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The impact of the euro adoption on the complexity of goods in Slovenian exports[1]

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Abstract

The aim of this paper is to verify the impact of the euro adoption on the complexity of goods in Slovenian exports. To the best knowledge of the authors, it is the first study on the consequences the elimination of a national currency may have for that feature of trade. According to Ricardian and Hechscher-Ohlin models of trade such a policy decision (seen as an example of trade liberalization) may lead to specialization in the production of either more or less sophisticated goods – on outcome depends on country's technology and factor endowment. At the same time increased FDI flows may make a particular economy more engaged in international production chains with ambiguous influence on exports complexity. Given the fact that it is impossible to (a priori) theoretically predict the impact of monetary integration on the complexity, it is reasonable to search for the effects of the integration empirically. The authors used the Synthetic Control Method to compare the actual levels of exports complexity in Slovenia after the adoption of the euro with the counterfactual scenario with Slovenia not entering the Eurozone. The results indicate that the membership in the European Monetary Union (EMU) has led to temporary increase in complexity of exported goods.

Key words: *Eurozone, international trade, Slovenia, complexity, synthetic control method*

JEL classification:*C21, F14, F15*

1. Introduction

Theory of international trade went through a substantial evolution from a classical, fully macroeconomic approach based on comparative advantages to the so called New New Trade Theory focused on microeconomic foundations of international trade. In a similar matter, the

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view on the role of international trade evolved from general consideration of trade as such to more detailed observations of trade's specific aspects and characteristics. One of the recently explored fields of analysis is the composition of trade, especially export's complexity, which is believed to play a significant role in facilitating country's economic growth, both in terms of its pace and sustainability.

Recent half-century is the era of general globalization, but also regional integration at the same time. Political decisions result in lessening barriers for international economic activity. Entering a monetary union is one of the highest forms of mentioned integration, which should affect all possible aspects of international trade. It is interesting how joining such a union might influence export's complexity of a small country. We focus on Slovenia as one of the countries to recently access the Eurozone. Therefore the aim of this article is to verify the impact of the euro adoption on the complexity of goods in Slovenian exports. With that goal in mind we verified the hypothesis that the adoption of the euro has significantly affected exports complexity in Slovenia.

In the second section we review literature on currency union's trade effects and economic complexity. The third section includes a description of the complexity of Slovenian export. In the fourth section we discuss the data and the applied methodology (Synthetic Control Method). Results of our research are discussed in the fifth section, while the last section concludes.

2. Literature review

2.1 Currency union effects

The discussion about the benefits of a currency union has been intense at least since Mundell (1961). It has been argued that elimination of national currencies and adoption of a single currency may lead to increased trade between integrating countries due to higher price predictability and lack of conversion costs. However, it was only the creation of the euro that accelerated empirical verification of that hypothesis. Rose (2000) is regarded as probably the first – and highly controversial – study of the trade consequences of currency unions. The author estimated parameters of the gravity model of trade that included the currency union dummy:

(1) $$T_{ij} = \alpha_0 Y_i^{\alpha_1} Y_j^{\alpha_2} \exp(x_{ij}\beta + \gamma CU_{ij})\eta_{ij}$$

where T_{ij} stands for trade flows between countries i and j, Y_k is the GDP of country k ($k \in \{i, j\}$), x_{ij} is the vector of variables dampening trade flows (especially, geographical distance between analyzes countries), CU represents currency union and η_{ij} is an error term with unit conditional mean.

After log-linearization one can estimate the model of the form:

$$(2)\ \ln(T_{ij}) = \ln(\alpha_0) + \alpha_1 \ln(Y_i) + \alpha_2 \ln(Y_j) + x_{ij}\beta + \gamma CU_{ij} + \ln(\eta_{ij})$$

According to Rose (2000) estimates the currency union effect is high – that form of economic integration increases bilateral trade between member countries by 200%. Such a result seemed implausible, initiating a wave of research on the trade implications of the Eurozone (see, for example, Micco, Ordoñez and Stein, 2003, De Nardis and Vicarelli, 2003, Santos Silva and Tenreyro, 2006, Berger and Nitsch, 2008, Glick and Rose, 2016). Subsequent papers diminished the euro trade effect by dealing with many empirical problems like reverse causality, existence of zeroes in trade data, time lag before materialization of the effect and heterogeneity of member states. All those studies show that the establishment of the Eurozone increased bilateral trade between member states, but the scale of such an increase was milder than expected and ranged in general from 15 to 30% (see Baldwin, 2006, and Frankel, 2010, for an overview), although several studies found no effect of the Eurozone (see Santos Silva and Tenreyro, 2010).

The Synthetic Control Method, used in our research, has also been applied to verify the euro trade effect[4]. Saia (2016) studied bilateral flows between seven countries that adopted the single currency in 1999. He found that the euro has led to more trade between member states compared to the counterfactual scenario based on the synthetic control groups.

Another strand of the literature focuses on the firm-level effects the adoption of the euro. Those papers may provide microfoundations to the aggregate results from mentioned studies and usually they focus on the decision of a firm whether to export or not. The framework used in models of firm's decision to engage in exports (the so called *New new trade theory* or *Trade theory with heterogeneous firm*) was developed by Melitz (2003). According to our knowledge, however, models of such decisions in the context of nominal exchange rate volatility are still lacking. At the same time few authors investigated the role of the level of nominal exchange rate in firm's engagement in exports (see, especially, Chaney, 2016). Hence, the only model of

[4] The same method was also utilized by Gomis-Porqueras and Puzzello (2015) in their analysis of the impact of the euro on GDP per capita of member states. The same topic was the research interest of Žúdel and Melioris (2016), who also applied the Synthetic Control Method – however, they focus on the case of Slovakia.

trade with heterogeneous firms that directly applies to the Eurozone experience is Bergin and Lin (2012) in which the authors focus on the elimination of transaction costs after the formation of the EMU (instead of changes in the nominal value of the currency). Nominal exchange rate volatility could be seen as another source of uncertainty affecting firm-level trade (that field has been developed by, for example, Crozet, Koenig and Rebeyrol, 2008, and Segura-Cayuela and Vilarrubia, 2008). For the thorough overview of the links between exchange rates and trade see Auboin and Ruta (2013).

Those studies may be put in broader context of studies decomposing the euro trade affect or at least focusing on only some of its aspects. The decision of firms to engage in trade is the basis of the so called extensive margin of trade (number of exporters/importer or number of goods in exports/imports). The New Goods Hypothesis has been analyzed by, for instance, Baldwin and DiNino (2006), Flam and Nordström (2007) and Nitsch (2007). Other trade consequences of the adoption of a single currency that have been studied are, among others, pricing policy of exporters (Berman, Martin, Mayer, 2012), the quality of exports (Ito and Okubo, 2016) (see also Baldwin, DiNino, Fontagné, De Santis and Taglioni (2008), Fontagné, Mayer and Ottaviano (2009), Berman, Martin and Mayer (2012) for the overview and the simultaneous analysis of many aspects of trade). To the best of our knowledge there is no study of the impact of the euro adoption on the complexity of exported goods, hence our article fills an important research gap.

Slovenia has not been at the center of the debate about the euro trade effects since studies focused primarily on the first member states. There are, however, exceptions. Aristovnik and Meze (2009) investigated how the introduction of the euro in 1999 affected Slovenian trade as an example of the impact the single currency might have on trade flows with non-member states. They found no permanent effect with transitory decrease in Slovenian imports from the EMU and increase (though anticipated) in exports from that country to the Eurozone. Although that finding seems interesting, it does not tell anything about the consequences of the adoption of the euro by Slovenia and not by other countries.

In contrast Cieślik, Michałek and Michałek (2013) studied that issue and utilized a probit model to verify the determinants of export decisions of firms. The model had the following form:

$$(3) \quad Y_i = \begin{cases} 1 \; if \; Y_i^* > 0 \\ 0 \; if \;\; Y_i^* = 0 \end{cases}$$

where $Y_i^* = X_i\theta + \varepsilon_i$, X_i is the vector of regressors affecting firms' decisions (including the Eurozone dummy), ε_i is an error term with zero mean, Y_i is the binary variable indicating firm i-th export status. The probability of i-th firm being an exporter is:

(4) $\Pr(Y_i = 1|X_i) = \Phi(\beta + X_i\theta)$

The authors used firm-level data for Slovenia and Slovakia. They obtained the results indicating that the adoption of the euro by Slovenia increased the propensity of firms from that country to export.

Cieślik, Michałek and Mycielski (2014) also studied the euro trade effects in new member states. They estimated the panel model using data for a broad range of countries, including Slovenia. They used several specifications of the model, categorizing countries as the old members and new members. According to results, there is no evidence that the adoption of the single currency stimulating bilateral trade between a new member and other countries belonging to the EMU[5]. In their previous research (Cieślik, Michałek and Mycielski 2012) they focused on Slovakia and Slovenia and applied fixed effects, random effects and Hausman-Taylor estimators to assess whether countries in question experienced trade expansion after the euro adoption (the authors utilized the gravity model of trade). They found no evidence of trade expansion.

2.2 Export's complexity

Complexity can be understood in two ways: as technological advancement of the exported goods (Lall, 2000) or as the width of components used for production (Hausmann, Hwang, Rodrik, 2007). The latter is more common. However, both are correlated, as more technologically advanced processes usually require more production stages and more varied inputs.

Hausmann, Hwang and Rodrik (2007) proved that higher complexity of export is a significant stimulant of economic growth in countries with moderate national income (small countries), as trade in more processed or advanced goods is more profitable and enables stronger international competitive advantage. Further research complemented that result by specifying, that this effect is especially strong when countries implement liberal trade policy and tend not to overvalue

[5] When one includes variables linked to the so called Great Trade Collapse (GTC) of 2008-2009 the EMU membership was statistically insignificant. When such a variable is excluded, membership in the EMU negatively affects bilateral trade.

their real exchange rate (Anand, Mishra, Spatafora, 2012). Hidalgo and Hausmann (2009) also shown that export's complexity is correlated with national welfare measured with GDP per capita. Unfortunately, the research concerning the importance of export complexity for the economic growth is still largely underdeveloped and initial results were subject to criticism, mainly concerning the utilised complexity measure (Gertler, 2006)[6].

Apart from facilitating the pace of economic growth or having possible general welfare effects, export's complexity is believed to improve country's resilience to shocks. Koren and Tenreyro (2013) implied that more complex export can be resistant to supply side shocks. This is because more complex goods, with wider range of inputs, are less dependent on each single component. Moreover, among numerous inputs only limited amount can be specific, which means that most of them can be easily replaced should a supply side shock occur.

If export complexity can stimulate economic growth in a small country, then another important question is how to influence complexity. Basically, complexity depends on the range of competence that is available for the national economy (Hidalgo, Hausmann, 2009). This means that export complexity requires not only technological advancement, but also high human capital (Anand, Mishra, Spatafora, 2012). That potential can be improved by educational and R&D policy. However, it seems that it easier to establish new comparative advantages if the country obtains them close to their initial specialization, with new export products being related to older ones (Hausmann, Klinger, 2007). Some competences, absent on a domestic market, can be internationally transferred (Hidalgo, Hausmann, 2011), which is a natural process e.g. within transnational corporations (Costinot, Oldensky, Rauch, 2009).

Technological development also depends on natural resources. Despite some doubts concerning possible negative effects of economic overdependence on natural resources, majority of research results prove that it has positive economic outcome (Lederman, Maloney, 2012). It has also been proved that good institutional environment for entrepreneurship enables successful implementation of more complicated production processes in the economy, therefore it stimulates export complexity as well (Costinot, 2009).

Hausmann, Hwang and Rodrik (2007), who should be considered pioneers in research on complexity, suggest a set of possible export complexity determinants, that consists of: area,

[6] Of course, Gertler's critique refers to older version of the research, published as a NBER working paper (Hausmann, Hwang, Rodrik, 2005).

population, human capital index, rule of law index and GDP per capita. In their approach area approximates natural resources. Population describes the size of labour force, while human capital index presents its quality. GDP per capita is a proxy for the development (technology) level, while rule of law is believed to reflect institutional development of the domestic market.

The open question is whether economic integration leads to higher complexity of exports. According to our knowledge, there is no study on the effects of such processes, and especially of forming the currency union, on that characteristic of trade flows. There are, however, studies that may shed some light the issue. Young (1991) showed that after trade liberalization developing countries are likely to specialize in more traditional sectors that exhausted their learning-by-doing possibilities. It is reasonable to assume that such sectors produce less sophisticated – and less complex – products. Similarly, Galor and Mountford (2008) modelled countries' accumulation patterns after opening to trade. They found that after lowering of trade barriers developing countries invest less in human capital, hence specializing in less advanced sectors. Due to the fact that in 2007 (year before the Eurozone accession) Slovenia had GDP per capital level equal to 80% of the Eurozone average[7], it would suggest that after the accession Slovenia should have experienced the decline in exports complexity.

On the other hand, the elimination of a national currency may also lead to changes in FDI patterns across countries. Xu and Lu (2006), Harding and Javorcik (2012) and Eck and Hubert (2016) found that FDI inflows result in higher exports quality and sophistication. Since economic integration may lead to increase in FDI from third countries (see Antras and Foley, 2011), it is reasonable to think of Slovenia as the recipient of FDI from non-member states.

The adoption of the euro by Slovenia may be seen as a unique example of economic integration resulting in trade and factor movement liberalization. Given inconclusiveness of the literature on the effects of such processes, we tried to verify whether the adoption of the euro had an impact on exports complexity in Slovenia.

3. Complexity of Slovenian Exports

Export complexity can be evaluated with different measures. The simplest solution is to determine which product groups are to be considered complex (e.g. high-tech) and to measure

[7] Based on OECD data at current prices with PPP. The Eurozone was defined as the block of 19 countries, hence it undervalued the GDP per capita level of 2007 Eurozone which was then formed by the most economically advanced countries of the European Union. It implies that the comparison of the income per person in Slovenia and 2007 Eurozone would reveal even bigger differences.

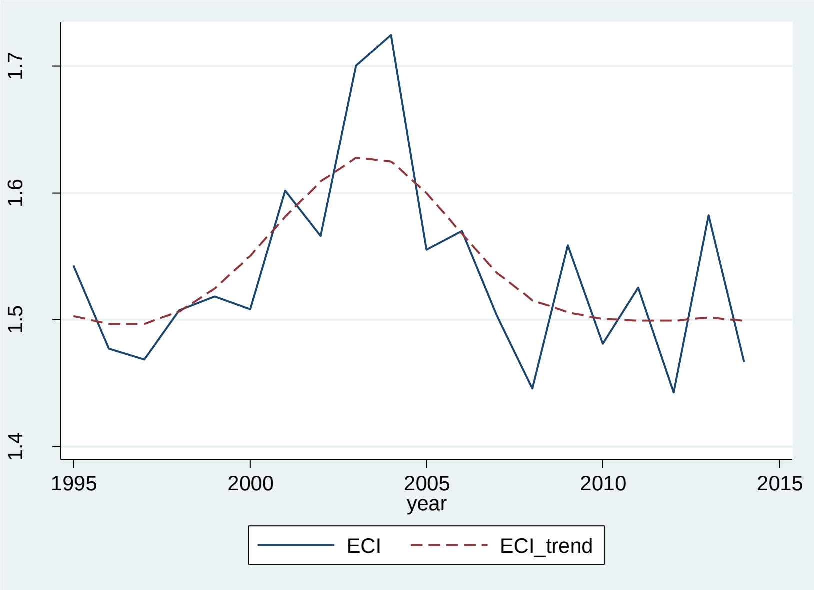
their share in export (Lall 2000). A similar, but more advanced approach is to produce a synthetic index that would be able to assess the complexity of all the produced goods.

Hausmann, Hwang and Rodrik (2007) suggested such an index – EXPY. It is based on an average of the PRODY indices for all the exported goods, weighted with their share in country's export. PRODY are product ubiquity indices, describing how common these goods are in world trade. The assumption is that if country's export stream is on average composed of more unique products (higher PRODY), it is also more advanced and complex.

In our analyses we chose another measure, the Economic Complexity Index (ECI), provided by the Atlas of Economic Complexity (AEC) – a project conducted by the Center for International Development at Harvard University. It is an index based on similar assumptions as EXPY, however it is more advanced. Product ubiquity is not simply measured by its share in world trade, but by the amount of countries displaying a comparative advantage in the good. Moreover, ECI considers the diversity of export in terms of the amount of different goods exported by the country (see AEC website).

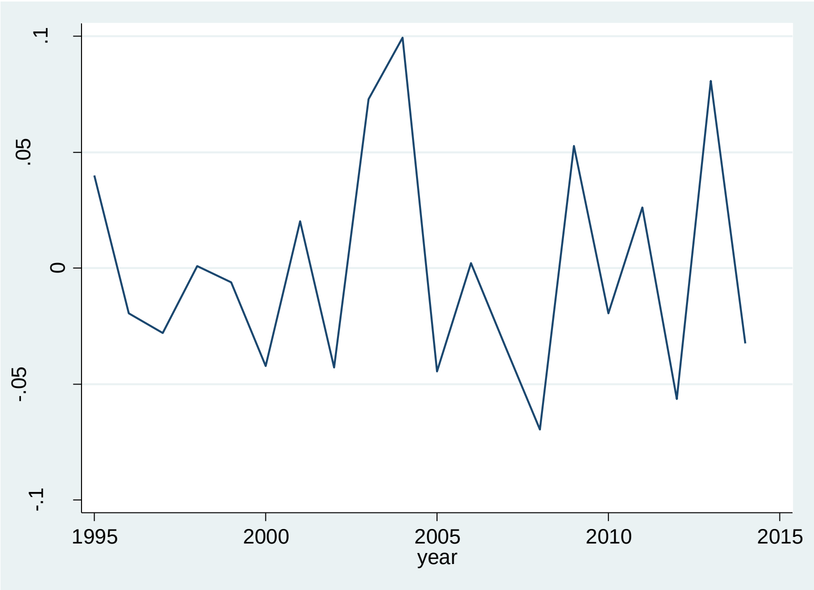
ECI varied in Slovenia during 1995-2014 period reaching its maximum level (1.725) in 2004 and the minimum level (1.443) in 2012. As the Figure 1 and Figure 2 illustrate, one can decompose actual values of that indicator, obtaining its cyclical component and trend (such a decomposition was generated by the application of the Hodrick-Prescott filter with usual parameters for yearly data).

Figure 1. ECI and its trend – Slovenia, 1995-2014



Source: Authors' calculation

Figure 2. The cyclical component of ECI – Slovenia, 1995-2014



Source: Authors' calculation

During the first years of the timeframe of our analysis the Economic Complexity Index in Slovenia grew from 1.469 (in 1997) to 1.725 (in 2004). The trend component itself indicates that strong upward tendency in the data. Surprisingly, the maximum level of that component was achieved in 2003, although the Economic Complexity Index reached in peak a year later (hence, the value of the indicator in 2004 was significantly affected by a transitory shock – see the cyclical component in Figure 2 for that year).

Starting from 2003/2004 Slovenia has experienced the decline of the Economic Complexity Index. The trend component had characterized a stable decrease until 2008, plateauing since then. As the trend has become stable and the cyclical component has been very volatile throughout the analyzed period, the actual (aggregated) value of the Economic Complexity Index has varied since 2008.

Dividing the timeframe of our analyzes into sub-periods is also revealing (see Table 1 and 2). Since the adoption of the euro Slovenia has achieved lower average value and lower volatility of the Economic Complexity Index (compared to the whole sample and sub-periods before the adoption of the single currency and before the EU accession).

Table 1. ECI in Slovenia – descriptive statistics

Period	1995-2014 (the whole sample)	2007-2014 (after the adoption of the euro)	1995-2006 (before the adoption of the euro)	1995-2003 (before the EU accession)
Mean	1.537	1.501	1.562	1.543
Standard deviation	0.075	0.052	0.081	0.072
Coefficient of variation	4.90%	3.43%	5.16%	4.68%

Source: Authors' calculation

The data on trend indicate similar patterns. The mean and standard deviation has decreased since the adoption of the euro. Lower volatility is especially worth highlighting – the standard deviation during 2007-2014 was only 0.014 (that means fluctuations around the mean within the +/- 0.92% bound). As we have mentioned, the trend component has stabilized since 2008, affecting the values of the standard deviation and the coefficient of variation.

Table 2. The trend component of ECI in Slovenia – descriptive statistics

Period	1995-2014 (the whole sample)	2007-2014 (after the adoption of the euro)	1995-2006 (before the adoption of the euro)	1995-2003 (before the EU accession)
Mean	1.539	1.512	1.557	1.544
Standard deviation	0.046	0.014	0.051	0.051
Coefficient of variation	2.99%	0.92%	3.28%	3.29%

Source: Authors' calculation

It should be clearly stated that one should not infer that the adoption of the euro led to the decrease of the Economic Complexity Index in Slovenia (or even the decrease of its trend component). The sub-period 2007-2014 was plagued by events like the sub-prime crisis (with the resulting global financial crisis) and the so called Global Trade Collapse. What is more, the

EU accession might have had lagged implications for Slovenian exports. That is why we adhered to more scrutinized analysis that is presented in the following section.

4. Methodology and data description

4.1. Synthetic control method

The problem of the impact of accessing the Eurozone on Slovenian export's complexity is a part of a larger discussion about proper capturing causal inference in the process of modelling panel data. Such inference has a form of a country-specific effect, but with a time-varying coefficient. Models typically applied in such cases are fixed effects models (FE), difference in difference models (DD) or models with lagged dependent variable (LDV). However, they are only able to control for country-specific and time-varying effects separately, while in reality the process includes interaction, and might be as complicated as in model (5).

(5) $$Y_{it} = X_{it}\beta + Z_i\theta_t + \lambda_t\mu_i + \epsilon_{it}$$

Where X_{it} denotes independent variables with stable parameters from vector β and Z_i denotes covariates with time-varying parameters θ_t, while ε_{it} stands for an error term. In this model, $\lambda_t\mu_i$ represents heterogeneous responses to multiple unobserved factors, which is the problematic interaction. In FE or DD models these responses can only be represented by a linear expression of two types of factors $\delta_t + \alpha_i$, which are only special cases of the $\lambda_t\mu_i$ response.

Abadie, Diamond and Hainmueller (2010) came up with a solution to this problem, under the restriction of the country-specific effect being reserved to only one country and the time-varying effect being continuous after its introduction. In fact, these restrictions mean that their approach is ideal to observe effects of a standing policy decision introduced in a particular year in a certain country. Their method is known as the synthetic control method (SCM).

Following Abadie, Dimaond and Hainmueller's (2010) description of the method, let us assume, that we observe J+1 units (countries) in T periods (years). One of the units, and we can assume that it is unit enumerated by zero (leaving units 1,…,J in the control sample), is subject to a treatment (e.g. political decision)inyearT_0, so the effects of interference are observed in unit zero for periods T_0,…,T, while they remain unobserved in periods 0,…,T_0-1. In general, we can formulate these conditions as below.

(6) $$Y_{it} = Y_{it}^N + \Delta_{it}D_{it}$$

(7) $\Delta_{it} = Y_{it}^{I} - Y_{it}^{N}$

(8) $D_{it} = \begin{cases} 1\ if\ i = 0\ and\ t = T_0, \dots, T \\ 0\ otherwise \end{cases}$

Where Y_{it} is the observed variable which might have two outcomes: Y_{it}^N is the outcome without the effect of interference (neutral) and Y_{it}^I is the outcome with interference included (interfered). D_{it} is a binary switching function and Δ_{it} is a difference of two potential outcomes for country I in period t.

SCM is based on an idea that we can model Y_{it}^N and the treatment effect is the Δ_{it} difference between observed value of Y (which in the post-treatment period is in fact the interfered outcome) and its theoretical neutral value. The factor model of neutral outcome is as follows.

(9) $Y_{it}^{N} = \delta_t + Z_i\theta_t + \lambda_t\mu_i + \epsilon_{it}$

Where δ_t is an unobserved time-varying (but common to all units) factor, while Z_i, θ_t, λ_t, μ_i and ε_{it} are interpreted as in (5), with reservation that vector dimensions need to be controlled so that vector products $Z_i\theta_t$ and $\lambda_t\mu_i$ are well defined as scalars. Let us e.g. assume, that Z_i is a (1xr) vector and θ_t is a (rx1) vector, while λ_t is a (1xs) vector while μ_i is a (sx1) vector. It is worth noting, that adding an assumption that λ_t is in fact constant in time transforms equation (9) into a standard DD/FE model, thus SCM can be treated as a generalized form of the DD approach.

In the case of panel data, we can base our conclusions on post-treatment outcomes for unit zero both on the treated unit itself before treatment and on the control sample of the units that were not subject to treatment. The aim of the SCM method is to use pre-treatment data to construct a set of weights, which could be used to produce a synthetic treated unit as a linear combination of the control units. It is crucial to choose a control set that forms a kind of band for the actual observed outcome values, as SCM, by its construction, cannot successfully create suitable counterfactuals for outliers or units with extreme values of the measured outcomes. The first reason for that is that outliers usually are characterized by different patterns of outcome generation. The second is more technical: for practical reason we impose a condition, that all the weights must be non-negative and sum up to 1, thus we determine that the synthetic unit is within a convex hull of the control set (Fremeth, Holburn, Richter, 2013: 13). Considering these reservations, we can define potential controls W as in (10).

(10) $W = (w_1, \dots, w_J);\ \forall_{i=1,\dots,J} w_i \geq 0 \wedge \sum_{i=1}^{J} w_i = 1$

Let us now consider the vectors of country-specific characteristics Z_i and a family of linear functions of pre-treatment outcomes Y_i^k, with k=1,…,m and m ≥ s (a relatively large family). Let us now assume that we can choose a control vector W* that meets condition (11).

$$(11)\quad W^* = (w_1^*, \dots, w_J^*);\ \sum_{i=1}^{J} w_i^* Z_i = Z_0, \sum_{i=1}^{J} w_i^* Y_i^1 = Y_0^1, \dots, \sum_{i=1}^{J} w_i^* Y_i^m = Y_0^m$$

In that case, we receive an approximately unbiased estimator of the Δ_{it} for the treated country.

$$(12)\quad \widehat{\Delta}_{0t} = Y_{0t} - \sum_{i=1}^{J} w_i^* Y_{it}, t = T_0, \dots, T$$

Of course, in reality it might be impossible to find a control vector W* that could meet condition (11). However, the estimator holds if we determine a control vector $\hat{W}$ that, solves the minimization problem (13) when assumption (10) stands.

$$(13)\quad \widehat{W} = \min ||X_0 - X_J W||$$

In (13) the problem is expressed in a matrix notation, in which X_0 stands for a (r+m x 1) vector of characteristics of the treated country, defined as $(Z_0, Y_0^1, \dots, Y_0^m)'$. X_J is a (r+m x J) matrix of the same characteristics for the J control sample countries.

In a more operational form, optimization problem (13) can be rewritten as (14), where the distance representing discrepancy between X_0 and X_jW can be expressed using V, which is a (r+m x r+m) symmetric and positive semi definite matrix. In terms of interpretation, V measures the relative importance of characteristics included in the X_0 vector and X_J matrix (Campos, Coricelli, Moretti 2014, p. 10)

$$(14)\quad \widehat{W} = \min\{(X_0 - X_J W)' V (X_0 - X_J W)\}$$

There are many ways to choose matrix V, but the standard way, utilized by STATA when performing the SCM procedure “synth” command, is to compose it in a way that minimizes mean squared error in the pre-treatment period.

4.2. Data description

We employed SCM procedures to determine, whether joining the Eurozone had an influence on the complexity of the goods exported by Slovenia. To measure export complexity we have chosen the Economic Complexity Index (ECI) provided by the Atlas of Economic Complexity. However, ECI tends to be subject to sufficient volatility, while we were interested in comparing stable paths of development of export complexity between actual and synthetic Slovenia. That is why not only ECI but also Hodrick-Prescott filtered trend of ECI was used as the observed outcome variable of the research.

Our choice of the time-varying covariates (Z_i) of the observed ECI was inspired by Hausmann, Hwang and Rodrik (2007). Therefore we included information on population, real GDP at constant prices (effectively used as GDP per capita) and Human Capital Index provided by the Penn World Table, version 9.0 (Feenstra, Inklaar, Timmer, 2015). Data on the countries' area came from CEPII GeoDist Database (Mayer, Zignago, 2011) and data on the Rule of Law Index estimates has been drawn from the World Bank's Worldwide Governance Indicators database.

The first main identification assumption of the SCM is that the variables used as pre-treatment characteristics should be able to approximate the path of the treated unit, but at the same time they should not anticipate the effect of intervention (Campos, Coricelli, Moretti, 2014: 11). In that matter Hausmann, Hwang and Rodrik's (2007) selection of variables seems to be well fitted in economic theory as factors related to export complexity, which indicates good approximation of the treated unit's path. As for the problem of possible anticipation of the intervention, while population and area can be easily treated as free from such risk, it seems impossible to find a typically economic variable that would not anticipate entering the Eurozone, especially since Slovenia has joined ERM II mechanism in 2004, which was a clear signal for the most possible nearest future. Furthermore, integration is a continuous process, not a zero-one switch (Campos, Coricelli, Moretti, 2014), thus anticipation is its immanent element. Nevertheless, we believe that Human Capital Index (being mostly dependent on the system of education) and Rule of Law Index (as a derivative of social and political factors that seem to be largely independent from the change of the legal tender) evolved with not more than a minimal anticipation effects. The only really problematic variable is GDP per capita, but it seems to be so basic a welfare indicator, that it could not be omitted when matching countries is involved.

The second assumption claims, that countries used in the control sample should not be affected by the treatment, both directly or indirectly (Campos, Coricelli, Moretti, 2014). That is why our research utilizes for the donor pool mostly non-European countries (10 countries: Australia, Canada, Chile, Israel, Japan, Korea, Mexico, New Zealand, Turkey and the USA) and European countries that are outside European Union (2 countries: Norway and Switzerland). Our choice of control sample has been limited by the availability of data, especially about ECI.

Finally, to increase the fit between model and real values of ECI, we have also included observations of ECI from pre-treatment period. These observations work as a Y_0^k type linear function of pre-treatment outcomes. If fitting pre-treatment ECI is the key to create synthetic Slovenia, it might seem tempting to use the outcomes from all the pre-treatment years as control variables. However, Kaul, Klößner, Pfeifer and Schieler (2016) prove, that doing so makes all the other covariates insignificant, as synthetic counterfactual is then fitted only according to pre-treatment outcome values. If the covariates are important explanatory variables for the variation of the outcome, then such a situation might lead to a growing bias in the post-treatment period. That is why they suggest to use either an average value of the pre-treatment outcomes or just a few values from the pre-treatment period, preferably the last ones. Our slightly different choice was dictated by a relatively large volatility of the ECI values in Slovenia – we wanted to control for the turning points of the long-term trends. Thus, we tried using ECI observations from the first year of the sample period and the last pre-treatment period to make sure that synthetic Slovenia is not shifted at the boundaries of the pre-treatment period. We have also included local extreme values of the ECI trend to facilitate good fitting in the turning points.

5. Results and discussion

5.1. Estimation results

We used STATA "synth" command to execute SCM procedure on a pool of 13 countries (treatment unit included). We used data from 1995-2014. Our treatment unit was Slovenia and the treatment period was 2007 – the year at which Slovenia turned to Euro as its currency. Table 3 presents variable names and numeric symbols of the control pool countries.

Table 3. Names and abbreviations used in the research to address variables and countries

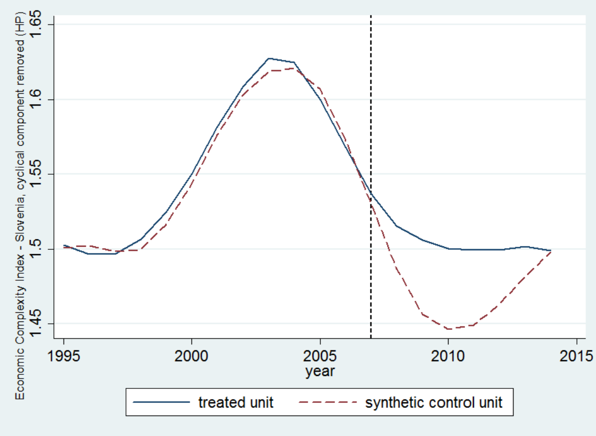
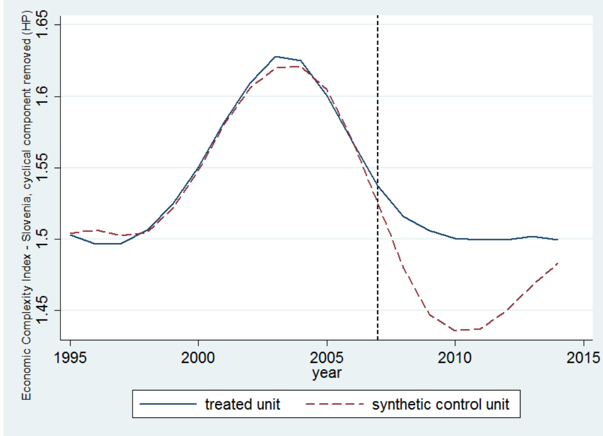
Variables		
Name	Description	Source
ECI	Economic Complexity Index	Atlas of Economic Complexity
HCI	Human Capital Index	Penn World Tables 9.0 (Feenstra, Inklaar. Timmer, 2015; further in the table: PWT)
Population	Population in millions	PWT
Area	Area in square km	CEPII GeoDist (Mayer, Zignago, 2011)
rGDPpc	Real GDP at constant 2011 national prices (in mil. 2011USD) divided by country's population	PWT
RoL	Rule of Law Index: estimates	Worldwide Governance Indicators, World DataBank
XXX_trend	Suffix referring to the fact that the variable XXX has been rid of cyclical component with the Hodrick-Prescott filter	Own elaboration
RMSPE	Root Mean Squared Prediction Error	Own elaboration

RMSPE%	Root Mean Squared Prediction Error in reference to mean average pre-treatment outcome (in %)	Own elaboration
Donor pool (research units)		
Number	Country name	
1	Australia	
2	Canada	
3	Switzerland	
4	Chile	
5	Israel	
6	Japan	
7	Republic of Korea	
8	Mexico	
9	Norway	
10	New Zealand	
11	Slovenia – the treatment unit	
12	Turkey	
13	USA	

Source: Authors' elaboration

In the paper we do not present all of the estimations conducted – just a sample of them to illustrate best our findings. First of all, when ECI was filtered and its trend obtained it turned out that it has two local extremes in the pre-treatment period: a minimum in 1996 and a maximum in 2003. Even though we focused on the ECI trend, in the first stage we used all the data on covariates in its primal form (without filtering). Figure 3 presents results based on unfiltered Hausmann, Hwang and Rodrik's (2007) suggestions. In the first variant we control for pre-treatment ECI levels using only data from 1995, 1996, 2003 and 2006, which reflect edges and extremes of the pre-treatment outcomes. However, to test if strengthening such control could significantly improve SCM procedure, we exploited a second approach, joining the previously mentioned observations into two connected sub-periods (though each year controlled independently), the beginning of the pre-treatment period 1995-1996 and the its ending 2003-2006.This approach was presented in the second variant.

Figure 3. SCM procedure results with unfiltered covariates

<table>
<tr><td>Variant 1</td><td>Variant 2</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>RMSPE = 0.0054764
RMSPE% = 0.35%

Non-zero unit weights:
6 | 0.262
7 | 0.183
8 | 0.555

| Treated Synthetic
RoL | 1.005687 0.205442
Area | 9.916206 13.50084
Population | 1.990951 98.60003
HCI | 3.258213 2.803086
rGDPpc | 20902.88 20271.26
ECI_trend(1995) | 1.502886 1.500596
ECI_trend(1996) | 1.496562 1.502409
ECI_trend(2003) | 1.627756 1.618707
ECI_trend(2006) | 1.568102 1.573053</td><td>RMSPE = 0.0046729
RMSPE% = 0.30%

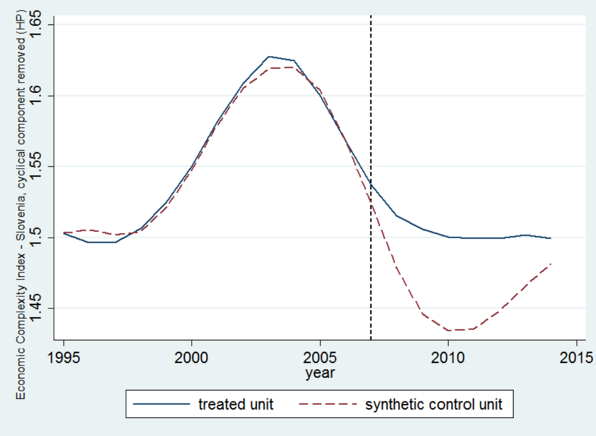
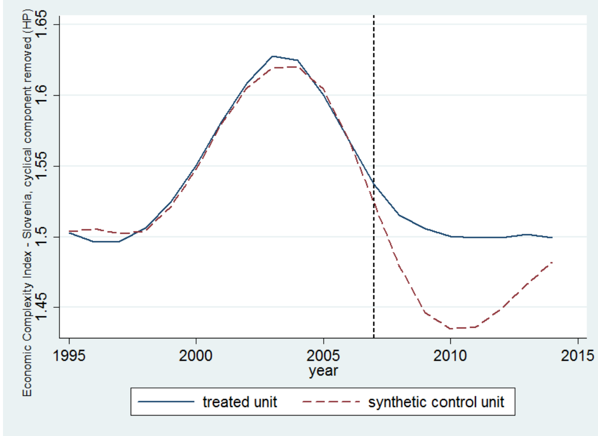
Non-zero unit weights:
6 | 0.266
7 | 0.156
8 | 0.578

| Treated Synthetic
RoL | 1.005687 0.178032
Area | 9.916206 13.58766
Population | 1.990951 100.3524
HCI | 3.258213 2.789282
rGDPpc | 20902.88 20157.16
ECI_trend(1995) | 1.542874 1.503962
ECI_trend(1996) | 1.496562 1.506175
ECI_trend(2003) | 1.627756 1.619853
ECI_trend(2004) | 1.625010 1.620798
ECI_trend(2005) | 1.600075 1.604774
ECI_trend(2006) | 1.568102 1.569180</td></tr>
</table>

Source: Authors' calculation

The covariates used in the research at the first stage were unfiltered, as we believed that ECI, even filtered, reacts to changes of actual values of the presented covariates, not necessarily purified ones. However, at the second stage we decided to look at more long term, stable factors and we have filtered data on Human Capital Index, Rule of Law Index and real GDP per capita. Only area and population, which are typically stable (or even constant, at least in the research period) in fact needed no filtering. Figure 4 presents our estimations with trends. Again, we consider two variants of pre-treatment outcome specification. Variant 3 controls only for extremes and edges of the pre-treatment period outcomes, while variant 4 binds them into two connected sub-periods.

Figure 4. SCM procedure results with filtered covariates

<table>
<tr><td>Variant 3</td><td>Variant 4</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>RMSPE = 0.0046802
RMSPE% = 0.30%

Non-zero unit weights:
6 | 0.266
7 | 0.154
8 | 0.580

| Treated Synthetic
RoL_trend | 1.008874 0.171295
Area | 9.916206 13.59363
Population | 1.990951 100.4662
HCI_trend | 3.258583 2.787783
rGDPpc_trend | 20982.89 20147.20
ECI_trend(1995) | 1.502886 1.503312
ECI_trend(1996) | 1.496562 1.505589
ECI_trend(2003) | 1.627756 1.619251
ECI_trend(2006) | 1.568102 1.568300</td><td>RMSPE = 0.0046718
RMSPE% = 0.30%

Non-zero unit weights:
6 | 0.266
7 | 0.155
8 | 0.579

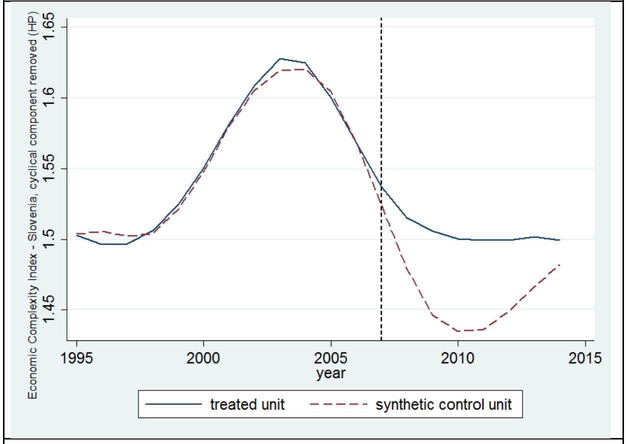
| Treated Synthetic
RoL_trend | 1.008874 0.172629
Area | 9.916206 13.59065
Population | 1.990951 100.4093
HCI_trend | 3.258583 2.788556
rGDPpc_trend | 20982.89 20155.56
ECI_trend(1995) | 1.502886 1.503637
ECI_trend(1996) | 1.496562 1.505882
ECI_trend(2003) | 1.627756 1.619552
ECI_trend(2004) | 1.625010 1.620458
ECI_trend(2005) | 1.600075 1.604383
ECI_trend(2006) | 1.568102 1.568740</td></tr>
</table>

Source: Authors' calculation

As stated in section 4.2, matching with the full set of pre-treatment outcome observations is dangerous, because it can lead to a bias of the post-treatment synthetic predictions. However, in order to have a wider range of possible controls to compare, we have also tried a variant with all 1995-2006 values of the filtered ECI. Of course, since in such a case technical matching intercepts all the significance from the characteristics of the donor pool units, we omitted any other control covariates. The results are presented in figure 5.

Figure 5. SCM procedure results with full pre-treatment outcome matching

Variant 5



RMSPE = 0.0046718
RMSPE% = 0.30%

Non-zero unit weights:

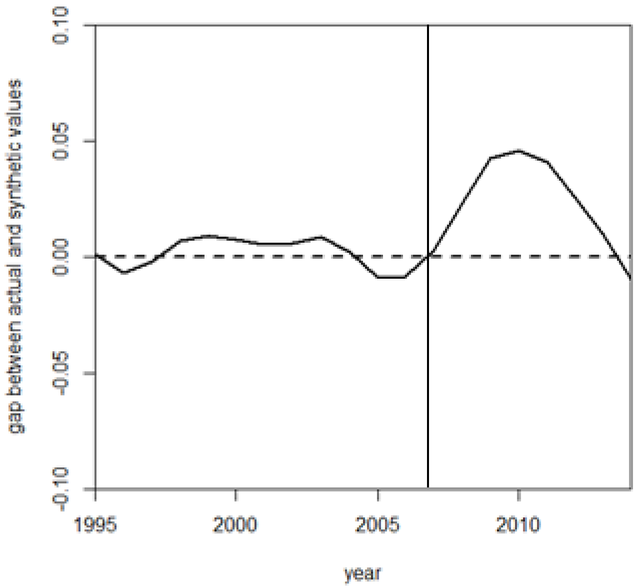
6	0.266
7	0.155
8	0.579

	Treated	Synthetic
ECI_trend(1995)	1.502886	1.503637
ECI_trend(1996)	1.496562	1.505882
ECI_trend(1997)	1.496637	1.502136
ECI_trend(1998)	1.506401	1.504258
ECI_trend(1999)	1.524655	1.521264
ECI_trend(2000)	1.550347	1.547900
ECI_trend(2001)	1.581424	1.579838
ECI_trend(2002)	1.609081	1.605459
ECI_trend(2003)	1.627756	1.619552
ECI_trend(2004)	1.625010	1.620458
ECI_trend(2005)	1.600075	1.604383
ECI_trend(2006)	1.568102	1.568740

Source: Authors’ calculation

First observation is that the prediction errors are generally small (and obviously smaller when utilizing more pre-treatment ECI values). Treated and synthetic characteristics are close to each other, apart from area, population and Rule of Law index. However, the donor pool is dominated by countries larger that Slovenia, thus overestimation of at least one of two parameters, population or area, was expected. In consequence, area is slightly overestimated, while population is largely overshot. Surprisingly low synthetic Rule of Law Index, on the other hand, is a flaw of the result. A large error of synthetic counterfactual might indicate that in fact Rule of Law Index is not strongly correlated with ECI values.

Figure 6. Gaps between actual and synthetic values of ECI (HP-filtered) in Slovenia – based on Variant 1 of the estimations



Source: Authors' calculation

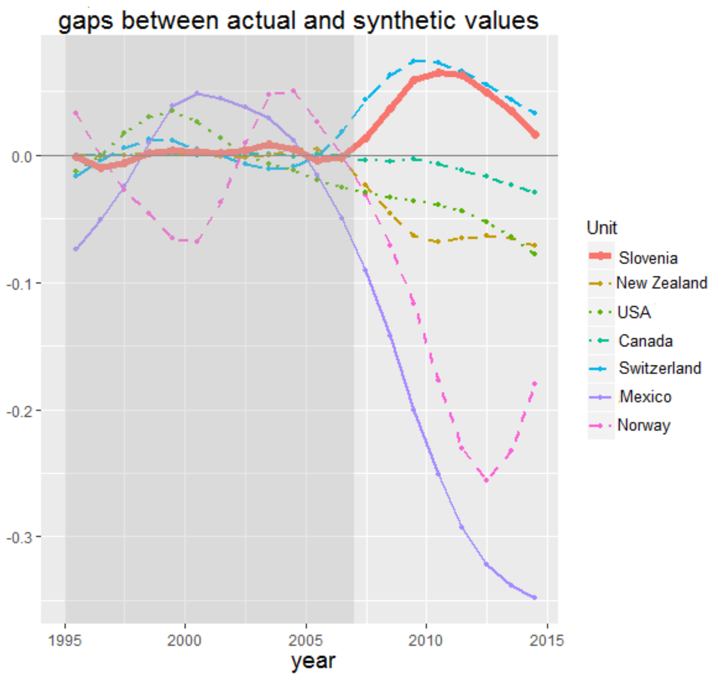
All presented SCM results demonstrate the same pattern of difference between synthetic and actual values of filtered ECI – as presented on figure 6. We believe, that when Slovenia entered EU, the complexity of its export started to decrease due to the fact that Slovenia was a relatively less developed EU member state (in comparison to "old" 15 EU member states) and its comparative advantages in reference to its European partners were manifested in less technologically advanced sectors. Entering the Eurozone helped stopping the downward trend initiated in 2003 and prevented Slovenian ECI to drop below 1.45 in 2010. The trend for synthetic Slovenia did not undergo a rebound before 2010, reaching levels close to actual values only at the end of the sample period. At the same time, the real trend of ECI dropped minimally after 2007 and was rather constant in the last five observed years. It seems then, that joining the Eurozone facilitated the pace of adjustment, which otherwise would be much more time-consuming, but all in all would probably lead to the present levels of Slovenian export's complexity. Such acceleration might have been caused by stronger integration within the Eurozone, which might have led to quicker establishing of stable comparative advantages, resulting in a more efficient formation of export composition.

5.2. Robustness

In order to verify robustness of our results, placebo test – suggested by Abadie, Diamond and Hainmueller (2010) – was conducted. In such a test the same SCM procedure was applied to every unit belonging to the donor pool. The procedure resembles a permutation test. The first step is the exclusion of the treated unit (Slovenia in our case) from the donor pool. Then the remaining units form a new donor pool that is used in such a way that each unit is treated as if the intervention occurred. The calculation of the difference between actual outcome and synthetic values forms the basis for verification of the null hypothesis that the intervention had no effect. In our case the null hypothesis stipulates that the accession to the Eurozone had no impact on the complexity of Slovenian exports. That hypothesis would be proved wrong if estimated treatment effects were similar to calculated placebo effects.

Figure 7 illustrates the results of the placebo test. Red bold lines are ECI (HP-filtered) gaps for Slovenia. The other lines are gaps for placebo units. The placebo test was conducted using MSCMT package in R described in detail in Becker and Klößner (2016). We excluded from our analysis those control units that had pre-treatment RMSPE of more than 10 times the Slovenian pre-treatment RMSPE. In other words, we included only those placebo units that had a relatively good fit in the 1995-2006 period.

Figure 7. Placebo test results for the Eurozone accession effects on Slovenia's ECI



Source: Authors' calculation

As figure 7 illustrates, the gaps for Slovenia stood out. Those gaps were positive, while in majority of placebo cases the gaps were negative. The only exception was Switzerland – that country had similar differences between actual and synthetic values. However, we do not think it supports the null hypothesis of no intervention effects. The gap in Switzerland appeared before the year of intervention (the year of the adoption of the single currency by Slovenia). Precisely, that gap was visible for post-2005 years indicating that other shocks could drive the behaviour of Swiss ECI. Spillover effects from the 2004 EU enlargement may be a better explanation of the gap for Switzerland. Bearing that in mind, placebo test may be seen as a proof that the introduction of the euro had an impact on Slovenian export's complexity.

6. Conclusions

The article's aim was to verify the impact of the euro adoption on the complexity of goods in Slovenian exports. The analysis conducted with the SCM method proved that accessing the Eurozone significantly altered the evolution path of the trend of the Slovenian export's complexity. In both cases, real and synthetic counterfactual, HP-filtered ECI was falling after the date of implementing euro, but in synthetic case without joining the Eurozone that fall at first was much deeper and longer, resulting in significant differences between synthetic and actual ECI. However, both scenarios turned out to be convergent in a longer period, causing the gap closing since 2012. These results were robust.

We believe that accessing EU as such reduced trade barriers between Slovenia and European partners, altering costs and resulting in a reset of the relative comparative advantages. Slovenian export composition was forced into switching to a bundle of less complex goods. This notion is supported by the fact, that the filtered ECI time series has a local maximum in 2003, just before EU accession, and it starts to decrease radically after 2004. Adopting euro enabled such an adjustment to be quicker and less volatile. Thus, the new stable level of ECI was reached around 2009/2010, rather than 2015/2016.

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