▪ Journal of Competitiveness

Joining a currency union to improve financial development and competitiveness: The case of Slovakia

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Abstract

Enhancing competitiveness is a priority for nations seeking to promote economic growth. One of the critical drivers of a nation's sustainable competitiveness is financial system development. However, whether joining a currency union has a positive impact on a country's financial system development requires further investigation. This study evaluates the impact of euro adoption on Slovakia's financial system development using a synthetic control method with lasso regularization methodology. A comprehensive index that captures the depth, access, and efficiency of financial institutions and markets is used to measure financial system development. Based on a donor pool composed of non-euro OECD countries, the analysis constructs a synthetic counterfactual of Slovakia's financial system development had it not adopted the euro in 2009. This enables a comparison between real and synthetic Slovakia. The results show that Slovakia's transition to the common currency contributed positively to the development of its financial system. The findings show that from 2010 - 2021, Slovakia realized a 19 percent increase in its financial system development relative to the counterfactual after adopting the euro. Robustness checks using a different donor pool and alternative specification with additional covariates produce varied, but still positive, effects confirming the study's main findings.

Keywords: *National Competitiveness, Financial system, Financial development, Euro adoption, Synthetic control method, Policy evaluation*

JEL Classification: C21, F36, F45

Article history: Received: September 2023; Accepted: December 2023; Published: December 2023

1. INTRODUCTION

Attempts to achieve economic integration in Europe began in the early 1950s. In the aftermath of World War II, political leaders of the leading European countries sought to tie their economies together and rebuild them through a mutually coordinated effort. This common interest subsequently led to the signing of a series of treaties and the establishment of several organizations, e.g., the Treaty of Paris, which formed the European Coal and Steel Community (ECSC) in 1951, and the Treaty of Rome, which formed the European Economic Community (EEC) in 1957. The most defining moment of economic integration in Europe was the adoption of the 1985 Single European Market program and, subsequently, the Single European Act in 1987. A common currency is a key feature of a single market, making adopting a single currency inevitable. In 1989, the Deloros report proposed a clear road to a single currency, and in 1992, the Maastricht Treaty was signed. It established the three stages that must be taken in the adoption process and the criteria member states must meet to qualify for the monetary union.

The beginning of the third and final stage of the Economic and Monetary Union (EMU) occurred on January 1, 1999, when 11 European countries that had met the criteria adopted the euro as their common currency. As time passed, additional EU member states adopted the euro, which is currently the official currency of 20 countries.

Slovakia is one of eight countries that joined the European Union in 2004. In November 2005, as the next phase of regional integration, Slovakia joined the exchange rate mechanism with the intention of euro adoption in 2009. In July 2008, the European Council approved Slovakia's adoption of the euro. It switched from the Slovak koruna to the euro on January 1, 2009. Initially, there was a 15-day period when cash payments could be made in korunas or euros, but on January 16, 2009, korunas could only be changed into euros at banks.

In March 2006, the National Bank of Slovakia research department prepared a report, "The Effects of Euro Adoption on The Slovak Economy" (Šuster et al., 2006). The comprehensive, forward-looking report tried to anticipate the costs and benefits of euro adoption. The report highlighted several effects related to financial system development (financial development). The term "financial system" used herein refers to the entire network of financial institutions, markets, instruments, and regulations that facilitate the flow of money in an economy. The direct and indirect benefits included reduced financial transaction costs, elimination of exchange rate risk against the euro, and reduced cost of capital. A potential impediment to financial development was the cost to banks of exchanging euro for koruna and the long-term loss of revenue from reduced currency exchange services.

Fig. 1 shows that in 2005, Slovakia trailed the other Visegrad countries in financial development, as measured by the IMF's Financial Development Index (FD). The figure illustrates the difference in FD between Slovakia (FD_{SVK}) and the average FD for Czechia, Hungary, and Poland ($\overline{FD}_{V3}$) from 2005 to 2021 (FD Gap = $\overline{FD}_{V3} - FD_{SVK}$). When Slovakia joined the Exchange Rate Mechanism (ERM), its FD trailed the other three Visegrad countries by 0.20.

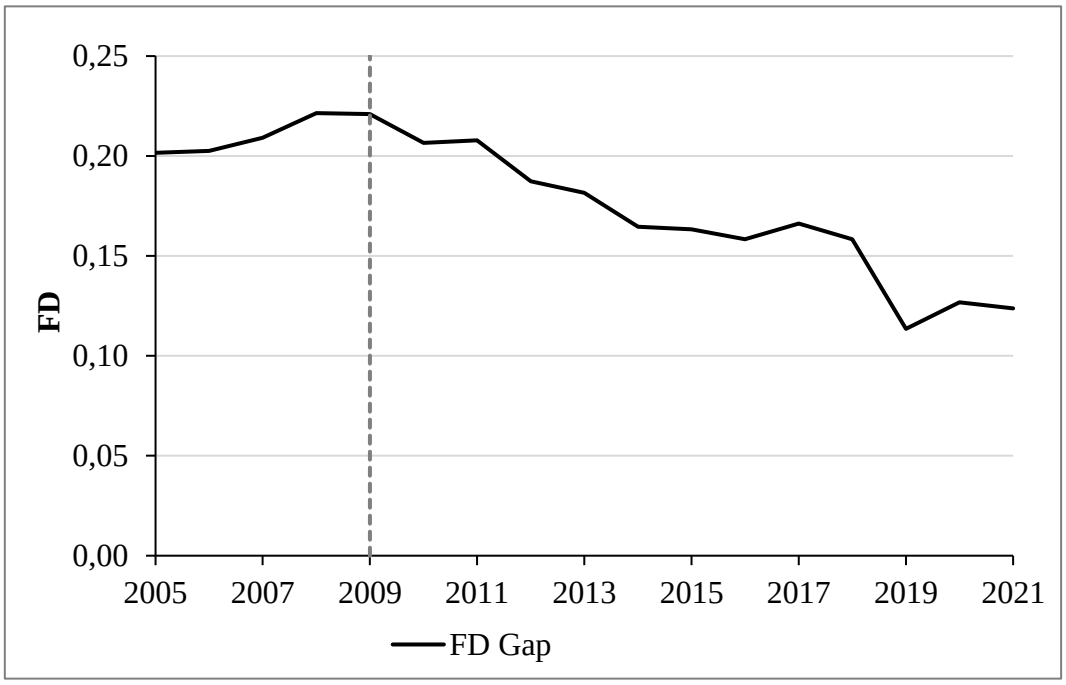

Fig. 1 – $FD\ Gap = \overline{FD}_{V3} - FD_{SVK}$, the difference in FD between Slovakia the and the average of the other Visegrad countries. Source: Authors' calculation

The difference increased slightly over the next four years until euro adoption in 2009. Although it appears that financial development in Slovakia gained ground on the other Visegrad 4 countries after euro adoption, as evidenced by the decreasing FD Gap, empirical tests utilizing the synthetic control with lasso methodology will be employed to help determine if this improvement is due to euro adoption.

Although Michael Porter's book *The Competitive Advantage of Nations* (Porter, 1990b) discusses in detail the role that government policies play in national competitiveness, his *Harvard Business Review* article the same year (Porter, 1990a) was succinct when it came to exchange rates: "avoid intervening in factor and currency markets." He argues that government intervention is often ineffective, or even detrimental, to domestic industries' improvement and sustainable competitive advantage. By adopting the euro, Slovakia's government removed the ability, and more importantly, the temptation, to interfere with market-driven exchange rates.

The initial expectations regarding the impact the adoption of the common currency would have on the Slovak economy were largely optimistic (Árendáš, 2006; Šuster et al., 2006; Zeman, 2012). However, because the currency transition happened amidst the global financial crisis, the anticipated economic benefits did not materialize as quickly as predicted. Still, Fidrmuc et al. (2013) noted that the timely adoption of the euro partially shielded Slovakia from the worst of the crisis. Furthermore, some researchers have reported positive impacts of the switch post-crises. Žúdel and Melioris (2016) reported a 10% GDP per capita gain due to euro adoption. Lalinsky and Meriküll (2021) found that adopting the euro boosted Slovakia's exports to the euro area by 18%. Accordingly, economic literature and policy documents mainly refer to Slovakia's transition from the Slovak koruna to the euro as a convergence success story in the EU (Bod et al., 2021; International Monetary Fund, 2017; Nič et al., 2014). Conversely, other studies reported an underwhelming or insignificant impact (for example, Cieślik et al., 2012; Kotliński, 2021; Polyak, 2016). Considering the impact on financial development, while existing research provides some evidence of euro-induced financial integration, the empirical literature examining the impact on overall financial development, particularly on the late joiners of the eurozone, like Slovakia, is limited.

Considering this, the current study empirically evaluates the impact of the euro on Slovakia's financial development. It constructs a credible counterfactual depicting how Slovakia's financial development would have evolved without adopting the euro. It uses a recent variant of the standard synthetic control method (SCM) called synthetic control with lasso (SCUL). The SCUL method offers a robust estimate of an intervention effect by constructing a synthetic control unit that closely matches the treated unit before the intervention so that the only post-intervention difference between the two units is the treatment effect. In order to capture the multidimensionality of financial development, the empirical analysis employs a comprehensive index measuring the depth, access, and efficiency of financial institutions and markets (Svirydzenka, 2016).

A considerable number of studies have applied classic SCM to estimate the effect of joining the eurozone on various outcome variables, *inter alia*, on economic growth (Duque Gabriel & Pessoa, 2020; Fernández & García Perea, 2015; Lin & Chen, 2017; Puzzello & Gomis-

Porqueras, 2018; Verstegen et al., 2017), on trade (Gunnella et al., 2021; Saia, 2017), on income inequality (Bouvet, 2021; Kerschbaumer & Maschke, 2020), on current account balance (Hope, 2016), on tourism flows (Addessi et al., 2019), and more. Regarding Slovakia specifically, Žúdel and Melioris (2016) analyzed the country's 2009 euro adoption effect on its economic growth, estimating a 10% higher GDP per capita from 2009 – 2011 compared to the counterfactual scenario of non-adoption. Expanding the analysis to wider Eastern Europe, Cerqua et al. (2023) assessed the impact on the competitiveness of five late-adopting countries' regions (per NUTS-2 classification). Their results indicate that the euro introduction benefited most Slovak regions between 2009 and 2015, with Bratislava reaping the highest gain in terms of GDP per capita. Moreover, Gabrielczak and Serwach (2019) studied the implication of Slovakia's eurozone accession on its export complexity, concluding that the adoption did not increase the sophistication of the country's exports. Therefore, the current study contributes to this stream of literature by expanding the scope of financial development investigated and by utilizing SCUL, a new modification of classic SCM.

The remainder of the paper proceeds as follows: the next section reviews the literature related to currency unions and their impact on financial development; section 3 describes the research objective and empirical methodology, followed by the data used for the analysis; discussion of the result of the analysis is in section 4; and the conclusions in section 5.

2. THEORETICAL BACKGROUND

2.1. Theory of currency unions: The optimum currency area

Arguably, the genesis of the theoretical argument on currency unions begins with the theory of the optimum currency area (OCA). The basic notion of OCA, which Mundell (1961) pioneered in the early 1960s, is that participating in a currency union involves a trade-off between the advantages of the unification and the cost of losing exchange rates from the monetary policy toolbox. Based on that notion, it explores a set of criteria to assess a country's suitability for joining a currency union under the condition that the benefits outweigh the costs. Mundell proposes that the degree of factor mobility in a given area is a crucial criterion in determining whether a common currency should be established in that region. According to his argument, it is beneficial for a region with a high level of factor mobility to establish a common currency within its border, hence a fixed exchange rate.

Furthermore, if there is another region where those factors are immobile, the exchange rate between these two regions should be flexible. Mundell contends that it is only then that a flexible exchange rate can result in a stable price, full employment, and balance of payment equilibrium (Mundell, 1961). McKinnon (1963) contributed to OTC theory by suggesting that instead of factor mobility, it is the degree of openness, defined as the ratio between tradable (exportable and importable) to non-tradable goods within the area, which should determine the decision for establishing a common currency. In highly open economies, as domestic prices of goods and wages can adjust quickly and offset any exchange rate changes aimed at adjusting external deficits, flexible exchange rates are ineffective policy instruments. Therefore, he concludes that forming a common currency area benefits these economies.

On the other hand, unlike McKinnon, who regarded small economies (as they tend to be more open) as better suited for forming a currency union, Kenen (1980) deemed large economies more likely to engage in well-diversified production to be ideal candidates. He argues that the

extent of product diversification needs to be a key consideration in assessing region suitability for a currency union. According to his argument, if economies produce a mix of diversified products and have a diversified export sector, a negative asymmetric demand shock on one product would be smoothed out by a positive shock on another. As a result, there will not be a need to change exchange rates to adjust trade balances in such economies, and instead, they may find a currency area more advantageous.

In the years that followed, numerous scholars have significantly contributed to the advancement of OTC theory by either analyzing the abovementioned criteria or introducing new ones for evaluating whether a currency union is desirable in a region. The similarity in inflation rate and flexibility of prices and wages (Fleming, 1971), the extent of political integration and will (Mintz, 1970; as cited in Tavlas, 1993), the level of financial market integration (Ingram, 1969; as cited in Ishiyama, 1975) and business-cycle correlation (Frankel & Rose, 1998) are some of the other criteria that have been proposed. Perhaps the most notable addition to the theory, however, is the 'endogeneity of OCA' hypothesis, which gained more popularity after the launch of the EMU. The basic intuition of this theory is that introducing a currency union in a region leads the participating countries toward meeting the abovementioned OCA criteria (Frankel & Rose, 1998). Therefore, countries can meet the criteria after joining the union or ex-post, even if they fail to do so ex-ante.

The often-cited cost associated with joining a currency union is the loss of independent exchange rate adjustments or monetary policy in general as a stabilization instrument. The participating countries' central banks can neither change the exchange rate of their currency nor determine the quantity of their national currency circulating in the economy. Besides, once a country joins a currency union, the government neither finances its deficit by printing money nor enjoys seigniorage revenues independently. On the other hand, the most important benefit attributed to currency unions is the elimination of exchange-rate fluctuations risks and the transaction costs involved in converting currencies. Eliminating this cost enhances trade and substantially increases economic and financial integration in the participating countries.

2.2. Currency unions and financial development

One of the direct consequences of a currency union is financial integration across the participating countries (Ingram, 1973). Financial integration refers to the accessibility of a country's financial services to other countries' economic agents under the same set of terms and conditions. Whereas the traditional OCA theory considers financial integration in terms of capital mobility as a precondition that an economy must satisfy prior to joining a currency union, the endogenous OCA literature views it as a development that follows participation in such arrangements (Mongelli, 2008; Schiavo, 2008). It even has been argued by Arestis et al. (2005) and others that multiple currencies with different exchange rates are a primary barrier to financial integration.

Using a single currency eliminates exchange rate volatility and removes the need for currency risk premiums for investing in foreign financial instruments. This, in turn, enhances the substitutability of securities issued in different parts of the currency area and lessens agents' home bias in portfolio holding. Using a single currency also standardizes financial products' price expressions, facilitating financial transactions. Moreover, as Fornaro (2022) shows, forming a currency union increases the stock of foreign countries' assets that a home country

can sustain without defaulting, given that they are all members of the union. This is because the member states delegate a supranational institution, i.e., a central bank, to set all monetary policies. Unlike national governments, the institution has no incentive to expropriate creditors. These conditions cause an increase in financial flows and financial integration among the union members. The empirical evidence supports this theorized increase in the degree of financial integration after the launch of the Economic and Monetary Union (EMU) and the single currency in the eurozone (Kalemli-Ozcan et al., 2010; Kılınç et al., 2017; Lane, 2008).

For many reasons, increased financial integration is associated with improved financial development. First, an integrated financial system increases competition among financial intermediaries and markets in the currency union. This competitive pressure promotes financial innovation and improves the quality of services these institutions provide while driving down the cost of the services for households and firms. The institutions can also benefit from economies of scale, which decreases their overhead costs. Furthermore, the standardization of countries' financial regulations, a pre-requirement for financial integration, improves their regulatory and supervisory frameworks to the best of international standards (Jappelli & Pagano, 2008). In addition, from a theoretical perspective, integrated financial and capital markets make cross-border investment portfolio diversification achievable, thereby enabling risk sharing across countries. According to Karlinger (2002), this, coupled with eliminating exchange rate volatility, should foster financial system stability.

Notwithstanding the above advantages, the experience of recurrent financial crises in the last few decades has led economists and policymakers to acknowledge that there are also drawbacks associated with deeper financial integration, which is contrary to the notion that international risk-sharing results in financial stability. For example, the Asian and global financial crises showed how extensive integration can exacerbate financial contagion (Agénor, 2003; Stiglitz, 2010). Theoretically, Dell'Ariccia and Marquez (2006) show how the financial integration-induced reduction of financing cost comes at the expense of a potential credit boom and banking crisis. The authors argue that this is due to the threat of competition, making the local banks lower their credit screening standards. A similar argument has also been set forth by Tressel and Verdier (2011), who model international financial integration's impact on the governance of domestic financial intermediaries. They demonstrate how international capital flow increases the likelihood of banks colluding with their corporate borrower in countries with pre-existing institutional weaknesses.

To sum up, most of the theoretical literature on the financial development effect of a currency union suggests that using a single currency contributes to better financial development in the participating countries. Nevertheless, there is also some skepticism about its benefits, as financial contagion may accompany the high degree of financial integration driven by a currency union. Either way, the abandonment of sovereign currencies for a common currency like the euro is expected to reshape the financial system of the joining country.

3. RESEARCH OBJECTIVE, METHODOLOGY, AND DATA

3.1. Research objective

The objective of this study is to empirically evaluate Slovakia's financial development after adopting the euro in 2009. Specifically, the analysis quantifies the impact of the currency change on the depth, accessibility, and efficiency of Slovakia's financial institutions and markets in the

years after adoption relative to a counterfactual scenario without euro adoption. To achieve this, the study implements a novel approach developed by Hollingsworth and Wing (2022): synthetic control with lasso. As financial development is a multidimensional process (Svirydzenka, 2016), traditional unidimensional measures like credit or market capitalization ratios provide an incomplete picture. Hence, to capture the potential impact of the euro on multiple dimensions of financial development, we use an index recently developed by the IMF that measures the depth, access, and efficiency of financial institutions and markets. Details about the SCUL method and the measure of financial development are provided in subsequent sections.

3.2. Methodology: Synthetic control with lasso

This study evaluates the impact of the euro on Slovakia's financial development by estimating the trajectory it would have taken had the country not adopted the common currency. The main challenge of such counterfactual analysis is that it is impossible to observe the latter. We can only observe the output variable of the adopter compared to that of non-adopters. This study employs the SCUL technique, a recent variant of the classic synthetic control method, to overcome this issue. SCM provides a systematic way of constructing a synthetic control or counterfactual unit that simulates how the treated unit's outcome of interest would have evolved without a 'treatment' (Abadie et al., 2010). This synthetic control unit is constructed based on a weighted average of the units in the donor pool - a set of potential comparison units that did not receive the treatment, in which the weights represent the contribution of each of these units in its construction. Then, the causal effect of the treatment can easily be measured by comparing the difference between the output of the treated unit and the synthetic control.

More formally, suppose we are observing a panel of J units (in the case of our study, countries) indexed by $j = 1, 2, \cdots, J$ over the period $t = 1, 2, \cdots, T_0, T_0 + 1, \cdots, T$. Of these countries, assume only the first one received a specific treatment, D_{jt}, at year T_0 (treatment year), while all the other countries did not. Thus, the remaining countries represent the donor pool. If Y_{jt} denotes the observed outcome of country j at time t, it can be written as:

$$Y_{jt} = \begin{cases} Y_{jt}^0 \\ Y_{jt}^1 = Y_{jt}^0 + \tau_{jt} D_{jt} \end{cases}, where\ D_{jt} = \begin{cases} 1\ if\ j = 1\ and\ t > T_0 \\ 0\ otherwise. \end{cases} \quad (1)$$

Y_{jt}^0 and Y_{jt}^1 are the outcomes of country j at a time t in the absence of the treatment and with the treatment, respectively. τ_{jt} is the causal effect of the treatment for a country j at time t that can be defined as:

$$\tau_{jt} = Y_{jt}^1 - Y_{jt}^0 \quad (2)$$

However, one can only observe either Y_{jt}^0 or Y_{jt}^1. If j is a treated country, Y_{1t}^0 is unobservable after period T_0. To calculate the treatment effect on the treated country (τ_{1t}), the values of Y_{1t}^0 for $t > T_0$ need to be estimated. This is the primary benefit of SCM, a way of estimating robust values of Y_{1t}^0 for the post-treatment periods. It creates a plausible counterfactual that replicates the path Y_{1t}^0 would have followed in the post-treatment period if country $j = 1$ did not receive the treatment.

The key assumption in applying SCM is that a combination of control countries provides a better counterfactual than a single country. Y_{1t}^0 can, therefore, be approximated by a synthetic control

unit constructed as a weighted average of the outcomes of the other $J-1$ untreated countries. This can be formulated as:

$$\hat{Y}_{1t}^{0} = \sum_{j=2}^{J} \hat{w}_j Y_{jt}^{0} \quad (3)$$

The weights of each potential control country are denoted w_j, for $j = 2, \ldots, J$. They are selected in such a way that the pre-intervention weighted synthetic control unit's outcomes match the treated unit's outcomes. There are a variety of alternative approaches to determining the weights. For example, the classic SCM proposed by Abadie and Gardeazabal (2003) and Abadie et al. (2010) choose w_js that minimize the difference between the treated and the synthetic control unit over the pre-treatment years, subject to the restriction that the weights must be non-negative and sum to one. These restrictions are imposed to prevent extrapolation biases and to ensure the pre-intervention outcomes of the synthetic control lie inside the 'convex hull'- the pre-intervention outcome range realized in the donor countries. Doudchenko and Imbens (2016) demonstrate the use of penalized regression based on elastic net regularization to estimate the weights without restricting the signs and sum of the weights. Athey et al. (2021) introduce a regularized matrix completion approach for estimating the synthetic control weight matrix.

In this study, we adopt the SCUL approach suggested by Hollingsworth and Wing (2022), which proposes a penalized regression method similar to Doudchenko and Imbens (2016) for synthetic control weighting. The main distinction is that Doudchenko and Imbens's technique employs an elastic net regression, which uses a combination of lasso (L1) and ridge (L2) penalties. In contrast, Hollingsworth and Wing's approach uses only a lasso penalty. Comparing the two approaches, the lasso produces the most sparse weights, i.e., only a few donor units will have non-zero weights (Abadie, 2021). This is desirable because it makes the procedure transparent, and with fewer effective control units, there is less risk of overfitting the outcome in the pre-intervention period.

As in classic SCM, SCUL solves for control weights that minimize mean squared prediction error before the intervention but adds a lasso penalty that enforces sparsity in the weights. Specifically, the optimization function takes the form:

$$\widehat{W}^{*} = arg \min_{W} \left(\sum_{t=1}^{T_0} \left(Y_{1t} - \sum_{j=2}^{J} w_j Y_{jt} \right)^2 + \lambda \sum_{j=2}^{J} |w_j| \right) \quad (4)$$

One important feature of SCUL is that it does not constrain the weights to be non-negative or their sum to equal one as classic SCM does. Although the desirability of these restrictions for mitigating extrapolation is undeniable, there are cases where they can inhibit researchers from finding the best pre-intervention fit. One of these cases is when some of the control units in the donor pool have a negative correlation with the treated unit (Amjad et al., 2018). The other case is when the pre-intervention outcomes of the treated unit are outside the support of the donor pool outcomes (Hollingsworth & Wing, 2022). In the context of the current study, for example, Slovakia's financial development level is below all the non-euro EU countries except Romania across the full 1992-2008 period (see Fig. 2), as well as lower than the majority of the broader non-euro OECD member donor countries. Hence, despite the availability of potential countries in the donor pool that adequately predict pre-euro Slovakia's financial development fluctuations, traditional SCM fails to produce a synthetic Slovakia that matches the real Slovakia's financial development.

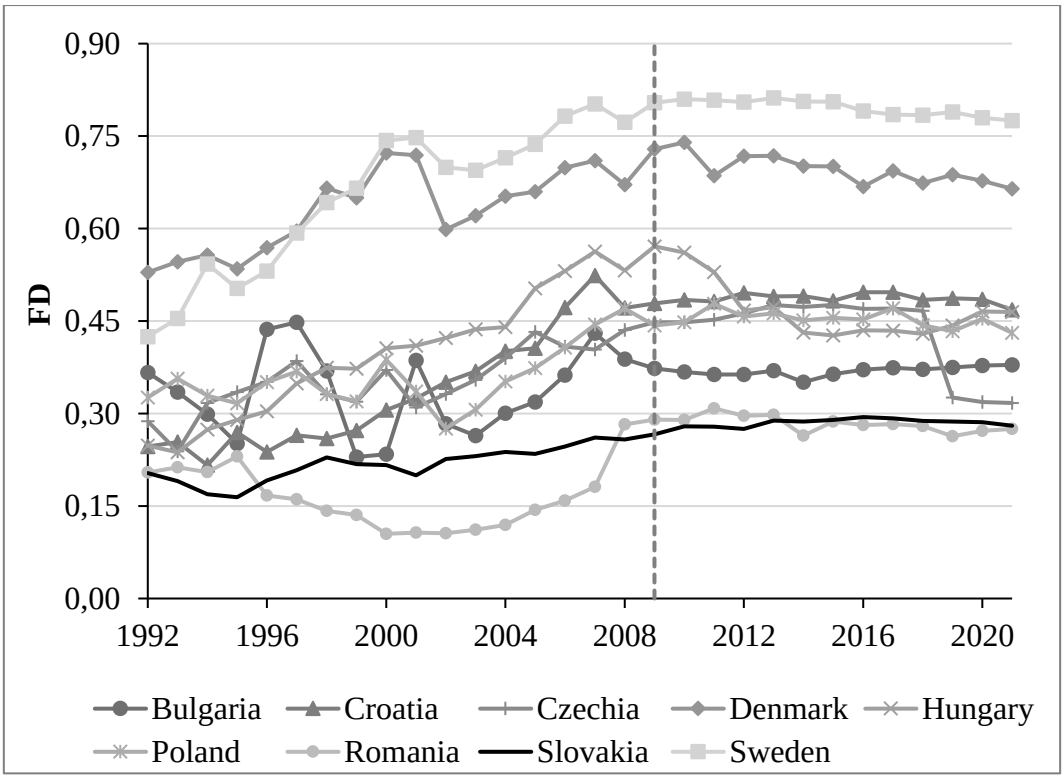

Fig. 2 – FD trend of Slovakia and non-Euro EU countries. Source: Authors' calculation

Instead of imposing the above restrictions, SCUL penalizes the sum of the absolute value of the control weights for reducing extrapolation and overfitting. This is denoted by the second component in Equation (4). The penalty parameter, λ, imposes a shrinkage effect on the control unit weights to improve sparsity. If a particular donor unit does not contribute sufficiently to reducing squared prediction error, its weight is reduced, even to zero. When the value of λ is too low, SCUL produces less sparse weights, resulting in fitting to noise, and when it is too high, all control weights shrink to zero, resulting in underfitting. Therefore, proper selection of λ is critical in the process.

Accordingly, the optimal λ is determined through the time-series cross-validation process (Greathouse, 2022a). The procedure involves splitting the pre-intervention outcome series into multiple training (earlier periods) and validation (later periods) sets. Using a set of λ candidate values between one and zero, a lasso synthetic control model is fit for each training data series to predict the counterfactual outcomes in the validation period and calculate the prediction error. After evaluating the mean squared prediction errors (MSPEs), the optimal λ that minimizes the average MSPE across all the validation periods is selected and used for estimating Equation (4). The study implements SCUL based on the STATA adaptation by Greathouse (2022b) of the original R code by Hollingsworth and Wing (2022).

The other feature of SCUL that differentiates it from classic SCM is that it does not require the availability of additional covariates other than the pre-treatment outcome to estimate the synthetic control unit. Predictor selection is a debated subject in the literature when it comes to SCM applications. The earlier SCM applications, including Abadie and Gardeazabal (2003) and Abadie et al. (2010), included observed covariates, in addition to a subset of (not all) pre-

treatment outcomes to predict the synthetic control unit. However, subsequent extensions have demonstrated that as long as the SCM gives a satisfactory match based on the pre-treatment outcomes, including covariates is optional rather than required (Amjad et al., 2018; Botosaru & Ferman, 2019). Furthermore, no clear direction exists on the number of pre-treatment outcomes that should be included. Ergo, one of the criticisms of classic SCM is that it gives substantial user discretion involving its implementation, such as predictor selection. This opens a door for 'cherry-picking' a specification that produces the best result (Ferman et al., 2020).

By comparison, there is less researcher discretion involved in the SCUL framework. For one thing, rather than leaving the task of selecting predictive pre-treatment outcome variables to the researcher, the SCUL method is designed to select them from the available data based on their relevance. In addition, the method's capability to produce robust synthetic control, regardless of the inclusion of additional covariates, alleviates some of the ad hoc choices made by researchers. The SCUL specification employed is without covariates, as shown in Equation (4), to remove all researcher discretion regarding which covariates to include in the empirical tests. However, to demonstrate the reliability of the results, a SCUL specification with covariates that are believed to be correlated with the outcomes variable is included as a robustness check.

After constructing the synthetic control, its pre-treatment goodness of fit is assessed by calculating the root mean square prediction error (RMSPE) between the synthetic control and the treated country and Cohen's D statistic. RMSPE was proposed by Abadie et al. (2010), and while they did not specify an exact cut-off, a lower RMSE generally indicates a better pre-treatment fit. Hollingsworth and Wing (2022) proposed Cohen's D statistic as the second assessment method, calculated as the standardized mean difference between the synthetic and the treated unit's pre-treatment outcomes. They suggest Cohen's D < 0.25 as a threshold.

Once the synthetic control is constructed, estimating the treatment effect is straightforward. It is calculated as the difference between the post-treatment outcome of the treated country and its synthetic counterpart during the post-treatment year. Suppose $\hat{Y}_{st} = \sum_{j=2}^{J} \hat{w}_j Y_{jt}$ is the estimated outcome of the synthetic control country (s) at year (t). Then, the treatment effect on the treated country in year $t = T_0 + 1, T_0 + 2, \cdots, T$ is given by:

$$\hat{\tau}_{1t} = Y_{1t} - \hat{Y}_{st} \tag{5}$$

To summarize the overall impact of euro adoption over the entire post-treatment period considered, the average treatment effect for the treated country (ATT) is calculated as:

$$ATT = \frac{1}{T - T_0} \sum_{t=T_0+1}^{T} \left(Y_{1t} - \hat{Y}_{st}\right) \tag{6}$$

Finally, we use placebo analysis to conduct statistical inference on our ATT estimates. The placebo analysis is a falsification test that involves applying SCUL to each country in the donor pool iteratively as if they were treated. The remaining countries in the original donor pool serve as control countries. If the ATT on the treated country is large compared to the pseudo-ATTs from untreated counties, then the estimated ATT on the treated country is less likely to be spurious.

3.3. Data

In order to capture the impact of the euro on different dimensions of Slovakia's financial development, we use the financial development index (FD) developed by IMF researchers as our outcome variable (Svirydzenka, 2016). The index measures the development of different dimensions of financial development in a country. It combines six sub-indices measuring financial institutions and markets' depth, access, and efficiency. The types of institutions and markets considered for constructing the index include banks, institutional investors, equity markets, and debt markets. While the depth indices capture the size and liquidity of markets and institutions, the access indices measure how easily financial services are accessible to individuals and companies. In addition, two efficiency indices track the effectiveness of institutions and capital markets in offering financial services at a low cost with stable revenue. According to Svirydzenka (2016), around 20 raw underlying indicators are tracked, normalized, and aggregated using principal components analysis (PCA) to construct these sub-indices. The six sub-indices are then combined into the final composite index, FD, also using PCA. The FD is normalized between 0 and 1, with the endpoints being the lowest and highest country scores. The most recent version of the dataset, published in 2023, covers 183 economies over 42 years (between 1980 and 2021). Since its introduction in 2016, the FD has been used by many researchers and in several IMF publications to measure financial development.

As the treatment of interest in this study is Slovakia's euro adoption, 2009 serves as the treatment year. The primary criterion for choosing the evaluation period is the availability of FD data for the treated and control countries. Having sufficiently long pre-treatment outcome data points for both groups is one of the data requirements in synthetic control designs (Abadie, 2021). Moreover, the SCUL method requires complete outcome data for all countries in the sample, both treated and untreated, to construct the synthetic counterfactual. Any gap in the outcome time series will disturb the estimation procedure. Given these conditions, the years between 1992 and 2021 are selected as the study period. The 1992 start date allows the maximization of series completeness while enabling the inclusion of sufficient potential controls. This provides 17 pre-intervention years. The euro effect is then estimated over 2010 – 2021, spanning 12 post-intervention years.

For the construction of the donor pool, Abadie (2021) recommends using control units that resemble the treated unit to reduce potential interpolation biases, which can arise if units with outcome values far from the treated unit are selected. Hence, the control group comprises OECD members that remained outside the eurozone over the study period (1992 - 2021). These include Australia, Canada, Chile, Colombia, Costa Rica, Czechia, Denmark, Hungary, Iceland, Israel, Japan, Korea, Mexico, New Zealand, Norway, Poland, Sweden, Switzerland, Turkey, United Arab Emirates, and the United Kingdom. This ensures the availability of sufficient potential donors for the construction of synthetic Slovakia while restricting the pool to economies that likely exhibit characteristics aligned with the treated country.

4. RESULTS AND DISCUSSION

This section presents and discusses the estimated effect of euro adoption on Slovakia's financial development. We first display the results from the preferred specification, in which the SCUL procedure is carried out using only the pre-intervention outcome values without additional covariates. Assessment of the findings' significance using placebo tests is then presented in the

statistical inference sub-section. Moreover, as robustness checks, we show the findings from the re-estimation of the treatment effects by changing the donor pool and by including additional covariates (in addition to the pre-treatment outcomes) as predictors in the SCUL specification.

4.1. Treatment effect

Fig. 3 depicts the evolution of overall financial development during the pre-euro (1992 – 2008) and post-euro (2010 – 2021) years in real and synthetic Slovakia. The vertical dotted line is drawn at the year when Slovakia adopted the euro: 2009. The solid curve depicts the path of Slovakia's financial development, while the dashed one represents the counterfactual, or what may have happened if Slovakia had not adopted the euro in 2009.

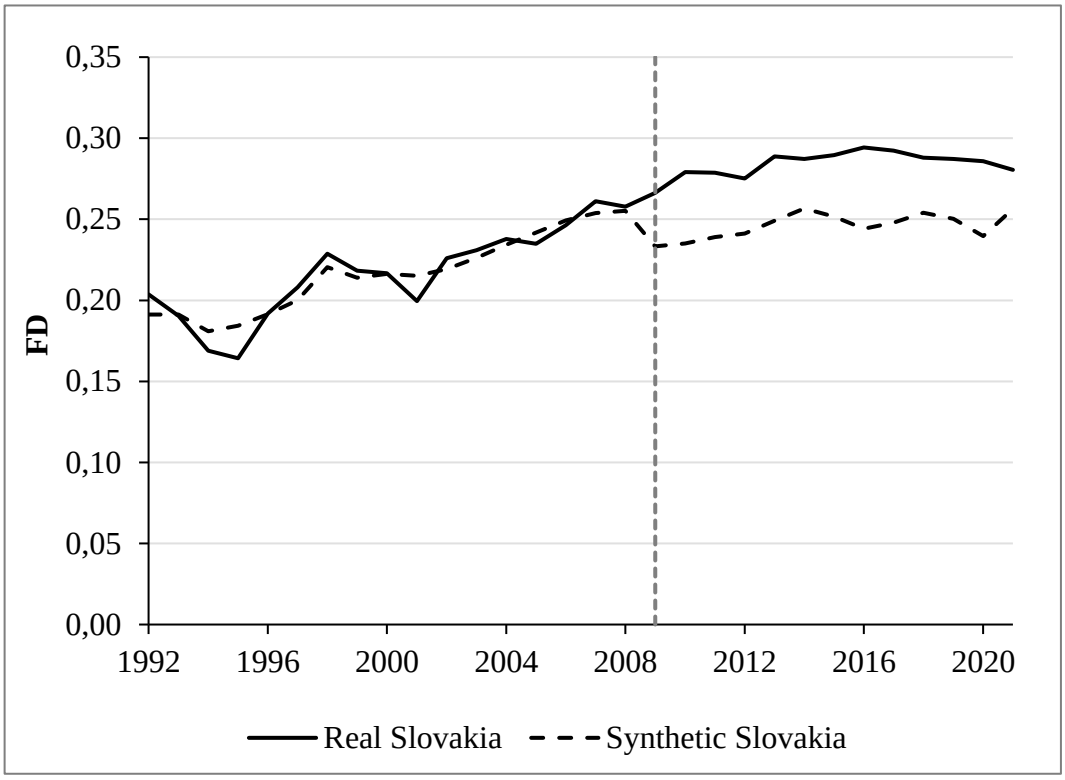

Fig. 3 – FD trend of real and synthetic Slovakia. Source: Authors' estimation based on SCUL

Looking at the graph, one can notice that, despite some minor discrepancies, the course taken by synthetic Slovakia throughout the pre-treatment period is relatively consistent with that of real Slovakia. This indicates that the synthetic control adequately replicates the pre-euro level of Slovakia's financial development. Hence, synthetic Slovakia's post-euro trajectory reasonably approximates the financial development path that would have occurred had Slovakia not joined the eurozone. In addition to visual inspection, pre-intervention goodness of fit was assessed using RMSPE and Cohen's D statistics. According to our SCUL result, the pre-treatment RMSPE between the real Slovakia and its synthetic equivalent is 0.013, indicating a good overlay. However, the full pre-euro Cohen's D value of 0.383 exceeds the 0.25 benchmark suggested by Hollingsworth and Wing (2022) for model fit. Importantly, though, Fig. 3 shows the alignment between real and synthetic Slovakia strengthening as the 2009 adoption years approaches. Supporting that, restricting the pre-treatment Cohen's D statistics to 2004 - 2008

yields a value of 0.203, which is within the 0.25 threshold. This suggests that the large full pre-euro statistic reflects earlier years' divergence rather than problematic fit immediately pre-adoption. Furthermore, the first out-of-sample prediction error (the gap between real and synthetic Slovakia in 2009) is just 0.016, demonstrating a reasonable predictive validity right at the transition point. Therefore, despite some divergences in the earlier pre-treatment years, these diagnostics support that synthetic Slovakia captures the pre-euro FD trends near the adoption, giving credibility to the estimated impacts.

Given the parallel FD paths of Slovakia and its synthetic counterpart during the pre-euro period, the divergence between the two lines in the post-euro years is striking. As shown in Fig. 3, after 2009, the trajectories of FD for the real and synthetic Slovakia begin to deviate noticeably. Specifically, the line depicting the progress of the real Slovakia's financial development is above its counterfactual throughout the post-euro period under study. This implies that real Slovakia substantially outperformed synthetic Slovakia after joining the monetary union.

To show the impact more clearly, Tab. 1 reports the magnitude of the estimated euro adoption effects on Slovakia's financial development in each post-treatment year. The impacts are quantified as the difference between the actual financial development outcome and the synthetic control trajectory (see Equation 5). The effects in terms of percentages are reported in the table's rightmost column.

Tab. 1 – Euro effect on Slovakia's financial development

Post-euro year	Slovakia		Treatment effect (index)	Treatment effect (%)
	Real	Synthetic		
2010	0.279	0.249	0.030	12.0%
2011	0.279	0.244	0.034	14.1%
2012	0.275	0.236	0.039	16.5%
2013	0.289	0.239	0.050	20.9%
2014	0.287	0.234	0.053	22.7%
2015	0.289	0.235	0.054	23.1%
2016	0.294	0.236	0.058	24.7%
2017	0.292	0.239	0.054	22.5%
2018	0.288	0.238	0.050	21.1%
2019	0.287	0.240	0.047	19.5%
2020	0.286	0.245	0.041	16.6%
2021	0.280	0.241	0.039	16.1%

Source: Authors' estimation based on SCUL

Confirming the general impression of Fig. 3, the estimates reported in the table indicate that Slovakia's adoption of the euro in 2009 has had a positive effect on the country's financial

development. In 2010, a year after the adoption, the gap in FD between Slovakia and its synthetic control was 0.030 units. This shows that Slovakia's FD was 12% higher than it would have been without the euro adoption. The estimated treatment effect steadily increased from year to year up to 2016, suggesting a growing euro impact over time. In 2016, seven years after the adoption, the percentage deviation of Slovakia's superior performance over its synthetic counterfactual peaked at 24.7%. The effect moderates slightly in the subsequent post-euro years, i.e., between 2017 – 2021, but remained positive and substantial, with financial development attributable to the adoption ranging from 0.054 units (22.5%) in 2017 to 0.039 units (16.1%) in 2021. The overall ATT for the entire post-treatment period amounts to 0.046, which suggests that over the period 2010 – 2021, Slovakia's financial development progressed at an average annual rate of 19.1% due to adopting the euro. These results indicate that introducing the euro advanced Slovakia's financial system depth, efficiency, and stability in the decades thereafter. This aligns with the theoretical argument that currency unions increase financial integration in participant countries (Fornaro, 2022). The results also reinforce empirical evidence of the euro's positive influence on financial integration and development reported by Kalemli-Ozcan et al. (2010) and Kılınç et al. (2017). Furthermore, the trend in Slovakia's financial development since adopting the single currency reflects the broader patterns of economic and competitiveness convergence documented in the country (see Fidrmuc et al., 2013; Havlat et al., 2018; Lalinsky & Meriküll, 2021) and other member states following their accession into the eurozone (Boltho, 2020; Heller & Warzala, 2019; Miron et al., 2022).

Tab. 2 - Control countries' weights in synthetic Slovakia

Control countries	Weights
Colombia	0.006
Hungary	0.125
Japan	0.076
Norway	0.006

Source: Authors' estimation based on SCUL

Another output of the SCUL estimation is Tab. 2, which shows the estimated lasso regression coefficients or the weights of the control countries that make up synthetic Slovakia. These weights are the solution to the minimization problem stated in Equation 4 $(\widehat{W}^*)$. According to the table, four control countries received non-zero weights out of the twenty-one non-euro OECD countries in the donor pool. Synthetic Slovakia is a product of the weights of Colombia, Hungary, Japan, and Norway and their corresponding financial development levels. Hungary, followed by Japan, have the highest weights, suggesting that they contributed the most to the synthetic control matching real Slovakia's trajectory in the pre-treatment period. Norway and Colombia obtained a minimal weight of 0.006 each, which shows their modest contribution. It is important to mention that, unlike classic SCM, one cannot interpret the magnitude of the weights as the percentage share of the donor countries in synthetic Slovakia (Hollingsworth & Wing, 2022); they can only be interpreted by comparison.

4.2. Statistical inference: In-space placebo test

In order to assess the statistical significance of the results presented above, we conduct placebo analyses, the inferential technique suggested by Abadie et al. (2010). This is carried out by estimating pseudo-treatment effects on the control countries and comparing them with the treatment effect on Slovakia. To avoid comparing the main effects presented above with pseudo effects estimated based on poorly matched placebos, placebo countries whose pre-intervention RMSE is two times greater than that of Slovakia are dropped from the analysis. This resulted in eliminating just two control countries from the placebo analysis, indicating the excellent quality of the donor pool.

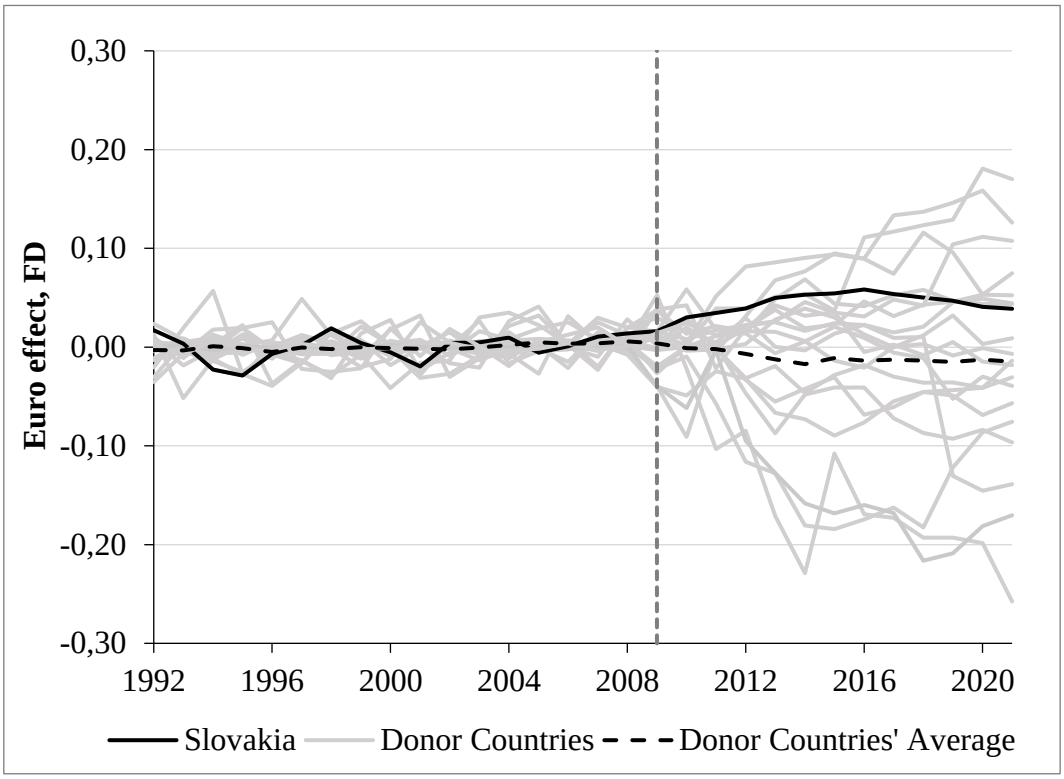

Fig. 4 – Placebo tests of the estimated euro effects. Source: Authors' estimation based on SCUL

Fig. 4 presents the results from the placebo exercise. The solid black line shows the impact of euro adoption on Slovakia's financial development. While the light gray lines represent the pseudo-euro effect on the control countries, the dotted black line represents the average placebo effect. Consistent with the estimated treatment effects reported in Tab. 1, the graph shows a clear and consistent benefit in Slovakia's financial development from euro adoption. While this effect is not greater than all other individual placebo distributions for the entire post-euro period, over two-thirds of the placebo effects are below it. Furthermore, the graph demonstrates that the effect on Slovakia's financial development is higher than the placebo means, indicating that the true euro effect size is greater than the placebo distribution center. This provides further support for the credibility of our euro-effect estimates.

4.3. Robustness checks

We conduct robustness checks to test the validity of our main SCUL estimates. This sub-section presents the findings of the evaluations. First, we check whether the treatment effects are sensitive to the size and composition of the donor pool used. Our main analysis relies on the broader pool of non-euro OECD countries to construct synthetic Slovakia. This allowed us to have a larger donor pool and more degrees of freedom to construct optimal synthetic pre-euro trajectories. However, this restriction excludes non-euro European countries (i.e., Bulgaria, Croatia, and Romania) that may share similar governmental and economic institutions with Slovakia from the donor pool. It may also result in the inclusion of countries the financial developments of which are driven by structural processes different from Slovakia's. Both cases could distort the estimation and raise doubts about the credibility of the results presented above. To address this concern, we re-estimate the treatment effect by changing the donor pool to include only EU countries not part of the euro area, including Bulgaria, Czechia, Croatia, Denmark, Hungary, Poland, Romania, and Sweden. Fig. 5 plots the actual and synthetic Slovakia's FD trend constructed using this donor pool.

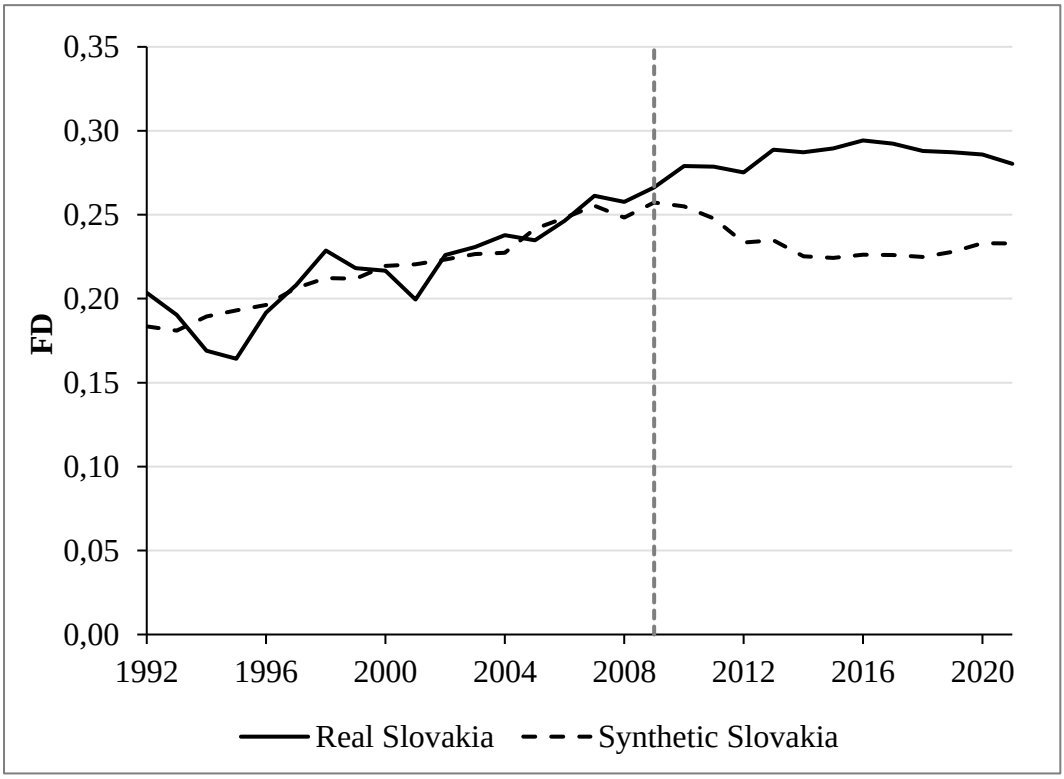

Fig. 5 - FD trend of real and synthetic Slovakia: Alternative donor pool. Source: Authors' estimation based on SCUL

The figure shows that the pre-euro fit of the new synthetic Slovakia is similar to the one depicted in Fig. 3. This is also reflected by the pre-treatment RMSPE value of 0.013 and Cohen's D value of 0.373, which are close statistics obtained when the original set of donor countries was used. However, the divergence between the two lines in the post-treatment period is bigger than in

Fig. 3. The ATT over the period amounts to 0.053 units or 22.7%. Nevertheless, similar to the pattern portrayed in Fig. 3, the FD path of real Slovakia is above that of synthetic Slovakia in all post-treatment periods, indicating the positive effect of the euro. Even though the effect is less, the direction of the euro effect remains unchanged and greater than zero. This indicates that the main results are robust to a change in the control countries used to predict the synthetic counterfactual of Slovakia. As before, the significance of this estimate is also examined through placebo analysis. However, unlike the OECD-based placebos, the true effect, in this case, is well within the placebo effects distribution (see Fig. 6), implying a need for cautious interpretation of the estimated treatment effects when relying on the non-euro EU donor pool.

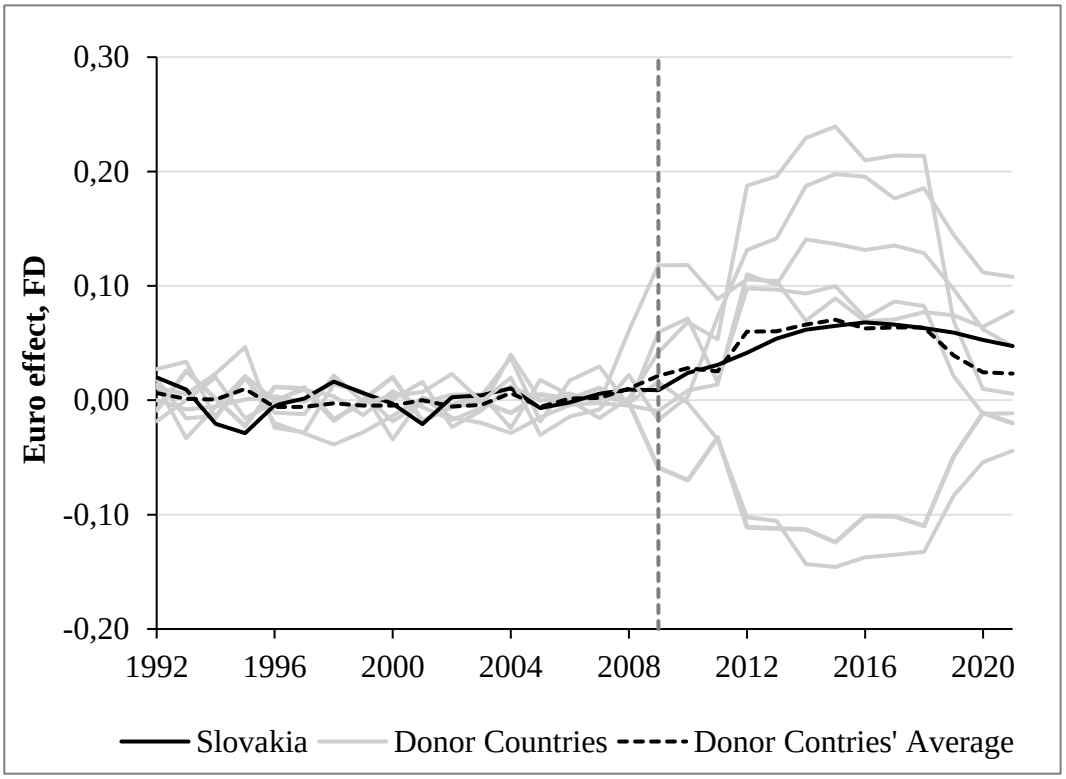

Fig. 6 - Placebo tests: Alternative donor pool. Source: Authors' estimation based on SCUL

In our baseline analysis, the SCUL specification utilized to estimate synthetic Slovakia's outcome trajectory includes just pre-euro FD values and did not incorporate any additional predictor covariates. However, it is possible that including covariates as a predictor in the model may help generate a better synthetic control and, hence, alter the estimated euro effect. To address this concern, we re-estimate an alternative specification incorporating potential confounding factors: GDP growth, trade openness, inflation, and gross capital formation. According to prior literature, these variables are selected based on their relevance for computing the synthetic control's financial development trajectory. Data for these additional covariates are drawn from World Development Indicators. Fig. 7 shows the real and synthetic Slovakia's financial development paths estimated under this expanded model.

Again, this robustness check produces a synthetic control trend that closely resembles the original synthetic control obtained by the preferred specification, further validating the estimated euro effect. The included covariates' contribution in improving the pre-treatment fit

is minor as the synthetic Slovakia trend does not show a large change, particularly before 2009. This confirms that the initial synthetic Slovakia effectively adjusted for differences between Slovakia and the control countries based solely on replicating the pre-euro FD path. While the gap between Slovakia and its synthetic counterpart during the post-euro years is slightly narrower than that of the main model, the graph shows that the estimated treatment effect remains positive. The line that shows Slovakia's actual financial development path lies above the synthetic control for the entire post-euro period. However, the ATT value of 0.038 (15.6%), which is smaller than the magnitude estimated using the baseline model, reflects the decrease in the estimated euro effect's value. The shrinkage in the gap can be due to upward bias correction introduced by the included covariates. Overall, the persistence of Slovakia's post-adoption gains in terms of financial development under the alternative specification gives credibility to the positive effect of the euro, which is inferred from our main analysis findings.

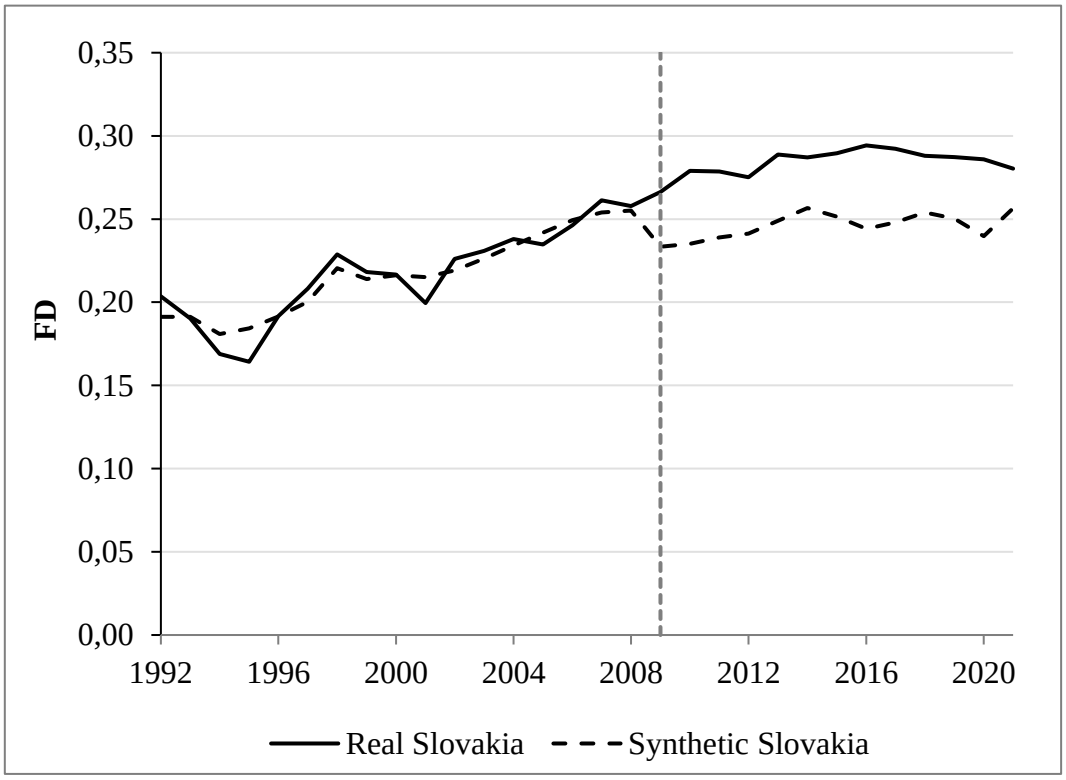

Fig. 7 - FD trend of real and synthetic Slovakia: Covariates augmented estimation. Source: Authors' estimation based on SCUL

5. CONCLUSION

Since its inception, the investigation into the pros and cons of euro adoption has been at the center of a substantial body of research. Previous studies provide evidence regarding its impact on trade, economic growth, and income inequality, among others. Our study contributes to this stream of literature by focusing on the effect of the euro on financial development.

The paper set out to empirically analyze the effect of eurozone accession on Slovakia's financial development. To this end, we implemented the SCUL method, a variant of synthetic control

modeling, and estimated the hypothetical trajectory of the development of Slovakia's financial institutions and markets had it not adopted the euro in 2009. The counterfactual was constructed as a weighted average combination of the financial development trends of OECD countries outside the eurozone. The results demonstrate that in the years following the adoption, Slovakia consistently outperformed the synthetically constructed counterfactual, suggesting a positive effect of the euro on financial development. We found that, relative to the counterfactual scenario, Slovakia's financial development increased by about 19% on average between 2010 and 2021 due to euro adoption, with the largest boost occurring in 2016. To ensure that these results are not subject to bias due to the choice of donors and predictors used to construct the synthetic outcome, we evaluated the sensitivity of the findings by changing these elements. While there is a slight difference in magnitude, the results from these robustness checks further confirm the positive effect of euro adoption.

Beyond providing plausible evidence that euro adoption benefited the financial development of relatively new adopters like Slovakia, this study is among the first research works to adopt the relatively new SCUL approach for causal analysis. It shows that the approach offers a useful methodology for policy evaluations. The study's findings, however, should be interpreted with caution since they are subject to a significant limitation. First, the precise magnitude of the euro effect is uncertain, and the statistical precision of the estimates could be higher. Therefore, further research with additional sensitivity tests will be important to establish the effect size. Furthermore, as it is outside the scope of the current study, it does not identify the specific channel driving the estimated gains in financial development. It is, for example, likely that the euro adoption effect differs between financial institutions and markets. Hence, we hope this work will encourage more investigations into these topics to advance our understanding of currency unions' impact on financial system development.

Acknowledgment: Etsub T. Jemberu would like to express gratitude to Tomas Bata University in Zlín for providing financial support through the "Support of International Cooperation for 2022," which facilitated a research visit to Chapman University and enabled the development of this work.

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