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The Impact of EU Accession on Farm Production in the Czech Republic: A Synthetic Control Method Approach*

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Abstract

Czech farmers experienced an enormous exogenous shock when they joined the common agricultural market (CAM) and the Common Agricultural Policy (CAP) in 2004. Using the World Bank's dataset, we apply the synthetic control method to establish a counterfactual case of the Czech Republic food production index in the absence of the CAM and CAP. The results show that the Czech Republic would have had a higher food index if it had not entered the CAM and CAP. Moreover, we show that the CAP and CAM had different impacts on farms in the Czech Republic and Bulgaria, which have the most comparable agriculture according to the results of the synthetic control method.

1. Introduction

The common agricultural market (CAM) has opened for the Czech Republic since it joined the EU in 2004. Moreover, the Czech agricultural sector had to incorporate the Common Agriculture Policy (CAP) with direct support for farms, known as decoupled subsidies from production (direct payments, agro-environmental measures (AEM), subsidies for less favourable areas (LFA) and rural development programmes (RDP)) and '*defined as subsidies in this article.*'[1] Therefore, entering the CAM and joining CAP are two important events that could be considered as an exogenous shocks for Czech farmers. This article aims to evaluate the effect of entering the CAM and joining the CAP on the production of farms.[2]

The purpose of decoupled subsidies was to make the farmers more market oriented. And therefore, to leave them freely decide what is the most profitable type of product in the market. There are several studies which aim on the evaluation of the effect of subsidies on farm level in the Czech Republic such as (Pechrová, 2013), (Pechrová & Vlasicova, 2013), (Čechura & Malá, 2014), (Doucha & Foltyn, 2008) and (Malá, Červená, & Antoušková, 2014). The objective of this article is to estimate the overall

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[1] See European Commission (2011) for detailed information about the CAP and direct payment scheme.

[2] We mean the food production index by production of farms. The World Bank defines the food production index as follows: 'Food production index covers food crops that are considered edible and that contain nutrients. Coffee and tea are excluded because, although edible, they have no nutritive value.'

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effect of joining the CAP and CAM on the country level. We contribute to the literature on the impact of joining the EU by analysing the development of food production. As far as we know, this paper is first to analyse the impact of joining the EU using the synthetic control method (SCM).

We use the SCM approach for its systematic way of choosing the comparison units in comparative case studies (Abadie & Gardeazabal, 2003). Furthermore, given the long adjustment period in the agricultural sector we treat joining the CAP and CAM as an idiosyncratic event for the farmers and therefore the SCM as a valid method to find the counterfactual development. However, using the SCM has several limits. The main shortcomings are related to the fact that the optimal result depends on a subjectively chosen subset of donors and covariate matrix (Amjad, Shah, & Shen, 2018). Moreover, the SCM performs poorly in the cases of missing data or strong levels of noise in the data set.

Using the World Bank dataset, we apply SCM to establish a counterfactual case of the Czech Republic food production index in the absence of the Common Agricultural Market and the Common Agricultural Policy.

The results show that Czech Republic would have had a higher food index if it had not entered the CAM and joined the CAP. Our findings could correspond to the findings of Esposti (2017). He evaluates the reform of CAP from the year 2005 on the Italian farmers production choice using the Farm Accountancy Data Network (FADN). His results show that the farm's response in terms of market (re)orientation happens but mostly in more subsidy sensitive farms. In addition, the response occurs both in terms of new production and in change of production mix.

Other study done by Brady, Kellermann, Sahrbacher, & Jelinek (2009) evaluates the decoupled scheme on the landscape mosaic. They investigate the change in Swedish, Italian and Czech regions. As for the Vysočina (the region in the Czech Republic) they claim that the landscape mosaic improved because the area of grains declined. They argue that it was mainly due to an increase in the relative profitability of intensive beef production, which need fodder crop. Our results are in line with their findings.

Furthermore, Baun, Kouba, & Marek (2009) examine the impact of CAP on the Czech Republic in terms of economic, social and political impact. They claim that Czech agriculture reported net profit in 2004 for the first time. Moreover, they add on p. 289 that EU membership has not led to rapid increase in agricultural wages, nor has it helped bridge the growing disparity between agricultural and non-agricultural wages.

There are two important facts worth mentioning when interpreting the results of our study. Firstly, the Czech food production remained quite stable after 2004. Gorton, Davidova, & Ratinger (2000) show that Czech cereal producers were competitive at the EU prices. As a result, we do not see a significant drop in the food index production.[3]

[3] On the other hand, Gorton, Davidova, & Ratinger (2000) show that Czech livestock production was not competitive at EU prices. As a result, total animal output decreased (see Figure 13).

Secondly, the results of SCM are mainly driven by Bulgaria, which entered the CAM and joined the CAP in 2007. The development of the agricultural sector in Bulgaria after joining the EU in 2007 differs from the one in the Czech Republic. We show that joining the CAP and the CAM had different impacts on Czech agriculture and Bulgarian agriculture. For example, while the number of small farms in the Czech Republic stayed relatively stable after joining the CAP and the CAM, there has been a sharp decrease in the number of small farms in Bulgaria. Furthermore, the low cost production of cereals remained relatively stable in the Czech case compared to the significant increase in the Bulgarian case.

We claim that the differences in reactions to joining the CAP and the CAM for both countries could arise from the level of subsidies. Both countries received almost the same level of subsidies per hectare (218 EUR/ha in Bulgaria and 258 EUR/ha in the Czech Republic). In terms of the GDP per capita, Czech citizens enjoyed almost twice as much as Bulgarian citizens. Therefore, the subsidies for Bulgarian farmers played a more important role than they did for Czech farmers. For Bulgaria, Ministry of Agriculture and Food (2009) studied the producers of vegetables, and found that farmers switched to lower value added crops, such as cereals, while they enjoyed high profits due to the subsidies. As a result, we suggest using objective criteria: adjusting the EU flat rate by the objective criteria based on economic, physical and/or or environmental indicators, as proposed by European Commission (2011), could serve as a plausible policy.

2. Evaluation of Subsidies and the Use of the Synthetic Control Method in the Literature

There are several articles related to the evaluation of the impact of the subsidies on Czech agriculture. For example, Pechrová (2015) uses stochastic frontier analysis to assess the impact of the subsidies on the technical efficiency of farms in the Liberec region. Based on her results, she demonstrates that subsidies lower farmers' engagement in efficient production. Čechura & Malá (2014) compare the technical efficiency of the diary industry between the Czech and Slovak Republics. They find that Czech farms are more technically efficient than Slovakian farms. Moreover, they show that farms that received subsidies achieved only 44.6% of the potential production compared to 60.4% for farms without subsidies. Other studies on the technical efficiency of farms were carried out by Pechrová (2013), Pechrová & Vlasicova (2013), Pechrová (2014) and Kroupová & Malý (2010). In general, they conclude that subsidies increase inefficiency.

Doucha & Foltyn (2008) study the profitability of farms receiving subsidies. They find that subsidies have a positive impact on farms' profitability. This is in line with Beránek (2014)'s findings. He studies the impact of subsidies on farms' economical performance and uses the descriptive statistics to show the changes in cost efficiency and rentability between different types of farms in the Czech Republic. His results show that subsidies significantly help farmers to earn a profit. Malá, Červená, & Antoušková (2014) study the overall impact of the Common Agricultural Policy on plant production in the Czech Republic. They construct a production function model from more than 100 agricultural holdings. Their results indicate that subsidies have a negative effect on the plant production of agricultural holdings in terms of output represented by the production in constant prices for the year 2005. Their model statistically verifies that one percent increase in direct payments means a fall in production of 0.185%.

Using the SCM, we contribute to the literature on this topic by exploring the hypothesis that the Czech agriculture would have higher food production if it had not entered the EU. However, the past CAP reforms were intended not to lead to the overproduction of agricultural commodities, but rather to enhance new opportunities for farmers and support their income.[4]

The SCM was introduced by Abadie & Gardeazabal (2003), Abadie, Diamond, & Hainmueller (2010) and Abadie, Diamond, & Hainmueller (2015) to answer the question about finding the counterfactual development of a treated unit. In general, the SCM assigns weights to control units so that these units best fit the pre-treatment characteristics of the treated unit. Recently, the SCM was used for various topic in economics. Firpo & Possebom (2017) used the SCM for their study list and this method has been used for many topics, such as trade liberalization (Billmeier & Nannicini (2013), Gathani, Santini, & Stoelinga (2013) and Hosny (2012)) or political reforms (Billmeier & Nannicini 2009, Carrasco, de Mello, & Duarte 2014.

Since the introduction of SCM there has been several articles that extends the SCM. For example Acemoglu, Johnson, Kermani, Kwak, & Mitton (2016) and Cavallo, Galiani, Noy, & Pantano (2013) modify SCM in the way that more than one treated unit could be used to assess the intervention effect. Another extension was proposed by Wong (2015), where he applies SCM to cross sectional setting and derives the synthetic control asymptotic distribution when the number of individuals in the sample goes to infinity.

Kreif, Grieve, Hangartner, Turner, Nikolova, & Sutton (2016) examine SCM in contrast with Difference–in–Difference method in the health policy context. They find that in contrast to the DiD method, for the incentivised condition, SCM reports that pay–for–performance (P4P) initiative did not significantly reduce mortality. Furthermore, their study supports the concerns of Abadie (2005) that the major assumption underlying the DiD approach may not be feasible in settings where there are large differences in outcome between the control groups in pre-intervention period.

The developing of new inference procedures of SCM or modifying those originally developed by Abadie, Diamond, & Hainmueller (2010) and Abadie, Diamond, & Hainmueller (2015) designate an important research topic. Their original inference procedures consist of estimating p-values through permutation tests. Using this procedure, they test the null hypothesis of no effect of the intervention. Ando & Ando (2015) design two new test statistics that have more power when applied to test the null hypothesis than the those introduced by Abadie, Diamond, & Hainmueller (2010) and Abadie, Diamond, & Hainmueller (2015).

Another inference procedure that uses confidence intervals was proposed by Gobillon & Magnac (2016). They use a bootstrap technique to compute confidence intervals for the policy effect on more than one treated unit. To obtain valid results, a large number of treated and control regions are necessary. The issue regarding the validity of confidence intervals for a small number of control units was solved by

[4] We thank to anonymous referee for this valuable comment.

Firpo & Possebom (2017). They extend the original inference procedures in a way that allows for different treatment assignment probabilities across the units – any region could have a different probability to face the intervention of interest. Moreover, their modified inference procedure allows for testing any kind of sharp null hypothesis – any other from the null hypothesis of no effect proposed by Abadie, Diamond, & Hainmueller (2010) and Abadie, Diamond, & Hainmueller (2015).

Finally, their inference procedure allows for the construction of confidence intervals for the post-intervention outcome as any function of time. We use the modified inference method of Firpo & Possebom (2017) to show that the production of Czech farms would have been higher if the Czech Republic had not joined the CAM and the CAP.

3. Synthetic Control Method

This section is subdivided into three parts.The first one presents the data used for the analysis,while the second and third ones describe the synthetic control method and its inference procedure,respectively.The notation and ideas mainly follow those of Abadie,Diamond,& Hainmueller (2010) and Abadie,Diamond,& Hainmueller (2015).

3.1 Control Units

The data set used to analyse the impact of joining the CAM and CAP is based on the World Bank's agricultural database. The fact that many potential control countries joined the CAM and CAP in 2004 lead us to use the following control set: Belarus, Bulgaria, Croatia, Georgia, Romania, Turkey and the Ukraine. Moreover, Bulgaria and Romania joined the CAM and CAP in 2007.Therefore,we use the time span between 1995 and 2007; however, we show the results for the latest available data (until 2016).We show that the SCM results for the latest available data may be upward biased because of the performance of Bulgarian agriculture.

We choose the Food Production Index (covers only food crops) as our outcome variable and as covariates, Cereals' Yield, Final Consumption Expenditures, the Livestock Production Index, the Crop Production Index, Arable Land (% of Land Area), Trade Share (as a % of GDP), Agriculture Forestry and Fishing Added Value, Foreign Direct Investment Net Inflows, Adjusted Net National Income, GDP per capita, Inflation, Unemployment and Rural Population. For details, see Table A1 and Table A2 in the Appendix for the descriptive statistics of the variables for the periods until 2007 and the whole period, respectively. These covariates reasonably reflect the national agricultural sector as well as the development of the economy.

For describing the development of agriculture in control units, we use the Eurostat database, which allow us to find more details about the number of holdings, the utilized agricultural area (UAA) and the average level of subsidies per hectare

3.2 Methodology

Suppose that we gather data for $J + 1$ countries. Let us assume that only the first country continuously faces the intervention of interest from period $t_0 \in \{1, \dots, T\}$ Abadie, Diamond, & Hainmueller (2010). Therefore, there are J countries remaining as eventual control units that are not influenced by the intervention. Let

Y_{it}^N denote the potential outcome of interest in the absence of the intervention for country *i* in period *t*, where $i \in \{1, \ldots, J+1\}$ and $t \in \{1, \ldots, T\}$.

Consequently, let T_0 be the number of pre-intervention periods fulfilling the condition $1 \leq T_0 \leq T$. Depending on the anticipation effect of the intervention, T_0 can be reset to the period when the first effect of the intervention is assumed to appear Abadie, Diamond, & Hainmueller (2015). Let Y_{it}^I denote the outcome of interest affected by the intervention for country i in period $t \in \{1, \ldots, T\}$. Naturally, we assume that the intervention has no effect on the outcome in pre-intervention periods; therefore, $Y_{it}^N = Y_{it}^I$ for $t \in \{1, \ldots, T_0\}$. The effect of the intervention with $t > T_0$ is represented as follows:

$$\upsilon_{it} = Y_{it}^I - Y_{it}^N \tag{1}$$

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 $w = \{w_2, \ldots, w_{J+1}\}$ with $0 \leq w_j \leq 1$ for $j = 2, \ldots, J+1$ and

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

These restrictions are made to avoid an extrapolation Abadie & Gardeazabal (2003). Using the given weights $\{w_2, \ldots, w_{J+1}\}$, the synthetic control estimators of Y_{it}^N and υ_{it} are:[5]

$$\hat{Y}_{it}^N = w_2 Y_{2t} + \cdots + w_{J+1} Y_{J+1,t}$$

$$\hat{\upsilon}_{it} = Y_{it}^I - \hat{Y}_{it}^N$$

The next step is to choose the weights $\{w_2, \ldots, w_{J+1}\}$. According to Abadie & Gardeazabal (2003), the weights should best reflect the pre-intervention characteristics of the treated unit. Abadie, Diamond, & Hainmueller (2010) choose $w^* = \{w_2^*, \ldots, w_{J+1}^*\}$, which minimizes:

$$v_1(X_{11} - w_2 X_{12} - \cdots - w_{J+1} X_{1,J+1})^2 + \cdots + v_k(X_{k1} - w_2 X_{k2} - \cdots - w_{J+1} X_{k,J+1})^2 \tag{2}$$

v_1(where $\{v_1, \ldots, v_k\}$ represents the relative importance of the synthetic control assigned to predictors $\{X_{11}, \ldots, X_{k,J+1}\}$. Therefore, the problem comes down to choosing $\{v_1, \ldots, v_k\}$. As in most empirical studies using the SCM, the weights $\{v_1, \ldots, v_k\}$ are chosen to minimize the size of the prediction error, $Y_{it}^I - \hat{Y}_{it}^N$, in a selected pre-intervention period.[6] This can be done by solving a nested optimization problem with *v* selected, so that *w* minimizes the root mean square predicted error

[5] See Abadie, Diamond, & Hainmueller (2010), where it is proved that $\hat{\upsilon}_{it}$ is an unbiased estimator of υ_{it}.
[6] See Abadie, Diamond, & Hainmueller (2011), which describes other approaches for choosing the weights $\{v_1, \ldots, v_k\}$

(RMSPE) during a selected periods.[7] Therefore, each choice of v results in a different country weight $w(v)$, which then gives a value for the RMSPE.

To precisely minimize RMSPE, control units need to fulfil the following conditions. First, the country that adopted the similar intervention should be excluded from the data set to avoid potential bias in the output. For this reason, we omitted countries that joined the CAM and CAP in 2004 and countries that were already members of the EU. Furthermore, Bulgaria and Romania joined the CAM and CAP in 2007; therefore, we show the results for the whole period (1995-2016) and between the years 1995-2007. Furthermore, we exclude Bulgaria from the control units, which results in a poor pre-intervention fit (see Figure A1 in the Appendix). Therefore, in the result section we limit the post-intervention period rather than the control units.

Second, for a good fit of the counter-factual outcome, there is a need for comparison units to have similar economic performance to a unit exposed to the intervention. Taking this assumption into account, we consider post-Soviet countries, Balkan countries and Turkey as suitable comparison units. Moreover, countries that may be affected by the intervention in the "treated" country should be excluded from the sample Abadie, Diamond, & Hainmueller (2015). Since the fact that each country from the control group represented less than 1% of Czech total export in the year 2004, we consider negligible effect of the entrance of Czech Republic in CAM and CAP on control units.

3.3 Inference Procedures

This empirical study uses three inferential methods for the SCM. Two of these methods were initially introduced by Abadie & Gardeazabal (2003), in which they run "placebo" effects. The third method is based on constructing a confidence interval, which was briefly used in Opatrny, 2017. However, the later study of Firpo & Possebom (2017) provides a theoretical background for setting the confidence intervals. Additionally, we use the common difference-in-difference method to confirm the results of the SCM. As Kreif, Grieve, Hangartner, Turner, Nikolova, & Sutton (2016) stress that the main distinction between these two methods is that DiD estimation assumes the constant effect of unobserved confounders over time, the synthetic control method allows for changes in those effects over time. This is the main reason for using the SCM in this study. However, both methods are used to evaluate the effect of the *treatment*.[8]

The first inference method that uses the SCM to construct a placebo study suggests applying the synthetic control method to all control units. In this way, we obtain a synthetic control for the 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 was used to estimate a large effect to a unit where the intervention was not set up. Formally, for each country $i \in \{1, \ldots, J+1\}$ and period $t \in$

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[7] The RMSPE has the following formula: $RMSPE = (\frac{1}{T_0}\sum_{t=1}^{T_0} (Y_{1t} - \sum_{j=2}^{J+1} w_j^* Y_{jt})^2)^{\frac{1}{2}}$

[8] For example, see the study Zhou, Taber, Arcona, & Li (2016) for a formal description of the method.

$\{T_0, \ldots, T\}$, Abadie, Diamond, & Hainmueller (2015) compare the effect of the intervention in the treated country, $\hat{v}_{it}$, with the effect of the intervention in control units $\hat{v}_{it}$. To solve the problem that $|\hat{v}_{1t}|$ could be atypically larger than $|\hat{v}_{it}|$ for some periods but not for others, they suggest using the distribution of following statistic:

$$RMSPE_i := \frac{\sum_{t=T_0+1}^{T} (Y_{it} - \hat{Y}_{it}^{N})^2/(T - T_0)}{\sum_{t=1}^{T_0} (Y_{it} - \hat{Y}_{it}^{N})^2/(T_0)} \tag{3}$$

Due to the equation 3, they were able to compute a p-value:

$$p := \frac{\sum_{i=1}^{J+1} D_i}{J+1}, \tag{4}$$

where D_i equals 1 if $(RMSPE_i \geq RMSPE_1)$. Therefore, Abadie, Diamond, & Hainmueller (2015) could reject the null hypothesis of no effect of the intervention if p is less than some prespecified significance level.

However, Firpo & Possebom (2017) claim that how the p-value is designed in equation 4 implicitly assumes the uniform distribution of the probability of being treated. Therefore, their extension of the inference method suggests a parametric form of treatment probabilities. For $\bar{\imath} \in \Omega := \{(1), \ldots, (J+1)\}$, such that $RMSPE_{(1)} > RMSPE_{(2)} > \ldots > RMSPE_{(J+1)}$and $RMSPE_{\bar{\imath}} = RMSPE^{obs}$- if there is more than one $i' \in \Omega$ with that property, Firpo & Possebom (2017) propose to choose the largest one.

They define the treatment probabilities as

$$\pi_{(i)}(\phi) = \frac{\exp\left(\phi v_{(i)}\right)}{\sum_{i' \in \Omega} \exp(\phi v_{i'})}, \tag{5}$$

where $\phi \in R_+$ is the sensitivity parameter and $v_{i'} \in \{0,1\}$ for each $i' \in \Omega$. This provides an intuitive way to analyse the sensitivity of the parameter to deviations from the uniform distribution assumption. For example, the interpretation of ϕ is as follows: a unit $i_{(1)} \in \Omega$ with $v_{(i1)} = 1$ has $\Phi := exp(\phi)$ times higher probability to be treated than unit $i_{(2)} \in \Omega$ with $v_{(i2)} = 0$ (Firpo & Possebom, 2017).[9] Due to the assumption 5, they use the following formula for computing the p-value:

$$p(\phi, v) := \sum_{(i) \in \Omega} \frac{exp(\phi v_{(i)})}{\sum_{i' \in \Omega} exp(\phi v_{i'})} D_i, \tag{6}$$

where D_i equals 1 if $(RMSPE_{(i)} \geq RMSPE_{\bar{\imath}})$ and $v := (v_1, \ldots, v_{J+1})$. This allows us to reject the exact null hypothesis if $p(\phi, v)$ is less than some prespecified significance level.

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[9] See section 3 in Firpo & Possebom (2017) for the details.

In the empirical section below, we use the Firpo & Possebom (2017) approach. Using the time span 1995-2016, the Czech Republic obtains the highest RMSPE score. Given the fact that $(J + 1) = 8$, the probability that any control unit would receive the same treatment effect reaches a maximum of 1/8. This equals the p-value of 0.125 according to the equation 4 proposed by Abadie, Diamond, & Hainmueller (2015). Applying the standard rejection rule when the p-value equals 0.1, we do not reject the exact null hypothesis H_0: There is no effect of the intervention, $Y_{1t}^N = Y_{1t}^I$ for $t \in \{1, \dots, T\}$.

However, the restriction made by the number of control units resulting in the minimum p-value of 0.125 may lead to a type II error – H_0 is false, and we do not reject it. When we apply the sensitivity analysis that allows us to vary the parameter ϕ, we have to set $\phi = 1.1$ to reject the H_0 at the 10% significance level. As Firpo & Possebom (2017) suggest, when the exact null hypothesis, H_0, is false and we do not reject it, we want the sensitivity parameter $\phi \in R_+$ to be small because a more robust result could keep us from making a type II error. We argue that $\phi = 1.1$ is reasonably small according to section 5.2 in Firpo & Possebom (2017). In conclusion, our result indicates that H_0: There is no effect of the intervention, $Y_{1t}^N = Y_{1t}^I$ for $t \in \{1, \dots, T\}$ may be false.

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, Diamond, & Hainmueller (2015) mention, a large placebo estimate would undermine the credibility of the result. For example, if there is a significant effect of the intervention in an earlier period, the confidence of the effect would greatly diminish.[10]

The third method is based on the construction of a confidence interval. As mentioned earlier, in the study conducted by Opatrny (2017), they used the point-wise confidence intervals. Using the original RMSPE computed by the SCM, we derived the respective confidence sets for the outcome Y_{1t}^N in the postintervention periods $t \in \{T_0, \dots, T\}$.[11] In this empirical research, we use the confidence sets proposed by Firpo & Possebom (2017). They provide the theoretical background for the confidence sets with constant and linear in the time intervention effects. As for the linear in the time version, they assume

$$H_0': Y_{it}^I = Y_{it}^N + (\hat{c} \times (t - T_0))D_t, \tag{7}$$

for each unit $i \in \{1, \dots, J+1\}$ and time period $t \in \{1, \dots, T\}$, where D_t equals 1 if $t \geq T_0 + 1$ and $\hat{c} \in R$.[12] Therefore, Firpo & Possebom (2017) assume constant in space, but linear in time intervention effect. Moreover, they suggest that we can apply the inference procedure described earlier in this section 3.3 to the empirical distribution of $RMSPE^{\hat{c}}$ as a test statistic.[13] Consequently, the $(1 - \gamma)$ – the confidence interval for the linear in time intervention effect – becomes

[10] We can choose random periods prior to the intervention.
[11] The formula mentioned in the footnote in section 3.2.
[12] For constant in time intervention, they exclude the term $(t - T_0)$ from equation 7.
[13] The inference procedure is mentioned as *the first method*.

$$CI_{(1-\gamma)}(\phi, v) := \begin{Bmatrix} f \in R^{\{1,\dots,T\}}: f(t) = \left(RMPSE^{\hat{c}} \times (t - T_0)\right) * D_t \\ and \quad p^{\hat{c}}(\phi) > \gamma \end{Bmatrix} \subseteq CI_{(1-\gamma)}(\phi, v), \qquad (8)$$

where $\gamma \in (0,1) \subset R$. Intuitively, as Firpo & Possebom (2017) state, the confidence interval contains all linear in time intervention effects, for which H_0' is not rejected by the inference procedure described earlier in this section 3.3.

4. Synthetic Outcome Is Better than the Real One

In Figure 1a, we can see that the synthetic output outperforms the real one by almost 25 points in the year 2016. In other words, the food production index would have been higher if the Czech Republic had not joined the CAP and CAM in 2004.[14] However, the results are mainly driven by the output of Bulgarian agriculture, which obtains the weight of 0.55 by the synthetic control method. Other synthetic controls are Turkey and Croatia with weights of 0.27 and 0.18, respectively.

As we mentioned earlier, Bulgaria joined the CAP and CAM in 2007; therefore, in Figure 1b, we show the result for the period until 2007. We can see that the synthetic output would have been higher, albeit not statistically significant, as we show below (see Figure 3b). Moreover, in the year 2007, the grain harvest was hit by unusual drought and floods in Bulgaria. The maize production achieved only one-sixth of the previous year's harvest and wheat only two-thirds of the previous year's production (Oxford Business Group, 2008). Therefore, for the purpose of setting the synthetic outcome for the short postintervention period 2005-2007 in Figure 1b, we put the average of the food index from years 2006 and 2008 as the observation for the year 2007.

Figure 2 shows the estimation of the intervention effect for the Czech Republic and the control units.[15] We can see that the intervention effect does not abnormally differ from that of the other control region (Figure 2a). Using Abadie, Diamond, & Hainmueller (2010) and Abadie, Diamond, & Hainmueller (2015)'s approach, the p-value equals 0.125, implying not to reject the null hypothesis H_0': There is no effect of joining the CAP and CAM on the food production index in the Czech Republic.[16] However, when we apply the sensitivity analysis proposed by Firpo & Possebom (2017) as we show below, the results may suffer from a type II error – H_0' is false, and we do not reject it.

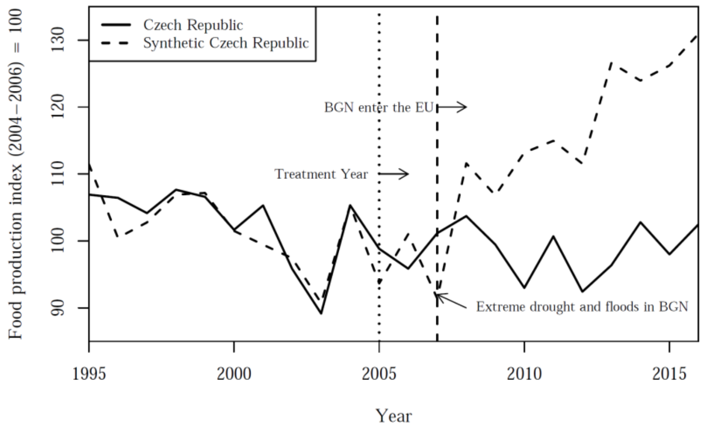
As Abadie, Diamond, & Hainmueller (2010) and Abadie, Diamond, & Hainmueller (2015) point out, we should exclude the control units having a poor pre-intervention fit (they suggest units which have pre-intervention RMSPE five times larger than the Czech pre-intervention RMSPE); therefore, we exclude Bulgaria, Croatia and Georgia (Figure 2b). As Firpo & Possebom (2017) claim, placebo studies for these units are not informative about the relative rarity of the post-intervention

[14] We set the treatment to the year 2005 because the effects (i.e receiving subsidies) of joining the CAM and CAP were fully revealed in that year.
[15] We apply this inference method for the period 1995-2007; however, due to a small number of postintervention periods, we do not draw any conclusion.
[16] Computing the p-value is described in section 3.3 by equation 4.

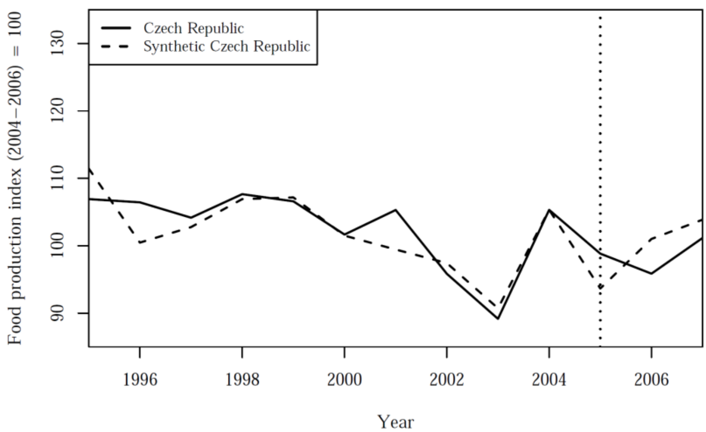
effect for the Czech Republic. In this case, the p-value is equal to 1/5; however, the small number of control units does not allow us to draw any absolute conclusion.

Figure 1 Synthetic Output Outperforms the Real One

(a) Whole Period



(b) Period until 2007*

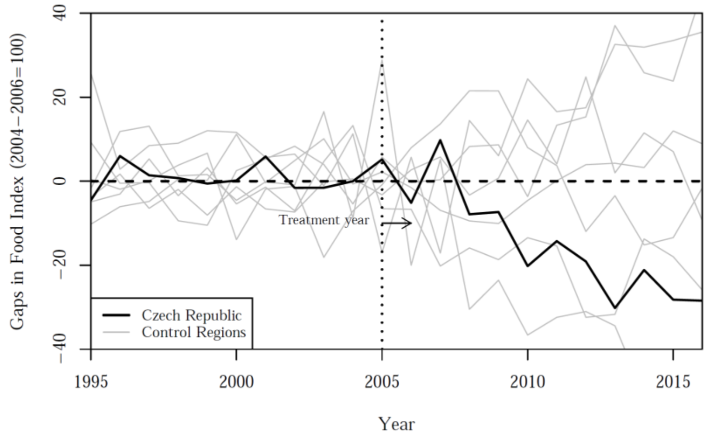


Notes: *We use the average of the food production index from years 2006 and 2008 as the observation for the year 2007.

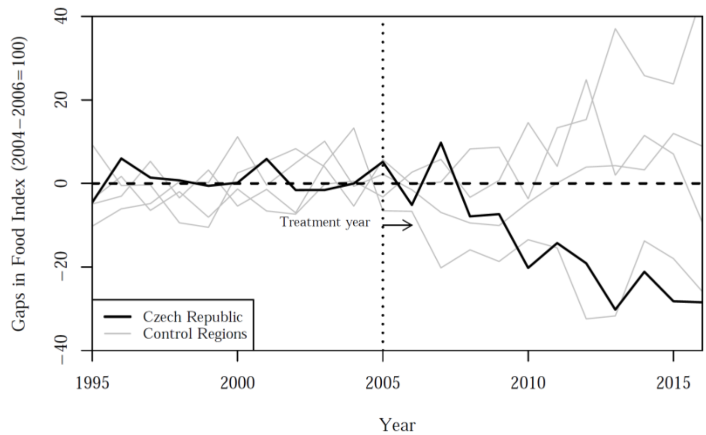
Source: Author's computation based on the World Bank's dataset.

Figure 2 Intervention Effect Does Not Look Abnormally Large in the Czech Republic

(a) Full Set of Control Units



(b) Control Units with Good Pre-intervention Fit



Source: Author's computation based on the World Bank's dataset.

In Figure 3 below, we show the statistical significance of the results. Intuitively, if the confidence interval does not include the zero function, we reject the null hypothesis H0′: There is no effect of joining the CAP and CAM on the food production index in the Czech Republic.[17] Since we have 8 control units, and the Czech Republic obtains the highest RMSPE ratio, our significance level can be a maximum of 1/8 (87.5%). In other words, using Abadie, Diamond, & Hainmueller (2015)'s explanation, the probability that one would obtain the same result reaches 1/8.

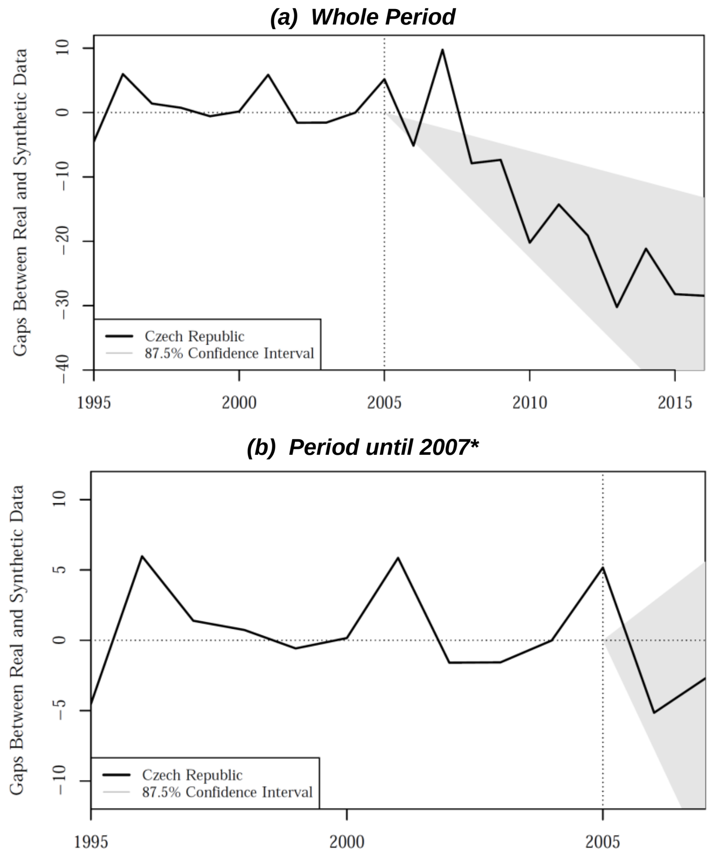
Regarding the whole period (1995-2016, Figure 3a), we can conclude that there is a statistically significant negative effect of joining the CAP and CAM at the

[17] Formally described in equation 7.

87.5% significance level. Since we need at least a standard 90% significance level for a robust conclusion, we cannot reject the null hypothesis H0′: There is no effect of joining the CAP and CAM on the food production index in the Czech Republic. As we mentioned in section 3.3, when we apply the sensitivity analysis proposed by Firpo & Possebom (2017), we have to set $\phi = 1.1$ to find the confidence set at the 90% significance level. Since the value of the parameter ϕ is reasonably small, we conclude that the results may suffer from a type II error – H0′ is false, and we do not reject it.

The fact that the outcome exceeds the confidence interval in the year 2007 is caused by the poor grain harvest in Bulgaria, which was described earlier. Regarding the period until 2007 (Figure 3b), the 87.5% confidence interval includes the zero function. However, the short post-intervention period does not allow us to draw any absolute conclusion.

Figure 3 The Synthetic Outcome Significantly Outperforms the Real One



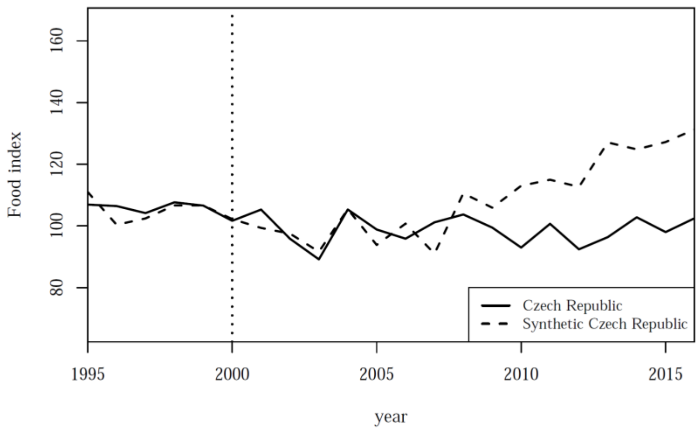
Notes: *We use the average of the food production index from years 2006 and 2008 as the observation for the year 2007.

Source: Author’s computation based on the World Bank’s dataset.

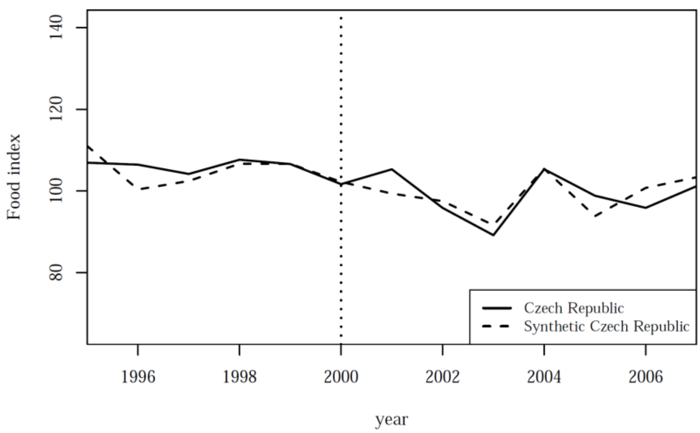
In Figure 4, we reassign the intervention period to the year 2000 (indicated as a dotted line on Figure 4). We can see that the synthetic output is almost identical to the one in Figure 1 for both periods, 1995-2016 (Figure 4a) and 1995-2007 (Figure 4b). This result suggests that by changing the intervention year to 2000, we obtain the same synthetic output as with the true intervention year. Therefore, as Abadie, Diamond, & Hainmueller (2015) point out, this placebo study does not undermine the credibility of the result.

Figure 4 There Is No Significant Effect of the Intervention in an Earlier Period

(a) Whole Period



(b) Period until 2007*



Notes: *We use the average of the food production index from years 2006 and 2008 as the observation for the year 2007.

Source: Author's computation based on the World Bank's dataset.

Finally, we use the DiD method to check the robustness of the results obtained by the SCM. Table 1 demonstrates the results for the food production index in both periods. The first column describes the name of the variables. The second column shows the values for the whole period, while the third column shows the values for the period until 2007. We do not observe a significant difference between the Czech Republic and the control units during the whole period (see the row Treated).

On the other hand, when we control for the intervention year, we can see that the food production index for all control units significantly increased after the year 2005 (see the row Year after 2005) for the whole period but not for the period until 2007. This result indicates that after the year 2005, the average food production index went up for the control units. We can see an increase in the food production index, especially in Bulgaria, after 2007, which may be influenced by the different reaction of joining the CAP and CAM by Bulgarian farms, as we show below.

Finally, when we control for the intervention year and the output of the Czech Republic (see the row Treated*Year after 2005), there is a significant drop in the food production index during the whole period but not in the period until 2007. In conclusion, this result corresponds with the results obtained by the SCM.

Table 1 Difference in Difference Method Confirms Synthetic Control Method Results

	Whole period	***Period until 2007*******
Intercept	95.62***	95.62***
	(1.98)	(1.38)
Treated	7.28	7.28
	(5.59)	(3.89)
Year after 2005	14.61***	3.40
	(2.68)	(2.86)
Treated*Year after 2005	−18.79*	-7.69
	(7.57)	(8.10)
R^2	0.15	0.04
Adj. R^2	0.14	0.01
Num. obs.	176	104
RMSE	16.54	11.51

Notes: $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, the variable of interest is the food production index

****We put the average of food production index from years 2006 and 2008 as the observation for the year 2007.

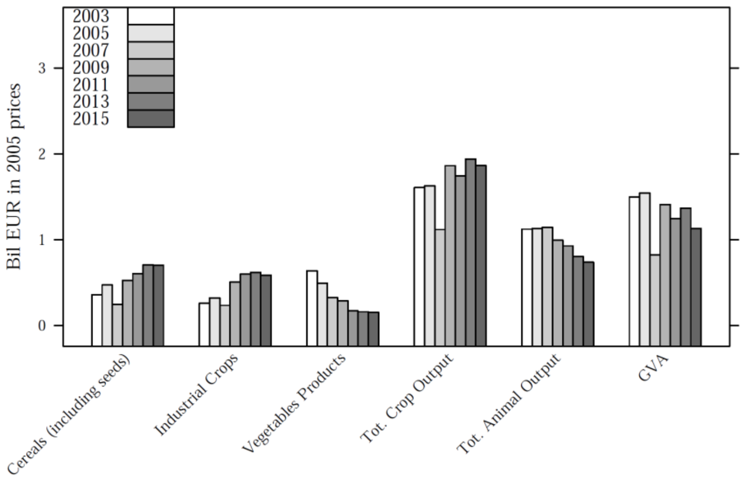
Source: Author's computation based on WorldBank dataset.

5. Bulgaria Reacted Differently to the CAP and CAM

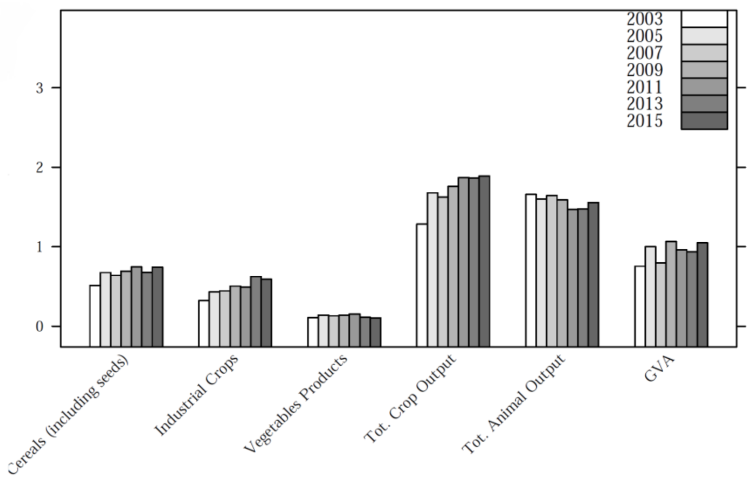
The fact that Bulgaria receives the highest weight naturally leads us to compare Bulgarian and Czech agriculture before and after joining the CAM and CAP. The Figure 5 below indicates several important facts about both countries. First, Bulgaria and the Czech Republic share similar values for the total crop output before joining the CAM and CAP. Moreover, the value of industrial and cereal production has an upward trend in both countries.

Figure 5 Bulgaria Has Low GVA After 2007

(a) Bulgaria



(a) Czech Republic



Source: Eurostat dataset.

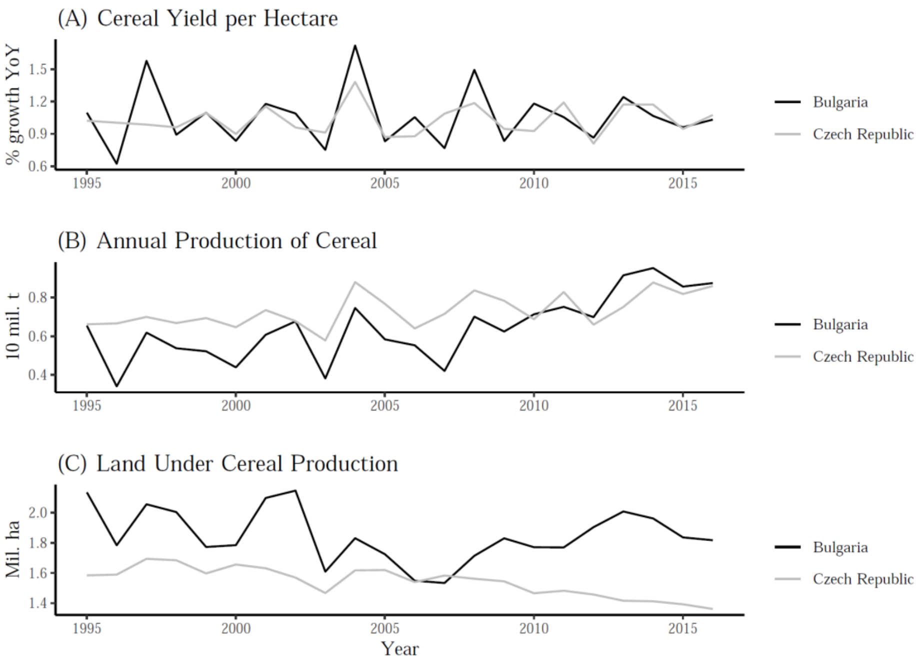
This trend is stronger in Bulgaria, especially, after joining the CAM and CAP. Second, the value of total animal output has a decreasing trend in both countries.[18] As before, this trend is stronger in Bulgaria after the year 2007. Consequently, the value of vegetable products sharply decreases in Bulgaria during the whole period compared to the stable value of vegetable production in the Czech Republic.

[18] As Gorton, Davidova, & Ratinger (2000) point out, the reason for this could be that the Czech and Bulgarian animal producers were not competitive at EU and world prices.

Finally, while the gross value added (GVA) of agricultural output (measured as total output minus intermediate consumption) has a declining trend in Bulgaria, it has a slightly increasing trend in the Czech Republic. All the mentioned facts indicate that there could be a different impact of joining the CAP and CAM on farmers' production for comparable countries such as Bulgaria and the Czech Republic.[19] These two countries responded differently to the CAP and CAM.

The fact that Bulgaria shows a remarkably increasing trend in the value of cereal production after 2007 motivates us to investigate the production of cereals in both countries; see Figure 6.

Figure 6 Bulgarian Production of Cereals Increased after 2007



Source: Author's computation based on the World Bank's dataset.

While the cereal yield growth per hectare remains similar for both countries, the annual production of cereal in Bulgaria overtakes that in the Czech Republic after the year 2007. Furthermore, we can see that there is a sharp increase in land under cereal production in Bulgaria compared to that of the Czech Republic. This result implies that farmers in Bulgaria increased the growing of low value added cereal after the year 2007 compared to the Czech Republic. This result is in line with the comment on vegetable production in Bulgaria noted in Ministry of Agriculture and Food (2009) p. 15: *"The adopted method of direct subsidising of land has also got a negative impact on this process, as it forces the agricultural producers to move onto*

[19] Moreover, as Gorton, Davidova, & Ratinger (2000) point out, the Czech and Bulgarian cereal producers were competitive at world and EU prices before joining the CAP and CAM.

production of lower value added crops per unit of land. In 2009, approximately 98% of the vegetable production is realized, as a large part of it is market oriented (72%)." We do not see this pattern in the Czech Republic after it joined the CAP and CAM.

Another difference between Bulgarian and Czech agriculture is summarized in Figure 7. We can see a significant drop in the number of Bulgarian holdings with less than 2 hectares after the year 2007 (see Figure 7a). On the other hand, we can see a light increase in the number of holdings with more than 100 hectares. Consequently, while the Utilized Agriculture Area (UAA) decreases for holdings with less than five hectares, it considerably increases for holdings with more than 100 hectares (Figure 7c). This result implies that small holdings go out of business, especially after the year 2007.

In the case of the Czech Republic, we see a slight increase in the number of holdings with more than 100 hectares (Figure 7b). However, we do not see any remarkable change in the UAA indicator (Figure 7d). Put differently, there is not any significant effect of joining the CAP and CAM on the number of holdings or the UAA indicator in the Czech Republic.

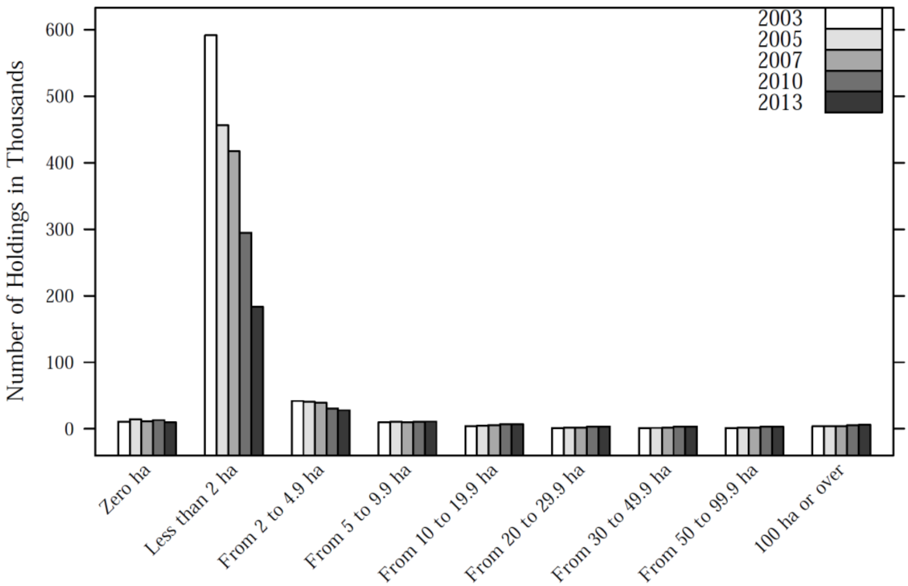
Given all the mentioned facts, we address the question of what could cause the different behavior of farmers after joining the CAP and CAM under the same policy. We claim that the absolute amount of direct payments per hectare could be one of the triggers for the different reactions to joining the CAM and CAP. Figure 8 shows the average amount of EUR per hectare on the vertical axis and GDP per capita in purchasing power standards (PPS) on the horizontal axis.

We can see that the Czech Republic appears in the upper right-hand corner, meaning that the Czech Republic is relatively rich and receives relatively large subsides in comparison with other countries. On the other hand, Bulgaria appears on the upper left side, meaning that Bulgaria is a relatively poor country but receives relatively large subsidies. Furthermore, the level of subsidies per hectare is comparable between the Czech Republic and Bulgaria, 258 EUR/ha and 218 EUR/ha, respectively. Therefore, Bulgaria received 84% of the Czech subsidies, while it had only 47% of the Czech GDP per Capita in PPS when joining the CAP and CAM. Moreover, as Scotti, Bergmann, Henke, & Hovarka (2011) show in their report, direct payments have the greatest influence on the overall farm income level per labor unit (weighted average for period 2004-2007, expressed in PPS) in the case of field crops.[20]

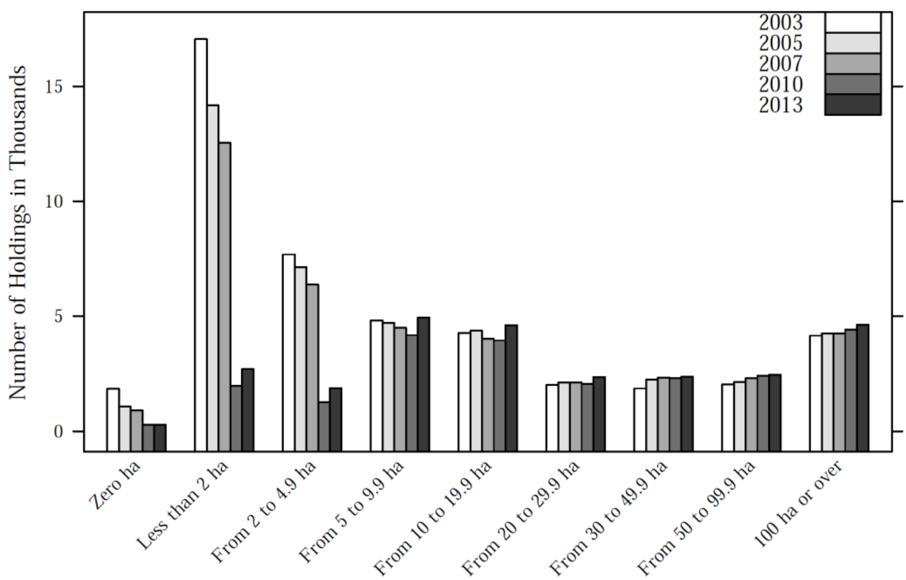
[20] See Table 15 on page 106 in the report of Scotti, Bergmann, Henke, & Hovarka (2011).

Figure 7 Bulgaria Has a Higher Increase in the Number of Large Farms and Its Utilized Agriculture Area Than the Czech Republic

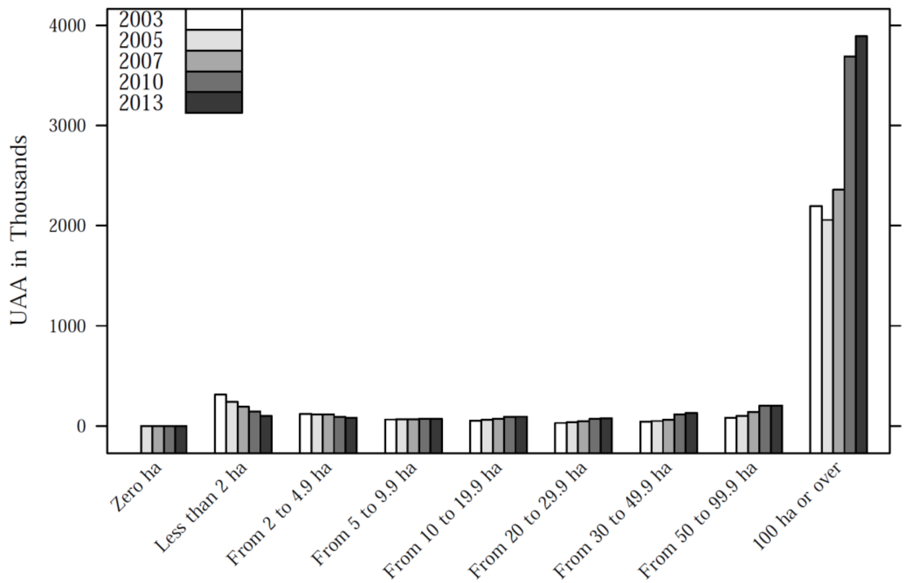
(a) Bulgaria



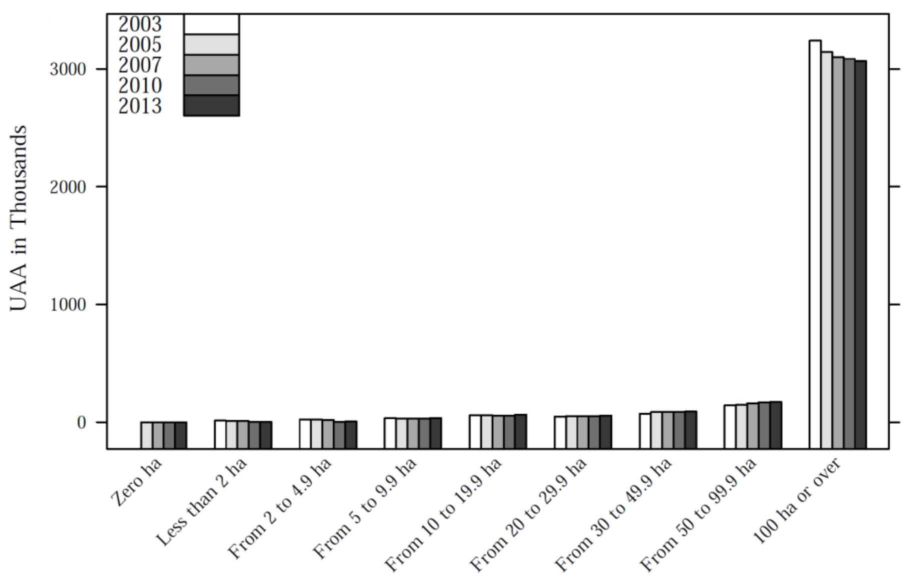
(b) Czech Republic*



(c) Bulgaria



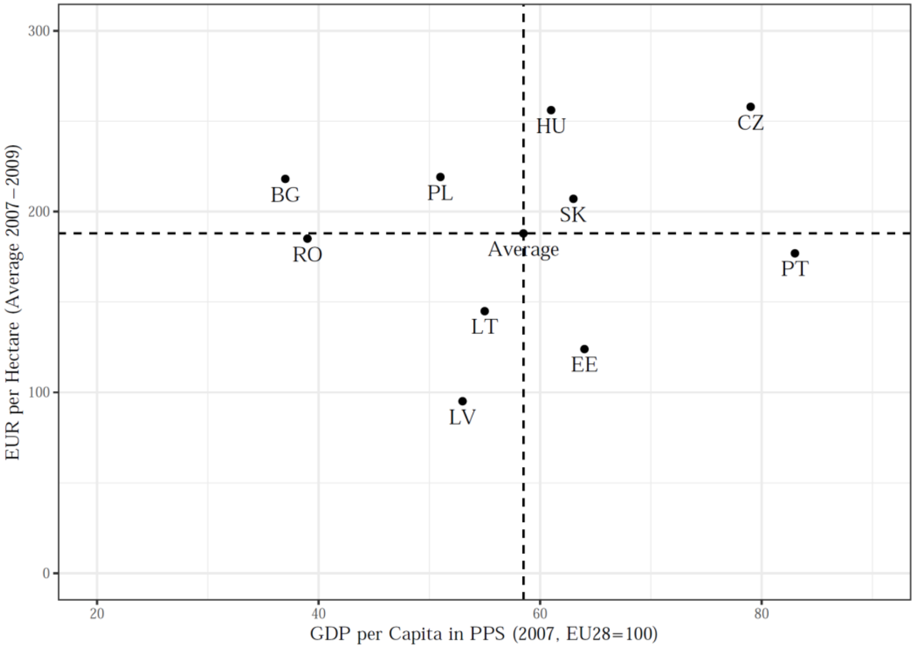
(d) Czech Republic



Notes: * The methodology for computing the number of holdings significantly changed in 2010; see Quality Reports Structure. Therefore, Figure 7b shows a significant drop in the number of holdings in 2010, which in fact, did not occur.

Source: Eurostat dataset.

Figure 8 Poor Bulgaria Receives Almost the Same as Rich Czech Republic



Note by Eurostat: simplified calculation of average direct payments based on the national envelopes of Member States after full phasing-in of direct payments in the EU-12 and the number of potentially eligible hectares communicated by MS in the Integrated Administration and Control System (IACS) for 2008 claim year.

Source: Eurostat dataset.

In conclusion, this result implies that the level of the direct payments in Bulgaria could help increase the production of low value added cereals, as we have shown above.

In the document *CAP towards 2020 Impact Assessment*, European Commission (2011) analyse the different possibilities for the redistribution of the direct payments per hectare in European countries. They assess four options European Commission (2011) (p.19):

- An ″EU flat rate″: direct payments are distributed on the total potentially eligible hectares across member states.
- A pragmatic approach: limited adjustment in the existing distribution to avoid major disruptions to current DP levels, while setting an EU-wide minimum level of per ha payment based on the share of the EU average.
- The use of objective criteria: the EU flat rate is adjusted by objective criteria based on economic, physical and/or or environmental indicators.
- A combination of the pragmatic approach and the objective criteria.

While the document *CAP towards 2020 Impact Assessment* assesses all options in detail at the microeconomic level for each European country, in the case of the Czech Republic and Bulgaria, we tried to show the length and modalities of a transition to the direct payment scheme. The direct payments in these countries satisfy their main goal to ensure that farmers can make a reasonable living. However, in the case of Bulgaria, we can see a strong move towards the production of low value added cereals and a significant drop in the number of small farms compared to the stable situation in the Czech Republic.

This leads to the conclusion that the way that the CAP was set up in Bulgaria did not satisfy the goal of the CAP to keep the rural economy alive by promoting jobs in farming, agri-food industries and the associated sectors mainly because of the drop in the number of small farms.[21] Therefore, to use the objective criteria based on economic, physical and/or environmental indicators, which would decrease the absolute amount of the subsidies in Bulgaria, and as a consequence, could nudge the farmers towards the production of higher value added goods, which would serve as a better tool to achieve the goal of keeping the rural economy alive with diversified products.[22] Nevertheless, to research the optimum level of subsidies for each country that would lead to achieving the goals of the CAP is beyond the scope of this article.

6. Conclusion

We examine the impact of joining the CAP (with subsidies as its main tool) and the CAM on the food production index in the Czech Republic. By using the synthetic control method developed by Abadie & Gardeazabal (2003), we establish the synthetic outcome and identify the effect of joining the CAM and CAP by comparing the synthetic outcome with its real counterpart. We use Firpo & Possebom (2017)'s approach to assess the inference method from the SCM. Moreover, due to the fact that Bulgaria receives the highest weight by the SCM, we compare the evolution of the Czech agricultural sector with the Bulgarian one.

Our estimates show a negative effect of joining the CAP and CAM on the food production index in the Czech Republic that is not statistically significant using the standard 95% level. Therefore, we cannot reject the $H_0^{'}$ hypothesis that there is no effect of joining the CAP and CAM. To check the robustness of the result, we use Firpo & Possebom (2017)'s approach to show that the results may suffer from a type II error – $H_0^{'}$ is false, and we do not reject it.

However, due to the fact that the results are mainly driven by Bulgaria, which receives the weight of 0.55, we compare the evaluation of the agricultural sector in both countries. We demonstrate that both countries show different reactions to joining the CAP and CAM. While in the Czech Republic we see that food production remains at the similar level as before 2004, Bulgarian farmers moved towards the production of low value added cereals. We claim that the absolute amount of direct payment per hectare could be one of the triggers of the different reactions to joining the CAM and CAP. As a result, we suggest the use of objective criteria: the EU flat

[21] See https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/cap-glance_en The common agricultural policy at a glance for details about the goals of the CAP.
[22] See Figure 12 on page 25 in European Commission (2011) for details about the impact on each European country.

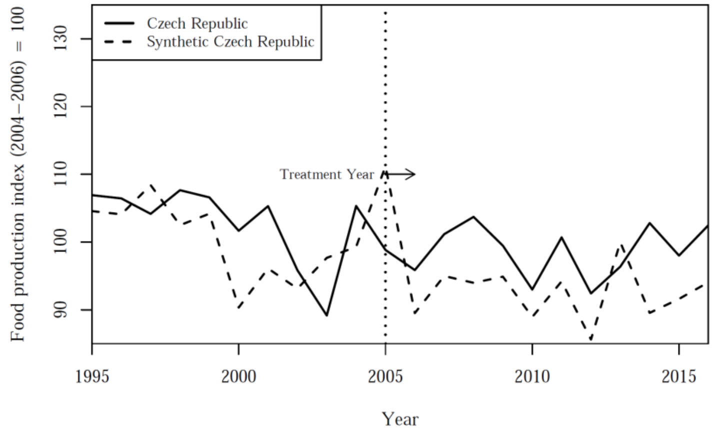
rate could be adjusted by objective criteria based on economic, physical and/or or environmental indicators, which could be a better option for achieving the goals of the CAP.

Overall, the estimated effect of joining the CAP and CAM is negative on the food production index in the Czech Republic. However, the result could suffer from the main shortcomings of the method. As Amjad, Shah, & Shen (2018) note, the shortcomings of the SCM are related to the fact that the optimal result depends on a subjectively chosen subset of donors and covariate matrix.

Finally, the direct payments, as one of the supports flowing from the CAP, do satisfy their goal of increasing the living standard of farmers; however, the amount of the direct payment could cause farmers in Bulgaria to have a different reaction than farmers in the Czech Republic. Moreover, the effect on each European country should be observed.

APPENDIX

Figure A1 Leave-Bulgaria Out Robustness Check*



Notes: *SCM weights are as follows: 0.58 Georgia, 0.33 Croatia and 0.09 Romania.

Source: Author's computation based on the World Bank's dataset.

Table A1 Descriptive Statistics of the Variables Used for the SCM Computation (1995–2007)

Statistic	*N*	*Mean*	*St. Dev.*	*Min*	*Pctl(25)*	*Pctl(75)*	*Max*
Cereals' Yield (kg/ha)	104	2985.591	1056.979	1369.000	2151.200	3914.700	5592.700
Final Consumption Expenditures (% of GDP)	104	81.176	8.618	65.483	76.310	85.426	113.016
Livestock Production Index (2004–2006 = 100)	104	101.215	16.465	77.240	91.927	104.535	157.700
Crop Production Index (2004–2006 = 100)	104	94.435	17.053	58.080	85.523	102.775	152.320
Arable Land (% of Land Area)	104	32.133	13.836	6.505	25.395	40.969	57.454
Trade (as % of GDP)	104	85.124	26.014	37.402	66.667	101.858	142.137
Agriculture Forestry and Fishing Added Value (% of GDP)	104	10.916	7.095	1.964	5.861	13.149	51.520
Foreign Direct Investment Net Inflows (% of GDP)	102	4.643	4.804	0.109	1.391	6.441	31.243
Food Production Index (2004-2006 = 100)	104	96.876	11.676	75.710	88.552	104.850	135.180
Adjusted Net National Income (current USD/capita)	101	3229.373	2711.642	492.851	1172.925	4508.111	13473.420
GDP/Capita (constant 2010 USD)	104	6637.398	4795.640	1010.251	2651.311	9712.162	20151.180
Inflation (Annual %)	104	47.488	132.212	0.108	4.637	40.153	1058.374
Total Unemployment (% of Labour Force)	103	8.542	4.243	0.600	6.070	11.609	19.920
Rural Population (% Total Population)	104	36.445	7.953	25.357	30.387	45.371	47.707

Source: Author's computation based on the World Bank's dataset.

Table A2 Descriptive Statistics of the Variables Used for the SCM Computation (1995–2016)

Summary Statistics	*N*	*Mean*	*St. Dev.*	*Min*	*Pctl(25)*	*Pctl(75)*	*Max*
Cereals' Yield (kg/ha)	176	3348.806	1228.700	1271.400	2371.125	4164.075	6742.300
Final Consumption Expenditures (% of GDP)	176	79.845	8.807	61.618	75.274	84.727	113.016
Livestock Production Index (2004–2006 = 100)	176	101.940	20.332	69.220	90.107	106.005	165.480
Crop Production Index (2004–2006 = 100)	176	100.452	20.756	58.080	87.875	110.597	192.240
Arable Land (% of Land Area)	168	31.435	14.087	5.756	25.010	40.781	57.454
Trade (% of GDP)	176	90.811	28.396	37.402	72.479	110.954	158.727
Agriculture Forestry and Fishing Added Value (% of GDP)	176	8.885	6.160	1.520	4.595	11.363	51.520
Foreign Direct Investment Net Inflows (% of GDP)	174	4.443	4.197	0.109	1.854	5.902	31.243
Food Production Index (2004–2006 = 100)	176	103.224	17.804	71.480	90.767	113.735	169.070
Adjusted Net National Income (current USD/capita)	170	4834.337	3684.232	492.851	1641.669	6702.124	16506.810
GDP/Capita (constant 2010 USD)	176	7769.792	5284.112	1010.251	3205.031	10728.680	21894.110
Inflation (Annual %).	176	31.119	103.577	–1.538	2.948	16.483	1058.374
Total Unemployment (% of Labour Force)	175	8.656	4.261	0.500	6.355	11.664	19.920
Rural Population (% Total Population)	176	35.453	8.350	22.954	27.685	45.144	47.707
Year	176	2005.500	6.362	1995	2000	2011	2016

Source: Author's computation based on the World Bank's dataset.

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