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Determinants of high-tech export in developing countries based on Bayesian model averaging*

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Abstract

Given the importance and role of high-tech exports in economic growth, it is necessary to identify variables affecting export. Accordingly, in this article we studied the determinants of export for 24 developing countries during the period 1996 to 2013 based on Bayesian Model Averaging (BMA) and Weighted-Average Least Square (WALS) technique. The results show that rule of law as a proxy for Institutional quality, human capital, import (as a measure of openness) and GDP with posterior inclusion probability 100% are the most important variables influencing the high- technology export in developing countries.

Key words: *high technology export, Bayesian model averaging, weighted-average least square, developing countries*

JEL classification: *F43, C11*

1. Introduction

Recently, the global economy has witnessed a boom in high-tech goods trade. To stimulate growth and exports, the developing countries under trade constraints, have no choice but to produce high-tech production and reduce production costs.

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The empirical literature assumes that high-tech products enjoy the fastest growing segment of international trade. In fact, there is strong evidence that developing countries are increasingly exporters of high-tech products (Srholec, 2007). In order to make any changes in the foreign trade sector, especially exports, it is necessary to identify the determinants of export. In the empirical and theoretical studies, there is a wide range of variables including production, exchange rates, inflation, economic openness, institutional arrangements as the determinants of exports(e.g. Filippini and Molini, 2003; Tebaldi, 2011; Sandu and Ciocanel, 2014). However, in the conventional econometric methods, a wide range of all variables cannot be considered. Thus, the researchers select the combinations of variables based on intuitions and individual judge to use in their models. However, generally, the estimation of each variable's coefficient depends on the combination of other variables included in the model. In fact, the econometric experts have always had uncertainties in selecting the proper variables and models (or combination of variables). The Bayesian econometric approach could overcome the uncertainty in the selection of variables, as well as models through the use of the "Bayesian Model Averaging (BMA)". The main hypothesis of the paper is that the standard theory based on the conventional variables such as price or scale ones cannot satisfactorily explain the evolution of high-tech export in developing countries. So in this article the determinants of the high-tech exports are reviewed and the share of each of these factors are estimated using the "Bayesian Model Averaging (BMA)" and "Weighted-Average Least Square (WALS)".

After introduction, in the second section, the theoretical foundations are discussed. The third part is devoted to the research methodology and model. The fourth section also analyzes the data and empirical results. Finally the fifth section concludes.

2. Literature review

High technology exports are considered as an important factor for sustainable economic growth for a country Export is the foreigners' demand for domestic goods. Several factors affect the trade flows among countries. Trade is attributed to the difference in technology between countries (Ricardian theory), relative abundance of factors or factors endowment (Heckscher-Ohlin theory) as well as the continuous renewal of the existing technologies and their transfer to other countries (Posner, 1961; Vernon, 1966). Vernon (1966) examines changes in international trade in constructing a 'product-cycle' hypothesis. He argues that innovation and production be likely to to be concentrated in countries where new needs and wants are first making themselves known. Vernon explicitly rejects not only factor proportions but also comparative costs as determining the location of production – and later export – of new products. Instead, he expects that new products will be first produced in, and later exported from, the country where they are first demanded. Only later still, when the product matures and becomes standardized, does its production move to a location of lower cost. Contrary to Vernon, Hirsch (1968) argues that new products go through a cycle of systemic changes in technology. New products at first need to large amounts of skilled labour in their production and development. As larger quantities are demanded, however, more capital intensive production techniques become appropriate. Eventually, when products mature and become standardized, the production process becomes routine, and less skilled labour can play a greater and greater role. He express the location of production by essentially applying the multi-factor Heckscher-Ohlin theory to this model of factor intensities among new, growing, and mature products. Heckscher-Ohlin theory suggests that the plenty of the factors in a country determines the relative cost of production and is therefore the specialization and composition pattern of the export basket of the country. Thus, it is expected that countries that have more abundant natural resources export natural resources or products that intensively use more natural resources. It is predicted that countries like China and India where labor is abundant produce and export labor-intensive goods such as toys and clothing. Similarly, it is expected the economies enjoying more sophisticated capitals export more complex and technology-intensive products such as pharmaceuticals, chemicals, and electronic machines (Schott, 2008).

As it is expected, a country's export basket is a combination of most productive goods; the relative abundance of the factors will play a central role in the pattern of export specialization and sophistication. In addition, based on the firm specialization and diversity of the consumer's preferences, new trade theories can explain how countries may trade similar products with each other (which are known as intra-industry trade). Therefore, the variety of the products that a country can produce and export is a function of the plenty of its resources (Krugman, 1979; Schott, 2008).

The production factors in a country can be categorized into natural resources, labor, physical capital, and knowledge-based capital. Natural resources such as land, crude oil, gas, and mining are the basic inputs in industrial development. At the same time, the Resource Curse Hypothesis suggests that the abundance of resources causes lower levels of physical and human capital accumulation, and therefore productivity growth. The empirical studies conducted by Sachs and Warner (1999, 2001) and Leamer et al. (1999) indicate that the abundance of natural resources has a negative effect on the long-term economic growth and technical upgrading. However, Sachs and Warner's results are not robust and depends on the estimation method of the abundance of the resources (Lederman and Maloney, 2003). Stijns (2005) concludes that natural resources can affect the economic growth both positively and negatively and the resource curse can be true about the oil and gas. Hausmann et al. (2007) study confirms the negative correlation between land area and the export sophistication level. On the other hand, Brunnschweiler (2008) using a new measurement of the natural resource richness found a positive correlation between the natural resources abundance and the economic growth during the period from 1970 to 2000.

Exchange rate appreciation would have been somewhat detrimental to exports, whilst depreciation would have somewhat aided exports. However, that exports surged during the period of currency appreciation could be attributed to one of the following possibilities or combinations of them. First, the import content of exports could have been relatively large so that exports would be little affected. Second, external demand could have been rising. Third, productivity could have been rising. Fourth, pricing policies could have countered the negative effects of currency appreciation. Given rigid nominal wages, the Mundell – Fleming model implies that for small open economies, an exchange rate appreciation would hurt exports and encourage imports. This standard textbook theory and its prescriptions assume that markets are perfect and prices are given by world markets. In several situations, as cited in Athukorala (1991) and Athukorala and Menon (1994), the authors argue that, in varying degrees, exporters maintain competitiveness in world markets by reducing their profit mark-up in the face of an appreciating currency.

In addition to the labor force and physical capital as the key factors in the productive activities, the new growth theories emphasize that knowledge and human capital as the engine and stimulator of the long-term growth (Romer, 1990). Knowledge and human capital can be acquired through transfer, and attraction of the international knowledge and participating in the international trade including the foreign direct investment. Human capital and research and development (R & D) are the two major factors that affect the creation of the indigenous knowledge (Fu and Gong, 2011; Lucas, 1988; Romer, 1990). When a country's human capital and skills increase, it provide institutional backgrounds that are more similar to the developed countries ones (Schott, 2008).

One of the most important prerequisite to high tech manufacturing and export is technology ownership. Technology ownership can be gained through technology transfer by the way of inward foreign direct investments (Gökmen and Turen, 2013). Imports and foreign direct investment (FDI) are the two important channels of international technology transfer. These factors as well encourage the development of the industrial technology in the domestic industries due to the effects of the vertical communication (Coe and Helpman, 1995). The imports and foreign direct investments are reflected on the technological progress of a country both directly through intermediate inputs and better machines and also indirectly through knowledge spillovers to the host country exports. In addition, due to the fragmentation of the global production chains and increase of the global outsourcing, some developing countries export technology-intensive products through participation in activities focused on processing and trading. However, such exports do not necessarily indicate that these countries have the ability to produce complex products: They are in fact the result of processing and assembling the imported intermediate into high-tech goods (Fu, 2011; Xu, 2010). However, the imports affect the complexity of the country's exports by importing the intermediate goods which are associated with the processing activities. All of these, to some extent, increase the share of the high-tech products exports in the total exports of the developing countries: This ratio has increased from 11% to 19% between the mid-1990s to 2004 (IMF, 2008).

According to Kravis (1956), international trade is caused by differences in the availability of certain products among countries. When poor availability at home is due to lack of natural resources, the comparative advantage explanation would be perfectly adequate, but Kravis's analysis points to differences in availability arising out of technological and product innovation. Technological progress causes comparative advantage in trade by reducing costs of production or supplying new products. High-tech products, with advanced and fast-changing technologies and complex skill needs, have the highest entry barriers. Indeed, the most innovative industries and high-tech exports call for large R&D investment, advanced technology infrastructure and close interaction between firms, universities and research institutions (Lall, 2000). Zhang (2007) show that a nation's industrial technology capability has a significantly positive impact on its complex exports; inward FDI flows may help raise per capita exports; infrastructure seems to have a positive impact on the complex export share Sunde (2017) show that both foreign direct investment and exports spur economic growth contrary to some studies, which found that FDI does not cause economic growth. Mathur (1999) and Dreze (1961) emphasize that the size of the country and scale economies are two important determinants of trade (Paas, 2000). Frankel and Cooper (1998) explains that countries with large populations are more inward-oriented than the smaller countries because they are more prone to exploit scale economies in their large domestic markets. So, bilateral trade flows may be inversely related to the population size.

Most of the empirical studies came to this conclusion that the population size of the trade partners has a significant negative effect on the trade flows (Ball and Linneman, 1967; Sapir, 1981; Bikker, 1987). Although there are exceptions in the literature (Brada and Mendez, 1983) trade barriers such as tariffs have significant negative effect on the trade flows among the countries. On the other hand, preferential trade agreement have significant positive effect on trade flows (Oguledo and MacPhee, 1994) because the group countries get more motivated to trade with each other. In addition, the culture, or cultural heritage and production and consumption patterns in these countries resemble to each other. Moreover, countries with common borders have had more trade than the countries without common borders (Karemera et al., 1999). Countries that are larger in terms of gross domestic production (GDP) offer more diverse products. Therefore, the trade significantly depends on the size of the country in terms of GDP (Paas, 2000). In fact, economies with higher incomes are more interested in differentiation and product specialization. Thus, they have more trades. The increase of the general prices increases the production costs and reduces the competitiveness of the products by increasing the ratio of the domestic to the foreign price and finally leads to a reduction in exports. It is expected that the inflation by disrupting the relative prices, especially exchange rates, has a deterrent effect on the investment and export.

In the international trade, under the general requirement of Marshall–Lerner, the changes in the exchange rates affect the exports and imports. Theoretically, if the relative prices between the country and its trading partners are constant, and other factors are unchanged, currency devaluation can improve the trade flow (Jafari et al., 2011). In traditional trade theories, such as Heckscher-Ohlin model, the pattern of trade between countries depends on the natural resources, skills, and factors of production. It is assumed that trades take place in a highly competitive world without friction and without distance or geographical characteristics. However, traditional views are not able to explain a variety of patterns of exports among countries. In the new theories of international trade, distance (physical geography) is included in order to explain the determinants of trade flows among the countries. Theoretical and empirical studies have found that distance has a significant effect on the international trade. The most useful study in this regard has been conducted by Ball and Linneman (1967) in which the role of distance in trade flows is discussed widely. Furthermore, MacPherson and Krugman (1992) argues that the distance between two countries is one of the most important factors determining the geographical pattern of trade. According to MacPherson and Krugman (1992), trade partners far apart will incur higher additional costs in their bilateral trades, reduces the potential benefits of trade and consequently hinders trade. The mere existence of a border has a negative effect on trade. However, Loungani et al. (2002) and Filippini and Molini (2003) stated that geographical distance is beyond physical geography. They believe that the geographical distance can represent the historical, cultural, lingual, social, and many other aspects. In addition, Blum and Goldfarb (2006) found that the distance is a good proxy for the differences in tastes and preferences. This suggests that even if the cost of transport and search costs and other barriers relating to trade costs are reduced to zero, such as the ones for E-commerce, distance effects will remain for a number of products.

3. Model and methodology

3.1. Econometric methodology

One of the most important challenges of the researchers is the selection of the potential variables that can be included in the econometric model, especially when there is a very wide range of explanatory variables. There is no acceptable way to solve this problem in the conventional econometric models. However, «Bayesian econometrics have solved this problem in selecting the models. This has been done by a technique called "Bayesian Averaging Model" developed by Jeffreys et al. (1985) and developed by researchers such as Inglis and Leamer (1981), Raftery et al. (1999), Wasserman (2000) and Koop (2001).

Several examples can be mentioned regarding the cases where researchers disagree with the variables that must be entered into the model. These disputes often lead to differences in results as well. Bayesian Model Averaging (BMA) in recent years managed to overcome uncertainty about the parameters as well as the models. The coefficients in BMA are estimated through weighted averaging of the estimated coefficients in all the possible models. The weights depend on probability of any model.

Bayesian econometrics is based on the Bayes theorem. Assuming that Y is the data matrix (the explanatory and dependent variables) and θ is the vector of parameters we have:

$$P(\theta \mid Y) = \frac{P(Y \mid \theta)P(\theta)}{P(Y)} \tag{1}$$

In Equation (1), $P(Y)$ can be removed because it does not give any information about θ, that is:

$$P(\theta \mid Y) \propto P(Y \mid \theta)P(\theta) \tag{2}$$

In this equation, $P(\theta)$ actually represents a set of information about the model parameters that we know prior to observing the data. Hence, $P(\theta)$ is the prior distribution. It should be noted that in cases where such information is not available, a non-informative or uniform prior is used. $P(Y \mid \theta)$ represents the density of data on the model parameters that refers to the process of data generation. For example, since in the linear models, the errors are often assumed to be normally distributed, this implies that $P(Y \mid \theta)$ has also a normal density. The $P(Y \mid \theta)$ is called a likelihood function.

$P(\theta \mid Y)$ is also what is to be calculated given the prior distribution and the likelihood function. This distribution is called as a posterior distribution. After calculating the posterior distribution, the average of the density posterior distribution can be considered as point estimate of the coefficients.

Suppose that R different models can be used to explain the export among which M_r represents the rth model (r = 1,2,3, ..., R), and θ represents its parameters. These parameters have prior distribution $P(\theta_r \mid M_r)$, likelihood function $P(Y \mid \theta_r, M_r)$ and posterior distribution $P(\theta_r \mid Y, M_r)$. The posterior distribution of these parameters is as follows:

$$P(\theta_r \mid Y, M_r) = \frac{P(Y \mid \theta_r, M_r) P(\theta_r \mid M_r)}{P(Y \mid M_r)} \tag{3}$$

Now, assume that φ is a vector of all parameters. Therefore, the Bayesian econometric logic says that all we know about these parameters can be summarized in the posterior distribution of $P(\varphi \mid y)$:

$$P(\varphi \mid Y) = \Sigma_{r=1}^{R} P(\varphi \mid Y, M_r)\, P(M_r \mid Y) \tag{4}$$

In fact, the posterior distribution for these parameters can be obtained by calculating the weighted average of the posterior distributions of the other models in which these parameters are available. Thereafter, the Bayesian Model Averaging can be calculated after obtaining the final likelihood and posterior distribution for the whole models.

3.2. Model specification

Based on the theoretical foundations, the variables affecting exports include: Ratio of capital to labor, land area per capita, human capital, ratio of research and development expenditure to GDP, ratio of foreign direct investment to GDP, ratio of imports of goods and services to GDP, population, institutional quality, gross domestic product (GDP), inflation, real effective exchange rate and distance.

We have specified the functional form between exports and its determinants as follows:

$$\begin{aligned} \log(EX) &= \beta_0 + \beta_1 \log(CL) + \beta_2 \log(LP) + \beta_3 \log(H) + \beta_4 \log(POP) + \\ &+ \beta_5 \log(ER) + \beta_6 \log(GDP) + \beta_7 \left(\frac{R\&D}{GDP}\right) + \beta_8 \left(\frac{FDI}{GDP}\right) + \beta_9 \left(\frac{IM}{GDP}\right) + \\ &+ \beta_{10}(IQ) + \beta_{11}(INF) + \varepsilon \end{aligned} \tag{5}$$

Where EX stand for high-tech exports of goods and services in constant 2010 US$ prices, CL, the ratio of capital to labor and LP, the land area per capita. These two variables reflect the plenty of the country's inputs including the physical capital, labor and natural resources. The physical capital is calculated from the gross capital formation. H represents the human capital measured by the gross tertiary education enrollment rate. R & D is the research and development expenditures. These two variables reflect a country's dimestic knowledge. FDI and IM are respectively the foreign direct investment (net inflow) and imports of goods and services which address the foreign knowledge resources available to the country. POP represents population and reflects the size of the country. Variable IQ is the institutional quality measured by the "Rule of Law Index". GDP is the gross domestic production in constant 2010 US$ prices, INF is the inflation and ER represents the real effective exchange rate.

As is discussed in the theoretical foundations, a wide range of variables affect the exports. Therefore, in this research, due to the large number of variables affecting exports, the Bayesian Model Averaging method and WALS approach are used to investigate the influence of these variables on exports. These methods are applied when the effect of a range of the independent variables on the dependent variable (in this study, export) are going to be estimated. In addition, the explanatory variables can be ranked based on the inclusion probability of the explanatory variables in the model. To analyze and assess the results of the Bayesian Model Averaging and WALS, the "STATA" software was used.

4. Data and empirical analysis

To investigate the Determinant of the exports, the panel data from 24 developing countries during the period 1996 to 2013 have been used. Sample countries include: Armenia, Costa Rica, Malaysia, Philippines, Bolivia, Ecuador, Mexico, Romania, Bulgaria, Hungary, Moldova, South Africa, Burundi, Iran, Morocco, Tunisia, China, Lesotho, Pakistan, Uganda, Colombia, Macedonia FYR, Paraguay, Ukraine. The countries were selected based on their structures similarities, data quality and availability. It must be noted that the observations used in this study are unbalanced panel data. All the data have been obtain from the World Development Indices (WDI) of the World Bank.

Table 1: Estimation of high-tech exports equation through BMA

Variables	Mean of the posterior coefficients	Posterior standard deviation	Posterior Inclusion probability
C	-23.88746	1.542956	1
Log of the ratio of capital to labor	-0.6767661	0.133494	0.99
log of land per capita	-0.03462	0.084541	0.19
human capital	0.8492413	0.0961432	1
Log of GDP	1.876709	0.1314289	1
log of real exchange rate	-0.0334835	0.1613727	0.08
Log of population	0.0311106	0.126132	0.1
The ratio of imports to GDP	0.040406	0.0041526	1
The ratio of FDI to GDP	-0.0042886	0.0110328	0.18
The ratio of R&D to GDP	-0.8958209	0.2600686	0.99
Institutional quality	2.12661	0.184573	1
Inflation	-0.0002836	0.0008193	0.15

Source: Author's calculations

The exports model is estimated through the Bayesian Model Averaging (BMA) and Weighted-Average Least Square (WALS). The results based on BMA and WALS have been reported in Table (1) and Table (2) respectively.

One of the advantages of BMA is that all explanatory variables are properly addressed. In this method, all the possible patterns with different combinations of variables are estimated (since this model has 11 explanatory variables, 2^11 or 2048 model with all the different combinations of explanatory variables have been estimated) and the estimated coefficients are averaged. Therefore, the coefficients are not only estimated based on a single model, but based on the weighted average of the coefficients in all models. The posterior weighted average of the coefficient β_1 is calculated as follows:

$$\hat{\beta}_1 = \Sigma_{i=1}^{I} \lambda_i \hat{\beta}_{1i} \tag{6}$$

Where λ_i is the posterior probability of the model i or M_i and $\hat{\beta}_{1i}$ is an estimate of β_1 obtained from M_i model. As shown in Table (1), the second column from the right side shows the weighted average of the posterior distribution of each variable's coefficients and the third column shows the standard deviation of the posterior distribution of variable's coefficients. The fourth column represents the inclusion probability of each of the variables in the 2048 models. With regard to the column which represents the inclusion probability, it can be found that among the explanatory variables, some of them including institutional quality, import ratio, GDP and human capital have definite effects on the high-tech exports with prior inclusion probability equal to one (they definitely belong to the exports model).

Table 2: Estimation of high-tech exports equation through WALS

Variables	Mean of the posterior coefficients	Posterior standard deviation	T-statistic
C	-21.45777	2.157085	-9.95
Log of the ratio of capital to labor	-0.4862157	0.1773019	-2.74
log of land per capita	-0.1199094	0.1065067	-1.13
human capital	0.893121	0.104825	8.52
log of GDP	1.577979	0.2288994	6.89
log of real exchange rate	-0.2048741	0.3967129	-0.52
log of population	0.246858	0.2480361	1
The ratio of imports to GDP	0.0351992	0.0041974	8.39
The ratio of FDI to GDP	-0.0150484	0.0137353	-1.1
The ratio of R&D to GDP	-0.7804083	0.2404507	-3.25
Institutional quality	2.190618	0.2054616	10.66
Inflation	-0.0018663	0.0012582	-1.49

Source: Author's calculations

To analyze the robustness of the results, the exports model was also estimated through Weighted-Average Least Square (WALS) technique. WALS is a common averaging method based on the least square regressions where the Laplace prior distributions are used (instead of the normal prior distributions in the BMA). In fact, the WALS Averaging method is similar to the BMA except for the use of the prior distribution. In other words, in the WALS model, the Laplace prior distribution is used instead of the normal prior distribution. In Table (2), the results of the WALS approach for estimating the exports models are presented. In this approach, the assessment of the effect of the explanatory variables on the exports (as the dependent variable) is done based on the t-statistics (while in the BMA approach, the assessment is done based on the inclusion probability of the variables in the model). The results based on WALS are qualitatively similar to BMA approach.

5. Results and discussion

According to the results of Table (1), The institutional quality (with an average coefficient of 2.12), human capital (0.85), the ratio of imports to GDP (0.04) and logarithm of GDP (1.87) have definite effects on the exports with inclusion probability of 100%. The sign of these coefficients are as expected. The human capital implies the creation of the endogenous knowledge. The knowledge-based capital is one of the key inputs for productive activities according to the endogenous growth theories so that more human capital improves the quality and productivity and ultimately leads to greater exports. A country which has a greater GDP, can supply more various products. Therefore, the trade greatly depends on the size of the country in terms of GDP (Pass, 2000). In fact, economies with higher income are more interested in specialization and sophistication of the products and have more trades. Import as an important channel of international knowledge spillover has a positive effect on the high-tech export. Import also affects the host country's export through various channels. In the long term, the countries can accelerate export sophistication through the dissemination of the foreign knowledge. Imports of intermediate and capital goods causes the transfer of the new technology into the country and reduce their production costs leading to high-tech exports. Some developing countries import large quantities of intermediate and tech-intensive goods and export them after simple assembling and processing the complex final products. The existence or establishment of appropriate institutions can empower the endogenous growth and productivity and therefore provide competitiveness and sustainable growth in a country's exports. Especially, improving the institutional quality and the rule of law increases the security of property rights and contracts enforcements and therefore creates a safe environment for the development of new markets, strengthening human capital, domestic research and development and information and communication technology. It also increases the rate of return of the capitals and the incentives for domestic and foreign investments through reducing the risk, and ultimately fortifies the competitiveness and exports.

The ratio of capital to labor as well as research and development expenditure to GDP with the probability of 99% have negative effects on the high-tech exports. The weighted average of these two variables' coefficients are respectively -0.68 and -0.89. The increase of the ratio of capital to labor and research and development expenditure in the developing countries (under study) with poor production structures do not have expected positive effect on increasing the high-tech exports. If the necessary institutional infrastructures are not provided, the development of the physical capital and even the research and development expenditures encloses the country's natural resource-based and traditional industries. Other explanatory variables including the land area per capita, the real effective exchange rate, the population, the ratio of FDI to GDP and inflation due to the low inclusion probability do not affect the exports.

The estimation of the exports model in two ways of "BMA" and "WALS" shows the robustness of the results to the prior distribution of the coefficients. As it is observed, the WALS results are qualitatively similar to the BMA method. In WALS approach, due to the high ratio of t-statistics for the variables institutional quality, human capital, ratio of imports to GDP, and GDP, it can be concluded that these variables are the most important factors affecting the high-tech exports. In overall, low t-ratios or inclusion probabilities for the price variables such as exchange rates or the land and capital per capita in both WALS and BMA approach implies that the standard theories cannot explain evolution high-tech export in developing countries. In other words, these variables do not have the expected standard impacts on the high-tech exports. These countries should develop and improve their institutions and business environment to upsurge export. The traditional reforms such as structural adjustment or stabilization ones without complementary institutional measures can not solely prepare necessary infrastructures to sustainable export growth.

6. Conclusion

This study examines the determinants of high-tech exports in developing countries during the period 1996 to 2013. One of the most important challenges of the empirical modeling is the selection of the potential variables that can be included in the econometric model, especially when there is a very wide range of explanatory variables. There is no acceptable way to solve this problem in the conventional econometric models. This article tries to fill this gap using Bayesian Model averaging and WALS econometrics approaches. Findings imply the traditional variables and models cannot explain evolution of the high-tech exports in the developing countries. The results show that the institutional quality index, the human capital (which is proxied by the index of gross tertiary education enrollment rate), the ratio of imports to GDP (as a proxy for the degree of trade openness) and the GDP are the most important determinants of the high-tech. The variables of the ratio of capital to labor, the ratio of the research and developments expenditures to GDP, the land area per capita, and the real effective exchange rate have not expected positive effects on the high-tech exports of the developing countries. Moreover, none of these variables are not significant in WALS approach, having low inclusion probability in BMA one. The empirical results confirm the direct and indirect effects of the GDP growth, the economy openness (represented by the ratio of the imports to GDP), human capital, and institutional quality on the exports growth. However, the results are incompatible with the theories discussed about the effects of the accumulation of the factors of production (land, capital and labor) which is the focus of the traditional trade theories. Therefore, as investigated in the present study, the traditional trade theories lack essential potentials to explain the tech-intensive exports in the developing countries. However, the institutions, the efficient human capital, higher GDP, the openness and the easier access to the foreign knowledge and investment can explain the behavior of the tech-intensive exports in the developing countries, confirming the main hypothesis of this article. Of course good governance maybe not perfect proxy of Institutional quality that should be addressed in future researches.

References

Athukorala, P. (1991) "Exchange rate pass-through: The case of Korean exports of manufactures", *Economics Letters*, Vol. 35, No. 1, pp. 79–84, doi: 10.1016/0165-1765(91)90108-w.

Athukorala, P., Menon, J. (1994) "Pricing to market behavior and exchange rate pass-through in Japanese exports", *The Economic Journal*, Vol. 104, No. 423, p. 271, doi: 10.2307/2234748.

Ball, R. J., Linneman, H. (1967) "An Econometrics Study of International Trade Flows", *The Economic Journal*, Vol. 77, No. 306, pp. 366–368, doi: 10.2307/2229319.

Bikker, J. A. (1987) "An International Trade Flow with Substitution: An Extension of the Gravity Model", *Kyklos*, Vol. 40, No. 3, pp. 315–337, doi: 10.1111/j.1467-6435.1987.tb00683.x.

Blum, B.S., Goldfarb, A. (2006) "Does the Internet Defy the Law of Gravity?" *Journal of International Economics*, Vol. 70, No. 2, pp. 384–405, doi: 10.1016/j.jinteco.2005.10.002.

Brada, J. C., Mendez, J. A. (1983) "Regional Economic Integration and the Volume of Intra-Regional Trade: A Comparison of Developed and Developing Country Experience", *Kyklos*, Vol. 36, No. 4, pp. 589–603, doi: 10.2307/1924798.

Brunnschweiler, C. N. (2008) "Cursing the blessing? Natural resources abundance, institutions and economic growth", *World development*, Vol. 36, No. 3, pp. 399–419, doi: 10.1016/j.worlddev.2007.03.004.

Coe, D. T., Helpman, E. (1995) "International R&D spillovers", *European Economic Review*, Vol. 39, No. 5, pp. 859–887, doi: 10.1016/0014-2921(94) 00100-e.

Dreze, J. (1961) "Leo Exportation Intra-CEE en 1958 et al Position Belge", *Recherches Economiques de Louvain (louvin)*, Vol. 27, pp.717–738.

Filippini, C., Molini, V. (2003) "The Determinants of East Asian Trade Flows: A Gravity Equation Approach", *Journal of Asian Economics*, Vol. 14, No. 5, pp. 695–711, doi: 10.1016/j.asieco.2003.10.001.

Fu, X. (2011) "Processing-trade, FDI and exports of indigenous firms: Firm-level evidence from high-technology industries in China". *Oxford Bulletin of Economics and Statistics*, Vol. 73, No. 6, pp. 792–817, doi: 10.1111/j. 1468-0084.2011.00673.x.

Fu, X., Gong, Y. (2011) "Indigenous and foreign innovation efforts and drivers of technological upgrading: Evidence from China". *World Development*, Vol. 39, No. 7, pp. 1213–1225, doi: 10.1016/j.worlddev.2010.05.010.

Gökmen Y, Turen. U. (2013) "The Determinants of High Technology Exports Volume: A Panel Data Analysis of EU-15 Countries". *International Journal of Management, Economics and Social Sciences*, Vol. 2, No. 3, pp. 217–232.

Hausmann, R., Hwang, J., Rodrik, D. (2007) "What you export matters", *Journal of Economic Growth*, Vol. 12, No. 1, pp.1–25, doi: 10.1007/s10887-006-9009-4.

Hirsch, S. (1968) "Location of Industry and International Competitiveness", *Operational Research Society*, Vol. 19, No. 4, pp. 485–487, doi: 10.2307/3008724.

Inglis, J., Leamer, E. (1981) "Specification Searches: Ad Hoc Inference with Non-experimental Data", *Technometrics,* Vol. 23, No. 1, pp. 112–113, doi: 10.2307/1267987.

Jafari, Y., Ismail, M. A., Kouhestani, M. S. (2011) "Determinants of Trade Flows among D8 Countries: Evidence from the Gravity Model", *Journal of Economic Cooperation and Development*, Vol. 32, No. 3, pp. 21–38.

Jeffreys, H., Moran, P. A. P., Chatfield, C. (1985) "Theory of Probability", Biometrics, Vol. 41, No. 2, p. 597.

Karemera, D. et al. (1999) "A Gravity Model Analysis of the Benefits of Economic Integration in the Pacific Rim", *Journal of Economic Integration*, Vol. 14, No. 3, pp. 347–367, doi: 10.11130/jei. 1999.14.3.347.

Koop, G. (2001) "Bayesian inference in models based on equilibrium search theory", *Journal of Econometrics,* Vol. 102, No. 2, pp. 311–338, doi: 10.1016/s0304-4076(01)00056-2.

Kravis, I. B. (1956) "Availability and Other Influences on the Commodity Composition of Trade", *Journal of Political Economy*, Vol. 64, No. 2, pp. 143–155, doi: 10.1086/257769.

Krugman, P. R. (1979) "Increasing returns, monopolistic competition, and international trade", *Journal of International Economics*, Vol. 9, No. 4, pp. 469–479, doi: 10.1016/0022-1996(79)90017-5.

Krugman, P. R. (1992) "Geography and trade", *Economic Geography*, Vol. 68, No. 2, pp. 216, doi: 10.2307/144207.

Lall, S. (2000), "The Technological Structure and Performance of Developing Country Manufactured Exports, 1985-98", *Oxford Development Studies*, Vol. 28, No. 3, pp. 337–369, doi: 10.1080/713688318.

Leamer, E.E. et al. (1999) "Does natural resource abundance increase Latin American income inequality?", *Journal of Development Economics*, Vol. 59, No. 1, pp. 3–42, doi: 10.1016/s0304-3878(99)00004-8.

Lederman, D., Maloney, W. (2003) "Trade structure and growth", *Policy Research Working Paper*, No. 3025, doi: 10.1596/1813-9450-3025.

Loungani, P., Mody, A., Razin, A. (2002) "The Global Disconnect: The Role of Transactional Distance and Scale Economies in Gravity Equations", *Scottish Journal of Political Economy*, Vol. 49, No. 5, pp. 526–543, doi: 10.1111/1467-9485.00246.

Lucas, R.E. (1988) "On the mechanics of economic development", *Journal of Monetary Economics*, Vol. 22, No. 1, pp. 3–42, doi: 10.1016/0304-3932(88) 90168-7.

Mathur, S. K. (1999) "Pattern of International Trade, New Trade Theories and Evidence from Gravity Equation Analysis", *The Indian Economic Journal*, Vol. 47, No. 4, pp. 68–88.

Oguledo, V., Macphee, C. R. (1994) "Gravity Models: A Reformulation and an Application to Discriminatory Trade Arrangements", *Applied Economics*, Vol. 26, No. 2, pp. 107–120, doi: 10.1080/00036849400000066.

Paas, T. (2000) "The gravity approach for modeling international trade patterns for economies in transition", *International Advances in Economic Research*, Vol. 6, No. 4, pp. 633–648, doi: 10.1007/bf02295374.

Posner, M.V. (1961) "International Trade and Technical changes", *Oxford Economic Papers*, Vol. 13, No. 3, pp. 323–341, doi: 10.1093/oxfordjournals.oep.a040877.

Raftery, A. E., Madigan, D., Hoeting, J. A. (1999) "Bayesian Model Averaging for Linear Regression Models", *Journal of The American Statistical Association*, Vol. 92, 437, pp. 179–191, doi: 10.2307/2291462.

Cooper, R.N., Frankel, J.A. (1998) "Regional Trading Blocs in the World Trading System", *Foreign Affairs*, Vol. 77, No. 2, pp. 144–145, doi: 10.2307/ 20048805.

Romer, P. (1990) "Endogenous Technological Change", *Journal of Political Economy*, Vol. 98, No. 5, pp. S71–S102, doi: 10.1086/261725.

Sachs, J.D., Warner, A.M. (1999) "The big push, natural resource booms and growth", *Journal of Development Economics*, Vol. 59, No. 1, pp. 43–76, doi: 10.1016/s0304-3878(99)00005-x.

Sachs, J.D., Warner, A. M. (2001) “The curse of natural resources”, *European Economic Review*, Vol. 45, No. 4–6, pp. 827–838, doi: 10.1016/s0014-2921(01)00125-8.

Sandu, S., Ciocanel, B. (2014) “Impact of R&D and Innovation on High-tech Export”, *Procedia Economics and Finance*, Vol. 15, pp. 80–90, doi: 10.1016/s2212-5671(14)00450-x.

Schott, P. (2008) “The relative sophistication of Chinese exports”, *Economic Policy*, Vol. 23, No. 53, pp. 6–49, doi: 10.1111/j.1468-0327.2007.00195.x.

Sapir, A. (1981) “Trade benefits under the EEC generalized system of preferences”, *European Economic Review*, Vol. 15, No. 3, pp. 339–355, doi: 10.1016/s0014-2921(81)80006-2.

Stijns, J.-P.C. (2005) “Natural resource abundance and economic growth revisited”, *Resources Policy*, Vol. 30, No. 2, pp. 107–130, doi: 10.1016/j.resourpol.2005.05.001.

Srholec, M (2007) “High-Tech Exports from Developing Countries: A Symptom of Technology Spurts or Statistical Illusion?”, *Review of World Economics*, Vol. 143, No. 2, pp. 227–255, doi: 10.1007/s10290-007-0106-z.

Sunde, T. (2017) “Foreign direct investment, exports and economic growth: ADRL and causality analysis for South Africa”, *Research in International Business and Finance*, Vol. 41, pp. 434–444, doi: 10.1016/j.ribaf.2017.04.035.

Tebaldi, E. (2011) “The Determinants of High-Technology Exports: A Panel Data Analysis”, *Atlantic Economic Journal*, Vol. 39, No. 4, pp. 343–353, doi: 10.1007/s11293-011-9288-9.

Vernon, R. (1966) “International Investment and International Trade in the Product Cycle”, *Quarterly Journal of Economics*, Vol. 80, No. 2, pp. 190–207, doi: 10.2307/1880689.

Wasserman, L. (2000) “Bayesian Model Selection and Model Averaging”. *Journal of Mathematical Psychology*, Vol. 44, No. 1, pp. 92–107, doi: 10.1006/jmps.1999.1278.

Xu, B. (2010) “The sophistication of exports: Is China special?”, *China Economic Review*, Vol. 21, No. 3, pp. 482–493, doi: 10.1016/j.chieco.2010.04.005.

Zhang, K. H. (2007) “Determinants of Complex Exports: Evidence from Cross-Country Data for 1985-1998”, *Economia Internazionale/International Economics*, Vol. 60, No. 1, pp. 111–122.

Odrednice visokotehnološkog izvoza u zemljama u razvoju temeljene na Bayesovom modelu

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Sažetak

S obzirom na važnost i ulogu visokotehnološkog izvoza u gospodarskom rastu, potrebno je identificirati varijable koje utječu na izvoz. Prema tome, u ovom se članku proučavaju odrednice izvoza za 24 zemlje u razvoju u razdoblju od 1996. do 2013. godine temeljene na tehnici Bayesian Model Averaging (BMA) i Weighted-Average Least Square (WALS). Rezultati pokazuju da su vladavina prava kao proxy za institucionalnu kvalitetu, ljudski kapital, uvoz (kao mjera otvorenosti) i BDP sa 100% vjerojatnosti poslije uključivanja, najvažnije varijable koje utječu na visoko-tehnološki izvoz u zemljama u razvoju.

Ključne riječi: *izvoz visoke tehnologije, Bayesian Model Averaging (BMA), ponderirani prosjek najmanjeg kvadrata, zemlje u razvoju*

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