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Quantifying the Effects of the CNB's Exchange Rate Commitment: A Synthetic Control Method Approach*

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Abstract

In this paper I evaluate the quantitative effects of the Czech National Bank's commitment to keep the Koruna from appreciating that were put in place in 2013. I focus on the policy's impact on output, unemployment, and inflation. I use the synthetic control method, which allows me to compute the counter-factual development of the Czech economy in the absence of the commitment. I find that the commitment helped decrease unemployment substantially. The effect on overall output is also strongly positive, almost 2 percentage points for growth in 2015, but only marginally statistically significant, which might be connected to disturbances created by changes in excise taxes. The effect of the commitment on inflation is positive but not statistically significant at standard levels.

1. Introduction

The exchange rate commitment of the Czech National Bank (CNB) had been a topic of policy and academic debate for a while when it was launched in the period Q4 2013. Since the CNB decreased the interest rate to "technical zero" in order to fight the falling of the Consumer Price Index (CPI), there was a demand for different monetary tool to achieve an inflation target set by CNB. Finally, in November 2013, CNB initiated a weakening of the Czech currency to the minimum level of 27 CZK per 1 Euro with the goal of increasing CPI and therefore avoiding a risk of deflation.

The objective of this paper is to evaluate the effect of the intervention on the Czech macroeconomic indicators – Gross Domestic Product (GDP) per capita, unemployment rate and Harmonized Consumer Price Index (IHCP) – using the synthetic control method.[1] The method provides a possible development of Czech macroeconomic indicators in the absence of the intervention. The principle of using this method is constructing a counter-factual for the Czech economy without the intervention by finding the weighted average of countries that match the development of key Czech indicators before the intervention. The important fact is that the counter-factual is not constructed by extrapolating pre–event trends from the treated unit but rather, as Abadie & Gardeazabal (2003) proposed, by building a synthetic control

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An online Appendix with data and code as well as empirical data and Stata source codes (Stata software at least version 13.0 is needed to open the file) are available as a zipped file at: http://journal.fsv.cuni.cz/mag/article/show/id/1396

[1] Note that, CNB looks at CPI, however, in this study we use HCPI to have the consistent data with other countries - Eurostat database provide the same methodology for computing the HCPI for all countries.

group. So far, there can be found many empirical studies related to the evaluation of the exchange rate intervention on a small open economy. However, thanks to the synthetic control method, this empirical study provides quantitative inference without excluding the application of qualitative approaches.

From the outset, we would like to stress out that we are not testing the relationship between Czech macroeconomic indicators and exchange rate commitment introduced by CNB. Instead, we attempt to establish a possible path of macroeconomic indicators and magnitude of the effect of the intervention on the Czech key macroeconomic indicators. As a result, we find that CNB's exchange rate commitment helped to decrease the unemployment rate on the level of 4.5% until the end of the year 2015 – in other words it helped to create around 120,000 working positions. Consequently, we demonstrate a slight positive effect on the GDP per capita and indecisive effect on HCPI.

This paper is structured as follows. In section 2 we describe the core literature used to establish this empirical study. In section 3, we refer to the methodological background of the synthetic control method. There, the reader can also find a brief subsection discussing the inference provided by the synthetic control method. Finally, we provide the results for GDP per capita, unemployment rate, and HCPI, respectively, computed by the synthetic control method. Moreover, for each variable there are included robustness tests to check the credibility of the results. The conclusion can be find in section 5.

2. Applications of the Synthetic Control Method

In this section I will present core papers to familiarize the reader with the synthetic control method. Since the synthetic control method was developed in 2003 by Abadie & Gardeazabal (2003), there are several empirical studies using the method.

Abadie & Gardeazabal (2003) introduce the synthetic control method in *The economic costs of conflict: a case study of the Basque country*, where they present evidence of the negative economic impact of the terrorist conflict in the Basque Country. Moreover, the study shows a 10 % average gap between the synthetic control group per capita GDP and Basque per capita GDP over the period of twenty years.

Adopting the synthetic control method, Lee (2010) challenges if the inflation targeting tool is an effective policy in emerging economies. His study shows that inflation targeting helped reduce the inflation rate in Columbia, the Czech Republic, Hungary, and Poland, when they adopted such policies in 1990s and 2000s. On the other hand, his study finds that no significant effect was found when there was a later start date of the policy.

The next Abadie (2011) paper *Using Synthetic Controls to Evaluate an International Strategic Positioning Program in Uruguay: Feasibility, Data Requirements, and Methodological Aspects* thoroughly describes the use of the synthetic control method. Furthermore, this paper provides a potential way to adapt the synthetic control method if some of the requirements are not met.

Abadie et al. (2012) also use the synthetic control method to estimate the effect of California's tobacco control program - Proposition 99. In this paper, they extend the synthetic control method by a procedure to produce inference that involves uncertainty about the validity of the control unit. Finally, they demonstrate that annual per-capita cigarette sales would have been about 26 packs higher in the absence of Proposition 99.

Billmeier & Nannicini (2013) apply The synthetic control method (SCM) to find consequences of economic liberalization. They investigate the impact of economic liberalization on real per capita GDP in a worldwide sample of countries. As a result, they demonstrate positive effect in most regions, but they also mention that the most recent liberalization, mainly in Africa, had no significant impact.

The next application of SCM is on the estimation of a natural disaster on economic growth by Cavallo et al. (2013). In this paper, they focus mainly on large natural disaster and its consequences. By researching 196 countries covering the period 1970–2008 they find that natural disasters do not have any significant effect on subsequent economic growth. Using the synthetic control method, Jinjarak et al. (2013) examine changes in Brazil's capital account regime during the period 2008–2011. They find that there is no evidence that any tightening of controls is effective in decreasing the level of capital inflows. On the other hand, they observe some modest success in preventing capital inflows when the capital controls are relaxed.

In the next paper related to SCM, Acemoglu et al. (2013) demonstrate the connectivity of financial firms with a political scene, namely with the Secretary of the Treasury in the USA. The paper shows that the announcement of Timothy Geithner as a nominee for the Secretary of the Treasury produced an abnormal cumulative return for financial firms connected with him. Expressed in numbers, this return was about 6% after the first day of trading and about 12% after 10 days of trading.

Aytug (2014) develops a model using the propensity score matching (PSM) and the synthetic control method techniques to evaluate the average effect of adopting the euro on economic growth. These techniques allow him to assess the effect for the member of Eurozone (using PSM) and also how each Eurozone member would have performed in the absence of the euro adoption (using SCM). As Aytug (2014) comments, the findings confirm the significant relationship between the exchange rate regimes and growth, even though the effect of adopting the euro on growth is negative.

Campos et al. (2014) present the economic benefits from membership with the European Union. They estimate GDP per capita and labour productivity for countries that joined the European Union in 1970s, 1980s, 1995 and 2004, in the absence of membership with the European Union. They find that, without political and economic integration, GDP per capita would have been, on average, approximately 12% lower.

As Abadie et al. (2015) point out in the empirical study *Comparative Politics and the Synthetic Control Method*, the synthetic control method might be used as a bridge between qualitative and quantitative approaches in empirical case studies. The core merit of this method lies in a systematic way of choosing comparison units in comparative case studies. Consequently, Abadie et al. (2015) apply the synthetic control method on German reunification, which took place in 1990. Their results indicate a negative effect of reunification over the entire period 1990-2003 on West Germany per capita GDP by approximately 1,600 USD per year on average.

The next application of the synthetic control method is performed by Gomis-Porqueras et al. (2015), where they estimate the effect of joining the monetary union on per capita income. The results show that, in contrast with Belgium, France, Germany and Italy, where the income per capita would have been higher without the Euro, that of Ireland would have been lower. For the Netherlands they observe an indecisive effect. In addition, they provide an explanation for those income effects, claiming that those countries which had adopted the euro earlier, had synchronized business cycles with the union, and were more open in intra union trade and migration, lost less or gained more from the euro adoption.

In their paper *Examination of the Synthetic control method for evaluation health policies with multiple treated units*, Kreif et al. (2015) extend the original synthetic control method approach to a setting where there are multiple treated units. By using this improvement on the synthetic control method, they examine the effect of a pay-for-performance initiative, the Advancing Quality scheme, in contrast to difference-in-differences (DiD) estimation method. The main distinction between these two methods is that DiD estimation assumes constant effect of unobserved con-founders over time, while the synthetic control method allows changes in those effects over time.

3. Methodological Aspects of the Synthetic Control Method

In comparative case studies, there is often stress to choose comparison units because using improper comparisons may lead to faulty conclusions. The synthetic control method provides a systematic way of choosing comparison units (Abadie et al. 2012). In addition, as Abadie et al. (2015) pp. 2 claim: Formalizing the way comparison units are chosen not only represents a way of systematizing comparative case studies ..., but it also has direct implications for inference. We demonstrate that the main barrier to quantitative inference in comparative studies comes not from the small-sample nature of the data, but from the absence of an explicit mechanism that determines how comparison units are selected. By carefully specifying how units are selected for the comparison group, the synthetic control method opens the door to the possibility of precise quantitative inference in comparative case studies, without precluding qualitative approaches to the same data set.

3.1 Description of the Method

Suppose that we gather data for $J + 1$ countries. Without loss of generality, we assume that only the first country is exposed to the intervention of interest. Therefore, there are J countries remaining as eventual control units not influenced by the intervention. Also, without loss of generality, we assume that the first country is continuously exposed to the intervention from the period when the intervention was launched (Abadie et al. 2015).

Let Y_{it}^N denote the potential outcome of interest in the absence of the intervention for country i in period t where $i \in \{1,...,J + 1\}$ and $t \in \{1,...,T\}$. Consequently, let T_0 be the number of pre-intervention periods fulfilling the condition $1 \leq T_0 \leq T$ (Abadie et al. 2015).

Let Y_{it}^I denote the outcome of interest for country i in period t under the intervention which takes place in periods $T_0 + 1$ to T. Naturally, we assume that the intervention has no effect on the outcome in pre-intervention periods, therefore $Y_{it}^N = Y_{it}^I$. When setting the intervention periods T_0 there is necessity to take into account any anticipation effect, so that T_0 can be reset to the period when the first effect of the intervention is assumed to appear (Abadie et al. 2015).

The constructing of control units requires certain attention. Firstly, the country which adopted the similar intervention should be excluded from a data set to avoid a potential bias of the output. For this reason, we omitted Switzerland[2] from a sample. Secondly, for a good fit of counter-factual outcome, there is a need for comparison units to have similar economic performance as a unit exposed to the intervention. Taking this assumption into account, we consider only European countries as suitable comparison units. Moreover, countries which may be affected by the intervention in the "treated" country should be excluded from a sample (Abadie et al. 2015).

The effect of the intervention with $t > T_0$ is represented as follows:

$$v_{it} = Y_{it}^{I} - Y_{it}^{N} \quad (1)$$

Given that Y_{it}^{I} is observed in equation (1), we must now estimate Y_{it}^{N}. The key aspect of a synthetic control is that it is defined as a weighted average of the control units with weights $w = \{w_2,...,w_J\}$ with $0 \leq w_j \leq 1$ for $j = 2,...,J$ and

$$\sum_{J=2}^{J} w_j = 1$$

These restrictions are made to avoid an extrapolation (Abadie & Gardeazabal 2003). Using given weights $\{w_2,...,w_J\}$ the synthetic control estimators of Y_{it}^{N} and v_{it} are:[3]

$$\hat{Y}_{it}^{N} = w_2 Y_{2t} + \cdots + w_J Y_{Jt}$$
$$\widehat{v_{it}} = Y_{it}^{I} - \widehat{Y_{it}^{N}}$$

The next step is to choose weights $\{w_2,...,w_J\}$. According to Abadie & Gardeazabal (2003) and Abadie et al. (2012), the weights should best reflect the pre-intervention features of the affected unit.[4] Furthermore, Abadie & Gardeazabal (2003) and Abadie et al. (2012) choose $w^* = \{w_2^*,...,w_J^*\}$ which minimizes:

$$v_1(X_{11} - w_2 X_{12} - \cdots - w_J X_{1J})^2 + \cdots + v_k(X_{k1} - w_2 X_{k2} - \cdots - w_J X_{kJ})^2 \quad (2)$$

where $\{v_1,...,v_k\}$ represent the relative importance of the synthetic control assigned to predictors $\{X_{11},...,X_{k1}\}$.

Therefore, the problem comes down to choosing $\{v_1,...,v_k\}$. In this paper,[5] the weights are chosen so that the synthetic controls minimize the size of the prediction error, Y_{it}^{I}-$\hat{Y}_{it}^{N}$, in a selected pre-intervention period, this can be done by solving a nested optimization problem with v selected so that w minimizes the root mean square predicted error Root Mean Square Predicted Error (RMSPE) during selected periods. Therefore, each choice of v results in different country weights $w(v)$, which then gives a value for the RMSPE.[6]

[2] See section 4 for more details.
[3] See Abadie et al. (2012) where it is proved that $\widehat{v_{it}}$ is an unbiased estimator of v_{it}.
[4] Note that SCM is mainly empirical approach with a goal to maximize in-sample and out-of-sample fit between real and synthetic outcome.
[5] See Abadie (2011) which describes several methods for choosing the weights $\{v_1,...,v_k\}$
[6] The RMSPE has following formula:

3.2 Inference Using the Synthetic Control Method

This paper uses three inferential methods. Two of these methods were initially introduced by Abadie & Gardeazabal (2003), in which they run "placebo" effects. The third method is based on constructing of a confidence interval using RMSPE for the computation. As Abadie et al. (2015) note, these tests provide good results only if there is a sufficiently large number of periods when no significant shocks to the outcome of interest took place.

The first method to construct a placebo study suggests applying the synthetic control method to all control units. In this way, we obtain a synthetic control for countries not exposed to the intervention. This allows researchers to evaluate the estimation of the effect between the treated unit and the units not exposed to the intervention. In other words, the confidence about the result would decrease if the synthetic control method were to estimate a large effect to a unit where the intervention was not set up.

The second method related to the placebo study applies the synthetic control method to the period when the intervention did not occur in a treated unit. As Abadie et al. (2015) mention, a large placebo estimate would undermine the credibility of a result. For example, if there is a significant effect of intervention in an earlier period, the confidence of the effect would greatly diminish.[7]

The third, and last, method is based on the construction of a 95% confidence interval. To create the confidence interval, we assume that the outcome of interest follows the student's distribution due to small a number of pre-intervention periods.[8] Using the RMSPE calculated by the synthetic control method, we can construct respective confidence intervals. Using a generated confidence interval, if the outcome of the interest exceeds the bounds of the interval, we would infer that the intervention has the effect on the output. In the empirical section below, we can see that there is an effect on the unemployment rate, and also a slight effect on the GDP per capita in the Czech Republic.

4. Quantifying the Effects of the CNB's Exchange Rate Commitment

4.1 Data and Sample

In this paper we use quarter panel data collected from the Eurostat database for the periods Q1 2005–Q4 2015.[9] For the Seasonally Adjusted GDP per capita, unemployment rate, however, we also provide additional results for the period Q1 2001–Q4 2015, and for HCPI for the periods Q4 2007–Q4 2015.[10] Our sample periods

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RMSPE = $(\frac{1}{T_0}\sum_{t=1}^{T_0}(Y_{1t} - \sum_{j=2}^{J+1} w_j^* Y_{jt})^2)^{\frac{1}{2}}$

[7] We can choose random periods prior to the intervention.

[8] The number of pre-intervention periods depends on the starting period of our data related to a chosen variable.

[9] The starting period Q1 2005 is chosen because of the Czech economy's close convergence with the European Union economy. Moreover, the Czech Republic joined the EU in 2004.

[10] However, CNB uses CPI computed by the Czech Statistical Office, we use HCPI in order to be fully consistent with the data of other countries. CPI and HCPI differ in the structure of basket using for computing the price index, therefore, the results may be slightly different.

end in Q4 2015, because during the writing of this paper it was the last available data.[11] The intervention of CNB occurred in Q4 2013, which means more than 30 pre-intervention quarters.[12] As Abadie et al. (2015) mention, nearly a decade-long period after the intervention, in our case 8 post-intervention quarters, seems like a plausible span for a prediction.

The control units include 21 European states: Austria, Belgium, Bulgaria, Croatia, Denmark, Estonia, France, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom. Since the synthetic Czech Republic should reproduce the output in the absence of the intervention, we omitted Switzerland from the control units, because the Swiss Central Bank adopted the exchange rate mechanism in Q1 2015 to achieve the inflation target. Moreover, we exclude Norway, because there are no data for Index of Wage in the Industry Sector,[13] which turn into the main predictor.[14] Furthermore, we omit Malta from the control units, because of the small size of its economy. We also exclude Finland due to its strong economic relationship with Russia, which could negatively affect the performance of the Czech Republic after the intervention.[15] Luxembourg is excluded from the control units because its economy is more highly developed than that of the Czech Republic in terms of per capita GDP.

As the output variables, we use Seasonally Adjusted GDP per capita, unemployment rate, and HCPI. A list of variables and their sources are provided in the appendix B. The set of predictors consists of Seasonally Adjusted GDP per capita, HCPI, Final Consumption per Capita, Real Exchange Rate, Index of Wage in Industry Sector, and unemployment rate. As Abadie et al. (2015) suggest, these predictors are chosen so that the real Czech Republic best fit its synthetic counterpart, regarding the fact that these predictors have an impact on the outcome variables.[16]

4.2 Seasonally Adjusted GDP per Capita

In the Figure 1 we can see per capita seasonally adjusted GDP and its synthetic counterpart during the period Q1 2005–Q4 2015. Moreover, the reader can see additional results for the period Q1 2001–Q4 2015 in the Figure 2. Take in consideration that all tables provided in this section are related to the period Q1 2005–Q4 2015, therefore to the results from Figure 1.[17]

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[11] Data for explanatory variables - Final Consumption per Capita, Real Exchange Rate, and Index of Wage in Industry Sector are provided until the period Q2 2015, which, in fact, does not have an impact on the results. The synthetic control method averages predictors prior to the intervention. In our case, prior to the period Q4 2013.

[12] The number of pre-intervention periods depends on the starting period. The period Q1 2005 is used here.

[13] During the writing of this paper, the Eurostat database did not provide data for the Index of Wage in Industry Sector for Norway.

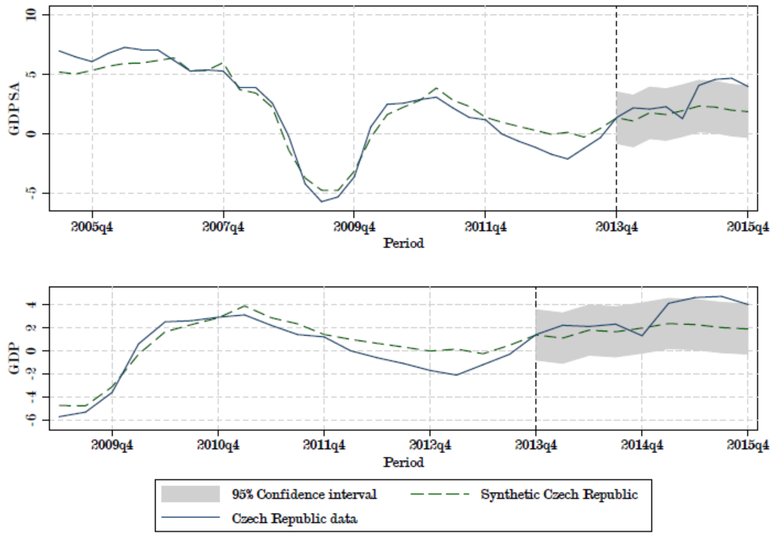
[14] See Tables 1,7, 4 for details.

[15] The Ukrainian crisis and a fall in the price of oil caused Russian economy to slow down, which consequently negatively affected Finish economic performance.

[16] See Appendix B for details about predictors.

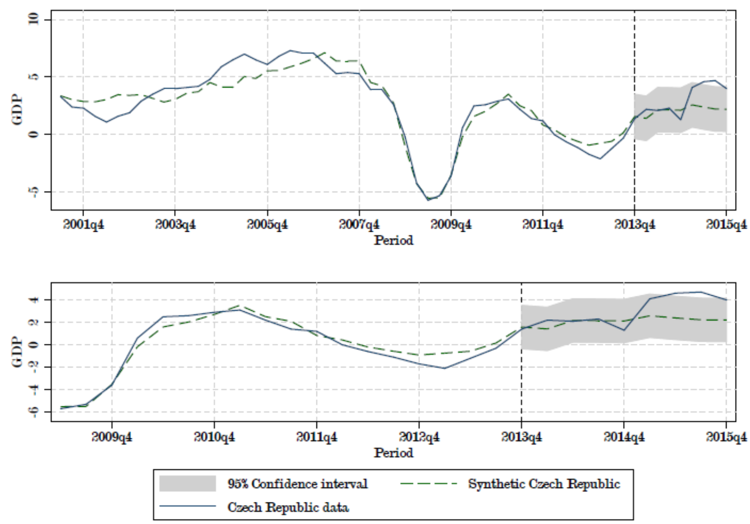
[17] See Appendix A for the results related to the Figure 2 during the period Q1 2001- Q4 2015.

Figure 1 Seasonally Adjusted GDP per Capita Q1 2005–Q4 2015



Source: Synthetic control method computation.

Figure 2 Seasonally Adjusted GDP per Capita Q1 2001–Q4 2015



Source: Synthetic control method computation.

The difference between per capita GDP and its synthetic version may be the effect of the intervention. Consequently, it can be seen in Figure 1 that the synthetic per capita GDP precisely follows the real version until Q4 2014. After the period Q4 2014 the real per capita GDP significantly increases. Furthermore, it slightly exceeds the 95% confidence interval of the estimation of the synthetic counterpart. Therefore, we can recognize the effect of the intervention. Nevertheless, it is necessary to take into account that the increase in GDP per capita could be contributed to several idiosyncratic events, such as an accelerated pumping of European structural funds during years 2014 and 2015 with peak in Q2–Q3 in 2015, which is described in detail in Ministry of regional development (2014), and increasing indirect taxes on tobacco products, which is discussed in the end of this section. Moreover, year 2015 was exceptional for the Czech Republic GDP growth due to EU–funds co–investments (fixed investments contributed to the growth by 2.2 percentage points in 2015). As a consequence, we provide additional results (see Figure A1 in appendix), where we apply SCM on Central and Eastern European (CEE) countries from our dataset. This approach should partially capture the effect of accelerated pumping of European structural funds since CEE countries enjoyed the similar effect of these funds. As a result, the increase in real GDP is not significant at 95% confidence level. Similarly, to partially capture the effect of increasing indirect taxes on tobacco products, instead of GDP, we employ Gross Value Added (GVA) indicator together with only CEE countries in our dataset, see Figure A2 in Appendix. The advantage of GVA indicator is that it is not affected by taxes and subsidies as GDP most probably is. In this case, the results are very similar to the Figure A1. This indicates robustness between these results.

Table 1 displays weights computed by the synthetic control method using the nested optimization process. As Abadie & Gardeazabal (2003) suggest, the outcome of interest can be included in synthetic control predictors during the pre-intervention period. We can see that the power of predictors decreases in the following order: Index of Wage in Industry Sector, Seasonally Adjusted GDP per capita, Real Exchange Rate, unemployment rate, HCPI, and Final Consumption per Capita.

Table 1 Predictor Weights

Country	***Synthetic Control Predictor Weight***
Seasonally Adjusted GDP per capita	0.0544
Final Consumption per Capita	0.0001
Real Exchange Rate	0.0013
Index of Wage in Industry Sector	0.9442
HCPI	0.0001
Unemployment Rate	0.0002

Source: Synthetic control method computations.

The Index of Wage in Industry Sector in Table 1 obtains unusually high prediction weight. In other words, this high prediction weight indicates that the weight of countries is chosen mainly according to the Index of Wage in Industry Sector.[18]

In Table 2 we compare predictor means of the synthetic control units and those of the treated unit before the intervention. The synthetic control units provide very similar results in terms of Seasonally Adjusted GDP per capita, Real Exchange Rate and Index of Wage in Industry Sector. The magnitude of the differences between Final

[18] See Appendix A with the results related to Figure 2.

Consumption per Capita, HCPI, unemployment rate and its synthetic counterpart are slightly larger but, as can be seen in Table 1, its predictive power is small.

Table 2 Predictor Means Before the Intervention

Country	*Treated Unit*	*Synthetic Unit*
Seasonally Adjusted GDP per capita	2.214	2.213
Final Consumption per Capita	0.840	1.776
Real Exchange Rate	113.451	113.012
Index of Wage in Industry Sector	88.060	87.977
HCPI	2.455	3.122
Unemployment Rate	6.590	7.884

Source: Synthetic control method computations.

In Table 3 the reader can see weights of the control units related to the Seasonally Adjusted GDP per capita. The synthetic counterpart is created by combining the following countries: Netherlands, Bulgaria, Slovakia, Denmark, and Estonia. Note that Ireland is excluded from the initial control units. The reason for Ireland's exclusion is that, during the whole sample period, the Eurostat database does not provide values for the seasonally adjusted GDP per capita.

Table 3 Country's Weights

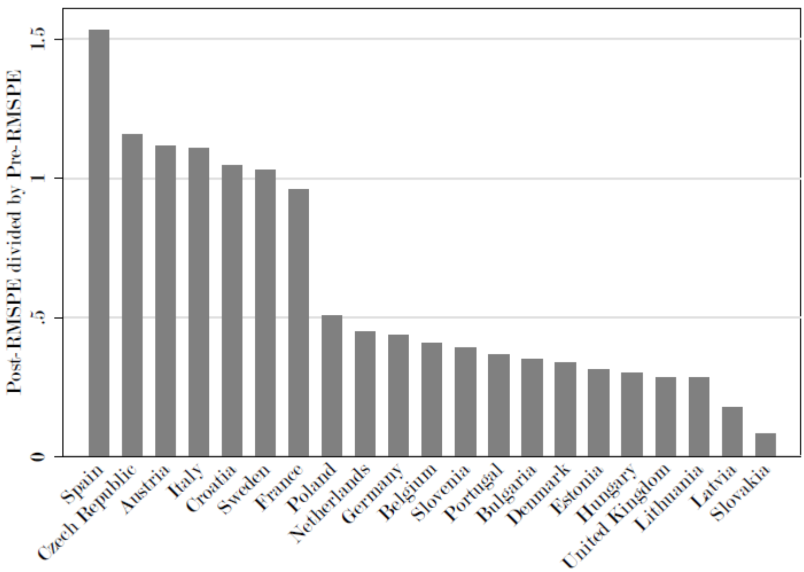
Country	*Synthetic Control Weight*
Austria	0
Belgium	0
Bulgaria	0.227
Croatia	0
Denmark	0.130
Estonia	0.132
France	0
Germany	0
Hungary	0
Italy	0
Latvia	0
Lithuania	0
Netherlands	0.365
Poland	0
Portugal	0
Slovakia	0.145
Slovenia	0
Spain	0
Sweden	0
United Kingdom	0

Source: Synthetic control method computations.

4.2.1 Robustness Tests

The credibility of the results can be clarified by running placebo studies, as described in Chapter 3. Firstly, we reassign the intervention to all control units and evaluate the ratio of post-intervention RMSPE to pre-intervention RMSPE. As Abadie et al. (2015) point out, a large post-intervention RMSPE is not indicative if the synthetic output of interest does not closely reproduce the real output of interest prior to the intervention. In other words, if the ratio between post-intervention RMSPE and pre-intervention RMSPE is large, then the effect of the intervention is also large. In Figure 3 we can see that the Czech Republic comes in second for the largest effect of the intervention. This indicates that the intervention has an impact on the Seasonally Adjusted GDP per Capita in the Czech Republic.

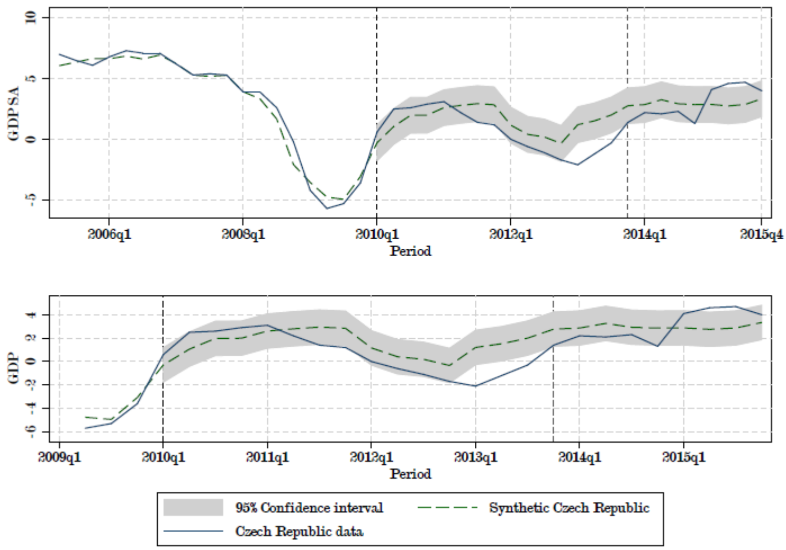
Figure 3 Ratio of Post-intervention RMSPE and Pre-intervention RMSPE Related to Seasonally Adjusted GDP per Capita



Source: Synthetic control method computation.

Secondly, we change the period of the intervention to Q1 2010 using the same technique of choosing control units weights. Figure 4 displays the output of the interest when the intervention period is set to Q1 2010. It can be seen that before the period Q4 2013 (which indicates the non–labelled dash line) the real output exceeds a lower bound of the 95% confidence interval of its synthetic counterpart. This exceeding might be due to the difference between per capita GDP and its synthetic counterpart in Figure 1 during the period Q3 2011 – Q4 2013. On the other hand, comparing Figures 4 and 1, the fit is very analogous in period Q1 2010 – Q4 2013. Moreover, Figure 4 shows that the real output exceeds an upper bound of the 95% confidence interval of its synthetic counterpart in the same period (Q1 2015) as in Figure 1 with a very similar magnitude. This suggests that the effect of the intervention is not negligible in terms of Seasonally Adjusted GDP per Capita. Additionally, we reassign the intervention period to Q3 2012, due to the fact, that the Czech Koruna weakened before November 2013. This could be the consequence of the verbal decision of the Bank Board of the Czech National Bank. See Figure A3 in Appendix A for the results. Figure A3 indicates that even if we reassign the intervention period one year before the actual intervention the results are very similar. In other words, it could mean that CNB managed to keep the decision in silence.

Figure 4 Seasonally Adjusted GDP per Capita Reassigned to the Period Q1 2010



Source: Synthetic control method computation.

Taking into account Figures 1 and 3, there might be an effect of the intervention on per capita GDP. Nevertheless, there are several events which had an impact on the effect of the intervention. For instance, the changes in indirect taxes mainly for tobacco products. As Holub (2013) comments, the acceleration of GDP growth was largely due to the increased collection of duty on tobacco products.

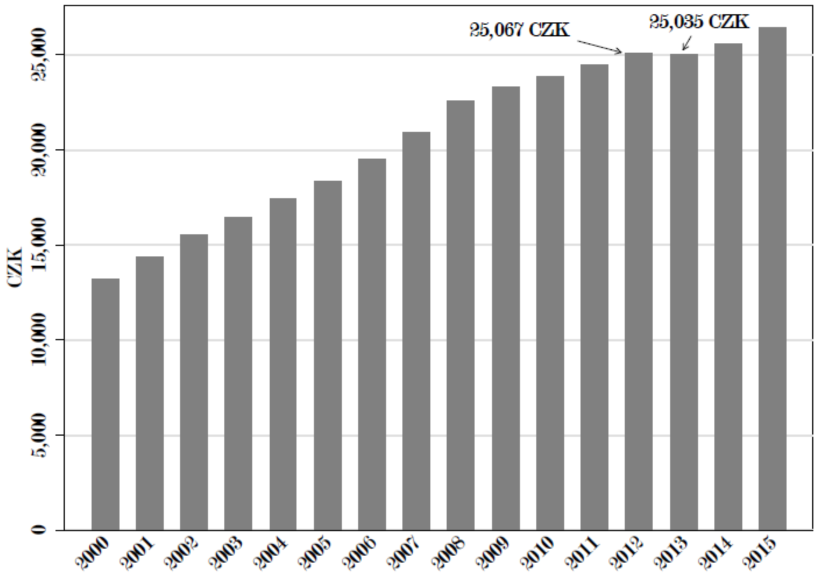
Another factor influencing the Czech economy is the restrictive fiscal policy at the beginning of the intervention. Together with the intervention, the restrictive policy might lead to an increase in net export and, therefore, to an increase in GDP growth.

Holub (2015) pp. 2 also adds:

> The Czech economy did not begin 2013 in good shape: it was still in a prolonged recession and falling ever deeper below its potential. In the middle of the year it reached the bottom of the economic downturn; nonetheless, even subsequent to this milestone it was still not possible to point to any significant recovery. At the same time, the growth of wages significantly slowed, and unemployment increased. The anti-inflationary domestic conditions caused a decline of inflation at the beginning of the year below the 2% CNB target, despite a January increase in indirect taxes, while at the same time core inflation remained negative.

Moreover, as can be seen in Figure 5, the nominal wages decreased in the year 2013.

Figure 5 Annual Nominal Wage



Source: CNB ARAD time series database.

In summary, all of these idiosyncratic events had an undoubted impact on the performance of the Czech Republic. Therefore, these events should be considered when evaluating the synthetic counterpart in Figures 1 and 4.

4.3 Unemployment

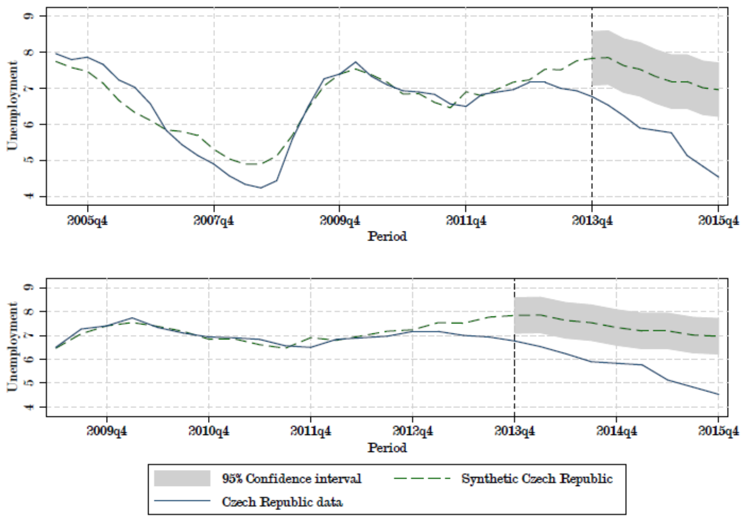
Figure 6 displays the effect of the intervention on the unemployment rate in the Czech Republic during the period Q1 2005–Q4 2015. The synthetic Czech Republic data mildly fit that of the real unemployment data in the pre-intervention period. Together with the close fit of predictor means (HCPI, Seasonally adjusted GDP per capita, Index of Wage in Industry Sector, and unemployment rate itself) in Table 5, we can conclude that there exists a combination of other European countries that reproduces economic characteristics of the Czech Republic before the intervention. Moreover, there is a significant positive effect of the intervention on the unemployment rate.

According to the data from Eurostat database, the exact number of unemployed people in the Czech Republic is 237 000 (4.5% in terms of unemployment rate) at the end of the period Q4 - 2015.[19] However, in the Czech Republic, there is the highest number of sole traders thanks to the tax–favourable conditions, which could be most probably the reason of the low unemployment rate. As a consequence, this could lead to the biased results when comparing real Czech Republic with its synthetic

[19] Any person between 15 and 64 years old - for Spain, Italy and United Kingdom 16 - 74 years old. See chapter A for detailed information.

counterpart.[20] The synthetic Czech Republic in Figure 6 indicates that the unemployment rate would be 6.9% without the intervention at the end of the period Q4 - 2015. In other words, there are 126,400 fewer unemployed people in the Czech Republic than there would be without the intervention, with a 95% level of significance.[21]

Figure 6 Unemployment Rate



Source: Synthetic control method computation.

In Table 4 we can see the predictor weights, which are computed by the nested optimization process. The weights selected by the process indicate that the most important predictor is unemployment rate, therefore, the results are mainly driven by this macroeconomic indicator. However, we provide additional results (see Figures A5 and A4 in appendix A), where we replace GDP with GVA as a predictor (Figure A5) and use longer pre–intervention period (Figure A4). These results indicate similar evolution of unemployment rate as in Figure 6, however, predictor weights are more spread around the indicators (see Table A8 in appendix A). As was mentioned in section 4.2, GVA should partially capture the effect of increased taxes on tobacco products, since GVA is not affected by change in taxes or subsidies. Furthermore, we apply SCM on CEE countries, see Figure A6 in Appendix A. As was mentioned in

[20] According to Association of Small & Middle Business (2015), sole traders, on average, contribute less, on yearly basis, to the national budget compare to employees. Therefore, the high number of sole traders compare to other countries in control unit could negatively bias the GDP of the Czech Republic. Since we use GDP as one of the main indicator to compute unemployment rate, the high number of sole traders could also bias the results of unemployment rate.

[21]Based on the author's computation, assuming that 4.5% is equal to 237,000, meaning that 6.9% is equal to 363,400. Finally, after deduction, the result is 126 400.

section 4.2, this approach should partially capture the effect of accelerated pumping of EU funds in 2015, since CEE countries enjoyed the similar effect of EU funds.[22]

Table 4 Predictor Weights

Country	*Synthetic Control Predictor Weight*
Seasonally Adjusted GDP per capita	0.083
Final Consumption per Capita	0.051
Real Exchange Rate	0.013
Index of wage in Industry Sector	0.001
HCPI	0.014
Unemployment Rate	0.839

Source: Synthetic control method computations.

Table 5 compares the pre-intervention characteristics of the Czech Republic to those of the synthetic Czech Republic. The synthetic units are very similar to the treated units in terms of HCPI and unemployment rate. On the other hand, the differences between the Seasonally Adjusted GDP per capita, Index of wage in Industry Sector, Real Exchange Rate and Final Consumption per Capita and its synthetic counterpart is larger. However, as Table 4 indicates, its predictive power is nearly negligible.

Table 5 Predictor Means Before the Intervention

Country	*Treated Unit*	*Synthetic Unit*
Seasonally Adjusted GDP per capita	2.289	2.093
Final Consumption per Capita	0.803	1.139
Real Exchange Rate	113.388	106.400
Index of wage in Industry Sector	87.488	93.244
HCPI	2.492	2.334
Unemployment Rate	6.580	6.619

Source: Synthetic control method computations.

Table 6 Countries Weights

Country	*Synthetic Control Weight*
Austria	0.438
Belgium	0
Bulgaria	0
Croatia	0
Denmark	0
Estonia	0.065
France	0
Germany	0
Hungary	0
Italy	0
Latvia	0
Lithuania	0
Netherlands	0.332
Poland	0
Portugal	0
Slovakia	0.165
Slovenia	0
Spain	0
Sweden	0
United Kingdom	0

Source: Synthetic control method computations.

[22] Figure A6 indicates positive significant effect of the intervention; however, the confidence interval is much larger. This could lead from the weak fit of the synthetic Czech Republic to its real counterpart.

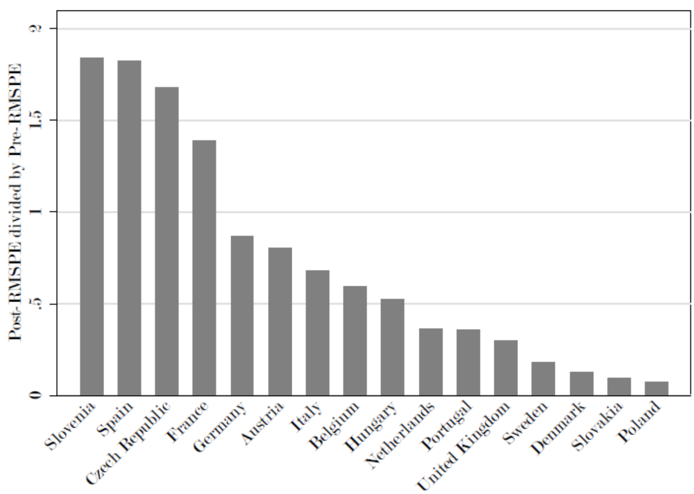
Table 6 shows the weights of each country from the control units. The synthetic Czech Republic related to the unemployment rate is a weighted average of Austria, Netherlands, Slovakia, and Estonia with weights decreasing in this order. All other countries obtain zero weights.[23]

4.3.1 Robustness Tests

To evaluate the significance of our estimates, we run placebo studies in the same manner as used to determine the Seasonally Adjusted GDP per capita.

Firstly, we reassign the intervention to each country in its control unit. Therefore, we obtain the RMSPE for both pre-intervention and post-intervention periods. Figure 7 shows the ratio of the post-intervention RMSPE and pre-intervention RMSPE. In this case, the Czech Republic has the third highest ratio. In other words, Figure 7 indicates that the effect of the intervention on the unemployment rate is large in comparison with other countries in the control unit.[24]

Figure 7 Ratio of Post-intervention RMSPE and Pre-intervention RMSPE Related to the Unemployment Rate



Source: Synthetic control method computation.

Secondly, we rerun the model with the intervention reassigned to the period Q1 2010, which is about 13 quarters earlier than when the intervention was launched. Again, we use the same technique for choosing the weights for the control units. In Figure 8 we can see the results.

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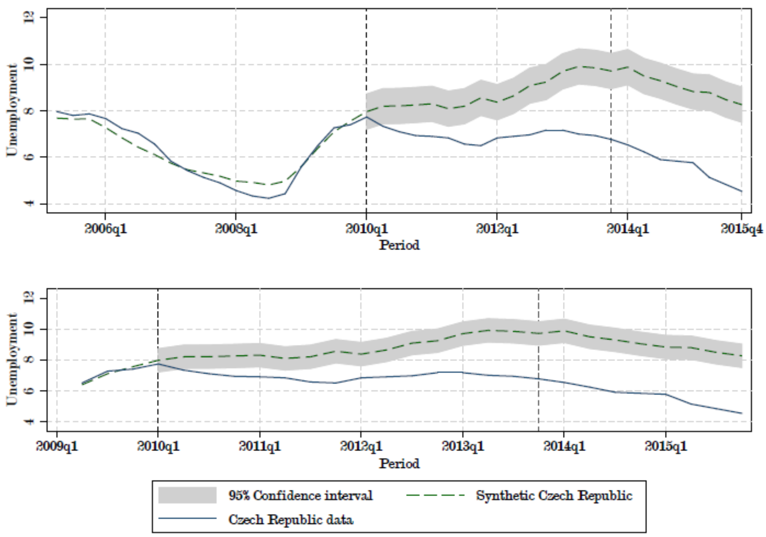
[23] We exclude Ireland because of missing values for Seasonally Adjusted GDP per capita for the whole sample period.

[24] Note that Latvia, Lithuania, Estonia, Croatia and Bulgaria are excluded from the robustness check due to its data availability - it is necessary that the outcome of interest consists of full matrix length (the whole period is available).

The synthetic Czech Republic precisely reproduces the trajectory of the unemployment rate until the period Q1 2010. Nevertheless, unemployment rate trajectories of the Czech Republic and its synthetic counterpart do differ during the period Q1 2010 - Q4 2013 period.[25] The possible reason might be low unemployment rate in the Czech Republic in comparison with the average unemployment rate of countries in control unit during Q1 2010 - Q4 2013, what indicates Figure 9. However, the trajectory of the synthetic Czech Republic follows the same path as that in Figure 6 during the period Q4 2013 - Q4 2015. This supports the finding of positive effect from Figure 6. Additionally, we reassign the intervention period to Q3 2012 as a robustness check, to see whether the market knew about the intervention in advance (see Figure A7 in Appendix A). The results indicate very similar outcome as the original Figure 6. Therefore, it suggests that the intervention was unexpected for the market.

Figure 8 Unemployment Reassigned to the Period Q1 2010

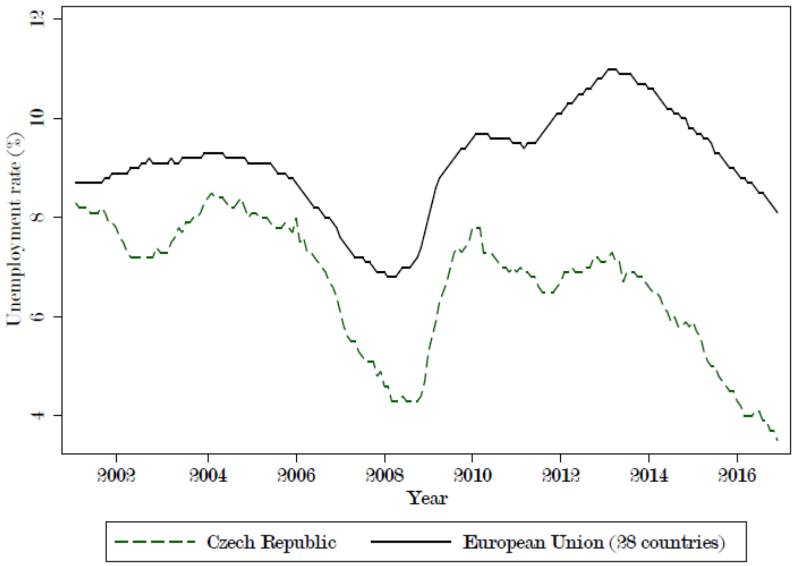


Source: Synthetic control method computation.

In conclusion, Figures 6, 7, and 8 show that there is an effect of the intervention on the unemployment rate in the Czech Republic. Moreover, compared to the GDP per capita in section 4.2, the effect is relatively large. This could be due to the fact that the unemployment rate is less dependent on the idiosyncratic events mentioned in the end of section 4.2.1. For instance, in contrast with GDP per capita, increasing the indirect tax on tobacco products and intensified pumping of structural funds from the EU did not have direct impacts on the unemployment rate.

[25] Indicated as a non-labelled dash line on Figure 8.

Figure 9 Comparison of Unemployment



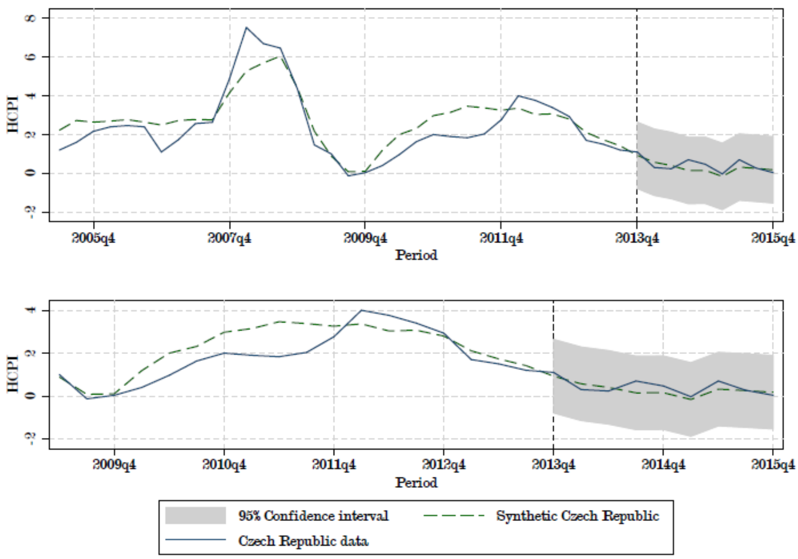
Source: Based on author's computation using data from Eurostat database.

4.4 Harmonized Consumer Price Index

In this section, we provide the results of the impact of the intervention on HCPI. In Figure 10, the reader can see the estimation of the HCPI synthetic counterpart during the period Q1 2005–Q4 2015. Additionally, we show the estimation for the period Q4 2007–Q4 2015 in Figure 11.[26] Furthermore, instead of GDP, we provide the results when we employ GVA as a predictor and the results when we apply SCM on CEE countries (these countries better capture the effect of EU funds on the Czech Republic).[27] In those cases, the positive effect of intervention increases, however, it still remains within 95% confidence interval. Keep in consideration that all tables below are related to the period Q1 2005–Q4 2015.

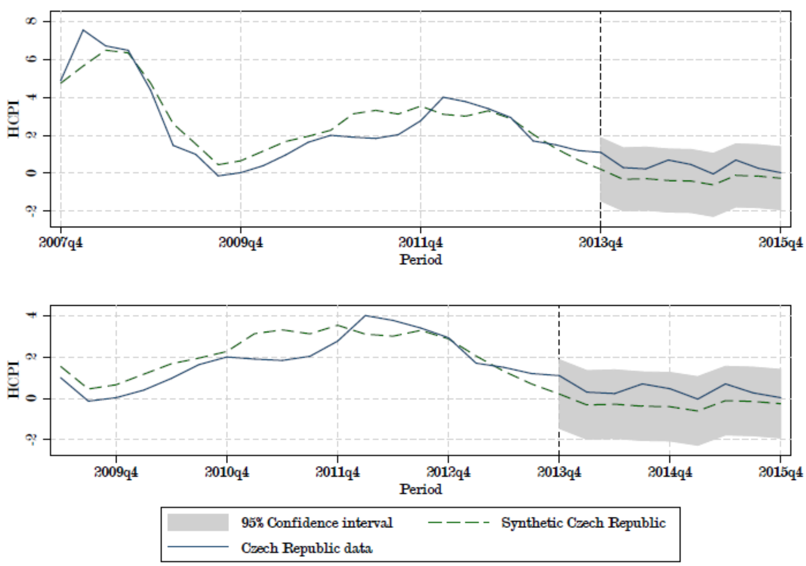
[26] Tables A14, A15 and A16 in Appendix A provide the results with weights of countries and predictors.
[27] See Figures A8 and A9 in Appendix A.

Figure 10 Harmonized Consumer Price Index Q1 2005–Q4 2015



Source: Synthetic control method computation.

Figure 11 Harmonized Consumer Price Index Q4 2007–Q4 2015



Source: Synthetic control method computation.

Both figures (Figure 10 only partially) indicate that the Czech Republic's synthetic counterpart would touch level zero of the HCPI from the negative side of y–axis. Furthermore, it remains below the real Czech Republic's HCPI after the intervention, which suggests the positive effect of the intervention on the HCPI in the Czech Republic. On the other hand, the real Czech data does not exceed the 95% confidence interval of its synthetic counterpart, which should be considered when interpreting the result.

Table 7 displays weights of predictors. The prediction power of the predictors decreases in following order: Final Consumption per Capita, unemployment rate, Real Exchange Rate, Index of Wage in Industry Sector, HCPI and Seasonally Adjusted GDP per capita.

Table 7 Predictor Weights

Country	*Synthetic Control predictor weight*
Seasonally Adjusted GDP per capita	0.002
Final Consumption per Capita	0.964
Real Exchange Rate	0.014
Index of Wage in Industry Sector	0.003
HCPI	0.003
Unemployment rate	0.014

Source: Synthetic control method computations.

In Table 8, the reader can see the difference between the predictor means of a treated unit and a synthetic one. As explained in Section 3, we use the nested optimization process to calculate the weight of predictors. The Table 7 shows that all predictors except Final Consumption per Capita obtain very small prediction weights. As Abadie et al. (2012) say, a small prediction power explains the discrepancy between the variables.

Table 8 Predictor Means Before the Intervention

Country	*Treated Unit*	*Synthetic Unit*
Seasonally Adjusted GDP per capita	2.214	0.868
Final Consumption per Capita	0.840	0.848
Real Exchange Rate	113.451	109.012
Index of Wage in Industry Sector	88.060	90.826
HCPI	2.455	2.765
Unemployment Rate	6.590	7.161

Source: Synthetic control method computations.

In the next Table, 9, we can see the weights of countries computed by the synthetic control method. The weights reported in the table indicate that the HCPI in the Czech Republic is best reproduced by a combination of Denmark, Estonia, Italy, Netherlands and Bulgaria with weights decreasing in this order. Note that Ireland is excluded from control units, because of its missing values for Seasonally Adjusted GDP per capita during the whole period Q1 2005–Q4 2015.

Table 9 Countries Weights

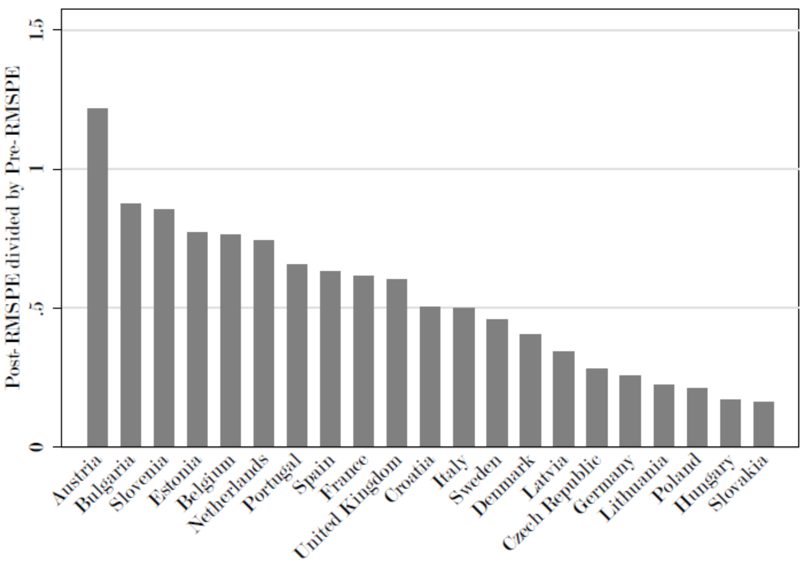
Country	*Synthetic Control Weight*
Austria	0
Belgium	0
Bulgaria	0.017
Croatia	0
Denmark	0.433
Estonia	0.250
France	0
Germany	0
Hungary	0
Italy	0.207
Latvia	0
Lithuania	0
Netherlands	0.093
Poland	0
Portugal	0
Slovakia	0
Slovenia	0
Spain	0
Sweden	0
United Kingdom	0

Source: Synthetic control method computations.

4.4.1 Robustness Tests

In this subsection we provide robustness tests of results related to the HCPI. As can be seen in Figure 12, the Czech Republic stands sixth to last. This indicates that the magnitude of the intervention's effect on the HCPI is not large in comparison to other countries in the control unit. At the end of this subsection, we provide discussion about possible factors that might make the detection of the effect more difficult.

Figure 12 Ratio of Post-intervention RMSPE and Pre-intervention RMSPE Related to the HCPI

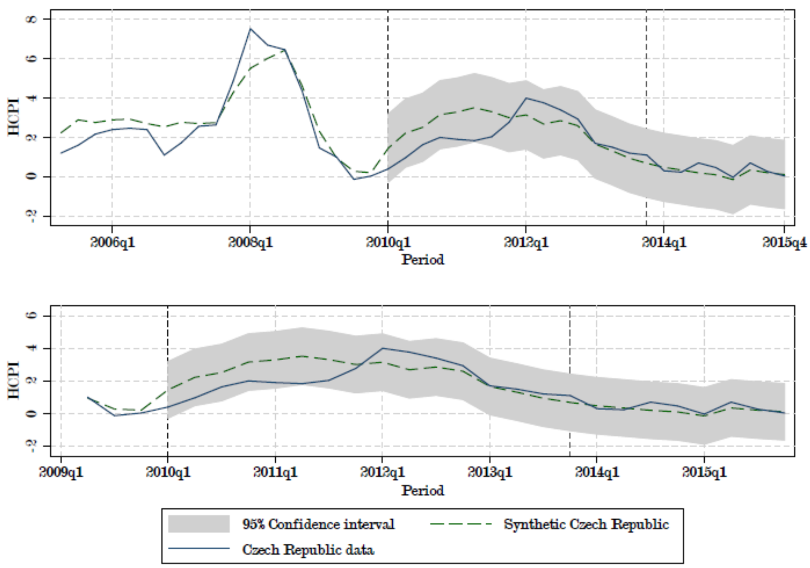


Source: Synthetic control method computation.

Figure 13 shows the result of the synthetic Czech Republic when the intervention period is reassigned to the period Q1 2010. Trajectories of real the output and its synthetic counterpart during the period Q1 2010–Q3 2013 do not differ substantially compare to Figure 10. This indicates that reassignment of the intervention has no significant effect on the output. Moreover, the output after the intervention is very similar to the one in Figure 10. Additionally, we reassign the intervention to the period Q3 2012 for the same reasons as were mentioned in sections 4.2.1 and 4.3.1 (see Figure A10 in Appendix A). The trajectories of the synthetic Czech Republic on both Figures 10 and A10 do not substantially differ from each other, indicating robustness of the actual date of intervention.

When evaluating the effect of the intervention on the HCPI, we should consider several idiosyncratic events that affected both the Czech economy, and also other economies in the control unit. Some of the events that influenced the performance of the Czech economy were mentioned in section 4.2.1, such as an accelerated pumping of EU funds in the year 2015 and increasing indirect tax on tobacco products. On the other hand, the non–standard steps taken by the European Central Bank (ECB) during the crisis had an impact on the economies of the countries in the control unit.

Figure 13 HCPI Reassigned to the Period Q1 2010



Source: Synthetic control method computation.

As Mersch (2013) pp. 2 said in his speech at the UniCredit Business Dialogue, Hamburg, 17 June 2013, the ECB introduced non-standard steps to support economies in the synthetic control unit:

> One of these non-standard measures is the policy of full allotment in our refinancing operations against appropriate collateral. We have also extended the

maturities of our refinancing operations up to three years and have expanded the collateral framework. These measures are geared towards bank's refinancing conditions, which in turn make it easier for credit institutions to provide sufficient credit to the economy at favourable terms.

Last summer we decided on more far-reaching measures - notably the announcement of the Outright Monetary Transactions. Prior to this announcement, we had to observe that market financing conditions were increasingly characterized by the fears among market participants that Member States would revert back to their national currencies. The markets hence priced in a conversion risk premium. Owing in part to this premium, the refinancing conditions of many commercial banks - and thereby the real economy - deteriorated dramatically.

The monetary policy of ECB is committed to maintaining price stability in the euro area as a whole. So, we had to take measures that would ensure that our single monetary policy would take effect in all Member States.

All mentioned idiosyncratic events should be considered when interpreting the results of this paper related to the Harmonized Consumer Price Index.

5. Conclusion

In this paper we examine the impact of the Exchange Rate Commitment introduced by the CNB in the period Q4 2013. By using the synthetic control method developed by Abadie & Gardeazabal (2003), we estimate an effect of the intervention on the Seasonally Adjusted GDP per capita, unemployment rate, and Harmonized Consumer Price Index. The procedure involves identifying the effect by comparing the real path of the outcome of interest with its synthetic counterpart computed by the SCM.

Our estimates show a positive significant effect of the intervention on the unemployment rate, which could lead to creation of around 120,000 working positions by the end of the year 2015. We also demonstrate a slight positive significant effect on the GDP per capita and an insignificant effect on the Harmonized Consumer Price Index. However, in the case of GDP per capita and HCPI, there are several idiosyncratic events that might make the visibility of the magnitude of the effect more difficult. The accelerated pumping of EU structural funds in the year of 2015 and increasing an indirect tax on tobacco products might overestimate the results. On the other hand, the restrictive fiscal policy at the beginning of the intervention, the decreasing of the nominal wage in the year 2013, and the deflation expectation might underestimate the effect of the intervention. Moreover, the introduction of the non–standard steps of the ECB during the crisis in order to fight the falling economies of the Eurozone plays a negative role in discovering the effect of the exchange rate commitment.

Overall, the estimated effects of the Czech National Bank's Exchange Rate Commitment are positive to neutral for selected macroeconomic predictors. However, the decisiveness of the results related to GDP per capita and HCPI are negatively affected by idiosyncratic events influencing the Czech economy before and after the intervention of the Czech Nation Bank. The long-term effects are subject to be observed.

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APPENDIX

A Additional results and data

Description of acronyms used in this paper.

RMSPE
: Root Mean Square Predicted Error

CNB
: Czech National Bank

ZLB
: Zero lower bound

HCPI
: Harmonized Consumer Price Index

GDP
: Gross Domestic Product

ECB
: European Central Bank

SCM
: The synthetic control method

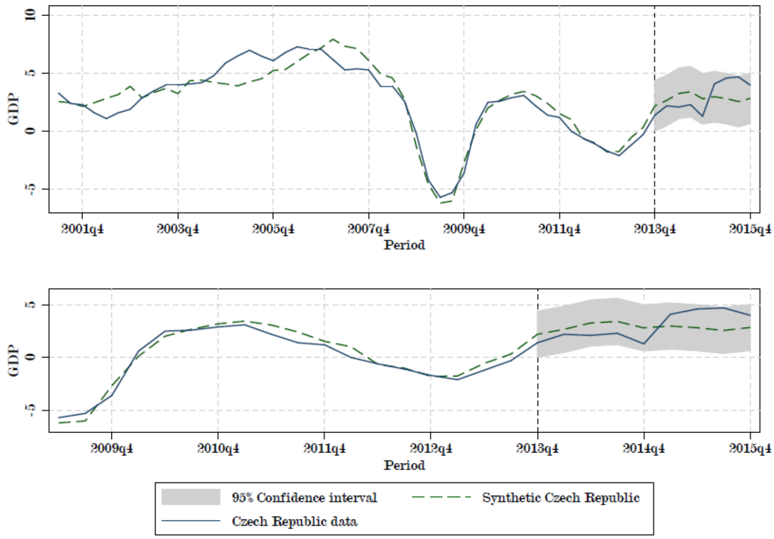
CPI
: Consumer Price Index

CEE
: Central and Eastern European

GVA
: Gross Value Added

Figure A1 shows the results regarding only CEE countries such as Poland, Slovakia, Slovenia, Bulgaria, Croatia, Estonia, Latvia, Lithuania and Hungary.

Figure A1 Seasonally Adjusted GDP per Capita Q1 2001–Q4 2015 for CEE Countries



Source: Synthetic control method computation.

Table A1 Predictor Weights for period Q1 2001–Q4 2015 for CEE Countries Related to Figure A1

Country	***Synthetic Control Predictor Weight***
Seasonally Adjusted GDP per capita	0.086
Final Consumption per Capita	0.083
Real Exchange Rate	0.304
Index of Wage in Industry Sector	0.328
HCPI	0.122
Unemployment Rate	0.076

Source: Synthetic control method computations.

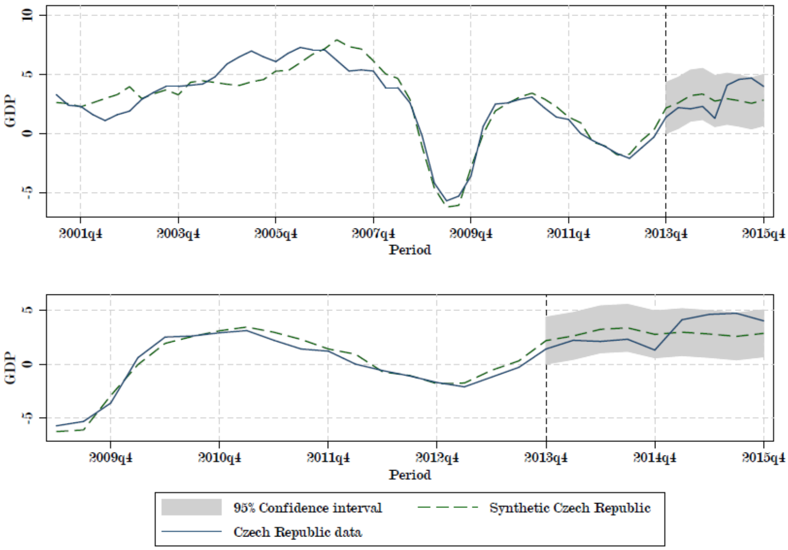
Table A2 Countries Weights for Period Q1 2001–Q4 2015 for CEE Countries Related to Figure A1

Country	***Synthetic Control Weight***
Bulgaria	0
Croatia	0
Estonia	0.061
Hungary	0
Latvia	0
Lithuania	0
Poland	0.329
Slovakia	0
Slovenia	0.610

Source: Synthetic control method computations.

Figure A2 shows the results regarding only CEE countries such as Poland, Slovakia, Slovenia, Bulgaria, Croatia, Estonia, Latvia, Lithuania and Hungary with GVA as a macroeconomic indicator (we replace GDP in the list of indicators to capture the effect of increased taxes on tobacco products).

Figure A2 Seasonally Adjusted GDP per Capita Q1 2001–Q4 2015 for CEE Countries with GVA Indicator



Source: Synthetic control method computation.

Table A3 Predictor Weights for Period Q1 2001–Q4 2015 when GVA is Employed (Related to Figure A2)

Country	*Synthetic Control Predictor Weight*
GVA	0.001
Final Consumption per Capita	0.093
Real Exchange Rate	0.098
Index of Wage in Industry Sector	0.786
HCPI	0.018
Unemployment Rate	0.004

Source: Synthetic control method computations.

Table A4 Countries Weights for Period Q1 2001–Q4 2015 when GVA is Employed (Related to Figure A2)

Country	*Synthetic Control Weight*
Bulgaria	0.036
Croatia	0
Estonia	0.055
Hungary	0
Latvia	0
Lithuania	0
Poland	0.303
Slovakia	0
Slovenia	0.605

Source: Synthetic control method computations.

Tables related to the Seasonally Adjusted GDP per capita for the period Q1 2001–Q4 2015 in Figure 2.

Table A5 Predictor Weights for Period Q1 2001–Q4 2015

Country	*Synthetic Control Predictor Weight*
Seasonally Adjusted GDP per capita	0.986
Final Consumption per Capita	0.002
Real Exchange Rate	0.001
Index of Wage in Industry Sector	0.010
HCPI	0.001
Unemployment Rate	0.001

Source: Synthetic control method computations.

Table A6 Predictor Means Before the Intervention for Period Q1 2001–Q4 2015 in Figure 2

Country	*Treated unit*	*Synthetic Unit*
Seasonally Adjusted GDP per capita	2.537	2.538
Final Consumption per Capita	1.754	2.208
Real Exchange Rate	106.489	106.812
Index of Wage in Industry Sector	79.675	80.331
HCPI	2.347	3.611
Unemployment Rate	6.997	8.271

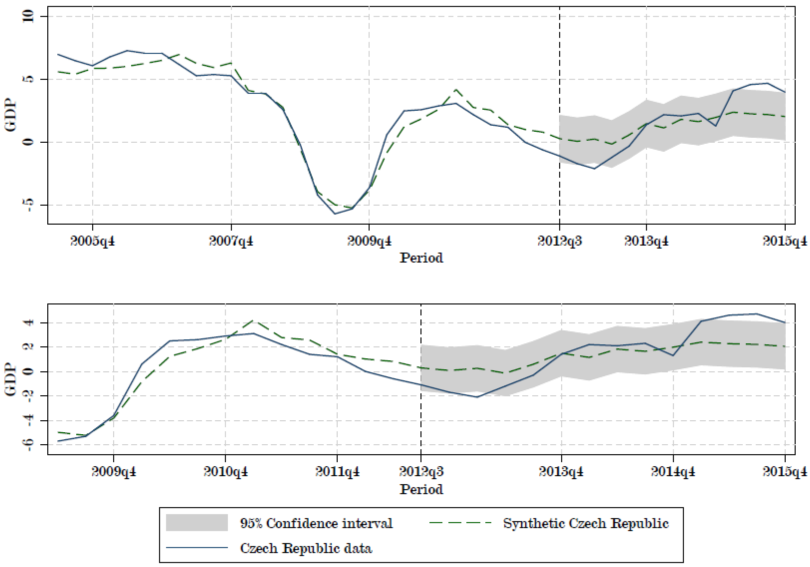
Source: Synthetic control method computations.

Table A7 Countries Weights for Period Q1 2001–Q4 2015 in Figure 2

Country	*Synthetic Control Weight*
Austria	0
Belgium	0
Bulgaria	0.172
Croatia	0
Denmark	0
Estonia	0.094
France	0
Germany	0
Hungary	0
Italy	0
Latvia	0
Lithuania	0
Netherlands	0.338
Portugal	0
Slovakia	0.132
Slovenia	0.264
Spain	0
Sweden	0
United Kingdom	0

Source: Synthetic control method computations.

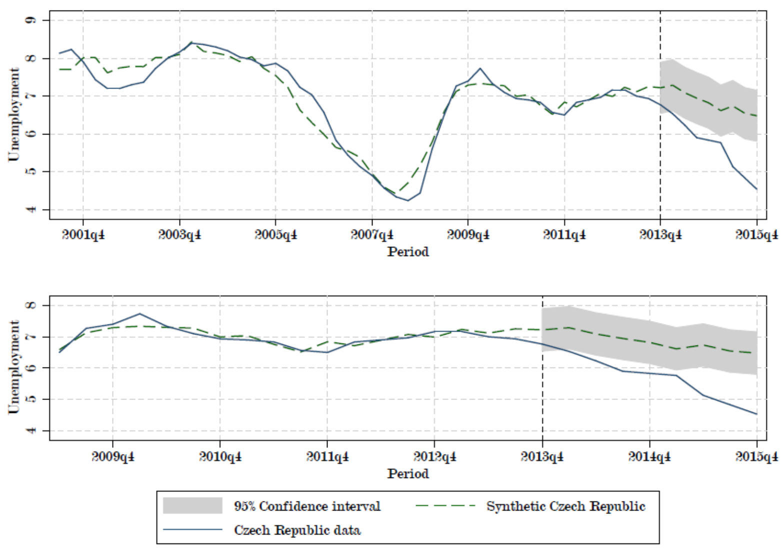
Figure A3 Seasonally Adjusted GDP per Capita Q1 2005–Q4 2015 Reassigned to Q3 2012



Source: Synthetic control method computation.

Figure and tables related to the unemployment rate with GVA as a predictor.

Figure A4 Unemployment Q1 2001–Q4 2015 when GVA is Employed



Source: Synthetic control method computation.

Table A8 Predictor Weights for Period Q1 2001–Q4 2015 when GVA is Employed (Related to Figure A4)

Country	*Synthetic Control predictor weight*
GVA	0.238
Final Consumption per Capita	0.008
Real Exchange Rate	0.001
Index of Wage in Industry Sector	0.001
HCPI	0.366
Unemployment Rate	0.388

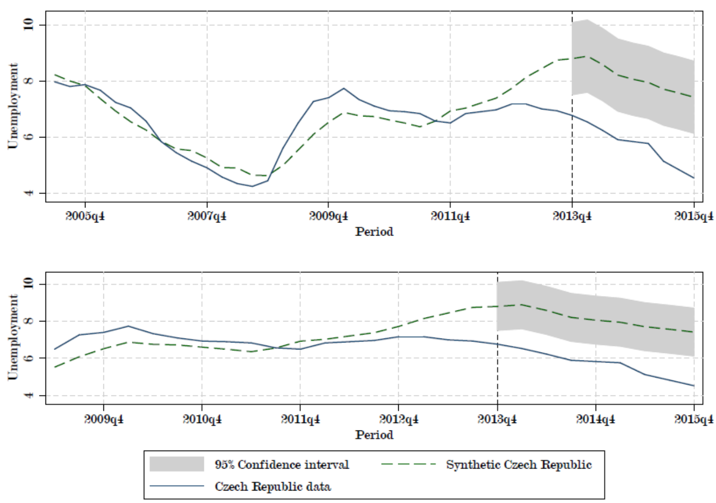
Source: Synthetic control method computations.

Table A9 Countries Weights for Period Q1 2001–Q4 2015 when GVA is Employed (Related to Figure A4)

Country	*Synthetic Control Weight*
Austria	0.579
Belgium	0
Bulgaria	0.001
Croatia	0
Denmark	0
Estonia	0
France	0
Germany	0
Hungary	0
Italy	0
Latvia	0
Lithuania	0.131
Netherlands	0.143
Poland	0.146
Portugal	0
Slovakia	0
Slovenia	0
Spain	0
Sweden	0
United Kingdom	0

Source: Synthetic control method computations.

Figure A5 Unemployment Q1 2005–Q4 2015 when GVA is Employed



Source: Synthetic control method computation.

Table A10 Predictor Weights for Period Q1 2005–Q4 2015 when GVA is Employed (Related to Figure A5)

Country	*Synthetic Control predictor weight*
GVA	0.036
Final Consumption per Capita	0.207
Real Exchange Rate	0.001
Index of Wage in Industry Sector	0.001
HCPI	0.001
Unemployment Rate	0.755

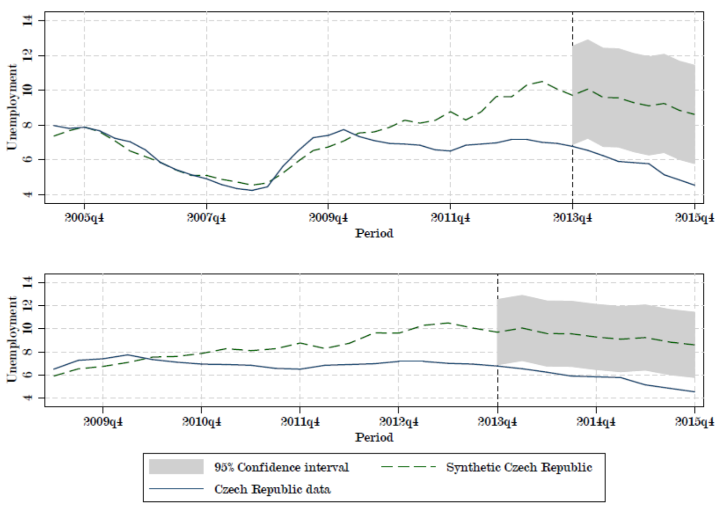
Source: Synthetic control method computations.

Table A11 Countries Weights for Period Q1 2005–Q4 2015 when GVA is Employed (Related to Figure A5)

Country	*Synthetic Control Weight*
Austria	0
Belgium	0
Bulgaria	0
Croatia	0
Denmark	0
Estonia	0
France	0
Germany	0
Hungary	0
Italy	0
Latvia	0
Lithuania	0
Netherlands	0.795
Poland	0.043
Portugal	0
Slovakia	0.162
Slovenia	0
Spain	0
Sweden	0
United Kingdom	0

Source: Synthetic control method computations.

Figure A6 Unemployment Q1 2005–Q4 2015 for CEE Countries



Source: Synthetic control method computation.

Table A12 Predictor Weights for Period Q1 2005–Q4 2015 when CEE Countries are Employed (Related to Figure A6)

Country	*Synthetic Control Predictor Weight*
Seasonally Adjusted GDP per capita	0.123
Final Consumption per Capita	0.245
Real Exchange Rate	0.002
Index of Wage in Industry Sector	0.059
HCPI	0.381
Unemployment Rate	0.188

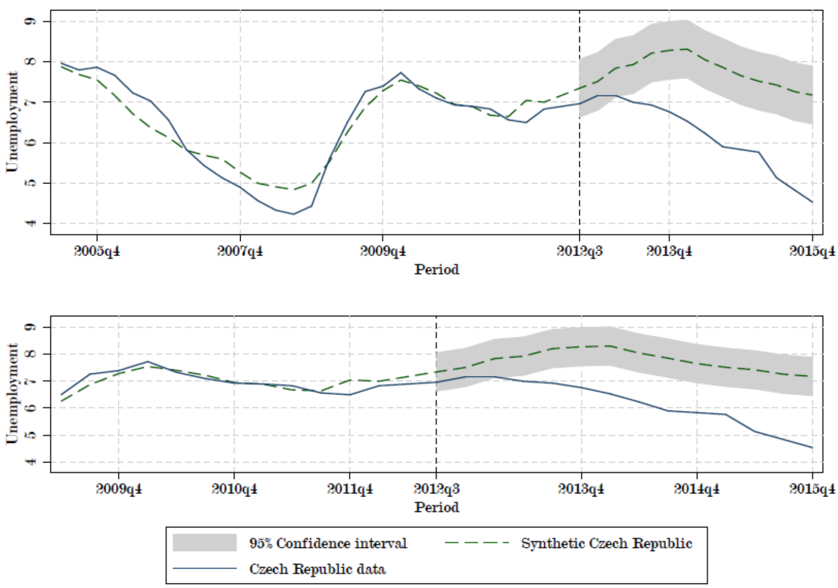
Source: Synthetic control method computations.

Table A13 Countries Weights for Period Q1 2005–Q4 2015 (Related to Figure A6)

Country	*Synthetic Control Weight*
Bulgaria	0
Croatia	0
Estonia	0
Hungary	0
Latvia	0
Lithuania	0
Poland	0.104
Slovakia	0
Slovenia	0.896

Source: Synthetic control method computations.

Figure A7 Unemployment Rate Q1 2005–Q4 2015 Reassigned to Q3 2012



Source: Synthetic control method computation.

Tables related to the HCPI in the period Q4 2007–Q4 2015 in Figure 11.

Table A14 Predictor Weights for Period Q4 2007–Q4 2015

Country	*Synthetic Control predictor weight*
Seasonally Adjusted GDP per capita	0.001
Final Consumption per Capita	0.291
Real Exchange Rate	0.217
Index of Wage in Industry sector	0.492
HCPI	0.001
Unemployment Rate	0.001

Source: Synthetic control method computations.

Table A15 Predictor Means Before the Intervention for Period Q4 2007–Q4 2015

Country	*Treated Unit*	*Synthetic Unit*
Seasonally Adjusted GDP per capita	0.464	0.973
Final Consumption per capita	0.208	0.208
Real Exchange Rate	117.599	117.602
Index of Wage in Industry Sector	93.888	93.889
HCPI	2.679	2.925
Unemployment Rate	6.369	9.930

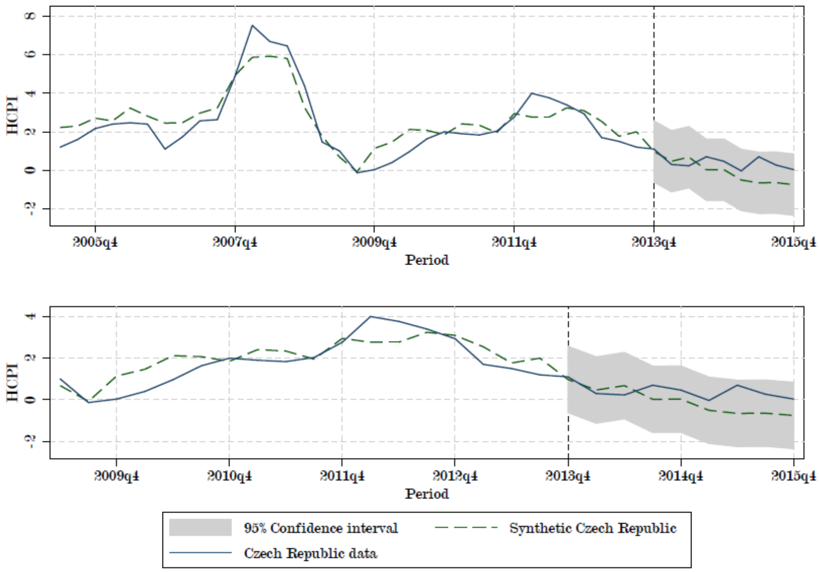
Source: Synthetic control method computations.

Table A16 Countries Weights for Period Q4 2007–Q4 2015

Country	*Synthetic Control Weight*
Austria	0
Belgium	0
Bulgaria	0.258
Croatia	0
Denmark	0
Estonia	0
France	0
Germany	0
Hungary	0
Italy	0.425
Latvia	0
Lithuania	0
Netherlands	0
Poland	0
Portugal	0
Slovakia	0.268
Slovenia	0
Spain	0
Sweden	0.049
United Kingdom	0

Source: Synthetic control method computations.

Figure A8 HCPI Q1 2005–Q4 2015 when GVA is Employed



Source: Synthetic control method computation.

Table A17 Predictor Weights for Period Q1 2005–Q4 2015 when GVA is Employed (Related to Figure A8)

Country	*Synthetic Control predictor weight*
GVA	0.002
Final Consumption per Capita	0.996
Real Exchange Rate	0.001
Index of Wage in Industry sector	0.001
HCPI	0.001
Unemployment Rate	0.001

Source: Synthetic control method computations.

Table A18 Predictor Means Before the Intervention for Period Q1 2005–Q4 2015 when GVA is Employed (Related to Figure A8)

Country	*Treated Unit*	*Synthetic Unit*
GVA	111.817	110.316
Final Consumption per capita	0.840	0.843
Real Exchange Rate	113.451	106.752
Index of Wage in Industry Sector	88.060	90.854
HCPI	2.455	2.697
Unemployment Rate	6.590	7.792

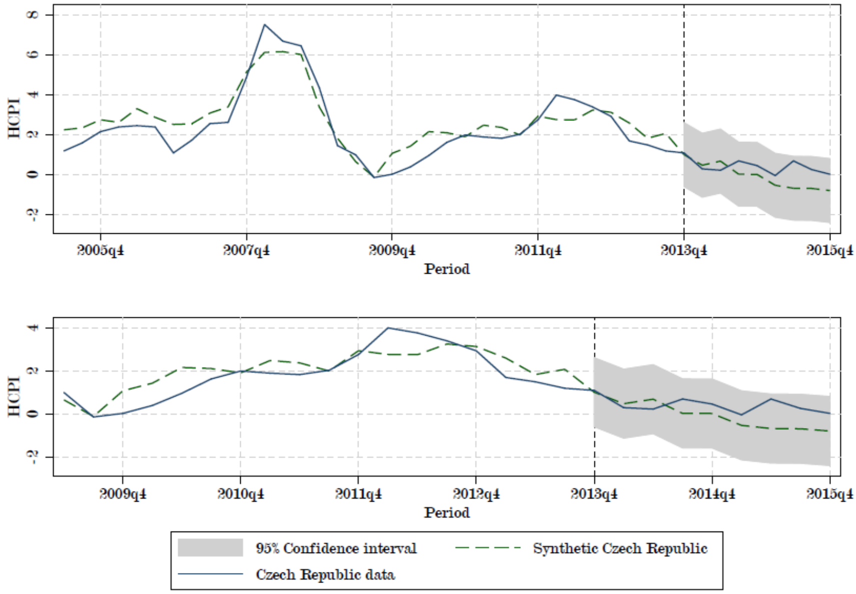
Source: Synthetic control method computations.

Table A19 Countries Weights for Period Q1 2005–Q4 2015 when GVA is Employed (Related to Figure 21)

Country	*Synthetic Control Weight*
Austria	0
Belgium	0
Bulgaria	0
Croatia	0
Denmark	0
Estonia	0
France	0
Germany	0
Hungary	0
Italy	0.055
Latvia	0
Lithuania	0
Netherlands	0
Poland	0
Portugal	0
Slovakia	0.138
Slovenia	0.808
Spain	0
Sweden	0
United Kingdom	0

Source: Synthetic control method computations.

Figure A9 HCPI Q1 2005–Q4 2015 for CEE Countries



Source: Synthetic control method computation.

Table A20 Predictor Weights for Period Q1 2005–Q4 2015 for CEE Countries (Related to Figure 22)

Country	***Synthetic Control predictor weight***
Seasonally Adjusted GDP per capita	0.396
Final Consumption per Capita	0.052
Real Exchange Rate	0.147
Index of Wage in Industry sector	0.001
HCPI	0.169
Unemployment Rate	0.236

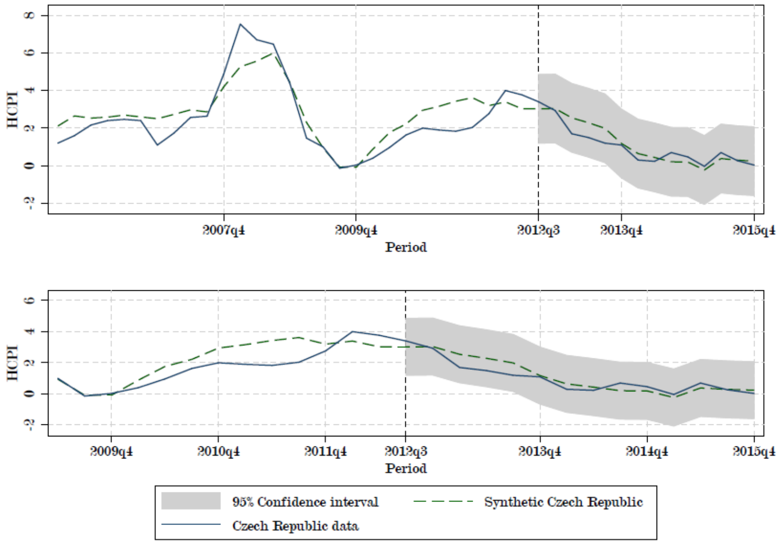
Source: Synthetic control method computations.

Table A21 Countries Weights for Period Q1 2005–Q4 2015 for CEE Countries (Related to Figure 22)

Country	***Synthetic Control Weight***
Bulgaria	0
Croatia	0
Estonia	0.024
Hungary	0
Latvia	0
Lithuania	0
Poland	0
Slovakia	0.145
Slovenia	0.831

Source: Synthetic control method computations.

Figure A10 HCPI Q1 2005–Q4 2015 Reassigned to Q3 2012



Source: Synthetic control method computation.

B Data

Table 31 Description of Variables

Variable	*Description*	*Code in Eurostat*
Seasonally Adjusted GDP per capita	Gross domestic product at market prices. Seasonally adjusted and adjusted data by working days. Chain linked volumes, percentage change compared to same period in previous year. For Slovakia data from ECB.	namq_10_gdp
GVA	Gross value added as an index (2005=100). Seasonally unadjusted data.	namq_10_a10
Final Consumption per Capita	Main GDP aggregates per capita.Chain linked volumes, percentage change compared to same period in previous year, per capita. Not seasonally adjusted data.	namq_10_pc
Real Exchange Rate	Real effective series are a measure of the change in competitiveness of a country, by taking into account the change in costs or prices relative to other countries. A rise in the index means a loss of competitiveness. To construct Real Exchange rate we deflate nominal exchange rate by unit labour costs in total economy.	ert_eff_ic_q
Index of Wage in Industry Sector	Wage index 2012=100. Wages and salaries. Industry, construction and services (except activities of households as employers and extra-territorial organisations and bodies).	lc_lci_r2_q
HCPI	All–items HCPI. HCPI (2005 = 100) - monthly data (annual rate of change) – recalculated to quarterly data by author.	prc_hicp_manr
Unemployment rate	Age and sex in total, monthly avarage percentage – recalculated to quarterly data by author.	une_rt_m

Source: Eurostat database.

Table 32 Descriptive Statistics Summary

Variable	*Obs*	*Mean*	*Std. dev*	*Min*	*Max*
SA GDP per capita	1493	2.10	3.56	-17.90	14.20
NSA GVA	1496	104.58	12.56	61.70	166
Final Consumption per Capita	1500	1.70	3.45	-17.70	24.80
Real Exchange Rate	1508	104.39	12.31	78.01	161.25
Index of Wage in Industry Sector	1306	87.02	18.15	29.00	125.30
HCPI	1560	2.44	2.20	-3.87	17.53
Unemployment Rate	1560	8.75	4.16	1.83	26.23

Source: Stata software computation.

Table 33 Data Availability

Country	*GDP per capita SA*	*Final consumption per capita*	*Unemployment rate*
Austria	Q1 2001–Q4 2015	Q1 2001–Q2 2015	Q1 2001–Q4 2015
Belgium	Q1 2001–Q4 2015	Q1 2001–Q2 2015	Q1 2001–Q4 2015
Bulgaria	Q1 2001–Q4 2015	Q1 2001–Q2 2015	Q1 2001–Q4 2015
Croatia	Q1 2001–Q4 2015	Q1 2001–Q2 2015	Q1 2001–Q4 2015
Denmark	Q1 2001–Q4 2015	Q1 2001–Q2 2015	Q1 2001–Q4 2015
Estonia	Q1 2001–Q4 2015	Q1 2001–Q2 2015	Q1 2001–Q4 2015
France	Q1 2001–Q4 2015	Q1 2001–Q2 2015	Q1 2001–Q4 2015
Germany	Q1 2001–Q4 2015	Q1 2001–Q2 2015	Q1 2001–Q4 2015
Hungary	Q1 2001–Q4 2015	Q1 2001–Q2 2015	Q1 2001–Q4 2015
Ireland	NA	Q1 2001–Q2 2015	Q1 2001–Q4 2015
Italy	Q1 2001–Q4 2015	Q1 2001–Q2 2015	Q1 2001–Q4 2015
Latvia	Q1 2001–Q4 2015	Q1 2001–Q2 2015	Q1 2001–Q4 2015
Lithuania	Q1 2001–Q4 2015	Q1 2001–Q2 2015	Q1 2001–Q4 2015
Luxembourg	Q1 2001–Q4 2015	Q1 2001–Q2 2015	Q1 2001–Q4 2015
Netherlands	Q1 2001–Q4 2015	Q1 2001–Q2 2015	Q1 2001–Q4 2015
Poland	Q1 2003–Q4 2015	Q1 2003–Q2 2015	Q1 2001–Q4 2015
Portugal	Q1 2001–Q4 2015	Q1 2001–Q2 2015	Q1 2001–Q4 2015
Slovakia	Q1 2001–Q4 2015	Q1 2001–Q2 2015	Q1 2001–Q4 2015
Slovenia	Q1 2001–Q4 2015	Q1 2001–Q2 2015	Q1 2001–Q4 2015
Spain	Q1 2001–Q4 2015	Q1 2001–Q2 2015	Q1 2001–Q4 2015
Sweden	Q1 2001–Q4 2015	Q1 2001–Q2 2015	Q1 2001–Q4 2015
United Kingdom	Q1 2001–Q4 2015	Q1 2001–Q2 2015	Q1 2001–Q4 2015

Source: Eurostat database.

Table 34 Data Availability

Country	*Real Exchange Rate*	*Index of wage in IS*	*HCPI*
Austria	Q1 2001–Q2 2015	Q1 2009–Q2 2015	Q1 2001–Q3 2015
Belgium	Q1 2001–Q2 2015	Q1 2001–Q2 2015	Q1 2001–Q3 2015
Bulgaria	Q1 2001–Q2 2015	Q1 2001–Q2 2015	Q1 2001–Q3 2015
Croatia	Q1 2001–Q2 2015	Q1 2008–Q2 2015	Q2 2008–Q3 2015
Denmark	Q1 2001–Q2 2015	Q1 2001–Q4 2008 and Q1 2011–Q2 2015	Q1 2001–Q3 2015
Estonia	Q1 2001–Q2 2015	Q1 2001–Q2 2015	Q1 2001–Q3 2015
France	Q1 2001–Q2 2015	Q1 2008–Q2 2015	Q1 2001–Q3 2015
Germany	Q1 2001–Q2 2015	Q1 2001–Q2 2015	Q1 2001–Q3 2015
Hungary	Q1 2001–Q2 2015	Q1 2001–Q2 2015	Q1 2001–Q3 2015
Ireland	Q1 2001–Q2 2015	Q1 2001–Q2 2015	Q1 2001–Q3 2015
Italy	Q1 2001–Q2 2015	Q1 2001–Q2 2015	Q1 2001–Q3 2015
Latvia	Q1 2001–Q2 2015	Q1 2001–Q2 2015	Q1 2001–Q3 2015
Lithuania	Q1 2001–Q2 2015	Q1 2001–Q2 2015	Q1 2001–Q3 2015
Luxembourg	Q1 2001–Q2 2015	Q1 2001–Q2 2015	Q1 2001–Q3 2015
Netherlands	Q1 2001–Q2 2015	Q1 2001–Q2 2015	Q1 2001–Q3 2015
Poland	Q1 2001–Q2 2015	Q1 2001–Q2 2015	Q1 2001–Q3 2015
Portugal	Q1 2001–Q2 2015	Q1 2001–Q2 2015	Q1 2001–Q3 2015
Slovakia	Q1 2001–Q2 2015	Q1 2001–Q2 2015	Q1 2001–Q3 2015
Slovenia	Q1 2001–Q2 2015	Q1 2001–Q2 2015	Q1 2001–Q3 2015
Spain	Q1 2001–Q2 2015	Q1 2006–Q2 2015	Q1 2001–Q3 2015
Sweden	Q1 2001–Q2 2015	Q1 2008–Q2 2015	Q1 2001–Q3 2015
United Kingdom	Q1 2001–Q2 2015	Q1 2001–Q2 2015	Q1 2001–Q3 2015

Source: Eurostat database.