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Impact of Grain Export on the Russian Empire's Industrial Development in the Late 19th and Early 20th Centuries

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Article info

Key words: grain export, foreign trade, industrial development, Russia Empire, VECM.

JEL: N5, N13

Abstract

This paper deals with the problem of the grain export impact on Russia's industrial development in the late 19th and early 20th century. Authors estimated VECM models to analyze how grain export affected industrial growth. It was concluded that grain export had a long-term negative impact on industry growth in Russia. There are four possible channels of influence: through consumption, through savings, through the distribution of labor and through investment. The authors considered the investment-related channel of influence and concluded that grain export had a negative long-term impact on industrial capital. Their argument stems from the fact that at the end of the 19th and beginning of the 20th century, grain exporters were predominantly small, export profits were widely dispersed among intermediaries and traders preferred to invest not in Russia but elsewhere.

Влияние экспорта зерна на промышленное развитие Российской

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империи в конце XIX - начале XX веков

Наталья Розинская, Анна Архина

Информация о статье

Ключевые слова: экспорт зерна, внешняя торговля, промышленное развитие, Российская Империя, VECM.

JEL: N5, N13

Аннотация

Данная статья посвящена проблеме влияния экспорта зерна на промышленное развитие России в конце XIX - начале XX века. Авторы используют модель VECM для анализа влияния экспорта зерна на промышленный рост. В статье делается вывод о том, что экспорт зерна оказывал долгосрочное негативное влияние на рост промышленности в России в рассматриваемый период. Авторами обсуждается четыре возможных канала влияния: через потребление, через сбережения, через распределение рабочей силы и через инвестиции. В результате исследования последнего канала влияния авторы приходят к выводу, что экспорт зерна оказывал долгосрочное негативное влияние на промышленный рост через негативное влияние на промышленный капитал. В определенной степени это можно объяснить тем, что в конце 19-го и начале 20-го века экспортеры зерна были преимущественно небольшими, экспортная прибыль распределялась между большим количеством посредников, а трейдеры предпочитали вкладывать средства не в Россию, а в другие страны.

Introduction

The influence of export on economic development has long been discussed, and this discussion remains relevant to this day. Studies on this topic may be split into two groups. The first group includes papers examining the role of high-added-value agricultural export (sausage, cheese, wine, etc.) in economic growth. These studies do not question the beneficial impact of this type of export on economic development but only consider the mechanisms of such impact, causal relationships, methods that stimulate such exports, and so on (Bernard and Jensen, 1999, 2004a, 2004b; Baldwin, 2000; Giles and Williams, 2000a, 2000b; Lopez, 2005; Wagner, 2006a, 2006b).

Studies in the second group examine how the export of low-added-value goods (grain, cocoa beans, copper, oil, etc.) affects economic, particularly industrial, growth. In post-Soviet Russia, the economic significance of oil and gas exports highlighted how commodity export may influence economic development. Relevant publications discuss problems related to the “resource curse” and “Dutch disease” (Sachs and Warner, 1997; Ross, 2001; Mehlum et al., 2006; Bjørnland and Thorsrud, 2016). In addition to being the global leader in oil and gas exports, Russia currently leads grain exports, which raises questions on the impact of this type of resource export on industrial development.

Researchers started examining how grain export affects economic development in as early as the 19th century, a period when several European countries were attempting to transition from agricultural to industrial societies. German economist F. List (2005) was one of the first scholars to address this point, as evidenced by his 1841 work *National System of Political Economy*. At the time, grain export played a particularly significant role in the economic development of the Russian Empire since the country remained a predominantly agrarian society at the end of the 19th century, with approximately 85% of the population depending on the agricultural sector for their livelihood (Statistical Yearbook of Russia, 1915, p. 61) and grain being the most important component of the regional food balance. Therefore, the period’s core research issues were factors affecting the prices of various grain types and adequacy of the produced amount of grain with respect to consumers’ standards. Another highly concerning issue faced by Russian economists was changes in grain marketability—the dynamics of growth in the share of grain entering the domestic or foreign market. This issue raised further problems related to grain export and its impact on the economy (Kulyabko-Koretsky, 1903; Lyaschenko, 1912; Broshniovsky, 1914; Kondratyev, 1922).

The next step of the problem discussion was the publication of Gerschenkron’s works, in which he investigated the stages of and factors affecting Russian Empire’s industrialization during the late 19th and early 20th centuries. Further, Gerschenkron (2015) concluded that, despite having a negative impact on peasants’ standard of living, grain export was one of the forces driving industrialization and it positively influenced industrial production at the time. For a long time, this perspective was generally accepted.

Petr Lyashchenko believed that trade surplus enabled the accumulation of initial capital and grain exports significantly contributed to the achievement of a trade surplus (Lyashchenko, 1927). Further, Soviet historian Taisiya Kitanina drew attention to the positive impact of grain export on economic development. In her works, she asserted that grain export was one of the locomotive powers driving the Russian Empire’s industrial growth, since it significantly contributed to the maintenance of the balance of payments and exchange rate stability. By compensating for the import costs and repayment of foreign debts, grain export helped stabilize the currency rate and facilitated an increase in foreign investments vital to fast-paced modernization (Kitanina, 2011).

Later, researchers started refocusing on pricing-related aspects and debating the extent to which Russia was integrated into the global grain market. Scholars examined how railways affected grain market prices, how the grain export from Russia affected the global grain market, how the Russian economy reacted to the changes in grain prices in world markets, and so on (Metzer, 1974; Mironov, 1985; Goodwin and Grennes, 1998).

Most of the contemporary Russian researchers examined how grain export affected people's standard of living. Similar to Gerschenkron (2015), a number of experts believed that grain export reduced consumption among peasants, who were forced to sell grain to cope with high taxes. However, in contrast to Gerschenkron, they opined that a general decline in consumption led to the stagnation of demand for industrial goods and, thereby, hindered industrial development (Nefyodov, 2010; Chistyakov, 2013). However, . another group of researchers refute this position. According to this group, consumption continued to grow regardless of the variation in export growth and this benefited the industry (Mironov, 2010; Davydov, 2016). This point was discussed in some Western publications, as well (Plaggenborg, 1990).

Some authors, such as Popov and Chibisova (2016), insisted on the negative impact of grain export on modernization. These researchers opined that an increase in bread export had a disastrous impact on investments in the manufacturing industry: According to them, the export of labor-intensive goods may provoke an outflow of capital to countries specialized in producing capital-intensive products, since the export of labor-intensive goods decreases the demand for capital. Therefore, based on these authors' perspective, Russia's grain export had negative long-term consequences, such as slowing down modernization (Popov and Chibisova, 2016). Therefore, at present, there is no consensus among researchers regarding the following: whether grain export influenced the Empire's industrial growth; in case there was any influence, whether this influence was positive or negative. The answers to these questions are our contribution to the discussion about the impact of grain exports on the industry in the Russian Empire in the late 19th and early 20th century. In a broader sense, it may also contribute to the resource curse debate (Papyrakis 2017).

In this paper, we provide new systematic empirical evidence on long-term relationship between grain export and industrial output in the Russian Empire in the late 19th and early 20th centuries. As shown above, there are different points of view on this issue in the literature. Even though the methodology used to carry out empirical analysis does not establish causality our analysis sheds light on ongoing debate. We ultimately document a negative relationship between grain export and industrial output.

Given significant amount of persistence in the time-series we opt for VAR/VECM models which allow us make conclusions about joint behavior of grain export and industrial output. One of the advantages of using this methodology is that it enables us to reveal pattern in which variables co-move together in the long run and share a common stochastic trend.

Historical Overview

In the second half of the 19th century, the economic development of the Russian Empire lagged behind that of the leading economies of Western Europe. At the time, Russia was an agrarian society having a huge, unevenly populated territory, and the majority of the population lived and worked in the European part of the country. According to the first general census conducted in 1897, peasants were the largest social class, comprising 78% of the total population. Therefore, the majority of the population comprised illiterate peasants, whereas the commercial and industrial classes comprised less than 0.3% of the population (Troitsky, 1905, pp. 160–163).

The 1980s witnessed rapid industrial growth in the Russian Empire, and the end of the 19th century is rightfully called the time of the industrialization of the Russian Empire (Mathias and Postan, 1978, p. 265). The Empire's industrial growth was triggered by the rapid construction of railways during the 1860s–1870s (Figure 1). During this period, the development of heavy, medium, and light industries was supported by government policy, as well. American economist Jaconson described the role played by the Russian state in the global economy as follows: "In short, the Russian government is the largest landlord, the largest railway builder, and the largest entrepreneur in the whole world" (Martynov, 2002, p. 218). In the 1880s, the government revised its policy from a predominantly free-trade customs policy to a protectionist one to support domestic industries. The Ministry of Finance considered as its goal the maintenance of currency stability to stimulate foreign investment. In 1897–1899, a monetary reform was implemented and, as a result, the gold standard was adopted. However, the slow growth of the labor force hampered industrial growth. Institutional restrictions were present in both the industrial sector (Cheremukhin et al., 2017) and the agricultural sector, where the *obshchina* (agricultural commune) remained the prevalent owner of peasants' land. It was only in 1906 that individual land ownership started being promoted.

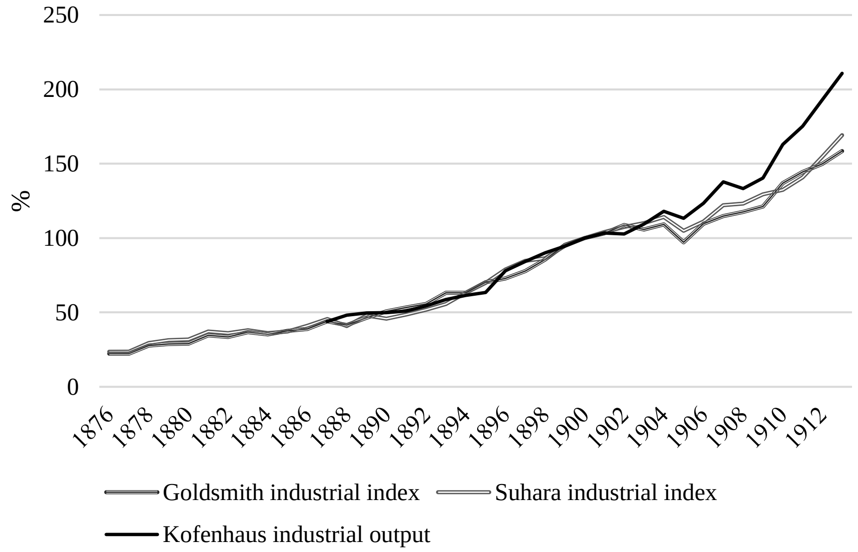

Figure 1. Industrial growth in the Russian Empire over the years

Source: Kafenhaus L.B. (1994) *Evolutsiya Promyshlennogo Proizvodstva Rossii* (The Evolution of Industrial Production in Russia). Moscow: Epifaniya.

Although the country experienced successful industrial development, peasants continued to form the majority of its population and grain remained a significant constituent of domestic export. In the second half of the 19th century, grain constituted approximately half the country's export volume. However, an important change that occurred during this period was the growth of grain export associated with a significant increase in the demand for food in developed European countries, which was driven by population growth (Thompson, 2008).

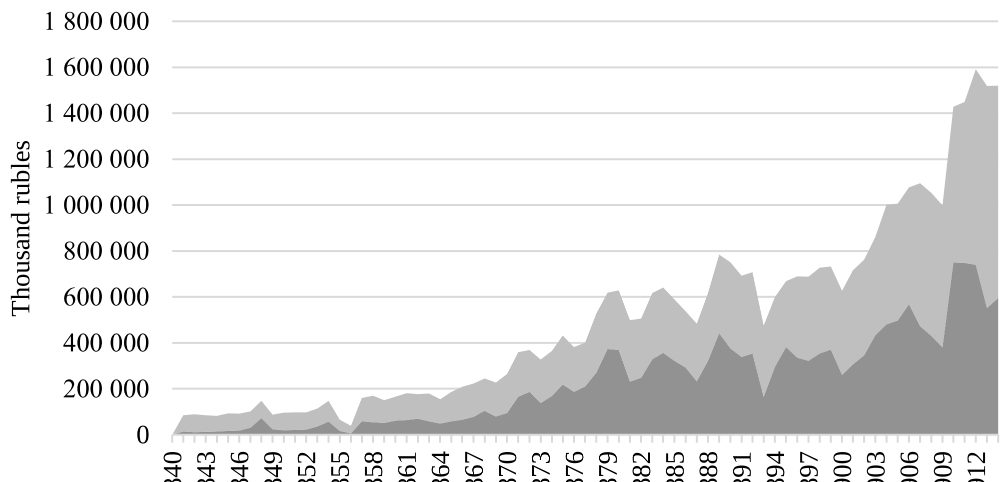

Figure 2. Dynamics of the Russian Empire's export during the 19th century

Source: *Obzory Vneshney Torgovli Rossii po Yevropeyskoy i Aziatskoy Granitsam za* [1840–1915 gg.] (Surveys of Russian Foreign Trade on the European and Asian Borders in [1840–1915]). St. Petersburg-Petrograd: Ministry of Finance Yearbook, 1842–1917.

In the 1880s, Russia held the leading position in the global grain market. In 1893–1897, the country's share in the worldwide trade of four grains (rye, barley, oat, and corn) amounted to 38.0%. Further, the country's shares were 28.3% in 1898–1902 and 35.1% in 1908–1912 (Kitanina, 2011, p. 391). In 1903–1914, Russia exported 24.7% of the world's exported wheat, 37.1% of rye, 42.3% of oat, and 75.8% of barley (Rafalovich, 1918, pp. 13–14).

Despite being one of the leading grain exporters, Russia lagged far behind other countries in grain production efficiency. In fact, it was one among the last countries in Europe and lagged behind major grain-producing countries such as the United States and Canada. In Russia, the average yields of basic bread crops were more than 1.5 times lower than the yield in the United States and more than 2.3 times lower than the yield in Canada (Chistyakov, 2015, pp. 292–293).

Further, in Russia, the growth of grain export was supported by the rapid growth in grain supply (Wheatcroftm, 1991, pp. 171–172). During the second half of the 19th century, grain supply increased due to several reasons. First, the supply from peasants' farms increased significantly, which, due to demographic pressure, were forced to plow up new lands. Second, the development of railways played an important role in increasing grain supply. In the pre-reform era, the railways in Russia were poorly developed, due to which the grain from many regions could not reach the main markets in time. Lyashchenko (1908, p. 236) notes that railways started playing a significant role in the country's economic growth in the mid-1970s, which witnessed the completion of the skeletal railway network connecting the main production regions with the major grain markets.

In the pre-reform era, grain was supplied to the market by landowners. The bread trade was conducted by a big business, which was closely connected with its region and the circle of producers. The construction of railways changed the nature of grain purchases. It created a large number of small buyers who bought and sold bread in small batches. The most affected by the changes was average capital, which could not compete with either the small buyers in the grain trade or the big capital involved in bread production and trade (Kitanina, 2011, p. 80). In this scenario, peasants were the main suppliers of grain to the market.

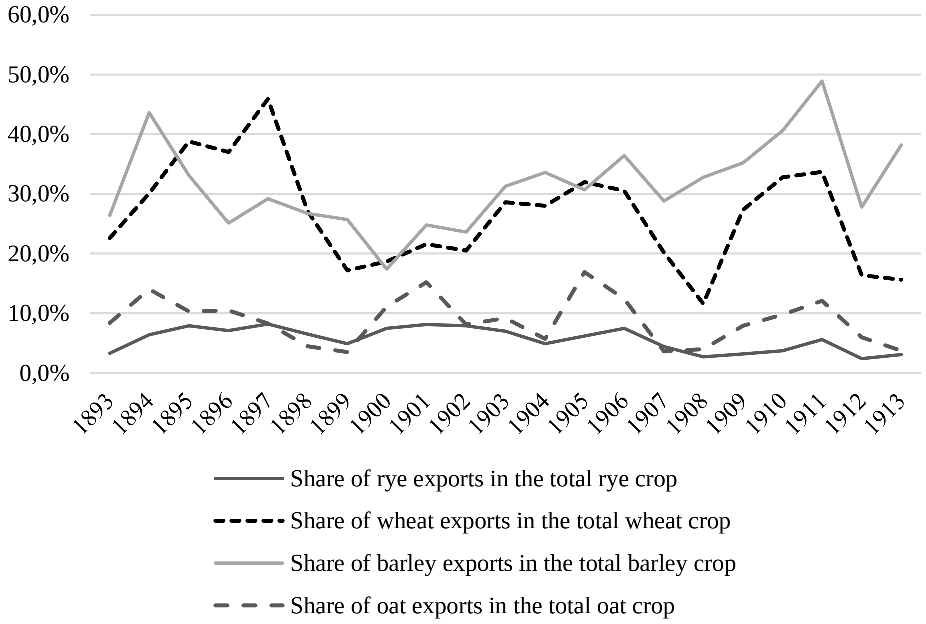

Figure 3. Share of grain exports in the total volume of grain produced

Source: Davydov M.A. (2016) *Dvadcat' let do Velikoj vojny. Rossijskaya modernizaciya Vitte-Stolypina* (Twenty Years before the Great War. Russian Modernization of Witte-Stolypin). Saint Petersburg: ALETEYA.

Wheat was the main export crop during the late 19th and early 20th centuries. It was followed by barley, which even exceeded wheat in terms of export volume in some years (Ostrovskij, 2013, p. 273).

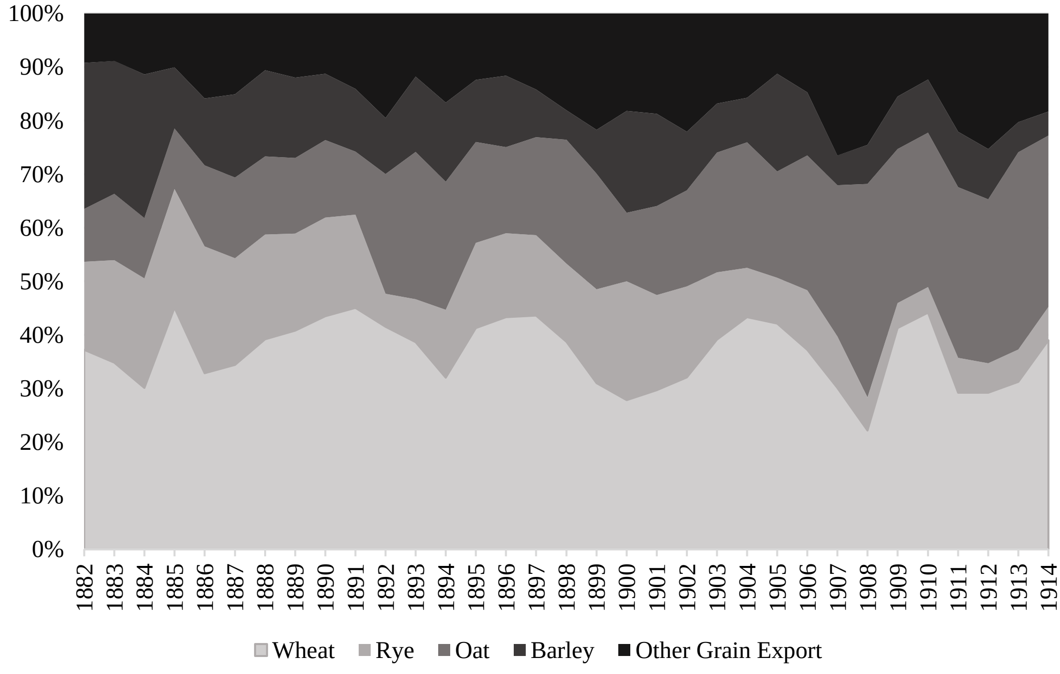

Figure 4. Share of various crops in total grain exports

Source: *Obzory Vneshney Torgovli Rossii po Yevropeyskoy i Aziatskoy Granitsam za* [1840–1915 gg.] (Surveys of Russian Foreign Trade on the European and Asian Borders in [1840–1915]). St. Petersburg-Petrograd: Ministry of Finance Yearbook, 1842–1917.

At the time, grain exports were subject to close government scrutiny. With its help, it wanted to maintain an active trade balance and, thereby, pay off its external debts (Tompson, 2008). Some (Kitanina, 2011) believed that grain export maintained the balance in trade and payment and, thereby, helped stabilize the currency rate. Since grain export constituted approximately half of the total export volume, it could prevent the currency and gold outflows caused by import and loan costs, which, in turn, stabilized the currency rate.

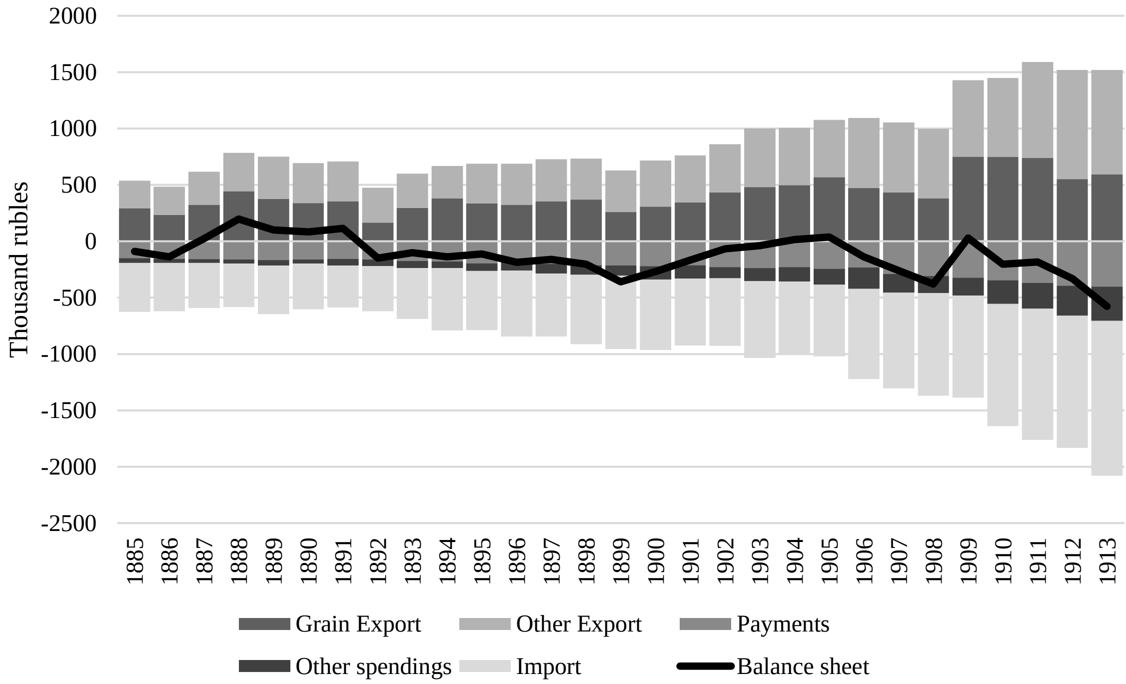

Figure 5. Changes in the Russian Empire's balance sheet over the years

Sources: *Obzory Vneshney Torgovli Rossii po Yevropeyskoy i Aziatskoy Granitsam za* [1840-1915 gg.] (Surveys of Russian Foreign Trade on the European and Asian Borders in [1840–1915]). St. Petersburg-Petrograd: Ministry of Finance Yearbook, 1842–1917.; Gregory P. (2003) *Ekonomichesky Rost Rossiyskoy Imperii (Konets XIX - Nachalo XX v.): Noviye Podschety i Otsenki* (Economic Growth of the Russian Empire (Late XIX–Early XX Centuries): New Calculations and Estimates). Moscow: ROSSPEN

During 1885–1913, the Russian settlement balance largely remained negative, and the Russian Empire was a net debtor. Until 1897, the Empire officially maintained a flexible exchange rate and a currency outflow that weakened the ruble This further increased import prices and prevented the establishment of a favorable investment environment. The 1897 monetary reform initiated by Sergey Witte resulted in the introduction of gold monometallism and free exchange of gold for paper notes at a fixed rate, which effectively meant the establishment of a fixed exchange rate. To cover the deficit in the balance of payments, the Russian Empire had to utilize its gold reserves. Meanwhile, the growth of grain export enabled the limitation of gold outflow and, thereby, contributed to economic stability.

Therefore, during the aforementioned period, grain exports increased, first, due to a number of objective reasons, that is, an increase in demand by foreign states, an increase in the land plowed by peasants in Russia, and the development of railways, and, second, due to the government's policy aimed at increasing grain exports to stabilize the balance of payments, which was supposed to attract investment for industrial development. In this context, it is interesting to examine whether grain exports influenced industrial development as intended by the government.

Empirical Analysis

Taking into account the aforementioned discussion on grain export's impact on the industrial development of the Russian Empire and the Empire's economic trends during the late 19th and early 20th centuries, it is interesting to analyze the statistical relationships that were established between the following factors at the time: industrial output, grain exports, imports (imports of machinery and equipment affected industrial production), and the growth rate of railways (the growth of railways is believed to have contributed to the growth of industry). Since all these variables are endogenous, this study does not attempt to identify any causal relationship but estimates a flexible model without making any a priori assumptions regarding the data-generating process. Although the data were assumed to be governed by a Vector autoregression (VAR) process, we did not make any assumptions necessary for causal inference.

To clarify how the growth of grain export affected modernization, it was necessary to examine whether there was any link between grain export and industrial growth and whether this link was positive or negative. Further, to identify relevant changes in industrial output, the following time series were considered: the Goldsmith industrial index for 1860–1913 (Goldsmith and Raymond, 1961), Suhara industrial index for 1860–1913 (Suhara and Manabu, 2005), Kofenhaus industrial index for 1887–1913 (Kafenhaus, 1994), and gross industrial output for 1887–1913 in million rubles (Kafenhaus, 1994).

To identify industrial capital (investments), we considered the industrial fixed assets and inventories of the factory industry in Russia for 1885–1913, in million rubles (Strumilin, 1958). Further, we obtained data on exports and imports from surveys on the Russian foreign trade conducted on the European and Asian borders during 1887–1915. The grain export includes the following types of grain: wheat, rye, barley, oats, buckwheat, millet, corn, peas, beans, cereals, millet, flour, bran. Finally, to understand the changes that occurred in the railway network, we considered the time series of changes in the lengths of railroads for 1860–1913 in versta[3] (Zheleznodorozhnyj Ezhegodnik, 1904, p. 79; Zheleznodorozhnyj Ezhegodnik, 1905, p. 30; Strumilin, 1958, chapter 4, table 1) and changes in rail freight for 1887–1913 (Strumilin, 1958, pp. 640–641).

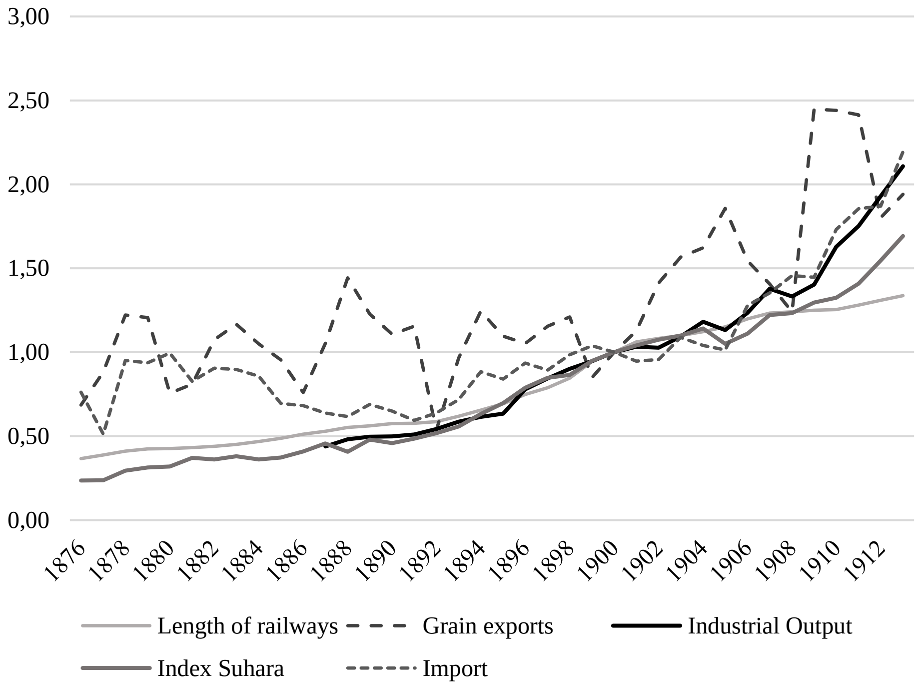

Figure 6. The growth rates of grain export, import and industrial output, and length of railways, in accordance with the Suhara Industrial Index (baseline: 1900)

Sources: *Obzory Vneshney Torgovli Rossii po Yevropeyskoy i Aziatskoy Granitsam za [1840–1915 gg.]* (Surveys of Russian Foreign Trade on the European and Asian Borders in [1840–1915]). St. Petersburg-Petrograd: Ministry of Finance Yearbook, 1842–1917.; Kafenhaus L.B. (1994) *Evolutsiya Promyshlennogo Proizvodstva Rossii* (The Evolution of Industrial Production in Russia). Moscow: Epifaniya.

Since all the variables were endogenous, we estimated the VAR and VECM models according to different specifications, depending on the presence of cointegration between variables and on our assumptions of their relationship. It is noted that while testing for the presence of a relationship between different time series, one should consider the series' specific nature. We first

[3] Versta – 1,0668 km

performed an integration analysis that enabled us to test for stationarity and determine the order of integration (i.e., the least possible number k such that the k-th difference is stationary).

To test for stationarity, we used the Augmented Dickey Fuller tests for different levels of variables and their differences in various orders. Stationarity is rejected in the levels for all variables which we are going to use in the study; it failed to be rejected for their first differences. This suggests that the time series are of the first order of integration (Appendix 1 and 2).

Since the series were stationary in the first differences, we conducted the Johansen cointegration test after checking for the required number of lags. The lags for the autoregressive model were selected according to the information criteria (Appendix 1 and 2). Further, we focused on the presence of cointegration, that is, a pattern in which variables co-move together in the long run and share a common stochastic trend. It is noted that if the relationship between macroeconomic variables is in the form of equilibrium interdependence but we fail to take it into account, then the validity of further empirical investigation will necessarily be questioned. Hence, we attributed paramount importance to testing for the existence of a long-term relationship; further, if the variables happened to be cointegrated, we intended to conclude that they are subject to a common stochastic or deterministic trend. If the cointegration was rejected, then we intended to conclude the absence of long-run co-movements among variables and run the VAR model.

The next step in our empirical analysis was to test for cointegration, which was implemented using Johansen's test. Using the selected variables, we checked for cointegration among different sets of three or four variables. First, the tests rejected the presence of cointegration in sets of four variables. Second, the tests indicated no cointegration for the series for the period 1860–1913. Third, for several sets of three variables for the period 1876–1913, cointegration was not rejected by the trace statistic and Johansen's test revealed the presence of cointegration with one equation (normalization). Since the data for the period 1887–1913 were more abundant and reliable those for other periods, we ran Johansen's tests for the time series for this period and obtained several sets of three variables for which cointegration was not rejected by the trace statistic (Appendix 1-2). Hence, we proceeded to estimate the VECM model for these sets of variables and fitted a VAR model for the remaining sets.

The VECM is the correct specification of a VAR model in the presence of cointegration, which refers to short-term fluctuations of variables around the long-term equilibrium ratio. The coefficients of the error correction terms (ECTs) in each equation will help us evaluate the speed of adjustment to long-term equilibrium. The ECT is the lagged value of the residuals obtained from the cointegrating regression of the dependent variable on the regressors. It contains information derived from the long-run cointegrating relationship.

To run the VECM, we used specifications that showed cointegration according to Johansen’s test. However, we obtained a significant ECT coefficient for only a single specification for the period 1876–1913 and a single specification for the period 1887–1913:

$$\Delta \text{IndSuhara}_t = \sum_{i=1}^{m-1} a_i \Delta \text{IndSuhara}_{\,t-i} + \sum_{j=1}^{n-1} b_j \Delta \text{GrowthR\_GrExp\_b}_{t-j} + \sum_{p=1}^{k-1} c_k \Delta \text{LogR\_road}_{t-k} + \lambda ECT_{t-1} + \varepsilon_t \quad (1)$$

$$\Delta \text{GrowthR\_GrExp\_b}_t = \sum_{i=1}^{m-1} d_i \Delta \text{GrowthR\_GrExp\_b}_{t-i} + \sum_{j=1}^{n-1} h_j \Delta \text{IndSuhara}_{\,t-j} + \sum_{p=1}^{k-1} g_k \Delta \text{LogR\_road}_{t-k} + \delta ECT_{t-1} + \epsilon_t \quad (2)$$

$$\Delta \text{LogR\_road}_t = \sum_{i=1}^{m-1} r_i \Delta \text{LogR\_road}_{t-i} + \sum_{j=1}^{n-1} e_j \Delta \text{GrowthR\_GrExp\_b}_{t-j} + \sum_{p=1}^{k-1} w_k \Delta \text{IndSuhara}_{\,t-k} + \mu ECT_{t-1} + \zeta_t \quad (3)$$

where "IndSuhara" is the Suhara Production Index, "GrowthR_GrExp_b" is growth rate of grain export, "R_road" is the length of the railways (we took it in log to make the first difference of series be stationary).

For the time series for 1887–1913, cointegration was found for the following specification:

$$\Delta \text{Ind\_output\_b}_t = \sum_{i=1}^{m-1} z_i \Delta \text{Ind\_output\_b}_{\,t-i} + \sum_{j=1}^{n-1} s_j \Delta \text{Grain\_export\_b}_{t-j} + \sum_{p=1}^{k-1} f_k \Delta \text{Import\_b}_{t-k} + \theta ECT_{t-1} + \omega_t \quad (4)$$

$$\Delta \text{Grain\_export\_b}_t = \sum_{i=1}^{m-1} q_i \Delta \text{Grain\_export\_b}_{t-i} + \sum_{j=1}^{n-1} x_j \Delta \text{Ind\_output\_b}_{\,t-j} + \sum_{p=1}^{k-1} o_k \Delta \text{Import\_b}_{t-k} + \rho ECT_{t-1} + \psi_t \quad (5)$$

$$\Delta \text{Import\_b}_t = \sum_{i=1}^{m-1} v_i \Delta \text{Import\_b}_{t-i} + \sum_{j=1}^{n-1} l_j \Delta \text{Grain\_export\_b}_{t-j} + \sum_{p=1}^{k-1} u_k \Delta \text{Ind\_output\_b}_{\,t-k} + \varpi ECT_{t-1} + \tau_t \quad (6)$$

where " Ind_output_b " is the growth rate of the value of industrial products, " Grain_export_b" is growth rate of grain export value, "Import_b" is growth rate of import value.

The model's cointegration vector was normalized by the first coefficient of the dependent variable (Appendix 1-2). This indicates that the cointegration relation is a stationary series:

$$ECT_{t-1} = 1.000\text{*IndSuhara}_{t-1} + 1530.648\text{*GrowthR\_GrExp\_b}_{t-1} - 3970.423\text{*LogR\_road}_{t-1} + 15789.99 \quad (7)$$

$$\textbf{IndSuhara}_{t-1} = -15789.99 - \mathbf{1530.648\text{*GrowthR\_GrExp\_b}_{t-1}} + 3970.423\text{*LogR\_road}_{t-1} + ECT_{t-1} \quad (8)$$

$$ECT_{t-1} = 1.000\text{*Ind\_output\_b}_{t-1} + 0.054\text{*Grain\_export\_b}_{t-1} - 2.665\text{*Import\_b}_{t-1} + 1.079 \quad (9)$$

$$\textbf{Ind\_output\_b}_{t-1} = -1.079 - \mathbf{0.054\text{*Grain\_export\_b}_{t-1}} + 2.665\text{*Import\_b}_{t-1} + ECT_{t-1} \quad (10)$$

The results indicate the following: First, there was a negative long-term relationship between industrial growth and grain export, since the long-run ECT is significant in all the four specifications. Second, the grain export coefficient in the cointegration equation is negative in all specifications (Appendix 1-2).

Further, we implemented standard tests to examine the properties of the errors in the VECM model that, at least, partly provided us with additional evidence for the adequacy of the assumptions. We checked whether autocorrelation was present in the errors and the hypothesis of presence of autocorrelation (Appendix 1-2) was rejected. We further inspected whether the errors were normal by running a Jarque–Bera test, which supports the assumption of normal errors, and proceeded our calculations within the normal maximum likelihood framework (Appendix 1-2). In this manner, the analysis revealed a long-term negative relationship between grain export and industrial output.

To identify the relationships among the remaining variables that were not co-integrated, we ran a VAR model. A VAR model is a linear vector model in which the variables simultaneously depend on each other, as well as on their own lags and the lags of other model variables. Therefore, with the help of the VAR model, we identified the correlational dependence both between the factors that determined industrial output and between these factors and the industrial output.

The specification for the VAR model is as follows:

$$\text{Goldsmith\_b}_t = \sigma + \sum_{i=1}^{k} \beta_i \text{Goldsmith\_b}_{t-i} + \sum_{j=1}^{k} \varphi_j \text{Grain\_export\_b}_{t-j} + \sum_{p=1}^{k} \psi_k \text{Truckind\_b}_{t-k} + u_{1t} \quad (11)$$

$$\text{Grain\_export\_b}_{t} = \text{a} + \sum_{i=1}^{k} \beta_i \text{Goldsmith\_b}_{t-i} + \sum_{j=1}^{k} \varphi_j \text{Grain\_export\_b}_{t-j} + \sum_{p=1}^{k} \psi_k \text{Truckind\_b}_{t-k} + u_{2t} \quad (12)$$

$$\text{Truckind\_b}_{t} = \text{b} + \sum_{i=1}^{k} \beta_i \text{Goldsmith\_b}_{t-i} + \sum_{j=1}^{k} \varphi_j \text{Grain\_export\_b}_{t-j} + \sum_{p=1}^{k} \psi_k \text{Truckind\_b}_{t-k} + u_{3t} \quad (13)$$

where "Goldsmith_b" is the Goldsmith Production Index, "Grain_export_b" is the growth rate of the grain export value, "Truckind_b" is the growth rate of the rail freight.

We included a rail freight growth variable in the model to control for the growth of the railroad network, which influenced industrial growth (Gerschenkron, 2015). In doing so, we ignored imports, since the import of machinery and equipment amounted to only a relatively small share of the overall import volume. As shown in Figure 8, machinery and equipment imports averaged 10.05%, ranging from 5.86% in 1889 to 15.95% in 1899. We did not run a VECM model for this specification since tests did not confirm the presence of cointegration in these three variables.

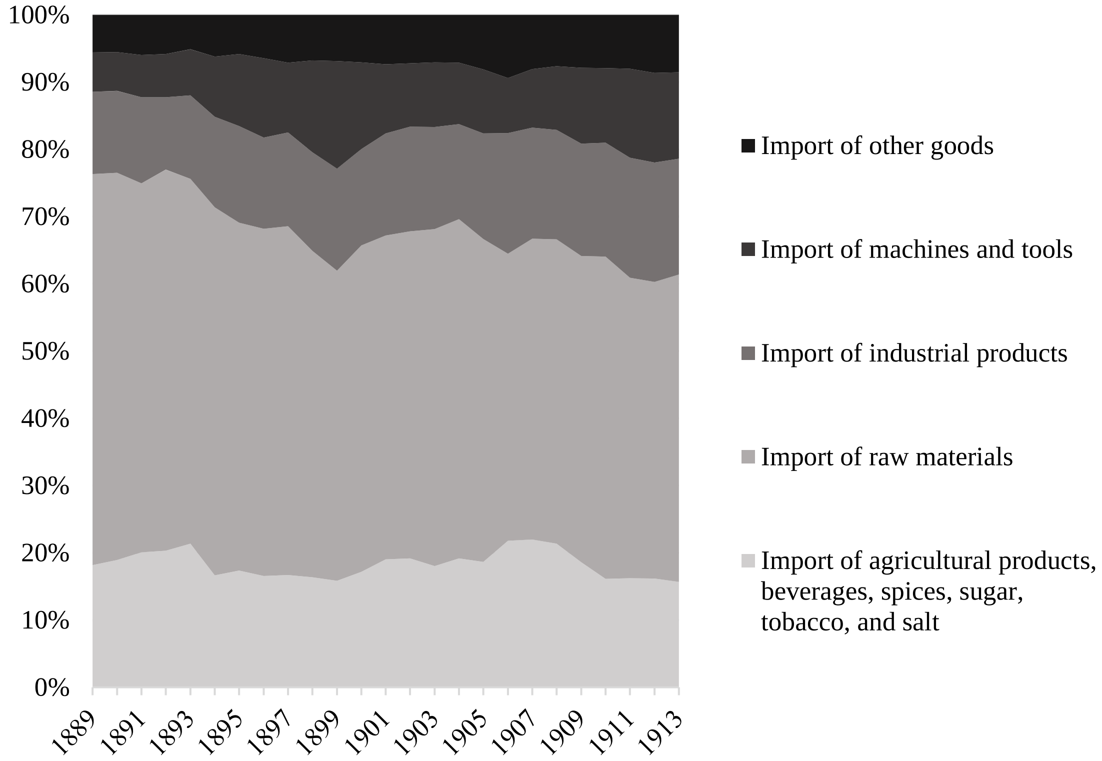

Figure 8. Imports in the Russian Empire during the 19th century

Source: *Obzory Vneshney Torgovli Rossii po Yevropeyskoy i Aziatskoy Granitsam za [1840–1915 gg.]* (Surveys of Russian Foreign Trade on the European and Asian Borders in [1840–1915]). St. Petersburg-Petrograd: Ministry of Finance Yearbook, 1842–1917.

For this model, the corresponding criteria showed the optimal number of lags - 1 (Appendix 3).

Due to the simultaneous interdependence that existed between variables, we could not establish the direction of causality using the VAR model (Appendix 3). In other words, we could not interpret the coefficients in a regular manner. To evaluate the magnitude of changes in the output, we considered its response to an unanticipated grain export shock. We estimated an impulse response function in an exogenous innovation to grain export was captured by the corresponding change in the error term in the relevant equation.

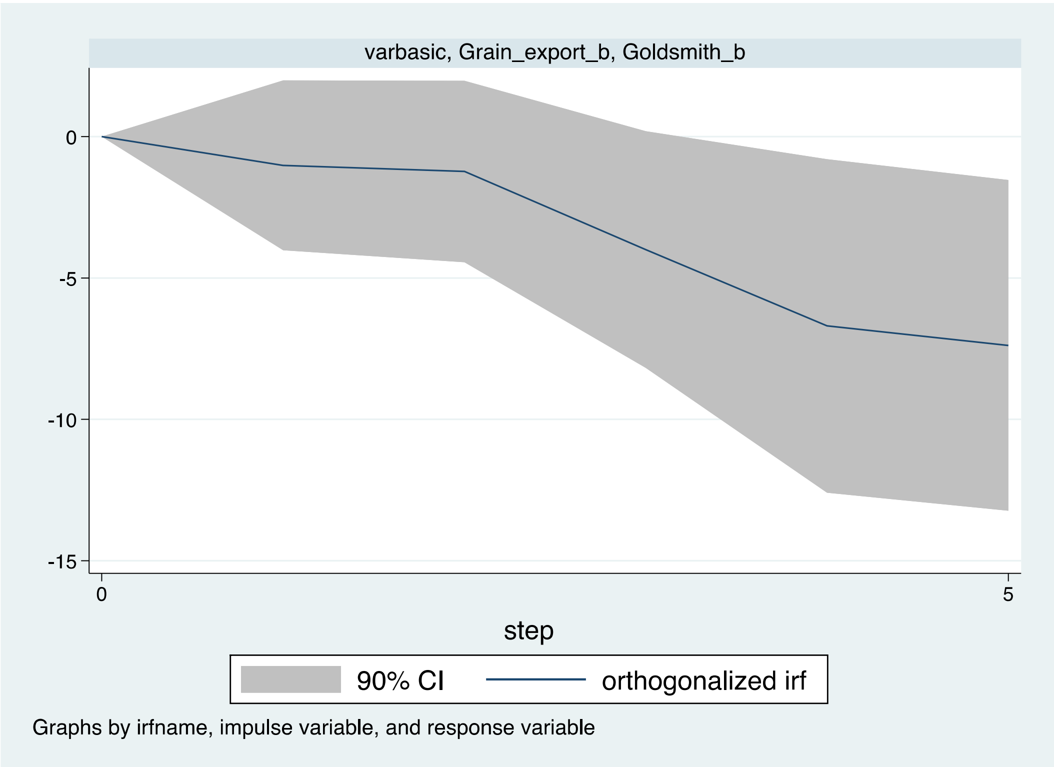

Figure 7. CI: confidence interval, irf: impulse response function ("varbasic" means that this graph is based on the VAR model which is discussed above)

As shown in the graph №7, the output index does not change in response to the unanticipated shock of grain export, since the forecast is not significant for periods 1 and 2. Nevertheless, in the medium-run, a positive shock of grain export implies a drop in the output, as indicated by the forecast based on the information available up to the current period. One standard deviation shock of grain export causes a 7% decrease in the industrial output index.

To obtain an in-depth understanding of the nature of the dependence of variables, we carried out the Granger test (Pistoresi and Rinaldi, 2012). The pairwise Granger causality test reveals whether there is a bilateral impact of grain export on the industrial output, and vice versa. The model reveals the presence of a two-way Granger causal relationship for grain export and the industrial output.

Table 1

Results of the pairwise Granger causality tests

Equation	Excluded	chi2	df	Prob > chi2
Goldsmith_b	Grain_export_b	4.2394	4	0.375
Goldsmith_b	Truckind_b	8.8406	4	0.065
Goldsmith_b	**ALL**	**22.849**	**8**	**0.004**
Grain_export_b	Goldsmith_b	19.395	**4**	0.001
Grain_export_b	Truckind_b	29.832	**4**	0.000
Grain_export_b	**ALL**	**49.493**	**8**	0.000
Truckind_b	Goldsmith_b	51.083	**4**	0.000
Truckind_b	Grain_export_b	21.697	**4**	0.000
Truckind_b	ALL	71.841	**8**	0.000

Based on our empirical analysis, we draw the following conclusions regarding grain export's impact on industrial output. During the late 19th to early 20th centuries, a long-term two-way relationship existed between grain export and industrial growth in the Russian Empire; further, this relationship was negative, that is, grain export negatively affected industrial growth.

Possible Explanations of Grain Export' Impact on Industrial Growth

The results of our econometric analysis can be explained in different ways. Further, there were several possible channels whereby grain export influenced industrial development: consumption, savings, the distribution of labor, and investment.

First, consumption could have facilitated the effect of grain export on industry. A growth in the income of peasants could have led to an increase in demand for industrial goods and, consequently, stimulated the development of the industrial sector. Many studies have investigated the welfare of peasants in the Russian Empire during the second half of the 19th century. One group of authors, headed by Sergei Nefedov, argues that the Russian peasantry suffered from a lack of food during the period. Among other things, this occurred because the growth of population exceeded the growth of agricultural output. Moreover, Nefedov argues that the export of bread further aggravated peasants' starvation (Nefedov, 2010, p. 42). In other words, the increase in grain export led to a decrease in consumption among peasants. Accordingly, the peasants indicated a low demand for manufactured goods.

Another group of authors, headed by Boris Mironov, disputes this conclusion and argues that peasants' well-being increased during this period (Mironov, 2010). Further, in his book *Twenty Years before the Great War*, Mikhail Davydov (2016) particularly refutes the thesis of the so-called "hungry export." He argues that the yield statistics provided by the Central Statistical Committee of the Ministry of Internal Affairs are not completely reliable and the export of bread did not lead to mass starvation (Davydov, 2016). Since the researchers did not reach any consensus on this issue, we cannot say for sure whether grain exports through the consumption channel had a positive or negative impact on industrial growth.

Second, grain exports could have influenced industry by enhancing peasant savings. An increase in the accumulation of peasants' money in bank accounts could be used for lending to the industry. However, the use of peasants' savings to enhance industrial growth is a controversial topic. On the one hand, if the peasants did not have sufficient money for consumption, then, consequently, they practically had no savings. Some authors commented on the almost complete absence of savings among the Russian peasantry at the time (Bruckus, 1922, p. 72). Moreover, the average level of savings per capita of wealthy peasants (4.6 rubles) in 1911 was much lower than that of German (33.05 rubles) or British (78.2 rubles) peasants (Moshenskij, 2014, p. 221). On the other hand, Mikhail Davydov cites statistics pertaining to the growth of savings in various regions, including rural areas. According to these statistics, the amount of deposits of the rural population in the Russian Empire increased by 518.31% between 1897 and 1913, whereas the rural population itself increased by 35.5% over the same period (Davydov, 2016, p. 388). Such contradictory figures require additional research and checking.

Third, grain exports could have influenced industrial growth through the distribution of labor. The high demand for labor in agriculture caused by the growth in grain demand, together with the implementation of institutional restrictions, could have caused a slowdown in the growth of industrial labor supply. The constant growth in demand for grain exports increased the overall demand for grain in the country and, thereby, slowed down the process of peasant impoverishment. Hence, the flow of labor from the agricultural to industrial sector was hampered by not only institutional constraints but also the high demand for grain caused by the growth of grain export.

It is difficult to accurately assess the impact of the aforementioned channels of influence of grain exports on imports. The literature does not provide any clear answers to questions on peasants' welfare and savings. Further, in the context of labor distribution, the main obstacle to the flow of labor from city to village was institutional restrictions (the preservation of the *obshchina* by the government prior to 1906), rather than grain export. Therefore, it is difficult to accurately assess the direction of influence in these channels. However, we assessed how grain exports influenced industrial growth through the investment channel.

To analyze the relationship between grain export and investment, we used the same approach, using as a dependent variable the cost of industrial fixed assets and the commodity and material stocks of Russia's factory industry (Strumilin, 1958, p. 537), which indicated the accumulated industrial capital. The changes in this variable indicate changes in investment in the industry.

$$\Delta\text{LogInvest}_t = \sum_{i=1}^{m-1} a_i \Delta\text{LogInvest}_{t-i} + \sum_{j=1}^{n-1} b_j \Delta\text{LogGr\_exp\_p}_{t-j} + \sum_{p=1}^{k-1} c_k \Delta\text{LogTruck}_{t-k} + \lambda ECT_{t-1} + \varepsilon_t \quad (14)$$

$$\text{LogGr\_exp\_p}_t = \sum_{i=1}^{m-1} f_i \Delta\text{LogGr\_exp\_p}_{t-i} + \sum_{j=1}^{n-1} g_j \Delta\text{LogInvest}_{t-j} + \sum_{p=1}^{k-1} h_k \Delta\text{LogTruck}_{t-k} + \mu ECT_{t-1} + \tau_t \quad (15)$$

$$\text{LogTruck}_t = \sum_{i=1}^{m-1} w_i \Delta\text{LogTruck}_{t-i} + \sum_{j=1}^{n-1} e_j \Delta\text{LogGr\_exp\_p}_{t-j} + \sum_{p=1}^{k-1} r_k \Delta\text{LogInvest}_{t-k} + \nu ECT_{t-1} + \xi_t \quad (16)$$

where "Invest" is the growth rate of the industrial investment, "Grain_export_p" is the growth rate of the grain export, "Truck" is the growth rate of the rail freight.

The model revealed a negative long-term relationship between grain exports and industrial capital (Appendix 4).

We obtained the same result even after adding an additional variable, a real import:

$$\Delta\text{LogInvest}_t = \sum_{i=1}^{m-1} a_i \Delta\text{LogInvest}_{t-i} + \sum_{j=1}^{n-1} b_j \Delta\text{LogGr\_exp\_p}_{t-j} + \sum_{p=1}^{k-1} c_k \Delta\text{LogTruck}_{t-k} + \sum_{z=1}^{q-1} d_k \Delta\text{LogImport}_{t-k} + \lambda ECT_{t-1} + \varepsilon_t \quad (17)$$

$$\text{LogGr\_exp\_p}_t = \sum_{i=1}^{m-1} f_i \Delta\text{LogGr\_exp\_p}_{t-i} + \sum_{j=1}^{n-1} g_j \Delta\text{LogInvest}_{t-j} + \sum_{p=1}^{k-1} h_k \Delta\text{LogTruck}_{t-k} + \sum_{z=1}^{q-1} o_k \Delta\text{LogImport}_{t-k} + \mu ECT_{t-1} + \tau_t \quad (18)$$

$$\text{LogTruck}_t = \sum_{i=1}^{m-1} w_i \Delta\text{LogTruck}_{t-i} + \sum_{j=1}^{n-1} e_j \Delta\text{LogGr\_exp\_p}_{t-j} + \sum_{p=1}^{k-1} r_k \Delta\text{LogInvest}_{t-k} + \sum_{z=1}^{q-1} u_k \Delta\text{LogImport}_{t-k} + \nu ECT_{t-1} + \xi_t \quad (19)$$

$$\text{LogImport}_{t_t} = \sum_{i=1}^{m-1} u_i \Delta\text{LogImport}_{t-i} + \sum_{j=1}^{n-1} s_j \Delta\text{LogTruck}_{t-j} + \sum_{p=1}^{k-1} v_k \Delta\text{LogGr\_exp\_p}_{t-k} + \sum_{z=1}^{q-1} x_k \Delta\text{LogInvest}_{t-k} + \eta ECT_{t-1} + \varsigma_t \quad (20)$$

$$ECT_{t-1} = 1.000{*}\text{LogInvest}_{t-1} + 5.750{*}\text{LogGr\_exp\_p}_{t-1} - 1.0063{*}\text{LogTruck}_{t-1} - 3.049{*}\text{LogImport}_{t-1} - 22.122 \quad (21)$$

$$\text{LogInvest}_{t-1} = 22.122 - 5.750{*}\text{LogGr\_exp\_p}_{t-1} + 1.0063{*}\text{LogTruck}_{t-1} - 3.049{*}\text{LogImport}_{t-1} + ECT_{t-1} \quad (22)$$

The model revealed a negative long-term relationship between grain export and industrial capital (Appendix 5).

To understand why the relationship between the value of accumulated capital in industry and grain export was negative, we clarified the connection between the grain export trade and industry. As mentioned earlier, in the 1960s and 1990s, most of the grain exporters and traders were small entities who did not have sufficiently large capitals to influence the industry. The peasant reform of 1861 and development of railway communication in the 1960s and 1990s resulted in the involvement of remote territories in the grain trade and increased the disunity among grain producers. Marketable grain was no longer monopolized by those with large capitals (as it was—distributed among a few landlords—in the first half of the century), and the grain-trading apparatus was largely made up of small entities (buyers and commission agents) that directly delivered goods to ports and railway stations. During this period, the domestic exporters themselves broke up into smaller units, and a growing number of small and untrustworthy firms seemed to be engaged in grain export (Kondratyev, 1922). Further, more than half of Russia's grain exports during the period were supported by foreign capital (Kitanina, 2011, p. 236).

At the time, foreign investments played a key role in enhancing the Russian Empire's industrial growth. Foreign companies actively invested in the creation of industrial enterprises and participated in the management of banks and joint-stock enterprises. According to some estimates, from 1880 to 1913, foreign investments accounted for approximately half of the Empire's industrial investments (Milyukov, 1909; Ol, 1922). However, in time, domestic capital started playing an important role in industrial development. In particular, the last third of the 19th century witnessed the revival of domestic entrepreneurship and the finance sector. If industrial development had previously been supported by public investments, most enterprises were financed by joint-stock capital—both domestic and foreign—in the beginning of the 20th century (Moshensky, 2014, p. 114). The nobles sought out new ways to generate income: although some of them created their own industrial enterprises and participants in joint-stock companies (e.g., A.I. Putilov), most preferred to invest their capital and the money received from redemption payments in shares and bonds of industrial enterprises. On being freed from serfdom, artisans and peasants started establishing their own businesses, as well. Finally, both old (the Stroganovs) and newly formed (the Morozovs) industrial dynasties started finding uses for their capital.

The beginning of the 20th century witnessed the return of large commercial capital to grain trade. Gradually, merchants began to actively use their bank credits, although smaller buyers tended to rely on personal connections, and grain elevators and large buyers associated with banks started making an appearance. Before the First World War, large capital demonstrated activity in both the grain trade and the foundation of flour mills and joint-stock companies. For example, in 1913, the Stakheev & Co Trade and Industrial Partnership was founded, and its participants were I.I. Stakheev, a merchant, and A.I. Putilov, an industrialist and the head of the Russian–Asian Bank. This partnership became one of the largest monopolistic associations within the Russian Empire and had diverse interests, including the grain trade, metalworking, oil fields, the textile and coal industry, and railways. Some other notable bank-affiliated enterprises were N. Meshkov's trading firm and Hessen-Dyomkin's finance and industry group. In Siberia, the Kruppar Union engaged in grain buying and trade. This union had diverse interests encompassing flour mills, Siberian gold and timber enterprises, a Baltic export partnership, and a Russian–Chinese shipping company.

Nevertheless, the movement toward the concentration of grain trade began only by the beginning of the 20th century. Further, even prior to the outbreak of the First World War, the

Russian grain trade occurred with many intermediaries, among whom profits were eroded (Kitanina, 2011, p. 94). This hindered capital accumulation and investment growth during the period. Moreover, despite the development of domestic firms, foreign capital predominated the period's export trade (Kitanina, 2011, p. 236). Hence, the firms that received capital from the Russian export trade engaged in investment activities not in Russia, but abroad (Tompson, 2008). We found another explanation for the negative impact of grain export on investment in the work titled "Foreign trade and grain prices in the Russian Empire. For or against the neoclassical theorems of foreign trade?" by Popov and Chibisova (2016). Based on the neoclassical model and the theory proposed by P. Samuelson, the authors believe that without grain exports, the Russian Empire would have adopted one method to ensure the balance of payments—the import of capital. In the middle of the 19th century, the country's level of grain exports was low and the Russian Empire was an importer of capital. Subsequently, the high level of grain exports at the end of the 19th century led to a positive trade balance for the Russian Empire, on the one hand, and, according to Popov and Chibisova, a capital outflow abroad, since the capital obtained from the sale of labor-intensive goods tends to flow to countries that produce capital-intensive goods, on the other.

Conclusions

This study analyzed the relationship between grain exports and industrial growth in the Russian Empire during the late 19th and early 20th centuries. We found that a long-term, two-way negative relationship existed between the Empire's grain exports and industrial growth during the period. Subsequently, we offered four explanations for this result:

The first channel of influence is consumption. The growth of peasants' income could have led to an increase in demand for manufactured goods and, thereby, industrial development. However, researchers working on this issue have not reached an unambiguous conclusion regarding the impact of grain exports on consumption.

Savings forms the second channel of influence. An increase in the peasants' income could have led to an increase in their savings in bank accounts and, thereby, an increase in the possibility of lending to industry. However, the literature does not provide any unambiguous assessment of the level of peasants' savings and their relationship with grain exports.

The third channel is the distribution of labor. High grain exports could have increased the demand for labor in rural areas and, thereby, slowed down the flow of labor to cities. However, the demand for grain was not a decisive factor in labor migration.

In this study, we further assessed the fourth channel, that is, investments. We conclude that grain export had a negative long-term impact on the growth of industrial capital. During the latter part of the 19th century, grain exporters were predominantly small entities. Toward the beginning of the 20th century, bread exporters began to grow larger; however, there still remained many intermediaries, who caused the erosion of grain export profits among them. Moreover, firms involved in export preferred to invest outside the Russian Empire. We would however refrain at this point from making deliberate statement regarding resource curse in Russia during the period in question. In our opinion, such a statement would require additional study on what exactly is meant by resource curse, as well as on mechanisms of its manifestation and other relevant issues being widely discussed in the literature.

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Appendix 1. Specification 1.

```
Step 1.

IndSuhara, trend lags(0)

Dickey-Fuller test for unit root                   Number of obs   =        37

                              ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
```

```
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -0.300            -4.270            -3.552            -3.211
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.9895
```

D.IndSuhara, trend lags(0)

```
Dickey-Fuller test for unit root                   Number of obs   =        36

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -5.397            -4.279            -3.556            -3.214
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000
```

GrowthR_GrExp_b, lags(0)

```
Dickey-Fuller test for unit root                   Number of obs   =        37

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -2.580            -3.668            -2.966            -2.616
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0972
```

D.GrowthR_GrExp_b, lags(0)

```
Dickey-Fuller test for unit root                   Number of obs   =        36

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -5.497            -3.675            -2.969            -2.617
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000
```

LogR_road, lags(0)

```
Dickey-Fuller test for unit root                   Number of obs   =        37

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -0.901            -3.668            -2.966            -2.616
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.7876
```

D.LogR_road, lags(0)

```
Dickey-Fuller test for unit root                   Number of obs   =        36

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -2.686            -3.675            -2.969            -2.617
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0764
```

Step 2.

```
Selection-order criteria
   Sample:  1880 - 1913                         Number of obs      =       34
  +---------------------------------------------------------------------------+
  |lag |    LL      LR      df    p      FPE       AIC      HQIC      SBIC    |
  |----+----------------------------------------------------------------------|
  |  0 | -137.634                      .785853   8.27259   8.31852   8.40727  |
  |  1 |  -9.2959  256.68    9  0.000  .000705    1.2527   1.43642   1.79142  |
  |  2 |  9.15471  36.901*   9  0.000   .00041*  .696782*  1.01829*  1.63953* |
  |  3 |  15.4213  12.533    9  0.185  .000499   .857568   1.31686   2.20436  |
  |  4 |  21.1161  11.389    9  0.250   .00065     1.052   1.64908   2.80282  |
  +---------------------------------------------------------------------------+
   Endogenous:  IndSuhara GrowthR_GrExp_b LogR_road
    Exogenous:  _cons
```

Step 3.

IndSuhara GrowthR_GrExp_b LogR_road, trend(constant)

```
                       Johansen tests for cointegration
Trend: constant                                         Number of obs =      36
Sample:  1878 - 1913                                             Lags =       2
-------------------------------------------------------------------------------
                                                         5%
maximum                                      trace    critical
  rank    parms       LL       eigenvalue  statistic    value
    0      12     -8.9908567           .     40.4285    29.68
    1      17      6.3563593     0.57370      9.7341*   15.41
    2      20      11.098126     0.23159      0.2505     3.76
    3      21      11.223401     0.00694
-------------------------------------------------------------------------------
```

Step 4.

Vector error-correction model

```
Sample:  1879 - 1913                            Number of obs     =        35
                                                AIC               =   .6984303
Log likelihood =  13.77747                      HQIC              =   1.097275
Det(Sigma_ml)  =  .0000913                      SBIC              =   1.853832

Equation           Parms      RMSE     R-sq      chi2     P>chi2
----------------------------------------------------------------
D_IndSuhara           8     4.64014   0.5603   34.40005   0.0000
D_GrowthR_GrEx~b      8     .353273   0.6772   56.64914   0.0000
D_LogR_road           8     .008688   0.8174    120.861   0.0000
----------------------------------------------------------------

------------------------------------------------------------------------------
                 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-----------------+------------------------------------------------------------
D_IndSuhara      |
            _ce1 |
             L1. |   .0021059   .0018886     1.12   0.265    -.0015957    .0058075
                 |
       IndSuhara |
             LD. |   .1046895   .1959951     0.53   0.593    -.2794539    .4888329
            L2D. |   .2773216   .2082316     1.33   0.183    -.1308048    .6854479
                 |
  GrowthR_GrExp_b |
             LD. |  -2.977451   1.963878    -1.52   0.129    -6.826582    .8716791
            L2D. |  -.4157691   2.343504    -0.18   0.859    -5.008952    4.177414
                 |
       LogR_road |
             LD. |   174.7604   102.4153     1.71   0.088    -25.96996    375.4907
            L2D. |  -148.5262   110.5187    -1.34   0.179     -365.139    68.08652
                 |
           _cons |     .35539   2.624097     0.14   0.892    -4.787746    5.498526
-----------------+------------------------------------------------------------
D_GrowthR_GrExp_b |
```

```
            _ce1 |
              L1. |  -.0008193   .0001438    -5.70   0.000    -.0011011   -.0005375
                  |
        IndSuhara |
              LD. |   .0267183   .0149219     1.79   0.073    -.0025281    .0559647
             L2D. |   .0458674   .0158535     2.89   0.004     .0147951    .0769397
                  |
  GrowthR_GrExp_b |
              LD. |   .6841949   .1495179     4.58   0.000     .3911452    .9772447
             L2D. |   .3001054   .1784203     1.68   0.093    -.0495921    .6498028
                  |
        LogR_road |
              LD. |  -1.296447   7.797288    -0.17   0.868    -16.57885    13.98596
             L2D. |  -21.82949   8.414236    -2.59   0.009    -38.32108   -5.337886
                  |
            _cons |   .9134771   .1997831     4.57   0.000     .5219095    1.305045
------------------+----------------------------------------------------------------
D_LogR_road       |
             _ce1 |
              L1. |   1.09e-06   3.54e-06     0.31   0.757    -5.84e-06    8.03e-06
                  |
        IndSuhara |
              LD. |  -.0002692    .000367    -0.73   0.463    -.0009885      .00045
             L2D. |     .00018   .0003899     0.46   0.644    -.0005842    .0009442
                  |
  GrowthR_GrExp_b |
              LD. |  -.0019547   .0036772    -0.53   0.595    -.0091618    .0052525
             L2D. |  -.0001162    .004388    -0.03   0.979    -.0087165    .0084841
                  |
        LogR_road |
              LD. |    .680422   .1917631     3.55   0.000     .3045732    1.056271
             L2D. |  -.0034871    .206936    -0.02   0.987    -.4090743    .4021001
                  |
            _cons |   .0037828   .0049134     0.77   0.441    -.0058473    .0134128
-----------------------------------------------------------------------------------
```

Cointegrating equations

```
Equation           Parms    chi2     P>chi2
-------------------------------------------
_ce1                  2   32.42155   0.0000
-------------------------------------------

Identification:  beta is exactly identified

                 Johansen normalization restriction imposed
---------------------------------------------------------------------------------
           beta |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
----------------+----------------------------------------------------------------
_ce1            |
      IndSuhara |          1          .        .       .            .           .
GrowthR_GrExp_b |   1530.648   268.8609     5.69   0.000     1003.691    2057.606
      LogR_road |  -3970.473   843.3177    -4.71   0.000    -5623.345   -2317.601
          _cons |   15789.99          .        .       .            .           .
---------------------------------------------------------------------------------
```

Step 5.

Lagrange-multiplier test

```
  +--------------------------------------+
  | lag  |      chi2    df   Prob > chi2 |
  |------+-------------------------------|
  |   1  |    7.4505     9     0.59032   |
  |   2  |   10.4034     9     0.31882   |
  +--------------------------------------+
   H0: no autocorrelation at lag order
```

Jarque-Bera test

```
  +----------------------------------------------------------+
  |          Equation |            chi2   df  Prob > chi2 |
  |-------------------+--------------------------------------|
  |        D_IndSuhara |           3.246   2    0.19731   |
  |  D_GrowthR_GrExp_b |           2.957   2    0.22801   |
  |        D_LogR_road |           1.926   2    0.38182   |
  |                ALL |           8.128   6    0.22885   |
  +----------------------------------------------------------+

dfk estimator used in computations
```

Appendix №2 Specification 2.

Step 1.

Ind_output_b, trend lags(0)

```
Dickey-Fuller test for unit root                   Number of obs   =        26

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)              0.547            -4.371            -3.596            -3.238
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.9969
```

D.Ind_output_b, trend lags(0)

```
Dickey-Fuller test for unit root                   Number of obs   =        25

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -4.595            -4.380            -3.600            -3.240
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0010
```

Grain_export_b, trend lags(0)

```
Dickey-Fuller test for unit root                   Number of obs   =        26

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -3.031            -4.371            -3.596            -3.238
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.1236
```

D.Grain_export_b, trend lags(0)

```
Dickey-Fuller test for unit root                   Number of obs   =        25

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -5.704            -4.380            -3.600            -3.240
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000
```

Import_b, trend lags(0)

```
Dickey-Fuller test for unit root                   Number of obs   =        26
```

```
                      ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -0.264            -4.371            -3.596            -3.238
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.9903
```

D.Import_b, trend lags(0)

```
Dickey-Fuller test for unit root                   Number of obs   =        25

                      ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -5.758            -4.380            -3.600            -3.240
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000
```

Step 2

Selection-order criteria
Sample: 1891 - 1913 Number of obs = 23

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-26.4669				.002603	2.56234	2.59958	2.71044
1	28.6601	110.25	9	0.000	**.000048***	**-1.44871***	**-1.29971***	**-.856274***
2	32.8547	8.3892	9	0.495	.000076	-1.03085	-.770104	.00591
3	41.3889	17.068	9	0.048	.00009	-.990341	-.617854	.490739
4	53.8514	24.925*	9	0.003	.000087	-1.29143	-.807196	.633974

Endogenous: Ind_output_b Grain_export_b Import_b
Exogenous: _cons

Step 3

Johansen tests for cointegration

Trend: constant Number of obs = 26
Sample: 1888 - 1913 Lags = 1

maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value
0	3	18.819806	.	31.6109	29.68
1	8	27.703758	0.49509	**13.8430***	15.41
2	11	32.253954	0.29532	4.7426	3.76
3	12	34.625251	0.16674		

The test showed that there is cointegration between industrial output, grain exports and import, and there is one cointegration equation.

Step 4

Vector error-correction model

```
Sample:  1889 - 1913                            Number of obs     =        25
                                                AIC               =  -1.014382
Log likelihood =  29.67977                      HQIC              =  -.7844981
Det(Sigma_ml)  =  .0000187                      SBIC              =  -.1855463
```

Equation	Parms	RMSE	R-sq	chi2	P>chi2
D_Ind_output_b	5	.125385	0.7259	52.96307	0.0000

```
D_Grain_export_b      5      .34806   0.1277   2.927133   0.7112
D_Import_b            5     .165961   0.4124   14.03464   0.0154
----------------------------------------------------------------

----------------------------------------------------------------------------------
                 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-----------------+----------------------------------------------------------------
D_Ind_output_b   |
            _ce1 |
             L1. |   -.191885    .052608    -3.65   0.000    -.2949948   -.0887751
                 |
    Ind_output_b |
             LD. |  -.1591768   .2218791    -0.72   0.473    -.5940519    .2756982
                 |
  Grain_export_b |
             LD. |   .0817295   .0756826     1.08   0.280    -.0666056    .2300646
                 |
        Import_b |
             LD. |  -.1208706   .2149505    -0.56   0.574    -.5421658    .3004247
                 |
           _cons |  -.0160177   .0474674    -0.34   0.736    -.1090522    .0770168
-----------------+----------------------------------------------------------------
D_Grain_export_b |
            _ce1 |
             L1. |  -.1289786   .1460362    -0.88   0.377    -.4152043    .1572471
                 |
    Ind_output_b |
             LD. |  -.8902399   .6159207    -1.45   0.148    -2.097422    .3169425
                 |
  Grain_export_b |
             LD. |  -.2050816   .2100895    -0.98   0.329    -.6168494    .2066861
                 |
        Import_b |
             LD. |  -.0380846   .5966874    -0.06   0.949     -1.20757    1.131401
                 |
           _cons |   .0189622   .1317663     0.14   0.886    -.2392949    .2772194
-----------------+----------------------------------------------------------------
D_Import_b       |
            _ce1 |
             L1. |  -.0968132   .0696324    -1.39   0.164    -.2332902    .0396638
                 |
    Ind_output_b |
             LD. |   .1626428   .2936809     0.55   0.580    -.4129611    .7382468
                 |
  Grain_export_b |
             LD. |   .1141397    .100174     1.14   0.255    -.0821978    .3104772
                 |
        Import_b |
             LD. |  -.3915279   .2845101    -1.38   0.169    -.9491575    .1661016
                 |
           _cons |   .0064851   .0628283     0.10   0.918    -.1166561    .1296262
----------------------------------------------------------------------------------
```

Cointegrating equations

```
Equation           Parms    chi2     P>chi2
-------------------------------------------
_ce1                   2   101.3438   0.0000
-------------------------------------------

Identification:  beta is exactly identified

                 Johansen normalization restriction imposed
--------------------------------------------------------------------------------
          beta |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
---------------+----------------------------------------------------------------
_ce1           |
  Ind_output_b |          1          .        .       .            .           .
Grain_export_b |    .054338   .5116588     0.11   0.915    -.9484947    1.057171
      Import_b |  -2.665352   .3899698    -6.83   0.000    -3.429678   -1.901025
         _cons |   1.078735          .        .       .            .           .
```

Step 5

Lagrange-multiplier test

lag	chi2	df	Prob > chi2
1	9.3894	9	0.40213
2	16.1084	9	0.06465

H0: no autocorrelation at lag order

Jarque-Bera test

Equation	chi2	df	Prob > chi2
D_Ind_output_b	0.622	2	0.73289
D_Grain_export_b	0.443	2	0.80142
D_Import_b	0.809	2	0.66739
ALL	1.873	6	0.93100

Appendix №3 Specification 3

Step 1.

Goldsmith_b, trend lags(0)

Dickey-Fuller test for unit root Number of obs = 26

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-0.410	-4.371	-3.596	-3.238

MacKinnon approximate p-value for Z(t) = 0.9866

D.Goldsmith_b, trend lags(0)

Dickey-Fuller test for unit root Number of obs = 25

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-3.800	-4.380	-3.600	-3.240

MacKinnon approximate p-value for Z(t) = 0.0166

Truckind_b, trend lags(0)

Dickey-Fuller test for unit root Number of obs = 26

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-2.645	-4.371	-3.596	-3.238

MacKinnon approximate p-value for Z(t) = 0.2597

D.Truckind_b, trend lags(0)

Dickey-Fuller test for unit root Number of obs = 25

	Test Statistic	Interpolated Dickey-Fuller: 1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-5.972	-4.380	-3.600	-3.240

MacKinnon approximate p-value for Z(t) = 0.0000

Step 2.

Goldsmith_b Grain_export_b Truckind_b

Selection-order criteria

Sample: 1891 - 1913 Number of obs = 23

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-138.48				44.2196	12.3026	12.3399	12.4507
1	-80.0101	116.94	9	0.000	.605295	8.00088	8.14987	8.59331*
2	-69.8595	20.301	9	0.016	.575184	7.90083	8.16157	8.93758
3	-58.154	23.411	9	0.005	.515773	7.66556	8.03805	9.14664
4	-41.3954	**33.517***	**9**	**0.000**	**.342586***	**6.9909***	**7.47514***	8.91631

Endogenous: Goldsmith_norm Grain_export_b Truckind_b
Exogenous: _cons

Step 3

Vector autoregression

Sample: 1891 - 1913 Number of obs = 23
Log likelihood = -41.39537 AIC = 6.990902
FPE = .3425862 HQIC = 7.475136
Det(Sigma_ml) = .0073428 SBIC = 8.916305

Equation	Parms	RMSE	R-sq	chi2	P>chi2
Goldsmith_norm	13	12.0363	0.9920	2853.75	0.0000
Grain_export_b	13	.25655	0.8748	160.7562	0.0000
Truckind_b	13	.105593	0.9971	7897.309	0.0000

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Goldsmith_norm						
Goldsmith_norm						
L1.	.7245977	.2250949	3.22	0.001	.2834198	1.165776
L2.	.1207296	.3226656	0.37	0.708	-.5116834	.7531426
L3.	.2381938	.2998568	0.79	0.427	-.3495148	.8259024
L4.	-.8933196	.3230685	-2.77	0.006	-1.526522	-.260117
Grain_export_b						
L1.	-.6358522	9.703115	-0.07	0.948	-19.65361	18.3819
L2.	3.926108	9.546586	0.41	0.681	-14.78486	22.63707
L3.	-15.02396	9.012687	-1.67	0.096	-32.6885	2.640583
L4.	-1.787421	11.49278	-0.16	0.876	-24.31286	20.73802
Truckind_b						
L1.	37.85109	23.36792	1.62	0.105	-7.949188	83.65137
L2.	-20.09018	17.14	-1.17	0.241	-53.68395	13.5036
L3.	38.60918	20.86407	1.85	0.064	-2.283655	79.50201
L4.	1.200681	29.84483	0.04	0.968	-57.2941	59.69547
_cons	47.09102	25.9422	1.82	0.069	-3.75476	97.93681

```
Grain_export_b |
Goldsmith_norm |
           L1. |  -.0009841   .0047978    -0.21   0.837    -.0103877    .0084194
           L2. |   -.014458   .0068775    -2.10   0.036    -.0279377   -.0009784
           L3. |  -.0025114   .0063913    -0.39   0.694    -.0150382    .0100154
           L4. |  -.0047135   .0068861    -0.68   0.494      -.01821     .008783
               |
Grain_export_b |
           L1. |  -.0183472   .2068184    -0.09   0.929    -.4237039    .3870095
           L2. |  -.2452124   .2034821    -1.21   0.228      -.64403    .1536051
           L3. |  -.4077577   .1921022    -2.12   0.034    -.7842711   -.0312443
           L4. |  -.1701012   .2449645    -0.69   0.487    -.6502228    .3100205
               |
    Truckind_b |
           L1. |   .4619793   .4980789     0.93   0.354    -.5142373    1.438196
           L2. |   1.350089   .3653329     3.70   0.000     .6340493    2.066128
           L3. |   .7064351   .4447103     1.59   0.112    -.1651811    1.578051
           L4. |  -.5389994   .6361319    -0.85   0.397    -1.785795    .7077961
               |
         _cons |    1.99259   .5529488     3.60   0.000     .9088299    3.076349
---------------+----------------------------------------------------------------
Truckind_b     |
Goldsmith_norm |
           L1. |   .0083282   .0019747     4.22   0.000     .0044578    .0121986
           L2. |   .0022597   .0028307     0.80   0.425    -.0032884    .0078077
           L3. |  -.0059887   .0026306    -2.28   0.023    -.0111445   -.0008328
           L4. |  -.0086273   .0028342    -3.04   0.002    -.0141823   -.0030723
               |
Grain_export_b |
           L1. |  -.2768506   .0851238    -3.25   0.001    -.4436902    -.110011
           L2. |  -.0779551   .0837506    -0.93   0.352    -.2421033     .086193
           L3. |   -.184612   .0790668    -2.33   0.020    -.3395801    -.029644
           L4. |   -.353059   .1008242    -3.50   0.000    -.5506709   -.1554471
               |
    Truckind_b |
           L1. |  -.1071081   .2050028    -0.52   0.601    -.5089063      .29469
           L2. |  -.0615297   .1503663    -0.41   0.682    -.3562423    .2331828
           L3. |   1.196419    .183037     6.54   0.000     .8376727    1.555165
           L4. |   .5670743   .2618237     2.17   0.030     .0539094    1.080239
               |
         _cons |   .8085587   .2275866     3.55   0.000     .3624972     1.25462
--------------------------------------------------------------------------------
```

Step 4

```
Lagrange-multiplier test
  +--------------------------------------+
  | lag  |      chi2    df   Prob > chi2 |
  |------+-------------------------------|
  |   1  |   11.3810     9     0.25049   |
  |   2  |   20.3408     9     0.01592   |
  |   3  |    6.9208     9     0.64536   |
  |   4  |    4.5557     9     0.87119   |
  +--------------------------------------+
   H0: no autocorrelation at lag order


   Jarque-Bera test
  +--------------------------------------------------------+
  |           Equation |           chi2   df  Prob > chi2 |
  |--------------------+-----------------------------------|
  |     Goldsmith_norm |          1.104   2    0.57576   |
  |     Grain_export_b |          1.256   2    0.53371   |
  |         Truckind_b |          0.949   2    0.62223   |
  |                ALL |          3.309   6    0.76921   |
  +--------------------------------------------------------+
```

Appendix №4 Specification 4

Step 1.

LogInvest, trend lags(1)

```
Augmented Dickey-Fuller test for unit root        Number of obs   =        25

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -2.471            -4.380            -3.600            -3.240
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.3426
```

D.LogInvest, trend lags(1)

```
Augmented Dickey-Fuller test for unit root        Number of obs   =        24

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -4.232            -4.380            -3.600            -3.240
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0040
```

LogGr_exp_p, trend lags(0)

```
Dickey-Fuller test for unit root                  Number of obs   =        26

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -3.355            -4.371            -3.596            -3.238
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0577
```

D.LogGr_exp_p, trend lags(0)

```
Dickey-Fuller test for unit root                  Number of obs   =        25

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -5.174            -4.380            -3.600            -3.240
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0001
```

LogTruck, trend lags(0)

```
Dickey-Fuller test for unit root                  Number of obs   =        26

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -1.201            -4.371            -3.596            -3.238
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.9103
```

D.LogTruck, trend lags(0)

```
Dickey-Fuller test for unit root                  Number of obs   =        25
```

```
                           ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -5.053            -4.380            -3.600            -3.240
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0002
```

Step 2.

```
Selection-order criteria
   Sample:  1890 - 1913                              Number of obs      =        24
  +---------------------------------------------------------------------------+
  |lag |    LL      LR      df    p      FPE       AIC      HQIC      SBIC    |
  |----+----------------------------------------------------------------------|
  |  0 | -1.89961                      .000302   .408301   .447368   .555558  |
  |  1 |  65.7651  135.33    9  0.000  2.3e-06  -4.48042  -4.32415   -3.8914  |
  |  2 |  82.3298   33.13*   9  0.000  1.3e-06* -5.11082* -4.83735* -4.08002* |
  |  3 |  90.7106  16.761    9  0.053  1.5e-06  -5.05921  -4.66854  -3.58665  |
  +---------------------------------------------------------------------------+
   Endogenous:  LogInvest LogGr_exp_p LogTruck
    Exogenous:  _cons
```

Step 3

```
vecrank LogInvest LogGr_exp_p LogTruck, trend(constant)
```

Johansen tests for cointegration

```
Trend: constant                                        Number of obs =      25
Sample:  1889 - 1913                                            Lags =       2
-------------------------------------------------------------------------------
                                                             5%
maximum                                        trace    critical
  rank    parms       LL        eigenvalue  statistic     value
    0      12      68.95017          .        34.8373     29.68
    1      17     81.664717     0.63838        9.4082*    15.41
    2      20     85.929545     0.28907        0.8785      3.76
    3      21     86.368812     0.03453
-------------------------------------------------------------------------------
```

Step 4

Vector error-correction model

```
Sample:  1889 - 1913                               Number of obs     =         25
                                                   AIC               =  -5.173177
Log likelihood =  81.66472                         HQIC              =  -4.943294
Det(Sigma_ml)  =  2.92e-07                          SBIC              =  -4.344342

Equation           Parms      RMSE     R-sq      chi2     P>chi2
----------------------------------------------------------------
D_LogInvest          5      .074585   0.6555   38.04999   0.0000
D_LogGr_exp_p        5      .196002   0.6790   42.30341   0.0000
D_LogTruck           5      .054359   0.6377   35.20931   0.0000
----------------------------------------------------------------

-------------------------------------------------------------------------------
              |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
--------------+----------------------------------------------------------------
D_LogInvest   |
         _ce1 |
          L1. |  -.0981293   .0273582    -3.59   0.000     -.1517504   -.0445082
              |
    LogInvest |
          LD. |   .5134837   .1909166     2.69   0.007       .139294    .8876735
              |
```

```
   LogGr_exp_p |
           LD. |   .0402042   .0660601     0.61   0.543    -.0892712    .1696796
               |
      LogTruck |
           LD. |   .1703925   .3294507     0.52   0.605    -.4753191     .816104
               |
         _cons |  -.0042177   .0257651    -0.16   0.870    -.0547165     .046281
-------------+----------------------------------------------------------------
D_LogGr_exp_p |
         _ce1 |
           L1. |  -.3463186   .0718947    -4.82   0.000    -.4872295   -.2054077
               |
     LogInvest |
           LD. |   1.937721   .5017098     3.86   0.000     .9543881    2.921055
               |
   LogGr_exp_p |
           LD. |   .0976022   .1735993     0.56   0.574    -.2426461    .4378506
               |
      LogTruck |
           LD. |  -2.525553   .8657636    -2.92   0.004    -4.222419   -.8286876
               |
         _cons |  -.0007409   .0677082    -0.01   0.991    -.1334466    .1319648
-------------+----------------------------------------------------------------
D_LogTruck    |
         _ce1 |
           L1. |  -.0101161   .0199391    -0.51   0.612     -.049196    .0289638
               |
     LogInvest |
           LD. |   .2003822   .1391431     1.44   0.150    -.0723333    .4730977
               |
   LogGr_exp_p |
           LD. |   .0037543   .0481456     0.08   0.938    -.0906094    .0981181
               |
      LogTruck |
           LD. |  -.2579081    .240109    -1.07   0.283    -.7285131    .2126968
               |
         _cons |   .0662768   .0187781     3.53   0.000     .0294725    .1030811
------------------------------------------------------------------------------
```

Cointegrating equations

```
Equation           Parms    chi2     P>chi2
-------------------------------------------
_ce1                  2   60.21331   0.0000
-------------------------------------------

Identification:  beta is exactly identified

                 Johansen normalization restriction imposed
------------------------------------------------------------------------------
        beta |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
_ce1         |
   LogInvest |          1          .        .       .            .           .
 LogGr_exp_p |   2.224373   .4143327     5.37   0.000     1.412296     3.03645
    LogTruck |  -1.552885   .2091794    -7.42   0.000    -1.962869     -1.1429
       _cons |  -19.63157          .        .       .            .           .
```

Step 5.

```
Lagrange-multiplier test
  +--------------------------------------+
  | lag  |      chi2    df   Prob > chi2 |
  |------+-------------------------------|
  |   1  |    5.5606     9     0.78297   |
  |   2  |    6.1920     9     0.72056   |
  +--------------------------------------+
   H0: no autocorrelation at lag order
```

Jarque-Bera test

Equation	chi2	df	Prob > chi2
D_LogInvest	1.576	2	0.45475
D_LogGr_exp_p	1.213	2	0.54517
D_LogTruck	0.877	2	0.64507
ALL	3.666	6	0.72175

Appendix №4 Specification 5

Step 1

LogImport_p, trend lags(0)

Dickey-Fuller test for unit root   Number of obs   =   26

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-2.306	-4.371	-3.596	-3.238

MacKinnon approximate p-value for Z(t) = 0.4309

D.LogImport_p, trend lags(0)

Dickey-Fuller test for unit root   Number of obs   =   25

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-4.501	-4.380	-3.600	-3.240

MacKinnon approximate p-value for Z(t) = 0.0015

Step 2.

Selection-order criteria
Sample: 1889 - 1913   Number of obs   =   25

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	13.2322				5.6e-06	-.738578	-.684488	-.543558
1	103.8	181.14	16	0.000	1.5e-08	-6.70401	-6.43356	-5.72891*
2	124.086	**40.571***	16	0.001	**1.2e-08***	**-7.04685***	-6.56004*	-5.29167

Endogenous: LogInvest LogGr_exp_p LogTruck LogImport_p
Exogenous: _cons

Step 3.

vecrank LogInvest LogGr_exp_p LogTruck LogImport_p, trend(constant)

Johansen tests for cointegration
Trend: constant   Number of obs =   25
Sample: 1889 - 1913   Lags =   2

maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value
0	20	99.024636	.	50.1221	47.21
1	27	112.5376	0.66076	**23.0962***	29.68
2	32	121.52958	0.51294	5.1122	15.41

```
    3      35      124.07848     0.18447      0.0144     3.76
    4      36      124.08569     0.00058
-------------------------------------------------------------------------------
```

Step 4.

Vector error-correction model

```
Sample:  1889 - 1913                               Number of obs     =         25
                                                   AIC               =  -6.843008
Log likelihood =  112.5376                         HQIC              =  -6.477898
Det(Sigma_ml)  =  1.45e-09                         SBIC              =  -5.526622

Equation           Parms      RMSE     R-sq      chi2     P>chi2
----------------------------------------------------------------
D_LogInvest           6      .08064   0.6174   30.65942   0.0000
D_LogGr_exp_p         6     .201639   0.6772   39.86894   0.0000
D_LogTruck            6     .053891   0.6618   37.17164   0.0000
D_LogImport_p         6     .143036   0.2517   6.389793   0.3810
----------------------------------------------------------------

-------------------------------------------------------------------------------
              |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
--------------+----------------------------------------------------------------
D_LogInvest   |
         _ce1 |
          L1. |  -.0437611   .0145522    -3.01   0.003    -.0722828   -.0152394
              |
    LogInvest |
          LD. |   .2924049   .2746423     1.06   0.287    -.2458841    .8306938
              |
  LogGr_exp_p |
          LD. |   .0747412    .080547     0.93   0.353     -.083128    .2326104
              |
     LogTruck |
          LD. |   .1610026   .3613072     0.45   0.656    -.5471465    .8691517
              |
  LogImport_p |
          LD. |   .0429263   .1593745     0.27   0.788    -.2694421    .3552946
              |
        _cons |  -.0050156   .0280121    -0.18   0.858    -.0599183    .0498872
--------------+----------------------------------------------------------------
D_LogGr_exp_p |
         _ce1 |
          L1. |  -.1690288   .0363872    -4.65   0.000    -.2403464   -.0977112
              |
    LogInvest |
          LD. |   1.038718   .6867343     1.51   0.130    -.3072565    2.384693
              |
  LogGr_exp_p |
          LD. |    .274296   .2014052     1.36   0.173    -.1204509    .6690428
              |
     LogTruck |
          LD. |   -2.55572   .9034372    -2.83   0.005    -4.326424   -.7850155
              |
  LogImport_p |
          LD. |   .1975425    .398511     0.50   0.620    -.5835246    .9786097
              |
        _cons |  -.0092077   .0700434    -0.13   0.895    -.1464903    .1280749
--------------+----------------------------------------------------------------
D_LogTruck    |
         _ce1 |
          L1. |  -.0106998   .0097251    -1.10   0.271    -.0297606    .0083609
              |
    LogInvest |
          LD. |   .0815886   .1835408     0.44   0.657    -.2781447     .441322
              |
  LogGr_exp_p |
```

LD.	.032475	.0538288	0.60	0.546	-.0730274	.1379775
LogTruck						
LD.	-.2414949	.2414582	-1.00	0.317	-.7147442	.2317544
LogImport_p						
LD.	.0674173	.1065085	0.63	0.527	-.1413355	.27617
_cons	.0638868	.0187202	3.41	0.001	.0271958	.1005777
D_LogImport_p						
_ce1						
L1.	-.0399411	.0258118	-1.55	0.122	-.0905314	.0106491
LogInvest						
LD.	.2098552	.4871457	0.43	0.667	-.7449327	1.164643
LogGr_exp_p						
LD.	.2131981	.1428699	1.49	0.136	-.0668218	.4932179
LogTruck						
LD.	-.3455696	.6408672	-0.54	0.590	-1.601646	.9105071
LogImport_p						
LD.	-.1857073	.2826899	-0.66	0.511	-.7397694	.3683548
_cons	.0273472	.0496864	0.55	0.582	-.0700363	.1247308

Cointegrating equations

Equation	Parms	chi2	P>chi2
_ce1	3	43.83539	0.0000

Identification: beta is exactly identified

Johansen normalization restriction imposed

beta	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
_ce1						
LogInvest	1	.	.	.	.	.
LogGr_exp_p	5.750715	1.076232	5.34	0.000	3.641339	7.860091
LogTruck	-1.006204	.8849022	-1.14	0.256	-2.74058	.7281724
LogImport_p	-3.04869	2.047797	-1.49	0.137	-7.062299	.9649194
_cons	-22.12245	.	.	.	.	.

Step 5.

Lagrange-multiplier test

lag	chi2	df	Prob > chi2
1	9.3834	16	0.89679
2	9.8099	16	0.87636

H0: **no autocorrelation at lag order**

Jarque-Bera test

Equation	chi2	df	Prob > chi2
D_LogInvest	1.089	2	0.58001
D_LogGr_exp_p	0.450	2	0.79851
D_LogTruck	0.227	2	0.89282
D_LogImport_p	0.340	2	0.84366
ALL	2.106	8	0.97758

+---+

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