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Empirical evidence on Heckscher-Ohlin trade theorem: the case of international trade between Croatia and the rest of the European Union member states*

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Abstract

The goal of this research is to test the Heckscher-Ohlin' theorem of comparative advantages on the sample of the Republic of Croatia and other European Union member countries. Heckscher-Ohlin theorem of comparative advantages can largely explain international trade in cases where the sample of countries is heterogeneous, in terms of the achieved level of development and the production factors abundance. In regards to aforementioned research hypothesis was tested using several regression models. Based on the research results, it can be concluded that the international merchandise trade between Croatia and other European Union (EU) members is in accordance with the assumed by Heckscher-Ohlin comparative advantages theory. The difference in production factors abundance between Croatia and other European Union members better explains differences in production factor unit prices than net merchandise trade. Empirical testing show that merchandise trade between Croatia and other European Union members is correlated with the capital abundance. We found no significant correlation between merchandise trade and relative education level of Croatian labor force in regards to other EU countries. Furthermore, based on the empirical testing, it can be concluded that Croatia in regards to EU27 average, is a labor abundant country and net exports of Croatian manufacturing is labor intensive. Estimated results point out the production factor importance as a base for further merchandise exports development and economic development as a whole. Finally, basic conclusion is that Croatia needs to put more effort on investment attraction and therefore capital to labor ratio increase.

Key words: *Heckscher-Ohlin trade theorem, Croatia, European Union*

JEL classification: *F1, F2*

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1. Introduction

In the paper Heckscher-Ohlin (Heckscher, 1919; Ohlin, 1933) trade theory of comparative advantages is tested on the sample of the Republic of Croatia and other European Union (EU) members. Heckscher-Ohlin (H-O) theory sees the differences in comparative advantages as a consequence of exogenous differences in production factors abundance (Heckscher, 1919). According to Debaere (2003), H-O theory of comparative advantages can largely explain international trade in cases where the sample of countries is heterogeneous, taking into account larger differences in development level and production factors abundance. In this sense, it represents appropriate theoretical base for the research of direction and structure of merchandise trade among the Republic of Croatia and other EU countries.

H-O theory of comparative advantages (Heckscher, 1919; Ohlin, 1933) is based on the model that includes two countries, two products and two production factors. Taking into account other assumptions of the model (perfect production factors mobility in the country and immobility outside the country, full employment, identical technology and tastes, no transport costs, and no limitations to international trade, no reverse factor intensity, different factor proportions among countries), a country will export the good that uses relatively more abundant production factor intensively because higher production factors abundance means lower relative price. According to the H-O theoretical assumptions production factors abundance in a country and not absolute production factors amount is crucial for international trade. A country with larger portion of capital in its production factors in relation to the portion of capital in production factors of other country is relatively more abundant with capital than the other country. The research hypothesis is defined as follows: Heckscher-Ohlin theorem of comparative advantages explains merchandise trade between Croatia and other EU member states. Out of the research hypothesis the trade pattern between Croatia and other EU member states will be determined. Furthermore, the recent literature on this topic is scarce. H-O theorem has not been tested on comparable sample countries nor has trade pattern between Croatia and other EU member states been determined.

The paper consists of six parts. After the first, introductory part, in the second part literature review is given. The third part describes the conception of analysis, and the fourth empirical data. Fifth part is devoted to research results. Conclusion is given in the sixth part.

2. Literature review

Available empirical research does not give consistent conclusions about the validity of the H-O theory of comparative advantages because they were conducted in different conditions. Debaere (2003) and Romalis (2004) confirm the relevance of

the H-O theory in determining trade patterns. H-O theory that focused on analyzing different dimensions (countries, products and production factors) did not find confirmation in its original form (Maskus 1985; Bowen, Leamer and Sveikauskas, 1987; Staiger, 1988). Its intuitivism and lack of alternative theories that would explain trade of factor service created the need for additional research.

First empirical testing of the multidimensional H-O theory was done in 1985 (Maskus, 1985) and then in 1987 (Bowen, Leamer and Sveiskaus, 1987). Research results showed that the relation between the left and the right side of the equation of factor content trade was confirmed in 61% of analyzed countries, while random probability of that kind of relationship is 50%. The research also confirmed the suspicions of theorists regarding the credibility of the theory in measuring the direction of trade that were based on the Leontief paradox. Although that was not an empirical testing of the H-O theory in various dimensions, Leontief paradox is often connected to multidimensional model of H-O theory (Trefler, 1993). Leontief's paradox was later tested (Leamer, 1980) and it was concluded that Leontief did not use conceptual appropriate test for testing the H-O theory. After Leamer used the appropriate test and the same data as Leontief, his paradox disappeared (Leamer and Levinsohn, 1995). On the basis of Leontief paradox and other empirical testing a consensus was reached that multidimensional H-O theory does not explain trade patterns well (Krugman and Obstfeld, 1994). However, dismissing the mentioned theory was a problem because there was no alternative theory.

There were efforts to modify theoretical assumptions, and, in the same time, to test the existing assumptions but on more appropriate data. H-O theory gained more credibility after the publication of some empirical papers (Trefler, 1993 and Trefler, 1995) which represented alternative approach to the problem identified in the previous research that tested H-O theory (Bowen, Leamer and Sveiskaus, 1987).

Following Leontief's idea that H-O theory does not explain bilateral international exchange due to differences in production factor productivity, Trefler (1995) chose productivity that is efficiency of production factors and therefore modified H-O theory to better explain trade patterns. The first research in that direction (Trefler, 1993) focused on analyzing differences in production technology and related differences in production factor prices. It was shown that differences in productivity correlate with differences in wages and rents which led to the suggestion that the way of analyzing production factor prices equalization should change. Leaving the assumptions of equal technology and equal production factor prices, new and modified multidimensional model of H-O theory was reached. By leaving the assumptions of equal technology and equal production factor prices among countries, the relationship between theoretical model and real trade of factor services patterns improved considerably. Differences in productivity among countries are explained in two ways (Trefler, 1993). One possible explanation is that workers in one country simply work more. The other is that certain countries have

access to technology that makes them more efficient. Higher labor productivity is connected to larger capital abundance as a production factor (Dollar, Wolff and Baumol, 1988).

The later research (Trefler, 1995) focused on the demand side. By defining the regression model without the constant, exchange of factor contents was tested in relation to differences in production factor abundance. When factor content of trade is measured as predicted factor content of trade then coefficient of linear regression is equal to one. This coefficient is lower than 1 in the conducted research, and the author concluded that there is "missing trade" which is explained by the bias of domestic demand (Armington, 1969). Further research of H-O theory focused on explaining the impact of differences in production technology (Davis and Weinstein, 2001) as well as the impact of costs of trade. The impact of distance was also analyzed having in mind the gravity model, and it had great success in explaining trade theory (Tinbergen, 1962). Taking into consideration differences in production technology among countries and gravity model of international trade, better application and credibility of H-O theory was achieved.

To rule out the impact of aggregate supply in the rest of the world Debaere (2003) analyzed abundance between pairs of countries and their net trade in goods. This kind of analysis reaches better explanation power of trade using the H-O theory, as well as better explanation power of trade among developed and developing countries in relation to situations when both countries are developed or developing.

Different preferences among countries are an assumption opposite to H-O assumptions. Some research tried to modify H-O theory to real trade flows leaving the assumption of homogeneous preferences. The research of correlation between demand preferences and H-O theory shows that high income countries have demand more oriented towards capital intensive goods as opposite to low income countries (Reimer and Hertel, 2010).

Following the assumption of homothetic preferences, one of the original H-O theory assumptions, the structure of consumption should not change with the increase of income, only the quantity of consumption. Leaving this assumption leads to better explanation power of H-O theory in explaining international trade (Reimer and Hertel, 2010).

3. Methodology and methods of analysis

We firstly tested whether or not the differences in the production factors abundance between Croatia and other European Union countries positively correlate with comparative advantages of Croatia in production factors' prices and net merchandise trade between Croatia and other European Union countries.

In order to test the effect of production factor abundance on their relative prices on the example of Croatia and other EU countries, the following regression model is defined:

$$\log\left(\frac{w_{lc}/w_{kc}}{w_{lcro}/w_{kcro}}\right)=\alpha+\beta\cdot\log\left(\frac{V_{lc}/V_{kc}}{V_{lcro}/V_{kcro}}\right)+\varepsilon_{lkc} \quad (1)$$

where:

w_{lc} – unit cost of labor in EU member country $EU_{1\text{-}27,}$

w_{kc} – unit cost of capital in EU member country $EU_{1\text{-}27,}$

w_{lcro} – unit cost of labor in Croatia,

w_{kcro} – unit cost of capital in Croatia,

V_{lc} – labor supply in EU member country $EU_{1\text{-}27,}$

V_{kc} – capital supply in EU member country $EU_{1\text{-}27,}$

V_{lcro} – labor supply in Croatia,

V_{kcro} – capital supply in Croatia.

Table 1 shows the features of the variables production factors abundance and the relative unit price of production factors.

In order to test the effect of production factors abundance on net merchandise trade on the sample of Croatia and other EU countries, following regression model is defined:

$$\log\left(\frac{I_{mpc}}{E_{xpc}}\right)=\alpha+\beta\cdot\log\left(\frac{V_{lc}/V_{kc}}{V_{lcro}/V_{kcro}}\right)+\varepsilon_{lkc} \quad (2)$$

where:

I_{mpc} – merchandise imports of Croatia from the EU member country $EU_{1\text{-}27,}$

E_{xpc} – merchandise exports of Croatia in the EU member country $EU_{1\text{-}27,}$

$\left(\frac{I_{mpc}}{E_{xpc}}\right)$ – net merchandise exports (defined as import – export ratio) of Croatia in the EU member country $EU_{1\text{-}27.}$

Like above mentioned, Table 1 shows the features of the variables production factors abundance and relative unit price of production factors.

Afterwards we wanted to test the influence of the education level abundance on net merchandise trade between Croatia and other European Union countries, so the model represented by equation (2) is extended. We additionally captured the influence from difference in highly educated and law educated labor. Inclusion of mid-educated labor influence in the model would cause multicollinearity so we left the mid-educated labor influence out of the model.

In order to empirically test this assumption the following multiple linear regression model is defined:

$$\ln\left(\frac{I_{mpc}}{E_{xpc}}\right)=\beta_0+\beta_1\cdot\ln\left(\frac{L_{HEc}}{L_{HEcro}}\right)+\beta_2\cdot\ln\left(\frac{L_{LEc}}{L_{LEcro}}\right)+\beta_3\cdot\ln\left(\frac{V_{kc}/V_{lc}}{V_{kcro}/V_{lcro}}\right)+\varepsilon_i \quad (3)$$

where:

I_{mpc} – merchandise imports in Croatia from EU member country $EU_{1\text{-}27}$,

E_{xpc} – merchandise exports of Croatia to EU member country $EU_{1\text{-}27}$,

$\left(\frac{I_{mpc}}{E_{xpc}}\right)$ – net merchandise exports (defined as import – export ratio) from Croatia to EU member country $EU_{1\text{-}27}$,

L_{HEc} – share of highly educated labor force in total labor force in EU member country, $EU_{1\text{-}27}$,

L_{cro} – share of highly educated labor force in total labor force in Croatia,

L_{LEc} – share of low educated labor force (primary education and lower) in total labor force in EU member country $EU_{1\text{-}27}$,

L_{LEcro} – share of low educated labor force (primary education and lower) in total labor force in Croatia,

V_{kc}/V_{lc} – ratio of capital to labor in EU member country $EU_{1\text{-}27}$,

V_{kcro}/V_{lcro} – ratio of capital to labor in Croatia.

The relationship between the ratio of capital to labor and net merchandise trade is tested by estimating the significance of β_3 coefficient in the multiple linear regression model defined in the equation (3). The relationship between highly educated labor abundance and net merchandise trade is tested by estimating the significance of β_1 coefficient in the multiple linear regression model defined in the equation (3). The relationship between the low educated labor abundance and net merchandise trade is tested by estimating the significance of β_2 coefficient in the multiple linear regression model defined in the equation (3). Empirical test was performed using regression analysis on variables shown in the Table 3.

Furthermore, we wanted to check whether or not the net merchandise export of Croatia on the European Union market is intensive with production factors that are abundant in Croatia in regards to other European Union countries.

In order to test production factors abundance in Croatia compared to other EU countries, production factors are analyzed on the level of labor (*L*) and capital (*V*) and conclusions are made for every EU member country (i) and then compared to Croatia using the following method:

if e $\frac{L_i}{V_i} > \frac{L_{RH}}{V_{RH}}$ country *i* is abundant with labor compared to Croatia.

New variable Foz is defined and it represents factor abundance of a country. The variable Foz can take the values as described in the following part.

If $\max(\frac{L_i}{V_i}, \frac{L_{RH}}{V_{RH}}) = \frac{L_{RH}}{V_{RH}}$ then Foz(i) = 1, and if $\max(\frac{L_i}{V_i}, \frac{L_{RH}}{V_{RH}}) = \frac{L_i}{V_i}$, then Foz(i) = 0.

Using the above described relation conclusion can be made about factors abundance in Croatia and in other EU member countries. If Foz(i) = 1, then Croatia id abundant with labor compared to EU country (i) , and if Foz(i) = 0, then Croatia is abundant with capital compared to EU country (i). Conclusion about capital and labor abundance of Croatia compared to other EU countries are made by counting the values of variable Foz(i) for every country (i). If the variable Foz(i) takes larger number of value Foz(i) = 1 compared with Foz(i) = 0, Croatia is abundant with labor on the EU market, and if Foz(i) takes larger number of value Foz(i) = 0 compared to the values of Foz(i) = 1, then Croatia is abundant with capital on the EU market.

After bringing the conclusion on production factor abundance in Croatia compared to other EU countries, follows the research of the branches of manufacturing industry in which Croatia has positive net merchandise exports to the EU market, and the variable Fid is defined (factor intensity of an economic activity branch) which takes the values as described.

Economic activities of Croatian manufacturing industry are divided into the two main groups. The first group consists of those economic activities that have positive net merchandise exports to the EU market, while the second group consists of all other branches of activities in the Croatian manufacturing industry. For every branch of activity of the manufacturing industry variable Fid is defined as described below.

Factor intensity is analyzed according to the labor and capital intensity.

If $\max(\frac{L_i}{V_i}, \frac{L_j}{V_j}) = \frac{L_j}{V_j}$ then follows that Fid(j) = 1, and if $\max(\frac{L_i}{V_i}, \frac{L_j}{V_j}) = \frac{L_i}{V_i}$ then Fid(j) = 0,

where *i* and *j* are economic activities of the manufacturing industry in Croatia.

Branches of activities (*j*) of the manufacturing industry in Croatia belong to the group of activities that generate positive net merchandise exports to the EU market, and activities (*i*) belong to the group of other activities in manufacturing industry. By counting different values that the variable Fid takes in the first and the second group, conclusions about factor intensity of Croatian net merchandise exports to the EU market are made.

In all econometric models that use the least square method for parameter evaluation certain assumptions of efficiency and neutrality have to be tested.

The first step in building a model implies the use of appropriate statistical tests, primarily Augmented Dicky Fuller Test in order to test the stationarity of analyzed variables. After testing the stationarity by using the least square method, parameters of the defined model are evaluated. Evaluations of model assumptions are conducted using appropriate statistical methods.

Since we use regression models, Gauss-Mark conditions need to be met. Residual autocorrelation is tested with Durbin Watson's test, Breusch-Godfrey's test as well as through correlogram. Heteroscedasticity of variance is tested with White's test, while for testing the normality of residual division Jarque-Bera's test is used.

4. Data and empirical analysis

In order to estimate capital supply in Croatia and other 27 EU countries double declining balance method is used for the 15 year period as in Leamer (1984) and Trefler (1993). Data is available on Eurostat webpage for the period 1995 – 2011. The amount of capital supply (K) is calculated based on investments in fixed capital (I) using the following equation:

$$K^c = \sum_{t=1995}^{2011} (1-0{,}1333)^{(2011-t)} \cdot I_t^c \tag{4}$$

For the parameter estimation in the model, Eurostat data on unit prices of analyzed production factors were used for the year 2011, data on investments in fixed capital for the period 1995 – 2011 and the World Bank data on labor supply according to the level of education in sample countries available for the year 2011.

Table 1 shows properties of the variable production factors abundance and the variable relative unit price of production factors in Croatia in relation to the EU27:

$\frac{w_{kc} / w_{lc}}{w_{kcro} / w_{lcro}}$ – dependent variable of the linear regression model,

$\frac{V_{kc} / V_{lc}}{V_{kcro} / V_{lcro}}$ – independent variable of the linear regression model.

Table 1: The features of the variable production factors abundance and the variable relative unit price of production factors in Croatia in relation to the EU27

Descriptive statistics	$\frac{V_{kc}/V_{lc}}{V_{kcro}/V_{lcro}}$	$\frac{w_{kc}/w_{lc}}{w_{kcro}/w_{lcro}}$
Min	17.50	0.40
Max	97.70	1.70
Average	54.60	0.80
Mid-range	57.60	1.02

Source: Author's calculations

In the model variables are used in logarithmic form.

Common problem in a cross-section model is heteroscedasticity of variance. Therefore, values that significantly deviate, so called outliers, are separated from the sample. The sample includes the values of production factors of 20 EU countries and in Croatia. The final sample includes the following countries: Cyprus, Denmark, Estonia, Finland, France, Hungary, Ireland, Italy, Latvia, Lithuania, Malta, Netherlands, Germany, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden.

Table 2 shows the properties of the variables production factors abundance and net merchandise trade of Croatia with the EU27.

Table 2: The features of production factors abundance and the variable net merchandise trade of Croatia with the EU27

Descriptive statistics	$\frac{V_{kc}/V_{lc}}{V_{kcro}/V_{lcro}}$	$\frac{I_{mpc}}{E_{xpc}}$
Min	17.50	0.20
Max	97.70	11.00
Average	54.60	2.70
Mid-range	57.60	5.59

Source: Author's calculations

Table 3 shows the properties of variables capital abundance, labor abundance, highly educated labor abundance, mid-educated labor abundance and net merchandise trade of Croatia with the EU 27 countries. Merchandise trade data of Croatia with the EU 27 countries are available from the National Bureau of Statistics for the year 2011.

Table 3: The features of variables capital abundance, labor abundance, highly educated labor abundance, mid-educated educated labor and net merchandise trade of Croatia with the EU 27 countries

Descriptive statistics	$\frac{V_{kc}/V_{lc}}{V_{kcro}/V_{lcro}}$	$\frac{I_{mpc}}{E_{xpc}}$	$\frac{L_{MEc}}{L_{MEcro}}$	$\frac{L_{HEc}}{L_{HEcro}}$
Min	17.50	0.20	0.30	0.80
Max	97.70	11.00	1.20	2.00
Average	54.60	2.70	0.80	1.40
Mid-range	57.60	5.59	0.76	1.40

Source: Author's calculations

The data in the sample for testing production factor intensity of Croatia's net merchandise exports are: capital and number of employees according to the level of professional competence by branches of economic activity according to the National Classification of Activities (NACE 2007) at the level of subsections (second level) of manufacturing industry (codes C10 to C33) in Croatia, available at the National Bureau of Statistics for the year 2011.

5. Results and discussion

According to the assumed by H-O theory of comparative advantages, in international trade relative abundance of the production factors in the country is relevant, not their absolute amount. Based on the number of labor active population in countries and the abundance of capital by country, the ratio of abundance of capital and the number of labor active population by country is shown. Ratio of capital to labor is an indicator of the relative abundance of labor and capital in each country (Table 4).

Table 4: Ratio of capital to labor in the EU countries in 2011 (EUR)

Country	Ratio of capital to labor (EUR)
Belgium	92,89
Bulgaria	14,22
Denmark	97,72
Germany	69,56
Estonia	32,44
Ireland	95,06
Spain	70,33
France	83,67
Italy	79,81
Ciprus	45,42
Latvia	26,50
Lithuania	22,75
Luxembourg	194,27
Hungary	28,39
Malta	37,61
Netherlands	80,55
Austria	88,61
Poland	22,33
Portugal	42,67
Romania	17,49
Slovenia	49,60
Slovakia	29,57
Finland	82,78
Sweden	77,97
UK	61,54
Norway	138,86
Croatia	35,26

Source: Author's calculations

Preliminary to estimation of parameters of a regression model is necessary to check the stationarity properties of the observed variables. The results of the test are shown in Table 5.

Table 5: Augmented Dickey-Fuller test of stationarity of relative unit factor prices, factor abundance and net merchandise trade in Croatia

Variable	Augmented Dickey-Fuller Test	P-value
$\frac{w_{kc}/w_{lc}}{w_{kcro}/w_{lcro}}$	around zero	0.11
	around the constant	0.02
$\frac{V_{kc}/V_{lc}}{V_{kcro}/V_{lcro}}$	around zero	0.21
	around constant	0.00
$\frac{I_{mpc}}{E_{xpc}}$	around zero	0.02
	around constant	0.00

Source: Author's calculations

Following the completion of stationarity test, as shown in Table 6, with significance level of 5% it can be concluded that the variable that represents the ratio of relative unit labor costs and capital and the variable that represents the labor abundance and capital abundance achieve stationarity around the constant. In the same way, with the significance level of 5%, it can be concluded that the variable that represents net exports achieves the property of stationarity around zero.

After the rejection of the null hypothesis that assumes a non-stationary variable for all observed variables the assumption of stationarity of the observed variables is satisfied and the assumed model can be estimated After estimating the model using least squares method (which is also the best linear unbiased estimator), the results obtained were as shown in Table 6.

Table 6: Estimated model of production factor abundance and their relative prices

Variable	Model description	Constant value(α)/ value of the coefficient of independent variable (β)	P-value
$\log\left(\frac{w_{kc}/w_{lc}}{w_{kcro}/w_{lcro}}\right)$	dependent variable		
α	constant	5.778491	0.00
$\log\left(\frac{V_{kc}/V_{lc}}{V_{kcro}/V_{lcro}}\right)$	independent variable	-1.039372	0.00
significance of the model (F-test)			0.00
determination coefficient (R^2)	0.955347		

Source: Author's calculations

After estimating the model, according to the coefficient of determination it can be concluded that constant and independent variable well explain the dependent variable. After making t-tests on the significance of constants and independent variables, with significance level of 1% the null hypothesis can be rejected, this assumes that the constant and independent variable are insignificant. Negative sign with the independent variable is in line with expectations and suggests that higher production factors abundance is correlated with lower production factor unit prices.

Testing normality of errors is conducted with Jarque-Bera test that uses coefficients of skewness and kurtosis of residuals. The distribution of the residual errors is normal. Also, on the basis of the White's test, the null hypothesis can be accepted, which assumes homoscedastic variance. The results of the Jarque-Bera test confirm the null hypothesis that assumes a normal distribution of error or residuals. Based on the correlogram, it can be concluded that a problem of autocorrelation among the residuals does not exist.

So, all the assumptions of the model are met and the independent variable is significant as well as the estimated model. Estimated parameters of the regression equations are negative and are interpreted as the coefficients of elasticity of the dependent variable changes with respect to the independent variable. The estimated model can be interpreted as follows: if the relative ratio of capital to labor in Croatia in relation to other EU member countries increases by 1%, the ratio of unit cost of capital and unit cost of labor in Croatia compared to the same ratio in other EU countries will be reduced by 1.039372%. In conclusion, according to the empirical testing, the assumption can be accepted.

Furthermore, after the evaluation of model which links the production factors abundance and net merchandise trade using the least squares method, the results obtained were as in Table 7.

As shown in Table 7, according to the results of the F-test, with a significance level of 5%, the estimated model can be accepted. T-test results showed that the independent variable in the model is significant at the significance level of 5%. The coefficient of determination shows that 18.9% of change in the dependent variable is explained by changes in the independent variables.

Based on the White's test, the null hypothesis which assumes homoscedastic variance can be accepted. The results of the Jarque-Bera test confirm the null hypothesis that assumes a normal distribution of error terms or residuals. Based on the correlogram, it can be concluded that the problem of autocorrelation among the residuals does not exist.

As shown, all the conditions of the model are met, and the independent variable, as well as the estimated model is significant. Estimated parameters of the regression equations are positive, and are interpreted as coefficients of elasticity of the dependent variable changes with respect to the independent variable.

Table 7: Estimated model of production factor abundance and net merchandise trade

Variable	Model description	Constant value (α)/ value of the coefficient of independent variable (β)	P-value
$\log\left(\frac{I_{mpc}}{E_{xpc}}\right)$	dependent variable		
α	constant	-2.113510	0.13
$\log\left(\frac{V_{kc}/V_{lc}}{V_{kcro}/V_{lcro}}\right)$	independent variable	0.717304	0.05
significance of the model (F-test)			0.05
determination coefficient (R^2)	0.189487		

Source: Author's calculations

The estimated model can be interpreted as follows: if the ratio of capital to labor in the EU member in relation to the one in Croatia increases by 1%, the share of merchandise imports from that country in merchandise exports will increase by 0.717304%. In conclusion, after the empirical testing of the model, the model can be accepted. It can also be concluded that the production factors abundance better explains their relative production factor unit costs than net merchandise trade between Croatia and other European Union members.

The following assumption is tested also by regression analysis. The stationarity of variables test is shown in Table 8.

In accordance with the implemented test of stationarity, it can be concluded that the observed variables are stationary around the constant or around zero at significance level of 5%.

Table 8: Augmented Dickey-Fuller Test of model variables: ratio of capital to labor and relative education of labor force

Variable		P-value
$\frac{L_{HEc}}{L_{HEcro}}$	around zero	0.51
	around constant	0.00
$\frac{L_{MEc}}{L_{MEcro}}$	around zero	0.80
	around constant	0.00
$\frac{V_{kc}/V_{lc}}{V_{kcro}/V_{lcro}}$	around zero	0.21
	around constant	0.00
$\frac{I_{mpc}}{E_{xpc}}$	around zero	0.02
	around constant	0.00

Source: Author's calculations

Following the stationarity test, parameter estimates are shown in Table 9. On the basis of the assessment results, it can be concluded that the observed variables have an impact as assumed. However, the observed variables did not achieve adequate statistical significance with which the assumption can be accepted.

Table 9: Estimated model of production factor abundance and net merchandise trade

Variable	Model description	Constant value (α)/ value of the coefficient of independent variable (β)	P-value
$\frac{I_{mpc}}{E_{xpc}}$	dependent variable		
α	constant	-1.707807	0.57
$\frac{V_{kc}/V_{lc}}{V_{kcro}/V_{lcro}}$	independent variable	0.039692	0.07
$\frac{L_{HEc}}{L_{HEcro}}$	independent variable	1.737531	0.22
$\frac{L_{MEc}}{L_{MEcro}}$	independent variable	-0.254986	0.22
significance of the model (F-test)			0.04
determination coefficient (R^2)	0.384368		

Source: Author's calculations

As shown in Table 9, in the estimated model with a significance of 10% only of capital abundance achieved satisfactory statistical significance. The contribution of the variables is in accordance with expectations.

White's and Jarque-Bera tests have been conducted as well, which show that the variance of the residuals are homoscedastic, and the null hypothesis of normality distribution of residuals can be accepted, at the significance of 1%. However, with a significance level of 5% the null hypothesis that assumes a normal distribution of residuals in the model is rejected. Based on the correlogram it can be concluded that the problem of autocorrelation of residuals in the model is not present.

Based on the empirical tests with significance level of 5%, this assumption cannot be accepted. However, at the significance level of 10%, we can accept this assumption. In conclusion, this assumption can be only partially accepted.

The production factors intensity of the Croatia's net merchandise exports is tested by comparing the factor intensity of net exports of manufacturing industry in Croatia and factor intensity in manufacturing industry in Croatia. Table 10 shows the calculation of the factor intensity of Croatian manufacturing industry.

Classification NACE 2002 was used and the corresponding activities according to NACE 2007. The NACE 2007 is more detailed and data are aggregated on the level of the NACE 2002. The available data for the period from 1999 to 2011 were used. Data for the period from 1995 to 1998 are not available and the assumption is examined on the available datasets.

The average ratio of capital to labor in manufacturing industry in the Croatia is 170,060 HRK per employee. Branches of economic activity that have larger ratio of capital to labor are capital intensive while those that have lower ratio of capital to labor are labor-intensive.

Table 10: Factor intensity of manufacturing industry 2011

Activities of manufacturing industry	Capital abundance (000 HRK)	Number of employed	Ratio of capital to labor
Leather and similar products manufacture	302,568	9,046	33.45
Manufacture of wearing apparel	721,332	16,521	43.66
Manufacture of computers and electronic devices	343,919	4,452	77.25
Manufacture of furniture, other production industry	769,854	8,855	86.94
Manufacturing of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	1,009,672	10,252	98.49
Manufacture of fabricated metal products, except machinery and equipment	2,186,599	22,103	98.93
Manufacture of machinery and equipment	1,160,230	10,305	112.59
Manufacture of rubber and plastic	865,748	7,221	119.89
Textile manufacture	526,798	4,311	122.20
Other vehicle manufacture	1,472,117	11,907	123.63
Manufacture of motor vehicles, trailers	288,890	2,131	135.57
Manufacture of electrical equipment	1,294,910	8,210	157.72
Metal manufacture	928,635	5,483	169.37
Parepa and paper products manufacture	685,569	3,602	190.33
Food and beverage manufacture	8,363,255	40,096	208.58
Printing and reproduction of recorded media	1,333,833	5,440	245.19
Chemicals and chemical products manufacture	2,926,594	10,657	274.62
Manufacture of other non-metallic mineral products	3,396,664	9,581	354.52
Manufacture of tobacco products	531,456	760	699.28
Manufacture of coke and refined petroleum products	3,907,813	3,211	1,217.01

Source: Croatian Bureau of Statistics, author's calculations

Ratio of capital to labor, that is, factor intensity of net merchandise exports is calculated as a weighted average of the ratio of capital to labor. As a weight, a relative share of net exports is taken. Table 11 shows the factor intensity of net merchandise exports of Croatia in 2011.

Table 11: Factor intensity of net merchandise exports of Croatia in 2011

Activities of manufacturing industry	Capital abundance (000 HRK)	Number of employed	Ratio of capital to labor	Relative share in net merchandise exports	Ratio of capital to labor[3]
Manufacture of furniture, other production industry	769,854	8,855	86.94	0.88%	0.763120125
Manufacturing of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	1,009,672	10,252	98.49	15.78%	15.54551094
Other vehicle manufacture	1,472,117	11,907	123.63	77.64%	95.99088929
Manufacture of electrical equipment	1,294,910	8,210	157.72	2.23%	3.524885902
Manufacture of other non-metallic mineral products	3,396,664	9,581	354.52	1.76%	6.243955077
Manufacture of tobacco products	531,456	760	699.28	1.70%	11.89297467
Ratio of capital to labor in net merchandise exports					133.961336

Source: Croatian Bureau of Statistics, author's calculations

Out of six net exporting industries we found four are labor – intensive. Furthermore, weighted average ratio of capital to labor of net merchandise exports is 133,96 while the average ratio of capital to labor in manufacturing industry is 170,06. On the basis of aforementioned, it can be concluded that the net export of Croatian manufacturing is labor intensive. Croatia is relatively abundant with labor as a production factor, and the assumption can be accepted.

[3] Relative share in net merchandise exports.

The main partner countries in Croatian merchandise exports and merchandise imports in the period 2008 – 2012 are shown in Tables 12 and 13.

Table 12: Main partner countries in Croatian merchandise exports 2008 – 2012

– in %

Merchandise exports by country	2008	2009	2010	2011	2012
Italy	31,48	31,41	30,52	26,32	26,27
German	17,62	18,15	16,96	16,86	17,64
Slovenia	12,73	12,22	12,82	13,85	14,77
Austria	9,49	8,89	8,67	9,55	11,21

Source: Croatian Bureau of Statistics

Table 13: Main partner countries in Croatian merchandise imports 2008-2012

– in %

Merchandise imports by country	2008	2009	2010	2011	2012
Italy	26,63	24,54	25,34	26,59	26,84
Germany	20,91	21,58	20,78	20,36	20,67
Slovenia	8,70	9,13	9,73	10,06	9,38
Austria	7,67	8,01	7,92	7,21	7,17

Source: Croatian Bureau of Statistics

As it can be seen from Tables 12 and 13, partner countries are relatively geographically close to Croatia. The main Croatian trading partners are Germany, Austria, Italy and Slovenia. These countries, except Germany, are neighboring countries of Croatia and if the presumption of no transportation costs is abandoned, it is potentially possible to reach better explanation of international merchandise trade of Croatia with other EU member countries.

6. Conclusion

Based on the results of empirical testing, we conclude that the research hypothesis which states that Heckscher-Ohlin's theorem of comparative advantages explains merchandise trade between Croatia and other EU member states is proved. In other words, the international merchandise trade between Croatia and other European Union member countries is in the accordance with the assumed by Heckscher-Ohlin theorem of comparative advantages. No recent research of Heckscher-Ohlin's theory can be applied either include Croatia which makes the contribution of conducted research even more important. Also, the results of conducted empirical tests showed

that the difference in production factors abundance between Croatia and other European Union members better explains differences in unit production factors prices than net merchandise trade of Croatia with other EU member countries. The main trading partner countries of Croatia are Germany, Austria, Italy and Slovenia. These countries, except Germany, are neighboring countries and if we leave the assumption of no transportation costs, it is possible to reach better explanation of international merchandise trade of Croatia with other EU member countries. We found no significant correlation between merchandise trade and relative education of Croatian labor force in regards to other EU countries. Based on the empirical testing, it can be concluded that Croatia is labor abundant and net exports of Croatian manufacturing industry is labor intensive. Out of the research results significant differences can be seen in production factor abundance between Croatia and other EU member states. Taking into account differences in production factor abundance between Croatia and other EU member states, appropriateness of the EU wide economic development policy may be questioned for Croatia since Croatia has no economic resources (capital investment) for development in line with more developed EU countries. Concerning limitations of conducted research, we found no education level significance for merchandise trade between Croatia and other EU member states and that might be the case due to multi-colinearity problems in estimated regression model. To eliminate mulitcollinearity the sample size should be enlarged. Since we are not able to enlarge the observed sample size, education level could have an influence but we were not able to capture that influence. Further research could be directed towards testing other theorems based on Heckscher-Ohlin's theory of comparative advantages since the observed merchandise trade between Croatia and the EU can be explained by this theorem. Estimated results point out the production factor importance as a base for further merchandise exports development and economic development as a whole. In order to converge to more developed EU countries, economic policy in Croatia needs to be directed toward increase in investment and therefore increase of capital abundance. For this, Croatia may take the advantage of capital mobility within the EU countries. However, in order to attract capital investments, increase in the public administration and institutions efficiency would be helpful. Croatia is supposed to compete on the EU market through technology competitiveness and not via cheap labor force. The huge obstacle for technology competitiveness development could be low capital abundance in Croatia.

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Empirijska provjera Hecscher-Ohlinove teorije trgovine: slučaj međunarodne trgovine između Hrvatske i ostalih članica Europske unije

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Sažetak

Cilj ovog istraživanja je testirati Heckscher-Ohlinov teorem komparativnih prednosti na uzorku trgovine Republike Hrvatske i ostalih članica Europske unije. Heckscher-Ohlinova teorija komparativnih prednosti u većoj mjeri može objasniti međunarodnu trgovinu u slučajevima kada je uzorak zemalja heterogen, u smislu većih razlika u dosegnutom stupnju razvoja i obilnosti proizvodnih faktora. Na temelju dobivenih rezultata proizlazi zaključak da je međunarodna robna trgovina između Republike Hrvatske i ostalih članica Europske unije kako pretpostavlja Heckscher-Ohlinov teorem komparativnih prednosti. U svrhu testiranja osnovne hipoteze rada koristi se više regresijskih modela. Razlika u opskrbljenosti proizvodnim faktorima između Republike Hrvatske i ostalih članica Europske unije bolje objašnjava razlike u jediničnim cijenama proizvodnih faktora nego neto robnu trgovinu Republike Hrvatske s ostalim članicama Europske unije. Empirijska je provjera potvrdila kako neto robna trgovina Republike Hrvatske s ostalim članicama Europske unije pozitivno korelira s relativnom ponudom kapitala. Nije pronađena značajna korelacija između robne trgovine i relativne obrazovanosti hrvatske radne snage, u odnosu na druge članice Europske unije. Na temelju provedene empirijske provjere, može se zaključiti da je Republika Hrvatska, u odnosu na prosjek EU27, relativno opskrbljenija radom kao proizvodnim faktorom te je neto robni izvoz prerađivačke industrije Republike Hrvatske radno intenzivan. Rezultati provedenog istraživanja ukazuju na važnost faktora proizvodnje kao osnove za rast robnog izvoza te gospodarskog razvoja u cjelini. Zaključno, Republika Hrvatska treba više napora uložiti u privlačenje investicija i porast omjera kapitala i rada.

Ključne riječi: *Heckscher-Ohlinova teorija trgovine, Hrvatska, Europska unija*

JEL klasifikacija: *F1, F2*

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