Pontifícia Universidade Católica
do Rio de Janeiro

Alice Oliveira Drumond

International Reserves and Interest Rates

Dissertação de Mestrado

Dissertation presented to the Programa de Pós–graduação em Economia da PUC-Rio in partial fulfillment of the requirements for the degree of Mestre em Economia .

Advisor: Prof. Márcio Garcia

Rio de Janeiro
July 2020

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Abstract

Oliveira Drumond, Alice; Garcia, Márcio (Advisor). **International Reserves and Interest Rates**. Rio de Janeiro, 2020. 46p. Dissertação de mestrado – Departamento de Economia , Pontifícia Universidade Católica do Rio de Janeiro.

Over the past two decades, the level of international reserves in emerging economies increased significantly. In Brazil, the 2019 level of around 360 billion dollars was considered high by some metrics, based on the precautionary motive. On the other hand, in addition to the opportunity cost, Latin America is also characterized by historically high costs of holding reserves, due to the payment of positive and high interest rates. Behind any model in the literature that studies the optimal level of reserves, there is a trade-off between the insurance benefits and the costs associated with the accumulation of reserves, so that a significant change in this rate is expected to be relevant in the optimization made by the Central Bank. In that sense, recently, the policy-related interest rate in Brazil (Selic) decreased considerably, from 14.25% until October 2016 to 2.25% until June 2020, an all-time low. Addressing this issue, this thesis studies the effect of this change in the direction of Brazil's monetary policy in the management of foreign exchange reserves. Our counterfactual results show that the net FX reserves level —a benchmark adopted by the Central Bank since August 2019 —, would have fallen in this period, but the decline in the interest rates made it possible for the Central Bank to keep a roughly stable level until 2019.

Keywords

International Reserves; Interest Rate; Artificial Counterfactual; Cost of Holding Reserves.

Resumo

Oliveira Drumond, Alice; Garcia, Márcio. **Reservas Internacionais e Taxa de Juros**. Rio de Janeiro, 2020. 46p. Dissertação de Mestrado – Departamento de Economia , Pontifícia Universidade Católica do Rio de Janeiro.

Nas duas últimas décadas, o nível de reservas internacionais nos países emergentes aumentou de forma significativa. No Brasil, o nível de 2019 de 360 bilhões de dólares era considerado alto por algumas métricas, com base no motivo precaucional. Por outro lado, além do custo de oportunidade, a América Latina também se caracteriza pelo custo historicamente alto de carregamento das reservas, devido ao pagamento de juros positivos e altos. Por trás de qualquer modelo na literatura que estuda que estuda o nível ótimo das reservas, existe uma ponderação entre os benefícios e os custos associados à acumulação das reservas, de forma que é esperado que uma mudança significativa nesta taxa seja relevante na otimização feita pelo Banco Central. Nesse sentido, recentemente, a taxa de juros alvo da política monetária no Brasil (Selic) caiu consideravelmente, de 14.25% até outubro de 2016 para 2.25% em junho de 2020. Com relação a esta questão, este trabalho estuda o efeito desta mudança na direção da política monetária brasileira na gestão de reservas cambiais. Nossos resultados contrafactuais mostram que o nível de reservas líquido —referência adotada pelo Banco Central desde Agosto de 2019 —teria caído neste período, controlando pelo efeito de outros determinantes ao nível ótimo de reservas, mas a queda na taxa de juros tornou possível que o Banco Central mantivesse um nível aproximadamente estável.

Palavras-chave

Reservas Internacionais; Taxa de Juros; Contrafactual; Custo de Carregamento das Reservas.

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ARA – Assessing Reserve Adequacy
IMF – International Monetary Fund
ArCo – Artificial Counterfactual
SC – Synthetic Control

1
Introduction

Over the last two decades, the large accumulation of international reserves in emerging markets, along with debt levels fluctuating around a roughly stable level, has intensified the debate concerning the optimal level of reserves. Considering the main emerging markets economies[1], the average level of reserves jumped from around 18% of GDP in 2002 to almost 30% in 2019. However, despite being an insurance against financial crises and capital flights, the accumulation of reserves is also costly.

According to many cost-benefit models in the literature[2], the optimal level of reserves balances the insurance benefits and costs due to positive spreads, the difference between the yield payed on foreign borrowing and received on reserve assets, evaluated in the same currency. As estimated in Rodrik (2006), this cost for emerging coutries -"an insurance premium"- represents 1% of GDP.

Even though, at first, the main characters in this process of foreign exchange accumulation were developing countries in Asia, their success and extremely high growth rates[3] motivated other regions, like Latin America, to adopt this behavior, despite the contrast between these economies.

When compared to Emerging Asia, Latin America's economic history is composed of much smaller current account surplus and investment. In addition, especially in Brazil and Mexico, the higher interest rates increase the cost of sterilized interventions and, therefore, the cost of accumulating foreign exchange reserves. That is, despite a global movement, it is essential to consider the peculiarities of each country when studying the optimal level of international reserves.

It is not clear what the optimal level of international reserves is, despite many efforts to estimate it. In that sense, Heller (1966) finds that the optimal

[1]The average level of international reserves was calculated considering 21 emerging countries for which we have monthly data: India, Korea, Indonesia, Taiwan, Thailand, Singapore, Malaysia, Vietnam, Brazil, Mexico, Argentina, Colombia, Chile, Peru, Russia, Turkey, Poland, South Africa, Israel, Czech Republic, Hungary

[2]See Aizenman and Marion (2004), Miller and Zhang (2006), Aizenman and Lee (2007) for models illustrating the basic trade-offs concerning the choice of optimal reserves.

[3]According to OECD Economic Indicators database, the Major 5 Asia countries - China, India, Indonesia, Japan and Korea - experienced growth rates from 5% in 2002 to 10% in 2006.

level of international reserves is the value that minimizes the total cost of adjusting or financing an external imbalance, where the cost of adjusting is incurred only in the case that a cumulative Balance of Payments deficit of a certain magnitude actually occurs.

Frenkel and Jovanovic (1981) add to that by gathering the role of stochastic characteristics of external transactions and of foregone earnings, which arise from the difference between international reserves earnings and market interest rate. However, until the beginning of the 21^{st} century, this literature was not micro-founded, since frequently the modeling work followed the Baumol-Tobin inventory model with exogenous costs and assumptions were often made considering small economies, especially the primary producing ones.

In light of the Asian Crisis, many studies thereafter were interested in estimating optimal levels of reserves for emerging market countries that face the risk of sudden stops. Caballero and Panageas (2004) present a model of sudden stops in order to study how emerging economies can be insured against this risk, while Ranciere and Jeanne (2006) look at the intertemporal optimization problem of the government in a small open economy that is hit by sudden stops in capital flows associated with a fall in output.

Ranciere and Jeanne (2006) use a more realistic dynamic structure than Aizenman and Lee (2007), which is based in a three-period stylized model of the optimal level of international reserves. That is interesting in the sense that it becomes easier to calibrate by reference to the data. Another benefit is that the authors find closed-form expressions for the optimal level of reserves, which avoids numerical approximations.

Both studies, though, aim to test whether the precautionary or exchange rate stability motive better explains international reserve accumulations by developed and emerging countries. The findings give support to both reasons but do not fully explain developed countries upsurge accumulation after 2000. Obstfeld et al. (2010) find better empirical evidence for developing and advanced countries, using a model based on financial stability and financial openness, calibrating reserve adequacy against the size of the banking sector.

There are some other studies interested in reserve policy around the global crisis of 2008. Dominguez et al. (2012) look the decision to purchase or sell reserve assets during the crisis period (and not only the total stock of international reserves) and find that higher reserve accumulations prior to the crisis are associated with higher post-crisis GDP growth. Dominguez et al. (2012) also introduced new data from the IMF's Special Data Dissemination Standard (SDDS) Reserve Template, which made possible the distinction

between valuation adjustment and interest returns from an actively managed component of reserves.

The 2008 Crisis was also followed by a remarkable rise of swap arrangements between Central Banks of larger economies and smaller economies. Concerned about the substitutability between them and foreign currency reserves, Aizenman et al. (2011) find that there is a limited capacity for swap lines to substitute for reserves, depending on how significant trade and financial connection are and how appropriate are moral hazard concerns.

The scope of quantitative sovereign default models has also been an important framework for studying the optimal accumulation of reserves, where governments can choose both holdings of sovereign debt and reserves. Alfaro and Kanczuk (2009) examine the effects of this joint decision, and find robust results that the optimal policy is not to hold reserves at all. Similarly, Bianchi et al. (2018), using a compatible structure, assign this result to the debt term: when there is only long-term debt the insurance value of transferring resources from repayment states to default states is not relevant. However, it is optimal to hold reserves with long-term debt, in view of the benefit of transferring resources across payment states, from states with low borrowing costs to states with high borrowing costs.

Not only the term is important, but also the currency in which debt is issued to finance the accumulation of reserves plays a very important role. Alfaro and Kanczuk (2019) build on this literature by proposing a simple model with debt issued in local currency. Considering devaluations effects caused by negative external shocks, accumulating reserves by issuing debt in local currency act as a hedge, decreasing liquid debt in bad times via two channels: lower debt measuared in dollar, and higher reserves.

Probably due to the absence of a consensus, rules of thumb are also often used to evaluate current levels of international reserves. The Guidotti-Greenspan rule, for example, states that a country's reserves should equal its short-term external debt (less than one-year maturity), and is broadly considered as a reference level. According to Rodrik (2006), it is a result of a principle enunciated by Pablo Guidotti (then deputy Finance Minister of Argentina) and subsequently endorsed by Fed Chairman Alan Greenspan[4].

Additionally, we have the three months of imports rule and 20% of broad money[5]. Restricting the study of optimal reserves level to one of these rules, however, often lead to mistakes. Contributing to that, the IMF made

[4]See Federal Reserve Speeches, April 29, 2009, `https://www.federalreserve.gov/BoardDocs/Speeches/1999/19990429.htm`

[5]See IMF policy papers (2011, 2013 and 2015) for analytical frameworks using these rules of thumb to assess reserve adequacy

available the ARA (Assessing Reserve Adequacy) metric[6], which condenses some relevant macroeconomic variables into these rule, namely exports, broad money, short-term debt, and other liabilities.

A key point that rules of thumb neglect, however, is the intrinsic trade-off in a Central Bank's optimal reserves policy, counterbalancing safety and fiscal costs. Cost-benefits models directly take into account that issue but tend to be sensitive to the stylized economic structures assumed. Indeed, this trade-off becomes especially interesting for countries with high interest rates and a vulnerable external sector.

Following that concern, the recent fall in Brazilian interest rates, since October 2016 until the end of 2019, may be an important factor to explain the upkeep of the high stock of international reserves in Brazil. In order to test this hypothesis, we propose a counterfactual analysis of the level of international reserves were the interest rates stable at 14.25% in Brazil, the highest level since 2007.

The remainder of the thesis is organized as follows. The next section presents some stylized facts regarding the accumulation os reserves and the evolution of debt and interest rates in emerging economies. Section 3 explains the empirical strategy we use and section 4 presents the data. Section 5 shows the results and we conclude in section 6.

[6]In the case of Fixed Exchange Rate: ARA Metric = 10% x Exports + 10% x Broad Money + 30% x Short-term Debt + 20% x Other Liabilities or Float Exchange Rate: ARA Metric = 5% x Exports + 5% x Broad Money + 30% x Short-term Debt + 15% x Other Liabilities

2
Facts

This thesis exploits a change of course in the interest rate level in Brazil, and its implications for the accumulation of international reserves. In order to understand the environment in which this change is relevant, this section displays some historical facts about the main variables of interest in this thesis, such as international reserves, public debt, and interest rates.

2.1
Stylized Facts

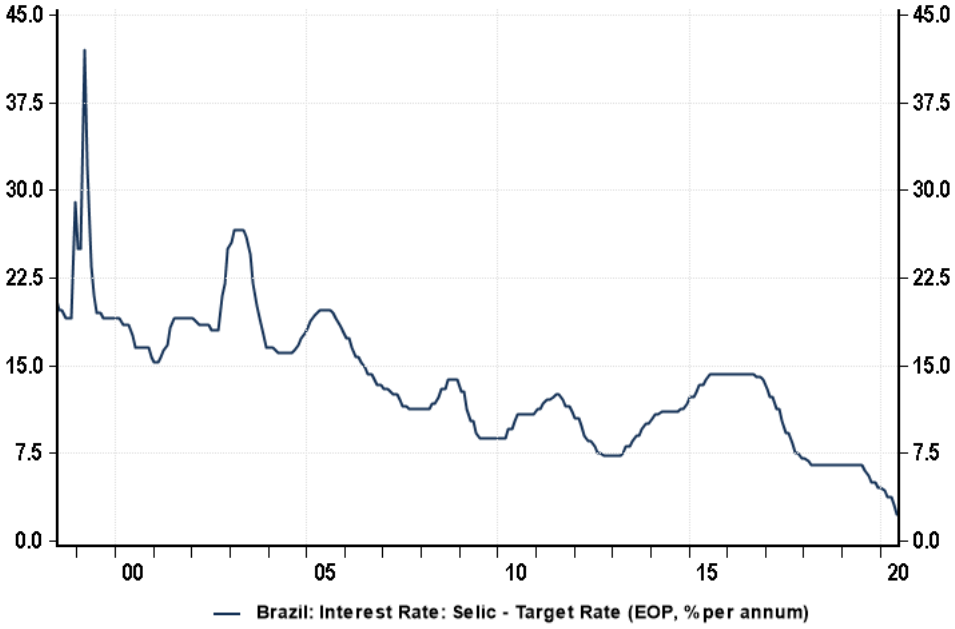
Considering that we are interested in the Central Banks decision to accumulate international reserves, a decrease in the interest rate means that the borrowing cost is also lower, so that the downside involved in the accumulation of reserves loses strength compared to the benefits.

There is a vast literature interested in the high interest rates in Brazil, since the Real Plan in 1994. Assigned to many factors, the most referred to are excessive government deficits, inflation bias, successive negative shocks and others, such as legal uncertainty (Arida et al. (2005)). Figure 2.1 shows the behavior of this series since the nineties.

Futhermore, even when compared to emerging economies also susceptible to similar risks and shocks, Brazil continues to stand out until 2017. In that sense, figure 2.2 shows interest rates in Brazil and other emerging market economies over the past decade. Even South Africa, known for its public debt sustainability challenges, is far from Brazil in terms of interest rate in this period.

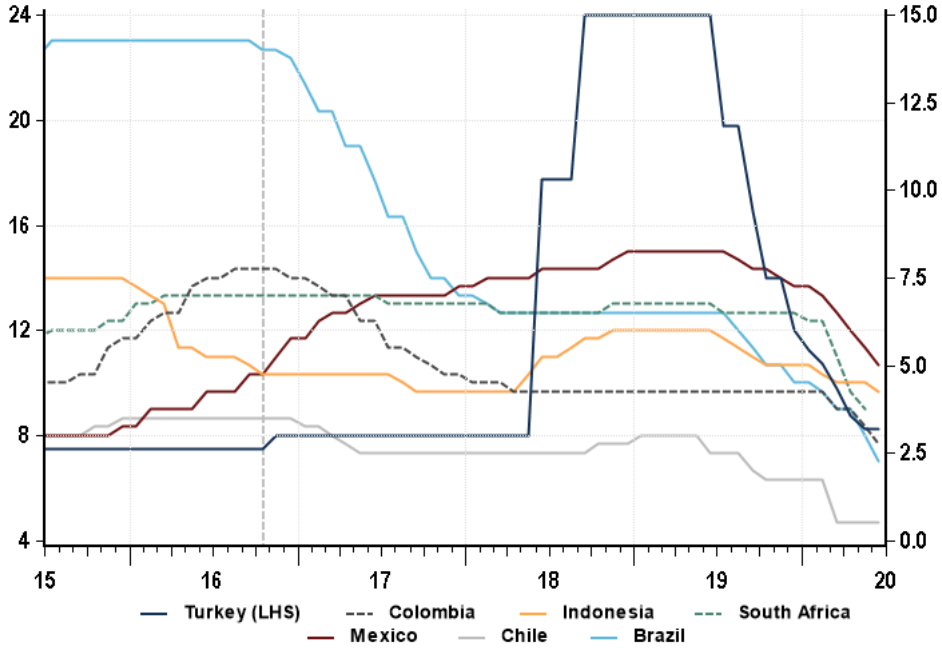
However, since October 2016, successive cuts in the interest rates were made by the Central Bank of Brazil, leading to the historical minimal value, of 2.25% in June 2020. It should be emphasized that in all of the COPOM (Monetary Policy Committee) meetings since this date, the decision was to keep the interest rate level, or cut it. Also, Figure 2.3 shows that, decomposing the interest rate by the covered interest parity components, another feature is the lower share of the forward premium in the composition of the interest rate compared to the exchange rate coupon.

Figure 2.1: Interest Rates in Brazil



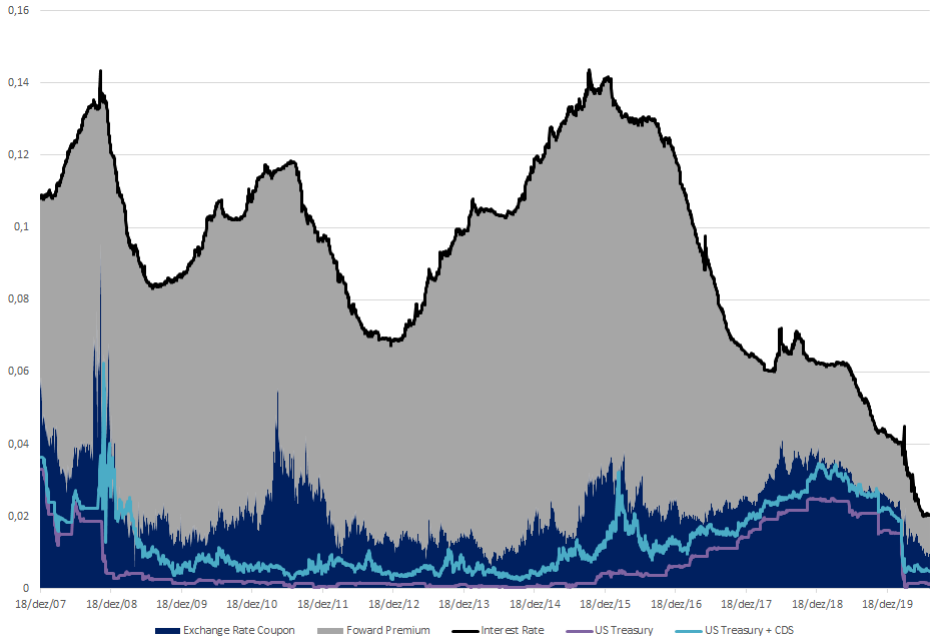
Notes: Figure plots the interest rates in Brazil since 1998.

Figure 2.2: Interest Rates in Emerging Economies



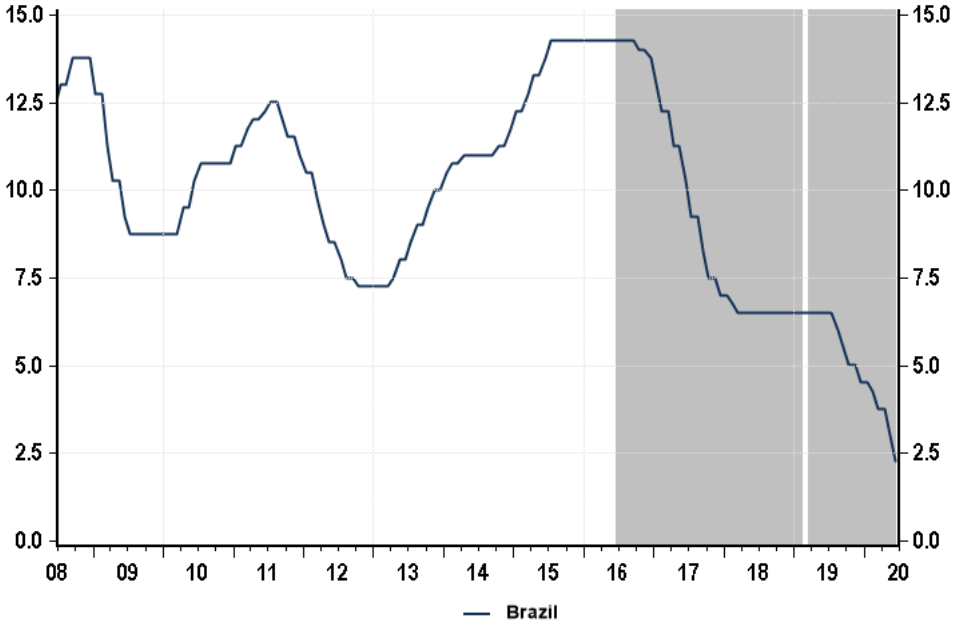
Notes: Figure plots the interest rates in emerging market economies in the last decade.

Figure 2.3: Covered Interest Parity



Notes: Figure plots the interest rate decomposed by the covered interest patiry. Variables are in logarithm and refer to the 6-month maturities yields.

Figure 2.4: Interest Rates in Brazil - Recent Years



Notes: Figure plots shadding areas relative to the each recent president of Central Bank of Brazil.

Another important feature that Figure 2.2 demonstrates, is that there was no global trend of easing when this movement started in Brazil, which is also important for the adequacy of the methodology applied in this thesis. That is very different from what the world experienced since the outbreak of COVID-19 pandemic that, having triggered one of the worst recessions in history, prescribed that fiscal and monetary policies helped aliviate economic damages from this health and social crisis.

In the beginning of June 2019, Ilan Goldfajn was confirmed as the new Brazil Central Bank governor, and his term ended at the end of February 2019. The new governor, Roberto Campos Neto, began his term in 28 February 2019 and continues to be responsible for conducting monetary policy in Brazil. Figure 2.4 plots the interest rate series in Brazil for the recent years, and the shadding areas separate the above mentioned terms.

From Figure 2.4, since 2008 (period that we consider in the empirical study), it is clear that before these two terms policy rates cycles of easing were always followed by equally balanced reversals thereafter. Also, these cycles were shorter than the period of almost four years since the beginning of this new trend in October 2016. Even before COVID-19 crisis, that ended up triggering aggressive policy easings worldwide, instead of reverting the fall from 2016 to 2018, SELIC was kept flat until the end of 2019.

On the other hand, even with high interest rates, the payment of sovereign spreads to hold reserves are optimal to indebted governments (Bianchi et al. (2018)), despite reducing debt could also be a way of minimizing the government vulnerability.

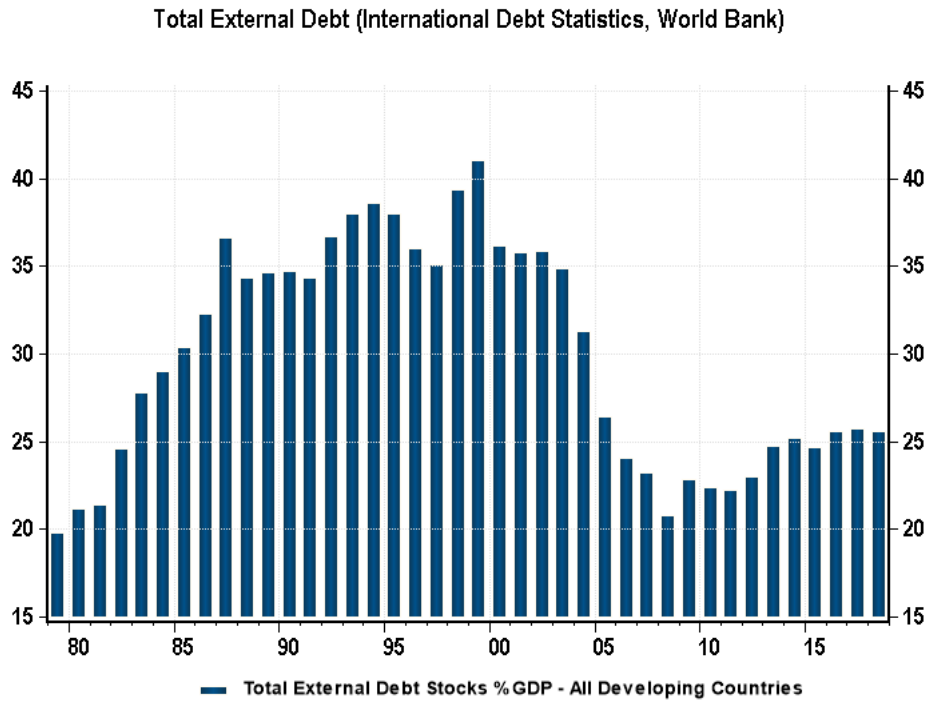
As figure 2.5 exhibits, external debt levels in emerging economies increased in the 80's, and were around 35-40% until the early 2000s. A new level, around 20-25% of GDP characterized the last decade. Yet, as detailed in Bianchi et al. (2018), total debt (domestic and external) have been roughly stable in terms of GDP, especially when compared to the increase in the level of reserves (also in terms of the GDP).

In that sense Alfaro and Kanczuk (2019) also emphasizes that what happened was a change in composition of debt: domestically-denominated debt as a fraction of total government debt increased in many emerging markets[1].

These considerations on the public debt of emerging economies are only partially true for Brazil. In fact, the share of domestically-denominated debt increased from 80% in 2005 to 95% in 2020. Yet, considering the last decade, Brazil experienced a surge in gross general government debt, from around 53% in 2012 to 76% in 2020. Figure 2.6 shows the evolution of debt in Brazil.

[1]See also Du and Schreger (2016) and Burger and Warnock (2007).

Figure 2.5: Total External Debt to GDP in Developing Economies, World Bank



Notes: Figure plots the average of debt in developing economies for the last four decades.

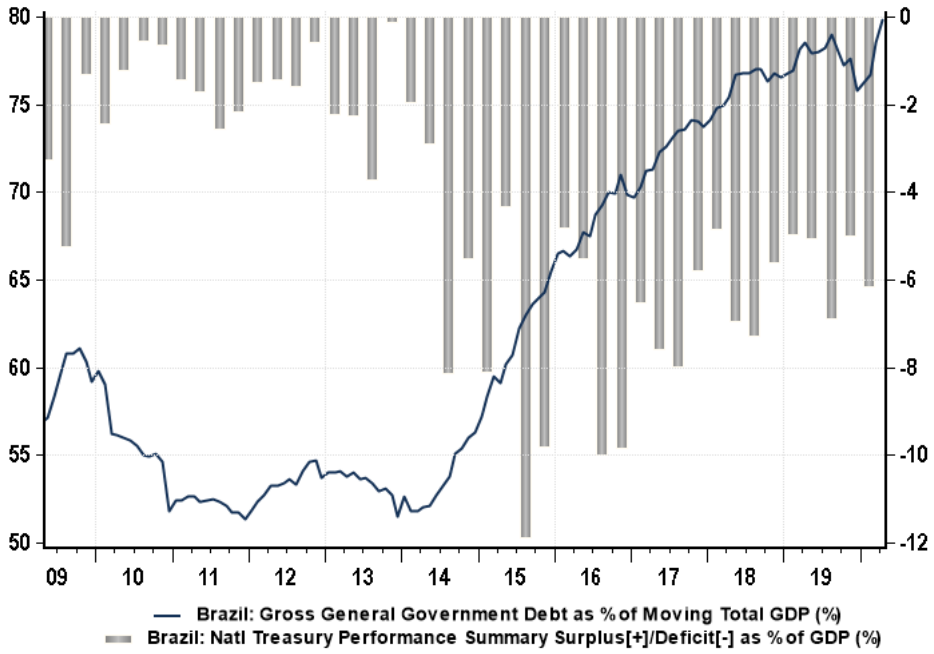
A significant part of this indebtedness, however, is the flip side of the accumulation of international reserves. According to the estimate of the Central Bank of Brazil[2], from 2006 to 2013, the accumulation of reserves was responsible for the increase of 16.1 points in the public debt in terms of GDP. It is a period in which, in fact, the central bank hoarded foreign exchange reserves[3] to a great extent, as shown in figure 2.7, which plots the increase in reserves accumulation, among many groups of developing economies.

We highlight that, considering the accumulation of reserves in the past two decades, the use of gross debt to evaluate the solvency and safety of an emerging economy should be complemented by the use of the net concept: that is, total debt less the stock of international reserves, both measured in dollar.

[2]See Quartely Inflation Report, Central Bank of Brazil, June 2013.

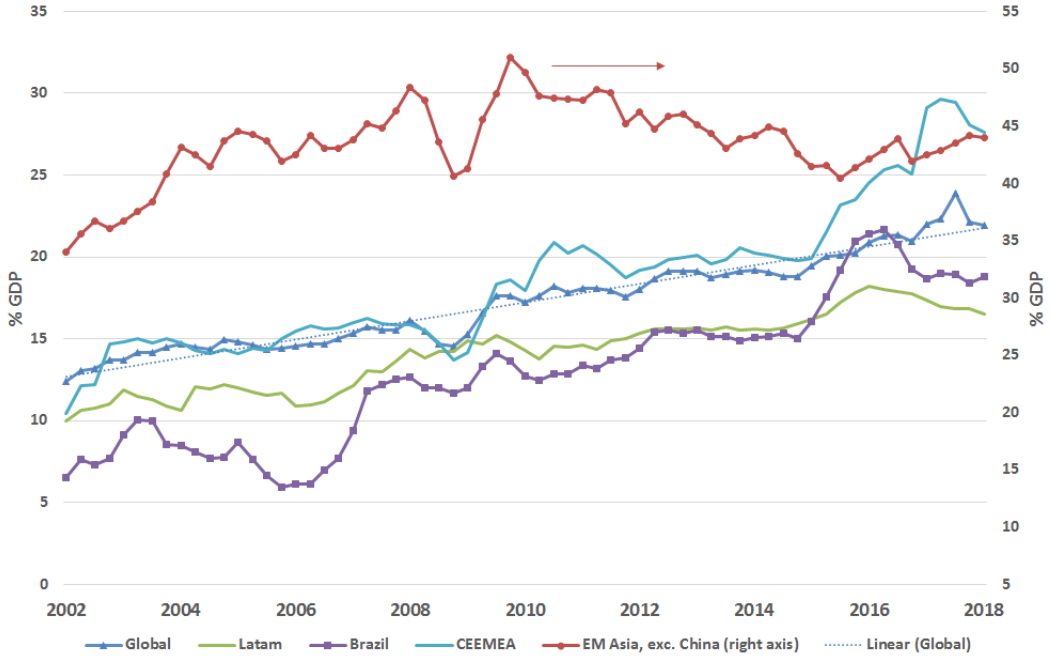
[3]Foreign exchange includes monetary authorities' claims on nonresidents in the form of foreign banknotes, bank deposits, trasury bill, short- and long-term government securities, and other claims usable in the event of balance of payments need.

Figure 2.6: Gross general government debt in Brazil, % GDP



Notes: Figure plots the gross general government debt, from 2007 to 2020 - excludes Federal securities in Bacen and includes Bacen repo operations.

Figure 2.7: International Reserves, 2002-2018



Notes: Figure plots the level of international reserves from 2002 to 2018.

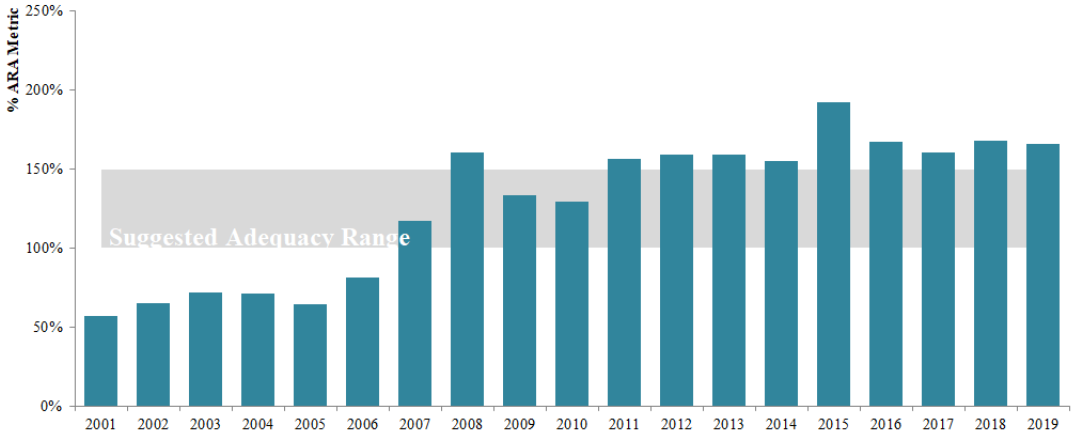
2.2 Rules of Thumb

Different metrics indicate the appropriate level of international reserves, based on indicators from the external sector and means of payment that seek to approximate the risk of capital flight from foreigners and brazilians in times of distrust. However, it is common to prescribe very different levels: for Brazil, with international reserves of around 20% of GDP, rules such as the coverage of short-term external debt or three months of imports pointed to appropriate levels of just over 3% and 7% of GDP, respectively, while the 20% rule for expanded means of payment indicated almost 17% of GDP.

Based on the IMF's own metric, the effective level of international reserves in Brazil slightly exceeds the limit of what is considered appropriate by the organization. Known as ARA (Assessing Reserve Adequacy), the minimum adequate level of reserves is calculated by adding 5% of the country's annual exports, 30% of the short-term external debt, 15% of the balance of other external obligations and 5% of the means payment terms, and considers effective levels between 100% and 150% of that amount to be adequate.

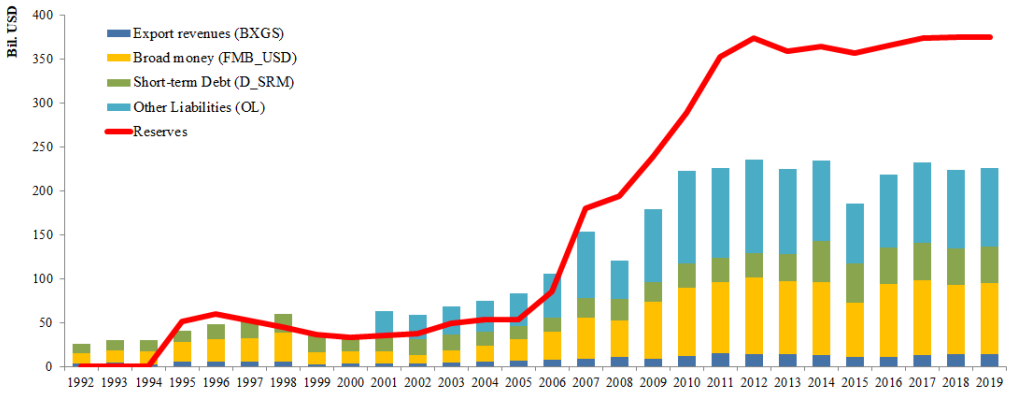
In 2019, according to the IMF forecast, the ratio between the level of reserves in Brazil and the appropriate minimum would be approximately 166% (in terms of GDP, the effective level in 2018 was around 20% and 100% of the ARA metric represented 12%). In absolute terms, this ratio indicates a surplus that varies between 150 and 36 billion dollars. Of the 226 billion dollars prescribed considering the 100%, 89 billion would be motivated by the 15% component of the balance in other external obligations, such as portfolio

Figure 2.8: Reserves as Percent of Metric, Brazil



Notes: Figure plots the international reserves levels as percent of the ARA metric.

Figure 2.9: ARA Metric Decomposition, Brazil



Notes: Figure plots actual reserves and the prescription according to the ARA metric, decomposed by each factor from ARA.

investment, 82 billion by means of payment, 41 billion by external debt and 14 billion by exports.

Figures 2.8 and 2.9 show the adequacy of reserves in Brazil according to the ARA metric, and the last one also plots the decomposition of ARA metric for Brazilian data. Interesting to notice that the main sources of need for protection are the amount of broad money[4] and other liabilities, with the size of exports revenues and short-term debt staying in the background.

So, in respect to the above mentioned rules of thumb, the clear message is that they support those who question whether the level of reserves maintained in Brazil over the past decade would not be higher than necessary. However, it is also evident that they only see part of the history: none of them takes into account the cost of accumulating reserves, measured by the interest rate spread, and which, as we highlighted in this section, is much lower now.

[4]Broad Money denotes a certain measure of money supply in a national economy. For the European Central Bank, encompasses the definitions of M2, M3 and M4. Yet, for OCDE, broad money is analogous to M3.

3
Methodology

This section presents the methodology used in this thesis, and also the reason why we chose this method among a range of possibilities proposed by the literature. From a statistical perspective, when measuring the effect of an intervention, the treated unit should be compared to a sufficiently similar one, but which has not been submitted to the intervention (a placebo). However, when units are countries, it is not trivial to find one that is similar enough, considering macroeconomic variables. Therefore, that is the reason why it is necessary to build a counterfactual based on econometric techniques, that can bring together similarities in different economic series and build a suitable benchmark.

3.1
Counterfactual Approach

Considering that there is no clear control group to compare with Brazil before the event, we use the Artificial Counterfactual method, hereafter ArCo, to assess the role of the new environment of low interest rates on the management of international reserves.

ArCo is an approach designed to handle high-dimensional panel time-series data, proposed by Carvalho et al. (2018), and is a method to estimate causal effects when a treated unit suffers a shock or an intervention, but there is not a readily available control group or counterfactual.

According to the Carvalho et al. (2018), ArCo is composed by two steps: in the first stage, an artificial counterfactual is estimated based on the data available for the untreated units using a variety of methods: from a simple ordinary least squares (OLS) to shrinkage methods, such as the Least Absolute Shrinkage Operator (LASSO).

In the second stage, the average intervention effect is estimated on a vector of variables associated with the treated unit. We estimate these weights in this thesis using linear regression, once neither the number of covariates is too high, nor T_0 is too small (that is, the time series before the event is not small compared to the dimension of out covariates).

Next, we show these two steps with a mathematical notation (following Masini and Medeiros (2020)). First, to simplify notation, take $y_t = z_{1t}$, that is, omitting the subscript that denotes the treatment unit. That being said, our core relation is: $y_t^{(1)} = \delta_t + y_t^{(0)}, t = T_0 \ldots, T$, where $y_t^{(1)}$ is the gross or net international reserves level observed after the intervention, and $y_t^{(0)}$ the hypothetical series if the intervention had never occurred. Accordingly, δ_t is the average effect we are interest in. That is, the null hyphotheses is:

$$\mathcal{H}_0 : \Delta_T = \tfrac{1}{T-T_0+1} \sum_{t=T_0}^{T} \underbrace{\left[y_t^{(1)} - y_t^{(0)}\right]}_{\equiv \delta_t} = 0 \quad \text{or}$$

$$\mathcal{H}_0 : \delta_t = 0, \forall t \geq T_0$$

However, we do not observe the counterfactual $y_t^{(0)}$. Therefore, we need to construct an estimate $\widehat{y}_t^{(0)}$ such that:

$$\widehat{\delta}_t \equiv y_t^{(1)} - \widehat{y}_t^{(0)} \quad \text{for } t = T_0, \ldots, T$$

In order to construct $\widehat{y}_t^{(0)}$, we need a parametric specification and a group of explanatory variables. Let the explanatory variables for the treatment unit be those that belong to the vector $\boldsymbol{x}_t$, definido como: $\boldsymbol{x}_t = \left(\boldsymbol{z}'_{0t}, \boldsymbol{z}'_{0t-1}, \ldots, \boldsymbol{z}'_{0t-p}\right)'$. With respect to parametric specification, take the following linear equation:

$$y_t^{(0)} = A\boldsymbol{x}_t + \nu_t$$

such that $\mathbb{E}(\nu_t) = 0$, and

$$\widehat{y}_t^{(0)} = \widehat{A}\boldsymbol{x}_t.$$

Therefore, the average estimator is given by:

$$\widehat{\Delta}_T = \frac{1}{T - T_0 + 1} \sum_{t=T_0}^{T} \widehat{\delta}_t$$

where $\widehat{\delta}_t \equiv y_t - \widehat{y}_t^{(0)}$, for $t = T_0, \ldots, T$. Now, with the aid of notation, we emphasize the two steps already mentioned above that are behind our empirical exercise. The estimator is computed in two-steps:

1. First step: estimation of A with the pre-intervention sample;

2. Second step: extrapolate A with actual data for $\boldsymbol{x}_t$ and compute $\{\delta_t\}_{t \geq T_0}$ and $\widehat{\Delta}_T$.

Lastly, the proper use of this method to estimate the effect of an intervention relies on a key assumption Let $\mathbf{z}_{0t} = (\mathbf{z}'_{2t}, \ldots, \mathbf{z}'_{nt})'$ denotes

the vector of all the observable variables for the untreated units. Then, the following independence hypothesis must hold: $\mathbf{z}_{0t} \| d_s$, for all t, s.

Within the framework of this thesis, we believe it is appropriate to assume the independence hypothesis: the intervention we study is the change in the course of interest rates in Brazil, from very high levels to a new environment much lower, and that is understood as a permanent, structural change.

The debate on the pillars of this change occured should not be that simple. There are two key factors, that are also intertwined: building reputation and credibility by the Central Bank in conducting their monetary policy, which allowed them to progressively lower the basic interest rate with anchored expectations; and the other factor is the controlled inflation environment, within the band. The last is certainly a by-product of the first, but it is also related to many other aspects, such as fiscal prudence.

The point is: regardless of the main reason one believes interest rates are lower in Brazil, the winds that took the Central Bank to this new policy are specific from Brazil, and can be assumed to be independent to any series of foreign exchange reserves considered in our estimation relative to the control units.

3.2 Why ArCo?

Although this study is focused on a single methodology, there are many alternative methods proposed by the literature, and it is important to understand the suitability of each one.

As detailed in Carvalho et al. (2018), this method have roots in three other sources: the Panel Factor model (Hsiao et al. (2012)), the Synthetic Control Method (Abadie and Gardeazabal, 2003; Abadie et al., 2010) and Pesaran and Smith (2016).

The best known competitor in literature would be the Synthetic Control Method, hereafter SC, proposed by Abadie et al. (2011). Despite the fact that both the ArCo and SC methods construct a counterfactual as a function of observed variables from a group of peers, the two approaches have some differences.

The main reason why we focus our efforts on this ArCo methodology is the availability of inferential procedures, which allows the construction of counterfactual confidence intervals. Despite availability of block bootstrap confidence intervals, we follow Masini and Medeiros (2020) and calculate the point-to-point interval, so that inference does not lose statistical power over time.

Moreover, Masini and Medeiros (2020) investigate the consequences of estimating counterfactuals when the data are potentially non-stationary, with either deterministic os sochastic trends. Also, the SC method relies on a convex combination of peers to construct the counterfactual, which, as pointed out by Ferman and Pinto (2016), biases the estimator.

Counterfactual approach is used to measure the impact of natural disasters, region specific policies (laws) and also used in new government policy regimes. Furthermore, it is robust to the presence of confounding effects, such as a global shock.

In our case, the central assumption is that a monetary policy change took place in T_0, what fits into the third specification. A reference in the literature for the applicability of this method to test effect of policy changes is Grier and Maynard (2016), a case study of the impact of Hugo Chavez on the Venezuelan economy, and for which the statistical framework is provided by Masini and Medeiros (2020).

4
Data

According to official publications concerning the Foreign Exchange Reserves Investment Policy[1], the Central Bank of Brazil take into account many instances. At first, as a long-term goal, it aims at strengthening market confidence in the country's ability to honor its external commitments and provide support to the execution of monetary and exchange rate policies. As developments of these objectives, a strategic allocation with countercyclical characteristics and which reduces the country's exposure to exchange rate fluctuations. Once considered foreign exchange coverage strategy for gross external debt and countercyclical allocation, investment is made with the aid of portfolio risk-return optimization techniques, observing the investment requirements safety, liquidity and profitability, prioritized in that order.

With that in mind, in order to identify only the effect of a reduction in the interest rate value to the managment of international reserves, it is important to control for the factors that motivate the accumulation of reserves by the central bank (in other words, the greater external vulnerability, the greater the benefit of this insurance). That is why we control for public debt, exports, other liabilities, and broad money, all measured in dollar (and we also control for exchange rate fluctuations and for the economy's size, measured by the GDP in dollar). Lastly, we control for the sovereign risk, measured by CDS. Table 4.1 presents the descreptive statistics for brazilian data.

These external vulnerabillity variables also encompass the ones that compose the ARA indicator, meeting the IMF methodology. Data for exports, other liabilities, short-term external debt and broad money were obtained from the International Financial Statistics (IFS), published by the IMF.

The data panel is from January 2008 to May 2020. In order to construct the synthetic counterfactual, by the ArCo estimates, we consider the following countries in our panel: Chile, Colombia, Indonesia, Israel, Korea, Malaysia, Mexico, Peru, Singapore, Thailand, and Turkey.

Ultimately, in addition to the independence hypothesis mentioned in the previous section, it is also sufficient for statistical purposes that the series used are trend-stationary. In case this hypothesis fail, Masini and Medeiros (2020)

[1]See "Relatório de Gestão de Reservas Internacionais" March 2019

Table 4.1: Descriptive Statistics, Brazil

USD bn, except for i_t and ER_t (defined as BRL/USD)					
Variables	Reserves	Net Res.	Interest Rate	GDP	ER
Mean	331.9	296.5	9.9	2044.4	2.69
Std. Deviation	65.3	57.2	2.8	331.5	0.9
Number of Obs.	149	149	149	149	149
USD bn					
Variables	Broad Money	Public Debt	Exports	Other Liab	CDS
Mean	1.518	1221.9	17.8	710.5	194.7
Std. Deviation	2.5	182.3	3.1	109.3	88.4
Number of Obs.	149	149	149	149	149

also consider a scenario in which there is at least one cointegrating relationship among the treated unit and the untreated peers.

Table 4.2 shows the results for the Philips-Ouliaris cointegration test (Phillips and Ouliaris (1990)), for which cointegration is statistically significant at a 1% level. Considering at least one cointegration relationship is enough, we test cointegration between our treated unit and a linear combination between the control group, weighted by OLS coefficients.

Both the dependent and independent variables are in logarithms (except for the exchange rate and CDS) and the model is estimated by OLS. Table 4.2 also presents the results of the augmented Dickey-Fuller (ADF) test for the null of unit roots against the alternative of a trend-stationary model, as well as the in-sample R-squared to access the suitability of the model (R-squared=0.86). For both the net and gross reserves series, the null of unit-roots are rejected, respectively at a 6% and 4% level. As the significant cointegration result is sufficient for the adequacy of the method, the ADF stationarity test is shown only for completeness.

Table 4.2: Pre-Intervention Model Estimation

	Dependent variable:	
	Net FX Reserves	Gross FX Reserves
	(1)	(2)
GDP	-0.049^{***}	0.0001^{***}
	(0.015)	(0.00002)
Exchange Rate	-0.00001^{***}	-0.00002^{***}
	(0.00000)	(0.00000)
Other Liabilities	0.296^{***}	0.293^{***}
	(0.015)	(0.016)
Broad Money	0.409^{***}	0.376^{***}
	(0.016)	(0.016)
Exports	0.132^{***}	0.121^{***}
	(0.016)	(0.016)
CDS	-0.0003^{***}	-0.0004^{***}
	(0.0001)	(0.0001)
Constant	4.615^{***}	4.627^{***}
	(0.117)	(0.126)
Observations	1,788	1,788
R^2	0.867	0.865
Adjusted R^2	0.866	0.865
Residual Std. Error (df = 1781)	0.277	0.284
F Statistic (df = 6; 1781)	$1{,}933.159^{***}$	$1{,}903.375^{***}$
ADF (statistic)	-3.4413	-3.6244
ADF (p-value)	0.05041	0.0335
Phillips-Ouliaris (Z-statistic)	-29.658	-30.033
Phillips-Ouliaris (p-value)	0.01	0.01
Note:		*p<0.1; **p<0.05; ***p<0.01

5
Results

This section presents the results. As mentioned previously, the panel data begins in January 2008 and ends in May 2020. The intervention whose effects we study took place in October 2016, when the Central Bank of Brazil cut the policy rate from 14.25 to 14 (as expected by the market at the moment), the first cut after four years. Amid weak growth and retreating inflation expectations, this date marks the beggining of an easing cycle of twelve consecutive cuts until May 2018.

From May 2018 to June 2019, COPOM kept the policy rate stable, and in June 2020 a new cycle of cuts began, and remains to date. Therefore, the post-event is understood as an environment with lower interest rates, given that the central bank has built greater credibility and inflation rates have shifted to a lower level with anchored expectations.

In August 2019, the Central Bank of Brazil announced that would start to base its interventions on the amount of foreign exchange reserves net of foreign exchange swaps. This is an interesting concept, once the decision to decrease the amount of reserves concomitantly with the decrease in swaps, for example, does not change the net foreign exchange position, which also includes repurchase lines.

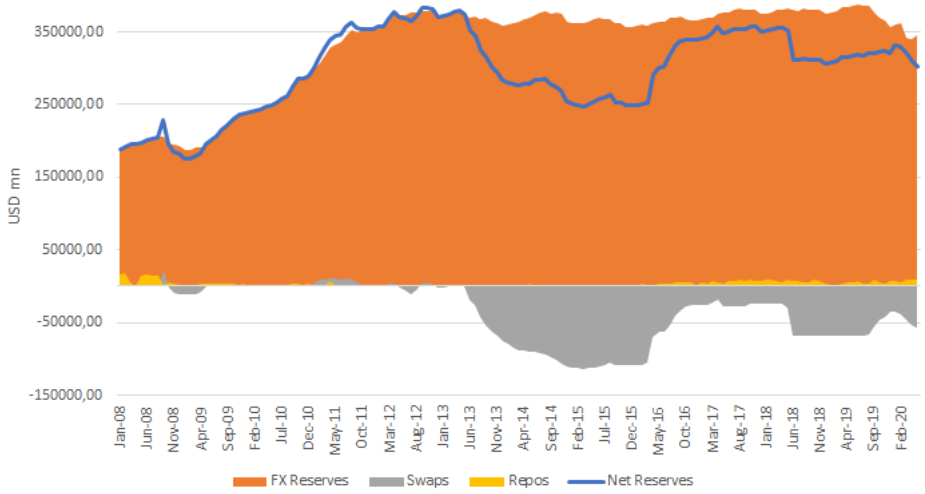
On the particularities of each form of intervention, when the real depreciates against the dollar, the Central Bank gains on foreign exchange reserves and loses on foreign exchange swaps, and vice versa. When the BCB buys currency swaps contracts—through the so-called 'traditional' FX swap auctions, the operation is financially equivalent to a sale of U.S. dollars in the futures market. The swap contracts seller is committed to pay the accrued daily Selic rate to the BCB, and will be financially protected if the exchange rate BRL/USD increases (a currency depreciation) over the life of the swap.

A swap exchange rate provides financial results similar to that obtained with a dollar application of funds taken in real. But companies cannot pay foreign debt with the reais earned on swap settlements. They have to access the spot market. Such a gap started to appear in the foreign exchange coupon market, which is the dollar rate paid for funds in reais. The exchange coupon increased with the relative scarcity of spot dollars. Good evidence that the new

BC's systematic approach was successful is that it managed to significantly reduce the exchange coupon and the high volatility produced by the scarcity of dollars, especially at the end of the month and quarters.

In addition, considering our focus in the effect of lower interest rates in the management os reserves, it is clear that the operation of currency swaps is more expensive the higher the spread between the local interest rate, related to Selic, and the foreign rates (LIBOR, for example). Figure 5.1 plots the amount relating to currency swaps that the Central Bank used in the past years.

Figure 5.1: Composition of Net FX Reserves



Notes: Figure plots the volume and composition, in million USD, of net international reserves since 2008 until 2020.

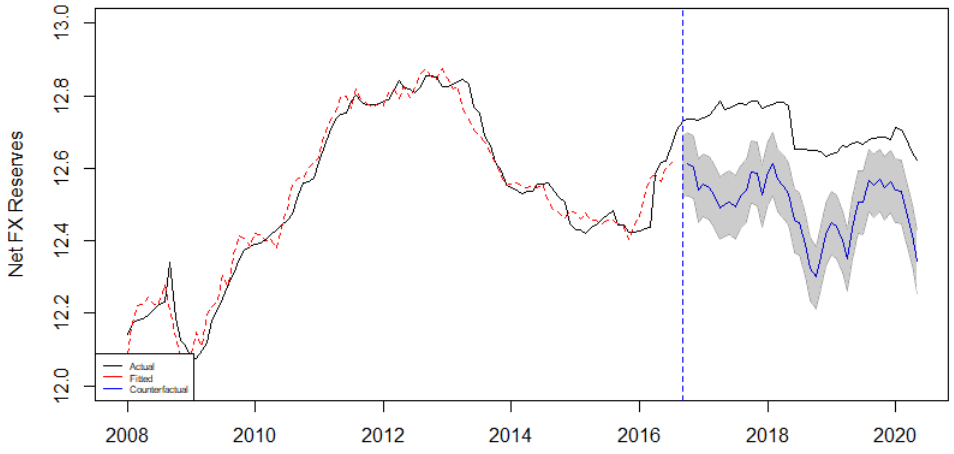
These considerations summarize the reason why the specification considered in our main results take the net foreign exchange reserves as the main variable, on which we estimate the effect. However, we also consider an alternative specification with the gross foreign exchange reserves.

5.1 Main result

Figure 5.2 contains the counterfactual estimates for the effect of lower interest rates on the Net Foreign Exchange Reserves management policy. The shaded area indicates the 95% confidence interval for the average effect on the counterfactual results. This is the estimate considering as controls Exports, Broad Money, Public Debt, Other Liabilities, motivated by the reserve accumulation theory considering the precautionary reason. We also control for the economy size (GDP) and the exchange rate.

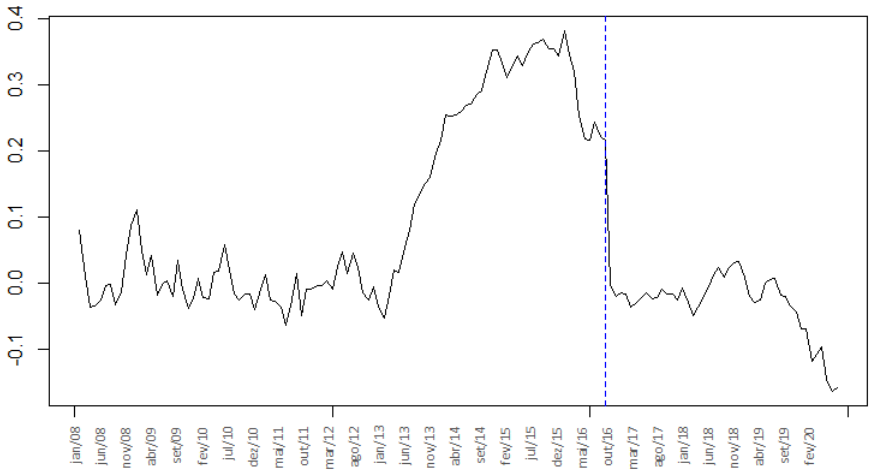
The results indicate that, in fact, the beginning of the interest rate decrease in October 2016 had an important effect on the efficient management

Figure 5.2: ArCo results - Net FX Reserves



Notes: Figure plots the actual net FX reserves (log) and implied by the synthetic estimates, besides fitted values before the intervention.

Figure 5.3: Gap Between Actual and Synthetic - Net FX Reserves



Notes: Figure plots the gap between actual net foreign exchange reserves and implied by the synthetic estimates.

of the net international reserves. If the interest rates were higher after the last quarter of 2016, or better, if the change in the monetary policy course hadn't occured, the counterfactual shows that the efficient level of reserves would have been lower (statistically significant for around two years).

However, as the cost of keeping this asset decreased considerable, the optimal level for the Central Bank, when weighing the costs and benefits of

keeping this insurance, stayed stable. Figure 5.3 shows the result in a different way: the gap between the actual net FX reserves observed in the data, and the counterfactual estimate provided by ArCo method. In this way, a significant change in level is also visible after October 2016.

5.2 Alternative specification

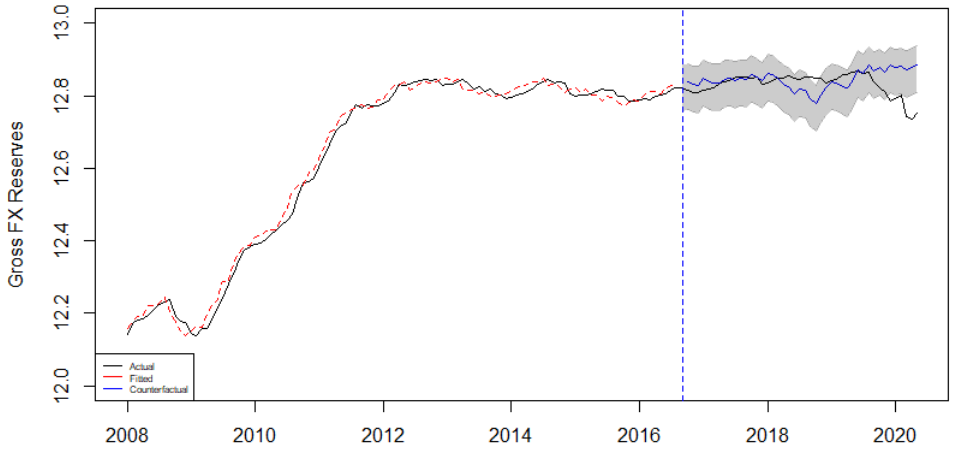
Figure 5.2 contains the counterfactual estimates for the effect of lower interest rates on the Gross FX Reserves management policy. The shaded area indicates the 95% confidence interval for the average effect on the counterfactual results. This is the estimate with the same controls as in the main specification.

Considering Gross Reserves, the results are quite different. For most months, with the exception of the last, the counterfactual is very close to that observed, and there is no statistically significant effect. However, only at the end of the sample, the result indicates that the counterfactual is higher than the actual gross FX reserves.We do not attribute this difference obtained at the end as related to the effect of lower interest rates.

The statistical significance appears after September 2019. In August 2019, the Central Bank of Brazil announced it would sell FX in the spot market, something that was not done since 2009. Thereafter, many operations on the spot market were done. At that point, selling FX reserves was not a prescription related to the optimal level management of reserves (that is, the one related to the precautionary motive against external vulnerability). The Central Bank intervened in the spot market to control dysfunctional movements in the exchange rate. The counterfactual remained more or less constant in relation to the beginning of 2019, while the actual level actually fell, turning the gap negative and significant.

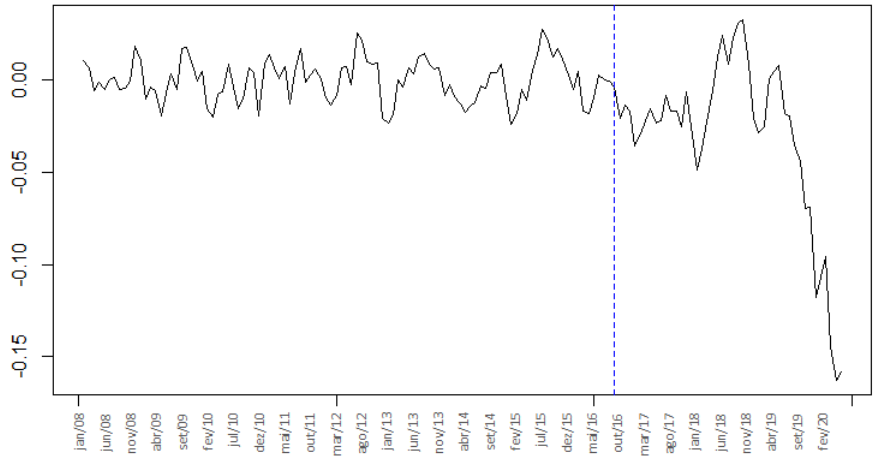
In any case, a relevant question would be why in the main specification this result did not appear. A way to address this issue is precisely looking to the fact that the Central Bank stayed ten years without using the intervention in the spot market as an instrument, unlike the use of currency swaps. However, the central bank also intervened via repos during this period, which affects the net position of foreign exchange reserves, but not the gross position. Figure 5.1 shows that the currency swaps was an important tool since 2013. In October 2014, these operations amounted for a hundred billion dollars, almost 27% of the international reserves level. Therefore, as the concept of net reserves has greater variability in the period of analysis, it reacted to the interest rate variation and the gross series did not, and the opposite for the spot

Figure 5.4: ArCo results - Gross FX Reserves



Notes: Figure plots the actual gross FX reserves (log) and implied by the synthetic estimates, besides fitted values before the intervention.

Figure 5.5: Gap Between Actual and Synthetic - Gross FX Reserves



Notes: Figure plots the gap between actual gross foreign exchange reserves and implied by the synthetic estimates.

interventions. However, the loss of significance at the end of the estimate for the net value may be related to these spot interventions.

Lastly, we conduct some robustness checks shown in Appendix A, in which we estimate the FX reserves counterfactual after the intervention for all countries used as controls in the empirical analysis. As expected, we do not find evidence that the change in the policy-related interest rate in Brazil was

significant to the management of international reserves in the control group.

6
Conclusions

The debate whether the current amount of international reserves is excessive or not has taken the attention of many governments and Central Banks of emerging economies. The current environment of high levels of reserves, however, is the outcome of a process that dates back to the 1997 Asian Crisis, passing through the 2008 financial collapse, and seems to play a key role in the way low-income and emerging markets react to hostile international financing conditions.

There is an intrinsic trade-off in a Central Bank's optimal reserves policy, trading-off safety and fiscal costs. Cost-benefits models directly take into account that issue, and they are naturally very sensitive to monetary policy-related interest rates. Indeed, this trade-off becomes especially interesting for countries with high interest rates and a vulnerable external sector.

Following that concern, the recent fall in Brazilian interest rates, since October 2016 until the end of 2019, may be an important factor to explain the upkeep of the high stock of international reserves in Brazil until the end of 2019. In order to test this hypothesis, we propose a counterfactual analysis of the level of international reserves were the interest rates stable at 14.25% in Brazil, the highest level since 2007.

Considering that there is no clear control group to compare with Brazil before the event, we use the Artificial Counterfactual method to assess the role of the new environment of low interest rates on the management of international reserves.

The results indicate that, in fact, the change in course in Brazilian monetary policy, with the start of successive falls in the basic rate in October 2016, had an important and significant effect on the management of the net international reserves. If the interest rates were higher after the last quarter of 2016, the counterfactual shows that the efficient level of reserves would have been lower.

However, as the cost of keeping this asset decreased considerably, the optimal level for the Central Bank stayed stable. Considering Gross Reserves, the results are quite different. For most months, with the exception of the last, the counterfactual is very close to the actual values, and there is no

statistically significant effect. We do not attribute this difference obtained at the end as related to the effect of lower interest rates, but to the resumption of interventions in the spot market by the central bank (which, as mentioned above, is an instrument that has not been used by the Central Bank for ten years, until recently).

Lastly, from the point of view of reserve management and exchange rate policies, what our results can add is that, in fact, policy makers need to take into account many factors before deciding to sell this asset: not only the optimal level of reserves depends on the determinants related to a country's level of vulnerability, but also on the cost of accumulating them. And, of course, the insurance value of reserves only arise in times of crises, so that the assessment of its benefits is not trivial and should not be limited to the use of rules of thumb.

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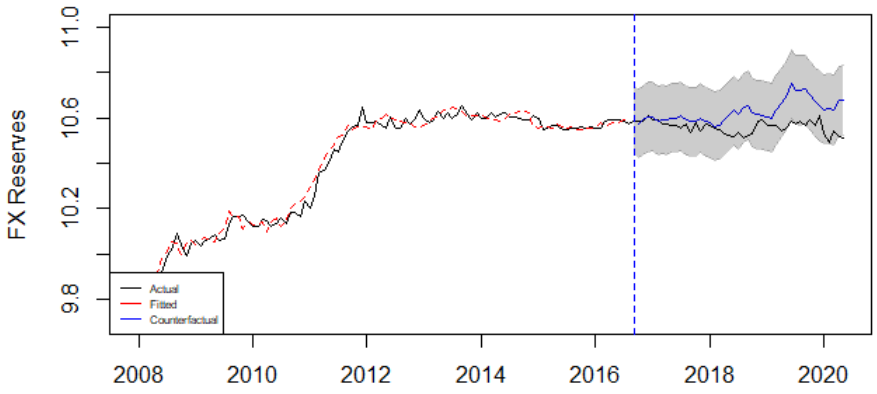
A
Appendix

As mentioned in section 5, we conduct some robustness checks in which we estimate the same empirical exercise proposed in this thesis for all countries used as controls in the artificial counterfactual. In order to be consistent with the prior presentation of the empirical results, we follow Masini and Medeiros (2020) and calculate the point-to-point interval, so that inference does not lose statistical power over time.

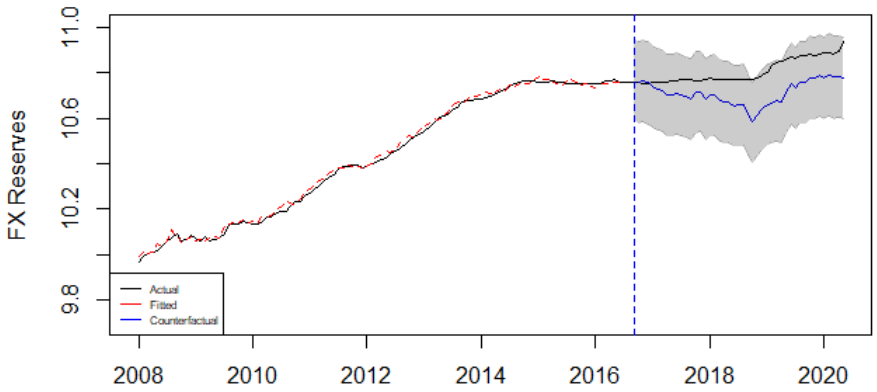
Figures A.1 to A.11 show, as expected, that there is no pattern in the way the counterfactual of other countries reacts in relation to the actual series. The intervention that took place in Brazil has no significant effect in international reserves management in other countries. The case of very brief periods of statistical significance for Israel, Malaysia, and Peru seems to be spurious, so it does not damage the confidence in our result.

Figure A.1: ArCo results - Chile



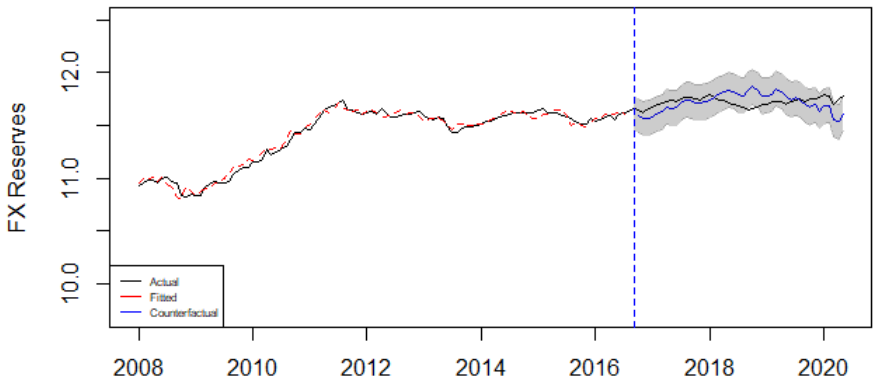
Notes: Figure plots the actual gross FX reserves (log) and implied by the synthetic estimates, besides fitted values before the intervention.

Figure A.2: ArCo results - Colombia



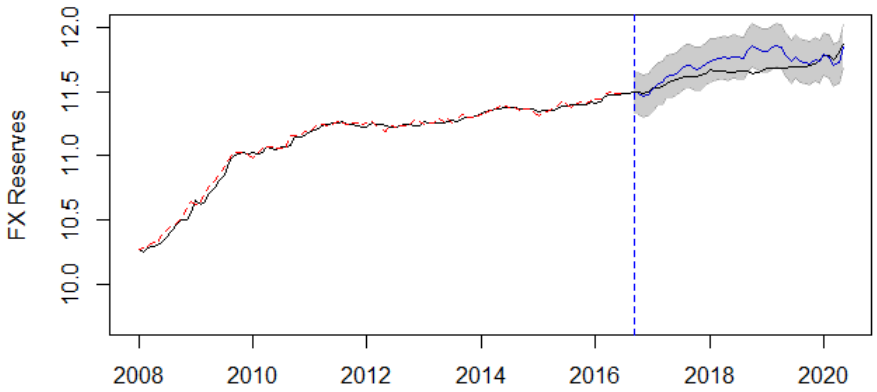
Notes: Figure plots the actual gross FX reserves (log) and implied by the synthetic estimates, besides fitted values before the intervention.

Figure A.3: ArCo results - Indonesia



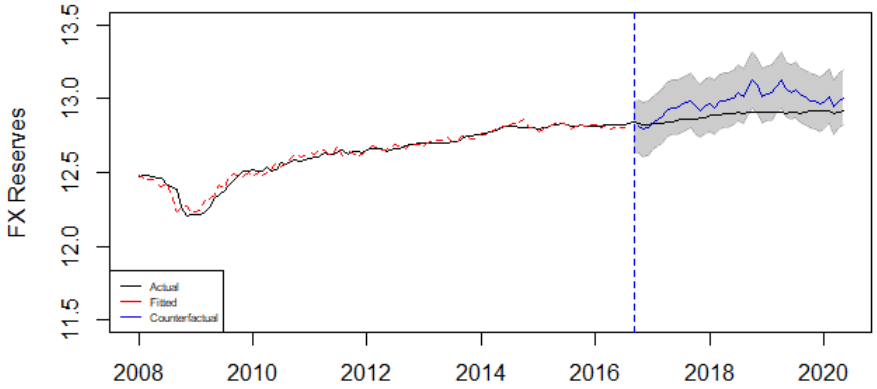
Notes: Figure plots the actual gross FX reserves (log) and implied by the synthetic estimates, besides fitted values before the intervention.

Figure A.4: ArCo results - Israel



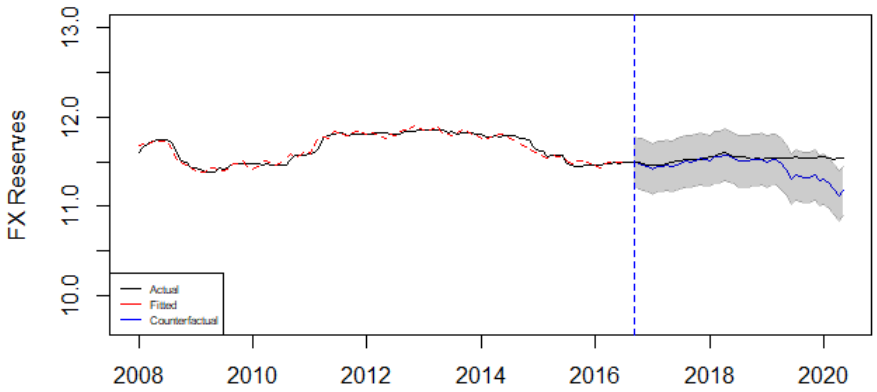
Notes: Figure plots the actual gross FX reserves (log) and implied by the synthetic estimates, besides fitted values before the intervention.

Figure A.5: ArCo results - South Korea



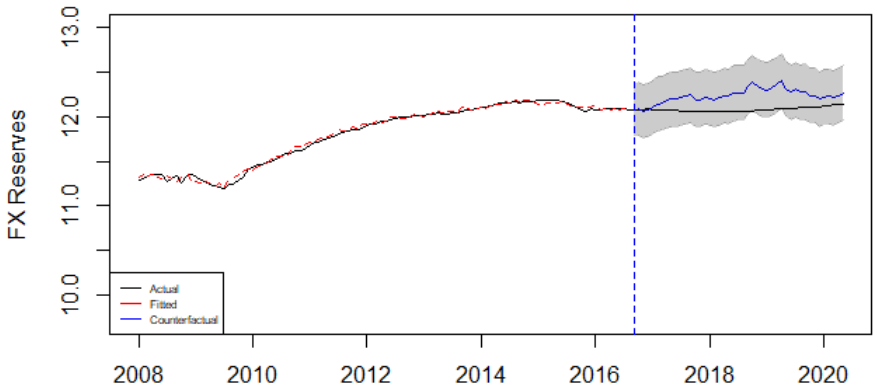
Notes: Figure plots the actual gross FX reserves (log) and implied by the synthetic estimates, besides fitted values before the intervention.

Figure A.6: ArCo results - Malaysia



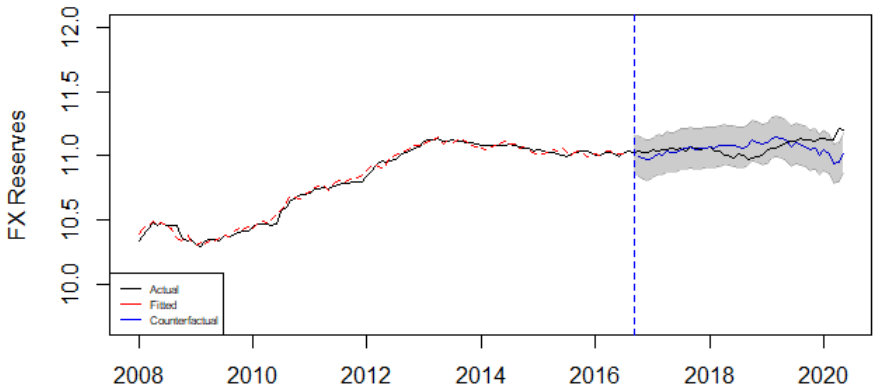
Notes: Figure plots the actual gross FX reserves (log) and implied by the synthetic estimates, besides fitted values before the intervention.

Figure A.7: ArCo results - Mexico



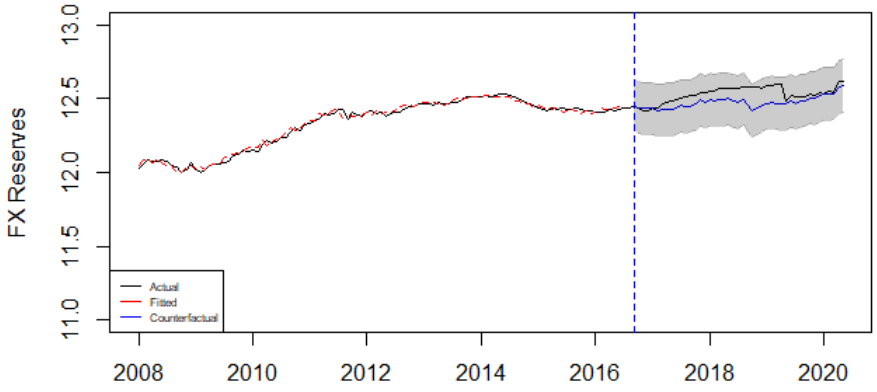
Notes: Figure plots the actual gross FX reserves (log) and implied by the synthetic estimates, besides fitted values before the intervention.

Figure A.8: ArCo results - Peru



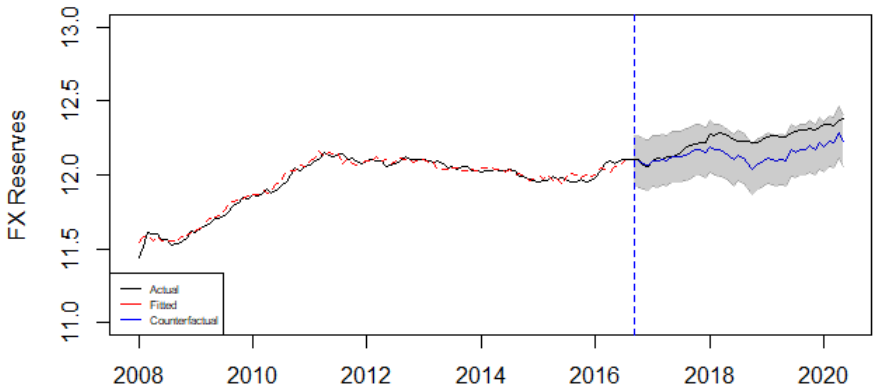
Notes: Figure plots the actual gross FX reserves (log) and implied by the synthetic estimates, besides fitted values before the intervention.

Figure A.9: ArCo results - Singapore



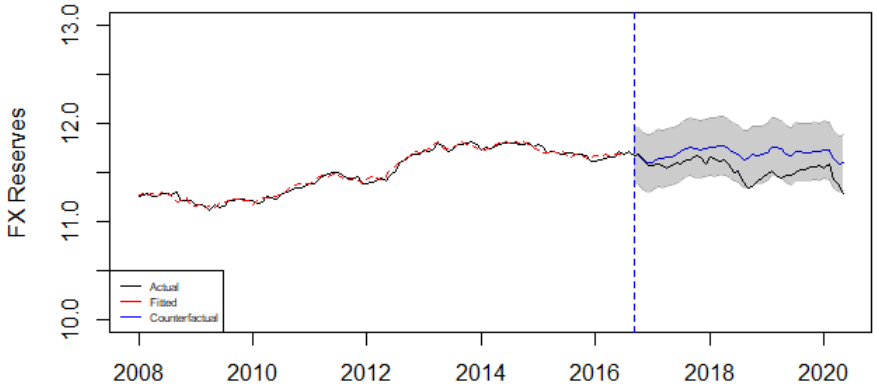
Notes: Figure plots the actual gross FX reserves (log) and implied by the synthetic estimates, besides fitted values before the intervention.

Figure A.10: ArCo results - Thailand



Notes: Figure plots the actual gross FX reserves (log) and implied by the synthetic estimates, besides fitted values before the intervention.

Figure A.11: ArCo results - Turkey



Notes: Figure plots the actual gross FX reserves (log) and implied by the synthetic estimates, besides fitted values before the intervention.