Long-Term Correlations between the Development of Rail Transport and the Economic Growth of the German Reich (1872-1913)

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Abstract:

Purpose: *This study is part of the trend of researching new economic history using econometric analysis (the new economic history paradigm), still not very popular in Europe and the world (outside the USA and UK). The main purpose of the article was to use the Granger cointegration test to confirm the long-term correlations between the level of economic growth and the development of the German Reich railways.*

Design/Methodology/Approach: *In the field of theoretical analysis, a review of international literature on the study of the interdependence of economic growth and the development of transport, including rail transport, was carried out. The empirical analysis was based on available statistical data for the period of 1872–1913. Econometric methods were used, including: stationary test using ADF and KPSS tests, Engle-Granger cointegration test, as well as the analysis of the impulse response function.*

Findings: *The results of the research received confirm that there was a long-term correlation between the level of economic growth in Germany (expressed as Net National Product (NNP) and the level of rail freight symbolizing the development of railways.*

Practical Implications: *The Granger causality test allows the elimination of economic variables that are not in a causal relationship, which in turn leads to a better explanation of the studied economic phenomenon. A special case in VAR auto-regression models when the analysed time series are integrated in the first degree I(1).*

Originality/Value: *Considering the importance of transport for the economy, it is particularly important to examine whether the development of transport had an impact on the level of economic growth, and whether economic growth led to the development of the transport industry, and perhaps this relationship was two-way. The obtained results are the foundation for the construction of vector-autoregressive models (VAR) and the study of long-term relationships.*

Keywords: *Cointegration, economic growth, development of rail transport.*

JEL classification: *A12, B41, O47.*

Paper type: *Research article.*

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1. Introduction

In the 19th and early 20th century, railways played a special role in the development of transport. Before the expansion of the railway, until mid-19th century in Europe, land transport was poorly developed and inefficient, and inland waterway transport was not able to respond to the growing demand from the developing economy (industrialization process).

There is a reason why railways are widely regarded in world literature, including German-language, as a leading sector of economic development[3]. In the years 1870-1913, the length of German rail routes increased from 43,000 to almost 64,000 km, at that time the average annual economic growth rate was close to 2.7%. Germany, still in the mid-19th century, being an agricultural, economically backward country, after unification (1871) quickly became one of the economic powers of the world, with growing importance of the industrial sector.

The authors, in search of patterns of economic growth, want to develop research in the field of assessing the impact of railways on the economic growth of individual counties during the industrialization period, including the German Reich[4].

The main aim of the article is to identify the causality and its direction between the level of economic growth in Germany and the transport of goods by railways, symbolizing the development of railways. The research results published by the author using traditional econometric modelling (interdependent equations) confirmed that there was a relationship between the economic growth of the German Reich and rail transport expressed in km and the other way around[5]. An important element of the research is the use of the still little-known latest estimates of the level of economic growth of the German Reich, developed by C. Burhop and G.B. Wolff

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[3]*Ziegler D. 1996. Eisenbahnen und Staat im Zeitalter der Industrialisierung. Die Eisenbahnpolitik der Deutschen Staaten im Vergleich, VSAG Beihefte 127, Stuttgart, Franz Steiner Verlag, 94, Myszczyszyn J. (2013) Wpływ kolei żelaznych na wzrost gospodarczy Niemiec 1850–1913, Łódź, Wydawnictwo Uniwersytetu Łódzkiego.*

[4]*Hoffmann W., Müller J. (1959) Das deutsche Volkseinkommen 1851–1957, Tübingen, Mohr, Hoffmann W., (1965) Das Wachstum der deutschen Wirtschaft seit der Mitte des 19. Jahrhunderts, Berlin, Springer-Verlag, Fremdling R. (1985) Eisenbahnen und deutsches Wirtschaftswachstum 1840-1879. Ein Beitrag zur Entwicklungstheorie und zur Theorie der Infrastruktur, Dortmund, Gesellschaft für Westfälische Wirtschaftsgeschichte E.V. 5-7, 14-22, 62, Fremdling R. (1988) National Accounts for the 19th and Early 20th Century A Critical Assessment, VSWG: Vierteljahrschrift für Sozial- und Wirtschaft sgeschichte 75(3), 344, Statistisches Jahrbuch für das Deutsche Reich. (1880-1916). Berlin, Herausgegeben vom Kaiserlichen Statistischen Amt.*

[5]*Myszczyszyn J., (2019) Wykorzystanie analizy kliometrycznej w ocenie wpływu kolei żelaznych na wzrost gospodarczy Niemiec, Wyd. Zachodniopomorski Uniwersytet Technologiczny w Szczecinie, Szczecin.*

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(2005) together with an attempt to increase the achievements in the field of cliometrics[6].

By adopting the assumptions for the Granger cointegration test, the authors investigated whether the correlations between economic growth and railway development were long-term. Statistical data from the works of R. Fremdling, W. Hoffmann, W. Hoffmann, J. Müler, C. Burhop and G.B. Wolff were used, as well as statistical data from the statistical yearbooks of the German Reich (1882-1916).

2. A Synthetic Review of Existing Research

There is no doubt that modelling of long-term relationships is of great importance in economics, especially in relation to macroeconomic problems. The study of cointegration serves to capture the long-term balance (dependence), while the study of the correlation between the first differences serves the study of short-term dynamics[7]. Considering the fact that time series for economic quantities are usually in the form of non-stationary cointegration studies, it is particularly important.

Transport, being one of the important factors of economic development, is the subject of many studies, among which a special role is attributed to the analysis of cause-effect relationships between transport demand and economic growth. Many studies have confirmed that there is a strong relationship between economic growth and the development of transport. On the other hand, the traditional methods used for this purpose (including the Classical Least Squares Method) may raise doubts without specifying the causality test of variables, which could lead to incorrect determination of structural parameters.

This state of affairs is reflected in research on the search for causality in transport, which uses:

> ➢ VAR (Vector Autoregressive Models);
> ➢ VECM (Vector Error Correction Model);
> ➢ IRF (Impulse Response Function) models, including the Granger and Johansen causality tests.

For example Groote, Jacobs, Sturm conducted a Granger causality test for a multi-equation model using the VAR method for the Netherlands (1853–1913), stating that

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[6]*Burhop C., Wolff G.B. (2005) A compromise estimate of German net national product 1851–1913, and its implications for growth and business cycles, Journal of Economic History 65, 621.*

[7]*W. Enders (2010) Applied Econometric Time Series, Willey, New York, Kusideł, E. (2001). Modelowanie wektorowo-autoregresyjne VAR. Metodologia i zastosowanie w badaniach ekonomicznych. Łódź: Absolwent.*

infrastructure investments in the transport and communication system have a positive impact on GDP growth, but GDP growth alone has a negative impact on the level of investments in the transport and communication sector[8].

Research conducted by Fedderke, Perkins and Luiz, confirmed two-way causality between various approaches to economic infrastructure, including transport and communication, and the economic growth of South Africa (1875-2001)[9].

Cullison analysed the impact of government investment in both physical and human capital on economic growth. He used Granger's causality test to determine the relationship between different types of government spending and US economic growth (1955-1992). The authors have not confirmed the causal relationship of the impact of expenditure on transport, including railways, air transport and motorways on economic growth[10].

The work of Kulshreshth, Nag and Kulshreshth is worth interest, devoted to the study of the relationship between GDP per capita and inland waterway transport per capita (Mg) for 15 EU countries (1970-2008). As the authors point out, bi-directional causality between GDP and inland waterway transport was observed in 8 countries[11]. Interestingly, two-way causality was observed in countries with the highest GDP per capita.

Another work is the use of the VAR model in the study of the demand for transporting cargo by Indian railways (1960–1995). The authors analysed, among others:

- ➢ demand for transport of goods (in million tkm);
- ➢ GDP level;
- ➢ number of registered vehicles (thousands).

The research showed that there is a two-way and long-term relationship between the demand for freight transport and the level of GDP[12].

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[8]*Groote, P., Jacobs, J., Sturm, J.E. (1999) Output Effects of Transport Infrastructure: The Netherlands, 1853-1913, Tijdschrift voor Economische en Sociale Geografie, 90 (1), 97-109.*
[9]*Fedderke, J. W., Perkins, P., Luiz, J.M. (2006) Infrastructural Investment in Long‑run Economic Growth: South Africa 1875-2001, World Development, 34 (6), 1037-1059.*
[10]*Cullison, W. E. (1993). Public Investment and Economic Growth, Federal Reserve Bank of Richmond Economic Quarterly, 79 (4), 19-34.*
[11]*Kulshreshtha, M., Nag, B., Kulshreshtha, M. (2001) A Multivariate Cointegrating Vector Auto Regressive Model of Freight Transport Demand: Evidence from Indian Railways. Transportation Research Part A: Policy and Practice, 35 (1), 29–45.*
[12]*M. A. Beyzatlar, M. Karacal, I. H. Yetkiner (2012). Granger-causality between Transportation and GDP: A Panel Data Approach. Working Papers in Economics 12/03, s. 1-17.*

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In summary, various studies have proved or ruled out a two-way relationship between economic growth and transport development, while demonstrating the usefulness of the cointegration test, including unit element tests. It is only proof that the analysis of such dependence for Germany is scientifically significant.

3. Research Methods

An extremely important issue in economic analyses is the need to combine conclusions regarding short-term dynamics and long-term balance. The traditional approach to modelling short-term imbalance is based on the partial adjustment model, and its development is the error correction model (ECM), taking into account the imbalance in past periods[13]. Importantly, the long-term versions of economic models correspond to the stationary state[14]. The cointegration relation equation can be used to present the state of long-term balance. Cointegration is usually assessed using the Engle-Granger test or the Johansen method[15]. The advantage of the Engle and Granger approach is its simplicity[16].

As it has already been indicated, most of the variables used in economic models are characterized by non-stationary waveforms, which can lead to the determination of apparent relationships (apparent regression) and lead to erroneous conclusions. The theory of cointegration, formulated by Granger and developed by Engle, eliminates the main obstacle in modelling non-stationary series[17].

According to the theory, two processes y_t, x_t are co-integrated, to the (d, b) degree,

$$(y_t, x_t \sim CI(d, b), d \geq b \geq 0),$$

if:

- the degree of integration d of both processes (y_t, x_t) is the same;

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[13] *Maddala G.S. (2008), Ekonometria, PWN, Warszawa, 622-327.*
[14] *McAdam, P. (1998). A pedagogical note on the long run of macroeconomic models. Kent: University of Kent, Granger, C. W. J. (1991). Developments in the study of cointegrated economic variables. in: R. F. Engle, C. W. J. Granger, Long-Run Economic Relationship, Readings in Cointegration. Oxford, Oxford University Press.*
[15] *Johansen S. (1988) Statistical Analysis of Cointegration Vectors, Journal of Economic Dynamics and Control, vol. 12, 231-54.*
[16] *Majsterek M. (2014) Modelowanie systemów skointegrowanych. Aspekty teoretyczne, Bank i Kredyt 45(5), 2014, 433–466, Majsterek M., Welfe A. (2013), Wielowymiarowa analiza kointegracyjna, w: P. Karp, P. Kębłowski, M. Majsterek, A. Welfe, Analiza kointegracyjna w makromodelowaniu, Polskie Wydawnictwo Ekonomiczne, Warszawa.*
[17] *Granger C.W.J (1981) Some Properties of Time Series Data of Their Use in Econometric Model Specification, Journal of Econometrics, vol. 67, 173-188, Engle R.F., Granger C.W. J. (1987) Co-Integration and Error Correction: Representation, Estimation and Testing, Econometrica No. 55, 251-276.*

- there is a linear combination of these processes $u_t = \beta_1 x_t + y_t$, which is integrated to the d–b degree.

Therefore, it can be written that when $Y_t \sim I(d)$ and $X_t \sim I(d)$, then Y_t and $X_t \sim CI(d, b)$, if $y_t - \beta x_t \sim I(d - b)$, where $b > 0$.

This means that the regression equation:

$$y_t = \beta x_t + u_t$$

makes sense because y_t and x_t do not move too much apart over time, and this means that there is a long-term balance between them.

In view of the above, a necessary condition in the study of economic time series is testing the degree of integration of time series using the so-called unit root test. For the analysed interdependence, cointegration occurs if each of the time series y_t and y_t is integrated in the first degree, which we write symbolically as (I(1)), i.e. the null hypothesis with a unit root is not rejected, and the residues u_t from the cointegration equation are not integrated for the I(1) degree, i.e. the null hypothesis with a unit root is rejected. For this purpose, one can use, for example, the following tests: Dickey-Fuller, Kwiatkowski-Philips-Schmidt-Shin (KPSS)[18].

The cointegration study was carried out for two variable groups (product level). The cointegration study was carried out for two variable groups:

– Germany's economic growth as a net national product level (NNP (million M.);
– development of the railways symbolized by the cargo transport by rail (tkm) (Mg).

In the case of the variable describing economic growth, the author examined four time series:

a)   NNP estimated by Burhop and Wolff: Compromise NNP (l_NNP_Comp), corrected NNP EH (expenditure method) (l_NNP_EH), corrected NNP IHM (income method) (l_NNP_IHM);[19]
b)   NNP estimated by Hoffmann (l_NNP_Hoff)[20].

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[18]*Batóg B. (2016), Badanie kointegracji wybranych zmiennych ekonomiczno-finansowych w województwie zachodniopomorskim, Studia i Prace Wydziału Nauk Ekonomicznych i Zarządzania, 45/2, 133-141, Dickey D.A., Fuller W. (1979) Distribution of the estimators for autoregressive time series with a unit root, Journal of the American Statistical Association, 74, 427-431.*
[19]*NNP time series estimated by: Burhop C., Wolff G.B. (2005) A compromise estimate of German net national product 1851–1913, and its implications for growth and business cycles, Journal of Economic History 65, 621.*

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In the case of cargo transport by rail, two time series:

a)   rail freight in million tkm (l_RF_tkm)
b)   rail freights in tonnes (l_RF_Mg).

Following the generally accepted practice, data was logged in individual time series in order to "smooth" them[21]. The research consisted of the following stages:

– unit root test for variables from points a) and b);
– unit root test for variables from points c) and d);
– determining the degree of integration of the analysed variables;
– for integrated variables, estimation of the cointegrating equation (Engle-Granger
   test);
– testing the significance of assessments of parameters of the cointegrating equation;
– determining the residuals of the cointegrating equation;
– unit root test for the residuals of the cointegrating equation;
– analysis of the obtained results.

The research was carried out using the GRETL v. 2018a program.

4.   Findings

At the initial stage of testing individual time series, their course was illustrated graphically in Figures 1, 2a, 2b. The degree of integration of the studied time series was tested using the extended Dickey-Fuller test (ADF). It was assumed that the level of significance was $\alpha = 5\%$.

In the ADF test, the H_0 hypothesis assumes that the series is non-stationary. Therefore, if the probability of type I error (p) is greater than 5%, H_0 cannot be rejected, which gives the reason to conclude that the time series is non-stationary.

A quick analysis of Figures 1, 2a and 2b leads to the conclusion that the analysed variables are non-stationary.

Table 1 presents the results of the ADF test for the tested variables. The conclusions is that all analysed time series are non-stationary. At the significance level of $\alpha = 5\%$, there were no grounds to reject the H_0 hypothesis. Hence, the author examined the test results for the first differences.

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[20]*Hoffmann W. (1965) Das Wachstum der deutschen Wirtschaft seit der Mitte des 19. Jahrhunderts, Berlin, Springer-Verlag.*
[21]*Comp. Enders W. (2010) Applied Econometric Time Series, Willey, New York, B. Marona, A. Bieniek (2013) Wykorzystanie modelu VECM do analizy wpływu bezpośrednich inwestycji zagranicznych na Gospodarkę Polski w latach 1996–2010, Acta Universitatis Nicolai Copernici, Ekonomia XLIV nr 2 333–350.*

Time series for the first differences for all variables are stationary, which gives the reason to conclude that the variables are integrated in the first degree I(1).

Figure 1. NNP estimated by Burhop and Wolff and Hoffmann, W (1872-1913)
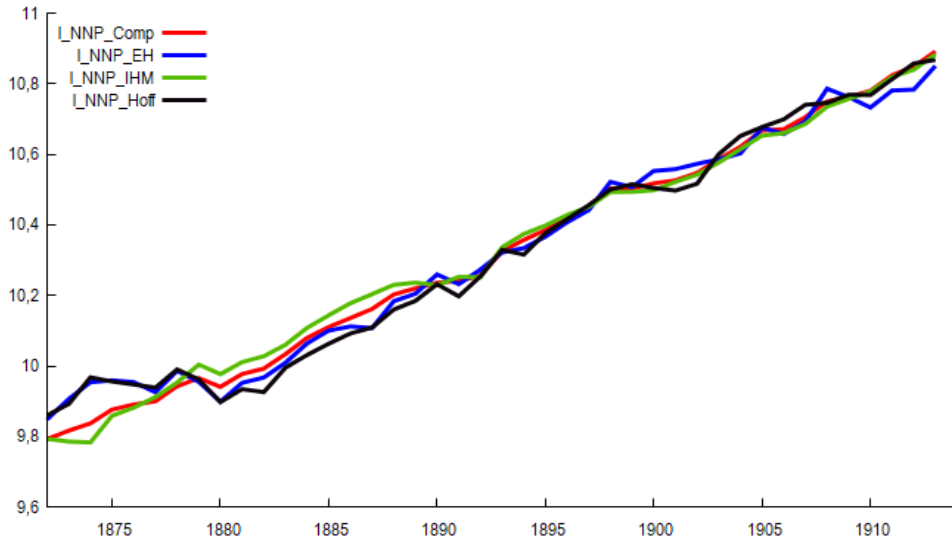
Source: *Authpr's calculations based on: Burhop, C., Wolff, G.B. 2005, Hoffmann, W. 1965.*

Figure 2a. *Variable: l_RF_Mg (1872-1913)*

Figure 2b. Variable: l_RF_tkm (1872-1913)
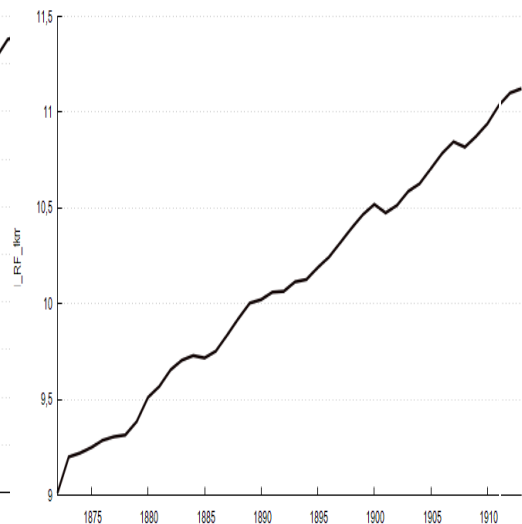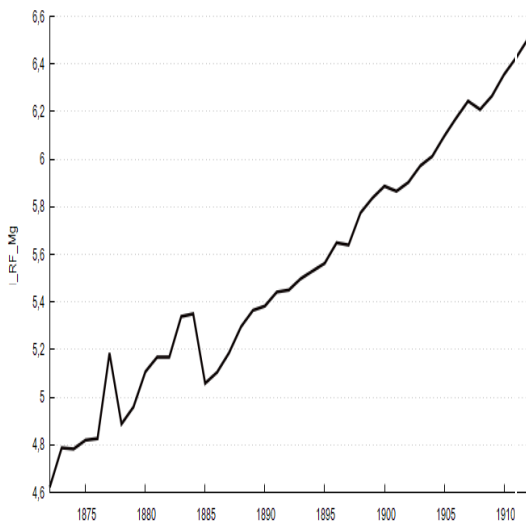
Source: *Authpr's calculations based on: Statistisches Jahrbuch für das Deutsche Reich 1880-1916, Fremdling, R. 1988.*

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Table 1. *The results of the ADF test for the tested variables (1872-1913).*

Zmienna	ADF test for the tested variables (p value)	ADF test for the for the first differences (p value)
l_NNP_Comp	0,9902	1,406e-006
l_NNP_EH	0,9853	1 9,28e-008
l_NNP_IHM	0,9745	3,944e-007
l_NNP_Hoff	0,9830	3,718e-006
l_RF_tkm	0,8496	1,618e-006
l_RF_Mg	0,9999	2,735e-006

Source: *Authors' calculations.*

Usually, the degree of integration of variables is simultaneously subject to the critical assessment with the inverse hypothesis test; hence the author used the KPSS test. The results are shown in table 2. In the KPSS test, the H_0 hypothesis assumes that the series is stationary. If the statistical value of this test is greater than the critical value for the significance level assumed by the author of $\alpha = 5\%$, then there are grounds to reject H_0, i.e. inferring that the time series is non-stationary.

Table 2. *The results of the KPSS test for the tested variables (1872-1913).*

Zmienna	KPSS test for the tested variables (p value)	KPSS test for the for the first differences (p value)
critical value ($\alpha = 5\%$) = 0,462		
l_NNP_Comp	0,81197	0,16421
l_NNP_EH	0,79945	0,11746
l_NNP_IHM	0,81364	0,09645
l_NNP_Hoff	0,79674	0,16653
l_RF_tkm	0,81399	0,14322
l_RF_Mg	0,81176	0,10931

Source: *Authors' calculations.*

The unit root studies using the ADF and KPSS tests have proven that both the variables related to Germany's economic growth (NNP series) and rail freight (tkm) and (Mg) are non-stationary series. All analysed series are (for $\alpha = 0.05$) integrated in the first degree I(1).

The identical degree of integration of the analysed time series enabled the author to conduct a Granger causality test.

In this test, H_0 assumes that the underlying variable does not affect the explained variable. The hypothesis is rejected when the probability (p) of making a type I error is less than 0.05.

In accordance with the cointegration method described by Engle and Granger, it was necessary to estimate the regression equation of a given variable relative to the second variable in the first stage using MNK and examine the significance of the estimated parameters of the equation. In the second stage, regression residues had to be determined and a unit root rest, e.g. ADF, was used to determine their stationary aspect. In the event that the ADF test indicates that the rest of the model is stationary, then this vector will be a cointegrating vector[22]. The results of calculations for individual pairs are presented in Table 3.

Table 3. *Granger causality test results between pairs of variables.*

#	Dependent variable	Independent variable	Coefficient $\hat{\beta}$	T-student statistics value	Value p	Determination coefficient R^2	ADF test statistics for the residual process	p-value of the ADF test for the residual process
1.	*l_NNP_Comp*	l_RF_tkm	*0,54675*	*63,2*	*0,0000*	*0,989837*	*-3,348*	*0,0485*
2.	*l_NNP_Comp*	l_RF_Mg	*0,61166*	*32,77*	*0,0000*	*0,963192*	*-4,07188*	*0,0130*
3.	l_RF_tkm	*l_NNP_Comp*	*1,81087*	*63,2*	*0,0000*	*0,989837*	*-3,40343*	*0,0420*
4.	l_RF_Mg	*l_NNP_Comp*	*1,57622*	*32,77*	*0,0000*	*0,963192*	*-4,21369*	*0,0091*
5.	l_NNP_EH	l_RF_tkm	0,51526	35,04	0,0000	0,967657	-2,99472	0,1336
6.	l_NNP_EH	l_RF_Mg	0,57654	25,82	0,0000	0,941967	-2,17107	0,4385
7.	l_RF_tkm	l_NNP_EH	1,87954	35,04	0,0000	0,967657	-3,12407	0,4385
8.	*l_RF_Mg*	*l_NNP_EH*	*1,63628*	*25,82*	*0,0000*	*0,941967*	*-3,95005*	*0,0175*
9.	*l_NNP_IHM*	*l_RF_tkm*	*0,53573*	*60,44*	*0,0000*	*0,988898*	*-6,02436*	*0,0000*
10.	l_NNP_IHM	l_RF_Mg	0,598533	31,24	0,0000	0,959645	-2,28928	0,3783
11.	*l_RF_tkm*	*l_NNP_IHM*	*1,84640*	*60,44*	*0,0000*	*0,988898*	*-5,85978*	*0,0000*
12.	l_RF_Mg	l_NNP_IHM	1,60497	31,24	0,00E+00	0,959645	-1,92443	0,5673
13.	l_NNP_Hoff	l_RF_tkm	0,529874	31,65	0	0,960637	-2,5797	0,2645
14.	*l_NNP_Hoff*	*l_RF_Mg*	*0,595649*	*26,32*	*0,00E+00*	*0,944056*	*-3,62929*	*0,0368*
15.	l_RF_tkm	l_NNP_Hoff	1,81476	31,65	0	0,960637	-2,79144	0,1899
16.	*l_RF_Mg*	*l_NNP_Hoff*	*1,58721*	*26,32*	*0,00E+00*	*0,944056*	*-3,8129*	*0,0242*

Source: *Authors' calculations.*

On the basis of Granger causality tests for individual variable pairs, the following was confirmed:

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[22]*Granger C.W.J., Engle R.F. (1987) Co-Integration and Error Correction: Representation, Estimation, and Testing, Econometrica, 55(2), 251–276.*

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Two-way long-term interdependencies:

a) The two-way relationship between NNP_Comp and cargo transport by rail was confirmed in both tkm (l_RF_tkm) and Mg (l_RF_Mg) (equations 1-4). In two cases, the influence of the NNP_Comp. variable on the dependent variable (freight transport by rail) was stronger (coefficient $\hat{\beta}$ was 1.811, R^2=98.98% (equation 3) and 1.576 and R^2=96,32% (equation 4)).

b) Equations 9 and 11 confirmed the two-way relationship between l_NNP_IHM and cargo transports by rail expressed in tkm (l_RF_tkm). Similarly to a), the influence of the l_NNP_IHM variable on the dependent variable (cargo transport by rail tkm) was stronger (coefficient $\hat{\beta}$ was 1.846, R^2=98.89% (equation 11), and for the independent variable l_RF_tkm the estimated $\hat{\beta}$ was 0.5357 (equation 9).

c) A two-way relationship between l_NNP_Hoff and cargo transport by rail expressed in Mg (l_RF_Mg) was confirmed (equations 14 and 16). Similarly to a) and b), the impact of the variable l_NNP_Hoff on the dependent variable (cargo transport by rail Mg) was stronger (coefficient $\hat{\beta}$ was 1.587, R^2=94.4% (equations 16), and for the independent variable l_RF_Mg the estimated $\hat{\beta}$ was 0.5956 (equation 14).

Long-term one-way impact:

a) The l_NNP_EH variable was the cause for the variable l_RF_Mg (estimated $\hat{\beta}$ was 0.5956, R^2=94.2% (equation 14), but also the variable l_RF_Mg was not the cause for the l_NNP_EH.

b) The long-term relationship for equations 5-7, 10, 12-13 and 15 was not confirmed.

According to Granger's theorem on representation, if the variables Y_y and X_t are integrated for the first degree I(1) and are cointegrated, then the relationship between them can be presented as a vector error correction model (VECM), and impulse responses, which will be the subject of further research of the authors[23].

5. Conclusions

The Engle and Granger cointegration method, although simple, can give measurable results in establishing long-term correlations between the analysed time series for economic variables, usually non-stationary.

The authors, after establishing (ADF and KPSS tests) that the variables are integrated in the first order I(1), used the two-stage Engle and Granger test for further research.

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[23] *Maddala G.S. (2008) Ekonometria, Wydawnictwo Naukowe PWN, Warszawa, 632-633.*

Research has shown that there was a long-term two-way relationship between economic growth estimated in the l_NNP_Comp model and rail freight transport expressed in both tkm and Mg. The correlation was also confirmed for the l_NNP_IMH series and rail freight, and for the variable pairs: l_NNP_Hoff and l_RF_Mg.

At the same time, it was observed that the variable l_NNP_EH is the cause for the variable RF_Mg. It is worth noting that for seven equations, the long-term relationship has not been confirmed.

Considering these results, it can be confirmed that the railways, being a symbol of the era, and also a leading sector of the German economy, however, played an important role in shaping the modern economy and multiplying Germany's social well-being, in that it can be considered as one of the causes of economic growth. On the other hand, the high economic growth rate of the German Reich was an important factor determining the development of transport, and at the same time it was proven that economic growth was a factor more strongly affecting rail freight than vice versa.

Thus, the obtained research results confirm the hypothesis about the long-term correlation of the time series of the considered variables, while being the starting point for further studies using a larger number of exogenous variables and the use of Johansen tests and VECM models. It is also a confirmation that under the conditions of Germany, the thesis about the great importance of railways, including the theory of leading sectors, formulated by Rostov, has been rightly emphasized[24].

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[24]*Rostow W.W. (1960) Th e stages of economic growth: A non-communist manifesto, New York, Cambridge University Press, 4–16.*

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