Five years in a balloon: Estimating the effects of euro adoption in Slovakia using the synthetic control method

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FIVE YEARS IN A BALLOON: ESTIMATING THE EFFECTS OF EURO ADOPTION IN SLOVAKIA USING THE SYNTHETIC CONTROL METHOD

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ABSTRACT/RESUMÉ

Five years in a balloon: estimating the effects of euro adoption in Slovakia using the synthetic control method

We analyse the effect of Slovakia's euro adoption in 2009 on the country's economic performance by using the synthetic control method. This method compares Slovakia's economic performance with that of a weighted combination of comparable Central European economies that have remained outside the Euro zone. We estimate that by adopting the euro, Slovakia gained 10% of real GDP per capita by 2011. Strong anticipation effects are present as two thirds of this gain occurred already in 2008. Nevertheless, had Slovakia postponed adoption of the EUR by one year and kept its own currency during the recession in 2009, the economy would have been temporarily better off that year by 2%. These results survive various robustness tests.

JEL Classification: C33, F15, F43, F47, O47,
Key words: economic growth, monetary union, euro area, synthetic controls

Cinq années en ballon : les effets de l'adoption de l'euro par la Slovaquie estimés par la méthode des contrôles synthétiques

Nous analysons l'effet de l'adoption de l'euro par la Slovaquie en 2009 sur la performance économique du pays en utilisant la méthode de contrôle synthétique. Cette méthode compare la performance économique de la Slovaquie avec celle d'une combinaison pondérée d'économies d'Europe centrale comparables qui sont restées en dehors de la zone Euro. Nous estimons qu'en adoptant l'euro, la Slovaquie a gagné 10% du PIB réel par habitant à l'horizon 2011. D'importants effets d'anticipation ont été à l'œuvre dans la mesure où les deux tiers de ce gain ont eu lieu en 2008. Néanmoins, si la Slovaquie avait reporté l'adoption de l'euro d'une année et gardé sa propre monnaie pendant la récession en 2009, les performances économiques aurait été amélioré temporairement de l'ordre de 2% en 2009. Ces résultats restent valides sous divers tests de robustesse.

Classification JEL: C33, F15, F43, F47, O47
Mots clef: croissance économiques, l'Union monétaire, zone euro, contrôle synthétique

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1.   Introduction

1.   Introduction of the euro on 1st January 2009 was an economic milestone for Slovakia. After a period of economic downturn in the late 1990s Slovakia introduced market reforms and set up an ambitious plan to be the first country in the Visegrad group to join the euro area. The expectations of net benefits from joining the euro club were high. Suster, et al. (2006) from the National Bank of Slovakia estimated that in the next 20 years after the euro adoption the economic growth in Slovakia would increase by additional 0.4 to 1 percentage point annually. The subsequent global events have damped such optimism, but are not necessarily linked to euro membership.

2.   Just in the very first year after becoming member of the Eurozone, Slovakia, together with the rest of the world, experienced a very sharp economic slump followed by a sovereign debt crisis in the European periphery. The relatively short Slovak experience with the euro was challenged by issues which were rather absent in the pre-accession debate, e.g. bailouts and fiscal restrictions. On the other hand, inflation developments, which were the major concern in the pre-accession debate, not only did not materialize, but took rather the opposite direction. Such unexpected developments in the euro area naturally lead to the question whether benefits from joining the euro club have outweighed the costs.

3.   To address the question of the effect of the euro adoption in Slovakia, we follow a relatively new stream of comparative case study literature using the synthetic control method (SCM) developed initially by Abadie and Gardeazabal (2003). The underlying idea of the SCM lies in the construction of a synthetic counterfactual for the Slovak economy as a weighted aggregation of control economies in a way that mimics the economic development of Slovakia before euro adoption. To obtain the effect of the euro adoption itself, the resulting synthetic economy is then compared to the actual performance of the Slovak economy observed after the euro was adopted. The SCM is used in several other studies related to our analysis[1], e.g. Saia (2014) together with Gomis-Porqueras and Puzzello (2015) evaluate the effect of the euro adoption in old EU member states; Campos, Coricelli and Moretti (2014) estimate benefits from membership in the EU; and Abadie, Diamond and Hainmueller (2015) study the effect of German reunification as well as contributing to the improvement of the SCM itself.

4.   Using the SCM we find that by adopting the euro Slovakia gained approximately 10% in terms of GDP per capita by 2011 as shown by the difference between the synthetic control and the actual GDP. Though most of the gain (i.e. 7%) is observed before the actual adoption of the euro itself, benefits after 2009 are substantial as well. Further, in line with the standard literature we find that had Slovakia kept the

floating currency regime during the recession in 2009, the economy would have been better off temporarily that year by roughly 2%.

5.   The rest of the paper is organized as follows: in Section 2 we discuss the background of the euro adoption process in Slovakia and present a simple comparative analysis. In Sections 3 and 4 we describe the methodology and data, respectively. In Section 5 we summarize results, and in Section 6 the robustness tests are presented. Section 7 then concludes.

2.   Background

6.   The process of becoming a member of the Euro zone began in mid-2003, when the Slovak government approved the Strategy for adopting the euro in Slovakia (MF and NBS, 2003). This happened, in fact, one year before the country actually joined the European Union in May 2004, confirming a strong political commitment. The aim of the government was to proceed fast: the plan was to adopt the euro in 2009, possibly even one year earlier. The country joined the ERM II unexpectedly on 28th November 2005, and its economic policy followed the Maastricht criteria. Because of a strong appreciation of Slovak Koruna, the exchange rate parity was revalued twice before the Council of the European Union in June 2008 accepted Slovakia as a new member of the Euro zone. The process of euro adoption was completed on 1st January 2009.

7.   Although the process of the euro adoption in Slovakia itself was considered a success, the economic benefits from euro may not be clearly visible within the scope of a simple comparative analysis of the economies in the region. After an initial sizeable downturn related to the transformation shock the growth of the Slovak economy stabilized with an exception of a recession in 1999. The pace of convergence accelerated after 2006, when Slovakia experienced a period of sizeable greenfield FDIs, yet similar acceleration is observable in other economies as well, e.g. Romania, Czech Republic and Poland (Figure 1). Thus, it is not clear whether the acceleration of the Slovak economy is a result of the anticipation effect of the euro adoption or just a coincidence. In the very first year of the euro adoption in Slovakia, however, the period of fast growth was followed by a sharp recession in response to the global economic crisis. The Slovak recession in 2009 was, in fact, sharper than those in neighbouring countries and one possible explanation could be related to the absence of the exchange rate channel for the Slovak economy. At the time currencies of neighbouring countries depreciated significantly, providing them with a competitive advantage. However, since 2010 the Slovak economy has outperformed its regional peers that are not members of the euro area. A similar pattern can be observed by examining export performance. The period of fast growth of exports was interrupted by a sharp decline during the crisis followed by a quick recovery (Figure 2).

Figure 1. GDP per capita (logs, chained PPPs) development in selected countries of CEE
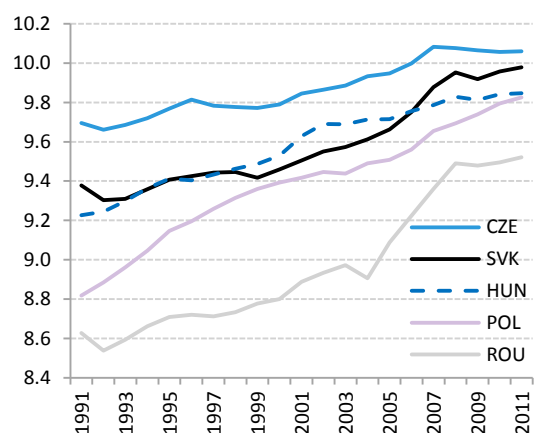
Source: Penn World Tables 8.1

Figure 2. Development of merchandise exports per capita in current PPPs (logs)
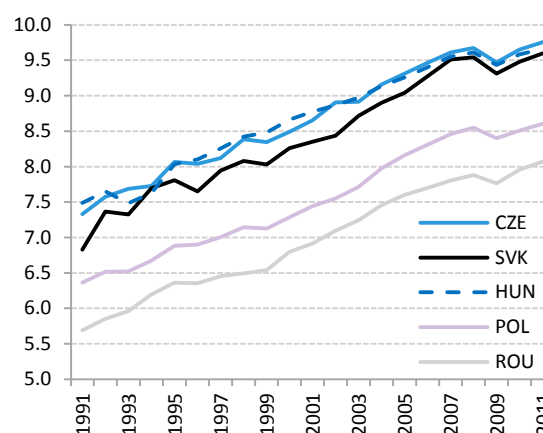
Source: Eurostat

8.   To fulfil the Maastricht Criteria, in 2005 the National Bank of Slovakia switched to an inflation targeting regime within the ERM II environment. The anchor of the new policy was to reduce the inflation rate below 2% by the end of 2007. In response to the new policy, the inflation rate, indeed, decelerated. After the euro adoption, inflation dynamics remained subdued and comparable with neighbouring countries, i.e. Czech Republic and Poland (Figure 3), although the nominal exchange rate convergence channel was not available any more. The lack of inflation pressures can be attributed mainly to the general disinflation trend in the euro area where inflation outcomes have been below the targeted 2% most of the time since 2009. Should the narrow inflation differential between the euro area average and Slovakia persist in the long run, however, the convergence of the Slovak economy will likely slow down as well.

9.   The commitment to a low inflation rate has anchored inflation expectations, which has in turn reduced the interest rate spread between Slovak and German bonds. Yet, the biggest drop in spread was observed in 2002, after pro-EU parties surprisingly won the parliamentary elections (Figure 4). The spread narrowed during 2005 and it remained negligible until 2009. The temporary spike observed in 2006 is related to the uncertainty about the commitment of the newly elected government to adopt the euro. The spread against German bund widened after the global financial crisis emerged in late 2008, yet the difference between Czech and Slovak yields continued to be negligible. The premium against Czech (and German) yields has risen, however, during the period of political and institutional instability in the euro area. Hence, benefits from the narrowing spread should be measurable rather within the anticipation period, i.e. before the official euro adoption in Slovakia.

Figure 3. Price development (2005Q1=100)
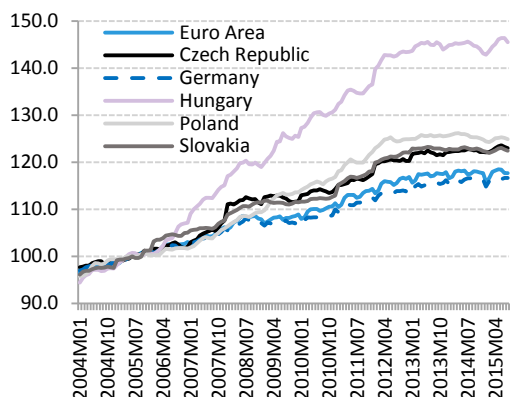
Source: Eurostat

Figure 4. 10Y government bond development
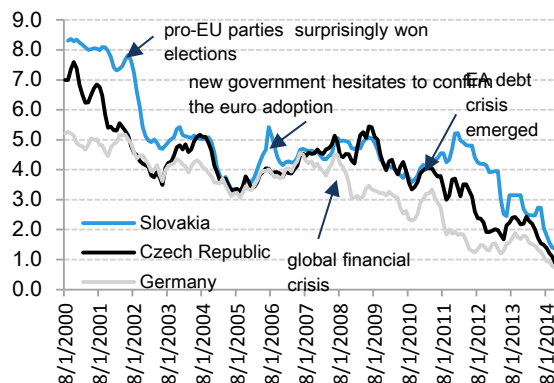
Source: Eurostat

3. Methodology

10. To estimate the effect of the euro adoption in Slovakia, we follow the most recent literature on comparative case studies and utilize the synthetic control method developed by Abadie and Gardeazabal (2003); Abadie, Diamond and Hainmueller (2010 and 2014). In contrast to standard regression techniques, which compare the countries in terms of exogenous covariates, SCM compares countries that are comparable in terms of the development of the pre-intervention endogenous outcome variable. The overall effect of the intervention can be then measured by comparing the difference between the actual development of the outcome variable and its synthetic counterfactual.

11. Our synthetic control approach can be described as follows. First, we restrict the control group to the new EU member states with floating exchange rate regimes (i.e. Czech Republic, Hungary, Poland, Romania) as these intuitively mimic the main economic milestones of the pre-euro Slovakia.[2] Second, following ADH (2015) we construct the database with exogenous predictors explaining the long-term economic growth for both Slovakia and the control group. Third, we construct a synthetic Slovak economy by choosing weights of each predictor and each country from the control group such that these minimize differences between the actual Slovak GDP and its synthetic counterpart in the pre-intervention period. Details can be found in Box 1.

12. There are two advantages of the SCM when compared to standard estimation techniques. The first stems from the fact that the common trend in the true model might be affected by the time-varying unobservable factors (ADH, 2015). In such a case the difference-in-difference approach, for example, might produce biased estimates as it assumes the unobservable fixed effects to be constant in time. Yet, under some fairly innocuous assumptions the matching on pre-intervention outcome variables eliminates such bias (ADH, 2010).

13. The second advantage of the SCM is related to the transparency of the approach and to the interpretation of the results. It can be shown that the OLS estimator is implicitly also a weighted average estimator with weights summing up to one as is the case for SCM. However, weights in the regression are not usually reported and additionally weights may be negative or greater than one thus allowing extrapolation beyond the support of the data (ADH, 2015). The SCM, on the contrary, restricts weights to

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2 Yet, we drop this restriction when performing the robustness test of our results to investigate whether inclusion of other countries improves the fit.

lie in between zero and one and is explicit in reporting weights. This enables the researcher to qualitatively discuss the results, especially in studies with a small number of comparative units.

Box 1. Synthetic control method

Formally, let X_1 be a vector of pre-intervention characteristics for the treated country (it includes exogenous outcome predictors of economic growth and possibly several linear combinations of pre-intervention outcomes themselves) and let X_0 be a matrix of the same variables for the control group. Further, let W be a vector of nonnegative weights of countries in the control group summing up to one. Then, the vector of country-weights W* is chosen to minimize:

$$(X_1 - X_0W)'V(X_1 - X_0W),$$

such that each country-weight lies in between 0 and 1 and all the weights W* together sum up to 1. Matrix V is diagonal and reflects the relative importance of the different outcome predictors and it is usually chosen to minimize root mean squared prediction error (RMSPE) between synthetic counterfactual and the pre-intervention actual outcome, besides other options available (e.g. regression based[3] and/or the cross-validation technique described in ADH, 2015).

The resulting SCM estimator is given by:

$$Y_1 - Y_0W^*,$$

where Y_1 is the vector of post-intervention outcome values for the treated unit and Y_0 is the matrix of post-intervention outcome values for the control group.[4]

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4.   Data and sample

14.   The main data source used is the annual country-level panel data from Penn World Tables 8.1 from 1991 to 2011 (latest available), which was supplemented by the World Bank database. As the outcome variable we use the expenditure-side real GDP per capita at chained PPPs.[5] Considering the choice of the exogenous predictors of the economic growth, we follow the literature (ADH, 2015) and use the human capital index, openness of the economy, investment-to-GDP ratio, capital-output ratio, real effective exchange rate and the share of industry in the economy. Inclusion of other predictors did not change the results substantially.

15.   Though Slovakia adopted the euro in January 2009, it is important to consider possible anticipation effects when setting the exact date of the intervention. There were three distinctive moments in the process of euro-adoption in Slovakia (Figure 5). First, in late November 2005 Slovakia rather unexpectedly joined the ERM II mechanism[6]. Second, after some initial hesitation the government newly elected in mid-2006 clearly approved the ongoing process of euro adoption. Third, in mid-2008 the Council of the EU approved Slovakia's application to join the euro area, and the currency was pegged to the euro. Examining the exchange rate volatility we set the year 2006 to be the cut-off point as the sudden

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3.   In this case a set of regressions of the outcome variable in the post-intervention period on the exogenous predictors is run only for the control units. Thus, matric V reflects the relative magnitude of the coefficients on exogenous predictors in these regressions, see Abadie (2012).

4.   Estimations are run in STATA and R.

5.   As a robustness test we use the output-side real GDP at chained PPP as well. This measure is suggested to capture the productive capacity of the economy instead.

6.   We consider the moment of joining the ERM II as rather unexpected, given the sudden appreciation of the domestic currency the next trading day.

and rapid currency appreciation suggests the market was convinced about the certainty of euro adoption in Slovakia. Nevertheless, we later modify this setting in the robustness test section showing that it does not alter the results.

Figure 5. Exchange rate development
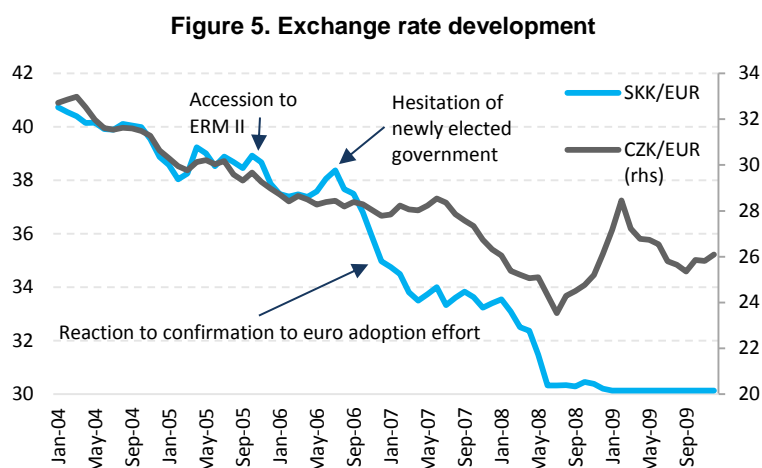
Source: Eurostat

5.   Results

16.   The synthetic Slovak economy matches the actual performance of the economy strikingly well over the entire period before the euro adoption (Figure 6), even though SCM suggests to construct the synthetic Slovak economy with floating currency as a weighted average of only two countries: Czech Republic (ca. 66%) and Romania (ca. 33%). Poland and Hungary thus receive no weight in the estimation. The weighted combination of Czech and Romanian economy mimics closely the actual Slovak economy before euro adoption in terms of averaged exogenous predictors with the exception of openness of the economy[7] (see Annex Table 1 and Table 2).

17.   Using weights based on SCM we find that by adopting the euro Slovakia gained approximately 10% in terms of GDP per capita[8] by 2011 as shown by the difference between the synthetic control and the actual GDP per capita after 2006 on Figure 6[9]. Though most of the gain is observed before the official adoption of euro in 2009 (roughly 7 percentage points), the benefits after 2009 are substantial as well (see Figure 7). The gap in GDP per capita widens between 2008 and 2011 by additional 3 percentage points. Further, in line with the standard literature we find had Slovakia kept the floating currency regime during the recession in 2009, the economy would have been temporarily better off that year by roughly 2% (see Figure 7).

18.   The results are confirmed by the RMSPE ratio test that compares the RMSPE in the post-intervention period to the RMSPE in the pre-intervention period. This ratio exceeds 4.1, meaning that there is a substantial divergence of the synthetic Slovak economy compared to the observed performance while controlling for the pre-intervention fit of the actual data. In fact, our synthetic Slovakia fits the actual data

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7.   We matched on averaged as well as non-averaged predictors without significant difference in results.

8.   Here we used the expenditure-side real GDP per capita at chained PPPs as a measure of living standards.

9.   Our results are very similar to those in Janota (2015) which are based on the data from WDI and IMF.

in the pre-intervention period better than the synthetic economy in Janota (2015)[10], which assumes the intervention in 2008 and computes two RMSPE ratios: one in 2004 (i.e. mimicking the effect from joining the EU) and the other in 2008 (i.e. focusing on the euro adoption). Due to a rather poor pre-intervention fit, Janota (2015) finds no sizeable difference between the two RMSPE ratios (3.2 and 3.06, resp.), thus claiming the gap after 2008 cannot be attributed to the euro adoption. Such result highlights merely the effect of entering the EU and adopting market reforms during early 2000s (e.g. banking sector restructuring, shift of the tax burden from direct to indirect taxes, labour market liberalization). Yet, when we follow the same approach, we find a substantial difference between the RMSPE ratio measuring the effect from joining the EU in 2004 and the other RMSPE ratio measuring the effect of the euro adoption in 2008 (i.e. 3.08 vs 4.13, resp.), thus confirming and highlighting rather the effect of the euro adoption.

Figure 6. By adopting euro Slovakia gained 10 % of GDP by 2011
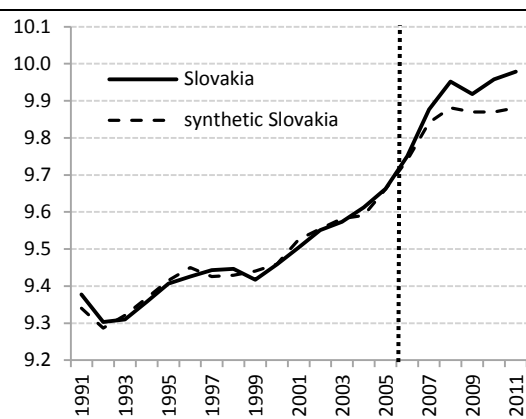
Figure 7. Percentage gap between actual and synthetic GDP

Source: authors' calculation
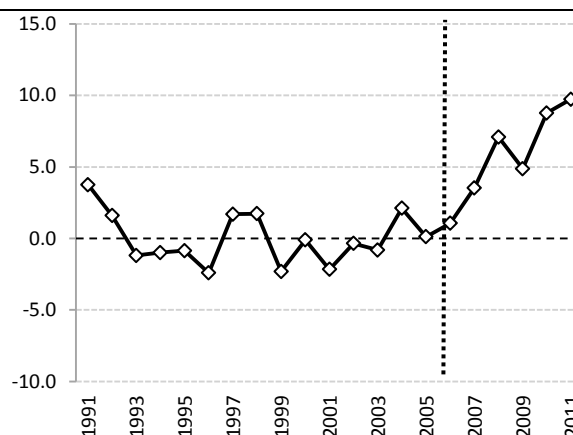
Source: authors' calculation

19.   An important concern related to the consistency of the SCM estimate often mentioned in the literature is the possible presence of spillover effects across economies (see for instance ADH, 2015). For the case of euro adoption in Slovakia, it means that if the euro adoption in Slovakia affects the Czech economy negatively, the gain from adopting the euro in Slovakia measured by the SCM is overestimated. If, on the other hand, the spillovers from the Slovak to the Czech economy are positive, the resulting gain from the euro adoption in Slovakia based on SCM is underestimated. Although SCM itself is unable to address this question, being explicit in weights for each control unit (i.e. the Czech Republic and Romania) enables further research to investigate the direction and magnitude of the possible spillovers.

6.   Robustness of the result

20.   When testing the robustness of the estimates, standard methods are usually not applicable to SCM. This stems from the fact that SCM is used mostly in the comparative case studies focusing only on few units of observation. Estimating confidence intervals is thus often not feasible. Yet, with sufficient number of cross-sectional observations it is possible to mimic the standard statistical inference, see Acemoglu, *et al.* (2013). But even if statistical inference is not feasible, as it is in our case study, other robustness tests can be implemented.

21.   First, we estimate the synthetic Slovak economy using growth rates of GDP and other measures of output. Estimating the synthetic *growth rates* of GDP confirms the positive effect of euro adoption in

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10. Importantly, calculations in Janota (2015) are based on the real GDP per capita in current PPPs. Using data based on   current PPPs for the inter-temporal comparison of volumes is, however, inappropriate (Eurostat-OECD, 2012).

Slovakia (see Figure 8). Using the output-side real GDP in PPP from Penn World Tables 8.1[11] we obtain very similar results, albeit both the effect of the euro adoption and the anticipation effect are slightly smaller (see Figure 9). Strong and positive results of euro adoption are obtained when using the GDP per capita measure from Eurostat as well[12].

Figure 8. SCM using growth rates of GDP at chained PPPs confirm the result

Figure 9. GDP as a measure of productive capacity (logs)

Source: authors' calculation
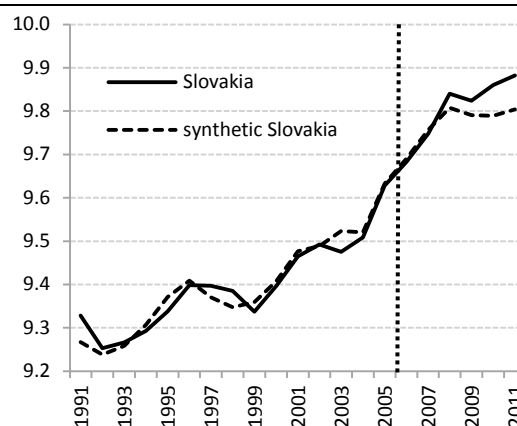
Source: authors' calculation

22.   Next, we follow ADH (2015) and implement the cross-validation technique. We divide the pre-intervention sample into a training period from 1991 to 1997 and validation period from 1998 to 2005. Then, using exogenous predictors from the training period (1991-1997), we let the algorithm select weights V such that the resulting synthetic control minimizes RMSPE over the validation period (1998-2005). As ADH (2015) notes, the cross-validation technique essentially selects weights V that minimize the out-of-sample prediction errors. Finally, the selected weights V and the exogenous predictors from the validation period (1998-2005) are used[13] to estimate the synthetic counterfactual for Slovakia. Despite a relatively short time span of the training and validation period, the estimated synthetic counterfactual confirms the significant positive effect of the euro adoption (Figure 10), though the fit in the training period is slightly poorer (see Annex Table 3 and Table 4 for details).

23.   Further, we perform an in-sample placebo test examining the result of SCM while assuming Slovakia adopted euro not in 2009, but already in 2000. In this exercise we thus estimate weights and minimize the RMSPE over the period 1992-2000, testing whether the baseline result is not just the artefact of the lack of the predictive power of the synthetic control. Yet, the placebo test had virtually no effect (Figure 11), thus reinforcing the baseline result.

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11. This measure is suggested to capture the productive capacity of the economy instead.

12. Note that Eurostat data are based on current PPS, thus measuring values, not volumes. Hence, we do not report it.

13. We exclude REER for the purpose of cross-validation as it is available only from 1997.

Figure 10. Cross-validation technique shows similar effect as the baseline measure

Source: authors' calculation

Figure 11. In-sample placebo test with hypothetical euro adoption in 2000
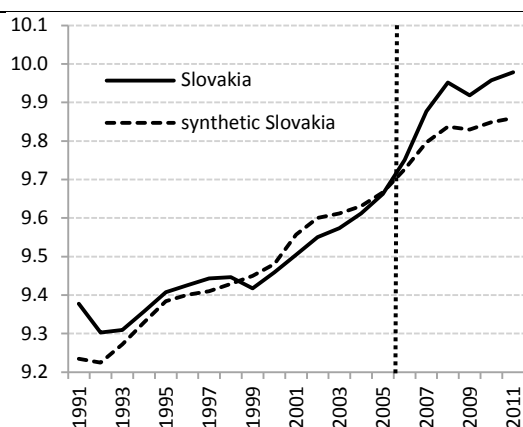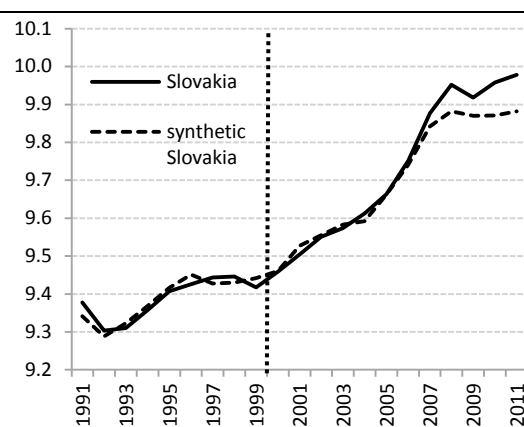
Source: authors' calculation

24.   In another robustness test, the restriction on the sample of countries initially chosen (the Czech Republic, Poland, Hungary, and Romania) is relaxed. Instead, we perform the standard synthetic control procedure with the donor pool of 27 EU member states keeping the same time span and the same exogenous predictors as in the baseline estimation. The resulting counterfactual is, once again, mostly based on the Czech Republic and Romania (Figure 12). In this case, however, Bulgaria received substantial weight as well (see Annex Table 5 and Table 6 for details). Importantly, the effect of euro adoption is positive, albeit slightly smaller compared to the baseline result. To illustrate the difference between SCM and the regression approach, we follow ADH (2015) and report weights for each country based on the OLS regression technique[14]. Though countries' weights in both approaches sum up to one, with the regression approach Belgium, France and Croatia received substantial negative weights, thus extrapolating outside of the support of the data (see Annex Table 5).

25.   Next, we discuss the performance of the Czech and Romanian economies after 2006, as they are the only countries receiving positive weights in our baseline synthetic counterfactual estimate for Slovakia. The first question is whether domestic policies and events did not significantly affect their economic performance. The Czech National Bank changed its monetary policy regime from January 2006 from interval targeting to a 3% inflation target and it did not use the exchange rate intervention from 2002 until the end of our sample in 2011. Romania decreased its inflation target gradually from 7.5% in 2003 to 2.5% in 2015, and exchange rate interventions were used only sporadically. Romanian accession to the European Union was by far the most important policy change in the period close to 2006. Yet, its accession is generally seen as a direct boost to the GDP growth, therefore it is rather underestimating the positive effect of the euro adoption in Slovakia. The second question is whether Slovakia outperforms the Czech economy or whether it is the case that the Czech economy performs worse due to a negative shock (unrelated to euro adoption) to its own economy. To address this question we estimate a synthetic counterfactual for the Czech economy itself. For these purposes we restrict the donor pool of control countries to EU26[15] and the resulting weights for the synthetic control are estimated as follows: Italy 34%, Romania 26%, Germany 24.2%, and other 15.8%. Figure 13 summarizes the outcome suggesting there was no substantial negative

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14. ADH (2015) shows that the regression-based weights are given by w=X0T(X0X0T)-1X1, where X0 and X1 contain the pre-intervention characteristics for the control group and for the treated country, respectively. Using regression-based weights we estimate that by adopting euro Slovakia gained roughly 4 per cent of GDP per capita.

15. For obvious reasons we drop Slovakia from the sample.

shock to the Czech economy after 2006. Although the fit is rather poor in this case, the absence of the negative shock in the Czech economy serves a further evidence of the positive effect of the euro adoption in Slovakia.

Figure 12. Positive effect of euro compared to counterfactual using pool of 27 EU countries
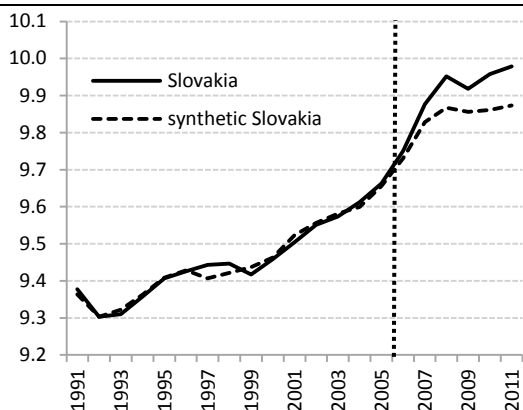
Source: authors' calculation

Figure 13. No significant change in the development of the Czech economy after 2006
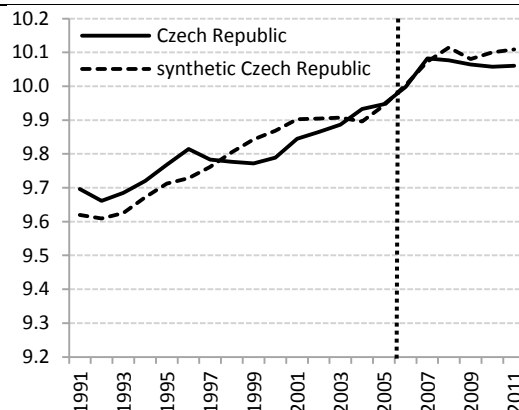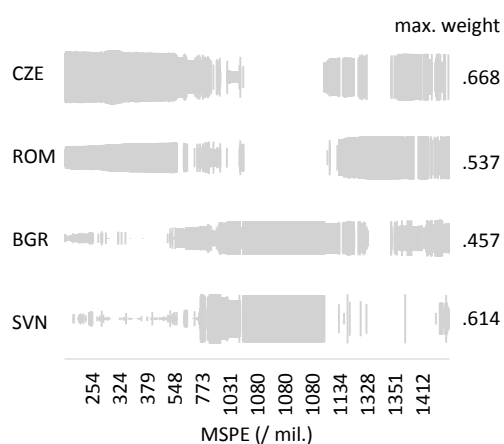

Source: authors' calculation

26.   Importantly, we investigate combinations of countries where the fit of the actual data is only slightly poorer compared to the best combination (i.e. in our case the Czech Republic and Romania). As the optimization algorithm picks only the best combination of countries with the minimum MSPE, our approach enables us to uncover, possibly, a new set of countries, different from those in the best combination, such that the MSPE of the new combination is only marginally higher than the minimum. This might be valuable, especially in the case when the best result is based on the combination of only few countries and therefore the second best combination may lead to a different counterfactual.

27.   To obtain the second best combination, we iteratively compute synthetic counterfactuals for Slovakia using all possible 5-combinations out of the donor pool of EU24[16] and sort them according to their MSPE fit. Then, we investigate countries and their weights within the best 5000 combinations out of the total of 42 504. Figure 14 shows that, indeed, the weighted average of Bulgaria and Slovenia is the second best match of the pre-intervention Slovakia, albeit with higher MSPE. After we restrict the control group to only Bulgaria and Slovenia and estimate the synthetic control once again, Bulgaria receives 41.7% of the weight and Slovenia 58.3%. As Figure 15 indicates, the positive effect of the euro adoption in Slovakia survives the new combination.[17]

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16. Due to computational demands we exclude Luxembourg, Malta and Cyprus.

17. Yet, the combination of Bulgaria and Slovenia is far from perfect for the purposes of a control group as the former pegs   its currency to euro and the latter joined the Euro zone three years before Slovakia and was subject to an idiosyncratic financial shock in 2011.

Figure 14 Weights of selected countries and MSPE within the best 5000 combinations

Source: authors' calculation

Figure 15. Combination of Bulgaria and Slovenia is a good match of the pre-intervention Slovakia
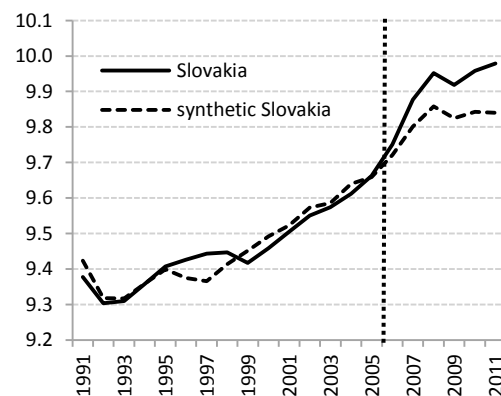
Source: authors' calculation

28.   Finally, we perform a series of placebo tests for 27 EU countries simulating a euro adoption in 2006 in each country, even though there was no such an event. Figure 16 displays the percentage gap between synthetic economies and their actual economic development, including Slovakia. Then, following ADH (2010) we exclude those countries where the pre-intervention MSPE exceeds the MSPE of Slovakia by more than 10 times. In such a case, Slovakia becomes, clearly, an outlier in terms of the positive post-intervention development (Figure 17). Being an outlier in a group of 18 countries underscores the significance of the effects of the euro adoption in Slovakia. Figure 18 summarizes the exercise for the EU countries[18].

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18. Note that we do not report results for UK in Figure 18. Although RMSPE ratio in the UK is the highest among EU countries, such result is driven probably by the idiosyncratic severity of the recession in the UK as the synthetic UK economy consisting mainly from Netherlands (51%) and Luxembourg (17%) performed after 2006 much better than the actual UK economy.

Figure 16. GDP gaps from placebo tests (27 EU countries, including Slovakia (black))
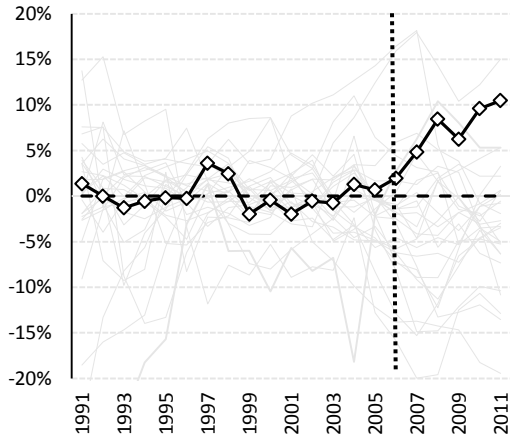
Figure 17. GDP gaps from placebo tests (countries with pre-intervention MSPE 10 times higher than Slovakia excluded)

Source: authors' calculation
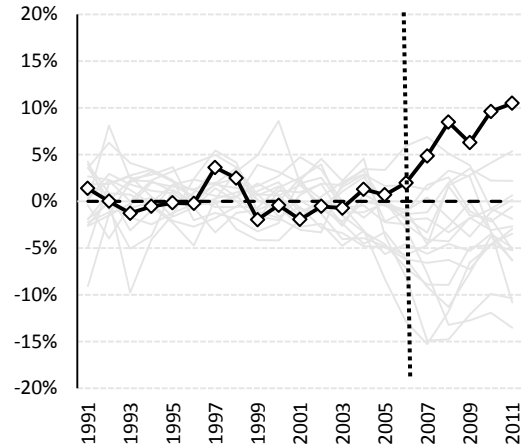
Source: authors' calculation

Figure 18. Ratio of post-2006 RMSPE to pre-2006 RMSPE

post-2006 period RMSPE / pre-2006 period RMSPE
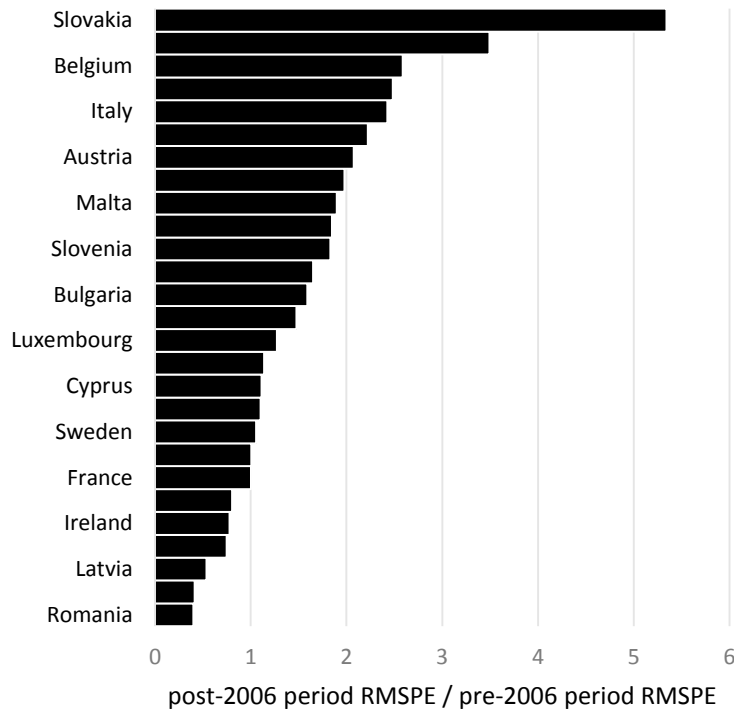
Source: Authors' calculation

Note by Turkey: The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the "Cyprus issue".

Note by all the European Union Member States of the OECD and the European Union: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

7.   Conclusion

29.   The purpose of this paper is to estimate the macroeconomic effect of euro adoption in Slovakia in 2009 using the synthetic control method (SCM). We find that the synthetic Slovak economy matches the actual performance of the economy strikingly well over the entire period before euro adoption, even though it consists of only two countries: the Czech Republic (ca. 66%) and Romania (ca. 33%). The weighted combination of Czech and Romanian economies mimics fairly closely the actual Slovak economy before euro adoption in terms of exogenous predictors with the exception of the openness of the economy.

30.   Comparing SCM with the actual performance of the Slovak economy after 2006 we find that by 2011 euro adoption increased the real GDP per capita in Slovakia by approximately 10%. Two thirds of the positive gain is observed already by 2008, emphasizing a strong anticipation effect. Nevertheless, the gap in GDP per capita widens between 2008 and 2011 by additional 3 percentage points. Further, in line with the standard literature we find that had Slovakia kept the floating currency regime during the recession in 2009, the economy would have been temporarily better off by roughly 2%.

31.   The empirical result survives several robustness tests. First, the positive gain from euro adoption materialized in various measures considered: the output as well as the income measure of GDP. Second, the positive gain from the euro is observed using the cross-validation technique and after the in-sample placebo test is performed. Third, our results hold even if the synthetic Slovakia is chosen from the unrestricted pool of EU27 countries. Fourth, using the same synthetic control method we find no evidence for a (negative) break in the performance of the Czech economy after 2006, which would potentially overestimate the positive effect of the euro in Slovakia. Fifth, we examine combinations of countries where the fit of the actual data is only marginally poorer compared to the best combination, and we find that not only the weighted average of Bulgaria and Slovenia fits the actual Slovak economy fairly well, but the new synthetic counterfactual confirms previous results. Finally, we conducted a series of placebo tests for 27 EU countries simulating that each country adopted the euro in 2006 and concluding that Slovakia is an outsider in a group of 18 in terms of the post intervention (euro adoption) period.

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ANNEX

Table 1. Country weights assigned by SCM

Treated country:	SVK
Control group	Weights
CZE	0.667
HUN	0
POL	0
ROU	0.333

Source: authors' calculation

Table 2. Comparison of exogenous predictors values with SCM simulation

Treated country:	SVK	
Exogenous predictors	Actual	Synthetic
Capital-output ratio	2.039591	2.662951
Trade openness	.6216829	.4781823
Industry share	35.4906	38.33036
Investment share	.2131424	.2112437
REER	4.944444	4.680156
Human capital index	3.124868	3.161881
GDP per capita (logs)	9.456758	9.456873

Note: GDP per capita, trade openness, investment share and human capital are averaged for 1991-2005. Capital-output ratio and industry share is averaged for 1995-2005. REER is averaged for 1997-2005.
Source: authors' calculation

Table 3. Country weights assigned by cross-validation SCM

Treated country:	SVK
Control group	Weights
CZE	.305
HUN	.436
POL	.103
ROU	.156

Source: authors' calculation

Table 4. Comparison of exogenous predictors values with cross-validation SCM simulation

Treated country:	SVK	
Exogenous predictors	Actual values	Synthetic values
Capital-output ratio	2.060317	2.253677
Trade openness	.8404096	.7799844
Industry share	.3515822	.3392224
Investment share	.2131424	.2112437
Human capital index	3.136403	3.173779
GDP per capita (logs)	9.528343	9.553348

Note: Predictors are averaged for 1998-2005
Source: authors' calculation

Table 5. Country weights for EU-27 SCM and basic OLS regression

Treated country:	SVK	
Control group	Synthetic Weights	Regression Weights
AUT	0.001	-0.0046
BEL	0.002	-0.0932
BGR	0.100	0.0978
CYP	0.004	0.0905
CZE	0.586	0.2813
DEU	0.002	-0.0167
DNK	0.002	-0.0079
ESP	0.002	0.0548
EST	0.004	0.0904
FIN	0.002	-0.029
FRA	0.002	-0.0808
GBR	0.002	-0.0144
GRC	0.002	-0.025
HRV	0.002	-0.0979
HUN	0.012	0.1367
IRL	0.005	0.0861
ITA	0.002	0.0357
LTU	0.005	0.0564
LUX	0.001	0.0893
LVA	0.002	-0.0193
MLT	0.002	0.0215
NLD	0.003	-0.0051
POL	0.003	0.0349
PRT	0.002	-0.0378
ROU	0.247	0.2249
SVN	0.004	0.1549
SWE	0.002	-0.0236

Source: authors' calculation

Table 6. Comparison of exogenous predictors values with EU-27 SCM simulation

Treated country:	SVK	
Exogenous predictors	Actual	Synthetic
Capital-output ratio	2.040	2.610
Trade openness	0.622	0.499
Industry share	0.355	0.369
Investment share	0.213	0.204
REER	4.944	4.666
Human capital index	3.125	3.120
GDP per capita (logs)	9.457	9.456

Note: GDP per capita, trade openness, investment share and human capital are averaged for 1991-2005. Capital-output ratio and industry share is averaged for 1995-2005. REER is averaged for 1997-2005.
Source: authors' calculation