behind the main combinations such as road and rail transport, road and maritime transport or road and inland waterway transport, which have been the object of interest of our previous researches. According to UIC (2020), airports are now becoming multimodal hubs concentrating cargo in their cargo centers and distribution platforms.

2. METHODOLOGY

The main objective of our research is to evaluate and assess the possibilities of combined transport of goods with a special focus on innovative non-traditional interconnection of air-rail transport modalities. The indroduction of this kind of innovations in logistics (Stojčić, 2019) can be a very interesting issue for our research interest, which is determined by two aspects. The first one is the ecology and environmentally friendly transport solutions and the second one is the geographical aspect which is represented with the region of EU 27 (except of Malta) and the United Kingdom. These two aspects are in line with the previous focus of our research topics of multimodal transport of dangerous goods and its impact on the ecology within EU countries (Minárik, 2019) and sustainable transport of goods using combined transport solutions. This research differs from the previous ones by its focus on bimodal air-rail transport solution.

The aim of the article is achieved by verifying the hypothesis which we formulate as follows:

H1: There is a complementary effect (bimodal air-rail transport solutions) between the fast and expensive freight air transport with environmental problems and relatively cheap and environmentally friendly rail transport.

All data, which were used for the research, come from Eurostat. These data were used to create a database to perform regression analysis in the statistical program gretl. We selected the air transport perfomance over national territory (including territorial sea) for the analyzed countries. This indicator is expressed in tonne-kilometres and it was identified with the dependent variable ln_Air_Transport_Tkm_2018 in the creation of the regression model. The indicator of the length of railways was identified with the independent variable ln_Railway_Transport_Km_2017. The indicator of the GDP per capita in euros for the EU 27 countries and the United Kingdom was included in the model, too, and it was identified with the independent variable ln_GDP_EUR_2017_P/C. This indicator determines and differentiates the economic performance of the countries. Taking the expenditure approach to the calculation of the GDP into account, it consists of four basic components: household consumption, total investments, government consumption and the net export (the difference between the export and import). The GDP´s component of the net export is also one of the reasons why the indicators of Intratrade import and export in tonnes within EU 27 and the United Kingdom were included in the creation of our regression model. The other reason is that the transport performance in tonne-kilometres is closely related to the volume of transported goods and the capacity of transport modes. We have chosen the indicators of Intratrade import and export for the year 2017 and 2018 as well (the independent variables Intra_IM_2017_tonnes, Intra_X_2017_tonnes, Intra_IM_2018_tonnes, Intra_X_2018_tonnes). The basic rule for the creation of the regression model is the recommendation to implement at least one-year time lag in the effects of the independent variables on the dependent one. We have purposely implemented the data for the Intratrade import and export not only from 2017 (with the time lag of one year) but also from 2018 (without any time lag), because we were inspired by two approaches to manage capacity and demand in air transportation. *They can be categorized on the basis of timescale relative to flight operations: strategic planning typically occurs months or even years in advance, tactical adjustments on a daily basis up to a few hours before operations, and real-time interventions immediately* (Barnhart et all, 2012). In other words, we assume that the Intratrade import and export from 2017 have the impact on the air transport performance in 2018 from the strategic planning point of view and the Intratrade import and export from 2018 have the impact on the air transport performance in 2018 from the tactical adjustments point of view.

In the case of the indicator of the length of railways in km in 2017 and the GDP per capita in 2017 (independent variables), we follow the recommendation to implement at least one-year time lag in the effects of them on the dependent variable.

The main purpose of this research was to identify a possible relationship between the air transport performance (the air transport is considered the fastest and the most reliable one) on one hand and the availability of the railways infrastructure (the rail transport is considered ecological and sustainable), the economic performance of the country (measured with the GDP per capita) and the Intratrade import and export from the strategic planning and tactical adjustments, too, on the other hand. The problemacy of the reliability and the performance of the air transportation services has already been treated by some authors, but their emphasis was placed on other aspects such as the demand and capacity management (Barnhart et all, 2012).

The existence of a direct relationship between the length of the railways and the air transport performance in Tkm could confirm that the air transport plays an important role in the combined transport operations within EU 27 countries (except of Malta) and the United Kingdom. The existence of an indirect relationship between the length of the railways in km and the air transport performance in Tkm could confirm that the air transport is being replaced by the railways and it could be an evidence of no combined air-rail transport solutions.

The very existence of the regression model of dependence of the air transport performance in Tkm on the length in km of the railways says, that there is a certain type of inteconnection between these two modes of transport and it could also imply the feasibility of the combined air-rail transport solutions.

Our first assumption was to create a regression model of dependence of the air transport performance in Tkm and the length in km of the railways, navigable inland waterways, motorways, GDP per capita and the Intratrade import and export. The lack of significance of almost all the transport modes in such a model of multimodal solutions conducted us to the creation of a simpler regression model of dependence of the air transport performance in Tkm and the length of the railways in km, GDP per capita and the Intratrade import and export. which is statistically significant.

To create the model, we originally used the OLS estimator in Gretl statistics program. Due to the presence of heteroscedasticity in the model we needed to find other, more suitable estimator like the Heteroscedasticity corrected, which was implemented to meet the homoscedasticity condition.

The resulting linear regression model has the following general equation: $y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \beta_3 x_{i3} + \beta_4 x_{i4} + \beta_5 x_{i5} + \beta_6 x_{i6} + u_i$.

3. RESULTS AND DISCUSSION

We found that it is possible to create a model of dependence of the air transport performance in Tkm on one hand and the length of railways in km, the amount of GDP per capita, the volume of Intratrade import and export among EU 27 countries and the United Kingdom, except of Malta on the other hand. This could indicate that there is a certain type of connection between air and rail transport modes and it also could imply for the future the feasibility of the combined air-rail transport solutions. In the following part, we focus on the relationship between the air and the rail transport. In the very first step it was used OLS estimator, but due to the presence of heteroscedasticity, it was used the estimator Heteroscedasticity corrected (tab. 2)

Table 2. Model Heteroscedasticity-corrected, using observations 1-27 (n = 25), Missing or incomplete observations dropped: 2, Dependent variable: ln_Air_Transport_Tkm_2018

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
Const	16,1197	0,974129	16,55	<0,0001	***
ln_Railway_Transport_ Km_2017	0,681387	0,100528	6,778	<0,0001	***
ln_GDP_EUR_2017_P/C	−0,218227	0,0898480	−2,429	0,0258	**
Intra_IM_2017_tonnes	−1,58276e-07	5,12531e-08	−3,088	0,0063	***
Intra_X_2017_tonnes	9,86826e-08	3,22228e-08	3,063	0,0067	***
Intra_IM_2018_tonnes	1,65889e-07	5,18498e-08	3,199	0,0050	***
Intra_X_2018_tonnes	−1,05150e-07	3,41058e-08	−3,083	0,0064	***
Sum squared resid	50,65785	S.E. of regression		1,677595	
R-squared	0,976260	Adjusted R-squared		0,968347	
F(6, 18)	123,3701	P-value(F)		1,26e-13	
Log-likelihood	−44,30119	Akaike criterion		102,6024	
Schwarz criterion	111,1345	Hannan-Quinn		104,9688	
Mean dependent var	19,78763	S.D. dependent var		1,008806	
Sum squared resid	5,347637	S.E. of regression		0,545060	

Source: Own processing based on the data from EUROSTAT 2017, 2018 using Gretl statitical program

To complete the regression analysis, we have also done the test for normality of residual -; Null hypothesis: error is normally distributed; Test statistic: Chi-square (2) = 0,104348; with p - value = 0,949164.

The linear regression model has the form in the tab. 3:

Table 3. Linear regression equation

$\hat{y}_i$	Constant	β		x_i
ln_Air_Transport_Tkm_2018	16,1197	+	0,681387	ln_Railway_Transport_Km_2017
		-	0,218227	ln_GDP_EUR_2017_P/C
		-	1,58276e-07	Intra_IM_2017_tonnes
		+	9,86826e-08	Intra_X_2017_tonnes
		+	1,65889e-07	Intra_IM_2018_tonnes
		-	1,05150e-07	Intra_X_2018_tonnes

Source: Own processing based on the data from EUROSTAT 2017, 2018 using Gretl statitical program

The above linear regression model from the tab. 2 and 3 can be interpreted as follows: if the availability of railway lines (the variable of ln_Railway_Transport_Km_2017) is increased by 10 % (data from 2017) and assuming the rest of independent variables (ln_GDP_EUR_2017_P/C, Intra_IM_2017_tonnes, Intra_X_2017_tonnes, Intra_IM_2018_tonnes, Intra_X_2018_tonnes) unchanged, the air transport performance (the variable of ln_Air_Transport_Tkm_2018) would increase by 6,81 % per year (2018). This claim is limited to the sample of analyzed countries. If the GDP per capita (the variable of ln_GDP_EUR_2017_P/C) is increased by 10 % ahead (data from 2017) and assuming the rest of independent variables (ln_Railway_Transport_Km_2017, Intra_IM_2017_tonnes, Intra_X_2017_tonnes, Intra_IM_2018_tonnes, Intra_X_2018_tonnes) unchanged, the air transport performance (the variable of ln_Air_Transport_Tkm_2018) would decrease by 2,18 % per year (2018).

If the volume of Intratrade import to the EU 27 countries and the United Kingdom, excluding Malta (the variable of Intra_IM_2017_tonnes) is increased by 1000 tonnes (data from 2017) and assuming the rest of independent variables (ln_Railway_Transport_Km_2017, ln_GDP_EUR_2017_P/C, Intra_X_2017_tonnes, Intra_IM_2018_tonnes, Intra_X_2018_tonnes) unchanged, the air transport performance (the variable of ln_Air_Transport_Tkm_2018) would decrease by 1,44 % per year (2018). This claim is limited to the sample of analyzed countries.

If the volume of Intratrade export to the EU 27 countries and the United Kingdom, excluding Malta (the variable of Intra_X_2017_tonnes) is increased by 1000 tonnes (data from 2017) and assuming the rest of independent variables unchanged (ln_Railway_Transport_Km_2017, ln_GDP_EUR_2017_P/C, Intra_IM_2017_tonnes, Intra_IM_2018_tonnes, Intra_X_2018_tonnes), the air transport performance (the variable of ln_Air_Transport_Tkm_2018) would increase by 3,31 % per year (2018). This claim is limited to the sample of analyzed countries.

If the volume of Intratrade import to the EU 27 countries and the United Kingdom, excluding Malta (the variable of Intra_IM_2018_tonnes) is increased by 1000 tonnes (data from 2018) and assuming the rest of independent variables unchanged (ln_Railway_Transport_Km_2017, ln_GDP_EUR_2017_P/C, Intra_IM_2017_tonnes, Intra_X_2017_tonnes, Intra_X_2018_tonnes), the air transport performance (the variable of ln_Air_Transport_Tkm_2018) would increase by 1,51 % per year (2018). This claim is limited to the sample of analyzed countries.

If the volume of Intratrade export to the EU 27 countries and the United Kingdom, excluding Malta (the variable of Intra_X_2018_tonnes) is increased by 1000 tonnes (data from 2018) and assuming the rest of independent variables unchanged (ln_Railway_Transport_Km_2017, ln_GDP_EUR_2017_P/C, Intra_IM_2017_tonnes, Intra_X_2017_tonnes, Intra_IM_2018_tonnes), the air transport performance (the variable of ln_Air_Transport_Tkm_2018) would decrease by 0,96 % per year (2018). This claim is limited to the sample of analyzed countries.

Table 4. Summary Statistics, using the observations 1 – 27, (missing values were skipped)

Variable	Mean	Median	Minimum	Maximum
ln_Air_Transport_Tkm_2018	19,688	19,893	16,994	21,933
ln_Railway_Transport_Km_2017	8,4698	8,3015	5,6021	10,561
ln_GDP_EUR_2017_P/C	10,106	10,057	8,9079	11,463
Intra_IM_2017_tonnes	7,0526e+007	2,8517e+007	3,8556e+006	4,0899e+008
Intra_X_2017_tonnes	7,0303e+007	3,0385e+007	7,6026e+005	3,5092e+008
Intra_IM_2018_tonnes	7,1347e+007	3,0775e+007	3,8587e+006	4,1217e+008
Intra_X_2018_tonnes	7,0411e+007	3,1825e+007	7,6026e+005	3,3064e+008
Variable	Std. Dev.	C.V.	Skewness	Ex. kurtosis
ln_Air_Transport_Tkm_2018	1,1090	0,056327	-0,50406	0,52242
ln_Railway_Transport_Km_2017	1,1764	0,13889	-0,21867	-0,29207
ln_GDP_EUR_2017_P/C	0,62771	0,062115	0,11739	-0,73164
Intra_IM_2017_tonnes	9,3229e+007	1,3219	2,1890	4,6937
Intra_X_2017_tonnes	8,9645e+007	1,2751	2,0227	3,3363
Intra_IM_2018_tonnes	9,3289e+007	1,3075	2,2143	4,8550
Intra_X_2018_tonnes	8,7698e+007	1,2455	1,9649	3,0603

Variable	5% Perc.	95% Perc.	IQ range	Missing obs.
ln_Air_Transport_ Tkm_2018	17,144	21,656	0,95825	0
ln_Railway_ Transport_Km_2017	6,0386	10,466	1,9056	2
ln_GDP_EUR_ 2017_P/C	9,0117	11,296	1,0100	0
Intra_IM_2017_ tonnes	5,0507e+006	3,3421e+008	6,9480e+007	0
Intra_X_2017_ tonnes	3,3742e+006	3,3647e+008	7,6867e+007	0
Intra_IM_2018_ tonnes	5,1510e+006	3,3816e+008	6,7026e+007	0
Intra_X_2018_ tonnes	3,3742e+006	3,2669e+008	7,9432e+007	0

Source: Own processing based on the data of EUROSTAT 2017, 2018 using Gretl statitical program

The independent variable of ln_Railway_Transport_Km_2017 represents the length of the railways in each of the analyzed countries in 2017.

The independent variable of ln_GDP_EUR_ 2017_P/C represents the volume of GDP per capita in each of the analyzed countries in 2017.

The independent variable of Intra_IM_2017_tonnes represents the volume of Intratrade import to each of the analyzed countries in 2017.

The independent variable of Intra_X_2017_tonnes represents the volume of Intratrade export from each of the analyzed countries in 2017.

The independent variable of Intra_IM_2018_tonnes represents the volume of Intratrade import to each of the analyzed countries in 2018.

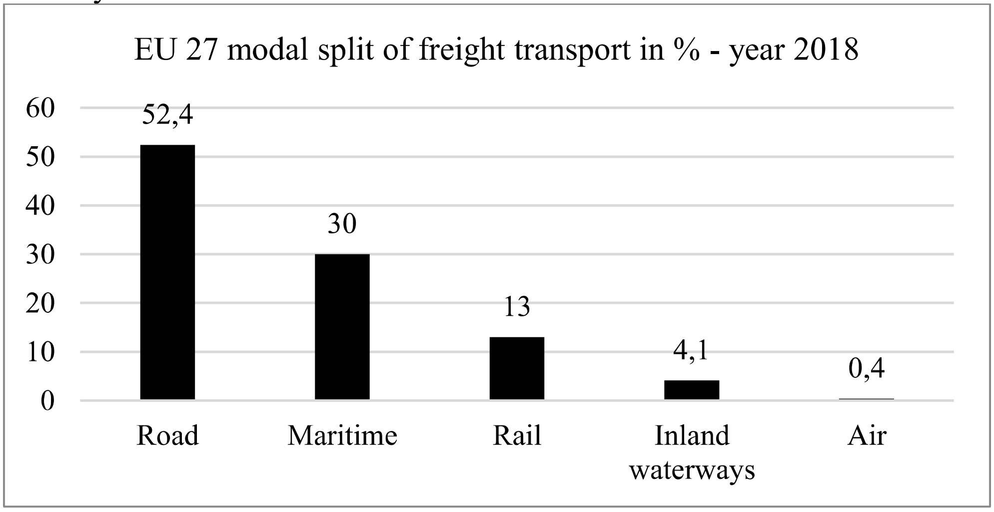
The independent variable of Intra_X_2018_tonnes represents the volume of Intratrade export from each of the analyzed countries in 2018.

The dependent variable of ln_Air_Transport_Tkm_2018 represents the transport performance of the air transport mode which is expressed with the tonnes multiplied by the kilometres.

The claim that if there is an increase in the length of railways, in other words an increase in their availability, there will also be an increase in the use of air freight transport is based on the current state of combined transport, which favors more air-rail combined freight transport within the European continent and less a single no combined air or rail transport.

Eurostat (2018) provides statistics which reveal that the air transport performance reaches about 0,4 % in 2018 of the total transport performance of all other modalities such as rail, road, maritime and inland waterways (fig. 3).

Figure 3. EU 27 countries´and the United Kingdom´s modal split of freight transport in % - year 2018



Source: own processing based on data from Eurostat (2018)

Returning to the description of our model, we see that the length and availability of railways, GDP per capita and the Intratrade export and import for the 2017 and 2018 have an important impact on the air transport performance in Tkm. We are talking here mainly about the complementary effect, which occurs not only as a model situation, but also as a real situation, especially in case of commodities that can be transported within the air-rail combined transport usually using containers as manipulation units. The above complementary effect can come from the assumption of the existence of a quality railway networks, which will also enable high-speed freight transport.

The commodities, which are time sensitive, perishable deliveries, or shipments of high value and, of course, smaller dimensions, are commonly transported by air. According to International Civil Aviation Organization the world´s air freight traffic reached 58 million of tonnes, Europe´s air freight traffic represents 26,1 % of total air freight tonne-kilometres (ICAO, 2018).

Table 5. Confidence interval t (18, 0,025) = 2,101

Variable	Coefficient	95 confidence interval
Const	16,1197	(14,0731, 18,1662)
ln_Railway_Transport_ Km_2017	0,681387	(0,470185, 0,892589)
ln_GDP_EUR_2017_P/C	-0,218227	(-0,406991, -0,0294638)
Intra_import_2017_tonnes	-1,58276e-007	(-2,65955e-007, -5,05973e-008)
Intra_export_2017_tonnes	9,86826e-008	(3,09849e-008, 1,66380e-007)
Intra_import_2018_tonnes	1,65889e-007	(5,69568e-008, 2,74821e-007)
Intra_export_2018_tonnes	-1,05150e-007	(-1,76804e-007, -3,34965e-008)

Source: Own processing based on the data of EUROSTAT 2017, 2018 using Gretl statitical program

The confidence interval from the tab. 5 discovers that if the length of railway networks (the variable of ln_Railway_Transport_Km_2017) increases by 10 %, the air transport performance (the variable of ln_Air_Transport_Tkm_2018) would increase by more than 4,7 % of Tkm and less than 8,93 % of Tkm per year 2018.

It also discovers a very interesting fact, if the amount of GDP per capita (the variable of ln_GDP_EUR_2017_P/C) increases by 10 %, the air transport performance (the variable of ln_Air_Transport_Tkm_2018) would surprisingly decrease by more than 0,29 % of Tkm and less than 4,07 % of Tkm per year 2018. The question why it should be so is not very easy to response, but we assume that a dominant part of the EU economy is composed with the tertiary service sector. Some sources (Eurostat, 2019) indicate that the service sector represents around 70 % of the EU´s GDP. When we are talking about the freight transportation we focus only on goods. The services are not the transportation issue. The GDP growth of the EU countries is mainly based on the growth of the service sector, but this growth does not directly contribute to the growth of the transport sector or transport performance. The quality of life and the comfort directly resulting from the development of transport technologies is growing with the development of the EU economy (Štimac & Vištica, 2018).

The previous response says only why the air transport performance does not increase, now, we also attempt to response why does it decreases. Finding a clear answer is difficult, too, but we assume that the main reasons are the EU initiatives of transforming the economy of the EU member states to an economy based on digitalization and knowledge. They are already making concrete steps.

The testing of hypothesis for the variable ln_Railway_Transport_Kilometre was processed, too: H_0: β1 = 0, H_1: β1 ≠ 0, $\left|(0,681487 - 0) / 0,100528\right| > 2,101$; $6,778 > 2,101$. Based on this testing, we reject H_0. The coefficient for the variable ln_Railway_Transport_Kilometre has a statistical significance. This claim means that the availability of the railway lines in km affects the air transport performance in Tkm.

It was used the same process for the testing of the hypothesis for the rest of the independent variables and for all of them the H_0 was rejected. It means that the coefficients for all of the independent variables included in the model are statistically significant and they affect the air transport performance in Tkm.

For the statistical significance, it also was proceeded the verification of our regression model as a whole at the level of significance $\alpha = 0,1$. H_0 means that the linear regression model shows the fact, that it is not statistically significant, H_1 means that the linear regression model shows the fact, that it is statisticaly significant. The critical value of $F_{0,1}$ (6,18) = 2,6613; the F value calculated from our regression model is 123,3701. Since 123,3701 > 2,6613, the null hypothesis H_0 is rejected.

Also the p - values from our regression calculations confirm the fact that on one hand the null hypothesis is rejected and on the other hand the alternative hypothesis H_1 is accepted.

Focusing on the coefficient of determination, we can see that it reaches $R^2 = 0,9763$. It means that our linear regression model with independent variables x_{i1} (length of railway lines in kilometres by the end of 2017), x_{i2} (GDP per capita in euros in 2017), x_{i3} (volume of Intratrade import to analyzed countries in 2017), x_{i4} (volume of Intratrade export from analyzed countries in 2017), x_{i5} (volume of Intratrade import to analyzed countries in 2018) and x_{i6} (volume of Intratrade export from analyzed countries in 2018) explains 97,63 % of the variability of dependent variable $\hat{y}_i$ (air transport performance, which is expressed in Tkm). The remaining 2,37 % of the variability of the dependent variable depends on the factors and random effects, which are not included in this regression model.

The main conclusion from this analysis is the claim that the linear regression model, which treats the dependence of air transport performance on the length of railways in km, GDP per capita and the volume of Intratrade import and export shows the statistical significance.

4. CONCLUSION

The topic of this acticle is inspired by our previous researches about the multimodal transport of dangerous goods and its impact on the ecology and others which were related to the idea of combined transport of goods. The main aim of the research presented in this article was to evaluate and assess the possibilities of combined transport of goods with a special focus on non-traditional interconnection of air-rail transport modalities. An in-depth analysis of data from Eurostat was performed to achieve this objective. The data we needed were related to the air transport performance in Tkm, the length of the railways in km, the amount of GDP per capita in euros and the volume of Intratrade imports and exports for 2017 and 2018. These data allowed us to form a database which was processed in Gretl statistical program into a regression analysis. The result of the regression analysis is a linear regression model of dependence between the air transport performance in Tkm on one hand and the quality or availability of railway infrastructure (length of railways in km), the GDP per capita in euros and the volume in tonnes of Intratrade import and export for 2017 and 2018.

The very existence of this model, which is statistically significant leads us to the conclusion that there is a certain type of interconnection between these two transport modalities and this fact also implies the feasibility of the combined air-rail transport solutions. On the basis of this claim, we accept the idea that the transport of goods in the EU 27 countries (except of Malta) and the United Kingdom is feasible through environmentally friendly combined transport solutions (the non-traditional combination of air-rail transport modalities).

Our resulting model depicts the direct relationship between the length of the railways in km and the air transport performance in Tkm. This direct relationship could be an evidence of combined air-rail transport solutions. This fact is seen as a complementary effect of these two modalities, it means that the air transport is being complemented with the railways. Due to the complementarity of the air transport with the rail transport, it also can be emphasized the aspect of environmentally friendly combined transport solution since the rail transport is generally seen as ecological. On the basis of this claim we accept the hypthesis H1 which says that *there is a complementary effect (bimodal air-rail transport solutions) between the fast and expensive freight air transport with environmental problems and relatively cheap and environmentally friendly rail transport.*

Our model attempts to confirm the possibility of creating a bimodal solution for the transport of goods within the EU 27 (except of Malta) and the United Kingdom, focusing on a non-traditional combination of air-rail transport modalities. This combination presupposes the existence of transport hubs on which the goods are, or in the future will be, transhipped from one modality (train) to another (aircraft) and vice versa. This solution may also be interesting due to the need to solve the high congestion of roads (UIC, 2020). Environmentally sustainable combined freight transport solutions have been implemented so far mainly on long journeys, as they have been inefficient for medium-long and short ones due to time delays in freight transport. The mere transfer of goods from one modality to another presupposes the need to calculate the additional time necessary for this transfer. The last question in this context which we will answer, is why the air-rail transport combination is not already widely used comparing the combinations of the rest of the transport modalities? The main problem is the need of developed infrastructure in the form of air-rail hubs and not only separate railway networks and airports.

Our further research will be focused on how the combined transport has been evolved within the EU 27 countries and the United Kingdom in the period of the last decade or more and which factors have had the biggest influence on the evolution.

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