Economic Integration and Export Complexity: The Case of Slovakia[1]

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Abstract

The goal of the article is to evaluate the impact of accession to the European Union (EU) on the complexity of goods in Slovak exports. The traditional theories of trade show that such an engagement in economic integration may lead to specialization in the production of either more or less sophisticated goods, depending on the country's technological advancement and factor endowment. At the same time, increased FDI flows may stimulate the engagement of a country in international production chains with ambiguous effects on export complexity. Because it is impossible to a priori predict the effect economic integration may have on the complexity, it is reasonable to verify it empirically. The authors used the Synthetic Control Method (SCM) to compare the observed post-accession levels of exports complexity in Slovakia with the counterfactual values of that country remaining outside of the EU.

Keywords: *economic integration, European Union, international trade, complexity, treatment effect, Synthetic Control Method*

JEL Classification: C21, F14, F15

Introduction

International trade theory has evolved in recent years and nowadays focuses not only on aggregate trade but also on myriads of detailed international exchange. One of those details is the composition of the export structure, and one

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of the most intensively studied areas has become the level of complexity of exported goods. There are reasons to believe that countries which specialise in more complex goods grow and develop faster. Trade flows are influenced by many factors, but economic integration is one of the vital elements in creating an environment for the international flow of goods. In this paper, we assess whether accession to the EU has boosted Slovak export complexity. In other words, we verify the null hypothesis that such a political and economic decision has had no effect on the sophistication of goods exported by Slovakia.

The structure of the paper is as follows. In the first section, we present a literature review on export complexity. The second section describes current trends in Slovak export complexity. The third section presents the data and the method applied (the *Synthetic Control Method* – SCM). We describe the obtained results in the fourth section, while in the fifth section we discuss the possible impact of adopting the euro on export complexity. The last section concludes.

1. The Importance of Export Complexity – Literature Review

Economic complexity has been intensively investigated as a potential determinant of growth and development since the seminal paper by Hausmann, Hwang and Rodrik (2007). There are at least two ways complexity can be defined: as a technological advancement of the exported goods (Lall, 2000) or as the array of components used in the production process (Hausmann, Hwang and Rodrik, 2007). Both definitions are correlated, since more technologically advanced processes typically necessitate more production stages and more input variety.

Economic complexity has been regarded as having an influence on the growth rate of income per capita. That impact may be especially visible in countries with liberalized trade and currencies which are not overvalued (Anand, Mishra and Spatafora, 2012). What is more, the complexity of goods in exports is linked not only to the dynamics of income but also to the level of GDP per capita, as proved by Hidalgo and Hausmann (2009).

The sophistication of exports can also be seen as a shock absorber. Koren and Tenreyro (2013) claim that more complex goods can be resistant to supply side shocks. This is because of the diversification of inputs used in production: more complex products, with a larger variety of inputs, depend less on each component. It is also worth mentioning that among the wide range of inputs, most are substitutes, hence they can be easily replaced after a supply side shock.

The question that arises, naturally, is how to influence export complexity. It has been proved that such a trade feature depends on the competences available in the country (Hidalgo and Hausmann, 2009). This means that both technological advancement and a significant amount of human capital are needed in the production of complex goods (Anand, Mishra and Spatafora, 2012). It is also reasonable to assume that educational and R&D policies may be of great importance. At the same time, however, one should bear in mind that it is easier to acquire new comparative advantages that are close to the initial pattern of specialization (Hausmann and Klinger, 2007). Some competences which are lacking in a particular country can be transferred across borders (Hidalgo and Hausmann, 2011). Such a process occurs e.g. within transnational corporations (Costinot, Oldensky and Rauch, 2009). The level of economic complexity also results from institutional quality, which enables the implementation of more sophisticated production processes (Costinot, 2009), country size, institutional quality and GDP per capita (Hausmann, Hwang and Rodrik, 2007).

Economic integration can influence FDI patterns (Antras and Foley, 2011), institutional quality (Tang and Wei, 2006; Rodrik, Subramanian and Trebbi, 2002) and specialization patterns (according to the country's comparative advantages). Each of those effects of integration may be a cause of the change in a country's economic complexity. That is why it is worth analysing empirically whether integration leads to higher or lower sophistication of goods produced in a particular country. To the best of our knowledge, such an analysis has not been conducted and our research fills an important research gap. The unit that we chose to investigate in depth is Slovakia – a small, open economy which participates heavily in international production chains and is a member of the EU (since 2004) and the Eurozone (since 2009). The null hypothesis in our study was that accession to the EU had no significant effect on the economic complexity in Slovakia.

The country we chose has not been at the centre of the debate about the consequences of EU membership. The literature devoted to the case of Slovakia is scant. Campos, Coricelli and Moretti (2014) used both SCM and a difference-in-differences model to assess the impact of the EU accession on real GDP per capita and labour productivity in member states. According to the result, the economic integration was insignificant for those variables in the case of the Slovak Republic. Žúdel and Melioris (2016) also used the SCM, but they focused on the adoption of the euro. Their results suggest that the elimination of the national currency made Slovakia better off – in 2011, real GDP per capita was 10% higher than in the counterfactual scenario.

Trade consequences of the integration have become the topic of several papers that focused on Eurozone membership. Cieślik, Michałek and Michałek (2013) utilized a probit model to assess the determinants of export decisions of firms from Slovakia and Slovenia. They found that the adoption of the euro increased the probability of engagement in export by the analysed firms. Cieślik, Michałek and Mycielski (2014) used a panel model for a broad range of countries, including Slovakia. They obtained results which indicate that the elimination of the national currency had no effects on bilateral trade between a new member and other countries belonging to the Eurozone. The same authors (Cieślik, Michałek and Mycielski, 2012) all presented other results for Slovakia and Slovenia. They applied panel data techniques (fixed effects, random effects, and Hausman-Taylor estimators) and found no evidence of trade expansion after the euro adoption.

2. Export Complexity in Slovakia

We used the Economic Complexity Index (ECI) calculated by the Atlas of Economic Complexity (AEC) to describe the sophistication of Slovak exports. That measure resembles another complexity indicator, EXPY, introduced by Hausmann, Hwang and Rodrik (2007). The basic advantages of the ECI are: (i) its coverage – it is calculated for 124 countries for a relatively long (1995 – 2014) period, and (ii) its construction – product complexity is calculated on the basis of the different capabilities that it requires instead of income of its exporters. Such a construction is based on the idea that countries do not simply supply the products and services they need, but the ones they can (Hausmann et al., 2011, p. 18). That is the reason why ECI has become the dominant measure of export complexity and why we utilize that indicator in our study.[2]

As Figures 1 and 2 present, by decomposing the ECI time series (using the Hodrick-Prescott filter with usual parameters for yearly data) it is possible to obtain trend and cyclical components. The trend was generally upward with only brief sub-periods of stagnation or rather minor declines.

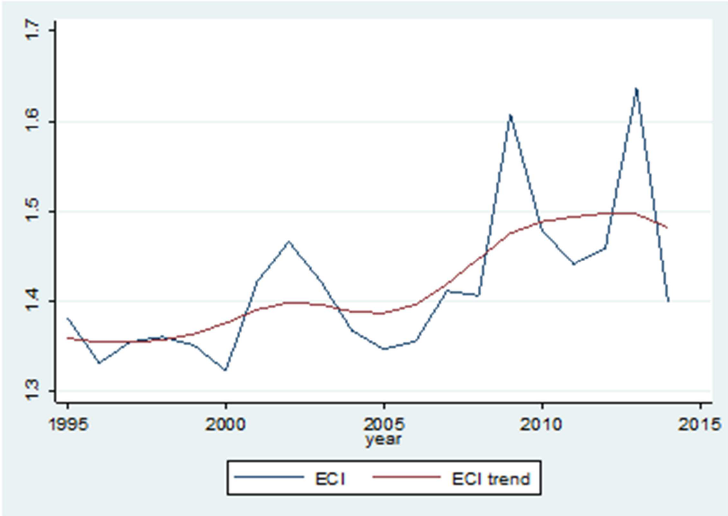
One may be surprised by the existence of two spikes after 2010 when aggregate ECI is analysed. We are convinced that such a pattern is not driven by the peculiarity of the database we used. It may be verified by the inspection whether other measures that may be associated with export complexity behaved in a similar way. For such an assessment we calculated the correlation coefficient for ECI and the share of hi-tech exports in total manufactured exports (source: World Bank). The correlation was positive (0.4612) and statistically significant at 0.05 level. When filtered data were used of both variables – just like we did in our estimations – the correlation coefficient was much higher (0.8956) and, unsurprisingly, statistically significant. We also checked the correlation between ECI and foreign value added in gross exports (source: OECD – Trade in Value Added

[2] A detailed description of EXPY and ECI with the assessment of both measures may be found, for instance, in Valette (2018).

Database). Due to data limitations in this case we used 1995 – 2011 period. Although for undecomposed data we obtained correlation coefficient that was insignificant at 0.05 level, when we filtered time series, the correlation coefficient became significant and positive (0.561).

F i g u r e 1

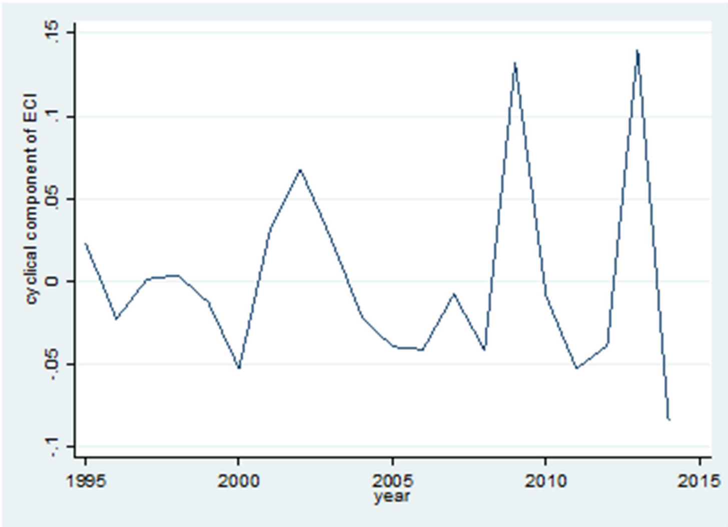
ECI and its Trend – Slovakia, 1995 – 2014



Source: Authors' calculation.

F i g u r e 2

The Cyclical Component of ECI – Slovakia, 1995 – 2014



Source: Authors' calculation.

Our timeframe may be split into two sub-periods – before and after Slovakia's accession to the EU (see Tables 1 and 2). One may notice that the ECI (both the aggregate value and the trend) was much more stable pre-accession. Since 2004, the ECI standard deviation has doubled (and the volatility of the trend has increased even more).

Table 1

ECI in Slovakia – Descriptive Statistics

Period	1995 – 2014 (the whole sample)	1995 – 2003 (before EU accession)	2004 – 2014 (after EU accession)
Mean	1.416	1.379	1.446
Standard deviation	0.084	0.048	0.097
Coefficient of variation (in %)	5.93	3.47	6.68

Source: Authors' calculation.

Table 2

The Trend Component of the ECI in Slovakia – Descriptive Statistics

Period	1995 – 2014 (the whole sample)	1995 – 2003 (before EU accession)	2004 – 2014 (after EU accession)
Mean	1.416	1.372	1.452
Standard deviation	0.054	0.019	0.046
Coefficient of variation (in %)	3.82	1.35	3.17

Source: Authors' calculation.

It should be noted that while the difference in means is insignificant when one uses undecomposed data, such a difference becomes statistically significant at any conventional confidence level when trend is analysed.

At the same time, it is worth analysing Slovak data with reference to other countries from the same region. It seems that Slovakia has on average lower ECI than Czech Republic, but higher than Poland. When comparing Slovakia and Hungary, one can observe an advantage the former had over the latter before the EU accession and the reversal of that situation in years 2004 – 2014.

3. Data and Methodology

3.1. The Description of the Data

In our research, we focus on export complexity (measured with the ECI) as the outcome variable. To avoid erratic cyclical effects, we focused on the ECI trend, which was obtained by smoothening the data with the standard annual Hodrick-Prescott filter.[3]

We mainly utilised a set of covariates based on an influential paper by Hausmann, Hwang and Rodrik (2007). We also introduced a more technical approach, using the pre-treatment values of the outcome variable (the ECI trend) as a covariate. Table 3 presents the full set.[4]

Table 3

Set of Covariates Used in the Research

Covariate	Source of data
Population Real GDP per capita Human Capital Index	Penn World Table 9.0 (Feenstra, Inklaar and Timmer, 2015)
Area Rule of Law Index Pre-treatment ECI (trend) values	CEPII GeoDist Database (Mayer and Zignago, 2011) Worldwide Governance Indicators Atlas of Economic Complexity

Source: Authors' calculation.

Since the research was conducted with the SCM approach, a proper set of covariates should withstand the conditions for that method. These were presented by Campos, Coricelli and Moretti (2014). Firstly, the covariates should determine the changes of the outcome variable. In the case of our data, that condition is proved true by Hausmann, Hwang and Rodrik (2007). Secondly, the covariates' capability of anticipating treatment should be minimal. Population and area were mostly resistant to treatment. The Human Capital Index is mainly based on educational components, which were also highly independent of the treatment. The Rule of Law Index might have been affected by Slovakia's pursuit of EU membership, however, the social and political changes in Slovakia had set a path towards higher institutional quality since the systemic transformation after the fall of the Soviet Bloc, thus their trend should not be treated as a result of EU accession negotiations.[5] GDP per capita is probably influenced most by expectations regarding EU membership, however, it seems unwise to exclude such a major macroeconomic parameter from the fitting process.

[3] As Abadie, Diamond and Heinmueller (2015) found, *units that may have suffered large idiosyncratic shocks to the outcome of interest during the study period should also be excluded if such shocks would have not affected the treated unit in the absence of the treatment*. In other words, those units should be excluded, when patterns of their characteristics are much different from the treated unit. However, by doing so, one may significantly reduce the donor pool. Our solution to that problem is the minimization of any idiosyncrasies of economies that we study by smoothing the time series of the outcome variable.

[4] Despite the ongoing debate about the quality of the Penn World Tables (see, for instance, Johnson et al., 2009), we decided to use that database for two reasons. Firstly, is was the source of data for Hausmann, Hwang and Rodrik (2007), hence it is easier to interpret the results with accordance to their work, when the same database is utilized. Secondly, it is the only database of such a coverage – it provided us with panel data for GDP per capita as well as its proximate determinants. It is especially noticeable in the context of the measurement of human capital. World Bank's Human Capital Index and Barro-Lee estimates are available for only 5-year spans.

Moreover, there are requirements towards the so-called donor pool – the sample of countries used as reference points in the SCM approach (Campos, Coricelli and Moretti, 2014). Firstly, the countries in the donor pool should not be affected by the treatment – directly or indirectly. Secondly, the treated country should not be an outlier or an extreme case in comparison to the used countries. In other words, the donor pool should generate a sort of convex hull around the treatment country. Taking that into consideration, we chose 10 non-European countries (Australia, Canada, Chile, Israel, Japan, Korea, Mexico, New Zealand, Turkey, and the USA) and two European but non-EU member-states (Norway and Switzerland). The temporal scope of our research was 1995 – 2014 and it was limited by the ECI data availability.

3.2. Methodology

We implemented the SCM, which was developed by Abadie, Diamond and Hainmueller (2010), to model shock responses in the panel data. It is restricted to continuous shocks (which means that once they occur, they remain unchanged for the rest of the sample period) specific for just one unit. This makes SCM suitable to evaluate the effects of a standing policy decision in a particular country. These restrictions are strong and make the use of SCM limited, however, in cases that meet the preconditions, SCM allows a very complex response to a shock and, in fact, it proves to be a generalised version of the difference in differences approach, which is often used for panel data estimations.

Let us assume that we observe $J + 1$ units (e.g. countries, enumerated from 0 to J) in T periods (e.g. years) and that unit zero (in our case – Slovakia) was

[5] Whether Slovak path to institutional development was clear or not is questionable, due to a period of Vladimír Mečiar's authoritarian administration – practically since 1990 to 1998 with small intermissions. After Slovakia became fully separated from Czech Republic in 1993, he was the first prime minister. When he held this office for the 1994 – 1998 term, Slovak negotiations with EU and NATO suffered because of Mečiar's undemocratic conduct of power and pro-Russian orientation. However, two arguments need to be formulated on why this had no effect on our study. First of all, this happened at the very beginning of Slovak Republic's contemporary independent existence and the social stress caused by observable regression towards adverse pre-transformation style of administration along with a relative loss of international position stimulated accelerated democratisation after 1998 (Pridham, 2002). Therefore the overall long-term trend has not been radically warped. The second argument is technical – Rule of Law Index, supplied by the World Bank, is only available since 1996 and is reported annually since 2002. Thus, the effect of Mečiar's administration is reflected by low initial levels of the Index (0.16 in 1996) and significant dynamics at the beginning of the series (up to 0.34 in 2000). As a result, the growing trend for Slovakia's Rule of Law Index is not only undistorted, but even stronger in the covered period of Mečiar's administration. When comparing countries in the region, the values of Rule of Law Index for Slovakia were significantly lower than those of Czech Republic, Poland or Hungary at that time. However, thanks to a growing trend (and at the same time a decline in Poland), Slovakia managed to surpass Poland in 2004.

subject to some kind of treatment (e.g. political decision, such as EU accession) in period T_0. In such a case, units 1, …, J are the donor pool and the effects of treatment are observed for unit zero during periods T_0, …, T, while they remain unobserved in periods 0, …, $T_0 - 1$.

Now let Y_{it} be the observed variable (the ECI in our research), which might have two outcomes:

- Y_{it}^N – neutral outcome, without the effect of treatment;
- Y_{it}^I – interfered outcome, which includes the effects of treatment.

Let D_{it} be a binary function and Δ_{it} be the difference of two potential outcomes for country *i* in period *t*. The initial conditions of our model could be summarised as follows:

$$i = 0,1,\ldots,J \quad \wedge \quad t = 1,2,\ldots,T_0,\ldots,T \tag{1}$$

$$Y_{it} = Y_{it}^N + \Delta_{it} D_{it} \tag{2}$$

$$\Delta_{it} = Y_{it}^I - Y_{it}^N \tag{3}$$

$$D_{it} = \begin{cases} 1 \ \mathit{if} \ i = 0 \ \mathit{and} \ t = T_0,\ldots,T \\ 0 \ \mathit{otherwise} \end{cases} \tag{4}$$

The idea behind SCM is that it is enough to estimate the neutral outcome after introducing a treatment with a factor model based on pre-treatment data, while considering the actual outcome values as interfered. Thus, Δ_{it} is the actual measure of the treatment effect.

The factor model for a neutral outcome is generally composed as follows.

$$Y_{it}^N = \delta_t + Z_i\theta_t + \lambda_t\mu_i + \epsilon_{it} \tag{5}$$

Such a shock response model considers:

- covariates (Z_i) with time-varying parameters (θ_t);
- an unobserved, common, time-varying factor (δ_t);
- heterogeneous responses to multiple unobserved factors ($\lambda_t\mu_i$);
- an error term (ε_{it}).

Let us note that, should we consider λ_t to be constant, (5) becomes a standard equation for the difference in differences model, which proves that SCM is more general in its domain.

After estimating the factor model, SCM uses pre-treatment information about outcome variable values along with the covariate characteristics of the treated country and the donor pool to create a synthetic treated unit as a linear combination of the donor pool units. This synthetic analogue of treated country depends on information from the past or from the countries that were neither directly, nor indirectly affected by the treatment. Therefore, counterfactually to the actual real data, synthetic unit zero has no effects of the treatment.

Results of estimating factor model (5) are crucial for the procedure of building the synthetic counterfactual values of outcome variable. First of all, in the pre-treatment period synthetic values are directly determined by this model and the more precise specification of the model, the better fit between actual and synthetic unit zero before the analysed treatment was introduced. Secondly, the estimator for post-treatment period, based on information from the donor pool, does not use actual data, but it utilizes estimates obtained from factor model (5).

The estimator is based on a linear combination, thence a proper set of weights is required. Let us define a family of linear functions of the pre-treatment outcomes: Y_i^k, $k = 1, \ldots, m$. An ideal set of weights W^* should simultaneously be able to produce characteristics of the treated country as linear combinations of characteristics of the donor pool countries, and pre-treatment outcome variable functions for the treated country as linear combinations of analogous functions for the donor pool countries. The second element is necessary to guarantee that synthetic counterfactual is sufficiently close to actual data before treatment. Therefore W^* should be expressed as:

$$W^* = \left(w_1^*, \ldots, w_J^*\right): \sum_{i=1}^{J} w_i^* Z_i = Z_0 \ \wedge \ \forall_{k=1,\ldots,m} \sum_{i=1}^{J} w_i^* Y_i^k = Y_0^k \tag{6}$$

One must also consider a boundary condition arising from the fact, that the donor pool is expected to form a convex hull of the treated country, therefore both outcome variable and the values of covariates for the treated unit should not be extreme within the sample. If this is the case, than we want the weights of the linear combination to be non-negative and sum up to 1, which means that the linear combination becomes a weighted average (Fremeth, Holburn and Richter, 2013).

$$w_1^*, \ldots, w_J^* \geq 0 \ \wedge \ \sum_{i=1}^{J} w_i^* = 1 \tag{7}$$

Determining the set of weights W^* that meets all the restrictions in conditions (6) and (7) guarantees obtaining an approximately unbiased estimator of the post-treatment Δ_{0t}, with outcome variable values for the donor pool countries estimated from factor model (5).

$$\widehat{\Delta}_{0t} = Y_{0t} - \sum_{i=1}^{J} w_i^* \widehat{Y}_{it}, \ \ t = T_0, \ldots, T \tag{8}$$

$$\widehat{Y}_{it} = \delta_t + Z_i \theta_t + \lambda_t \mu_i \tag{9}$$

In reality, it is virtually impossible to find such a perfect set of weights. However, Abadie, Diamond and Hainmueller (2010) argue that the demands towards W^* can be weakened. It is enough to take a vector of the characteristics of the treated country $X_0 = (Z_0, Y_0^1, \ldots, Y_0^m)'$ and the matrix X_J of the analogous characteristics of the donor pool countries. Estimator (8) holds if we choose W^* that, under boundary condition (7), solves the optimization problem:

$$\widehat{W} = \min \| X_0 - X_J W \| \tag{10}$$

Problem (10) uses the generalised idea of distance. To receive a more operational expression, we could state it with a quadratic form:

$$\widehat{W} = \min\{(X_0 - X_J W)' V (X_0 - X_J W)\} \tag{11}$$

V is a symmetric, positive, semi-definite matrix. It is interpreted as a measure of the relative importance of the characteristics included in the X_0 vector and X_J matrix (Campos, Coricelli and Moretti, 2014). Theoretically, the choice of V is arbitrary. Nevertheless, a standard approach suggests choosing V that minimises the mean squared error in the pre-treatment period.

4. Results

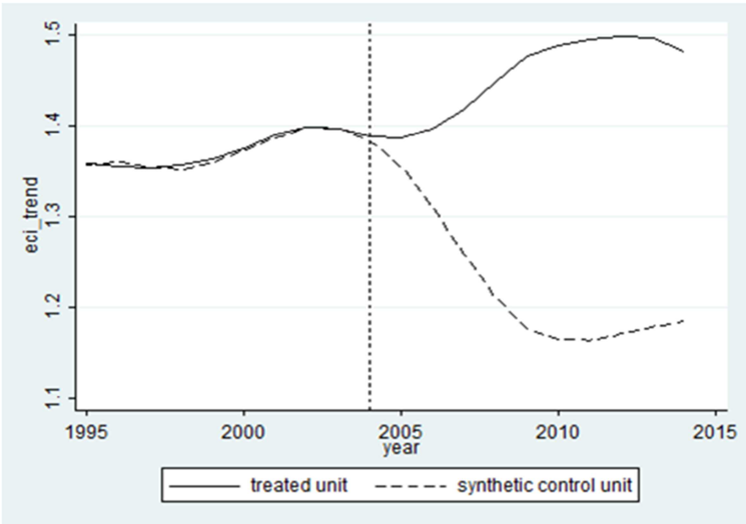
4.1. Basic Results

We applied SCM using the ‘Synth’ package for STATA. As described in Section 4.1, our choice of covariates was inspired by Hausmann, Hwang and Rodrik (2007), who pointed out crucial factors which affect complexity to be:

- natural/geographic potential (represented by area);
- the size and quality of the labour force (represented by population and the Human Capital Index);
- the quality of the institutional environment for business (represented by the Rule of Law Index);
- the country’s level of development (represented by real GDP per capita as a basic measure of welfare).

In our basic estimation, we used those covariates. However, to increase the fit between synthetic and actual Slovakia before accession to the EU, we also controlled for matching the outcome variable values in specific years of the pre-treatment period. Choosing too many pre-treatment outcome values in this procedure is said to cause a loss of statistical significance of the other covariates. If these covariates are, in fact, important explanatory factors for the outcome variable (which is the observed case), the result might be a bias of the estimated counterfactual in the post-treatment period (Kaul et al., 2016). On the other hand, using a full set of the pre-treatment outcome values should result in the best possible matching before the policy implementation. Therefore, we used both options to compare inferences. Figures 3 and 4 present the obtained results.

F i g u r e 3
SCM Results with EU Accession as the Treatment and Pre-treatment Covariates, Based on Hausmann, Hwang and Rodrik (2007)



Root Mean Squared Prediction Error (RMSPE): 0.0031524
RMSPE as a percentage of the mean outcome value: 0.23%

Unit weights (only non-zero):

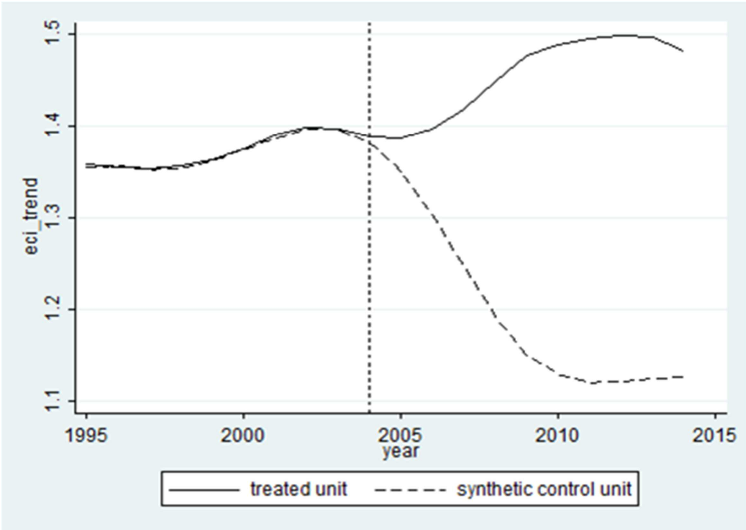
Unit	**Weight**
Australia	0.026
Chile	0.154
Japan	0.298
South Korea	0.049
Mexico	0.472

Predictor balance:

	Actual	**Synthetic**
Area (avg. 1995 – 2003)	10.80	13.73
Population (avg. 1995 – 2003)	5.38	90.12
GDP p.c. (avg. 1995 – 2003)	13 546.65	20 160.36
Human Capital Index (avg. 1995 – 2003)	3.27	2.79
Rule of Law Index (avg. 1995 – 2003)	0.22	0.39
ECI trend (1995)	1.36	1.36
ECI trend (1997)	1.35	1.35
ECI trend (2002)	1.40	1.40
ECI trend (2003)	1.40	1.40

Source: Authors’ calculation.

Figure 4
SCM Results with EU Accession as the Treatment and Pre-treatment Values of Outcome Variable Used as a Covariate



Root Mean Squared Prediction Error (RMSPE): 0.0017393
RMSPE as a percentage of the mean outcome value: 0.13%

Unit weights (only non-zero):

Unit	Weight
Australia	0.108
Japan	0.173
Mexico	0.553
USA	0.165

Predictor balance:

	Actual	Synthetic
ECI trend (1995)	1.36	1.35
ECI trend (1996)	1.35	1.36
ECI trend (1997)	1.35	1.35
ECI trend (1998)	1.36	1.35
ECI trend (1999)	1.36	1.36
ECI trend (2000)	1.38	1.37
ECI trend (2001)	1.39	1.39
ECI trend (2002)	1.40	1.40
ECI trend (2003)	1.40	1.40

Source: Authors' calculation.

The general results for both approaches are identical. The trend of the ECI had a turn in 2002, and both estimations predict that synthetic Slovakia would maintain a downwards trend until the 2010's, when the fall would stop. However, actual Slovakia underwent a rebound just after accessing the EU and its ECI strongly increased, reaching the level of almost 1.5 (cyclical component excluded) at its maximum in 2012. It proves that joining the EU facilitated Slovakia's economic development and the transition of its export profile to a group of more complex goods. The effect was strong enough to cause a change in the existing trend. What is more, the induced growth of the ECI was not even stopped by the outbreak of the global financial crisis, though one can observe a slowdown starting in 2009.

What may capture one's attention is the selection of countries that formed the synthetic values of ECI for Slovakia. Those were economies with rather different characteristics than the treated country. However, two things should be stressed. Firstly, it is the ability of the set of countries to jointly (as a combination) resemble a treated unit, not the individual similarity between any of them and the treated unit, that matters in the SCM algorithm. For example, although Mexico seems to be in many ways different from Slovakia, that country together with other economies formed a synthetic control group with a good fit with the treated unit. Secondly, the method applied in our study is based on the assumption that there is no impact of a treatment on a control group. That is why countries whose ECI values were directly or indirectly affected by the Slovak accession to the EU had to be eliminated from the donor pool. It is reasonable that such a situation could characterize especially other Central and Eastern European countries. In order to eliminate such a bias, we used only non-EU OECD members as a donor pool.

As predicted, estimation with full pre-treatment ECI values probably leads to a minor bias, since, even though the results are very close to the Hausmann, Hwang and Rodrik (2007) variant, the decline of the synthetic ECI is deeper and slightly longer. Moreover, the downturn was followed by stabilization of the ECI at relatively low levels in the 2010's, while in the estimation based on Hausmann, Hwang and Rodrik (2007) the rebound brings a rise of the synthetic ECI value to almost 1.2. Furthermore, the SCM procedure with a full set of pre-treatment ECI values as covariates resulted in smaller prediction errors and generally a better fit in the pre-treatment sub-period.

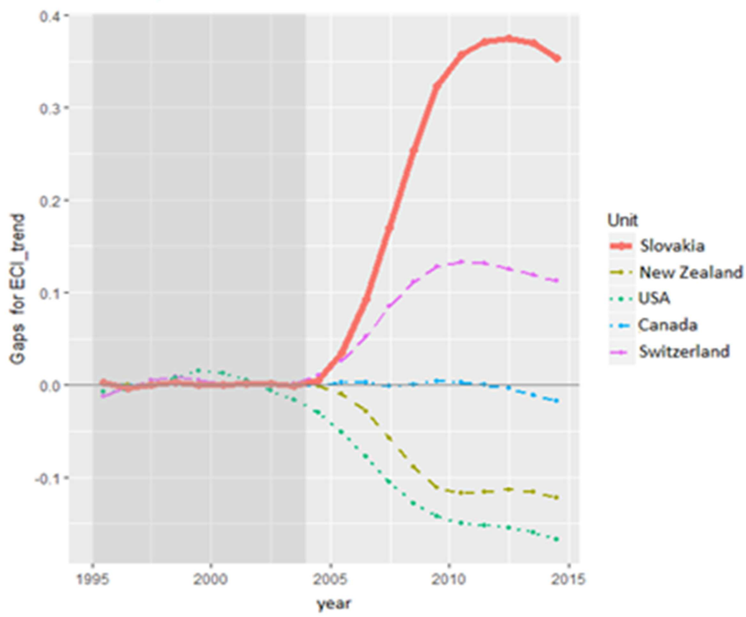
The basic estimation, presented in Figure 3, was also characterised by low RMSPE, however, not all of the covariates were well represented. It is especially worth noting that synthetic Slovakia was more heavily populated and had significantly higher GDP per capita. These misfits were probably caused by the fact that Slovakia is a rather small country and, in fact, for most donor pools consisting of countries with available data on economic complexity, it would be an outlier in that aspect.

SCM allows us to observe that EU accession enabled Slovakia to stimulate its export complexity. Unfortunately, the procedure does not explain the mechanism behind such a development. It could only be reasonably speculated that the ECI might have grown thanks to EU funds being used to finance numerous enterprises, with emphasis on innovative solutions which are associated with more complex goods. Another reason could be increased access to the markets of Western Europe, which meant more sophisticated demand and greater interest in more advanced, more complex goods.

4.2. Robustness

In order to check the robustness of the obtained results we used the placebo test described by Abadie, Diamond and Hainmueller (2010). That method applies SCM to every unit that belongs to the donor pool. Such a procedure resembles a permutation test. The treated unit (Slovakia) must be excluded from the donor pool and the remaining units form a new donor pool that is used in such a way that each unit is seen as if the intervention had occurred. The null hypothesis, that the intervention had no effect, is verified by examining the differences between the outcome and the synthetic values. In our study, the null hypothesis indicates that accession to the EU had no impact on the complexity of exports in Slovakia. If the gaps between the estimated treatment effects and the placebo effects were small, that hypothesis would be proved right.

Figure 5
Placebo Test Results for the EU Accession Effects on Slovak ECI



Source: Authors' calculation.

The results of the placebo test are presented in Figure 5. The bold red line shows the ECI (HP-filtered) gaps for Slovakia, while the other lines reflect the gaps for the placebo units. The MSCMT package in R, described in detail by Becker and Klößner (2017), was used to conduct the placebo test. We included only those placebo units that had a relatively good fit in years 1995 – 2003 by excluding those control units that had a pre-treatment RMSPE more than 10 times the Slovak pre-treatment RMSPE.

As Figure 5 illustrates, the gaps for Slovakia stood out significantly – they were different from the gaps for the placebo units. The only other placebo unit with positive gaps was Switzerland, but those gaps were much smaller. The gaps for other placebo units were rather negative (the gaps for Canada were close to zero for the majority of the post-2004 timeframe, but at the end of the post-treatment period they became negative). The results of the placebo test indicate that the positive impact of Slovakia's EU accession on its ECI was robust.[6]

5. The Euro Effect

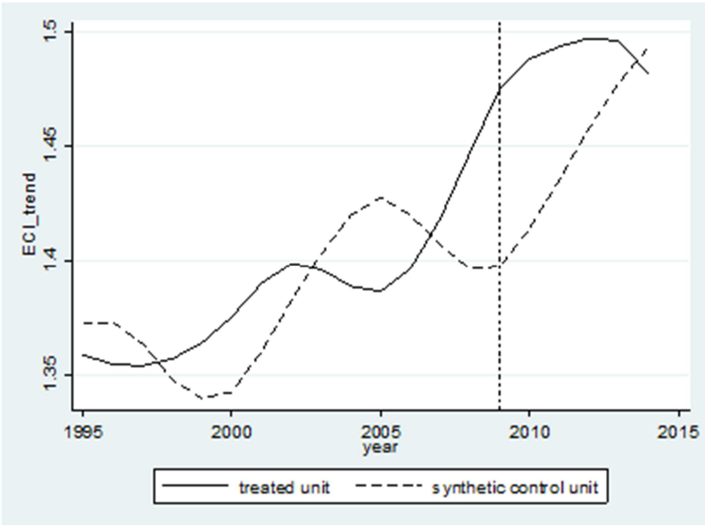
Monetary integration and the formation of a currency area may be seen as a more advanced form of economic integration with significant trade consequences. The lack of conversion costs should translate into higher price transparency, while the lack of exchange rate risk should lead to higher price predictability. The ultimate result should be an increase in trade between integrating countries. Many studies confirm that the formation of the Eurozone has led to an expansion of trade between the member countries (Micco, Ordoñez and Stein, 2003; De Nardis and Vicarelli, 2003; Santos Silva and Tenreyro, 2006; Berger and Nitsch, 2008; Glick and Rose, 2016), although the so-called euro trade effect is seen to be not as big as had been expected.[7]

[6] In the literature there is also another placebo test suggested – the so called placebo in time. It is used to determine whether the divergence between actual and counterfactual values indeed began in the specified treatment year and it is simply requires manipulating with the starting point of the treatment period. We checked whether setting the year of treatment for 2003 or 2002 may change the results. In both cases the positive impact of the treatment for Slovakia is seen only after 2004, so after the EU accession. That confirms our baseline results. It should be also highlighted that if any anticipation effect existed, it would be happening mostly though investment decisions (since investors prepare for the EU membership). However, according to the World Bank, the share of FDI net inflows in Slovakia's GDP was the highest in 2002 and then it dropped significantly in 2003. All those findings prove that the results we obtained were driven by the shock that happened in 2004, hence we are convinced that it is the EU accession, and no other event, that changed Slovak export complexity.

[7] Rose (2000) estimated that currency areas (those that existed before the formation of the Eurozone) increase trade between member countries by 200%, an order of magnitude much higher than it later turned out after the introduction of the euro.

Figure 6

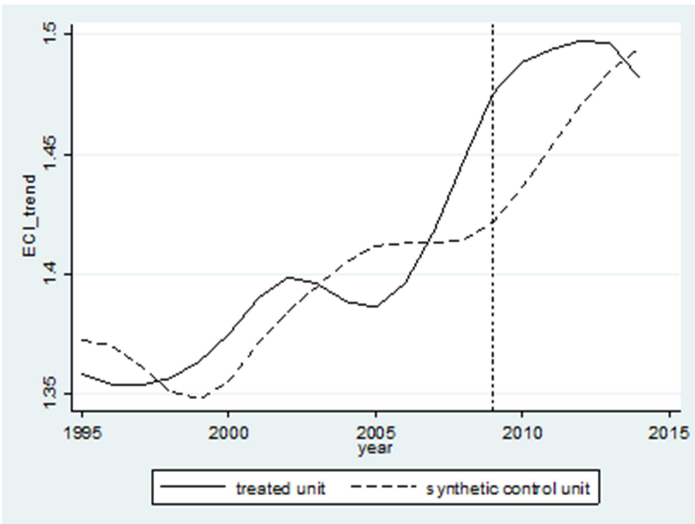
SCM Results with the Euro Adoption as the Treatment and Pre-treatment Covariates, Based on Hausmann, Hwang and Rodrik (2007)



Source: Authors' calculation.

Figure 7

SCM Results with the Euro Adoption as the Treatment and Pre-treatment Values of the Outcome Variable Used as a Covariate



Source: Authors' calculation.

Intuitively, the adoption of the euro should affect not only aggregate trade, but also export complexity. That is because such a process strengthens the mechanism through which trade liberalization (or, broadly speaking, economic integration) affects the sophistication of goods in exports. However, the empirical analysis for Slovakia is problematic. Slovakia entered the Eurozone in 2009, but after more than 3 years of engagement in the European Rate Mechanism II (ERM II). That is why strong anticipation effects may be observed and the application of SCM would lead to doubtful results. Figures 6 and 7 are illustrative of that problem. It should also be added that it is hard to achieve a good fit for the pre-euro period in Slovakia, even when all pre-treatment outcome variables are used as covariates.

Žúdel and Melioris (2016) suggest that Slovakia joined the ERM II unexpectedly in November, 2005, since the next trading day was characterized by strong appreciation of the domestic currency. That is why it is reasonable to change the year of treatment (adopting the euro) from 2009 to 2005 or, better, 2006. However, since Slovakia joined the EU in 2004, it would mean that two important processes (EU entry and euro adoption) strongly overlap and it would be hard to disentangle the impact that each of them has on export complexity.

At the same time, we think of the adoption of the euro as of a factor that at least did not help Slovakia boost its export sophistication (or it even diminished it). The gaps between outcome and synthetic values increased after Slovakia became an EU member and before the elimination of the national currency. After adopting the euro, those gaps stabilised. It may be due to the composition of Slovakian exports and peculiar circumstances (the global financial crisis). Slovakia is strongly dependent on exports of vehicles and car equipment – those goods are seen as postponable, since after an income shock customers may cease to buy them, postponing purchases. Slovakia entered the Eurozone in times of significant financial turbulence, and its heavy dependence on the automotive industry, without the possibility to depreciate the currency, meant that this relatively sophisticated sector shrank.

Summary and Conclusion

The aim of the article was to assess the effects of Slovakia's accession to the EU on the complexity of its exports. The research utilized SCM, which enabled us to build a counterfactual scenario in which Slovakia had not joined the EU. As the results indicate, Slovak export complexity has been much higher since the accession, when one compares it with the counterfactual synthetic values. We also found that the adoption of the euro might have had some influence on export sophistication in Slovakia. However, due to the fact that both EU accession and entry into the Eurozone significantly overlap, we urge the reader to remain careful when drawing conclusions.

We also want to highlight that our results show only the magnitude of the effect of EU membership on export complexity without pointing to any mechanism generating it. The question whether economic integration led to higher export complexity in Slovakia through specialization, a change in FDI patterns, technological upgrading, or any other channel, is still open and may be both an interesting and important area of future research.

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