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Does Euro Adoption Reduce Central Bank Staff?

Bachelor's thesis

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Declaration of Authorship

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Prague, August 1, 2023

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Abstract

The thesis examined the impact of euro adoption and joining the EU's Exchange Rate Mechanism (ERM II) on central bank staff using the synthetic control method. The first part of the work focused on assembling a data set on personnel development and proposing predictors for approximating central bank size. In the second part, the study presents the models and results, revealing a significant decrease in the number of employees at Latvijas Banka after joining ERM II. However, the research encountered limitations due to data unavailability, possible shocks experienced by donor pool countries, and poor fit of pre-intervention characteristics, leading to ambiguous findings regarding the size and significance of the negative effect of euro adoption on personnel development for Latvijas Bank, the National Bank of Slovakia, and Eesti Pank. The reliability of the results for the National Bank of Belgium and the Bank of Finland was affected by a short pre-intervention period and the risk of over-fitting.

Keywords	euro adoption, central banking, synthetic control method, European System of Central Banks
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Abstrakt

Táto práca skúmala vplyv prijatia eura a pripojenia k Európskemu mechanizmu výmenných kurzov (ERM II) na personálne zloženie centrálnej banky pomocou syntetickej kontrolnej metódy. Prvá časť práce sa zamerala na zostavenie súboru údajov o personálnom vývoji a navrhla prediktory pre odhad veľkosti centrálnej banky. V druhej časti sa predstavili modely a výsledky, odhaľujúce štatisticky významné zmenšenie počtu zamestnancov v Latvijas Banka po pripojení k ERM II. Avšak výskum narazil na obmedzenia týkajúce sa nedostupnosti dát, možných šokov, ktorým boli vystavené krajiny kontrolného regiónu, či nedostačujúcej podobnosti charakteristiky krajiny pred intervenciou, čo následne viedlo k nejasný záverom týkajúcich sa veľkosti a významu negatívneho vplyvu prijatia eura na na personálny vývoj Latvijas Banky, Národnej banky Slovenska a Eesti Pank. Dôveryhodnosť výsledkov pre Národnú banku Belgicka a Národnú banku Fínska ovplyvnila krátka doba pred intervenciou a riziko over-fitu.

Klíčová slova	přijetí evra, centrální bankovnictví, syntetická kontrolní metoda, Evropský systém centrálních bank
Název práce	Sníží přijetí evra počet zaměstnanců centrální banky?
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Acronyms

BNB Bulgarian National Bank

BoE Bank of England

DID Difference-in-Differences

ECB European Central Bank

EEA European Economic Area

ESCB European System of Central Banks

ERM II Exchange Rate Mechanism II

EU European Union

MNB Magyar Nemzeti Bank

MSPE Mean Squared Prediction Error

MU Monetary Union

NBB National Bank of Belgium

NBS National Bank of Slovakia

NCBs National Central Banks

OECD Organization for Economic Co-operation and Development

SCM Synthetic Control Method

Chapter 1

Introduction

With the de jure transfer of monetary sovereignty from eleven National Central Banks (NCBs) to the European Central Bank (ECB)[1] on January 1, 1999, central banking in Europe has entered an era of federalist reorganisation based on the principles of subsidiarity enshrined in the Treaties of Maastricht and Amsterdam (Hochreiter 2000). Over the course of time, the eurozone has expanded by nine additional members, and by 2023, the ECB's workforce has surged from a mere 700 employees to an impressive count exceeding 4,000. Henceforth, many researchers have attempted to quantify the effects of the final stage of European economic integration on the national economies or the European Union (EU) as a whole. Yet, none of the prior studies has attempted to quantify the effect of euro adoption on the NCBs, despite the significant changes these banks undergo upon entering the Eurosystem. As the former president of the ECB Willem F. Duisenberg declared, "[In the Eurosystem,] monetary policy is one and indivisible; it cannot react to situations in individual countries or regions in the euro area." (European Central Bank 2000, p. 2). This quotation emphasizes that becoming part of the Eurosystem involves, inter alia[2], relinquishing one of the most significant tools that NCBs possess - the ability to conduct independent monetary policy. Nonetheless, even after joining the Eurosystem and giving up their independent monetary policy, NCBs continue to play a crucial role in the decision-making processes of ECB. They are entrusted with the implementation

[1] Established on June 1, 1998.

[2] NCBs are subject to other major changes connected with the adoption of the euro. These include, for example, new responsibilities connected with contribution to ECB tasks or managing relations with the public on the national level when supporting and explaining the ECB's decisions in the implementation of monetary policy. For a full list of the major changes, consult Hochreiter (2000).

of the single monetary policy of the Eurosystem (Deutsche Bundesbank 2000; Oesterreichische Nationalbank 2000).

This thesis intends to explore whether euro adoption changes the amount of staff of NCBs of the Eurosystem. The link between the amount of bank staff and the euro adoption reflects the institutional changes which the individual NCBs have undergone since entering the European Monetary Union (EMU), and thus, the work contributes to an in-depth understanding of the transformation of the organizational structure of NCBs and functioning of European System of Central Banks (ESCB) as a whole. Besides analyzing the impact of euro adoption on personnel development, the thesis delves into the consequences of joining ERM II, as NCBs give up de facto independent monetary policy upon fixing the local currency to the euro. An additional contribution of the work is the collection of a dataset containing the number of employees of central banks in the EU and the Organization for Economic Co-operation and Development (OECD) over time. Furthermore, the work also describes the development that the central banks of the data set have undergone, or more precisely, the events that led to an organisational restructuring of the observed central banks. The size of the effect of euro adoption is analysed using Synthetic Control Method (SCM). SCM is an approach that builds upon the Difference-in-Differences (DID) but proposes a more systematic way to the choice of the control unit and is more suitable for a small sample of aggregate units, such as the central banks. By using SCM, we can construct a synthetic counterpart - a weighted combination of a subset of countries from the data set that have not adopted the euro - for every country that adopted the euro and then observe the difference in the evolution of bank staff between the two after the adoption. For SCM to work properly, choosing similar units for the synthetic control, in this case, central banks, is of utmost importance but also very challenging as there is no clear answer to what determines how large a central bank will be. This work addresses the aforementioned question by proposing a set of predictors for the size of a central bank. For the observed effect to be statistically significant, the synthetic control must approximate the development of the observed unit very closely in the pre-intervention period, among other requirements.

The thesis is structured as follows: Chapter 2 opens with an overview of the applications of the SCM. Next, it provides a technical description of the method, including a description of suitable inference techniques. A subsection on assumptions for correct application is also included. Chapter 3 describes the process of obtainment of the data set and provides a detailed portrayal of

the institutional development of the observed central banks. Chapter 4 focuses on the presentation of the models built and the obtained results, including a description of the statistical significance of the effects that were found. Finally, Chapter 5 summarizes our findings and contribution of the thesis.

Chapter 2

Synthetic Control Method: Applications and Methodology

The objective of this chapter is to introduce the SCM to the reader. The chapter opens with an overview of the most important applications of SCM, then continues to describe the technical aspects of the approach, the key assumptions it relies on and, finally, provides an outline of the inferential techniques that would be used for verification of the results presented in this work.

2.1 Applications of SCM: an Overview

This section provides a brief overview of the core literature on SCM and intends to familiarize the reader with the evolution of the statistical approach since its invention in 2003.

The method was first introduced by Abadie & Gardeazabal (2003) in *The Economic Costs of Conflict: A Case Study of the Basque Country*, where the authors compared the evolution of GDP per capita in the Basque country exposed to terrorism to a synthetically constructed region that was not exposed to terrorism. They arrived at the conclusion that there was a relative 10% decline in per capita GDP in the Basque Country compared to the synthetic region.

Furthermore, an inferential technique based on "placebo tests" was introduced by Abadie & Gardeazabal (2003) - the authors applied the same techniques to a similar region not exposed to terrorism, Catalonia, "[to] assess the ability of the synthetic control method to reproduce the evolution of a counterfactual Basque Country without terrorism" (Abadie *et al.* 2010, p.497).

In *Synthetic Control Methods for Comparative Case Studies: Estimating the Effect of California's Tobacco Control Program*, Abadie *et al.* (2010) further investigate the application of SCM in comparative study cases. Using a model that generalizes DID model, Abadie et al. derive the synthetic control estimator. In the article, SCM was applied to evaluate the effect of California's Tobacco Control Program on cigarette consumption and found that the program had a significant and sustained impact on reducing cigarette consumption in California compared to the synthetic unit.

Furthermore, Abadie *et al.* (2010) develop on the inferential techniques of Abadie & Gardeazabal (2003) and propose a generalisation of the placebo tests.

Abadie *et al.* (2011) introduced a paper on the usage of *Synth*, an R package implementing SCM for comparative case studies. By using *Synth*, a researcher can estimate the casual effects of a policy implementation or other events. More specifically, *Synth* was designed for aggregate-level events that influence a relatively small number of units.

Over the course of the past decades, SCM was applied in many fields. For instance, Cavallo *et al.* (2013) examined the effect of catastrophic natural disasters on economic growth, following the Abadie *et al.* (2010) SCM approach. Cavallo et al. arrived to the conclusion that it is only the large natural disasters that were followed by a radical political revolution that displayed a negative impact on economic growth, specifically on the growth of GDP. Another example of an application of SCM is a paper by Zudel & Melioris (2016), who examined the effect of euro adoption on the growth of GDP in Slovakia using SCM. They concluded that euro adoption led to a 10% increase in real GDP per capita by 2011.

In the following Abadie *et al.* (2015) paper, the authors describe SCM as the bridge between quantitative and qualitative research methods, provide a concise overview of the application, and address some of the criticism and limitation of SCM, most notably in relation to the choice of the control units and inference. In this paper, Abadie et al. apply SCM to the case of German reunification, which took place in 1990, and their results indicate a negative effect of the reunification of, on average, approximately $1,600 per year on the per capita GDP of West Germany over the period from 1990 to 2003.

The importance of SCM for policy evaluation was highlighted in the article *The state of applied econometrics: Causality and policy evaluation* by Athey & Imbens (2017) who claimed that: "...[SCM] is arguably the most important innovation in the policy evaluation literature in the last 15 years" (Athey &

Imbens 2017, p. 9). While it is a very strong statement, SCM has proven to be a substantially advantageous research approach in various fields, mostly social sciences, but also engineering or biology.

Finally, Abadie (2021) provides yet another updated practical guidance to the empirical application of SCM. In the paper, Abadie discusses the advantages of the method as well as the requirements that need to be met in order for SCM to succeed in the estimation of the policy effect.

2.2 Methodology

The synthetic control method (SCM) is a statistical approach used to evaluate the effect of a policy, or other intervention on a country, or other, usually aggregate-level, unit. The method builds on the difference-in-differences approach, but provides a more systematic approach to the choice of the control units, which is crucial in comparative studies, since choosing an improper control unit may lead to faulty results. More specifically, "The idea behind the synthetic control approach is that a combination of units often provides a better comparison for the unit exposed to the intervention than any single unit alone" (Abadie *et al.* 2010, p. 494).

2.2.1 Technical Description of Synthetic Control Method

Suppose that we have data available for $J+1$ units: $j = 1, 2, ..., J+1$. We may assume that the first unit is exposed to the intervention ($j = 1$) without loss of generality. Thus, the "donor pool" or the set of potential comparisons, $j = 2, ..., J+1$ is a set of J units not affected by the intervention of interest (Abadie 2021).

We assume that the data was collected over T time periods: $t = 1, 2, ..., T$ and that the first T_0 periods took place before the intervention. Let Y_{jt} be our outcome of interest $\forall j = 1, 2, .., J+1, t = 1, 2, ..., T$. We define Y_{jt}^N as the potential response without the treatment. For the treated unit, $j = 1$, we denote Y_{1t}^I to be the potential response with the treatment (Abadie 2021).

Therefore, the effect of the intervention for the treated unit in period t, such that $t > T_0$, can be expressed in the following form:

$$\tau_{1t} = Y_{1t}^I - Y_{1t}^N \tag{2.1}$$

Since unit "one" is the unit exposed to the intervention from period T_0 onward, it holds that $\forall t > T_0$:

$$Y_{1t} = Y_{1t}^I$$

In other words, for the treated unit, we observe the potential outcome under the intervention in the post-intervention period (Abadie 2021).

The challenge of the method is to estimate how the outcome of our interest would have behaved for the treated unit in the absence of intervention, id est, $\forall t > T_0$, we want to estimate the counterfactual outcome Y_{it}^N. An important remark is that Equation 2.1 allows the effect of the intervention to change over time (Abadie 2021).

For comparative case studies, when the data contains only a few aggregate units (such as countries), a single unit not affected by the treatment may not provide an appropriate comparison for the entity affected by the treatment. SCM solves this issue by creating the synthetic unit from a weighted combination of units from the donor pool that imitates the characteristics of the treated unit (Abadie 2021).

We can define the synthetic control as a $J \times 1$ vector of weights:

$$\mathbf{W} = (w_2, ..., w_{J+1})'$$

The synthetic control estimators[1] of Y_{1t}^N and Y_{1t}^I can thus be defined, respectively, as:

$$\hat{Y}_{it}^N = \sum_{j=2}^{J+1} w_j Y_{jt} \tag{2.2}$$

and

$$\hat{\tau}_{1t} = Y_{it} - \hat{Y}_{1t}^N \tag{2.3}$$

Additionally, when we assume that $0 \leq w_j \leq 1$ and $\sum_{j=2}^{J} w_j = 1$, extrapolation is avoided (Abadie 2021).

Intuitively, the next step is to choose the weights that will be used in the estimator. In most applications, it is only a small number of units that contribute to the estimation of the counterfactual of interest, id est $\hat{Y}_{1t}^N$, and the synthetic control weights represent the actual contribution of the units from the donor pool (Abadie 2021).

Abadie & Gardeazabal (2003) and Abadie *et al.* (2010) propose to choose the weights, $w_2, ..., w_{J+1}$, in such a way that "the resulting synthetic control

[1]For a proof on unbiasedness of the estimators, consult Abadie (2021).

best resembles the pre-intervention values for the treated unit of predictors of the outcome variable" (Abadie 2021, p. 396).

Furthermore, the synthetic control, $\mathbf{W^*} = (w_2^*, ...w_{J+1}^*)'$, that minimizes

$$\|\mathbf{X}_1 - \mathbf{X_0}\mathbf{W}\| = (\sum_{h=1}^{k} v_h(X_{h1} - w_2 X_{h2} - ... - w_{j+1}X_{hJ+1})^2)^{1/2} \tag{2.4}$$

should be chosen (Abadie 2021).

In Equation 2.4, $\mathbf{v} = v_1, v_2, ..v_k$, is a vector of non-negative constants which represent the relative importance of each of k predictors for the treated unit, $X_{11}, ..., X_{k1}$. Therefore, the problem narrows down to the choice of the vector $\mathbf{v}$, which can be achieved using constrained quadratic optimization (Abadie 2021).

2.2.2 Assumptions

The final assessment of the intervention's impact relies on a few key assumptions. The synthetic control region approximates the dependent variable in the treated country had there been no intervention. Consequently, countries in the donor pool must fulfil the criteria listed below. If a country violating some of these assumptions was included in the donor pool and assigned a non-zero weight ($\mathbf{w}$), it would lead to biased results.

1. The countries of the donor pool should not have been affected by the intervention in the treated country through spillover effects, they should not have implemented any policies or interventions similar to the treated country, and they should not have experienced any other influences that could affect the outcome variable unless the treated country would likely have experienced the same influences even without the intervention (Abadie *et al.* 2015).

2. According to Abadie *et al.* (2010), it is crucial not to include countries in the donor pool that possess significantly different characteristics, as this could create a synthetic control unit that merely averages out the data and, therefore, lead to a problem of overfitting the model. Building on this principle, Abadie *et al.* (2015) studied the impact of German reunification on the GDP of West Germany. To ensure a suitable donor pool, they selected only countries that belong to OECD as potential controls for West Germany.

3. If no forward-looking measures are available, applying SCM effectively may be challenging. In some studies, it may be necessary to predict the future outcomes of a unit (for example, a country or a central bank) based on the intervention. For instance, if you're studying the impact of a new policy on future GDP growth, but there's no reliable way to forecast GDP, the SCM may not provide accurate results (Abadie 2021).

4. A well-defined sampling mechanism or data-generating process is essential for accurate results. SCM relies on having a clear understanding of how the data was generated or collected. If this process is not well-defined, it can lead to biases in the estimates. For example, if the data collection process systematically excludes certain types of observations, the synthetic control may not accurately represent the counterfactual scenario (Abadie 2021).

5. The treatment of one unit must not affect the outcomes of other units. If this assumption is violated, for example, due to spillover effects, the estimates from the SCM can be biased. For instance, if a policy implemented in one country influences the outcomes in another country, the latter country cannot be used as a donor country (Abadie 2021).

2.2.3 Inference

The challenge in employing traditional statistical inference within this thesis arises from various factors. These include dealing with a small number of samples, the lack of randomization, and the absence of probabilistic sampling methods to select sample units. These constraints make it complicated to apply conventional statistical inference approaches. Therefore, this thesis will use three alternative inferential methods suitable for the nature of the research. The first one was introduced by Abadie & Gardeazabal (2003) and relies on the construction of "placebo tests". The second method, described by Abadie *et al.* (2010) and Abadie *et al.* (2015), is based on comparing ratio of post-intervention and pre-intervention MSPE[2], a measure of the magnitude of the gap in the dependent variable between each country and its synthetic counterpart. The third is a robustness test, described in Abadie *et al.* (2015).

[2] $RMSPE_i := \frac{\sum_{t=T_0+1}^{T} (Y_{it} - \hat{Y}_{it}^N)^2/(T-T_0)}{\sum_{t=1}^{T_0} (Y_{it} - \hat{Y}_{it}^N)^2/(T_0)}$ for $i = 1, ..J+1$.

I) Placebo tests

Suppose that the synthetic control estimated an effect of a seemingly significant magnitude. Our confidence about the validity of the results disappears if the synthetic control estimates a result of similar, or even larger, magnitude for a unit that has not undergone the intervention (Abadie *et al.* 2015). Therefore, we can run a series of falsification tests called "in-space placebos", where we artificially reassign the intervention to all the units from the donor pool that were not subjected to the intervention of interest. Based on this test, we can evaluate whether or not the magnitude of the effect for our unit of interest falls outside of the range of the effects estimated in the placebo tests (Abadie *et al.* 2015).

Furthermore, Abadie & Gardeazabal (2003) Abadie *et al.* (2010) recommend excluding units with a poor pre-intervention fit of the synthetic control from the placebo tests study. They propose to include only those whose pre-intervention MSPE is at most five times as high as that of the unit of interest.

Additionally, an "in-time" placebo test, based on artificial re-assigning of the treatment to a different point in time during the pre-intervention period, proposed by Abadie & Gardeazabal (2003), is casually used as an inference technique for the synthetic control method. However, in this thesis, the author decided not to proceed with this method, mainly because of the possible (delayed) effect caused by joining the ERM II[3] a few years before the adoption that could distort the results of the inference.

II) The Ratio of Post-Intervention and Pre-Intervention MSPE

Elaborating on the previous inference method, Abadie *et al.* (2010) and Abadie *et al.* (2015) propose to evaluate the significance of the effect based on ratios of post-intervention and pre-intervention MSPE of the observed unit and the placebo tests. The higher the ratio, the larger the difference between the actual outcome and the synthetic outcome is in the post-intervention period. In other words, a high ratio is connected to a large post-intervention MSPE, which is an indicator of the size of the effect of the intervention. Furthermore, a high ratio is linked to low pre-intervention MSPE, suggesting that the synthetic control is a good fit.

[3]In fact, for all countries of the data set that adopted the euro, a model for ERM II was built, but due to short pre-intervention period or a poor fit, most were eventually dropped and can be found attached in Appendix C.

Abadie *et al.* (2010) and Abadie *et al.* (2015) extend this approach to test the *null hypothesis of no effect whatsoever*. The test is based on creating a comparison of the ratios of MSPE of the treated and control units, i.e. $i = 1, ..., J + 1$:

$$RMSPE_i := \frac{\sum_{t=T_0+1}^{T} (Y_{it} - \hat{Y}_{it}^{N})^2/(T - T_0)}{\sum_{t=1}^{T_0} (Y_{it} - \hat{Y}_{it}^{N})^2/(T_0)}. \tag{2.5}$$

.

Next, the p-value is derived:

$$p := \frac{\sum_{i=1}^{J+1} \mathbb{I}[RMSPE_i \geq RMSPE_1]}{J + 1}, \tag{2.6}$$

where $\mathbb{I}[E]$ is an indicator function of event E. An important remark is that Abadie *et al.* (2015) assumes that the probabilities of treatment are the same across observed units.

Furthermore, Firpo & Possebom (2018) propose a procedure for testing the *sharp null hypothesis* in which the previously mentioned assumption is dropped. Firpo & Possebom (2018) also propose a procedure for constructing confidence intervals based on the parametric form of probabilities. However, as the procedure to calculate the confidence interval as per Firpo and Possebom's method is a complex process that requires a deep understanding of the statistical methods involved, which exceed those of an undergraduate student, the author decided not to proceed with it.

III) Test of Sensitivity

One final method to test the results, proposed by Abadie *et al.* (2015), is to check the sensitivity to changes in the country weights, W^*. The method is based on model re-estimation, dropping one of the most significant contributors at a time and comparing the gaps to the original model. If the model with the omitted contributor performs similarly well as the original one, it indicates the credibility of the result.

Chapter 3

Obtainment of the Data Set and Data Description

An essential part of studying the impact of the euro adoption on the personnel development of central banks is an obtainment of a data set containing information about the evolution of the number of employees of central banks. This chapter will describe how the data set was obtained and what can be observed from the data.

The research question requires that the data capture the trend of the evolution in the amount of central bank staff before and after the adoption of the euro. Since the first group of countries adopted the euro in 1999 it was attempted to collect the data from 1990 onward to obtain a sufficiently long pre-intervention period for all models.

Hitherto, there has not been any data set about the evolution of the numbers of central bank staff collected, or at least the author has not managed to find any that would capture the precise numbers of the personnel. Therefore, this work directly contributes to the study of central banks as organisations.

Furthermore, other variables contained in the data set that were used to create the synthetic control are described in detail in Appendix B.

3.1 Collecting the Data on Central Bank Staff

The first step was to create a list of countries for which the data would be collected. The SCM requires that data is collected for countries which have undergone the intervention, i.e. the euro adoption, as well as those which have not done so - European Economic Area (EEA) and OECD countries were chosen

because these are the countries that cooperate most closely with EU member states and are thus the most likely to experience shocks similar to those of EU economies. Choosing countries that exhibit similar characteristics as those that have undergone an intervention for the donor pool is necessary to ensure that SCM will work properly.

The next step was to collect contacts on personnel who could be requested about the delivery of the data. Already at this point, two countries, Columbia and Chile, had to be deleted from the list because, from their websites, it was neither possible to find any contact person responsible for data requests nor was it possible to extract the information about the personnel development from the documents that were publicly available.

Consequently, a request for data about the total number of central bank staff in the period 1990 to 2022 was sent. Multiple central banks provided the data thanks to this request; those were namely the National Bank of Belgium, the Bulgarian National Bank, the Croatian National Bank, the Czech National Bank, the Bank of England, the Bank of Finland, the Deutsche Bundesbank, the Bank of Japan, the Bank of Latvia, the Central Bank of Luxembourg, the Central Bank Malta, the National Bank of Slovakia, the Sveriges Riksbank, the Central Bank of the Republic of Turkey.

However, for a majority of countries, their Annual Reports had to be consulted, and the data had to be collected manually, if available. In the cases where the data were not available in the Annual Reports, or the data were not available for a period that would allow to observe a trend before euro adoption in the country, or where the methodology of collecting the data changed (and thus the data could not be used), the collection was discontinued. All the countries which were proceeded with are listed in Section 3.3.

An important remark is that different countries had different systems of reporting the total number of bank staff. For example, some used the average number of employees in the given year, and others used the total number of employees at the end of the year. For this research, it is not really important what methodology did the central bank use because only the difference between two consecutive years was examined. What is important, however, is that the central bank keeps reporting the number of bank staff using the same methodology. Otherwise, it would not be possible to observe the trend. A detailed description of the methodology that the central banks used can be found in Section 3.2.

3.2 Methodology of Reporting

This section briefly describes how the data was collected for each country and what methodology the central bank used for data reporting. Find below the list of the countries in alphabetical order. The sources can be found in Appendix A if the data was collected from the respective Annual Reports.

- **Australia**
  The data about the number of employees of the Reserve Bank of Australia were collected from the annual reports[1]. The data were collected in the period 1990 to 2022 and contain information about the total number of bank staff, excluding note printing employees, on June 30 of the corresponding year.

- **Belgium**
  The National Bank of Belgium provided the requested information via email on January 20, 2023, in response to the request from January 19, 2023. The data describe the evolution of the total number of employees in the period 1990 to 2023 on January 1 of the corresponding year. The number of employees has been steadily declining in the observed period.

- **Bulgaria**
  The Bulgarian National Bank provided the requested information via email on February 2, 2023, in response to the request from January 19, 2023. The delivered data does not mention the specific methodology used for collecting the data, but it will be assumed that it is the total number of the central bank staff because that was the type of data requested. The period observed is from 1990 to 2022.

- **Croatia**
  The Croatian National Bank provided the requested information via email on February 15, 2023, in response to the request from January 19, 2023. The delivered data do not mention the specific methodology used for collecting the data, but it will be assumed that it is the total number of the central bank staff because that was the type of data requested. The period observed is from 1990 to 2022. The number of employees has been steadily increasing in the observed period.

[1] See Appendix A

- **Czechia**
  The Czech National Bank emailed the requested information on February 8, 2023, in response to the January 19, 2023 request. The delivered data do not mention the specific methodology used for collecting the data, but it will be assumed that it is the total number of the central bank staff because that was the type of data requested. The period observed is from 1993 to 2022.

- **Denmark**
  For the Danmarks Nationalbank, the data about the number of full-time employees was collected from the annual reports[2]. The data describe the number of employees on December 31 of the corresponding year. The period observed is from 1990 to 2021.

- **Estonia**
  The Eesti Pank provided the requested information via email on January 25, 2023, in response to a request from January 19, 2023. The delivered data capture the total number of employees in the period observed from 1995 to 2022.

- **Finland**
  The National Bank of Finland emailed the requested information on January 30, 2023, in response to a request from January 19, 2023. The delivered data do not mention the specific methodology used for collecting the data, but it will be assumed that it is the total number of the central bank staff because that was the type of data I requested. The period observed is from 1990 to 2022.

- **France**
  In the case of the Bank of France, the data about the total number of employees was collected from 1990 to 2021 from the corresponding annual reports[3]. The data capture the number of employees on December 31 of the corresponding year.

- **Hungary**
  For Magyar Nemzeti Bank (MNB), the data about the average number of employees was collected from 2002 to 2021 from the corresponding annual

[2]Ibid.
[3]Ibid.

reports[4]. The information was not available in the report for 2004, and so, it was calculated based on the information that the number dropped by 1,3% between 2003 and 2004 (Magyar Nemzeti Bank 2005, p. 49).

- **Japan**
  The Bank of Japan provided the requested information via email on February 9, 2023, in response to a February 6, 2023 request. The delivered data do not mention the specific methodology used for collecting the data, but it will be assumed that it is the total number of the central bank staff because that was the type of data I requested. The observed data reports the number of employees at the end of the corresponding fiscal year from 1997 to 2021.

- **Korea**
  For the Bank of Korea, the data about the total number of bank staff, excluding the office of banks supervision, was collected for the period from 1997 to 2021 from the corresponding annual reports[5].

- **Latvia**
  The Latvijas Banka provided the requested information via email on January 20, 2023, in response to a request from January 19, 2023. The data delivered describe the evolution of the total number of staff in the period from 1991 to 2021.

- **Lithuania**
  For the Bank of Lithuania, two types of data about the number of staff at the end of the corresponding year were collected because the methodology has changed. In the period from 1999 to 2010, data describing the total number of bank staff on permanent contracts were available in annual reports[6]. In the period from 2010 to 2021, data describing the total number of bank staff were available in the annual reports[7].

- **Malta**
  The Central Bank of Malta provided the requested information via email on January 25, 2023, in response to a request from January 19, 2023. The

[4]Ibid.
[5]Ibid.
[6]Ibid.
[7]Ibid.

data delivered describes the evolution of the total number of staff in the period from 1990 to 2022.

- **New Zealand**
  For the Reserve Bank of New Zealand, the data about full-time-equivalent positions, not including vacancies, by June 30 of the corresponding year were collected in the period from 1993 to 2022 from the corresponding annual reports[8].

- **Norway**
  For the Norges Bank, the data about permanent employees at the end of the year were collected for the period from 1997 to 2022 from the annual reports[9].

- **Poland**
  For the National Bank of Poland, the data about the average number of employees were collected in the period from 1997 to 2021 from the corresponding annual reports[10].

- **Romania**
  For the National Bank of Romania, the data about the total number of employees by December 31 of the corresponding year were collected in the period from 2008 to 2021 from the annual reports[11].

- **Slovakia**
  The National Bank of Slovakia provided the data about the average number of employees in the period from 1993 to 2022 via email on February 16, 2023, in response to a request from January 19, 2023.

- **Slovenia**
  The Bank of Slovenia provided the data about the total number of employees in the period 1991 to 2022 via email on January 26, 2023, in response to a request from January 19, 2023.

- **Sweden**
  The Sveriges Riksbank provided the data via email on January 20, 2023, in response to a request from January 19, 2023. The delivered data does

[8] Ibid.
[9] Ibid.
[10] Ibid.
[11] Ibid.

not mention the specific methodology used for collecting the data but it will be assumed that it is the total number of the central bank staff because that was the type of data requested. The period observed is from 1990 to 2022.

- **Switzerland**
  For the Swiss National Bank, the end-of-year data about the total number of employees was collected for the period 1995 until 2021 from the corresponding annual reports[12].

- **Turkey**
  The Central Bank of the Republic of Turkey provided the data via email on February 13, 2023. The delivered data does not mention the specific methodology used for collecting the data but it will be assumed that it is the total number of the central bank staff because that was the type of data requested. The period observed is from 1990 to 2022.

- **United Kingdom**
  The Bank of England (BoE) provided the data via email on March 1, 2023, in response to a request from February 6, 2023. The delivered data describes the total end-of-February number of bank staff. The period observed is from 1990 to 2022, with one observation missing for 2003. Eventually, the missing observation was obtained from Bank of England (2004), where it is described that the amount of bank staff fell by 244 year-on-year.

3.3 Observations

This subsection will describe the development of the number of employees of the central bank of the respective country. First, the observations for the countries which adopted the euro (in chronological order) will be analyzed. Consecutively, the development in EU member countries which did not adopt the euro will be described, and lastly, the development of countries outside of EU will be outlined.

Furthermore, for each country, a dummy predictor *restruc* is described in detail in this section. *Restruc* is capturing that the CB has either undergone a restructuring that has led to a significant change in the number of employees

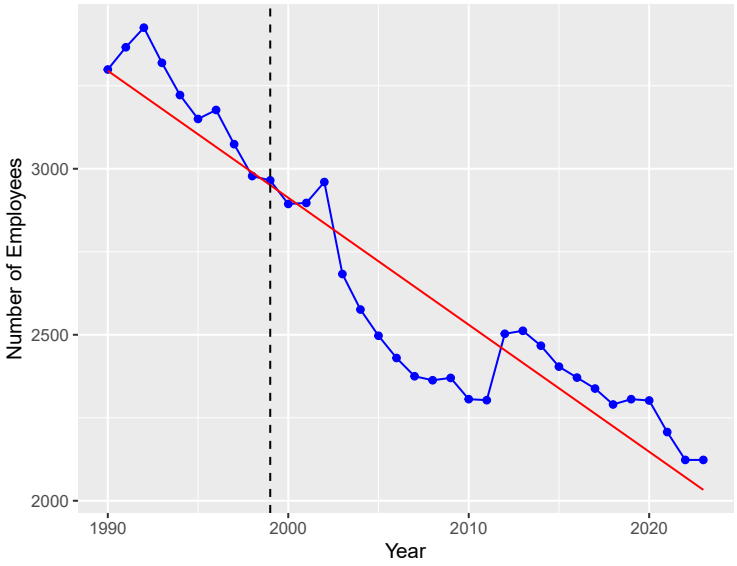
[12] Ibid.

($restruct = 1$), i.e. usually 15% or more compared to the previous two years, or the CB itself considers it as a significant restructuring ($restruct = 1$).

In 1999, the first eleven countries adopted the euro: Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Portugal and Spain. From this group, we have data available for Belgium, Finland and France because, for the others, it was not possible to collect the data that would describe the trend before the euro adoption or the methodology changed in the critical period.

In Belgium, the amount of bank staff has been, on average, declining steadily since the beginning of the 1990s. From Figure 3.1, it does not seem that euro adoption has significantly changed the amount of bank staff.

Figure 3.1: National Bank of Belgium: Personnel Development

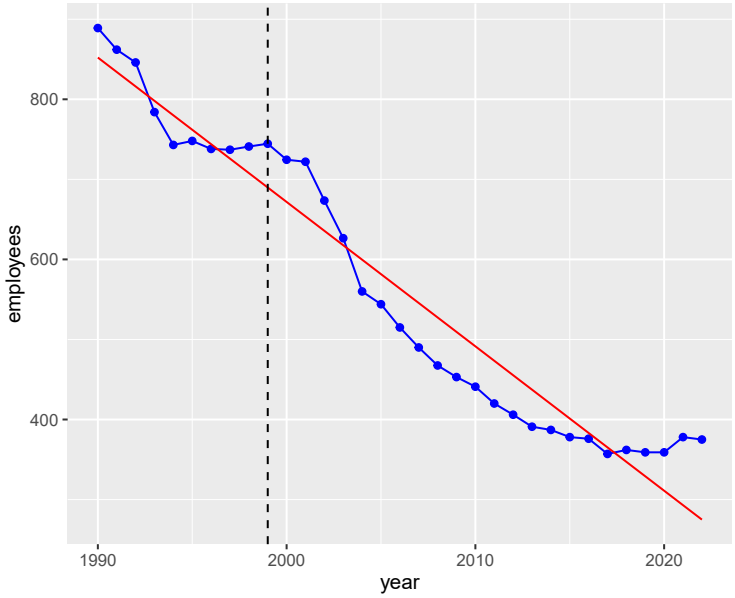


Counterintuitively, it appears that the number of employees has slightly risen following the adoption of the euro in 1999. There has not been any significant restructuring in the observed period.

In Finland, the number of employees has been, on average, on a decline since the beginning of the 1990s. From Figure 3.2, it can be inferred that the number of employees started to decline more steeply after the adoption of the euro than before the adoption. Furthermore, there was one significant staff reduction in 2004 of 16,4% compared to 2002 due to: "The adjustment measures introduced within the payment instruments sector [that] were completed in the course of 2004 and the operating strength of the currency supply function [which] fell

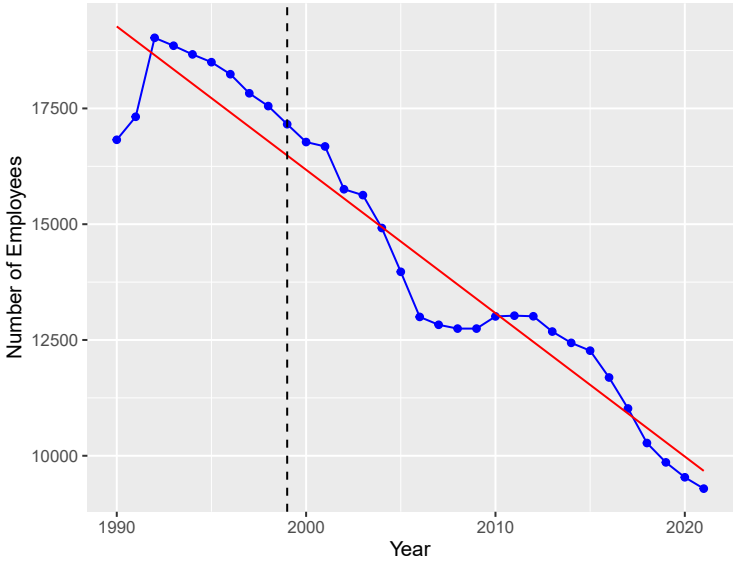
from 111 to 65 persons... [and that in] response to the Bank's tight permission based-recruitment policy, the number of staff in attendance declined by over 11% over 2004." (Bank of Finland 2005, p. 49). The year-on-year change in the number of employees was -10.61% between 2003 and 2004.

Figure 3.2: Bank of Finland: Personnel Development



In France, the number of employees has been, on average, declining. From Figure 3.3, it does not seem that the adoption of the euro led to a steeper decline compared to the trend before the adoption. In 1993, there was an amendment to the Status of Banque de France (Banque de France 1994). Otherwise, there has not been any significant restructuring in the observed period.

Figure 3.3: Banque de France: Personnel Development

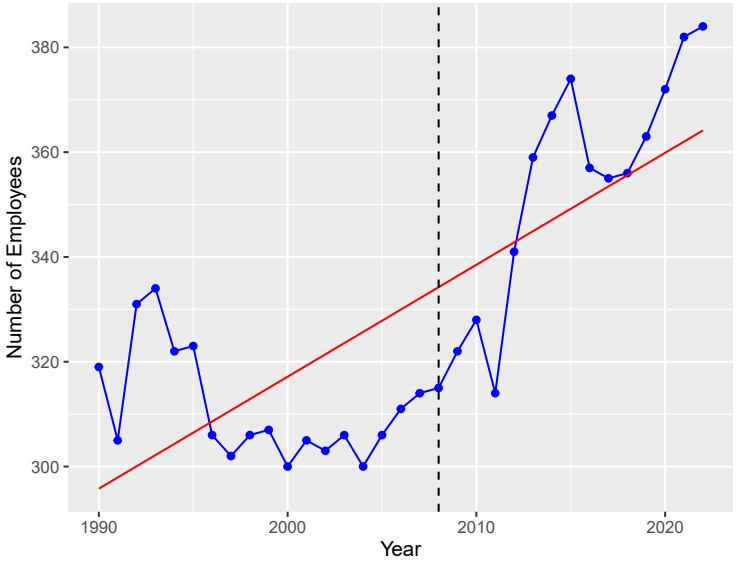


In 2001, Greece adopted the euro, but the data about the number of employees was not publicly available.

In 2008, Cyprus, Malta and Slovenia adopted the euro. From this group, the data was available for Malta and Slovenia.

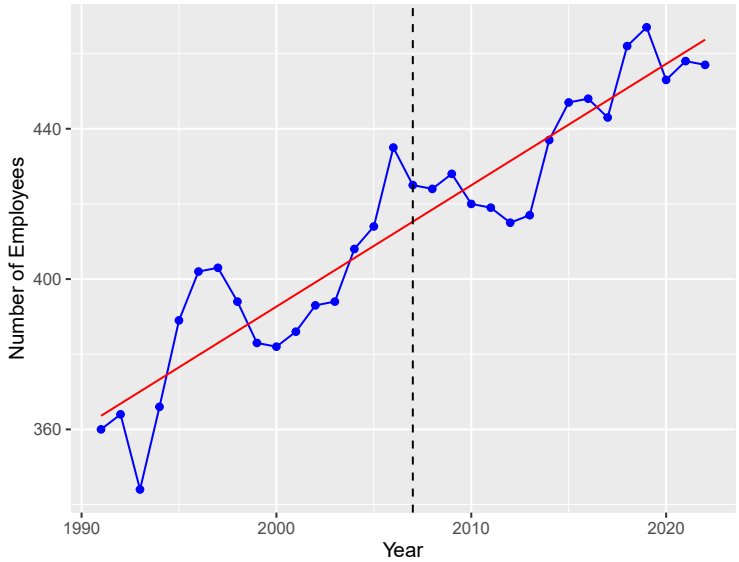
In Malta, the number of employees had been on the rise before the adoption, and continued to rise after the adoption, possibly even faster. Therefore, it does not seem that euro adoption has reduced the number of central bank staff. There was one significant restructuring in 1994, following new legislation and extensive revision of existent laws - the central bank was granted greater autonomy (Central Bank of Malta 2023).

Figure 3.4: Central Bank of Malta: Personnel Development



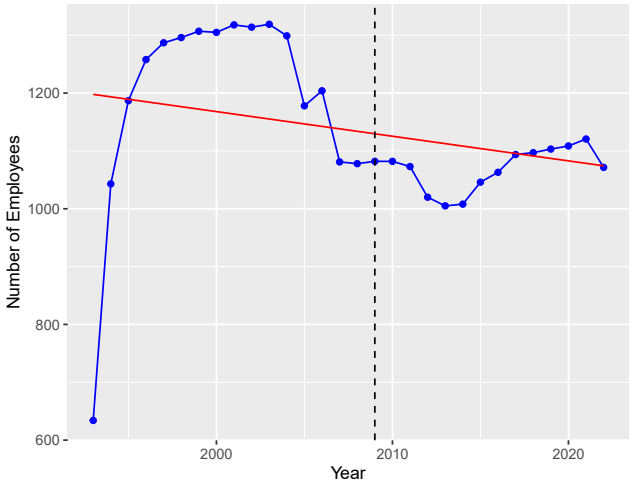
In Slovenia, the number of employees has also been on the rise, but there was a slight reduction in central bank staff after adopting the euro in 2008. No significant restructuring has taken place in the observed period. Similarly to other Central and Eastern European banks, the Bank of Slovenia was only established in 1991. However, there has not been any significant fluctuation in the number of employees in the initial years.

Figure 3.5: Banka Slovenije: Personnel Development



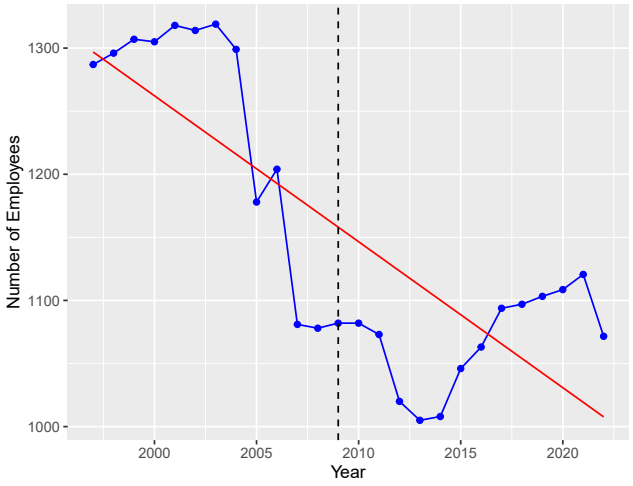
The next country to adopt the euro was Slovakia in 2009. In Slovakia, the number of employees has been on the rise since the early 1990s, which can be explained by the fact that the central bank was only established in 1993. The number of bank staff stabilized in the early 2000s and then started to decline. There does not seem to be any significant decline after the adoption of the euro. Five years after the adoption, the number of bank staff started to rise.

Figure 3.6: National Bank of Slovakia: Personnel Development



Since the Slovak National Bank was only established in 1993, it might be more reasonable to start observing the trend a few years after its establishment, when the amount of bank staff became more stable. See Figure 3.7 below.

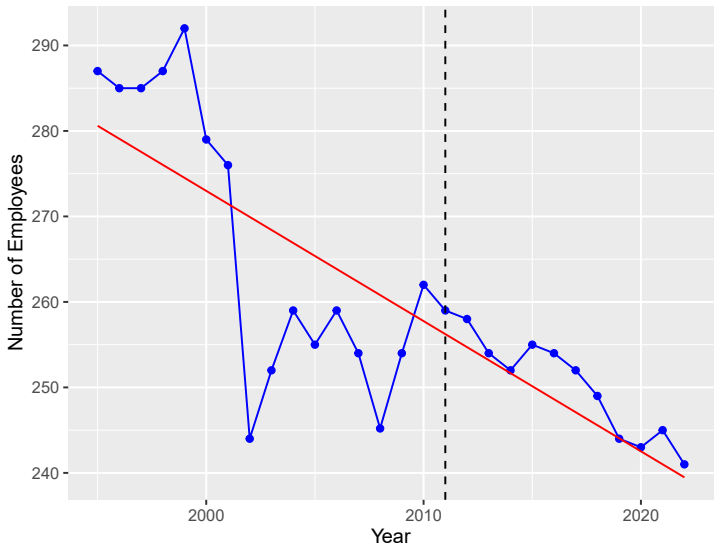
Figure 3.7: National Bank of Slovakia: Personnel Development - 1997 Onward



In 2005, the number of employees dropped by 9.3% due to organisational changes (Bank of Slovakia 2006). In 2007, the number of bank staff dropped by 10.22% due to a restructuring of the organisation (Bank of Slovakia 2008). There has not been any other significant restructuring in the observed period[13].

The next country to adopt the euro was Estonia in 2011. Eesti Pank was re-established in 1990, but since the data are only available from 1995 onwards, we do not have to delete the first few years from the data set, as the number of bank staff was already relatively stable. In the observed period, the bank has not undergone any significant restructuring[14]. In general, the number of employees has been on a decline, and there does not seem to be any significant change in the number of employees after the adoption of the euro. See the graph below.

Figure 3.8: Eesti Pank: Personnel Development



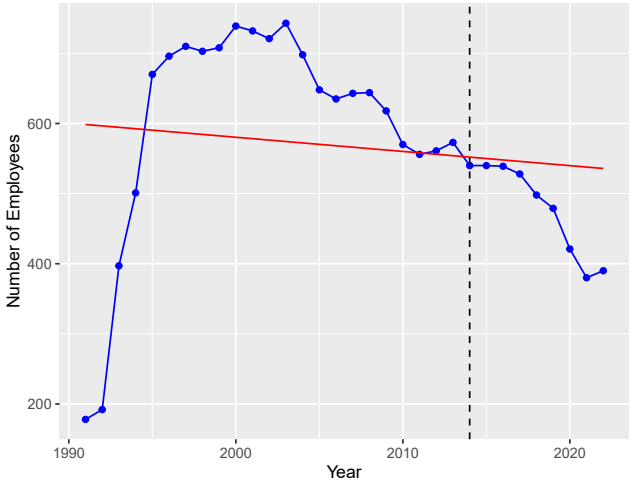
The next country to adopt the euro was Latvia in 2014. Similarly to Slovakia, the number of employees has risen rapidly during the first years of observation. This was due to the fact that Latvia regained its independence from the Soviet Union in 1991, and the Bank of Latvia could start to function as an independent central bank. In 2020, a significant restructuring that led to a decrease of 15.46% in the number of employees compared to 2018 took place.

[13]There has been a change of 64.51% between 1993 and 1994 and 87.22% between 1993 and 1995, but this was due to the fact that the National Bank of Slovakia was only established in 1993.

[14]In 2002, the number of employees fell by 11.59% year-on-year. However, no restructuring is mentioned in the annual report, so this is not considered a restructuring in the data set.

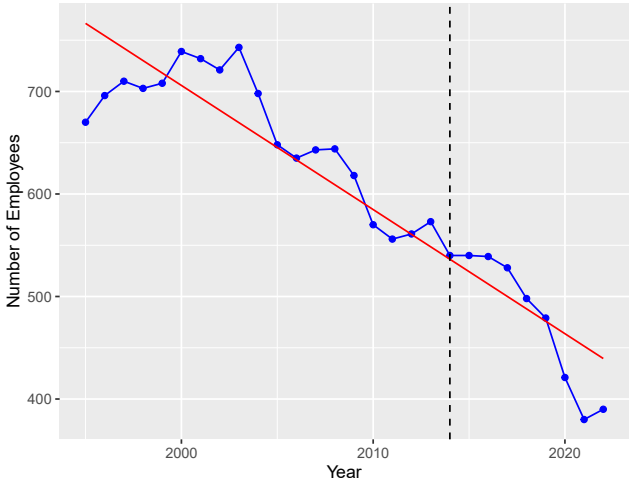
The decrease in the number of employees was caused mainly by the implementation of cost-efficiency measures, more specifically, by an upgrade of the cash processing equipment of the Riga Branch and the closing of the Liepaja Branch of Latvijas Banka in January 2020, among other measures (Latvijas Banka 2021, p. 104).

Figure 3.9: Latvijas Banka: Personnel Development



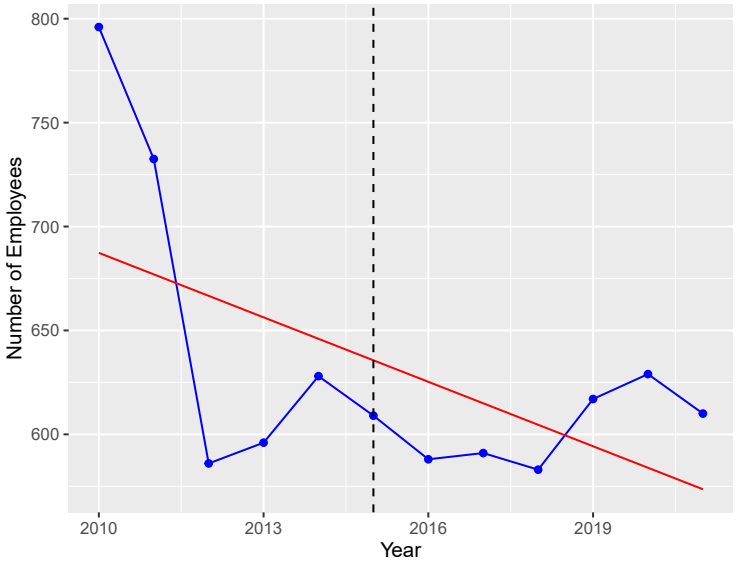
When we omit the first four years of observation, we can see that the number of employees was, on average, on a decline. After the adoption of the euro, the number of bank staff remained nearly unchanged and then, two years after the adoption, it started to decline. See Figure 3.10 below.

Figure 3.10: Latvijas Banka: Personnel Development - 1995 Onward



The next country to adopt the euro was Lithuania in 2015. Since the data collection methodology about the number of employees changed in 2010, we can observe the evolution from 2010 onward. See Figure 3.11 below.

Figure 3.11: Bank of Lithuania: Personnel Development

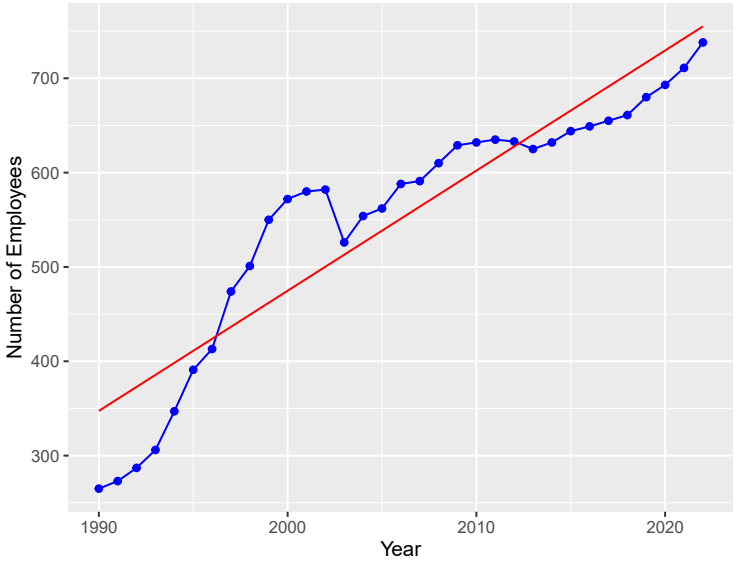


The number of employees has, on average, declined. After the adoption of the euro in 2015, the amount of bank staff remained more or less unchanged and then started to rise slightly in 2018. In 2012, the Bank of Lithuania underwent an institutional renewal[15], part of which was the establishment of the Supervision Service, that led to a 20% decrease in the number of employees between 2011 and 2012. In 2021, the organisational structure was flattened[16].

The last country to adopt the euro was Croatia which adopted it on January 1, 2023. Since it is very recent, the data will be used in the control group. As in the case of other nations whose central banks were (re-)established in the 1990s, the number of employees has risen steeply in the first years after the establishment of the Croatian National Bank in 1990. No significant restructuring has taken place in the observed period.

[15]For more information consult Bank of Lithuania 2013, pp. 81-82.
[16]For more details consult Bank of Lithuania 2022, p. 47.

Figure 3.12: Croatian National Bank: Personnel Development



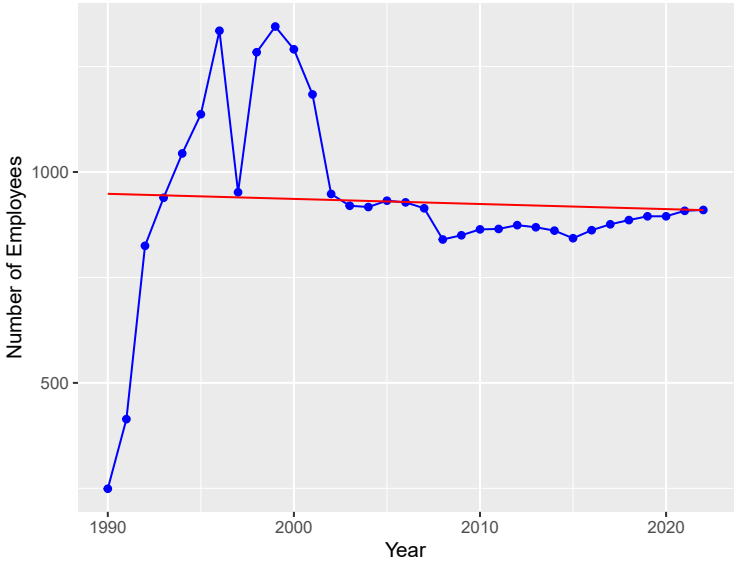
When we omit the first nine years, the overall growing trend of the number of employees is less steep. See Figure 3.13 below.

Figure 3.13: Croatian National Bank: Personnel Development - 1999 Onward

Now, we can proceed to the description of the development of central bank staff of EU member countries that did not adopt the euro. The countries will be presented in alphabetical order.

Bulgarian National Bank (BNB) experienced a sharp increase in the number of employees of the central bank in the early 1990s, and this can be explained by the fact that the Bulgarian banking system returned to open-market principles only in 1991. The responsibilities of the BNB have completely changed. In 1997, the bank underwent a restructuring following the adoption of a new BNB Law, which reorganised the monetary system[17].

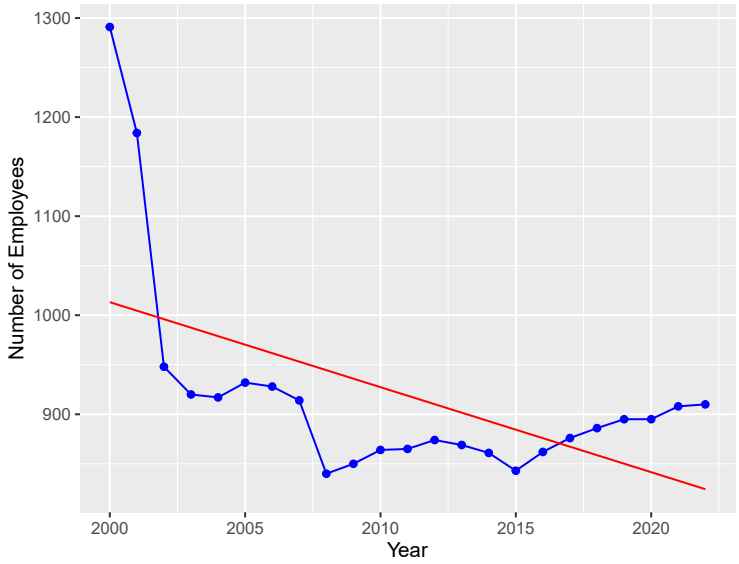
Figure 3.14: Bulgarian National Bank: Personnel Development



When we omit the first ten years of observation, when the number of employees fluctuated, the prevailing trend is a decline in the number of employees. See Figure 3.15 below.

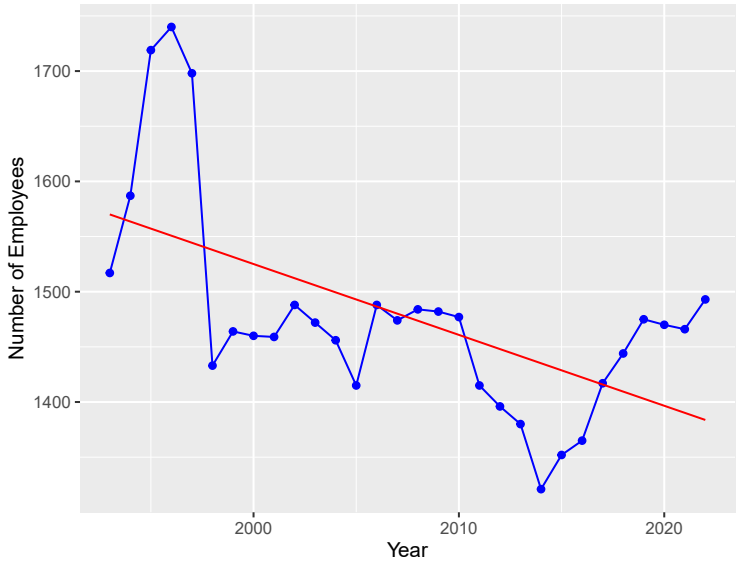
[17]For more details consult Bulgarian National Bank 1998.

Figure 3.15: Bulgarian National Bank: Personnel Development - 2000 Onward



In Czechia, the amount of central bank staff fluctuated over the five years of observation, and then, it stabilized, see Figure 3.16. Such development can, once again, be explained by the fact that the institution was established in 1993.

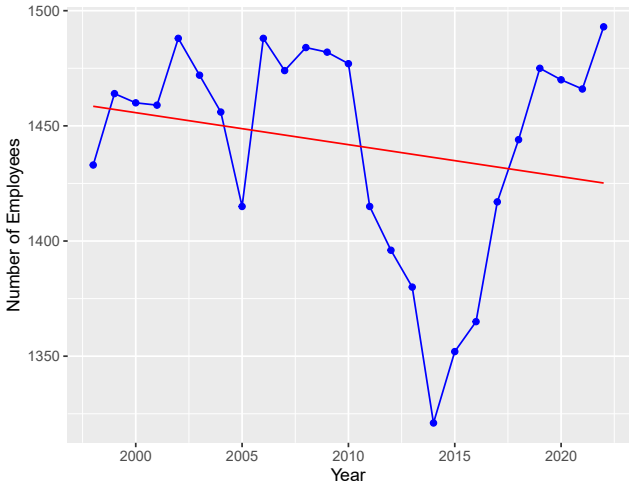
Figure 3.16: Czech National Bank: Personnel Development



When we omit the first five observations, we can see that the number of central bank staff has been, on average, on the decline, see Figure 3.17. There

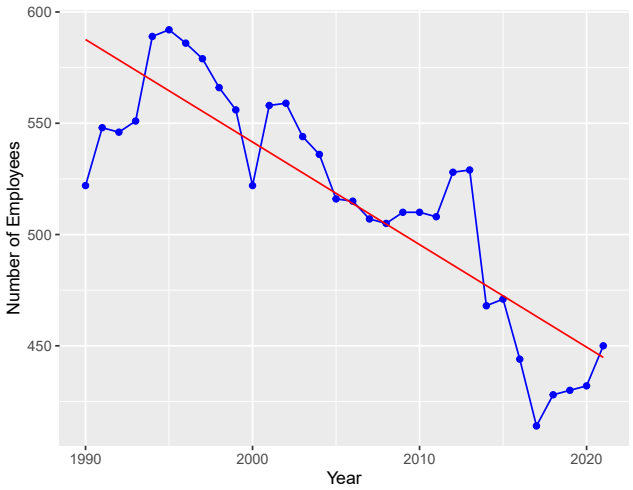
has been a significant decline in the number of employees between 2010 and 2014, after which the number of bank staff has begun to rise again. See Figure 3.16. The Bank underwent a process of "rationalisation" of its structure in 1998 (Czech National Bank 1999), due to which the number of employees fell by 15.61% year-on-year.

Figure 3.17: Czech National Bank: Personnel Development - 1998 Onward



The number of bank full-time bank staff in Denmark has been, on average, on a steady decline from 1987 to 2021. See Figure 3.18 below. No significant restructuring has been done over the observed period.

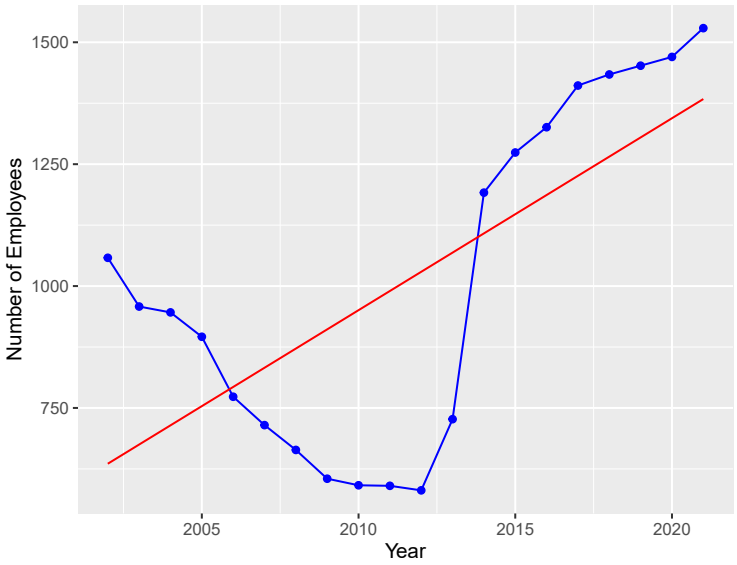
Figure 3.18: Danmarks Nationalbank: Personnel Development



For MNB, the average number of employees has, on average, increased in

the observed period of 2002-2021, see Figure 3.19. The number has been on a steady decline between 2002 and 2012, after which it doubled over the course of two years and continued to rise. MNB implemented an operational development programme in 2005 (Magyar Nemzeti Bank 2007), due to which the number of employees fell by 18.29% between 2004 and 2006[18]. In 2008, MNB implemented an efficiency-improving project that caused the number of employees to decline by 8.89% between 2008 and 2009, and by 15.37% between 2007 and 2009 (Magyar Nemzeti Bank 2009; 2010). In 2013, the Hungarian Financial Supervisory Authority was integrated into MNB (Magyar Nemzeti Bank 2014). As a result, the number of employees has risen by 25.13% year-on-year between 2012 and 2013[19].

Figure 3.19: Magyar Nemzeti Bank: Personnel Development



Source: Author

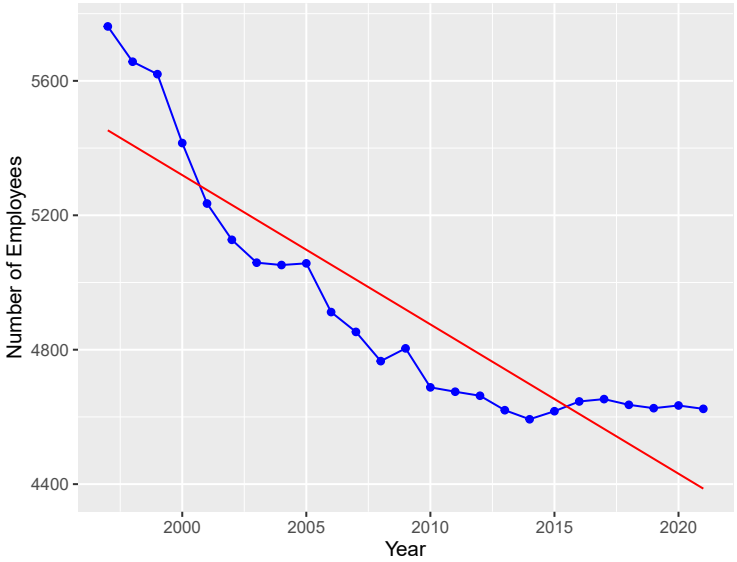
In Poland, the average number of central bank staff has been relatively stable between 1997 and 2002. From 2002 onward, the number has been decreasing steadily. There was a restructuring of the National Bank of Poland's territorial network in 2003, which resulted in the closing of twenty-two sub-branch offices of the National Bank of Poland and an 18.52% decline in the number of staff between 2002 and 2003[20]. (National Bank of Poland 2004)

[18]The number of employees continued to decrease rapidly in 2007 - there has been a fall by 20.22% between 2005 and 2007, which was most likely caused by the operational development programme adopted in 2005, year-on-year decline was only 7,53% between 2006 and 2007.

[19]The change in the amount of staff reached 105.1% between 2012 and 2014.

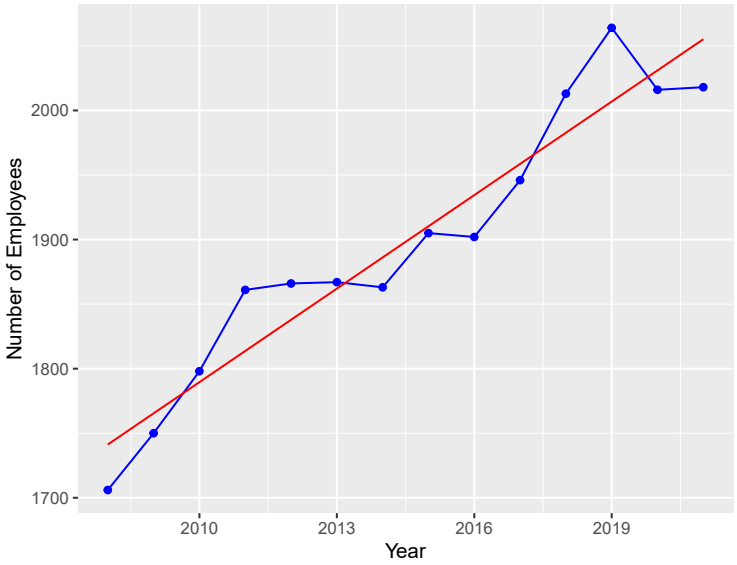
[20]The decline has reached 21.96% between 2002 and 2004.

Figure 3.20: Narodowy Bank Polski: Personnel Development



In Romania, the total number of bank staff has been steadily increasing between 2008 and 2021. No significant restructuring took place in the observed period for the National Bank of Romania.

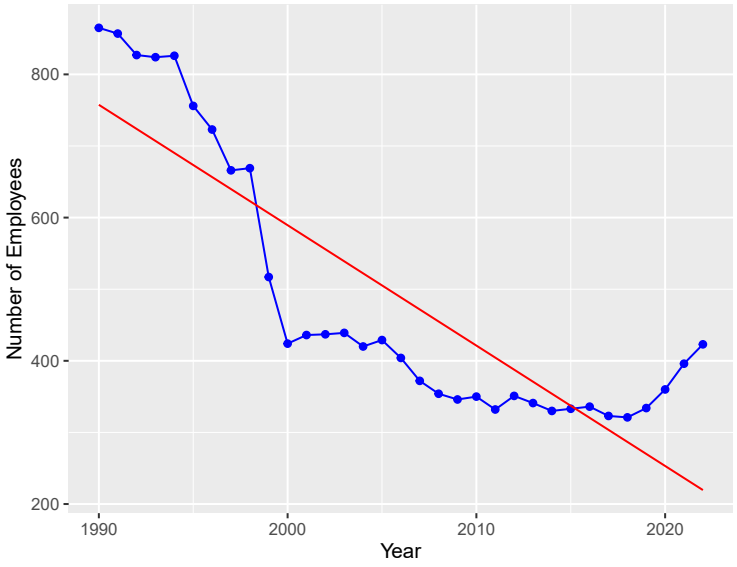
Figure 3.21: National Bank of Romania: Personnel Development



The number of employees of the Sveriges Riksbank has been, on average, on a decline. The sharpest decline in the number of employees can be seen between 1998 and 2002 when it fell from 669 to 424, which happened mainly due to the

reorganisation of the Cashiers' Department in 1999 (Sveriges Riksbank 2000). As can be inferred from Figure 3.22, the number of employees has begun to rise from 2019 onward[21].

Figure 3.22: Sveriges Riksbank: Personnel Development



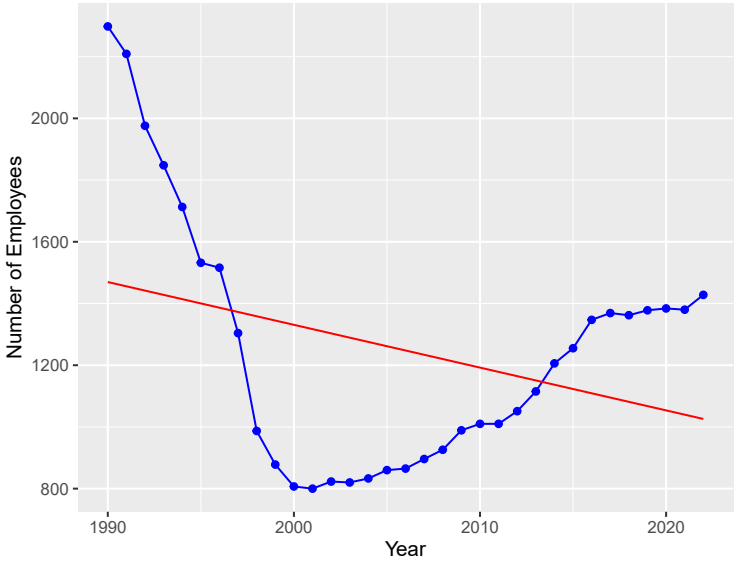
Next, we can proceed to the description of the trend of the number of central bank staff for non-member states. The countries will be presented in alphabetical order.

In Australia, the number of bank staff, excluding note printing, has been, on average, on a decline. In the early 1990s, the number of bank staff has been on a sharp decline due to the ongoing adjustment of the structure, which started in 1991[22].

[21]There has been an 18.6% increase in the number of employees between 2019 and 2021, yet neither in the corresponding annual reports nor on the website is the increase in the number of employees explained, and so, this was not considered a restructuring.

[22]For a more detailed description consult Reserve Bank of Australia (1991; 1992; 1993).

Figure 3.23: Reserve Bank of Australia: Personnel Development

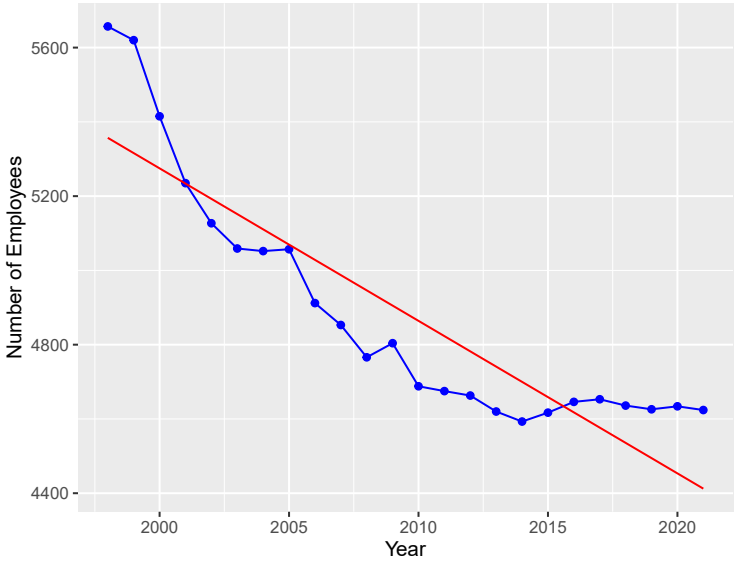


In 1998, the banking supervision function was transferred from the bank to a separate authority - the Australian Prudential Regulation Authority - and a new Payments System Board was established (Reserve Bank of Australia 1998). From 2001 onward, the number of employees has been increasing steadily.

In Japan, the amount of the central bank's personnel has been on a steady decline in the period 1997 to 2021. A structural reform took place in 1998 when the Bank of Japan Act of 1997 came into effect (Bank of Japan 2023), but this reform did not lead to any significant change in the number of employees[23].

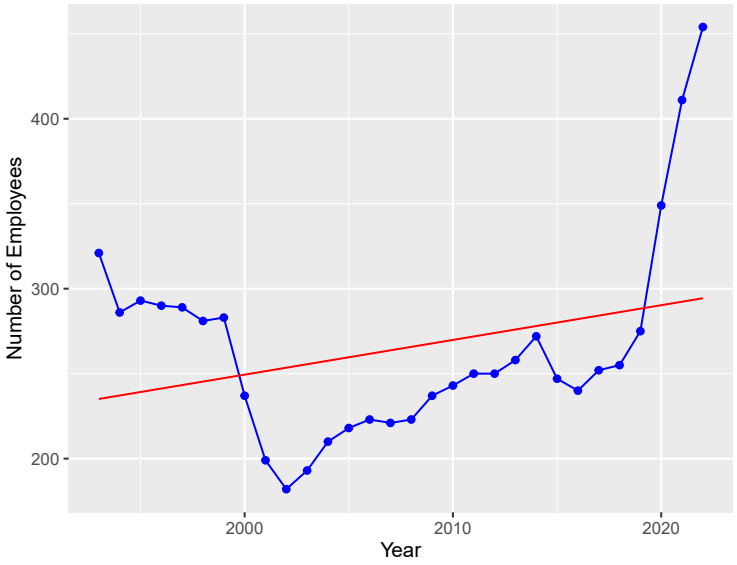
[23]There was a decline of 1.8% between 1997 and 1998.

Figure 3.24: Bank of Japan: Personnel Development



For the Reserve Bank of New Zealand, the total number of employees has been, on average, increasing in the observed period, see Figure 3.25.

Figure 3.25: Reserve Bank of New Zealand: Personnel Development



In 2000, the number of employees fell by 16.25% year-on-year due to the decisions to outsource the registry business and the closing of 2 regional branches (Reserve Bank of New Zealand 2000).

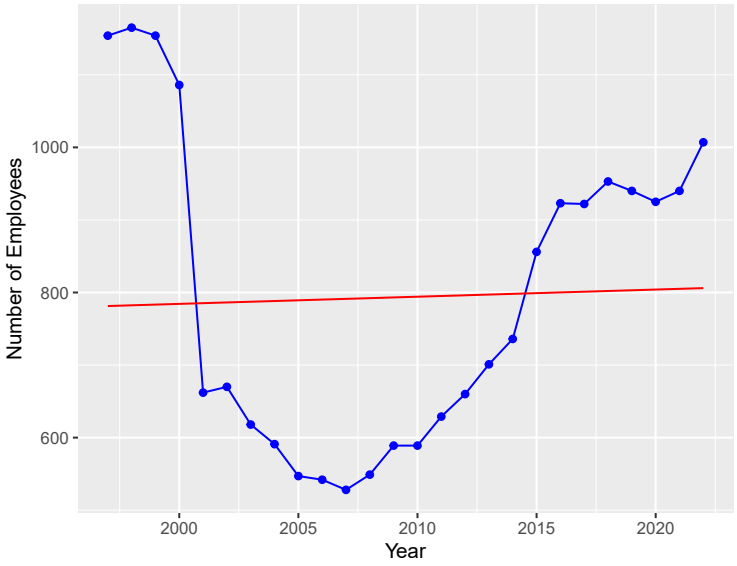
In 2002, two policy departments were merged to create a new Financial Stability Department[24] (Reserve Bank of New Zealand 2003).

In 2020, the Bank's Growth and Transformation programme was implemented. It resulted in recruiting an additional 75 full-time employees[25] (Reserve Bank of New Zealand 2020).

In mid-2022, the Reserve Bank Act 2021 came into effect, bringing about organisational changes (Reserve Bank of New Zealand 2022).

On average, the number of employees increased only slightly for Norges Bank. However, the number has been fluctuating a lot, falling very steeply in 2001. The fall in the number of bank staff was followed by a period of relative stability and began to rise in 2008.

Figure 3.26: Norges Bank: Personnel Development



The first significant restructuring occurred in 1997 when Norges Bank was entrusted with managing the Government Petroleum Fund (Norges Bank 2020). However, the implications it had on the amount of bank staff are unknown as the data is available only from 1997 onward.

In 2001, the bank underwent an extensive restructuring, especially in the area of cash handling, aiming to utilise its resources more efficiently and in-

[24]This step may have led to a 15.38% increase in the total number of full-staff employees between 2002 and 2004 since no other significant change is mentioned in the annual reports for this period.

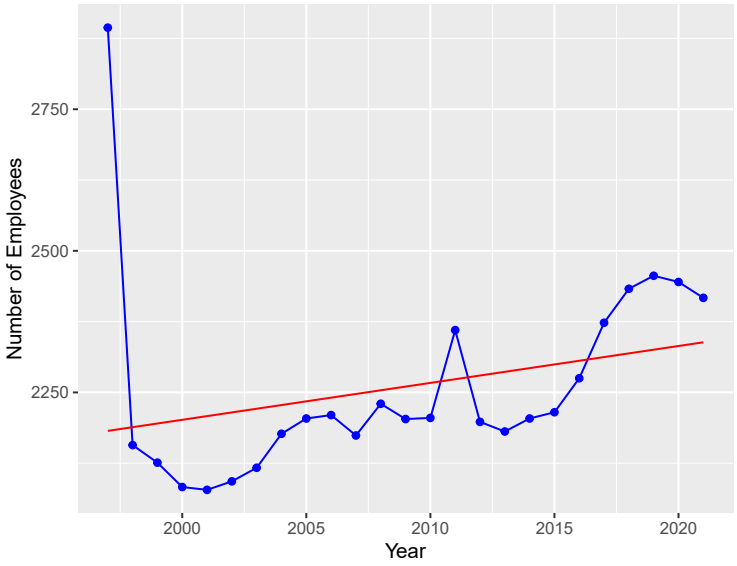
[25]The year-on-year increase in the number of full-time employees was 26.9% in 2020.

crease concentration on its core activities. Den Kongelige Mynt AS[26] became a separate entity[27] (Norges Bank 2002). Between 2000 and 2001, the number of employees fell by 39%. It was planned that the restructuring would continue in the Statistics Department[28], the Banking Department, the Norges Printing Works[29] and potentially others.

In 2015, the number of employees increased by 16.3%, mainly because of the increase in the number of employees of the Norges Bank Investment Management[30] (Norges Bank 2016), yet no systematic restructuring was described in the corresponding annual report or on the website.

In Korea, the total amount of bank staff fell sharply at the beginning of the observed period and then remained relatively stable.

Figure 3.27: Bank of Korea: Personnel Development



In 1998, the revised Bank of Korea Act came into effect, bringing about organisational changes. The most important change was the separation of the

[26]The Royal Mint.

[27]Norges Bank remained its sole owner, and Den Kongelige Mynt AS was sold to Samlerhuset AS Norge and Mint of Finland in 2003.

[28]Norges Bank's foreign payments statistics were discontinued in 2005 (Norges Bank 2006).

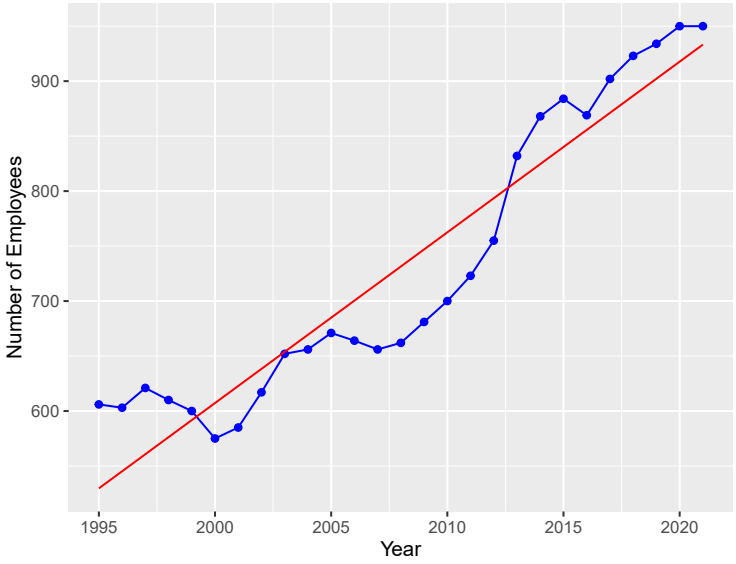
[29]The Norges Bank's Printing works were closed in 2007, and arrangements to purchase banknotes were settled with commercial security printers in France and the UK (Norges Bank 2008)

[30]NBIM hired new managers and analysts overseas to gain better access to investment opportunities (Norges Bank Investment Management 2016).

Office of the Bank Supervision of the Bank of Korea[31] (Bank of Korea 1999). In 1998, the amount of bank staff fell by 25.47% year-on-year. Based on the percentage change in the number of employees, there does not seem to be any other significant restructuring in the observed period.

In Switzerland, the total number of bank staff has increased steadily over the period. No significant reorganisation of the Swiss National Bank has taken place in the observed period. If there had been a large staff turnover, it was rather due to a combination of smaller factors than a structural reorganisation.

Figure 3.28: Swiss National Bank: Personnel Development



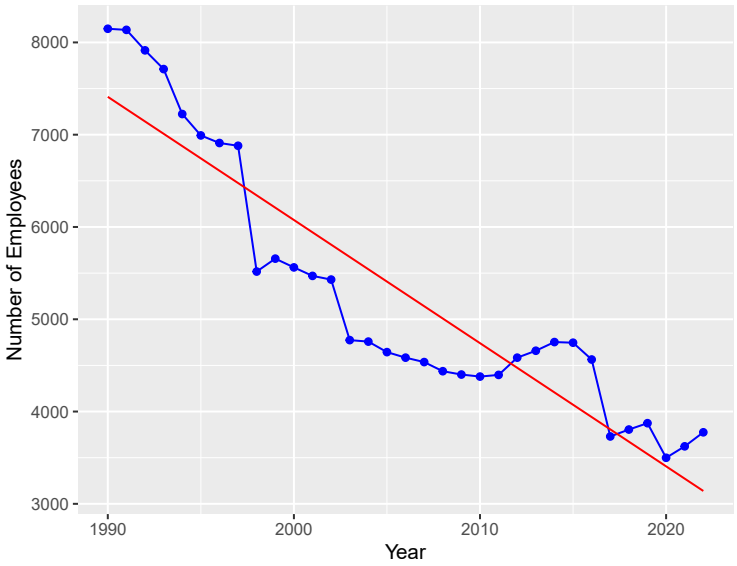
For the Central Bank of the Republic of Turkey, the number of bank staff has been declining on average. In 1998, the number of employees fell by 19.8% year-on-year. However, the exact cause is unknown as the English version of the Annual Report excludes the Personnel section. Therefore, the *restruc* variable was marked "non-available" (NA). In 2002, the bank adopted a new monetary policy strategy. This restructuring most probably did not lead to any significant change in the number of employees[32] (The Central Bank of the Republic of Turkey 2003). In 2017, the number of employees fell by 18.27%

[31] The Office of the Bank Supervision was merged, together with other supervisory bodies, into the Financial Supervisory Service (Bank of Korea 1999).

[32] Compared to 2001, the number of bank staff fell by 0.73%. Between 2002 and 2003, the number of bank staff fell by 12.08%. Yet, it is not possible to tell whether this change can be a delayed effect of the new monetary policy strategy, as the English versions of the Annual Reports exclude the section on personnel development. Therefore, 2003 is also marked NA in the *restruc* variable.

year-on-year. However, no significant restructuring was described in the annual report.

Figure 3.29: Central Bank of the Republic of Turkiye: Personnel Development

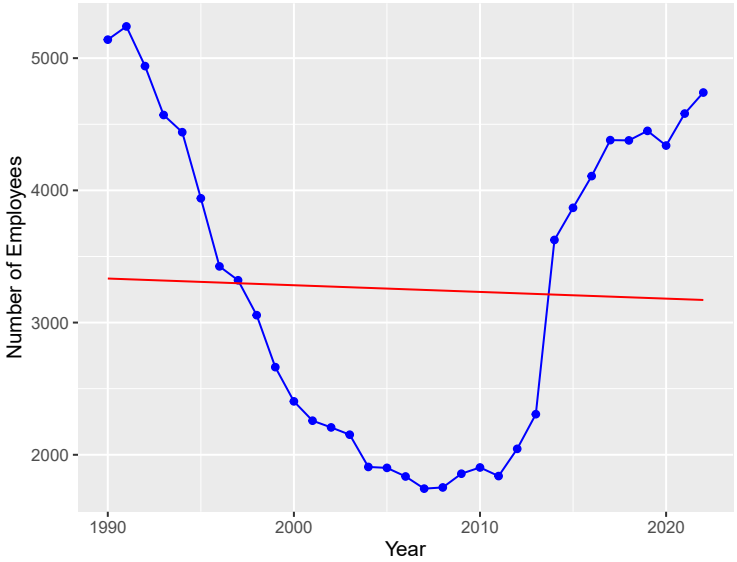


For BoE, the total number of employees was on the decline during the 1990s and early 2000s. Between 2004 and 2010, the amount of staff was almost unchanged; from 2011 onward, it started to rise. In July 1994, the internal structure of BoE underwent a reorganisation[33] (Bank of England 1995, pp. 8-9), which was expected to continue in 1995 and 1996 (Bank of England 1995, p. 26). In 1995, the number of bank staff fell by 11.26% year-on-year and in 1996, the number of bank staff fell by 13.07% year-on-year, which may be attributed to the internal restructuring of 1994. In 1998, BoE transferred the responsibility for the supervision of banks to the newly-established Financial Services Authority (Bank of England 1999) and, as a consequence, 460 staff left BoE[34]. Between 2013 and 2014, the staff increased by 57.13% and this change occurred mainly because of a transfer of employees from the Financial Services Authority to the Prudential Regulation Authority in April 2013 (Bank of England 2014).

[33]For more detail consult (Bank of England 1995, pp. 8-9).

[34]The year-on-year change amounted to -12.86% between 1998 and 1999.

Figure 3.30: Bank of England: Personnel Development



3.4 Other Variables of the Data Set

In order to build a reliable synthetic control, one must approximate the characteristics of the treated unit - in this case, the central bank, which has adopted the euro. The approximation of the size of a central bank is a challenging task as each central bank has undergone a unique development and covers different tasks besides regulating the monetary system. In this subsection, a set of variables approximating the size of the central bank in terms of employees is proposed. Note that as every central bank is different, the subset of variables actually used in the models might differ for the individual countries and periods of observation.

- **Complexity of the Local Economy**
  With the increasing complexity of an economy, regulation becomes more difficult, which may lead to the need for a larger central bank that controls the processes. There is no straightforward answer to how to measure the complexity of an economy. Still, the author decided to use GDP per Capita as a proxy variable since it captures a broad measure of the overall economic output per person in a country. Variable *GDPperCapita* was retrieved from the World Bank on April 4, 2023[35].

[35] See Appendix B.

- **Financial Crises**
  Financial crises open discussion about what went wrong in the market and may be followed by legislative changes or stronger regulation, which in turn can have an impact on the amount of central bank staff. There is a handful of ways to capture whether an economy is undergoing a crisis - for example, one can use a dummy variable that indicates whether the economy is hit by a crisis in the given year or not. However, such a procedure is less precise than using a set of variables whose change indicates economic performance and which responds to shocks. For this purpose, the unemployment rate and GDP were used as proxies for a financial crisis, as they reflect the shocks that an economy has experienced and simultaneously are commonly used over a sufficient time period. Please note that *GDP* should not be used simultaneously with *GDPperCapita*, as they are perfectly collinear. Variables *GDP* and *unemployment* were retrieved from the World Bank on April 4, 2023[36].

- **New Establishment**
  The data set contains a handful of countries whose central banks were established in the observed period, mainly after the collapse of the Soviet Union, or whose role has changed dramatically after the collapse and the return to an open economy. In the initial years after the establishment, the number of employees had the tendency to fluctuate significantly, and therefore, a dummy variable *new_est* was added to the data set indicating whether the central bank existed for less than ten years (id est *new_est* = 1) or it is an established institution (id est *new_est* = 0).

- **Membership in the European Union**
  Countries that entered the European Union in the observed period may have experienced (positive) economic effects of similar magnitudes and could, therefore, be ideal candidates for synthetic control. The membership in the EU is represented by a dummy variable *EU_member*, which signals whether the given country is a member in the given year (i.e. *EU_member* = 1) or not.

- **Population** The population of a country determines how big the economy will be, it does not do so perfectly, but from the data set it can be observed that the largest countries have significantly larger central banks

[36] Ibid.

than smaller countries. Therefore, it appears to be useful to choose countries of similar size when building a synthetic control. Variable *population* was retrieved from the World Bank on April 4, 2023[37]

[37]Ibid.

Chapter 4

Results and Analysis

This chapter aims to present the results of the empirical research of this thesis. The research attempts to test the following hypotheses:

H_0 : *Euro adoption has no effect on the amount of central bank staff.*
H_0 : *Joining ERM II has no effect on the amount of central bank staff.*

The research primarily focuses on countries that were the last to adopt the euro[1], as SCM works best for units where we are able to observe the trend for a sufficiently long time period prior to the intervention. However, the work also covers two models, Finland and Belgium, where the euro was adopted in 1999. For all ten countries of the data set that adopted the euro, both hypotheses were tested, if applicable, but due to the low fit of the models, most were discontinued and can be found attached in Appendix C.

4.1 Latvijas Banka: Euro Adoption

After adopting the euro in 2014, there did not seem to be any immediate effect on the size of Latvijas Banka. Two years after the adoption, however, the number of employees started to decline slightly[2]. To properly examine the effect of euro adoption on the institutional changes of Latvijas Banka, SCM was applied to a donor pool of 15 countries for which the data was available in the period 2002 to 2019. The pre-intervention period was divided into a training period and a validation period, as suggested by Abadie *et al.* (2015); Abadie

[1]Excluding Croatia.
[2]See Figure 3.10.

(2021). The validation period started in 2008, six years prior to the adoption of the euro, the training period is, therefore, 2002-2007.

Table 4.1 summarizes the contribution of individual countries from the donor pool to synthetic Latvia, excluding countries with contributions smaller than 0.1%.

Table 4.1: Contributors to the Synthetic Control of Latvia

weight[a]	country
0.001	Bulgaria
0.448	Croatia
0.453	Hungary
0.097	New Zealand

Source: Synthetic control method computations using *Synth* package in R

[a]The weights might not sum up to one due to rounding.

The most significant contributor of 45.3% is Hungary, followed by Croatia with 44.8% and New Zealand with 9.7%, complemented by Bulgaria with a contribution of approximately 0.1%. Considering the economic and historical background, the choice of the contributors looks quite logical as Hungary, Croatia and Bulgaria all experienced a similar shock of switching to a market economy in the 1990s and then started to prepare for joining the EU, which may have had similar impacts on the role and size of the respective central bank.

Table 4.2: Characteristics and Variable Weight

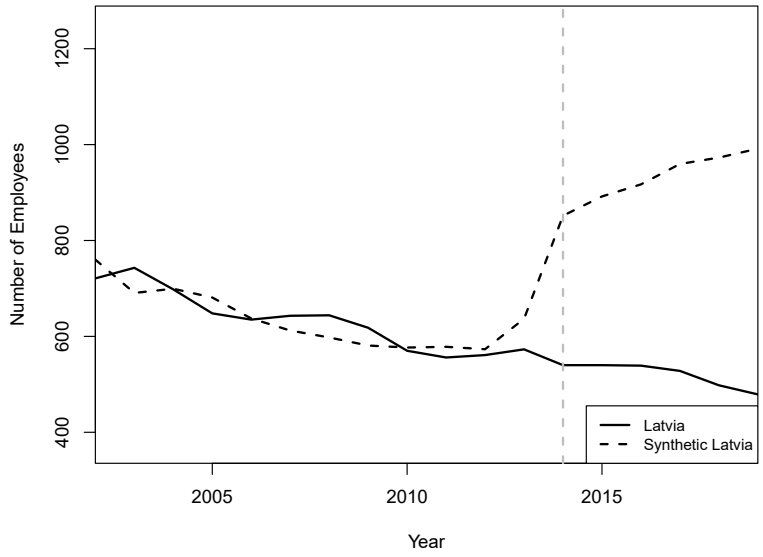
Variable	Latvia	Synthetic Latvia	Sample Mean	Weight
GDP per Capita	10792.211	14016.935	32804.817	0.001
Employees	634.167	635.356	1669.742	0.998
EU Member	0.833	0.416	0.411	0

Source: Synthetic control method computations using *Synth* package in R

The synthetic control managed to approximate the characteristics of Latvia significantly better than the sample mean. However, this model has certain limitations regarding the similarity in per capita GDP and EU membership. As both of these variables were only used as proxies for the complexity of an economy and its development, it should not be a problem that they do not match perfectly. Furthermore, the highest contribution of 99.8% has the variable *employees*, which is logical. However, in this case, it is essential not

to drop the variables GDP per Capita and EU membership, despite the low contribution, as the other optimization problem of minimizing the distance between synthetic and treated unit works much better in this setting.

Figure 4.1: The Effect of Euro Adoption on Latvijas Banka



Source: Synthetic control method computations using *Synth* package in R

As seen from Figure 4.1, the number of central bank staff could have increased rapidly had Latvia not adopted the euro. The reason for such a significant increase in synthetic Latvia may partially be attributed to the new responsibilities that the central banks have obtained - for example, as mentioned in Chapter 3, the Hungarian Financial Supervisory Authority was integrated into MNB in 2013, causing the bank staff to enlarge. On the other hand, the euro adoption may have caused a decrease in the number of employees, as the responsibilities of Latvijas Banka shrank or a part of its employees was transferred to ECB. Furthermore, notice that the personnel number started to decline slightly before 2014 - this could be attributed to a potential anticipation effect.

4.1.1 Inference

To verify the statistical significance of the obtained results, the inferential procedure outlined in Chapter 2 will be applied.

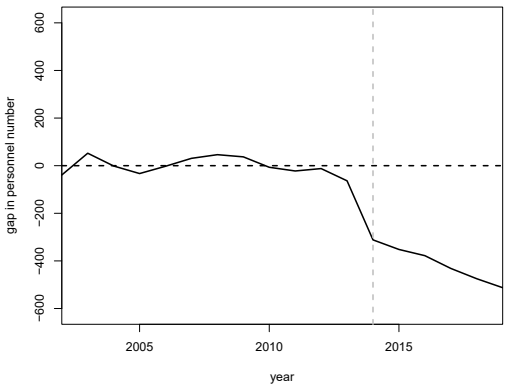


Figure 4.2: Personnel Number Gap

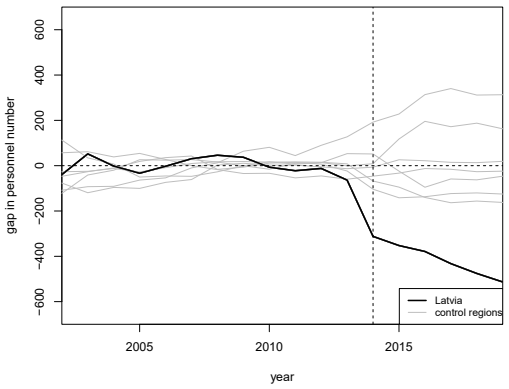


Figure 4.3: Placebo Tests

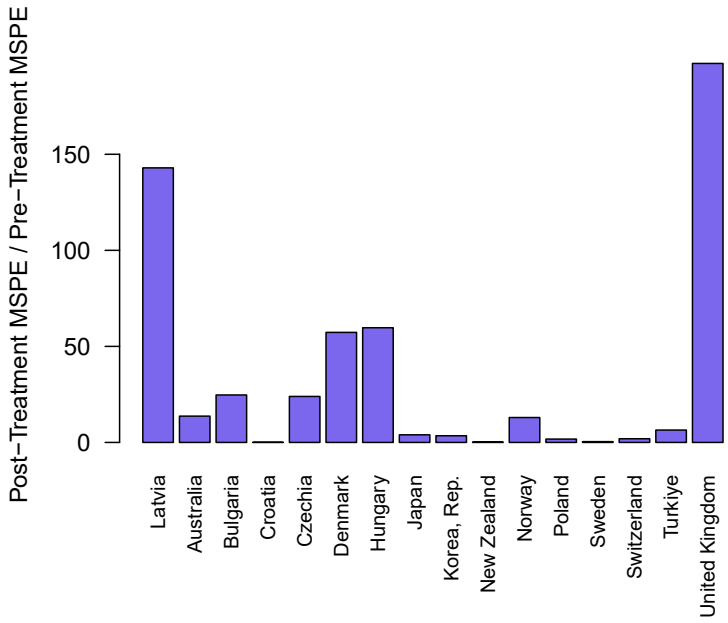
Source: Synthetic control method computations using *Synth* package in R

From Figure 4.2, it can be inferred that the euro adoption caused Latvijas Banka to be smaller by more than 500 employees five years after the adoption compared to a scenario when Latvia had not adopted the euro.

Furthermore, Synthetic Latvia seems to be an excellent fit as the gaps are relatively small both in the training period 2002-2005 and the validation period 2008-2013.

The placebo test, captured in Figure 4.3, clearly shows that the euro adoption had a genuine impact on the number of bank staff for Latvijas Banka, as the effect of the euro adoption on Latvia falls outside the range of placebo effects. To conduct the placebo test, only countries with MSPE smaller than five times the MSPE of Latvia in the pre-intervention period were chosen.

Figure 4.4: Ratio of Post-Treatment and Pre-Treatment MSPE



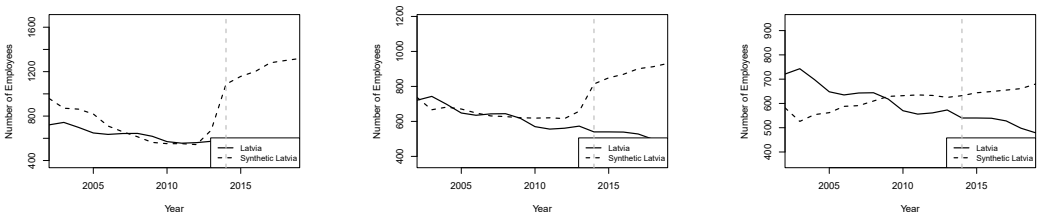
Source: Synthetic control method computations using *Synth* package in R

From Figure 4.4, it can be inferred that the euro adoption in Latvia, in fact, had a significant effect on the personnel number, as the ratio of MSPE is by far the second highest. However, the probability of obtaining a result as high as the one for Latvijas Banka at random from the sample is only $2/16 = 0.125$, id est 12.5%. Upon closer inspection, BoE underwent a significant restructuring between 2013 and 2014[3]. Keeping BoE in the donor pool is ambiguous as, on the one hand, restructuring of this size could be deemed as a large shock but, on the other hand, it is not totally unusual as we observed similar development for other central banks of the data set. If BoE is omitted, the above-mentioned probability drops to $1/15 = 0.067$, id est 6.7%. Nonetheless, we would consider keeping BoE in the donor pool as the more viable option, given that restructuring is a natural internal development that central banks undergo. Therefore, we can conclude that the null hypothesis of the euro adoption having no effect whatsoever on the personnel development of Latvijas Banka cannot be rejected on any standard significance level[4].

[3]For more details consult Chapter 3

[4]Further research is recommended.

Figure 4.5: Leave-One-Out: Synthetic Latvia



Source: Synthetic control method computations using *Synth* package in R

By applying the leave-one-out sensitivity test on the three largest contributors - New Zealand, Croatia and Hungary - we can see that the effect stays in the expected direction. However, the pre-treatment fit is much worse once we leave out Hungary or Croatia[5], and so, the significance of the effect when dropping one of the contributors is questionable.

4.1.2 Limitations

Even though the synthetic Latvia is a good fit, the model is subject to potential limitations.

- The pre-intervention period could be considered too short. As mentioned in Chapter 2, the pre-intervention period needs to be long enough for SCM to work appropriately. In this case, the period is 2002-2013, even though Latvijas Bank was established in 1992, and the data is available from 1995 onward. 2002 was chosen as the starting point to enlarge the donor pool, although at the cost of shortening the pre-intervention period. For further research, we would suggest expanding the donor pool to countries where the data was available before 2002.

- A country from the donor pool could have faced a significant shock. For SCM to work, the countries from the donor pool must not face an enormous shock that could distort the results. The above-mentioned example of integrating the Hungarian Financial Supervisory Authority into MNB in 2013 could be considered a shock. However, the integration of new supervisory authorities is very common for central banks and is a part of developing their roles. Therefore, despite this possible limitation, we decided to keep Hungary in the donor pool.

[5]The first and the third sub-figure of Figure 4.5.

- The country-level characteristics of Synthetic Latvia do not match perfectly. As described above, the characteristics of Synthetic Latvia do not precisely match those of Latvia in terms of GDP per Capita and EU membership. The difference is not crucial, but it is considerable. Adding new countries to the donor pool or choosing a different set of predictors could help mitigate this shortcoming. However, given the donor pool we work with, this combination of variables produced the closest Synthetic Control for the pre-intervention period.

- The results of the inferential procedure could have been affected by a significant shock. As mentioned above, BoE underwent a significant restructuring in the same period when Latvia adopted the euro. Such a significant year-on-year increase in personnel could have distorted the results of the inference.

- The model might be subject to a potential anticipation effect. It seems that a year prior to the adoption of the euro, the number of employees of Latvijas Banka had already decreased slightly, while that of Synthetic Latvia had already increased slightly. The observed phenomenon can potentially be attributed to an anticipation effect, which could mean that Latvijas Banka had already started to prepare for the adoption of the euro. Generally speaking, when building a synthetic control, the anticipation effect should be taken into consideration, and the year of intervention of the model should be moved to a sooner time point. However, the potential anticipation effect of this size should not pose a problem to the application of SCM, yet further research would be beneficial for understanding it.

4.2 Latvijas Banka: ERM II

An alternative hypothesis to test concerning euro adoption is the effect of fixing national currency against the euro, or in other words, joining the ERM II system. Latvia joined the system in 2005, and around this time, the number of employees started to decline slightly. This section properly examines the effect of joining ERM II on personnel development in Latvijas Banka. SCM was applied to a donor pool of 10 countries for which the data was available from 1995 to 2015. The validation period started in 1999, six years prior to the adoption of the euro.

The following Table 4.3 summarizes the contribution of individual countries from the donor pool to synthetic Latvia, excluding countries with contributions smaller than 0.1%.

Table 4.3: Contributors to the Synthetic Control of Latvia

weight[a]	country
0.682	Croatia
0.181	Czechia
0.136	Denmark

Source: Synthetic control method computations using *Synth* package in R

[a]The weights might not sum up to one due to rounding.

The most significant contributor of 68.2% is Croatia, followed by Czechia with 18.1% and complemented by Denmark with 13.6%. As described above, the choice of the contributors seems logical given the economic development.

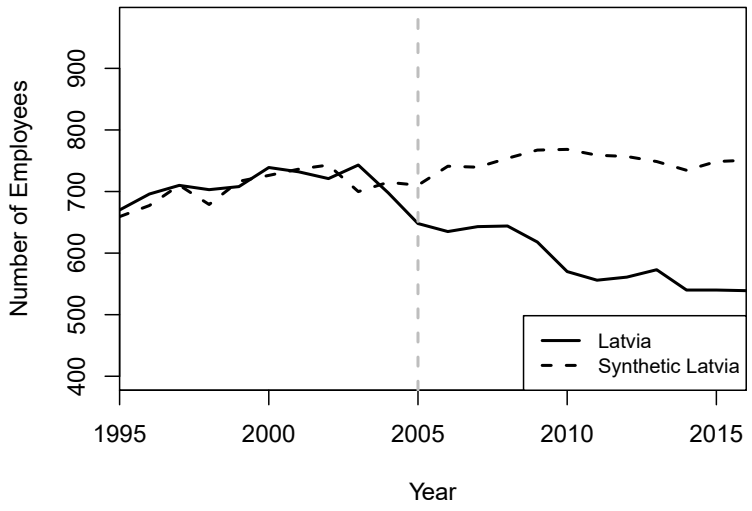
Table 4.4: Characteristics and Variable Weights

Variable	Latvia	Synthetic Latvia	Sample Mean	Weights
Population	2,326,075.333	5,565,586.896	19,218,878.317	0.007
EU Member	0.167	0.167	0.317	0.173
Employees	723.500	722.828	1,331.817	0.821

Source: Synthetic control method computations using *Synth* package in R

The synthetic control managed to approximate the characteristics of Latvia significantly better than the sample mean. However, there are certain limitations to this model in terms of population size - the population of Synthetic Latvia is more than twice as large as the Latvian population. This probably stems from the fact that Latvia has a significantly smaller population than the countries in the donor pool and no good comparison can be found. However, to minimize the distance between Latvia and Synthetic Latvia in the number of employees before the intervention, this combination of predictors does a very good job and dropping *population* leads to worse model performance.

Figure 4.6: The Effect of Joining ERM II on Latvijas Banka



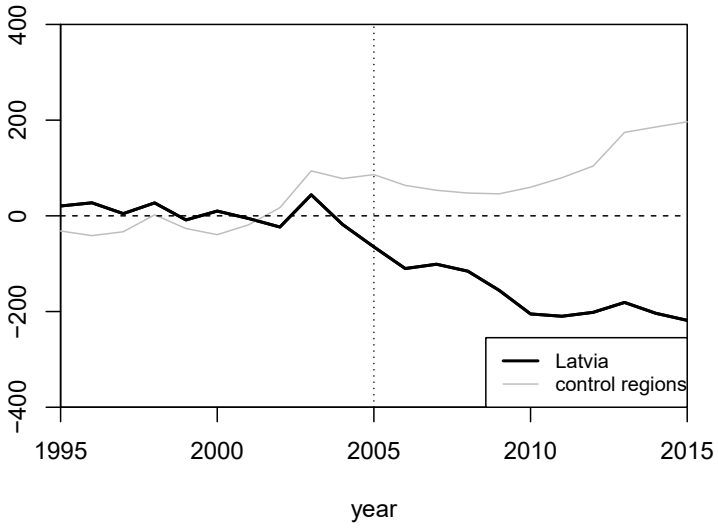
Source: Synthetic control method computations using *Synth* package in R

As seen from Figure 4.6, the number of central bank staff would continue to rise slowly had Latvia not adopted the euro. The euro adoption may have caused a decrease in the number of employees, as the responsibilities of Latvijas Banka shrank with the loss of the independent monetary policy, or possibly with the changes connected to preparations for euro adoption. The synthetic control seems to be a relatively good fit until 2004, when the gap enlarged by about 50 employees, anticipation could have caused this. The validation period was set to 1999-2004.

4.2.1 Inference

To verify the obtained results, the inferential procedure outline in Chapter 2 will be applied.

Figure 4.7: Placebo Test



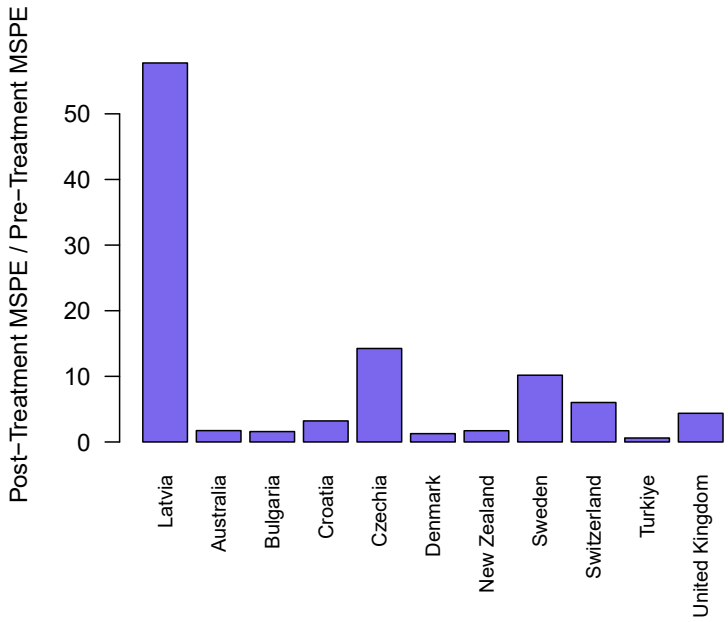
Source: Synthetic control method computations using *Synth* package in R

As mentioned in Chapter 2, only countries with MSPE smaller than five times the MSPE of Latvia in the pre-intervention period were used for the placebo tests, as a result, only one country became a suitable comparison - Switzerland.

From Figure 4.3, it can be inferred that joining the ERM II system caused Latvijas Banka to be smaller by more than 200 employees five years after the intervention compared to a scenario when Latvia had not adopted the euro. Furthermore, Synthetic Latvia is a good fit as the gaps are relatively small both in the training period 1995-1998 and the validation period 1999-2004.

The placebo test shows that joining ERM II could have had a genuine impact on the number of bank staff for Latvijas Banka, as the magnitude of the effect of the treatment is slightly larger than that of the placebo intervention. However, more countries in the donor pool would be needed in order to verify the significance of the effect with certainty.

Figure 4.8: Ratio of Post-Treatment and Pre-Treatment MSPE: Latvia - ERM II



Source: Synthetic control method computations using *Synth* package in R

As the ratio of post and pre-treatment MSPE is significantly higher than for any other control country, as can be inferred from Figure 4.8, we can conclude that the null hypothesis that joining ERM II has no impact on Latvijas Banka whatsoever can be rejected with $1 - p = 1 - 1/11 = 0,9091$, id est 90,91%, confidence.

4.2.2 Limitations

Even though the synthetic Latvia is a good fit and the effect seems to be statistically significant, the model is subject to the following limitations.

- The pre-intervention period could be considered too short. As mentioned in Chapter 2, for SCM to work appropriately, the pre-intervention period needs to be long enough. In this case, the pre-intervention period is 1995-2004. Since Latvijas Banka was established in 1992, there is little space for improvement, but using a different methodological approach could yield more reliable results.
- The country-level characteristics of Synthetic Latvia do not match perfectly. As described above, the characteristics of Synthetic Latvia do

not precisely match those of Latvia in terms of population. Adding new countries to the donor pool, especially smaller ones, could help mitigate this problem.

- Inference via placebo tests is not very reliable for this model. The problem stems from the limitations of the donor pool - there does not seem to be a sufficient number of suitable comparisons. Simply put, the data set lacks countries with relatively small central banks.

- The model might be subject to a potential anticipation effect. It seems that a year prior to joining ERM II, the number of employees of Latvijas Banka had already decreased slightly, while that of Synthetic Latvia had already increased slightly. The observed phenomenon can potentially be attributed to an anticipation effect, which could mean that Latvijas Banka had already started to prepare for the intervention. Generally speaking, when building a synthetic control, the anticipation effect should be taken into consideration, and the year of intervention of the model should be moved to a sooner time point. However, the potential anticipation effect of this size should not pose a problem to the application of SCM, yet further research would be beneficial for understanding it.

4.3 National Bank of Slovakia: Euro Adoption

After adopting the euro in 2009, there did not seem to be any immediate effect on the size of National Bank of Slovakia (NBS). The number of employees remained almost unchanged. Two years after the adoption, however, the number of employees started to decline slightly[6]. To properly examine the effect of euro adoption on the institutional changes of NBS, SCM was applied to a donor pool of 15 countries for which the data was available from 2002 to 2019. The validation period started in 2004, five years before the adoption of the euro.

The following Table 4.5 summarizes the contribution of individual countries from the donor pool to Synthetic Slovakia, excluding countries with contributions smaller than 0.1%.

[6]See Figure 3.7.

Table 4.5: Contributors to the Synthetic Control of Slovakia

weight[a]	country
0.001	Australia
0.369	Czechia
0.595	Hungary
0.001	Japan
0.001	Korea, Rep.
0.001	New Zealand
0.030	Poland
0.001	Switzerland
0.001	Turkiye

Source: Synthetic control method computations using *Synth* package in R

[a]The weights might not sum up to one due to rounding.

The most significant contributor of 59.5% was Hungary, followed by Czechia with 36.9% and complemented by Poland with 3%, and another six countries with a contribution of 0.1%. The choice of the contributors seems logical, as the two most significant ones experienced a similar switch to the market economy.

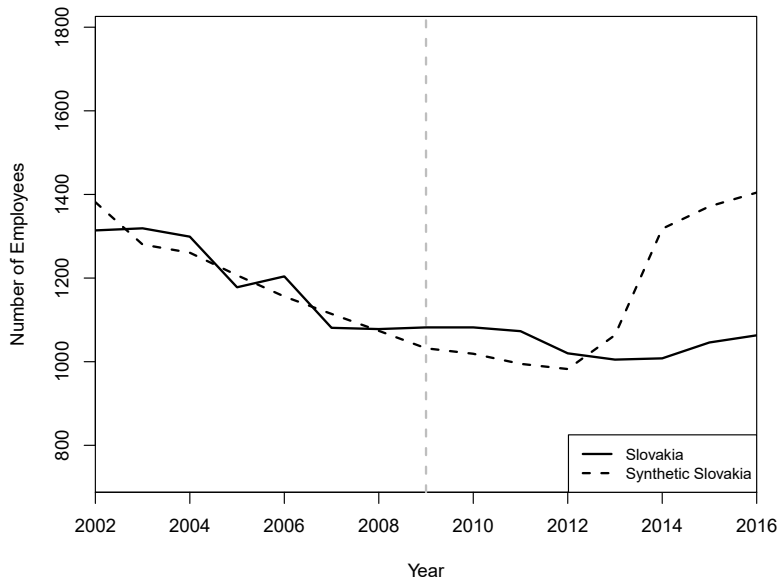
Table 4.6: Characteristics and Variable Weights

Variable	Slovakia	Synthetic Slovakia	Sample Mean	Weights
GDP per Capita	12,244.089	12,285.211	28,745.093	0.118
EU Member	0.714	0.711	0.362	0.034
New Establishment	0.143	0.053	0.010	0
Employees	1,210.429	1,210.455	1,713.569	0.847

Source: Synthetic control method computations using *Synth* package in R

The synthetic control managed to approximate the characteristics of Slovakia very closely across all predictors and significantly better than the sample mean. Variable *New Establishment* has weight close to zero, however, this particular setting performs very well both in terms of approximation of characteristics and minimization of the distance between Slovakia and Synthetic Slovakia, and therefore, it was kept in the model.

Figure 4.9: The Effect of Euro Adoption on Národná banks Slovenska



Source: Synthetic control method computations using *Synth* package in R

As seen from Figure 4.9, with a delay of three years, the number of central bank staff would have increased sharply had Slovakia not adopted the euro. As stated above, the significant increase in synthetic Slovakia may partially be attributed to the new responsibilities the central banks have obtained - such as integrating the Hungarian Financial Supervisory Authority into MNB in 2013. Au contraire, the euro adoption may have caused a decrease in the number of employees, as the responsibilities of the NBS shrank or a part of its employees was transferred to ECB.

4.3.1 Inference

To verify the obtained results, the inferential procedure outline in Chapter 2 will be applied.

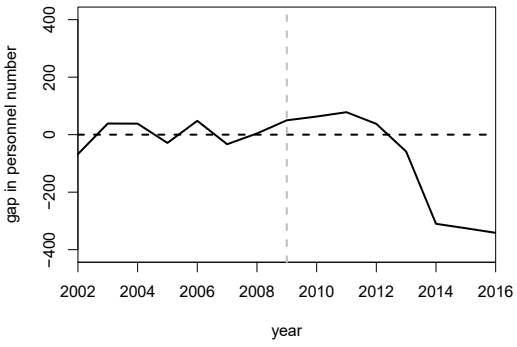


Figure 4.10: Personnel Number Gap

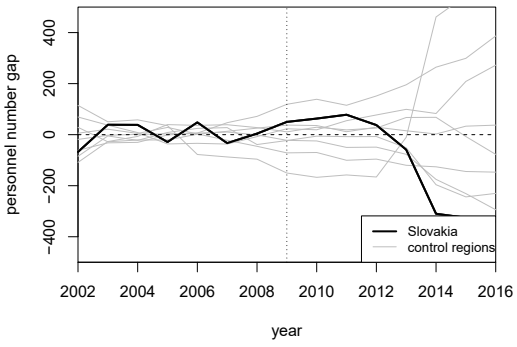


Figure 4.11: Placebo Tests

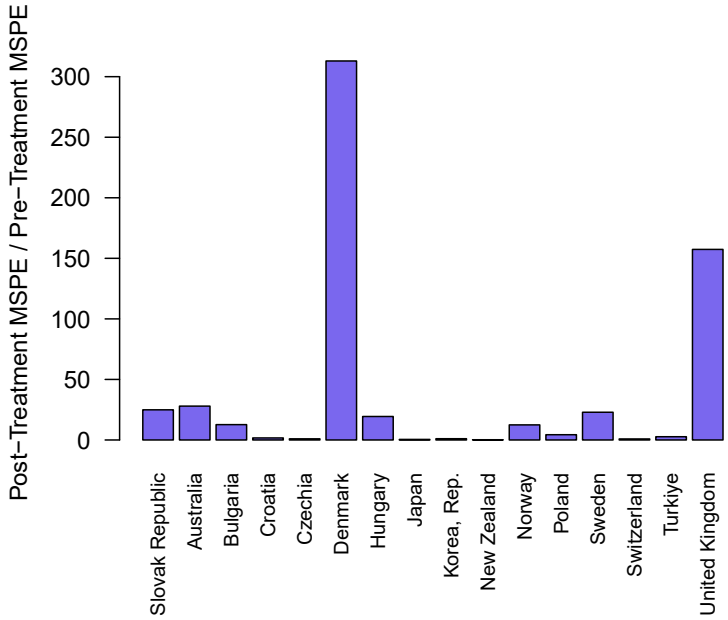
Source: Synthetic control method computations using *Synth* package in R

From Figure 4.10, it can be inferred that the euro adoption caused the Bank of Slovakia to be smaller by almost 400 employees seven years after the adoption compared to a scenario when Slovakia had not adopted the euro.

Furthermore, Synthetic Slovakia is not the greatest fit, but seems to follow the pre-treatment development consistently. The gaps are similar in the training period 2002-2003 and the validation period 2004-2008, however, as the training period is very short, overfit of the model cannot be ruled out.

The placebo tests, captured in Figure 4.11, show that the euro adoption had a genuine impact on the number of bank staff for Slovakia, as the effect of the euro adoption on Slovakia falls outside the average range of placebo effects. To conduct the placebo test, only countries with MSPE smaller than five times MSPE of Slovakia in the pre-intervention period were chosen. However, the effect is not as straightforwardly significant as for Latvijas Banka, because we can see that in a couple of placebo instances, the effect was of similar or even larger magnitude than for Slovakia, although in the opposite direction. Therefore, another inference technique needs to be implemented before making a definite conclusion.

Figure 4.12: Ratio of Post-Treatment and Pre-Treatment MSPE: Slovakia



Source: Synthetic control method computations using *Synth* package in R

Based on the findings summarised in Figure 4.12, the relatively low ratio of post-treatment and pre-treatment MSPE of NBS suggests that the result found is not statistically significant. To be more precise, the probability of obtaining a result of an equal or larger magnitude to that of NBS when randomly picking a country from the sample equals $p = 4/16 = 0.25$, id est 25%. Therefore, we definitely cannot reject the null hypothesis of the euro adoption having no effect on the size of NBS.

4.3.2 Limitations

Even though Synthetic Slovakia is a relatively good fit, the model is subject to the following limitations.

- The pre-intervention period could be considered too short. As mentioned in Chapter 2, for SCM to work appropriately, the pre-intervention period needs to be long enough. In this case, the pre-intervention period is 2002-2008. The data for Slovakia are available from 1993 onwards, but in order to enlarge the donor pool, the data starting in 2002 were used. An amelioration of the model could be achieved by enlarging the data set by similar countries for which the data is available from 1993 onward.

- The model could be prone to over-fitting. The synthetic control is generally created as a combination of a few units from the donor pool that yield similar characteristics. In this model, there are many contributors for Synthetic Slovakia which suggests that there may not have been enough countries suitable for comparison and the synthetic control was created in a way just to fit the actual development as well as possible over the validation period rather than really create a suitable comparison. Extending the training period could help mitigate this problem as it would show whether Synthetic Slovakia truly is a good comparison.

4.4 Eesti Pank: Euro Adoption

After adopting the euro in 2011, there did not seem to be any significant effect on the size of Eesti Pank, although the number of employees was slightly decreasing[7]. To properly examine the effect of euro adoption on the institutional changes of Eesti Pank, SCM was applied on a donor pool of 15 countries for which the data was available from 2002 to 2019. The validation period started in 2004, five years before the adoption of the euro.

The following Table 4.7 summarizes the contribution of individual countries from the donor pool to Synthetic Estonia, excluding countries with contributions smaller than 0.1%.

Table 4.7: Contributors to the Synthetic Control of Estonia

weight[a]	country
0.064	Hungary
0.935	New Zealand

[a]The weights might not sum up to one due to rounding.

As Estonia is the smallest country in the data set and the size of a country is a predictor of the size of the central bank, it is not surprising that the biggest weight, 93.5% is given to the smallest country of the donor pool - New Zealand. Another contributor is Hungary with 6.4%, the choice of which seems logical in economic and historical context.

The synthetic control managed to approximate the characteristics of Estonia significantly better than the sample mean. However, there are large

[7]See Figure 3.8.

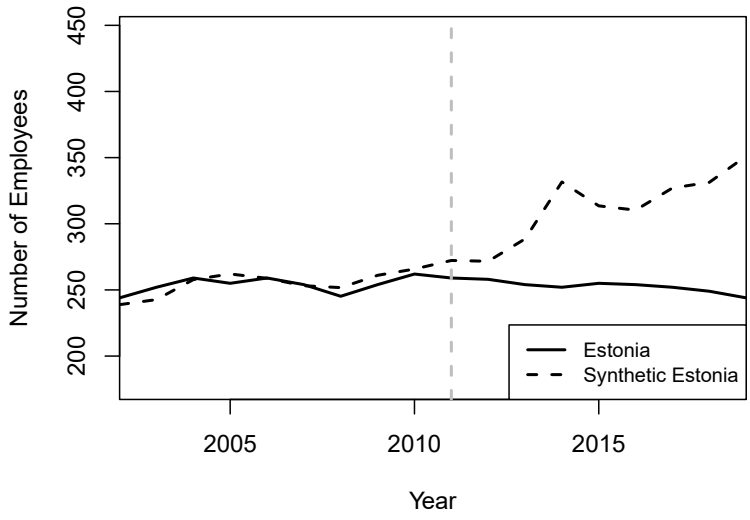
Table 4.8: Characteristics and Variable Weights

Variable	Estonia	Synthetic Estonia	Sample Mean	Weights
Population	1,350,885	4,554,418	28,593,400	0.001
GDP	16,273,880,000	114,075,800,000	795,322,000,000	0.018
EU Member	0.778	0.050	0.385	0
Employees	253.8	254.654	1,686.565	0.981

Source: Synthetic control method computations using *Synth* package in R

limitations to the similarity of Estonia and Synthetic Estonia - the population of Synthetic Estonia is more than twice as large as that of Estonia, with GDP it is even worse. This probably stems from the fact that Estonia has a significantly smaller population than the countries in the donor pool and no good comparison can be found. However, to minimize the distance between Estonia and Synthetic Estonia in the number of employees before the intervention, this combination of predictors does a very good job and dropping *population*, *GDP*, or *EU Member* from the model leads to worse performance.

Figure 4.13: The Effect of Euro Adoption on Eesti Pank



Source: Synthetic control method computations using *Synth* package in R

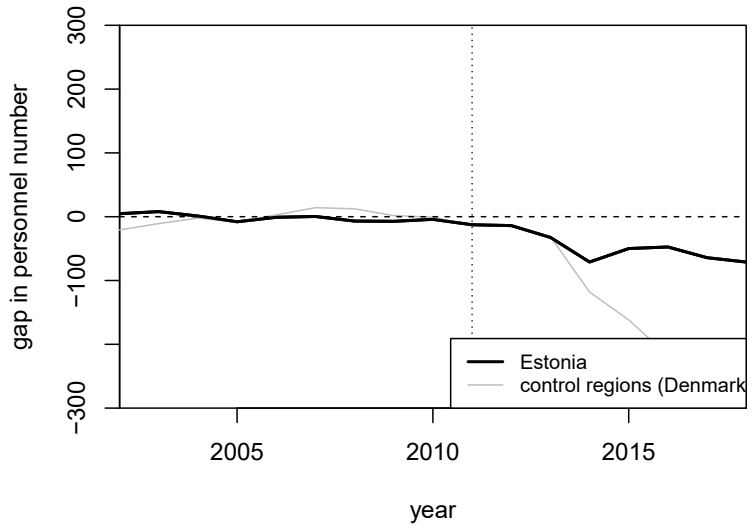
As seen from Figure 4.13, with a delay of three years, the number of central bank staff would have increased sharply had Estonia not adopted the euro. After the sharp increase, the staff number started to stabilize and then started

to rise again. The effect is in the expected direction from which it can be inferred that euro adoption has led to a decrease in the responsibilities of Eesti Pank or a possible shift of staff to ECB.

4.4.1 Inference

To verify the obtained results, the inferential procedure outline in Chapter 2 will be applied.

Figure 4.14: Placebo Test



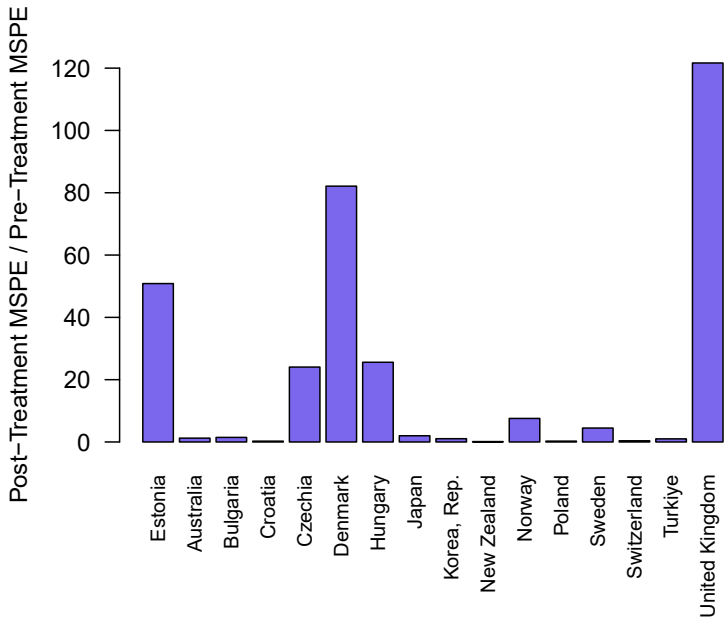
Source: Synthetic control method computations using *Synth* package in R

From Figure 4.14, it can be inferred that the euro adoption caused Eesti Pank to be smaller by less than 100 employees.

Furthermore, Synthetic Estonia is not the most excellent fit, as towards the end of the validation period, 2006-2010, the gaps began to rise. The gaps are low in the training period 2002-2005.

The placebo test, captured in Figure 4.14, shows that the euro adoption did not have a genuine impact on the number of bank staff for Estonia, as the effect of the euro adoption on Estonia falls inside the range of the placebo test performed on Denmark. To conduct the placebo test, only countries with MSPE smaller than five times the MSPE of Estonia in the pre-intervention period were chosen.

Figure 4.15: Ratio of Post-Treatment and Pre-Treatment MSPE: Estonia



Source: Synthetic control method computations using *Synth* package in R

Even though the effect seemed to be statistically significant, the ratio of post and pre-treatment of MSPE is lower for Eesti Pank than for BoE or Danmarks Nationalbank. The probability of obtaining a result of higher or equal magnitude than for Eesti Pank is equal to $p = 3/16 = 0,1871$, id est 18.75%. Therefore, we can conclude that the null hypothesis of the euro adoption having no effect whatsoever on Eesti Pank cannot be rejected.

4.4.2 Limitations

Even though Synthetic Estonia is a relatively good fit, the model is subject to the following limitations.

- The pre-intervention period could be considered too short. As mentioned in Chapter 2, the pre-intervention period must be long enough for SCM to work appropriately. In this case, the pre-intervention period is 2002-2010. The data for Estonia are available from 1995 onwards, but in order to enlarge the donor pool, the data starting in 2002 were used. An amelioration of the model could be achieved by enlarging the data set by similar countries for which the data is available from 1995 onward.

- The model might be prone to over-fitting, as Synthetic Estonia's characteristics are very different to Estonian. As mentioned earlier, Estonia is the smallest country in the data set, which has an influence on the size of the central bank. Therefore, no suitable comparison can be found for the building of Synthetic Estonia. The model might take dissimilar central banks into the synthetic unit to match the pre-intervention development of personnel of Eesti Pank. Besides adding more countries to the data set, attempting to prolong the training period might be a suitable way to mitigate the risk of over-fitting.

- The result of the inference using the ratio of post-treatment and pre-treatment MSPE could be distorted by a large shock to one central bank of the donor pool. As mention previously, the restructuring of BoE could possibly be deemed as a large shock to the central bank, and therefore, it might be considered to remove BoE from the control group.

4.5 Bank of Finland and National Bank of Belgium: Euro Adoption

This section will cover the effect of adopting the euro on two countries - Finland and Belgium, as both countries adopted the euro in the same year, and the models are subject to similar limitations.

After adopting the euro in 1999, neither of the countries seems to have experienced any sizeable change in the number of bank staff[8]. To properly examine the effect of euro adoption on the institutional changes of the Bank of Finland and the National Bank of Belgium, SCM was applied on a donor pool of 9 countries for which the data was available from 1993 to 2005. The validation period started in 1993, six years before the adoption of the euro.

The following Table 4.9 summarizes the contribution of individual countries from the donor pool to Synthetic Finland and Synthetic Belgium, excluding countries with contributions smaller than 0.1%.

[8]See Figure 3.1 and Figure 3.2.

Table 4.9: Contributors to the Synthetic Control

Country	weight[a] - Synthetic Belgium	weight[b] - Synthetic Finland
Bulgaria	0.420	0.053
Czechia	0.249	0.044
Turkiye	0.330	0.019
Australia	-	0.043
Croatia	-	0.268
Denmark	-	0.075
New Zealand	-	0.408
Sweden	-	0.061
United Kingdom	-	0.028

Source: Synthetic control method computations using *Synth* package in R

[a]Weights might not sum up to one due to rounding.
[b]Weights might not sum up to one due to rounding.

For NBB, the most significant contributor of 42% was Bulgaria, followed by Turkey with 33% and complemented by Czechia with 24.9%. The choice of the contributors is not totally straightforward but can possibly be explained by the size of economies.

For Finland, the most significant contributor of 40.8% was New Zealand, followed by Croatia with 26.8%, and complemented by Denmark with 7.5%, Sweden with 6.1%, Bulgaria with 5.3% and another four contributors with contributions below five per cent. The choice of the contributors can most likely be explained by the similarity in the size of the population of New Zealand, Croatia and Finland since population can be deemed as a proxy for the size of an economy, which subsequently influences the size of the central bank.

Table 4.10: Finland: Characteristics and Variable Weights

Variable	Finland	Synthetic Finland	Sample Mean	Weights
GDP	1.19964×10^{11}	1.202585×10^{11}	2.785709×10^{11}	0.002
employees	748.5	748.508	1877.574	0.988

Source: Synthetic control method computations using *Synth* package in R

From Table 4.10, it can be inferred that the synthetic control managed to approximate the characteristics of Finland very closely and significantly better than the sample mean. Even though the variable weight of *GDP* is only 0.2%, this combination of variables provides for the best performance of the model.

From Table 4.11, it can be inferred that the synthetic control managed to approximate the characteristics of Belgium very closely, especially in terms of

Table 4.11: Belgium: Characteristics and Variable Weights

Variable	Belgium	Synthetic Belgium	Sample Mean	Weights
employees	3153.333	3142.286	1877.574	0.923
population	10146296.500	25848346.160	19670250.796	0.008
unemployment	9.137	9.131	8.558	0.069

Source: Synthetic control method computations using *Synth* package in R

central bank staff and unemployment. However, the population of Synthetic Belgium is more than twice as large as the Belgian one, and the variable weight is only 0.8%. Again, the reason for keeping the variable in the model is to ameliorate the model in the other optimization problem that relates to minimizing the distance between Belgium and Synthetic Belgium in the number of employees during the pre-intervention period.

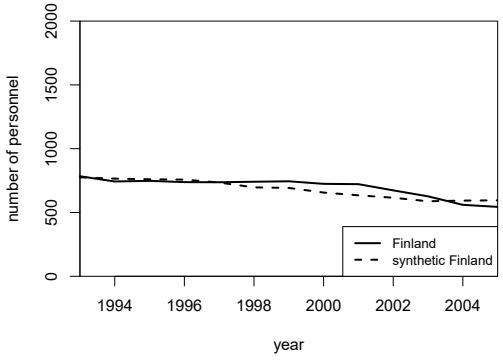


Figure 4.16: The Effect of Euro Adoption on Bank of Finland

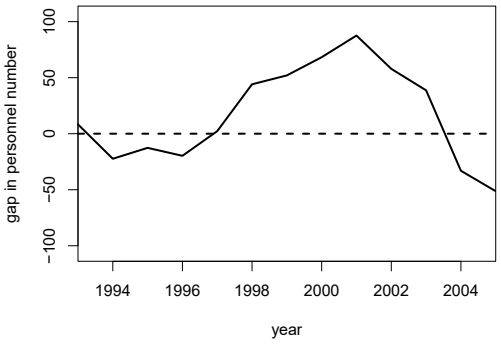


Figure 4.17: Personnel Number Gap

Source: Synthetic control method computations using *Synth* package in R

As seen from Figure 4.16, the development in Synthetic Finland is very similar to that of Finland, and therefore, it does not suggest that we should expect any significant effect of the adoption of the euro.

From Figure 4.17, it can be inferred that the euro adoption may have led to a short-term increase in the number of personnel. However, when comparing the size of pre-intervention and post-intervention gaps, it is rather unlikely that the effect would be statistically significant.

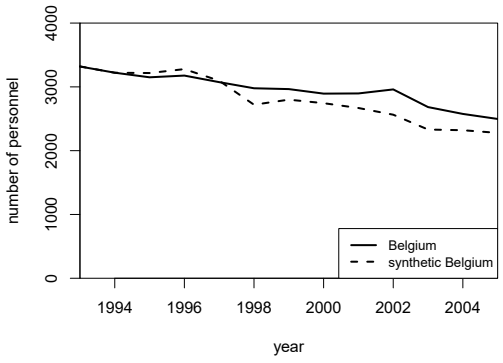


Figure 4.18: The Effect of Euro Adoption on NBB

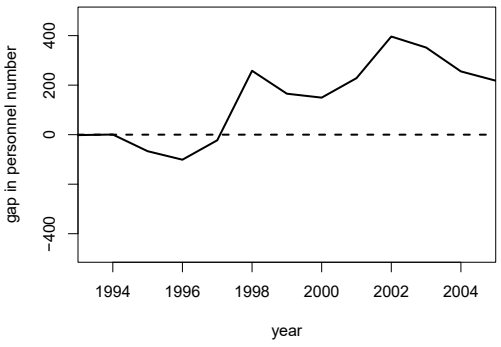


Figure 4.19: Personnel Number Gap

Source: Synthetic control method computations using *Synth* package in R

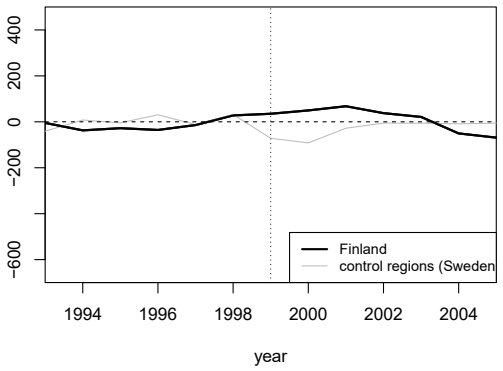
As seen from Figure 4.18, the development in Synthetic Belgium may have, paradoxically, led to a slight increase in the personnel number, compared to a scenario when NBB had not adopted the euro.

From Figure 4.19, it can be inferred that given the similar size of pre-intervention and post-intervention gaps, it is rather unlikely that the effect would be statistically significant.

4.5.1 Inference

To verify the obtained results, the inferential procedure outline in Chapter 2 will be applied.

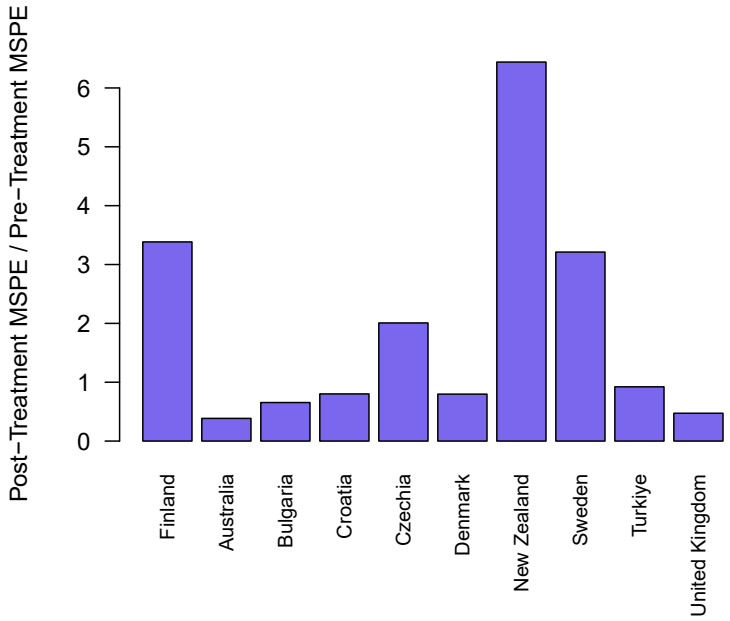
Figure 4.20: Placebo Test: Bank of Finland



Source: Synthetic control method computations using *Synth* package in R

From Figure 4.20, it can be inferred that the size of the effect of euro adoption on Finland falls within the range of the placebo intervention in Sweden. Therefore, the placebo test indicates that euro adoption did not genuinely impact the number of bank staff of the Bank of Finland. To conduct the placebo test, only countries with MSPE smaller than five times the MSPE of Finland in the pre-intervention period were chosen.

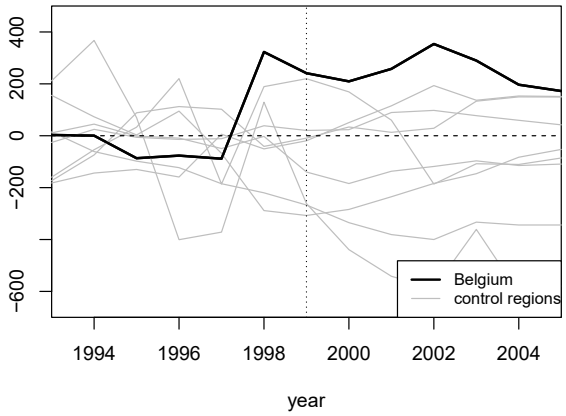
Figure 4.21: Ratio of Post-Treatment and Pre-Treatment MSPE: Finland



Source: Synthetic control method computations using *Synth* package in R

The ratio of post and pre-treatment of MSPE is lower for the Bank of Finland than for the Reserve Bank of New Zealand and very similar to that of Sveriges Riksbank. The probability of obtaining a result of higher or equal magnitude than for Bank of Finland is equal to $p = 2/9 = 0,2222$, id est 22.22%. Therefore, we can conclude that the null hypothesis of the euro adoption having no effect whatsoever on the Bank of Finland cannot be rejected.

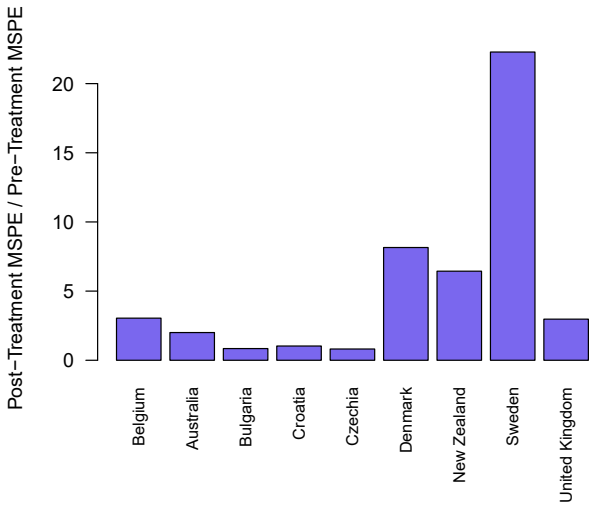
Figure 4.22: Placebo Tests: NBB



Source: Synthetic control method computations using *Synth* package in R

From Figure 4.22, it can be inferred that the size of the effect of euro adoption on Belgium falls within the range of the placebo interventions. However, Belgium has the most considerable effect with a positive sign. To conduct the placebo test, only countries with MSPE smaller than five times the MSPE of Belgium in the pre-intervention period were chosen - although as pre-intervention MSPE was relatively large for Belgium, the synthetic controls for the control regions are also of poor pre-intervention fit.

Figure 4.23: Ratio of Post-Treatment and Pre-Treatment MSPE: Belgium



Source: Synthetic control method computations using *Synth* package in R

The ratio of post and pre-treatment of MSPE is relatively low compared to other central banks, suggesting that the effect is not significant. The probability of obtaining a result of higher or equal magnitude than for NBB is equal to $p = 4/9 = 0,4444$, id est 44.44%. Therefore, we can conclude that the null hypothesis of the euro adoption having no effect whatsoever on the NBB cannot be rejected.

4.5.2 Limitations

Both Synthetic Finland and Synthetic Beglium are a relatively good fit, yet the models are subject to some major limitations.

- The pre-intervention period is too short, and there is no training period that would verify if the fit of the synthetic counterparts is truly good. As mentioned in Chapter 2, the pre-intervention period must be long enough for SCM to work appropriately. In this case, the pre-intervention period is 1993-1998. The problem arises because of the poor availability of data in the 1990s and before.

- The model might be prone to over-fitting, as Synthetic Belgium's characteristics are very different to Belgian. As mentioned above, Synthetic Belgium's population is more than twice as large as the Belgian. The problem most probably arises from the fact that no suitable comparison could be found. The model might take dissimilar central banks into the synthetic unit to match the pre-intervention development of personnel of NBB. Besides adding more countries to the data set, attempting to prolong the training period might be a suitable way to mitigate the risk of over-fitting.

- The model might be prone to over-fitting, as Synthetic Finland is composed of many contributors. Having many contributors to the Synthetic unit suggests that there may not have been a suitable comparison for the treated unit, and the model might have taken dissimilar central banks into the synthetic unit to match the pre-intervention development of personnel of the Bank of Finland. Besides adding more countries to the data set, attempting to prolong the training period might be a suitable way to mitigate the risk of over-fitting.

- SCM might not be suitable for the two models. Given the set of problems described above, the credibility of results narrows down to prolonging

the pre-intervention period and enlarging the data set. However, before the 1990s, the data were rarely available, so another statistical approach might yield more reliable results.

Chapter 5

Conclusion

The thesis examined the impact of euro adoption on central bank staff - the de jure transfer of monetary policy to the ECB - and the effect of joining ERM II, which entails the de facto transfer of monetary policy to the ECB. A total of fifteen models were tested in the study. Six of these models[1], for which SCM managed to find a suitable comparison, were covered in detail.

Furthermore, the thesis established the theoretical ground for assessing the size of central banks. It introduced a unique data set containing personnel development information from major central banks and proposed a set of variables to approximate the size of a particular central bank. These variables included factors such as the complexity of the economy or financial crises, which served as predictors in the analysis.

Regarding the findings, a significant and substantial effect was observed when Latvijas Banka joined ERM II. The event led to a permanent reduction of more than 200 employees, compared to a synthetic scenario where Latvia did not participate in the ERM II. However, it is important to acknowledge that the model used in the study has notable limitations, primarily due to the lack of suitable comparison data from the 1990s and the subsequent challenges encountered when conducting placebo tests[2], which posed constraints on the analysis.

Furthermore, the results concerning the impact of euro adoption on Latvijas Banka were inconclusive and open to interpretation. On the one hand, a relatively substantial negative effect, a reduction of more than 500 employ-

[1] Two models, one examining the effect of euro adoption and the other joining ERM II, were covered for Latvijas Banka. Four models, capturing the effect of euro adoption, were covered for the National Bank of Slovakia, Eesti Pank, Bank of Belgium and Bank of Finland.

[2] Only one country matched the condition for pre-intervention MSPE being at most five times the size of Synthetic Latvia.

ees compared to a synthetic scenario without euro adoption, was observed. This effect was by far the largest based on standard placebo tests. On the other hand, a different test, a comparison of ratios of post-intervention and pre-intervention MSPE, did not yield a significant result. It should be noted that this test may have been influenced by a shock experienced by the Bank of England, potentially introducing bias into the analysis.

Considering these limitations, it is advisable to explore alternative and more sophisticated forms of statistical inference. For instance, employing confidence intervals, as suggested by Firpo & Possebom (2018), could enhance the robustness and reliability of the results in this model.

In the remaining four models, no other statistically significant results were observed. Specifically, for Eesti Pank, a decrease of 100 employees was noted following the adoption of the euro. However, based on the data set used for this model, the probability of obtaining a result of this magnitude or higher purely by chance stands at 18.75%. Consequently, the null hypothesis, stating that euro adoption has no effect on the number of employees whatsoever, cannot be rejected at any conventional level of statistical significance. To achieve a more comprehensive understanding of the institutional development of Eesti Pank, incorporating other central banks from very small countries would be beneficial, as Estonia represented the smallest country in the data set and this fact imposed notable limitations on the application of SCM. By including additional central banks from similarly small nations, the analysis would be better equipped to account for the unique characteristics and challenges associated with central banks in such contexts. This broader approach would help to enhance the reliability and depth of the results concerning Eesti Pank's institutional development.

Similarly, in the case of the Bank of Slovakia, a reduction of nearly 400 employees was found. While placebo tests indicated that the result could be statistically significant, the test involving comparisons of the ratios of MSPE did not allow us to reject the null hypothesis that euro adoption has no effect on the number of employees at any standard level of statistical significance. The probability of randomly selecting a country from the sample with an effect of equal or greater magnitude was calculated to be 25%.

For the National Bank of Belgium and the National Bank of Finland, no significant impact of euro adoption was detected. However, it is essential to acknowledge that the two models were susceptible to overfitting, primarily due to the limited availability of pre-intervention data, resulting in a very short

observation period before the intervention. Consequently, the application of SCM in these cases raises doubts, and it is advisable to consider alternative statistical methodologies for a more robust analysis.

An important consideration to note is that the construction of the SCM relies on the utilization of a set of predictors that may not fully capture the determinants of the central bank's size. It is crucial to recognize that there is currently no empirically established theory concerning this particular subject matter. Consequently, the set of predictors proposed in this thesis may necessitate expansion or updating to encompass a more comprehensive range of factors that could better explain variations in the size of central banks.

Despite the models' limitations, SCM proved to be one of the most appropriate tools for this research. It was well-suited for quantifying the effects of the intervention, the euro adoption, considering the small sample size of aggregate data available. SCM's utility became evident in this study as it allowed us to draw meaningful insights despite the constrained data set.

In conclusion, this study contributes to the understanding of the impact of euro adoption on the size of central banks, despite the limitations of the models and the ambiguous significance of the effects observed, where further in-depth research is necessary before drawing definitive conclusions. The findings of this work can be beneficial for central banks that have recently adopted the euro or are planning to do so in the future, as they can gain insights into the potential changes in personnel they should anticipate. This work also provides a valuable baseline for future studies on the institutional development of central banks. The description of the most significant changes experienced by central banks offers a useful reference point for further investigations in this field. By building upon the insights from this research, future studies can delve deeper into the dynamics and factors that shape the evolution of central banks' structures and functions over time.

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Appendix A

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Appendix B

Description of Variables

Table B.1: Variable Definitions

Variable	Definition
GDP (in $)	GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current U.S. dollars. Dollar figures for GDP are converted from domestic currencies using single-year official exchange rates. For a few countries where the official exchange rate does not reflect the rate effectively applied to actual foreign exchange transactions, an alternative conversion factor is used.
GDP per Capita (in $)	GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current U.S. dollars.
Unemployment	Unemployment refers to the share of the labor force that is without work but available for and seeking employment.
Population	Total population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship. The values shown are midyear estimates.

Source: The World Bank

Appendix C

Discontinued Models

Find below the discontinued models; more information can be delivered upon request.

Figure C.1: Banque de France: Euro Adoption

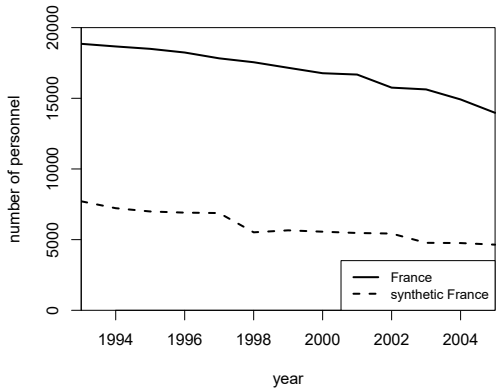

Figure C.2: National Bank of Slovakia: ERM II

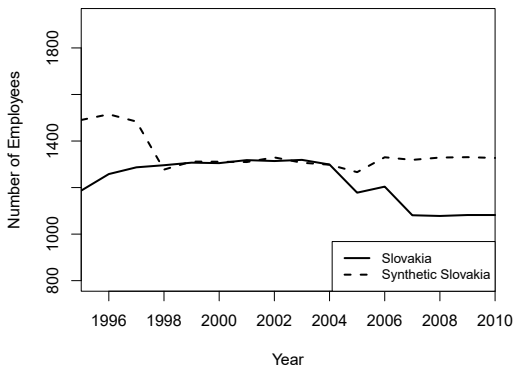

Figure C.3: Eesti Pank: ERM II

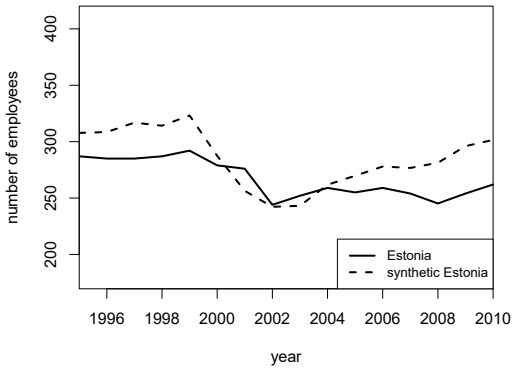

Figure C.4: Bank of Lithuania: ERM II

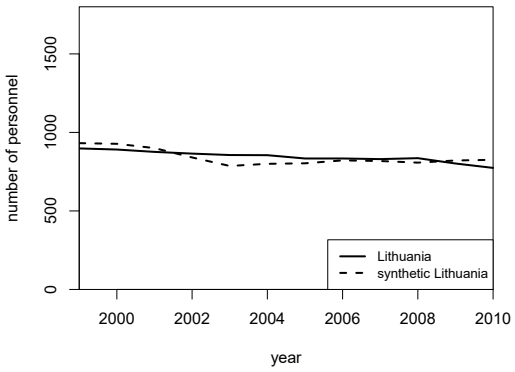

Figure C.5: Bank of Lithuania: Euro Adoption

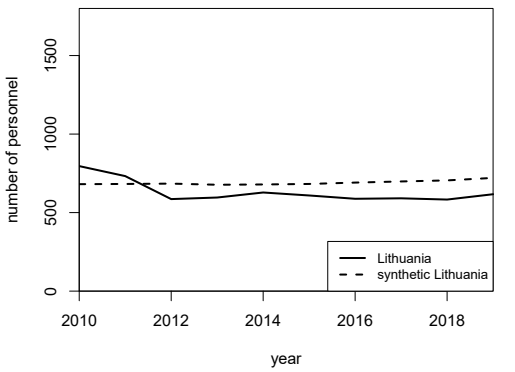

Figure C.6: Banka Slovenije: ERM II

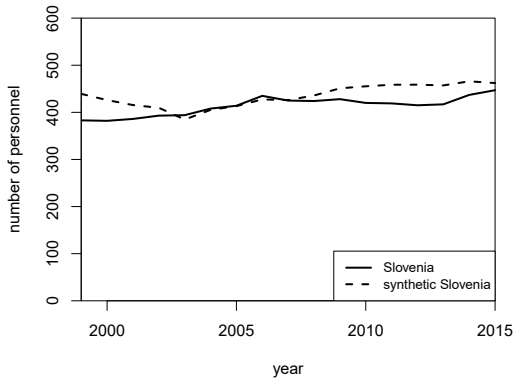

Figure C.7: Banka Slovenije: Euro Adoption

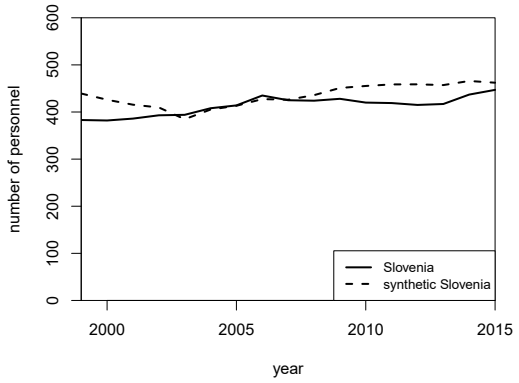

Figure C.8: Central Bank of Malta: ERM II

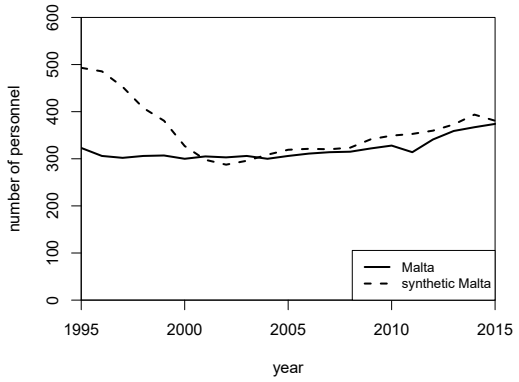

Figure C.9: Central Bank of Malta: Euro Adoption