EVALUATION OF THE INFLUENCE OF TRANSPORT AND ICT INFRASTRUCTURE IMPACT ON THE STATE ECONOMIC SECURITY IN THE FOREIGN TRADE SPHERE

ОЦІНКА ВПЛИВУ ТРАНСПОРТНО-КОММУНІКАЦІЙНОЇ ІНФРАСТРУКТУРИ НА ЕКОНОМІЧНУ БЕЗПЕКУ ДЕРЖАВИ В ЗОВНІШНЬОТОРГОВЕЛЬНІЙ СФЕРІ

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This research intends to examine whether transport and communication infrastructure affects countries' economic security indicators in the foreign trade sphere (by the example of the Ukraine's major export commodity group – steel and its articles). To estimate the impacts of transport and communication infrastructure (quality of sea ports, Internet, mobile phones, and fixed-telephones on bilateral trade flows in the steel industry), the author applies various gravity model specifications, including those capturing multilateral resistance terms. The study reveals a positive influence of the quality of sea ports, Internet and mobile phones proliferation on strengthening of countries' economic security in the sphere of foreign trade through increasing exports of steel and its articles.

Key words: *economic security of a state, foreign trade, transport and communication infrastructure, exports of steel, gravity model, quality of sea ports, Internet, mobile phones, steel industry.*

Досліджено проблему впливу транспортно-комунікаційної інфраструктури країни на зміну індикаторів економічної безпеки держави у зовнішньоторговельній сфері (на прикладі основної для України експортної товарної групи – сталі та виробів з неї). Для оцінки впливу чинників транспортної і комунікаційної інфраструктури країни (зокрема: якість морських портів, Інтернет, мобільні телефони, фіксовані телефони) на обсяги експорту та імпорту в металургійній промисловості застосовано різні характеристики гравітаційної моделі, з урахуванням багатосторонніх точок опору. Отримані результати дослідження засвідчили позитивний вплив таких чинників, як якість інфраструктури морських портів, застосування Інтернету і мобільних телефонів на зміцнення економічної безпеки держави у зовнішньоторговельній сфері завдяки збільшенню експорту сталі і її виробів.

Ключові слова: *економічна безпека, зовнішня торгівля, транспортно-комунікаційна інфраструктура, експорт сталі, гравітаційна модель, якість морських портів, Інтернет, мобільні телефони, металургійна промисловість.*

Исследована проблема влияния транспортно-коммуникационной инфраструктуры страны на изменение индикаторов экономической безопасности государства во внешнеторговой сфере (на примере показателя объема экспорта основной для Украины товарной группы – стали и изделий из нее). Для оценки влияния факторов транспортной и коммуникационной инфраструктуры страны (в частности: качество морских портов, Интернет, мобильные телефоны, фиксированные телефоны) на объемы экспорта и импорта в металлургической промышленности применены различные характеристики гравитационного модели, с учетом многосторонних точек сопротивления. Полученные результаты исследования показали положительное влияние таких факторов, как качество инфраструктуры морских портов, применение Интернета и мобильных телефонов на укрепление экономической безопасности государства во внешнеторговой сфере благодаря увеличению экспорта стали и ее изделий.

Ключевые слова: *экономическая безопасность, внешняя торговля, транспортно-коммуникационная инфраструктура, экспорт стали, гравитационная модель, качество морских портов, Интернет, мобильные телефоны, металлургическая промышленность.*

Introduction. The advances in Information and Communication Technology (ICT) over the last 20 years, particularly proliferation of the Internet, fixed-telephones, and mobile phones, have significantly reshaped the way modern firms do their business. Transport infrastructure for trade was also considerably enhanced over the last years by building new sea ports, logistic terminals, airports, highways etc. The impact of these two factors on economic security of the state can be twofold: as an opportunity to strengthen it and as a threat to its sustainability. Can governments be sure that development of transport infrastructure and further ICT proliferation will sustain country economic security in the foreign trade sphere? The economic literature suggests that both transport infrastructure and ICT could be potential trade-enablers, given their ability to reduce costs of search and communication between trade partners.

As a consequence, there is a possibility to increase country's main export flows and thereby strengthen its economic security in the foreign trade sphere. *The scientific (research) problem* is to find an acceptable equilibrium between the possibilities of strengthening the various components of the state's economic security in the conditions of rapid growth of ITC on the one hand, and the risks to it arising from inadequate development of different types of country's transport infrastructure on the other hand.

It should be noted that development of transport infrastructure and ICT requires significant investments from governments and private sector, and, therefore, a thorough scientific justification of the effects, primarily on the socio-economic sphere and,

through it, its impact on the economic security of the state should be analyzed.

Review of the latest research papers and publications. Certain aspects of the analysis and evaluation of economic security of the state in the sphere of foreign trade were discussed in research papers and articles of the domectic scientists, such as, V. Aranchiy [1], Y. Bazilyuk, S. Davydenko, O. Vlasyuk [2], T. Vlasyuka [3, 4], A. Vasil'yev [5], V. Klimchik [6], S. Pirozhkov [7], A. Sharov [8] etc. Approaches to the construction and use of gravity models in the sphere of international trade were elaborated mainly by foreign scientists, such as, J. Anderson [9], M. Melitz [10], J. Bergstrand [11-12], Santos J. Silva [13] and others.

At the same time, a comprehensive analysis of the impact of transport infrastructure and ICT on changes of economic security indicators in the foreign trade sphere requires the development of an empirical model that could form the foundation for justifying managerial decisions regarding the prevention of and overcoming the threats and risks in this sphere.

The research goal of the article is to empirically study the impact of the transport infrastructure and ICT on changing the indicators of economic security of the state in the foreign trade sphere using a gravity model of trade (by the example of Ukraine's main export commodity group – steel and products made of it).

Presentation of the main research material. When choosing a methodological approach, the following objective factors and conditions to be taken into account: i) suitability of the methodology for analyzing and interpreting a particular situation; ii) the reliability of the results obtained; iii) predictive capabilities; iv) availability of expert modeling tools; and, finally, v) the laboriousness of the methodology and the time required to carry out analytical work.

The most common methods used to perform empirical modeling of economic impact assessment are: general equilibrium calculation models (or so-called CGE models: computable general equilibrium models, gravity models [9-11], dynamic inter-industry models based on input-output tables [14], and multiple regression models for assessing the impact of factors on GDP dynamics [15]. In practical terms, estimation of the impacts transport infrastructure and ICT development have on changes in economic security of the state (primarily through indicators reflecting the results of foreign trade) can be done by applying a gravity model of trade that allows in a relatively simple form to assess the key factors of such influence.

In addition to the standard variables used in the modeling of economic security in foreign trade (GDP volume, foreign trade duty rates, transportation costs, exchange rates etc.), the gravity model allows to take into account the influence of institutional factors of a country, such as: existence of regional trade agreements, cultural differences, level of transport infrastructure development, availability and level of corruption and others. Further its main provisions and results are outlined.

To empirically determine the impact of transport infrastructure and ICT on export flows, I apply several specifications of the gravity model. Similar to Baier and Bergstrand [16] and Mattes et al. [17], the estimation procedure includes both the traditional gravity model and one accounting for multilateral resistance. I choose to use fixed effects rather than random effects for panel estimations as proposed by Baier and Bergstrand [16]. The entry point to the econometric analysis is a log-linearized basic specification of the gravity equation:

$$\ln T_{ijt} = \beta_0 + \beta_1 \ln(Y_{it} * Y_{jt}) + \beta_2 \ln D_{ij} + \beta_3 \boldsymbol{F}_{i(j)} + + \beta_4 \boldsymbol{F}_{it(jt)} + \beta_5 \boldsymbol{F}_{ij} + \beta_6 \boldsymbol{F}_{ijt} + \varepsilon_{ijt} \quad \text{Eq. (1)}$$

where exports from country *i* to country *j* is denoted by T_{ijt}, Y is a country's economic mass (GDP), D represents distance and may capture other trade costs, t is a time subscript, ε_{ij} is a bilateral error term, and β_1, β_2, β_3 are unknown parameters. As Table 1 depicts, vectors $\boldsymbol{F}_{i(j)}$, $\boldsymbol{F}_{it(jt)}$, $\boldsymbol{F}_{ij}$, and $\boldsymbol{F}_{ijt}$ refer to the set of both dummy and individual or bilateral country characteristics that are ether time-variant ($\boldsymbol{F}_{it}$, $\boldsymbol{F}_{jt}$, and $\boldsymbol{F}_{ijt}$) or constant over time ($\boldsymbol{F}_{i}$, $\boldsymbol{F}_{j}$, and $\boldsymbol{F}_{ij}$). Notably, not all variables are included to estimate the basic gravity equation (Eq. 1).

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According to Mattes et al. [17], ICT network effects may enhance trade volumes *«when both countries have good ICT development»*. Noteworthy, variables that do not change over time or across all trade partners, such as GDP or country's quality of ports in a given year, will correlate with time-varying country fixed effects. Hence, these variables cannot be included into a model with multilateral resistance (Yushkova, [18]). The same condition applies to country specific ICT variables, therefore the impacts of ICT are only observed through ICT interaction variables. The concluding model is augmented with both bilateral[1] and country-and-time fixed effects to control for any country-pairs' unobserved characteristics in a given year.

Having access to water transportation and better quality of ports are reported to have positive impacts on country's trade competitiveness. Values of currency's real effective exchange rate (REER) above unity are likely to weaken a country's competitiveness on foreign markets and may cause a decrease in exports.

While inclusion of the individual country-specific terms may be a sufficient measure to control for multilateral resistance in a cross-section dataset, in the panel, one needs to account for time-varying country-specific characteristics (Baier and Bergstrand, [17]).

[1] Bilateral fixed effect has the same value for both exports from country *i* to country *j* and exports from country *j* to country *i*, but only in a given year.

Lastly, the estimation procedure for three different samples (hereinafter referred to as «total trade sample», «steel sample», and «articles of steel sample») starts with basic gravity equation and continues by adding various forms of fixed effects such as time, country, country-and-time, and country-pair effects.

There are several issues that determine the estimation order and, thus, need to be clarified. First, to check the adequacy of the aforementioned model specifications, instead of steel exports I begin modeling with total exports as a dependent variable. This exercise permits (i) to find out whether obtained coefficients support theoretical findings; and (ii) to compare obtained coefficients with those of steel products later on. Second, due to the distinction between steel and articles of steel in the HS classifications[2] I estimate impacts of ICT on both «raw» and «processed» steel. This approach allows for finding differences in ICT impacts on both types of steel products.

Estimation of the impact of ICT in all samples is conducted using panel data over the period of 12 consecutive years (2001-2012). The number of exporting countries depends on which export flow is selected. For the sample with total exports there are 153 exporting countries; for the sample with exports of steel – 127 reporters; and for the sample with exports of articles of steel, the number of exporting countries is 128. Unavailability of historical data on ICT variables prior to 2000 hampers the extension of both the time period and country sample.

Even though I discuss the results obtained in all six specifications across three samples, I typically interpret coefficients from the specifications that include all possible unobserved fixed effects, unless otherwise stated. Because I employ log-liner models, all of the coefficients, with the exception of dummies, can easily be interpreted as a percentage change in respective export flow caused by percentage change in an independent variable. The results are laid out in the following order: country-specific and dummy variables; the results on the impacts of three ICT variables, namely the Internet, mobile phones, and fixed-telephones.

Transport infrastructure. Maritime transport is one of the major transportation tools for international shipments of steel and its articles. There are several reasons for that: (i) price of shipping by marine vessel per metric ton may be ten times cheaper as that by airfreight; (ii) marine transport has a comparative advantage against railway because railroads are limited by continent boundaries; and (iii) marine vessels can transport significant tonnage and by doing so increase returns to scale. To see whether quality of ports or ease of getting to the ports to landlocked countries has a significant effect on trade performance, I present estimation results on quality of ports infrastructure. In steel, quality of ports is only significant for exporters – a 10 percent increase in the ports index on average causes a 6 percent increase in steel exports. In articles of steel, the ports index improvement by 10 percent increases exports only by 2.5 percent. At the same time, an importer's quality of ports improvement of 10 percent predicts 0.9 percent higher imports of articles of steel. Thus, the importance of quality of ports for exporters is confirmed in both steel samples. Indeed, ports infrastructure basically determines how accessible ports are for other transportation means, how advanced storage yards are, whether cranes prevent cargo damages, and eventually how fast cargo will be loaded on board and shipped to customers.

Internet. The number of fixed broadband subscriptions appears to be positively significant for exporters in all specifications in total trade and articles of steel samples. The coefficients on the Internet variable lie between 0.05 and 0.3. On average a 10 percent increase in the number of fixed broadband subscriptions in the exporting country leads to a 0.68 percent increase in total exports and 0.48 percent rise in exports of articles of steel, respectively. The same variable happened to have no effect on imports, giving significant estimates only in basic specifications.

Meanwhile, neither specification yields significant results for the exports of raw steel. There are several possible explanations to why the Internet has no impact on trade in raw steel. First, technological advancements in the industry are somewhat slow, that is, mills can successfully work using technological inventions of the early 20th century. Supposedly, those firms who have cheaper raw materials or low labor cost, not high Internet proliferation, get competitive advantage. Second, products like slabs, billets, ingots, and flat-rolled coils are rather homogenous and often used for further processing. Thus, quality control can supposedly be performed without having extensive information technology software as compared with drilling pipes for hydraulic fracking. Third, these products not only can be purchased from mills, but also on open exchanges[3], which implies that the path from mill to customer may involve resellers in other countries and the use of transfer pricing schemes.

The most consistent positive effect of the Internet interaction variables of both exporter and importer in all six specifications is observed in articles of steel, confirming the hypothesis of positive influence of ICT network effects on trade (Mattes et al., [18]). The specification with a country-pair and time-varying effects implies that a 10 percent increase in the Internet interaction variable predicts 0.14 percent higher exports of articles of steel. In steel, coefficients on the same interaction variable receive positive values.

[2] The distinction is further explained in Chapter 6.

[3] Steel billet futures are traded on the London Metal Exchange, hot rolled coil futures – on the New York Mercantile Exchange (NYMEX), and rebar and wire rod futures on Shanghai Futures Exchange. Source: The Platts Steel Futures Guide, https://www.steelbb.com/steelfutures/

Though, in the last specification the Internet interaction loses its significance, which implies the presence of negative unobserved bilateral bias. That is, bilateral fixed effects may have caught unobserved bilateral factors, such as long-lasting contract relationships, supply chains within multinational steel companies, or transportation costs from country to country. A slightly lower coefficient on the Internet interaction is reported in total trade sample: its 10 percent increase leads to 0.06 percent higher volume of exports. Noteworthy, in total trade the Internet interaction variable becomes positive only in the last specification, when country-pair effects are included. Thus, the results demonstrate more significant impacts of Internet network effects on articles of steel rather than on total trade, and no particular effect on exports of raw steel.

As Mattes et al. [18] point out, in the presence of interaction terms, marginal effects of the term's components need to be duly calculated. The obtained coefficient, thus, reports *«the effect of exporting country i's ICT level on its exports for given levels of destination country j's ICT endowment»* (Mattes et al., [18]). Calculation of marginal effects gives some insight. The coefficient remains almost the same for the exporter's Internet endowment (0.066) in total trade. Coefficients in steel as reported earlier continue being insignificant. In articles of steel, the marginal effect of the Internet variable for the exporter rises to 0.08 as compared to previous coefficient's value of 0.05. Moreover, the marginal effect of the Internet for the importer is positive at 0.06.

Mobile phones. Increases in the number of mobile phone connections, which serves as proxy for mobile connectivity, positively affect exports capabilities of steel exporters. Notably, the estimates in steel are almost twice as high as those in articles of steel. On average a 10 percent increase in mobile usage in the exporting country leads to 7.4 percent more exports of raw steel and a 3.4 percent increase in exports of steel articles. Positive coefficients on mobile phone proliferation are also observed for importing countries. Again, higher values are reported in raw steel. A 10 percent increase in mobile phone use implies 8.9 percent higher imports of steel and a 5.7 increase in consumption of articles of steel. Mobile phone variables appear to be insignificant in total trade, when country and time effects are applied.

Unlike the Internet, network effects are not observed for the use of mobile phones when country-pair and time-varying fixed effects are included. Specifications yield somewhat mixed results with coefficients varying from -0.17 to 0.09. This might be explained by the high cost of international calls and that one would rather call to an office landline phone or would use Internet-supported applications such as Skype or a corporate Voice over Internet Protocol network.

Fixed phones. The number of fixed landline phones has negative coefficients in both steel samples and no particular impacts on total exports. However, it does not necessarily mean that higher level of fixed-telephone subscriptions reduces trade due to the presence of the interaction variable. While landline marginal effects were expected to be insignificant in the total trade sample, those turn insignificant in the steel sample. The only significant value of landline marginal effects is obtained for importers of articles of steel. Accordingly, marginal effects for importers receive a value of -0.31, somewhat lower than the ordinary importer's coefficient of -0.5. It can be inferred that fixed phones do not play a critical role in trade anymore, and have eventually been replaced by other communication channels such as emails, mobile connectivity, and Internet-based voice applications. Even fax machines got their Internet-based software substitutes. Though, landlines are still in use by businesses and primarily serve their domestic needs and often are used in combination with email communication.

Conclusions. The empirical analysis has found that the Internet penetration high quality of port infrastructure positively affects countries' capabilities to export articles of steel: a 10 percent increase in the number of fixed broadband subscriptions would lead to about a 0.48 percent growth in exports. Furthermore, the Internet network effects are observed in articles of steel, that is, one would expect higher volumes of trade if both partners are Internet advanced. Mobile phones also appeared to have positive influence on export performance. Accordingly, a 10 percent increase in mobile usage in exporting country would lead to approximately a 7.4 percent rise in steel exports and to about a 3.4 percent growth in exports of steel articles. The results on fixed-telephone use did not confirm the importance of landlines on exports of neither steel nor its articles. Quality of ports received positive coefficients and thus enhances export performance.

The study reveals a positive influence of the quality of sea ports, Internet and mobile phones on strengthening economic security of the state in the sphere of foreign trade through increasing exports of steel and its articles. Potential avenue for further research may include employing firm-level data to examine whether the impacts ICTs vary among individual firms different in size, revenue, location of assets etc. Finally, additional research needed to clarify whether the development of deep-water port terminals capable to accommodate large bulk-carriers, such as Capesize and Newcastlemax vessels, could maintain country's economic security in the energy and foreign trade spheres.

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EVALUATION OF THE INFLUENCE OF TRANSPORT AND ICT INFRASTRUCTURE IMPACT ON THE STATE ECONOMIC SECURITY IN THE FOREIGN TRADE SPHERE

This research intends to evaluate the influence of transport and communication infrastructure on countries' economic security indicators in the foreign trade sphere (by the example of the Ukraine's major export commodity group – steel and its articles). To estimate the impacts of transport and communication infrastructure (quality of sea ports, Internet, mobile phones, and fixed-telephones on bilateral trade flows in the steel industry), the author applies various gravity model specifications, including those capturing multilateral resistance terms. Three different panels for total exports, exports of steel, and exports of articles of steel are analysed over the period 2001-2012.

The empirical analysis has found that the Internet penetration high quality of port infrastructure positively affects countries' capabilities to export articles of steel: a 10 percent increase in the number of fixed broadband subscriptions would lead to about a 0.48 percent growth in exports. Furthermore, the Internet network effects are observed in articles of steel, that is, one would expect higher volumes of trade if both partners are Internet advanced. Mobile phones also appeared to have a positive influence on export performance. Accordingly, a 10 percent increase in mobile usage in exporting country would lead to approximately a 7.4 percent rise in steel exports and to about a 3.4 percent growth in exports of steel articles. The results on fixed-telephone use did not confirm the importance of landlines on exports of neither steel nor its articles. Quality of ports received positive coefficients and thus enhances export performance.

The study reveals a positive influence of the quality of sea ports, Internet and mobile phones on strengthening the economic security of the state in the sphere of foreign trade through increasing exports of steel and its articles.