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Research Article

Dollarization and Growth: An Application of the Synthetic Control Method to the Case of Ecuador[a]

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The debate on the potential impact of full dollarization for promoting economic growth has been controversial and based on limited empirical analysis. This work scrutinizes the impact of dollarization on real per capita GDP in Ecuador's experience. We apply a Synthetic Control Method, a transparent and data-driven statistical technique, aiming to construct an artificial control group and a plausible counterfactual against which impacts from dollarization could be evaluated as part of the historical record. We found that after the decision to officially dollarize was made in 2000, per capita GDP in Ecuador increased on average about 9.69 percentage points relative to the synthetic control country. Furthermore, this gap appears to show an inverted U-shape over time, which would indicate that the effects of dollarization on economic activity are very powerful at the beginning but fade out over time.

JEL codes: F31, F45, E42

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1 Introduction

As the literature on exchange rate theory and policy has developed over the postwar period, it has become clear that the choice of optimal exchange rate regime is still one of the most complicated and controversial issues addressed by economists and policymakers. In a recent chapter prepared for the Technical Assistance Handbook of the IMF on the choice of exchange arrangement, Casiraghi et al. (2022) argues that the choice of arrangement is a complex issue where there are no simple answers. Even an in-depth analysis of country-specific factors may not lead to a definitive conclusion about the optimal arrangement. Recent currency crises in Lebanon, Turkey, Argentina, Bolivia, Nigeria and Venezuela have once again brought to the fore the question of the optimal exchange rate regime in an emerging country. In the context of deep economic and political crises in some of these emerging economies, the dollarization debate has resurfaced, and analysts and policymakers

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have begun to argue that countries, such as Argentina and Venezuela, which are facing high inflation and macroeconomic imbalances, should dollarize.

Over the years, the dollarization literature has been mostly theoretical and highly speculative (e.g., Yeyati & Sturzenegger, 2003; Salvatore et al., 2003). While some economists argue that dollarization is a reckless straitjacket, other scholars consider it a good idea for troubled countries. A prime motive for dollarization has been to stop high inflation. In this respect, prima facie evidence indicates that official dollarization was effective at stabilizing prices in Ecuador (e.g., Naranjo, 2018; Cueva & Diaz, 2019; Bonilla-Bolaños & Villacreses, 2023).[1] However, price stability alone is insufficient to remedy a troubled economy, and, indeed, where the record has been less clear-cut and controversial, is in its potential for promoting higher economic growth.

The empirical analysis of the effects of dollarization on economic growth is limited. Previous studies in the literature using annual data for a pool of countries did not consistently show higher or lower growth levels than their non-dollarized counterparts. For example, Edwards & Magendzo (2006) examines the effect of dollarization using a yearly panel of 169 countries that covers 1970 through 1998. In their dataset, 20 out of 169 countries are identified as dollarized, most of which are small islands and microstates. Their propensity score matching method finds that GDP growth is not statistically different in dollarized and non-dollarized ones. However, since their dataset ended in 1998, it does not identify Ecuador as dollarized. Bajrami (2023) presents an update of this empirical exercise with an evaluation period that goes from 2000 to 2021. Notably, Ecuador is included among the seven dollarized countries of the pool (representing 5% of the pool). A key result from this study is that dollarized countries did not show differences in GDP growth from their non-dollarized counterparts.

A major problem of multi-country studies that use propensity score matching in the estimation of treatment effects to determine causal inference is that they seem to increase post-matching covariate imbalance, model dependence, researcher discretion, and the potential for bias (King & Nielsen, 2019). Therefore, there are good reasons to prefer a single-country analysis using a different quasi-experimental approach.

An increasingly suitable method for policy evaluation in single-country studies is the synthetic control method (SCM). The SCM constructs a weighted combination of control units that closely resembles a treated unit before the intervention. This creates a counterfactual scenario that shows what would have happened to the treated unit without the intervention. In other words, by creating a synthetic control unit (or country) that simulates what the outcome path of that country would be if it did not undergo a particular policy intervention, the method can be used to estimate the counterfactual outcomes.

In the case of Ecuador, to the best of our knowledge, there are few studies examining the causal effect of official dollarization on real GDP per capita using the SCM. Though these studies find a positive relationship between dollarization and real GDP per capita, they all have several shortcomings and limitations. In Cachanosky & Ramseur (2020), the

[1] There are also several studies that show the price stabilization properties of dollarization in Ecuador. Bonilla-Bolaños & Villacreses (2023) shows the convergence properties of inflation rates between Ecuador and the United States (U.S.) after dollarization. For a pool of countries, Koráb et al. (2023) shows that inflation is lower in fully dollarized economies than in partially or non-dollarized economies. The case of Ecuador also provides evidence for this observation; the average annual rate of inflation was nearly 40% in the 21 years before dollarization, while it was 3.2% after dollarization.

donor pool is limited to some Latin American countries that presumably share overall social and economic characteristics with Ecuador. However, one valid concern in this context is the potential existence of spillover effects on GDP per capita of those neighboring countries included in the SCM (Abadie et al., 2015).[2] Another concern arises if some of these countries have engaged in currency substitution, and it is well known that currency substitution - or partial dollarization- is a recurring problem in some Latin American nations. Hallren (2014) avoids these problems by expanding the donor pool to 57 developing and developed countries from which the SCM algorithm picks five countries. However, during the pre-treatment period, the synthetic control unit under his model poorly matches the treated unit (actual Ecuador). Besides, his study shows a major problem because the SCM could not replicate Ecuador's economic collapse of 1999. The point is that if the established unit representing the case of interest and the synthetic control unit do not have similar behavior over pre-intervention periods, then a discrepancy in the outcome variable following the intervention cannot be attributed to the intervention. Cachanosky et al. (2024) conducts two SCM estimations using a donor pool with and without Nigeria, the largest donor. Unfortunately, a placebo estimate differing significantly from the actual pre-treatment path calls the predictive power of both models, which leads to inconclusive results.

In this paper, we apply the SCM to investigate the impact of full dollarization on GDP per capita in Ecuador over a past horizon of 22 years. We explicitly differentiate between full dollarization (the focus of the research question) and varying degrees of (or partial) dollarization observed in several emerging economies.[3] Our analysis rests on two different strategies. First, we use a combination of other countries to construct a "synthetic" control country which resembles relevant economic characteristics of Ecuador before the outset of dollarization in the early 2000s. Then, the subsequent economic evolution of this "counterfactual" Ecuador without dollarization is compared to the actual experience of Ecuador.

Our work not only contributes to the still narrow empirical literature on the impact of official dollarization on economic growth but also improves previous studies by using better predictors and a donor pool that reproduces a model for which we have a sufficiently good pre-treatment fit and statistical significance. We show that a synthetic control can accurately reproduce the pre-2000 per capita GDP path for Ecuador. We find that once the decision to officially dollarize was made, per capita GDP in Ecuador increased about 9.69 percentage points relative to the synthetic control country. Furthermore, this gap appears to show an inverted U-shape over time, which would indicate that the effects of dollarization on economic activity are very powerful at the beginning but fade out over time.

After this introduction, in Section 2, we analyze the dollarization process in Ecuador and provide a concise history of the general economic difficulties experienced in the country, as well as details of the tumultuous situation in those days that served as an impetus to dollarization amid considerable controversy. Section 3 provides a summary of the dollarization debate (pros and cons) with a special focus on its implicit effects on economic growth. Section 4 briefly explains the SCM, showing how it is used to estimate the treatment effect

[2] In particular, it is possible that the dollarization in Ecuador had effects on per capita GDP in neighboring countries included in the donor pool. If spillover effects are substantial and affect countries in close geographical proximity, those countries may provide a biased estimate of the counterfactual outcome without intervention for the country affected by the intervention.

[3] We are aware that currently, the terms "dollarization" and "full dollarization" appear to be used interchangeably, which may cause confusion.

and describing the most known falsification tests. Section 5 describes the data employed in the study. Our empirical findings are presented in Section 6, and Section 7 concludes.

2 The Background and Road to Dollarization

As one of the lower-middle-income countries in Latin America, Ecuador was known for decades for its social unrest as well as political and economic instability. From its period of military rule in the 1960s to the decade of high inflation in the 1990s, the country was exposed to a series of transformations that led to a weak political and economic environment amid a context of very volatile oil prices, agricultural and domestic calamities caused by climate change, and financial turbulence. The transition to democracy in the 1970s coincided rather closely with the shift from an oil-driven and state-supported growth model (beginning in 1972) to a debt-burdened economy.[4] The Third World financial and economic crisis of the early 1980s appeared in Ecuador (as in several Latin American countries), most outstandingly in the form of a mounting unserviceable debt.

Moreover, the oil price crash of the early 1980s was not accompanied by any successful macroeconomic correction, and since foreign financial markets were closed, the different governments relied considerably on seigniorage and devaluations as a source of revenue.[5] This coincided with a whole decade of stabilization programs where frequent adjustment of the domestic currency (the sucre) and modifications of the exchange rate regime coexisted with an environment of high inflation rates and stagnant output. Indeed, stabilization and adjustment programs with different intensities and priorities did not enjoy stable legislative support, and chronic conflict prevailed (Larrea, 1996). Social conflict resulted in frequent setbacks, and a stable political consensus on economic policies was never reached. As a result of a hostile external environment and domestic instability, the economy of Ecuador did not take any step forward in terms of GDP growth and macroeconomic stabilization between 1982 and 1992.[6]

From 1992 to 1996, the administration of Sixto Duran Ballen managed to introduce what at the time was considered a sound macroeconomic program that generated a balanced budget and low levels of inflation. This stability, however, was later hindered by several events, including a territorial dispute with Peru entailing military intervention, a corruption scandal involving the vice president, and extended periods of electricity rationing. Under the subsequent president, Abdala Bucaram (who served from August 1996 to February 1997), amid a major corruption scandal, was removed from office based on "mental incompetency" after serving less than one year. Like his predecessors, the interim president, Fabian Alarcon (who served from February 1997 to August 1998), was unable to mitigate and overcome a series of internal and external shocks that eroded the credibility of economic authorities.

In 1997-1998, the Ecuadorian economy was affected by the episode of "El Niño", a large-scale ocean-atmosphere climate interaction that influenced weather patterns, and this shock not only negatively affected the export sector of the Ecuadorian coast but also damaged

[4] Beckerman (2001, 2002) beautifully summarizes how Ecuador adapted in the 1970s to a changing environment in the international oil market.

[5] On the domestic front, a border war with Peru in 1981 created an additional burden on the fiscal accounts and spread uncertainty and panic in the economy.

[6] Cueva & Diaz (2019) show that between 1982 and 1991, Ecuador's output per working-age person fell 19% below trend.

infrastructure as homes, roads, bridges, and drinking water systems succumb to some degree. Small farmers producing rice, corn, coffee, and cocoa bore income losses, and shrimp and banana producers, among other bigger producers, fell into default with the financial system. In late 1998, Ecuadorian oil prices fell to USD 7 per barrel, which had a further negative impact on the fiscal sector. These shocks created a situation where the public deficit grew uncontrollably, as the government had restricted access to international financing.

To top it off, a largely deregulated domestic financial sector had led banks to experience a credit boom since the mid-1990s, providing high-risk loans to well-connected customers. Bad incentives, poor supervision and adverse macroeconomic conditions allowed the development of a weak financial system, which was very vulnerable to disruptions. Signs of a banking crisis started in April 1998 with the failure of a small bank, but the ensuing atmosphere of uncertainty caused excessive withdrawals and triggered more bank failures throughout 1998.[7] A combination of exogenous and policy-induced shocks made the general public lose confidence in both the banking system and the domestic currency. Thus, by the late 1990s, the credibility of the monetary arrangement deteriorated, and high levels of inflation and exchange rate uncertainty caused a significant increase in financial dollarization.

Jamil Mahuad was elected president in 1998 and started to serve in August, just as the banking crisis was developing and the fiscal position was deteriorating. The public sector deficit ballooned from 2.6% of GDP in 1997 to 6.2% in 1998. Though his government cut energy subsidies, raised gasoline prices, hiked interest rates and devalued the exchange rate band by 15%, it was clear that much more had to be done.

By early 1999, numerous banks were failing and being taken over and closed by the deposit insurance agency AGD (Agencia de Garantía de Depósitos) while still providing a deposit guarantee.[8] Lacking resources, the agency had to issue bonds that were purchased by the central bank and use those funds to repay depositors. Initially, the liquidity injections were largely sterilized by losses of international reserves; however, in the face of sustained exchange rate pressure and dwindling international reserves, the central bank floated the sucre. In February 1999, after the Central Bank abandoned the crawling-peg band system, the sucre lost 30% of its value against USD over the next four weeks, inducing higher inflation and fears of hyperinflation (as consumer prices were 13.5% higher in March than in February). To stop further pressures on the exchange rate market and a bank panic, the government declared a national bank holiday in March 1999, which ended up lasting a whole week. At the end of the holiday, the government announced a widespread deposit freeze, in which deposits would be frozen for a full year. Although the freeze temporarily reversed the exchange-rate depreciation and slowed the rate of inflation, it inevitably disrupted real economic activity (Beckerman, 2001). Banking-system credit operations, already shrinking, virtually ceased with the freeze. By the end of the century, Ecuador was immersed in the worst economic crisis of its history. The country found itself in a vicious circle of collapsing financial and currency confidence, capital flight, a weakening currency, high inflation, rate hikes, and the lack of control of monetary aggregates.

On January 9, 2000, in the midst of a deep recession and extreme inflation, suffering a financial crisis and with its exchange rate in apparent free fall, President Mahuad decided that dollarization was the only feasible solution to stabilize the plummeting Ecuadorian

[7] De la Torre et al. (2021) provides a good summary of the financial crisis.
[8] The AGD had only been created right before the onset of the crisis.

economy.[9] The dollarization decision generated strong reactions from diverse groups. After weeks of street protests, a military rebellion and a strike against the Government, on January 21, President Mahuad, who had been in office for a five-year term, was forced from office and left the presidential palace under military escort and sought refuge in Chile. The Congress used the fact that Mahuad had sought refuge on foreign territory as a basis for his "abandonment" of his presidential duties and for appointing his successor.

Gustavo Noboa, the Vice President, assumed his role as the sixth President four years by January 22. Despite continued opposition to the initiative, Noboa supported Mahuad's initial plan and claimed that dollarization was the only way to control inflation, reverse the economy's rapid decline, and restore confidence to the nation. Thus, to legally implement dollarization, the key legislative instrument, the proposed Economic Transformation Law, was presented to the Central Bank for its review in February 2000. Promulgated by the congress in March 13, 2000, the law constituted the principal mechanism to be used in implementing dollarization.[10] The Congress approved it rapidly, partly because some parties abstained from the debate, and in early March, the President signed it into law.

3 The Dollarization Debate: Its Effects On Economic Growth

After the East Asian crises of 1997–98, the hypothesis of the vanishing intermediate regime was growing rapidly among scholars and the financial establishment. Frankel et al. (2020) argues that even at the level of international financial institutions, the growing belief was that intermediate regimes were not viable. The Meltzer report, commissioned by the U.S. Congress to recommend fundamental reform of the International Financial Institutions, adopted that view as well, and explicitly said: *"The Commission recommends that ... the IMF should use its policy consultations to recommend either firmly fixed rates (currency board, dollarization) or fluctuating rates."*[11]

The East Asian crisis, the balance of payments crises of dramatic development in Mexico-1994, Russia-1998 and Brazil-1999, as well as in other countries, also played their role and led to some observers to argue that developing countries should completely abandon their national currencies, to adopt instead the USD (or maybe the euro or yen, depending on geographic location). Influential works of Alesina & Barro (2001) and Calvo & Reinhart (2001) precisely pointed out that these regimes were much more credible than customary and ephemeral promises to peg the exchange rate. According to them, dollarization provided a much better commitment device than alternative forms of exchange rate regimes for many developing countries, since they lack the internal discipline and institutions that can provide a firm domestic commitment to a monetary policy dedicated to price stability. Of course, the proposals did not go unchallenged. Many economists maintain that the advocates of dollarization have exaggerated its economic benefits and downplayed its economic costs (e.g., Sachs & Larrain, 1999; Edwards, 2001, for early arguments against dollarization).

[9] Former President Jamil Mahuad's book, Mahuad (2021), writes about the journey towards dollarization.
[10] The dollarization legislation provided for the central bank to exchange on demand sucres at a rate of 25,000 per U.S. dollar.
[11] To recommend future U.S. policy toward several multilateral institutions in November 1998, the U.S. Congress established the International Financial Institutions Advisory Commission, also known as the Meltzer Commission, named for its chair, Professor Allan Meltzer.

Against the background of these developments, academic and policymaker interest in dollarization as well as a comprehensive analysis of the issues related to it ratcheted up. Great compilations (e.g., Salvatore et al., 2003; Yeyati & Sturzenegger, 2003) enriched the debate with new vistas and valuable insights unavailable elsewhere. In the playing field of the country experiences, Beckerman & Solimano (2002) not only examined the conditions that led to dollarization in Ecuador, but analyzed its initial results and early effects on inflation, growth, poverty, inequality, marginalization, and gender.

There is wide agreement today among economists that countries that give up their currency and delegate monetary policy to an advanced country's central bank will have lower inflation than countries that pursue an active domestic monetary policy. There is much less agreement, however, on the effects of dollarization on real economic variables, such as growth, employment and output volatility.

Whether dollarization will work for economic growth is still open to discussion. As with most discussions on exchange rate regimes, the focus of the debate has been on the pros and cons of dollarization in emerging market economies. One sharp minus to dollarization lies in the fact that less developed countries can become internationally uncompetitive as a result of either cross-country differences in productivity growth and inflation rates, or the appreciation of the adopted currency against other currencies (Palley, 2003). Thus, low productivity gains or an uncompetitive dollar may impair long-term growth prospects. Another sharp minus is that dollarized countries will have difficulties accommodating external shocks. Thus, in the presence of an adverse external shock, adjustments generally may result in a fall of nominal wages or a sharp increase in unemployment (Sachs & Larrain, 1999), affecting aggregate demand and output and lowering economic growth. Additionally, under dollarization, economic authorities are unable to use the design of a countercyclical policy that can respond optimally to economic disturbances. Without a "shock absorber" and with the lack of exchange rate and monetary policy, conventional arguments typically add the costs associated with the limited or no ability to provide lender-of-last-resort assistance to troubled banks and the economy.

In contrast, one of the central arguments for dollarization is that it may improve market perceptions of country risk and, thus, lower borrowing costs by reducing or even eliminating currency risk. Eventually, these effects would reduce the level and volatility of interest rates, ultimately stimulating investment and growth (Dornbusch, 2001; Berg & Borensztein, 2003).

A second central argument in favor of dollarization points out that giving control of the country's money supply to another country enforces discipline. From this perspective, a poor institutional framework in which the central bank is given freedom to issue domestic currency to finance fiscal expansions, though a popular move in the short run, will soon lead to inflation and a collapsing exchange rate and all prices, including the price of dollars in terms of domestic currency will soar. Thus, by definitively rejecting the possibility of inflationary finance, dollarization would prompt more fiscal discipline and might also strengthen institutions and create positive sentiment toward investment and growth.[12]

Thirdly, as long as the exchange rate risk is eliminated and discretionary monetary policy and inflationary finance are controlled, defenders of full dollarization would say that it contributes to a rapid reduction of inflation and inflationary expectations. Therefore,

[12] However, the resort to debt financing is available, and governments may substitute full money financing for higher public debts.

dollarization becomes a reliable nominal anchor to have low and stable inflation, which makes agents' economic horizon lengthen. Dornbusch (2001, p. 5) argues that "the lengthening of horizons, in turn, is conductive to investment and risk taking, which translates into growth and closes a virtuous circle". Citing the empirical evidence that shows that inflation hurts growth, Dornbusch (2001, p. 5) claims that "a monetary regime that delivers and maintains low inflation, other things equal, will help growth".

Dollarization may also bring other benefits that will enhance economic growth. It reduces exchange rate volatility, but also promotes a closer integration with both the U.S. and global economies, thereby lowering transaction costs in different currencies and raising productivity, trade, and growth (Frankel & Rose, 2020). Moreover, if a national currency as argued by Rose & van Wincoop (2001, p. 390) seems to be a significant barrier to trade, "reducing these barriers through currency unions like EMU or dollarization in the Americas will thus result in increased international trade".

Another powerful but somewhat hypothetical argument for legal dollarization is argued by Berg & Borensztein (2003, p. 83); "the change in monetary regime may establish a firm basis for a sound financial sector, which would provide the basis for strong and steady economic growth". Indeed, dollarization may foster financial deepening and avoid currency mismatches. With all monetary assets already dollarized and without significant currency mismatches in the banks' positions, depositors may be more confident in the domestic banking system (Calvo & Reinhart, 2001).

From the discussion above, it is worth pointing out that there is a route between dollarization and economic growth that works through a variety of channels that generally reinforce each other. In particular, we can distinguish among:

- The lower volatility and reduction in the borrowing cost
- The enforced monetary and fiscal discipline
- The inflation stability and the lengthening of horizons
- The lower barriers to trade
- The sound financial sector

Thus, if central to the debate over the choice of exchange rate regime is the question of which regime can provide a solid basis for economic growth, the supporters of full dollarization will answer that, with other things given, dollarized countries have a substantially higher chance of expanding economic growth in the long run.

What is surprising is that there have been very few attempts to empirically assess the impact of full dollarization on economic growth. The fact that only a small group of countries, beyond the U.S., uses the USD as a legal tender may be partly an explanation. Another brake may have been the difficulty of finding a methodology that evaluates a policy decision through detailed examinations of economic conditions before and after the policy is implemented.

4 The Synthetic Control Method

In order to estimate the effect of official dollarization on economic growth (as measured by the trajectory of per capita GDP over the time horizon of the study), we apply the SCM first developed by Abadie & Gardeazabal (2003) and Abadie et al. (2010). The SCM offers a data-driven method for constructing a synthetic counterfactual for the treatment country (in our

case, Ecuador) using data from countries that never received the treatment. The innovation of the synthetic control method is that it forms a weighted combination of the so-called untreated units (prior to the intervention) such that the values of its outcome variable match as closely as possible those of the treated unit. This weighted combination of untreated units represents the 'synthetic control', creating a counterfactual of what would likely happen to the treated unit if it were not subject to the intervention. The outcome variable trajectory in the post-intervention period is an estimate of the outcome variable path that would have been observed for the treated unit in the absence of this intervention. The effect of the intervention can then be inferred from the difference between the actual outcome variable path of the intervention unit observed after the intervention and the synthetic one determined by weighting the outcomes of control units with the weights representing their importance in the resulting synthetic control. To sum up, the success of the SCM depends crucially on the ability of the synthetic control's outcomes to be sufficiently close to those of the treated unit in the pre-intervention period.

More formally, assume that there are J countries in our data set indexed by j, and $t = 1, \ldots, T$ time periods. Ecuador is the "treated unit" $j = 1$, that is, the unit exposed to the event or intervention of interest, and our potential comparison countries $j \in [2, J]$ comprise the set of potential donors that make up the synthetic control unit. This means that the remaining J countries, the so-called donor pool, are those that did not experience the dollarization intervention during the sample period. The process of selecting the donor pool will be described in the following subsection. We assume that the sample is a balanced panel, that is, a longitudinal data set where all units are observed for all t. The sample over T years is divided into two periods: the pre-intervention period T_0, and the post-intervention period T_1. Then, $T = T_0 + T_1$.

For each country, j, and time, t, we observe the outcome of interest, Y_{jt} and a set of k predictors of the outcome: $X_{1j}, \ldots, X_{kj}$ (which may include pre-intervention values of Y_{jt}). For the country affected by the intervention, $J = 1$, and a post-intervention period, $t > T_0$, we define the potential outcomes that would have been observed with and without the intervention, Y_{1t}^I and Y_{1t}^N, respectively. Then, the effect of the intervention of interest for the affected country in period t (with $t > T_0$) is: $\tau_{jt} = Y_{1t}^I - Y_{1t}^N$. Note that the effect of the intervention on T_1 is known, since it is observed. However, we do not know Y_{1t}^N. Hence, we need to estimate the counterfactual Y_{1t}^N, which is the outcome variable of the treated country which had not adopted the treatment. In order to estimate the counterfactual, we use the linear factor model of the form:

$$Y_{1t}^N \;=\; \delta_t + \theta_t \; Z_i + \gamma_t \; U_t + \epsilon_{it} \tag{1}$$

where δ_t is an unknown common factor with constant factor loadings across countries, Z_i is a vector of observed covariates with coefficients θ_t, U_t, is a (F x 1) vector of unknown parameters, γ_t is a (1 x F) vector of unobserved common factors, and ϵ_{it} are idiosyncratic error terms with zero mean. Note that this specification allows the effects of confounding unobserved characteristics to vary with time ($\gamma_t \; U_t$), unlike in conventional difference-in-differences, which allows for the presence of unobserved confounders but restricts the effects of those confounders to be time-invariant ($\gamma \; U_t$) confounders.

Define a synthetic control unit as a weighted average of the units in the donor pool. That is, a synthetic control can be represented by a (J x 1) vector of weights, $W = (w_2, \ldots, w_N)'$

associated to the set $J^{`} = \{1, \ldots, N\}$ such that $w_i \geq 0$ for $J \in [2, J_N]$, and $w_2 + \ldots + w_N = 1$. Then the outcome variable for each potential synthetic control unit is given by:

$$\sum_{2}^{N} w_i \; Y_{it}^{N} \;=\; \delta_t + \theta_t \; \sum_{2}^{N} w_i \; Z_i + \gamma_t \; \sum_{2}^{N} w_i \; U_t + \sum_{2}^{N} w_i \; \epsilon_{it} \tag{2}$$

Let us remember that the synthetic control is a linear combination of the set of donor units in J adjusted by their respective weighted means. So, to determine a synthetic unit that reflects the behavior of unit $N = 1$ in the time period T_0, $Y_{it}^{I} - Y_{it}^{N} = 0$, we need to find the average weights of the donor units W^*. Thus, we may find the optimal vector of weights $W^* = (w_1^*, \ldots, w_N^*)$ such that when making the difference between the result variable in the treated unit and that of the synthetic control to be constructed, τ_{it}, we have:

$$\hat{\tau}_{it} \;=\; Y_{it}^{I} \; - \sum_{2}^{N} w_i^* \; Y_{it}^{N} \tag{3}$$

If $\hat{\tau}_{it}$ is large enough, we make a first guess that dollarization had a positive or negative effect on Ecuador's per capita GDP, as compared to its synthetic counterfactual. The donor units and their respective weights, w_i, must be optimal to obtain valid, reliable and unbiased results in $\hat{\tau}_{it}$ (Abadie et al., 2015, p. 495). The synthetic control method proposes selecting the value of W so that the characteristics of the treated unit best resemble the characteristics of the synthetic control.

Let then X_i be a (k x 1) vector containing the values of the pre-intervention characteristics, including values of the outcome variable, of the treated unit that we aim to match as closely as possible, and let X_0 be the (k x J) matrix collecting the values of the same variables for the units in the donor pool. The difference between the pre-intervention characteristics of the treated unit and a synthetic control is given by the vector $X_1 - X_0 \; W$. We select the synthetic control weights, W^*, minimizing the size of this difference in the following manner. For $m = 1, \ldots, k$, let X_{1m} be the value of the m^{th} variable for the treated unit and let X_{0m} be a (1 x J) vector containing the values of the m^{th} variable for the units in the donor pool. Given a set of non-negative constants, $v1, \ldots, vk$, Abadie & Gardeazabal (2003) and Abadie et al. (2010) choose W^* as the value of W that minimizes

$$\begin{gathered} \sum_{m=1}^{k} \; V_m \; \left(X_{1m} \; - \; X_{0m}\right)^2 \\ s.t. \\ w_i \geq 0, \forall_i \in [1, N] \quad and \quad \sum_{1}^{N} w_i \;=\; 1 \end{gathered} \tag{4}$$

where V_m is a weight that reflects the relative importance that we assign to the m^{th} variable when we measure the discrepancy between X_1 and $X_0 \; W$. Note that V_m is a diagonal matrix with non-negative components which reflect the relative importance of a particular outcome variable predictor. Now, since W^* depends on the vector V_m, there is something to be said about the choice of V_m. Abadie & Gardeazabal (2003) and Abadie et al. (2010)

choose V_m, such that the deviation of the outcome variable path of the synthetic control ($W\ V_m$) from the outcome variable path of the treatment country is minimized during the pre-intervention period. The resulting V_m^* is then used to construct the optimal weights, $W^* = W^*(V_m^*)$, which indeed determine the synthetic control used for the estimation of the path of counterfactual, i.e., post-intervention outcome variable.

Despite the results obtained by the SCM, as in other estimation methodologies, there are robustness tests to validate the results and the statistical inference potential underlying the method. The SCM enables researchers to conduct a wide array of falsification exercises termed "placebo studies". There are two kinds of placebo tests: in-space and in-time. In-space falsification means that we run the model with an assigned unit from the donor pool, one not affected by the intervention. We can run this for every unit in the donor pool and obtain a distribution of placebos with which we will compare the trajectory of the variable of interest for the treated unit. If the estimated effect of the intervention fell inside the distribution, our confidence that there is a causal relationship will be diminished. On the other hand, in-time falsification requires shifting the year of the treatment to a different time to observe whether there are any differences with the original model.

To assess whether the synthetic control makes a good counterfactual, we also rely on p-values to quantify the difference between the original synthetic control estimate and the artificially generated distribution of placebos. The p-value still has an interpretation as the probability of obtaining an estimate at least as large as the one obtained for the unit representing the case of interest when the intervention is reassigned at random in the data set. Recall that our goal here is to determine whether the results obtained using SCM are statistically significant. The p-values are calculated as the ratio of the square root of the mean prediction error (RMSPE) obtained in pre- to post-treatment. In particular, the RMSPE of the real and time-adjusted values have the following structure:

$$RMPSE\ =\ \left(\frac{1}{t_N - t_o}\sum_{t=t_{o+1}}^{t_N}\left(Y_{it}^I\ -\ \sum_1^N w_i^*\ Y_{it}^N\right)^2\right)^{1/2} \tag{5}$$

In equation (5), the RMSPE of the pre- and post-treatment period will be determined, so that when extracting the pre-treatment/post-treatment ratio, a p-value will be obtained, which, if it is less than 10%, the results of the intervention in the treatment unit can be concluded as significant.

5 Data and sample

We built a cross-country annual panel from 1980 to 2022 using primarily World Bank (2024). The pre-treatment period ranges from 1980 to 1999, adhering to the recommendation of Abadie et al. (2015) that the pre-treatment period should span at least 20 years. The treatment period extends from 2000 to 2022, which seems like a reasonable limit on the span of plausible prediction.

To capture economic growth, we look at the evolution of real GDP per capita as an outcome variable, retrieved from World Bank (2024) in 2010 USD. The SCM requires not only the input of an outcome variable, but also covariates which are believed to affect the outcome (where the covariates shouldn't be affected by treatment itself). Inspired in the

recompilation of cross-country studies of economic growth in Latin America carried out by Loayza et al. (2005), we used the following set of economic growth predictors: trade openness (total trade as a share of GDP), the investment rate (gross capital formation as a share of GDP), public spending (as a share of GDP), total population, and years of schooling (an indicator of human capital), which was obtained from Penn World Table (2019). In addition, given the monetary and financial nature of the prolonged economic catastrophe in Ecuador towards the end of the 20^{th} century, the credit used by private sector (as a share of GDP), the level of monetization (money supply as a share of GDP), and consumer price inflation were included as predictors. Besides, to fully capture the decline in GDP per capita during the 1998-1999 financial crisis, the "credit gap" defined as the difference between the credit-to-GDP ratio and its HP-filtered value is also used as an additional predictor.[13] Oil revenues (as a share of GDP) were also considered due to their strong association with economic growth found in several studies for the economy of Ecuador (Cepeda et al., 2016; Carrillo-Maldonado & Díaz Cassou, 2023; Cajas et al., 2022).

The database was constructed using a panel of 48 countries[14], ranging from low-income to upper-middle-income, during the period from 1980 to 2022. The donor pool excludes any country that enacted a policy intervention, i.e., official dollarization, during the selected period. In this case, El Salvador and Panama are excluded as dollarization occurred.

Our approach yielded a robust data panel of 2064 observations. Though initially there was less than a 3% loss of information, this was mitigated using imputation techniques and moving averages for human capital data between 2020 and 2022. As a result, the entire data set now contains 100% of the information.

6 Empirical findings

We present the results on the effect of dollarization on real GDP per capita in this section. From a pool of 48 countries, only six receive a weight of approximately 0.1 or more. Figure 1 shows that synthetic Ecuador consists of 43.3% Paraguay, 20.4% Republic of the Congo, 14.3% Brazil, 11.6% Honduras, 9.4% Gabon, 0.75% Saudi Arabia, and negligible shares of the other countries with positive weights in the donor pool. The reader may note that most of the donor countries are commodity exporters, and only three of them are oil exporters.

Next, we use the estimated weights to obtain the synthetic Ecuador and compare it to the actual Ecuador in pre-treatment characteristics. Table 1 compares the pre-treatment characteristics of Ecuador to those of the synthetic Ecuador, and also to those of a population-weighted average of the 48 countries in the donor pool. Overall, the results suggest that the synthetic Ecuador provides a much better comparison for Ecuador than the weighted average of all countries in the donor pool. This is particularly evident when we compare the GDP per capita in 2010 USD, where the values between the control and treatment units are virtually identical. Moreover, the values of most covariates used in estimating the synthetic Ecuador are very similar to those of the actual Ecuador. Compared to the average donor pool, synthetic Ecuador matches actual Ecuador much closer in terms of broad money, credit gap, and oil revenues (all as a percentage of GDP) and schooling. In other words, a good

[13] Studies such as Borio & Drehmann (2009) and Drehmann & Juselius (2014) show that credit gaps defined as deviations between the aggregate credit-to-GDP ratio from its long-run trend are good predictors of systemic banking crises.

[14] Table A.1 provides the list of countries.

fit has been achieved in the phase from 1980 to 1999, indicating that a common trend has been successfully captured.

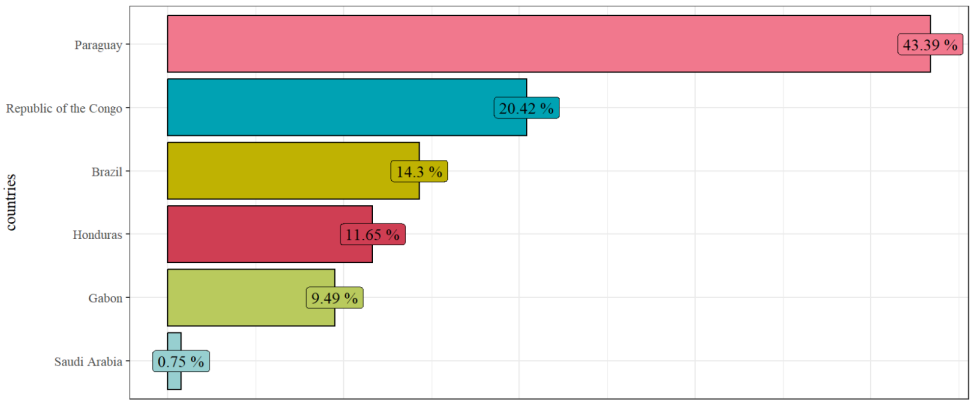

Figure 1: Set of donors forming the synthetic Equator

Figure 2 displays the per capita GDP trajectory of Ecuador and its synthetic counterpart for the 1980-2022 period. Clearly, the synthetic Ecuador almost exactly reproduces the per capita GDP for actual Ecuador during the entire pre-dollarization period. Further, and in contrast to other previous studies, the synthetic counterpart replicates Ecuador's economic collapse of 1999 quite well. This close fit for both the pre-dollarization per capita GDP and the GDP predictors in Table 1 demonstrates that there exists a combination of other countries that reproduces the economic attributes of Ecuador before dollarization.

Table 1: Economic growth predictors means before official dollarization (1980-1999)

Predictors	**Ecuador**	**Ecuador Synthetic**	**Donor Pool**
Trade openness[a]	40.25	75.98	69.52
Gross fixed capital formation[a]	18.30	23.09	22.13
Money supply[a]	15.95	23.57	37.84
Population	10,151,604	24,117,185	43,220,816
Schooling	2.20	1.85	1.74
Government spending[a]	29.98	17.11	19.83
Domestic credit to the private sector[a]	30.35	27.00	31.63
Credit Gap	0.97	0.97	0.16
Oil revenues[a]	7.41	7.33	3.99
Consumer Price Inflation	36.50	97.59	53.29
GDP per capita (Base year = 2010)	4,237.28	4,237.11	4,058.39

Source: The authors' elaboration using World Bank (2024) and Penn World Table (2019).
a: As a percentage of GDP

After dollarization, the actual Ecuador (with dollarization) performs much better than the synthetic Ecuador. The findings indicate that, during the treatment phase, the dollarization allowed Ecuador to experience an average increase of 9.69% in their GDP per capita with respect to the synthetic control unit. While the per capita GDP of the synthetic Ecuador falls up to 2002, the actual Ecuador (with dollarization) per capita GDP keeps ascending without interruption until the 2009 global financial crisis, which took its toll on individuals and institutions around the globe.

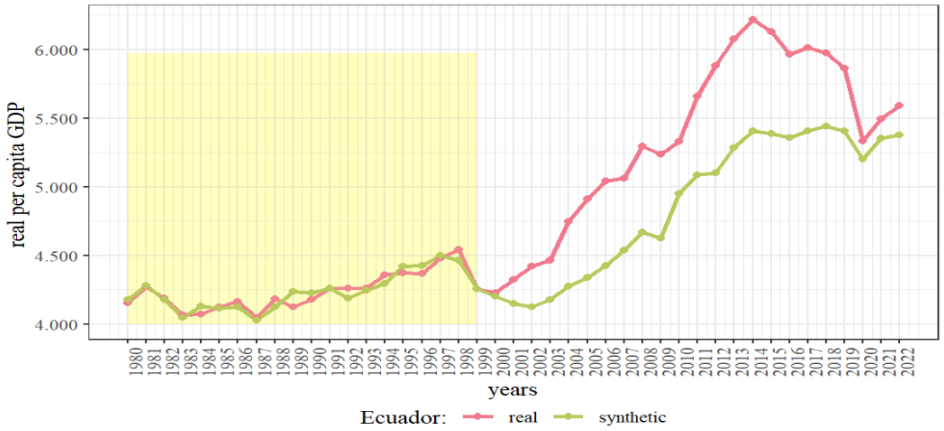

Figure 2: Evolution of real per capita GDP with and without dollarization
USD 2010 Numbers

The reader may observe that after 2014, just when the commodity price boom begins to take a sharp turn marking the end of the second oil boom, the treated unit (the dollarized Ecuador) underwent a continuous economic contraction. This contraction found an inflexion point during the COVID-19 pandemic, after which an upswing in per capita GDP was recorded. Conversely, the synthetic Ecuador displayed economic stagnation (but not a fall) from 2015 to 2019, an economic contraction in 2020, and a rebound between 2021 and 2022. While the downward turn in commodity prices between 2014 and 2020 may have affected the trajectory of Ecuador's GDP, it must also have affected the synthetic Ecuador as well, since five out of the six main donor countries that we use to construct the synthetic Ecuador are commodity exporters, and three of them are oil exporters. If both the synthetic control unit and the real Ecuador are affected by commodity prices, the sharpest fall in the real Ecuador may well be caused by what makes them different; in our case, dollarization. Thus, the change in trend in the treated unit (Ecuador with the dollar) since 2014, unlike what is happening in synthetic Ecuador, could suggest that the benefits of dollarization in terms of growth are running out.

In search of a plausible explanation for this poor performance of the Ecuadorian economy after 2014, we look at the U.S. Dollar Index, a measure that tracks the strength of the dollar against a basket of major currencies, designed and published by Intercontinential Exchange (2015). While between the years 2000 and 2013 the index trend is downward, going from a value of 105.9 to 80.05 and indicating that the U.S. dollar lost "strength" vis-a-vis other currencies, between 2014 and 2022 it changes dramatically and jumped by nearly 26%. This substantial overvaluation of the dollar against other currencies not only deteriorates the competitiveness of countries like Ecuador that have given up their monetary sovereignty but also harms economic growth.

Four observations can be drawn from the difference between the actual Ecuador and its synthetic version as given in Figure 3. First, the gap, $\hat{\tau}_{it}$, is clearly different from 0 and positive for the whole post-treatment period. Second, although positive, the gap develops over two clearly different phases. In the first, the gap between Ecuador's GDP per capita and the synthetic unit widens, while in the second, it narrows. Thirdly, despite the economic

downfall triggered by the COVID-19 pandemic, in the recovery period, the dollar seems to facilitate a better economic performance. Finally, although the gap narrows towards the end of the whole period, it still reflects an average increase in GDP per capita of USD 496.

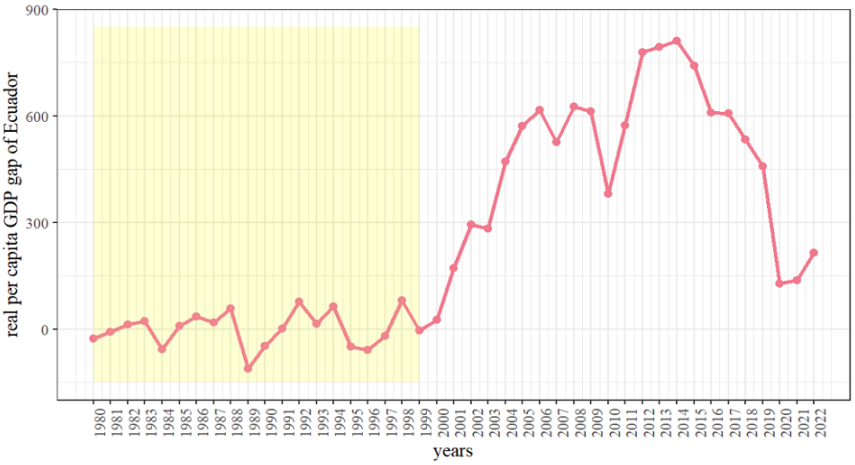

Figure 3: Real Per Capita GDP gap of Ecuador with and without dollarization
USD 2010 Numbers

We conduct the placebo tests as suggested by Abadie et al. (2015). By first relying on the in-space placebo analyses, we perform a series of simulations where the synthetic control estimator is iteratively applied to all the countries in the donor pool that did not undergo an irreversible policy intervention (dollarization) during the period of our investigation. The intuition behind this placebo experiments is straightforward. If permuting the implementation of full dollarization to all countries in the donor pool creates per capita GDP gaps of magnitudes similar to the one estimated for Ecuador, then the analysis likely does not corroborate the notion of a significant impact of dollarization. In contrast, if the iterative allocation of the treatment to donor units graphically indicates that the gap identified for Ecuador is unusually large, unique, and easily perceivable relative to the gaps in placebo simulations, then the analysis may provide some evidence supporting the notion of the significant effect of dollarization on Ecuador's economic growth.

With the expectation that no donor (or almost none) exhibits the effect observed in Ecuador (trend highlighted in black), the results of the placebo experiment can be seen in Figure 4. Indeed, it is evident that the impact of dollarization is estimated to be larger in Ecuador than in all of the placebo units between 2000 and 2022. Therefore, it could be inferred that the adoption of the USD as the official currency did indeed boost Ecuador's economic growth, as opposed to the scenario where it was not adopted.

Following Abadie et al. (2015), we also report the ratios between the post-2000 RMSPE and the pre-2000 RMSPE for Ecuador and for all the countries in the donor pool. A large post-intervention RMSPE indicates a large effect of dollarization if the synthetic control does closely reproduce the outcome of interest (real per capita GDP) prior to the intervention. Hence, with this placebo test, we expect to see that the ratio in Ecuador is sufficiently different from the donor pool. In Figure 5, Ecuador clearly stands out as the country with the highest RMSPE ratio. Indeed, for Ecuador, the post-intervention RMSPE is about 10.8

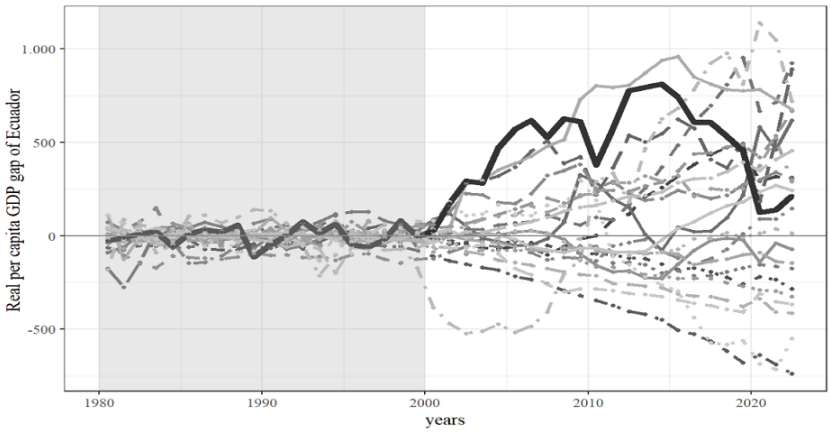

Figure 4: The Placebo First Experiment: Dollarization applied in each country of the donor pool and in Ecuador, GDP per capita in 2010 USD

times larger than the RMSPE calculated before the treatment.[15]

As mentioned by Abadie et al. (2015, p. 499), in comparative studies such as using SCM, there are limitations of randomization or probability sampling for selection of control and treatment units, causing the traditional statistical inference approach to be more difficult to apply. However, Becker & Klößner (2016, p. 16) develops placebo tests over time, assessing whether the treatment effect is equal to the control effect as the null hypothesis, while the alternative hypothesis is that the effect is different.

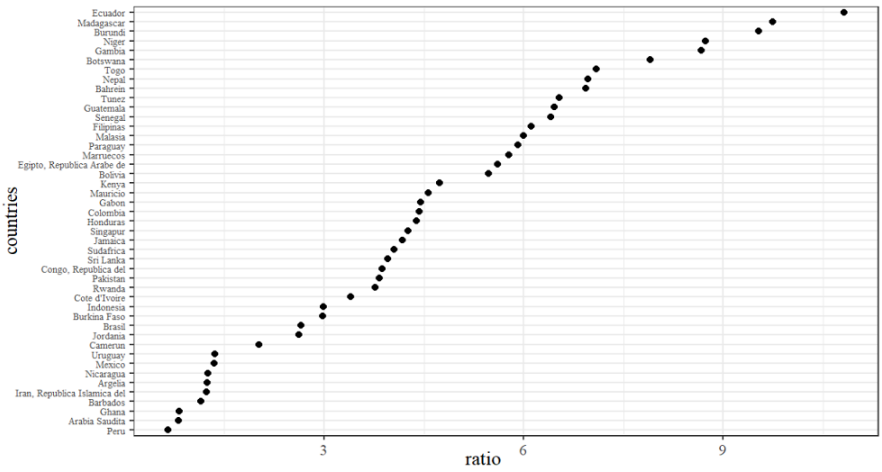

Figure 5: Ratio of post-to-pre-intervention RMSPEs for Ecuador and all countries in the pool
Source: Authors' elaboration using World Bank (2024) and Penn World Table (2019).

We conduct a time-based placebo test, which is a hypothesis test where we assess whether the difference between Ecuador with the dollar (treated unit) and Ecuador without the

[15] If one were to pick up a country at random from the donor pool, the chances for obtaining a ratio as high as this one would be $1/48 \approx 0.020$.

dollar (control unit) in each year of the treatment (2000 to 2022) is attributable to the official dollarization. A p-value of less than 0.10 will validate this hypothesis.

Table 2 indicates that, except for the year 2000, the dollar stimulated Ecuador's economic growth until 2015. However, following this period, when the economic downturn began after the oil prices plunge, it cannot be inferred that the higher GDP per capita in 2010 dollars in Ecuador with dollarization (treated unit) compared to Ecuador without dollarization (control unit) is exclusively due to the adoption of the dollar as the official currency.

Table 2: In-time Placebo Test at Time of treatment period

Year	P-value	Year	P-value	Year	P-value
2000	0.3182	2008	0.0455	2016	0.1363
2001	0.0909	2009	0.0909	2017	0.1818
2002	0.0455	2010	0.0909	2018	0.1818
2003	0.0960	2011	0.0909	2019	0.2727
2004	0.0455	2012	0.0909	2020	0.5455
2005	0.0455	2013	0.0909	2021	0.5455
2006	0.0455	2014	0.0909	2022	0.5455
2007	0.0455	2015	0.0909		

Source: Authors' elaboration using World Bank (2024) and Penn World Table (2019).

As a final step to validate whether there was an effect of the dollar as the official currency on Ecuador's economic growth over the period from 2000 to 2022, we employ a difference-in-differences estimator (Becker & Klößner, 2016, p. 16). This will test the null hypothesis of whether the treated unit (the actual Ecuador) experienced higher economic growth due to the dollar compared to the control unit (the synthetic Ecuador). The p-value less than 0.10 indicates that the adoption of the dollar as an official currency did indeed promote Ecuador's GDP per capita between 2000 and 2022.[16]

7 Conclusion

The decision to dollarize is the strongest commitment device in the monetary regime spectrum, therefore, it is a policy that is very costly, if not impossible to revert. Whether the benefits of dollarization outweigh the costs, and to what magnitude they do, is still widely discussed in the economic literature. In this study, we have made an effort to summarize valuable insights that were derived from the theoretical debate. The literature indicates a route between dollarization and economic growth that works through a variety of channels that generally reinforce each other.

We constructed an artificial control group and a plausible counterfactual against which growth impacts resulting from dollarization could be evaluated as part of the recent historical record of Ecuador. We show that a synthetic control can accurately reproduce the pre-2000 per capita GDP path for Ecuador. In other words, a good fit was achieved in the phase from 1980 to 1999, indicating that the common trend was successfully captured. We found that once the decision to officially dollarize was made, per capita GDP in Ecuador increased on average about 9.7 percentage points relative to the synthetic control country. Furthermore, this gap appears to show an inverted U-shape over time, which would indicate that the effects of dollarization on economic activity are very powerful at the beginning, but fade out over

[16] The results of the difference-in-differences are available upon request.

time. Placebo tests determine that such a fit and further effects are statistically significant. We argue that one of the reasons for the relatively lower performance that Ecuador shows compared to the synthetic control since 2014 may lie in the substantial strengthening of the USD with respect to other currencies. In perspective, if this loss of competitiveness associated with a strengthening of the dollar is to be reversed or mitigated, public policies in Ecuador should concentrate efforts on increasing productivity.[17]

Two important caveats are however in order: First, our results are specific to the case of Ecuador, a country that, unlike other countries (such as Panama or El Salvador) have opted for an extreme monetary arrangement in an unprecedented situation of turbulence and economic collapse. If any lesson can be drawn from our study, we may say in that respect that countries considering the shift from an intermediate exchange rate regime to one of full dollarization should assess what its effects may have on long-term growth. Secondly, the results stem solely from analyzing the possible impact of full dollarization on economic growth. Thus, limiting the analysis to dollarization facilitates the process of constructing counterfactuals, while enabling us to eliminate any effects from other relevant exogenous shocks such as sudden changes in oil and commodity prices or even the increase in remittances that surely occurred during the period under study.

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[17] Improving labor productivity is, in fact, one of the unfulfilled tasks of the Ecuadorian economy. The Conference Board (2024) data at purchasing power parity show that the labor productivity growth in Ecuador was barely 0.57% between 2000 and 2022 and -1.57% between 2014 and 2022.

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Appendices

Appendix A: Countries in the donor pool

Table A.1: Countries in the donor pool

Countries			
Algeria	Egypt	Madagascar	Philippines
Bahrain	Gabon	Malaysia	Republic of the Congo
Barbados	Gambia	Mauritius	Rwanda
Bolivia	Ghana	Mexico	Saudi Arabia
Botswana	Guatemala	Morocco	Senegal
Brazil	Honduras	Nepal	Singapore
Burkina Faso	India	Nicaragua	South Africa
Burundi	Indonesia	Niger	Sri Lanka
Cameroon	Iran	Nigeria	Togo
Colombia	Jamaica	Pakistan	Tunisia
Costa Rica	Jordan	Paraguay	Uruguay
Côte d'Ivoire	Kenya	Peru	

Source: Authors' elaboration using World Bank (2024) and Penn World Table (2019).