Research and Development Spending and Export Performance by the Technological Intensity of the Products

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Abstract

This article examines the effects of research and development (R&D) spending on merchandise export by low, medium-low, medium-high, and high technological intensity of the products between OECD countries by panel data econometric approaches using a gravity model. R&D spending is positively associated with merchandise exports, particularly for high technological intensity products in exporting countries. R&D spending can contribute to offsets the effect of distance on merchandise export, except for low technological intensity products. R&D spending fostered catching-up in merchandise export from developing to developed OECD countries in each technological intensity of the products, particularly for high and medium low technological intensity of the products and served in successful import penetration in medium-high and medium-low technological intensity of the products. R&D spending can play important role in strategies of export-oriented industrialization by a shift of merchandise exports towards higher technological intensity of the products and in successful import penetration.

Keywords: *merchandise exports; technological intensity; research and development spending; OECD countries; panel data analysis*

JEL Classification: C23, F14, O30, O50

Introduction

The purpose of this paper is to contribute to better understanding the effects of research and development (*R&D*) spending on manufacturing export by the technological intensity of the products using the panel gravity equation model

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for OECD countries. The previous research has underlined the role of different *R&D* policy measures in the economies (e.g. Baláž, 2011).

The changing global competitiveness and trade patterns between the nations have generated a search for the determinants which are causing these changes (e.g. Canina, Enz and Harrison, 2005). *R&D* spending is seen as one of the key factors in explaining the changes in technological gaps and in competitiveness in global export (Bojnec and Fertő, 2011).

This paper investigates the effects of *R&D* spending by analyzing the determinants of the bilateral manufacturing exports by the technological intensity of the products between OECD countries. The gravity equations are employed to identify the effects of *R&D* spending on bilateral manufacturing exports by the technological intensity of the products using a panel data analysis. Among possible explanation for differential in merchandise export performances by the technological intensity of the products between OECD countries might be differential in *R&D* spending, transportation costs, and level of economic development.

The novelty of this paper is in estimation of decomposed gravity models for merchandise exports by the technological intensity of the products and in use of model specifications with interaction terms of the *R&D* spending with distance and level of economic development. Therefore, the paper aims to contribute to the literature in three significant directions. First, the starting point of our investigation is the relationship between *R&D* spending and merchandise export performance by the technological intensity of the products between the OECD countries using a panel data analysis by applying the baseline gravity equation model. Second, the paper analyzes whether the *R&D* spending has mitigated the effect of distance on merchandise export, and therefore the rationale for long-distance on merchandise export by the technological intensity of the products is tested. The Freund and Weinhold's (2002; 2004) specification is employed for the investigation of the effects of *R&D* spending on distance and long-distance into the gravity equation model. Third, the impact of the level of economic development on merchandise export by the technological intensity of the products is investigated by investigating the effects of *R&D* spending and the level of countries' economic development.

The rest of the paper is organized as follows. The next section presents the literature review. In the next section after that the methodology and data used are presented by focusing on the *R&D* spending and merchandise export by the technological intensity of the products in the gravity regression analysis. After that, the regression results for alternative specifications of gravity models are presented and explained. The final section summarizes the main findings and gives conclusions.

Literature Review

Macro Level Approaches

The literature provides a theoretical background for export and *R&D* relationship at both macroeconomic and microeconomic level. Since our empirical study focuses on the macroeconomic level, we concentrate on the literature review and hypotheses development at the macroeconomic level.

Krugman (1979) showed that countries and products can be ranked by technological level and that economies ahead on this scale specialize in the technological intensive goods. Increasing returns to scale and product innovations generate trade specialization and first mover advantages. But in equilibrium, imitation reduces technological gaps between countries, and the monopolistic power of leaders is temporary. In addition, he argued that the causal chain ran from *R&D* and innovation to international trade and not the other way round.

Grossman and Helpman (1995) argued that, in a framework of monopolistic competition, a country could shift its export demand curve outwards by increasing the quality of goods it produces; meanwhile, it could shift its import demand curve inwards by increasing the quality of goods produced for the domestic market. These export and import demand-shift factors can possibly be proxied by factors that represent improvements in product quality such as *R&D*.

A wealth of literature provides evidence at the macroeconomic level on the linkage between a countries *R&D* and its spillovers (e.g., Klas, 2010). Empirical studies confirm the importance of *R&D*, as one of the major factors contributing to facilitating entry into global markets and thereafter maintaining competitiveness and boosting export performance (e.g., DiPietro and Anoruo, 2006).

In the gravity model exports is positively associated with the economy size in terms of gross domestic product (*GDP*) of exporting and importing countries and negatively associated with the distance between the countries (Anderson and van Wincoop, 2003). A positive association of exports is also expected with additional bilateral proximity variables: a common border, a common language and a free trade agreement. Exports can also be positively associated with the level of economic development expressed by GDP per capita (*GDPCAP*) in exporting and importing countries as an additional proximity variable.

Greater *R&D* spending is more likely to improved innovation by the increase of merchandise exports in differentiated products by the technological intensity of the products (DiPietro and Anoruo, 2006). This might mitigate also the effect of the distance on merchandise export owing from the decrease in transportation costs. Greater *R&D* spending can also help to overcome the level of economic development on merchandise export by the technological intensity of the products.

Micro Level Approaches

There are a growing number of studies at firm level on the export-*R&D* relationship, taking into account the heterogeneity of firm characteristics amongst exporting and non-exporting firms. A firm's export orientation has been extensively investigated in the literature (Barrios, Holger Görg and Strobl, 2003). Contrary to the uniformly positive export and *R&D* linkage revealed in the macro economics literature, some empirical studies at the firm level present contrary findings. Moreover, based on Japanese manufacturing firms, Ito and Pucik (1993) found that *R&D* was a significant determinant of a firm's export performance only when size was dropped from the regression. On the other hand, the firm size can be important in creating internal dynamics for reinforcing the absorptive capacity of *R&D* investments and exporting capacity.

The literature highlights three channels for *R&D* influencing the level of trade (Ghazalian and Furtan, 2007). First, *R&D* may foster the product differentiation, allowing for more product variety choices and higher quality products for consumers. Second, *R&D* may reduce the production costs, making firms more competitive on the international markets. Third, *R&D* may reduce the transaction costs along the supply chain and between trading partners, making exports more competitive.

The specific contribution of this paper is investigation of the association between *R&D* spending and merchandise exports by the four groups of the technological intensity of the products: low, medium-low, medium-high, and high technological intensity. The products are classified by the OECD classification of technological intensity of products (Hatzichronoglou, 1997).

Research Hypotheses

Baseline Gravity Model Variables

Traditional gravity trade theory indicates that bilateral trade is positively associated with their national incomes and negatively associated with their geographical distance (e.g. Anderson and van Wincoop, 2003). An adjusted standard gravity model explanatory variables are applied in a baseline gravity model including market size, which is expressed by *GDP* of exporter *i* and importer *j* countries; level of economic development, which is expressed by GDP per capita (*GDPCAP*) in exporting and importing countries; geographical factors like the continuous distance measure between capital cities (*Distance*) and common border (*Contiguity*), common cultural linkage (*Language*), and a dummy variable for Regional Free Trade Agreement (*RFTA*) membership as explanatory

variables. The literature argues that richer countries with higher *GDPCAP* and larger exporters and importers trade more, as do countries linked by regional trade agreements, a land border, or a common *language*; physically large countries do less trade, while that trade falls with geographic a continues *distance* measure. *Distance* can have an influence on technology transfer.

Merchandise export by the technological intensity of the products is expected to be positively associated with *GDP* in exporting and importing countries, with *GDPCAP* in exporting in importing countries, with having a common border, speaking the same *language*, and having a free trade agreement, respectively, but negatively associated with *distance*.

R&D Spending by the Technological Intensity of the Products

In the process of international expansion, *R&D* spending can play a significant role for the development of competitive advantage in differentiated products, high technology products and their varieties. A positive relation between a country's export performance and its *R&D* spending was confirmed by previous studies (e.g. Bojnec and Fertő, 2011). The focus is on the role of *R&D* spending in merchandise export by raise its technological intensity of the products. It is expected that the higher the *R&D* spending, the higher would be the merchandise export by the technological intensity of the products (e.g. DiPietro and Anoruo, 2006). Therefore, we set the hypothesis 1 (H1):

H1: *Merchandise export by the technological intensity of the products is positively associated with R&D spending in exporting and importing countries, respectively.*

The Effects of *R&D* Spending on Distance

The role of geographical a continuous distance measure as a proxy for transport costs can be offset by *R&D* spending and other factors. Among them can be advanced information and communication technologies and management strategies (Bojnec and Fertő, 2009). *R&D* spending by the technological intensity of the products may affect distance on merchandise export owing from the decrease in transportation and other transaction costs fostering the merchandise exports particularly of higher technological intensive products. The rationale for use of the interaction effect of *R&D* spending and long distance is that with more *R&D* spending it would be possible to overcome the greater distance by the increasing degree of merchandise export by its technological intensity of the products. If a particular *R&D* variable has reduced (increased) the effect of distance on manufacturing export by the technological intensity of the products, then the

regression coefficient on the interaction of *R&D* spending and long distance term should be positive (negative). Following Freund and Weinhold (2004) the hypotheses 2 (H2) is set to test the effect of *R&D* spending on the distance effect on merchandise export by the technological intensity of the products:

H2: *Merchandise export by the technological intensity of the products is associated with joint effect of long distance and R&D spending.*

The Effects of *R&D* Spending by the Level of Economic Development on Merchandise Export

The effects of *R&D* spending by the level of economic development on merchandise export by the technological intensity of the products might give an indication on possible merchandise export catching up from developing to developed OECD countries owing from *R&D* spending. Barrios, Holger Görg and Strobl (2003) argue that the effects of R&D do matter more for exports to technologically advanced countries, where exporters have to improve technology in order to be able to compete on those markets successfully. In addition, the rationale for use of the interaction effect of *R&D* spending and *GDPCAP* is that more economically developed countries with high higher *GDPCAP* can invest more in *R&D* spending and thus can increase merchandise exports through higher-valued product differentiation. On these bases the hypothesis 3 (H3) is set on the effects of the *R&D* spending on merchandise export by the technological intensity of the products in association with the *GDPCAP*:

H3: *Merchandise export by the technological intensity of the products is positively associated with joint effect of the GDPCAP and R&D spending.*

Methodology and Data

Model Specifications

The baseline gravity model specification for the merchandise exports by the technological intensity of the products (X_{ij}) is used:

$$lnX_{ij,t} = \alpha_0 + \alpha_1 lnGDP_{i,t} + \alpha_2 lnGDP_{j,t} + \alpha_3 lnGDPCAP_{i,t} + \alpha_4 lnGDPCAP_{j,t} + \\ + \alpha_5 lnDistance_{ij} + \alpha_6 Contiguity_{ij} + \alpha_7 Language_{ij} + \alpha_8 RFTA_{ij} + u_t \qquad (1)$$

where u_t means error term and t is time. *GDP* is a proxy for the market size and *GDPCAP* is a general proxy for economic development for both exporter and importer countries. The $Distance_{ij}$ variable measures the geographic continues distance between the countries' capitals i and j, whereas the other dummies reflect whether i and j share: a land border ($Contiguity_{ij}$), their primary *Language*, and membership in a *RFTA*.

To test the set H1, we employ an augmented gravity model with *R&D* spending variables by the technological intensity of the products:

$$lnX_{ij,t} = \beta_0 + \beta_1 lnGDP_{i,t} + \beta_2 lnGDP_{j,t} + \beta_3 lnGDPCAP_{i,t} + \beta_4 lnGDPCAP_{j,t} + \\ + \beta_5 lnDistance_{ij} + \beta_6 Contiguity_{ij} + \beta_7 Language_{ij} + \beta_8 RFTA_{ij} + \beta_9 R\&D_{it} + \\ + \beta_{10} R\&D_{jt} + u_t \quad (2)$$

The variables of a particular interest are the *R&D* spending by the technological intensity of the products.

To test the set H2, the following model specification is used:

$$lnX_{ij,t} = \beta_0 + \beta_1 lnGDP_{i,t} + \beta_2 lnGDP_{j,t} + \beta_3 lnGDPCAP_{i,t} + \beta_4 lnGDPCAP_{j,t} + \\ \beta_5 lnDistance_{ij} + \beta_6 Contiguity_{ij} + \beta_7 Language_{ij} + \beta_8 RFTA_{ij} + \beta_9 R\&D_{it} + \beta_{10} R\&D_{jt} + \\ + \beta_{11} R\&D_{it} * Longdistance_{ij} + \beta_{12} R\&D_{jt} * Longdistance_{ij} + u_t \quad (3)$$

where $Longdistance_{ij}$ is a dummy variable, which equals one if the distance between countries *i* and *j* exceeds the average distance between all the analyzed OECD countries.

To test the set H3, the following model specification is used:

$$lnX_{ij,t} = \beta_0 + \beta_1 lnGDP_{i,t} + \beta_2 lnGDP_{j,t} + \beta_3 lnGDPCAP_{i,t} + \beta_4 lnGDPCAP_{j,t} + \\ + \beta_5 lnDistance_{ij} + \beta_6 Contiguity_{ij} + \beta_7 Language_{ij} + \beta_8 RFTA_{ij} + \beta_9 R\&D_{it} + \\ + \beta_{10} R\&D_{jt} + \beta_{11} R\&D_{it} * GDPCAP_{it} + \beta_{12} R\&D_{jt} * GDPCAP_{jt} + u_t \quad (4)$$

The econometric approach is important to assure the accuracy of the results. The research takes into consideration possible endogeneity of *GDP* variables and *R&D* spending as suggested by new trade theory. Preliminary analysis using likelihood ratio tests, Wooldridge (2002) test for autocorrelations and Pesaran (2004) tests for cross-sectional dependence confirms the presence of heteroscedasticity, autocorrelation and cross-sectional dependence. Zero value is not an issue in our case, because we do not have zero values, except one for medium low technology intensity and three zero values for high technology intensity specification models. Therefore, there is no reason to use Heckman selection models or any similar methods (Helpman, Melitz and Rubinstein, 2008).

Finally, we have used panel methods and other econometric issues are carefully addressed in the paper. Because the analysed period is shorter than cross sectional units, to deal with issues of contemporaneous correlation the panel corrected standard error model (*PCSE*) is applied which controls for heteroskedasticity and the *AR(1)* type of autocorrelation and contemporaneous correlation across panels (Beck and Katz, 1996). The possible endogeneity of *R&D* spending and *GDP* variables are tested using the generalised method of moments (*GMM*). The advantage of *GMM* over other instrumental variable (*IV*) methods is

that a *GMM* estimator is more efficient than an *IV* estimator if heteroscedasticity is present, whereas a *GMM* estimator is not worse asymptotically than an *IV* estimator if heteroscedasticity is not present.

A test of over-identification is considered which tests the overall validity of the instruments by analysing the sample analogue of the moment conditions used in the estimation process. The instruments used in equation (2) are all exogenous variables and endogenous variables (*ln GDPi,t; ln GDPj,t; R&Dit,* and *R&Djt*) lagged by one to three periods. The Durbin-Wu-Hausman (*DWH*) tests suggest that the null hypothesis of exogeneity cannot be rejected at 10 per cent level for all types of intensity of trade. Similarly, the Hansen *J* tests also confirm the validity of instruments at the 10 per cent level for all cases. In sum, the *GMM* technique is not needed.

Data

Different sources of data for variables are used to create the panel data set. The merchandise exports (X_{ij}) data used is supplied by the OECD Bilateral Trade Database at the two-digit level of the International Standard Industrial Classification (ISIC) of all economic activities in US dollars. The source of data for *GDP* and *GDPCAP* is the World Bank, World Development Indicators (WDI) database. The source of data for $Distance_{ij}$, $Contiguity_{ij}$, *Language* and *RFTA* variables is the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII): <http://www.cepii.fr/anglaisgraph/bdd/distances.htm) database>.

The data for governmental *R&D* outlays are collected from the OECD STAN R&D dataset as the OECD *R&D* spending for total manufacturing (in million current USD in 2000 purchasing power parity – PPP – prices).

The sample contains 18 OECD countries between 1995 and 2003 resulting in 2,754 observations. The list of countries included in the data sample: Australia, Belgium, Canada, the Czech Republic, Finland, France, Germany, Ireland, Italy, Japan, South Korea, the Netherlands, Norway, Poland, Spain, Sweden, the United Kingdom, and the United States of America.

In the structure of merchandise exports, medium high technology products were more important than other three single product groups. The increase is faster for medium high and high technologically intensive products than for low and medium low technologically intensive.

R&D spending is ranged by the level of the technological intensity of the products. The greatest share with faster growth is for the high technologically intensity of the products, followed by the medium high technologically intensity of the products. Less *R&D* spending is invested into the low and medium low technologically intensity of the products.

Econometric Results

The Baseline Gravity Model Estimations

Table 1 presents our regression results based on the baseline gravity model without *R&D* spending variables by technologically intensity of merchandise exports. The size of *GDP* has a positive and statistically significant impact on bilateral merchandise export by the technological intensity of the products for exporting and importing countries. In the case of exporting countries, the regression coefficients are higher for the high and medium high technological intensity of the products than for the medium low and low technological intensity of the products. This suggests that the size of *GDP* and its increase in exporting countries are in a greater extent pertained to the high and medium high technological intensity of the products. Faster growth of higher technologically intensive merchandise export can be due to growth in demand for high technological intensity of products and their varieties.

T a b l e 1

The Baseline Estimations

	High technology	**Medium high technology**	**Medium low technology**	**Low technology**
ln GDP exporter	0.918***	0.994***	0.837***	0.592***
ln GDP importer	0.879***	0.825***	0.855***	0.943***
ln GDPCAP exporter	2.293***	0.708***	0.525***	0.701***
ln GDPCAP importer	0.511***	0.393***	0.843***	0.095
ln Distance	–0.603***	–0.685***	–0.920***	–0.577***
Contiguity dummy	0.542***	0.782***	1.051***	0.838***
Language dummy	0.596***	0.160	–0.183**	0.704***
RFTA dummy	1.072***	0.898***	0.440***	1.321***
Constant	–59.918***	–41.942***	–40.019***	–32.820***
N	2 751	2 754	2 753	2 754
R^2	0.9801	0.9881	0.9824	0.9918
Rho	0.826	0.898	0.868	0.923

Notes: * p < 0.1; ** p < 0.05; *** p < 0.01. Parameters are estimated by the Prais-Winsten estimator. The common AR(1) parameter is denoted by Rho. The z values are computed from standard errors that are corrected for heteroscedasticity and contemporaneous correlation of error terms across panels.

Source: Own calculations.

Similarly to the size of *GDP*, the level of economic development measured by *GDPCAP* has a positive and statistically significant impact on bilateral merchandise export by the technological intensity of the products for exporting and importing OECD countries. The coefficient of elasticity for exporting countries is the highest for the high technologically intensive merchandise exports, followed by the medium high technologically intensive merchandise exports. In the case of importing countries, the medium low technologically intensive merchandise export has the highest coefficient of elasticity.

As expected, the *Distance* between the countries' capitals has a negative and statistically significant impact on bilateral merchandise export by the technological intensity of the products between the OECD countries. The regression coefficient is the highest for the medium low technologically intensive merchandise export indicating the importance of geographical proximity and trade costs in conducting international merchandise trade business. The medium low technologically intensive export has also the greatest response on a fact of the having common border as suggested by the regression coefficients of the *Contiguity*, and vice versa in the case of having the *RFTA*, which seems to be the most important for low technologically intensive merchandise export. The empirical results for *Language* are mixed, of a positive sign and significant for the high and low technologically intensive merchandise export and of a negative sign and significant for the medium low technologically intensive merchandise export.

The Effects of *R&D* Spending on Manufacturing Export by the Technological Intensity of the Products

Table 2 presents the econometric results of the set H1 on the effect of *R&D* spending on merchandise export by the technological intensity of the products. The coefficient of elasticities for the size of *GDP* in exporting and importing countries remain of a positive sign and significant, but by their absolute size there is a drop in the size of the coefficient of elasticity for the high technologically intensive exports in exporting countries. This confirmed the presence of the correlation between the high technologically intensive export and the *R&D* spending in the OECD exporting countries. The size and the signs of the associations and statistical significance of the regression parameters for the other explanatory variables from the baseline gravity model are less substantial.

The regression coefficients that are pertaining to the *R&D* spending variables are positive and statistically significant. The absolute size of the coefficient of elasticity is higher for exporting than for importing countries. The coefficient of elasticity that is pertaining to the *R&D* spending is the highest for the high technologically intensive merchandise export in exporting countries, and for the medium low technologically intensive merchandise trade in importing countries. Therefore, these econometric results confirm the importance of *R&D* spending for competitiveness in the high technologically intensive merchandise export as well as for other merchandise export by the technological intensity of the products. It can play also significant role in export as well as mitigating import of merchandise products by the technological intensity of the products in importing countries.

T a b l e 2

The Effect of *R&D* Spending on Merchandise Export by the Technological Intensity of the Products

	High technology	Medium high technology	Medium low technology	Low technology
ln GDP exporter	0.178***	0.461***	0.393***	0.448***
ln GDP importer	0.646***	0.697***	0.619***	0.885***
ln GDPCAP exporter	1.099***	0.852***	0.427***	0.520**
ln GDPCAP importer	0.462**	0.289**	0.817***	0.176
ln Distance	–0.627***	–0.703***	–1.013***	–0.718***
Contiguity dummy	0.396***	0.601***	0.807***	0.735***
Language dummy	0.705***	0.425***	–0.009	0.812***
RFTA dummy	0.608***	0.843***	0.406***	1.198***
ln R&D exporter	0.734***	0.422***	0.468***	0.210***
ln R&D importer	0.181***	0.118***	0.256***	0.094***
Constant	–27.675***	–28.297***	–24.019***	–26.984***
N	2 751	2 754	2 753	2 754
R^2	0.9777	0.9909	0.9846	0.9923
Rho	0.531	0.524	0.880	0.953

Notes: * p < 0.1; ** p < 0.05; *** p < 0.01.

Source: Own calculations.

The Effects of *R&D* Spending on *Distance* for Merchandise Export by the Technological Intensity of the Products

The model specification assumes and empirical estimates in Table 3 for the set H2 confirm that the regression coefficient pertaining to the *Distance* is negative for merchandise export by the technological intensity of the products. However, the regression coefficients have changed only slightly when the interaction (*R&D* spending***Longdistance*) variables are included in the models. The regression coefficients on *R&D* spending variables remain positive and statistically significant. These results indicate that *R&D* spending has strong impacts on the *Distance* and merchandise export by the technological intensity of the products, particularly for encouraging the high technological intensive merchandise exports by exporting countries. This is further confirmed by the regression coefficients for the interaction (*R&D* spending***Longdistance*) variables. There is a positive and statistically significant association for exporting countries, and except for the high and medium high technologically intensive merchandise trade for importing countries. These results imply that the *R&D* spending has reduced the effect of distance on bilateral merchandise export by the technological intensity of the products for exporting OECD countries, and except for the high and medium high technologically intensive merchandise export also in importing OECD countries. The OECD countries, which have invested more in *R&D* spending, they have also expanded and strengthened their merchandise exports by increasing the technological intensity of products on longer distances.

The merchandise import specialization by importing OECD countries has become also stronger in the medium low and low technology intensive merchandise trade.

T a b l e 3

The Effect of *R&D* Spending on *Distance* for Merchandise Export by the Technological Intensity of the Products

	High technology	Medium high technology	Medium low technology	Low technology
ln GDP exporter	0.153**	0.473***	0.378***	0.475***
ln GDP importer	0.643***	0.690***	0.611***	0.878***
ln GDPCAP exporter	1.065***	0.912***	0.363***	0.521**
ln GDPCAP importer	0.362**	0.275**	0.873***	0.184
ln Distance	–0.344***	–0.671***	–0.821***	–0.478***
ln Longdistance	–1.676***	–1.269**	–2.392***	–1.819***
Contiguity dummy	0.691***	0.618***	1.047***	0.828***
Language dummy	0.745***	0.545***	0.102	0.879***
RFTA dummy	0.639***	0.870***	0.405***	1.199***
ln R&D exporter	0.686***	0.356***	0.438***	0.219***
ln R&D importer	0.243***	0.151***	0.147***	0.022
ln R&D exporter * ln Longdistance	0.150***	0.160***	0.111***	0.045
ln R&D importer * ln Longdistance	–0.020	–0.009	0.211***	0.160***
Constant	–27.653***	–28.891***	–23.929***	–28.940***
N	2 751	2 754	2 753	2 754
R^2	0.9797	0.9899	0.9828	0.9906
Rho	0.694	0.584	0.876	0.9563

Notes: * p < 0.1; ** p < 0.05; *** p < 0.01.

Source: Own calculations.

The Effects of *R&D* Spending on the Level of Economic Development for Merchandise Export by the Technological Intensity of the Products

The effect of *R&D* spending on the level of economic development for merchandise export by the technological intensity of the products according to the set H3 is included in the gravity regression model by the interaction effect of the *R&D* spending variables and *GDPCAP* variables. Table 4 presents the regression results for merchandise exports by the technological intensity of the products. The regression coefficients that are pertaining to the interaction *R&D* spending* *GDPCAP* variables are negative and statistically significant, except for insignificant regression coefficient that is pertaining to the interaction *R&D* spending* *GDPCAP* variable for the medium high intensive merchandise export for exporting countries, but also negative and statistically significant for the medium high and medium low merchandise trade in importing countries. These results indicate the increasing importance of less developed OECD countries in competitive merchandise exports in the high, medium low and low technologically intensive

merchandise exports as well as less successful import specialization in the medium high and medium low technologically intensive products in developed OECD countries in bilateral merchandise trade between the OECD countries. This finding suggests structural changes in composition of trade between the OECD countries.

T a b l e 4

The Effect of *R&D* Spending on Economic Development for Merchandise Export by the Technological Intensity of the Products

	High technology	Medium high technology	Medium low technology	Low technology
ln GDP exporter	0.332***	0.516***	0.530***	0.596***
ln GDP importer	0.596***	0.722***	0.662***	0.868***
ln GDPCAP exporter	4.859***	1.866**	3.264***	2.346***
ln GDPCAP importer	0.780**	1.299***	1.728***	0.176
ln Distance	–0.712***	–0.740***	–1.065***	–0.757***
Contiguity dummy	0.221**	0.568***	0.824***	0.573***
Language dummy	0.708***	0.489***	0.099	0.884***
RFTA dummy	0.421***	0.861***	0.357***	1.145***
ln R&D exporter	6.824***	1.948*	5.870***	3.694***
ln R&D importer	0.484	1.722**	1.887**	–0.037
ln R&D exporter * ln GDPCAP exporter	–0.613***	–0.154	–0.549***	–0.359***
ln R&D importer * ln GDPCAP importer	–0.026	–0.161**	–0.163**	0.015
Constant	–70.387***	–50.246***	–65.306***	–47.875***
N	2 751	2 754	2 753	2 754
R^2	0.9813	0.9897	0.9851	0.9918
Rho	0.517	0.537	0.894	0.949

Notes: * p < 0.1; ** p < 0.05; *** p < 0.01.

Source: Own calculations.

Research, Managerial and Policy Implications

Traditional gravity model variables are in a line of theoretical expectation. *GDP* and *GDPCAP* increased merchandise export in each of the technological intensity of the products. The inverse role of the distance on merchandise export is found to be the most crucial for medium low technological intensity of the products. Common border is the most important for medium low and low technological intensity of the products, while common language and free trade agreements particularly for low technological intensity of the products. These results imply the important role that can play proximity variables for merchandise exports in low technological intensity of the products.

The special focus has been on the association between the *R&D* spending and merchandise export by the technological intensity of the products. Consistently with the set H1, *R&D* spending is found to play significant positive role for merchandise export by the technological intensity of the products. *R&D* spending is important for merchandise export by the technological intensity of the products

in each product group, but their role for high technological intensity of the products in exporting countries is more important than for low, medium-low and medium high technological intensity of the products. This finding is important in order to develop supply-side export ability for merchandise export in high technological intensity of the products in exporting countries and demand-side growth potentials for technological diversified merchandise import of products.

Indirect effect of *R&D* spending is found on distance, as argued in the set H2, but the results are mixed by the technological intensity of the merchandise products. The longdistance single effect is found even more important than only for distance. *R&D* spending mitigated the effect of distance on merchandise export by the technological intensity of the products, except for low technological intensity of the products and in importing countries for medium low and low technological intensity of the products, where increasing transportation costs related to the geographical distance remained.

Significant lessons learnt in interest to the *R&D* policy makers, business community and managerial relevance is provided by testing the set H3. The *R&D* spending played an important role in catching-up merchandise export from less to more developed OECD countries by the technological intensity of the products. This particularly holds for high and medium low technological intensity of the products. The *R&D* spending has also served in successful import penetration in medium high and medium low technological intensity of the products. These results clearly revealed the important role that *R&D* spending can play not only in developed OECD countries, but particularly in developing OECD countries that through export-oriented growth are climbing up to become developed countries.

The implications of the results obtained are important for the *R&D* management in creating internal dynamics at the country, sector and enterprise levels for reinforcing the absorptive capacity of *R&D* investments in order to foster the merchandise exporting capacity, particularly in higher technological intensity of the products. Successful strategies of export-oriented merchandise growth has been supported by the *R&D* spending, which have created positive direct and indirect effects on increasing merchandise export advantages by the technological intensity of the products.

Conclusions

The paper has used country level panel data in order to explain country- and product-specific determinants for merchandise exports by the technological intensity of the products: low, medium-low, medium-high, and high technological intensity of the products. The results are relevant for the studied sample of the

OECD countries with novelty and contribution for merchandise exports by the technological intensity of the products and the differences across countries by the level of economic development.

Coefficients of elasticity are higher for merchandise export in higher technologically intensive products as a reason for their faster growth. Greater *R&D* spending positively affects the increase of exports in differentiated products. The greater *R&D* spending mitigates the importance of the distance for merchandise exporters by expanding their export opportunities particularly for low and medium-low technological intensive products in OECD exporting countries, and reduces the distance for importers' countries particularly for medium-high and high technologically intensive products in OECD importing countries. With the *R&D* spending, economically less developed OECD countries were catching-up in merchandise export with economically more developed OECD countries. The *R&D* spending in the economically most developed OECD countries have not been sufficient to sustain a competitive position in merchandise exports as well as in manufacturing import specialization particularly for medium high and medium low technologically intensive products.

Among issues for future research is to use a firm level data and conduct comparative study for industry/product-specific issues. This analysis could provide robustness test on a relationship between exports and *R&D* spending and technological capabilities focusing on certain countries, industries and products that are in interest to the business community, policy makers and managers of large companies and small and medium sized enterprises.

References

ANDERSON, J. E. – van WINCOOP, E. (2003): Gravity with Gravitas: A Solution to the Border Problem. American Economic Review, *93*, No. 1, pp. 170 – 192.

BALÁŽ, V. (2011): Research and Development Policies in the New Member States of the European Union. Ekonomický časopis/Journal of Economics, *59*, No. 9, pp. 875 – 894.

BARRIOS, S. – HOLGER GÖRG, H. – STROBL, E. (2003): Explaining Firms' Export Behaviour: R&D, Spillovers and the Destination Market. Oxford Bulletin of Economics and Statistics, *65*, No. 4, pp. 475 – 496.

BECK, N. – KATZ, J. N. (1996): Nuisance vs. Substance: Specifying and Estimating Time-Series Cross-Section Models. Political Analysis, *6*, No. 1, pp. 1 – 36.

BOJNEC, Š. – FERTŐ, I. (2009): Impact of the Internet on Manufacturing Trade. Journal of Computer Information Systems, *50*, No. 1, pp. 124 – 132.

BOJNEC, Š. – FERTŐ, I. (2011): Impacts of Research and Development on Manufacturing Trade. [Zbornik radova Ekonomskog fakulteta u Rijeci/Proceedings of Rijeka School of Economics.] Journal of Economics and Business, *29*, No. 1, pp. 65 – 88.

CANINA, L. E. – ENZ, C. A. – HARRISON, J. S. (2005): Agglomeration Effects and Strategic Orientations: Evidence from the U.S. Lodging Industry. Academy of Management Journal, *48*, No. 4, pp. 565 – 581.

DiPIETRO, W. R. – ANORUO, E. (2006): Creativity, Innovation, and Export Performance. Journal of Policy Modeling, *28*, No. 2, pp. 133 – 139.

FREUND, C. L. – WEINHOLD, D. (2002): The Internet and International Trade in Services. American Economic Review, *92*, No. 2, pp. 236 – 240.

FREUND, C. L. – WEINHOLD, D. (2004): The Effect of the Internet on International Trade. Journal of International Economics, *62*, No. 1, pp. 171 – 189.

GHAZALIAN, P. L. – FURTAN, W. H. (2007): The Effect of Innovation on Agricultural and Agri-Food Exports in OECD Countries. Journal of Agricultural and Resource Economics, *32*, No. 3, pp. 448 – 461.

GROSSMAN, G. M. – HELPMAN, E. (1995): Technology and Trade. Amsterdam – New York – Oxford: Elsevier – North-Holland.

HATZICHRONOGLOU, T. (1997): Revision of the High-Technology Sector and Product Classification. [OECD STI Working Papers 1997/2.] Paris: Organisation for Economic Cooperation and Development.

HELPMAN, E. – MELITZ, M. – RUBINSTEIN, Y. (2008): Estimating Trade Flows: Trading Partners and Trading Volumes. Quarterly Journal of Economics, *123*, No. 2, pp. 441 – 487.

ITO, K. – PUCIK, V. (1993): R&D Spending, Domestic Competition, and Export Performance of Japanese Manufacturing Firms. Strategic Management Journal, *14*, No. 1, pp. 61 – 75.

KLAS, A. (2010): Research as the Factor of Innovative Development. Ekonomický časopis/Journal of Economics, *58*, No. 9, pp. 871 – 887.

KRUGMAN, P. (1979): A Model of Innovation, Technology Transfer, and the World Distribution of Income. Journal of Political Economy, *87*, No. 2, pp. 253 – 266.

OECD (2006): ANBERD Database. Paris: Organisation for Economic Cooperation and Development.

PESARAN, M. H. (2004): General Diagnostic Tests for Cross Section Dependence in Panels. [Cambridge Working Papers in Economics, No. 0435.] Cambridge: University of Cambridge, Faculty of Economics.

WOOLDRIDGE, J. M. (2002): Econometric Analysis of Cross Section and Panel Data. Cambridge, MA: The MIT Press.