Effect of Reserve Accumulation on Employment

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September 11, 2024

Abstract

This paper studies the mechanism behind the effect of reserve accumulation on employment. Using panel data, I document positive correlation between reserve-gdp ratio and employment. I build a two sector (tradable/ non-tradable) dynamic stochastic model, that features reserve accumulation by the government, and foreign intermediaries that are subject to capital control and financial friction. The mechanism operates as follows. The reserve accumulation by the government is sterilized by issuing debt. The increase in government debt crowds out household borrowing, since net borrowing in the domestic financial market has to be zero. The reduced household borrowing increases employment due to income effect. However, reduction in consumption and leisure reduces welfare. I calibrate the model using quarterly data on Mexico. To establish the validity of the mechanism I show that the correlation between reserve and employment, and reserve and household saving in the calibrated model and data are of same sign.

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1 Introduction

Since 2000, governments in emerging economies have accumulated vast amount of reserves. There has been substantial accumulation of reserve after Asian Financial Crisis, and then after Global Financial Crisis around 2007-8. Adequate reserve balance is necessary to sustain domestic consumption during periods of low output. In addition to self insurance, reserve accumulation is also motivated by sharp movement of exchange rate.

But reserve accumulation in pursuit of these objectives may have unintended side effects. There are anecdotes that excessive reserve accumulation is associated with distortions and costs that outweigh the benefits[1]. Among the consequences of high reserve accumulation, the speech also mentions cross-sector distortions. The undervalued exchange rate lowers the relative price of tradable goods. Thus the production is skewed towards capital intensive manufactured goods, as a result the employment in the economy declines.

The purpose of this paper is to study the effect of reserve accumulation on employment. Table 1 shows that there is a positive correlation between employment and reserve gdp ratio. More specifically, 1 unit change in reserve-gdp ratio increases employment by 1.51%. The main contribution of this paper is to provide a mechanism for the effect of reserve accumulation on employment.

Empirical work such as Aizenman and Lee (2007), Rodrik (2008), and Choi and Taylor (2022) have provided evidence of effect of reserve accumulation on real exchange rate, growth, trade, and GDP. Theoretical literature provide model for specific purpose such analysing effect of learning by doing, e.g. Aizenman and Lee (2010) or provide theoretical foundation for reserve accumulation e.g. Bianchi et al. (2018) and Fanelli and Straub (2021). Quantitative literature focuses on macroprudential use of reserves, e.g. Bianchi and Lorenzoni (2022) and Bianchi and Sosa-Padilla (2023). However, to the best of my knowledge there is no work that analyses quantitative effect of reserve policy on macroeconomic variables.

I model a small open economy that features reserve accumulation by the government, and

[1]Speech by Lorenzo Bini Smaghi - https://www.ecb.europa.eu/press/key/date/2010/html/sp100210.en.html

foreign intermediaries that are subject to capital control and financial friction. Capital control takes the form of transaction limit i.e. intermediaries cannot lend/ borrow beyond this limit. In addition, intermediaries are required to pay a fee for transacting which gives rise to financial friction in the model. Incorporating capital control in the model is essential to make reserve accumulation effective as discussed in Gabaix and Maggiori (2015), and Fanelli and Straub (2021). The mechanism works as follows. The reserve accumulation by the government is sterilized by issuing debt. The increase in government debt crowds out household borrowing, since net borrowing in the domestic financial market has to be zero. The reduced household borrowing increases employment due to income effect. However, reduction in consumption and leisure reduces welfare.

To establish the validity of mechanism, I first calibrate the model using Mexican data on forex reserve, domestic interest rate, non-tradable employment, tradable employment, and international portfolio investment. I, then, compare the statistical properties of the data and the model. From the simualation, I find that correlation between reserve and employment, and correlation between reserve and household savings are both positive as discussed in the mechanism.

Table 1: Employment is positively correlated with forex-gdp ratio.

	Dependent variable:
	Employment
FbyG	1.509^{**}
	(0.612)
Observations	2,404
R^2	0.003
Adjusted R^2	-0.060
F Statistic	6.077^{**} (df = 1; 2260)
Note:	*p<0.1; **p<0.05; ***p<0.01

1.1 Literature Review

This paper contributes to two strands of literature. This paper is related to quantitative forex reserve literature. And it also contributes to empirical literature analyzing effect of reserve

accumulation on macroeconomic variables.

Bianchi et al. (2018) is an important quantitative paper in forex reserve level. They build a quantitative model of reserve accumulation with long term debt susceptible to sovereign default. This model can account for large accumulation of debt and reserve by emerging economies. Samano (2022) is another work in this direction that proposes a theory of reserve accumulation exploring the role of independent central bank. Bianchi and Sosa-Padilla (2023) argue that issuing debt to purchase reserves allows the government to stabilize demand when spreads rise and rolling over debt becomes expensive. Benigno et al. (2022) argue that foreign reserve accumulation depreciates real exchange rate and induces reallocation of production towards tradable sector. Arce et al. (2022) rationalizes simultaneous increase in foreign reserve and private capital inflow. Calvo et al. (2012) studies optimal reserve stock in presence of sudden stop and output cost. They find that optimal reserve holding before global financial crisis was close to the level suggested by the model. Kearns and Rigobon (2005) finds that central bank intervention lean against the wind and almost all of the impact of an intervention occurs during the day it is conducted.

Backus and Kehoe (1989) show that in absence of financial friction sterilized foreign reserve intervention is irrelevant. Gabaix and Maggiori (2015) built a two period model with financial intermediaries that have finite risk bearing capacity and imperfect fiancial market. In this environment foreign reserve intervention can have effect on real variables. Fanelli and Straub (2021) studies optimal foreign reserve intervention to address pecuniary externality arising due to capital flows. The model features partial segmentation of financial market similar to Alvarez et al. (2009) and capital control.

The paper is also related to literature on role of foreign reserve intervention in emerging economies. For example Blanchard et al. (2015), Sarno and Taylor (2001), Neely (2005), Menkhoff (2010), Menkhoff (2012), Benes et al. (2012), Ghosh et al. (2015), Gagnon (2013), and Bayoumi et al. (2014)

Benigno et al. (2022) rationalizes reserve accumulation and current account surplus in emerging economies. The model features a tradable sector with knowledge externality and a non tradable

sector lacking it.

Rest of the paper is organized as follows. In section 2, I discuss the model. The mechanism is then proposed in section 3. I then calibrate and validate the mechanism in section 4. Finally, section 5 concludes the paper.

2 Model

Time is discrete and infinite. There is small open economy populated by continuum of households, government, firm, and foreign intermediaries. The households derive utility from the consumption of non tradable goods ($c_{Nt}(s^t)$), tradable goods ($c_{Tt}(s^t)$), and leisure ($1-\ell_t(s^t)$). I assume that households have access to international goods market where they can trade tradable goods, but they do not have access to international financial market. The government accumulates foreign reserves ($b^*_{G,t+1}(s^t)$), sterilizes it by issuing debt in domestic financial market ($b_{G,t+1}(s^t)$), and chooses transfer ($t_t(s^t)$) to the household. There are continuum of intermediaries. The foreign intermediaries have access to domestic financial market where they can invest ($b_{I,t+1}(s^t)$) and the profits from investment is taken out of the economy. To ensure that reserve accumulation has real effects, these intermediaries are subject to capital control and financial frictions. Capital control sets the upper limit of transaction in each period to ($X > 0$), while financial friction implies that intermediary indexed by j pays j per dollar invested similar to Alvarez et al. (2009). The non tradable and tradable firms use labor as the only factor and produce goods using linear technology. They maximize profits and transfer wages to the households.

The state of the economy denoted by $s_t = (R^*_t, b_{Ht}, b^*_{Gt}, R^*_{t+1}, \varepsilon_t)$ is realized at the beginning of period t, where R^*_t is the world interest rate or interest rate paid on accumulated reserves in period t; b_{Ht} is the household saving carried forward from period $t-1$; b^*_{Gt} is the reserve level carried forward from period $t-1$; R^*_{t+1} is the interest rate to be paid on foreign reserves in period $t+1$; and ε_t is the AR(1) innovation is reserve level in period t. Notice that R^*_t, b_{Ht}, b^*_{Gt} are determined in $t-1$ while R^*_{t+1}, ε_t are realized in period t. Let s^t denote the history of states upto period t.

2.1 Household

There is a continuum of mass 1 households with preference over consumption and leisure given by

$$U = \sum_{t=0}^{\infty} \sum_{s^t} \beta^t \left(\log(c_t(s^t)) + \psi \log(1 - \ell_t(s^t)) \right) \pi(s^t),$$

where $c_t = c_{Nt}^{1-\alpha} c_{Tt}^{\alpha}$ is the aggregate consumption consisting of non tradable good (N), and tradable good (T). $\ell_t(s^t)$ is the labor supplied at time t. Each household supplies labor to only one firm.

$$s.t. \quad p_{Nt}(s^t)c_{Nt}(s^t) + c_{Tt}(s^t) + b_{H,t+1}(s^t) = w_t(s^t)\ell_t(s^t) + R_t b_{Ht} + t_t(s^t), \tag{1}$$

where $b_{H,t+1}$ is the saving by household in period t, and R_{t+1} is the interest rate in domestic financial market. I assume that households can freely trade in international goods market, but they do not have access to international financial market.

2.2 Government

Many emerging market economies have adopted floating exchange rate regimes. But official reserve intervention has remained an important policy tool. Countries accumulate reserve in response to capital inflows. However, the accumulation process varies across countries and time. Several countries in Latin America follow a set of rules, whereas in countries like India, the process is discretionary. Intervention can take place directly in spot market or though derivatives. In addition there are various motives for accumulation such as price stability, building reserve, external competitiveness, etc. In this paper, I assume that if the policy tool is used to attain multiple objectives and the policy is implemented in multiple ways, then the policy response can be taken as exogenous variable[2]. Furthermore, the assumption of exogenous reserve accumulation process simplifies numerical computation.

Based on the regression in Table 2, I will assume that the reserve accumulation process follows an AR(1). This assumption enables the use of Value Function Iteration for numerical

[2]In Appendix A, I provide a detailed description of reserve intervention in Mexico.

Table 2: Regression using monthly data.

	Dependent variable:
	$b^*_{G,t+1}$
b^*_{Gt}	0.998^{***}
	(0.003)
Constant	901.321^{***}
	(340.161)
Observations	239
R^2	0.998
Adjusted R^2	0.998
Residual Std. Error	2,295.453 (df = 237)
F Statistic	$142{,}781.300^{***}$ (df = 1; 237)
Note:	*p<0.1; **p<0.05; ***p<0.01

computation. I also assume that reserve accumulation is sterilized by issuing debt in domestic financial market. Sterilized reserve accumulation is interesting from theoretical point of view due to Backus and Kehoe (1989) result and this is most frequently used process for reserve accumulation according to BIS survey.

The government chooses debt, and transfer to the household, subject to the following constraints

$$b^*_{G,t+1}(s^t) - \mu = \rho(b^*_{Gt} - \mu) + \varepsilon_t,$$

$$\varepsilon_t \sim \mathcal{N}(0, \sigma^2_\epsilon),$$

$$b_{G,t+1}(s^t) + b^*_{G,t+1}(s^t) = 0, \tag{2}$$

$$b_{G,t+1}(s^t) + b^*_{G,t+1}(s^t) + t_t(s^t) = R_t b_{Gt} + R^*_t b^*_{Gt}. \tag{3}$$

where $b^*_{G,t+1}$ is the reserve level in period t, $b_{G,t+1}$ is the level of government debt, t_t is the transfer to households, ε_t is the innovation in reserve accumulation process.

The assumption $b_{G,t+1}(s^t) + b^*_{G,t+1}(s^t) = 0$ means that the intervention is sterilized.

2.3 Foreign intermediaries

The model element that makes reserve accumulation effective in the model are foreign intermediaries subject to capital control and financial friction. Backus and Kehoe (1989) shows that, in an environment with free movement of capital, sterilized reserve accumulation does not effect real variables. In contrast, the assumption of imperfect capital movement assumed in this paper will make domestic bond and international bond (reserves) imperfect substitute. Thus reserve accumulation by government effects domestic return, R_t relative to return on international assets, R_t^*. So, reserve accumulation by government, in an environment with imperfect capital movement, is effective in changing real variables like consumption, and labor.

There is a continuum of intermediaries labeled $j \in [0, \infty)$. These intermediaries can trade in international and domestic financial market. They choose their investment position $x_{j,t+1}(s^t) \in [-X, X]$, where $X > 0$ is the investment limit exogenously imposed by the economy. Intermediary j pays j per dollar intermediated.

The optimization problem of intermediary j is

$$\max_{x_{j,t+1}(s^t) \in [-X,X]} x_{j,t+1}(s^t)(R_{t+1}(s^t) - R_{t+1}^*) - j|x_{j,t+1}(s^t)|,$$

Since that optimization problem is linear in choice variable $x_{j,t+1}(s^t)$, there will be a corner solution if the intermediary chooses to transact in the domestic market i.e. $x_{j,t+1}(s^t) \in \{-X, X\}$. Specifically, $x_{j,t+1}(s^t) = -X$ if $R_{t+1} < R_{t+1}^*$, and $x_{j,t+1}(s^t) = X$ if $R_{t+1} > R_{t+1}^*$. Intermediary j's gross profit is $X|R_{t+1} - R_{t+1}^*|$, and the cost of transaction is jX. Thus, investing is optimal for intermediaries $j \in [0, \bar{j}]$, where $\bar{j} = |R_{t+1} - R_{t+1}^*|$. Intermediary $j > \bar{j}$ will not participate in domestic financial market, so $x_{j,t+1}(s^t) = 0$ for these intermediaries.

On aggregating we get,

$$b_{I,t+1}(s^t) = \int_0^\infty x_{j,t+1}(s^t) dj = \frac{1}{\Gamma}(R_{t+1}(s^t) - R_{t+1}^*), \tag{4}$$

where $\Gamma = X^{-1}$ is a measure of capital control. A large value of Γ indicates tight capital control i.e. the magnitude of transaction by intermediaries will be small. If $\Gamma \to \infty$, then there

will be no foreign intermediation ($b_{I,t+1}(s^t) = 0$) and the economy will be in financial autarky. On the other hand, a small value of Γ will imply large magnitude of transaction by foreign intermediaries. The limiting case where $\Gamma \to 0$ will imply perfect capital mobility, and bond demand in domestic financial market will imply $R_{t+1} = R^*_{t+1}$.

2.4 Firm

There are two sectors in the economy - non tradable and tradable. Both sectors use labor as the only input combined with a technology which is linear in labor. The optimization problem of a firm in non tradable sector is

$$\max_{y_{Nt}(s^t),\ell_{Nt}(s^t)} p_{Nt}(s^t)y_{Nt}(s^t) - w_t(s^t)\ell_{Nt}(s^t),$$

$$\text{subject to} \quad y_{Nt}(s^t) = \ell_{Nt}(s^t).$$

The tradable good is also produced with the linear technology. The objective of firm is to maximize profits.

$$\max_{y_{Tt}(s^t),\ell_{Tt}(s^t)} y_{Tt}(s^t) - w_t(s^t)\ell_{Tt}(s^t),$$

$$\text{subject to} \quad y_{Tt}(s^t) = \ell_{Tt}(s^t).$$

2.5 Balance of payments

We can derive balance of payments equation as follows.

$$nfa_{t+1}(s^t) = b^*_{G,t+1}(s^t) - b_{I,t+1}(s^t).$$

From the bond market clearing condition $b_{I,t+1}(s^t) = -b_{G,t+1}(s^t) - b_{H,t+1}(s^t)$. So,

$$nfa_{t+1}(s^t) = b^*_{G,t+1}(s^t) + b_{G,t+1}(s^t) + b_{H,t+1}(s^t).$$

Using the fact that reserve accumulation is completely sterilized, we get

$$nfa_{t+1}(s^t) = b_{H,t+1}(s^t) = w_t(s^t)\ell_t(s^t) + R_t b_{Ht} + t_t(s^t) - p_{Nt}(s^t)c_{Nt}(s^t) - c_{Tt}(s^t),$$

$$nfa_{t+1}(s^t) = b_{H,t+1}(s^t) = w_t(s^t)\ell_{Nt}(s^t) + w_t(s^t)\ell_{Tt}(s^t) + R_t b_{Ht} + t_t(s^t) - p_{Nt}(s^t)c_{Nt}(s^t) - c_{Tt}(s^t).$$

Market clearing condition in non tradable sector implies $c_{Nt}(s^t) = yNt(s^t) = \ell_{Nt}(s^t)$ and $p_{Nt}(s^t) = w_t(s^t)$. Hence,

$$nfa_{t+1}(s^t) = b_{H,t+1}(s^t) = w_t(s^t)\ell_{Tt}(s^t) + R_t b_{Ht} + t_t(s^t) - c_{Tt}(s^t).$$

Linear production technology in tradable sector gives $y_{Tt}(s^t) = \ell_{Tt}(s^t)$, therefore

$$nfa_{t+1}(s^t) = b_{H,t+1}(s^t) = y_{Tt}(s^t) - c_{Tt}(s^t) + R_t b_{Ht} + t_t(s^t).$$

Using government budget constraint, $t_t(s^t) = R_t^* b_{Gt}^* + R_t b_{Gt}$, we have

$$nfa_{t+1}(s^t) = b_{H,t+1}(s^t) = y_{Tt}(s^t) - c_{Tt}(s^t) + R_t b_{Ht} + R_t^* b_{Gt}^* + R_t b_{Gt},$$

$$\Rightarrow nfa_{t+1}(s^t) = y_{Tt}(s^t) - c_{Tt}(s^t) + R_t^* nfa_t + \frac{1}{\Gamma}(R_t - R_t^*)^2.$$

2.6 Equilibrium

Now I define the equilibrium for this economy.

Let $s_t = (R_t^*, b_{Ht}, b_{Gt}^*, R_{t+1}^*, \varepsilon_t)$ denote the state of the economy in period t, and s^t denote the history of states upto period t. A competitive equilibrium for the given economy will be

- prices $\mathbb{P} = \{p_{Nt}(s^t), w_t(s^t), R_{t+1}(s^t)\}_{\forall s^t\ t\in\{0,1,\cdots,\infty\}}$,
- households' choice $\mathbb{Z}_H = \{c_{Nt}(s^t), c_{Tt}(s^t), b_{H,t+1}(s^t), \ell_t(s^t)\}_{\forall s^t\ t\in\{0,1,\cdots,\infty\}}$,
- foreign intermediaries' choice $\mathbb{Z}_I = \{\{x_{j,t+1}(s^t)\}_{j\in[0,\infty)}\}_{\forall s^t\ t\in\{0,1,\cdots,\infty\}}$,
- non tradable goods producer's choice $\mathbb{Z}_N = \{y_{Nt}(s^t), \ell_{Nt}(s^t)\}_{\forall s^t\ t\in\{0,1,\cdots,\infty\}}$,

- tradable goods producer's choice $\mathbb{Z}_T = \{y_{Tt}(s^t), \ell_{Tt}(s^t)\}_{\forall s^t \; t\in\{0,1,\cdots,\infty\}}$,

such that

- Given $\mathbb{P}$, $\mathbb{Z}_H$ maximizes households' utility.
- Given $\mathbb{P}$, $\mathbb{Z}_I$ maximizes foreign intermediaries' profit.
- Given $\mathbb{P}$, $\mathbb{Z}_N$ maximizes non tradable goods producer's profit.
- Given $\mathbb{P}$, $\mathbb{Z}_T$ maximizes tradable goods producer's profit.
- $\mathbb{P}$ clears markets:
    1. Non tradable goods: $c_{Nt}(s^t) = y_{Nt}(s^t)$.
    2. Balance of payments: $nfa_{t+1}(s^t) = y_{Tt}(s^t) - c_{Tt}(s^t) + R_t^* nfa_t - \frac{1}{\Gamma}(R_t - R_t^*)^2$.
    3. Domestic bond market: $b_{H,t+1}(s^t) + b_{G,t+1}(s^t) + b^*_{G,t+1}(s^t) = 0$.
    4. Labor market: $\ell_t(s^t) = \ell_{Nt}(s^t) + \ell_{Tt}(s^t)$.

2.7 Recursive Form

I now describe the recursive form of the problem. The planner takes world interest rate today, the realized value world interest rate in the next period, household saving and reserve level today, and exogenous shock to the reserve level next period as given state of the world. Given the information, it then chooses non tradable consumption, tradable consumption, household saving in the next period, aggregate employment, employment in tradable and non tradable sectors, reserve level in the next period, tranfer to the household, non tradable price, labor compensation (wage), and next period domestic interest rate.

$$V(R^*, b_H, b_G^*, R'^*, \varepsilon) = \max_{\substack{c_N, c_T, b'_H, \ell, \\ \ell_N, \ell_T, b'_G, t \\ p_N, w, R'}} \log c + \psi \log(1-\ell) + \beta \mathbb{E}_{R''^*, \varepsilon'} V(R'^*, b'_H, b'^*_G, R''^*, \varepsilon'),$$

where

$$c = c_N^{1-\alpha} c_T^{\alpha}, \tag{5a}$$

$$p_N c_N + c_T + b'_H = w\ell + Rb_H + t, \tag{5b}$$

$$b'_G + b'^*_G + t = Rb_G + R^* b^*_G, \tag{5c}$$

$$b'_G + b'^*_G = 0, \tag{5d}$$

$$b'^*_G - \mu = \rho(b^*_G - \mu) + \varepsilon, \tag{5e}$$

$$b'_H = -b'_G - \frac{1}{\Gamma}(R' - R'^*), \tag{5f}$$

$$p_N = w = 1, \tag{5g}$$

$$c_N = \ell_N, \tag{5h}$$

$$\ell = \ell_N + \ell_T. \tag{5i}$$

The planner has to consider the constraints on households and firms while choosing optimal allocation. The recursive problem is solved under constraints (5a)-(5i). Equantion (5a) indicates how the goods produced in non tradable and tradable sector are combined to produced the composite consumption good. Equation (5b) is households' budget constraint. Equation (5c) is the government's budget constraint. The fact the reserve accumulation by the government is sterilized by issuing debt in domestic financial market is captured by the equation (5d). In this paper, I assume that the reserve accumulation by the government follows an AR(1) process as shown in equation (5e). Equation (5f) is the domestic bond market clearing condition, where $\frac{1}{\Gamma}(R' - R'^*)$ is the saving by financial intermediaries in domestic bond market. Equation (5g) is obtained from the first order condition of firms. Market clearing conditions for non tradable and labor market are captured by equations (5h) and (5i) respectively.

In Appendix C, I simplify the recursive problem to

$$V(R^*, R, R'^*, b^*_G, b'^*_G) = \max_{R'} \log c + \beta \mathbb{E}_{R''^*, b''^*_G} V(R'^*, R', R''^*, b'^*_G, b''^*_G), \tag{6}$$

where

$$(1+\psi)c = 1 + Rb_H + t - b'_H,$$

$$b'_G + b'^*_G + t = Rb_G + R^* b^*_G,$$

$$b'_G + b'^*_G = 0,$$

$$b'^*_G - \mu = \rho(b^*_G - \mu) + \varepsilon,$$

$$b'_H = -b'_G - \frac{1}{\Gamma}(R' - R'^*).$$

This problem, combined with transition matrix for $R*$, can be solved on a computer using Value Function Iteration.

3 Mechanism

The proposed mechanism works through the three equations highlighted below. First, the reserve accumulation is sterilized by issuing government debt in the domestic financial market as stated by (7d), the government debt crowds out household borrowing as in Equation (7f). In other words, an increase in government debt forces households to save more which reduces consumption and leisure by income effect, captured by equation (7b).

$$V(R^*, b_H, b^*_G, R'^*, \varepsilon) = \max_{\substack{c_N, c_T, b'_H, \ell, \\ \ell_N, \ell_T, b'_G, t \\ p_N, w, R'}} \log c + \psi \log(1-\ell) + \beta \mathbb{E}_{R''^*, \varepsilon'} V(R'^*, b'_H, b'^*_G, R''^*, \varepsilon'),$$

where

$$c = c_N^{1-\alpha} c_T^{\alpha}, \tag{7a}$$

$$\boxed{p_N c_N + c_T + b'_H = w\ell + Rb_H + t}, \tag{7b}$$

$$b'_G + b'^*_G + t = Rb_G + R^* b^*_G, \tag{7c}$$

$$\boxed{b'_G + b'^*_G = 0}, \tag{7d}$$

$$b'^*_G - \mu = \rho(b^*_G - \mu) + \varepsilon, \tag{7e}$$

$$\boxed{b'_H = -b'_G - \frac{1}{\Gamma}(R' - R'^*)}, \tag{7f}$$

$$p_N = w = 1, \tag{7g}$$

$$c_N = \ell_N, \tag{7h}$$

$$\ell = \ell_N + \ell_T. \tag{7i}$$

3.1 Mechanism

- Reserve accumulation **sterilized** using government debt.

$$b'_G + b'^*_G = 0.$$

- Government debt **crowds out** household borrowing.

$$b'_H + b'_G + \frac{1}{\Gamma}(R' - R'^*) = 0.$$

- Employment increases due to **income effect**.

$$p_N c_N + c_T + w(1 - \ell) = w + Rb_H + t - b'_H,$$

3.2 Unsterilized intervention

If reserve accumulation is not sterilized then $b'_G = 0$ in Equation (7c), (7d), and (7f). In this case the mechanism works via government transfers i.e. accumulation of reserve reduces government transfer to the households (7c). The reduced transfer decreases the leisure and hence increases employment due to income effect (7b).

3.3 Special cases

To get an idea of how the degree of capital control may effect the correlation, I explain two benchmark cases.

3.3.1 $\Gamma \to \infty$

In this case the economy is completely closed, so the variation in world interest rate will have no effect on domestic variables. Equation (7f) then becomes

$$b'_H + b'_G = 0.$$

From this equation we can see that there will be a perfect positive correlation between saving and reserve level which in turn leads to perfect positive correlation between employment and reserve level.

3.3.2 $\Gamma \to 0$

In this case the economy is completely open, therefore by no arbitrage condition R' will be close to R'^*, and any effect of reserve accumulation by the government will be nullified by flow of foreign investment. Thus reserve accumulation by the government will be irrelevant as far as changes in real domestic variables are concerned. More formally,

$$x_{j,t+1} = 2B_{t+1}\delta(j);$$

where $\delta(j)$ represents Dirac-delta function with following properties:

1. $\delta(j) = \infty; if j = 0;$

2. $\delta(j) = 0; if j \neq 0;$

3. $\int_{-\infty}^{\infty} \delta(j)dj = 1.$

And $B_{t=1} = -b_{H,t+1} - b_{G,t+1}$. These specifications imply that

$$b_{I,t+1} = \int_{0}^{\infty} x_{j,t+1}dj = -b_{H,t+1} - b_{G,t+1}$$

4 Quantitative Analysis

I now conduct quantitative analysis of the model. I document the patterns of reserve accumulation, employment for Mexico, and the world interest rate. I then calibrate the parameters of the model and finally, compare the statistical properties of the model with data.

4.1 Data Description

For quantitative analysis, I collect quarterly data on forex reserve, employment in non tradable (i.e. agriculture and services) and tradable (i.e. industry/manufacturing) sectors, and domestic interest rate for Mexico from 2005-Q1 to 2019-Q4. Recall that the gross domestic product in my model is equal to the total employment, so I normalize the reserve level in model relative to employment (GDP). Table 3 reports the key statistics on the behavior of the adjusted data.

Table 3: Statistics for adjusted data.

Variable	Mean	Std. dev.
Forex	0.295	0.08
Employment	0.607	0.0075
Non Tradable Employment	0.457	0.0057
Tradable Employment	0.151	0.0062

Data sources and units are recorded in Appendix B. Figures 1-4 show the evolution of adjustred reserve and employment over time.

Figure 1: Adjusted Reserve and Total Employment

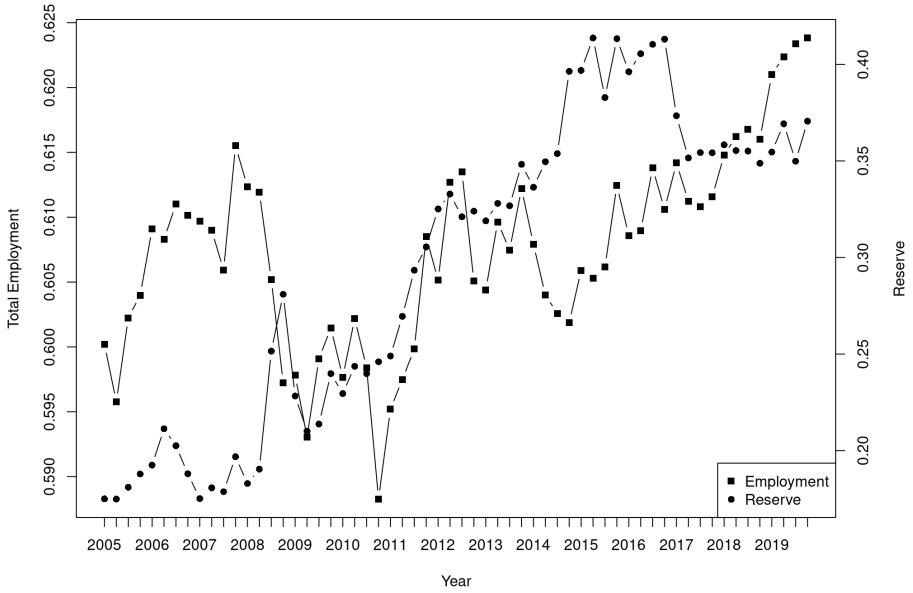


Figure 2: Adjusted Reserve and Tradable Employment

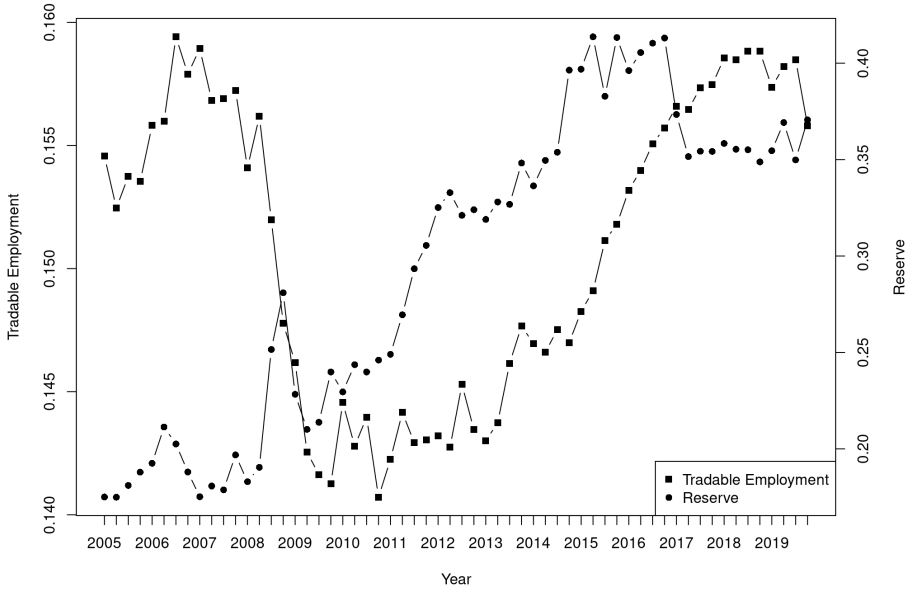


Figure 3: Adjusted Reserve and Non tradable Employment

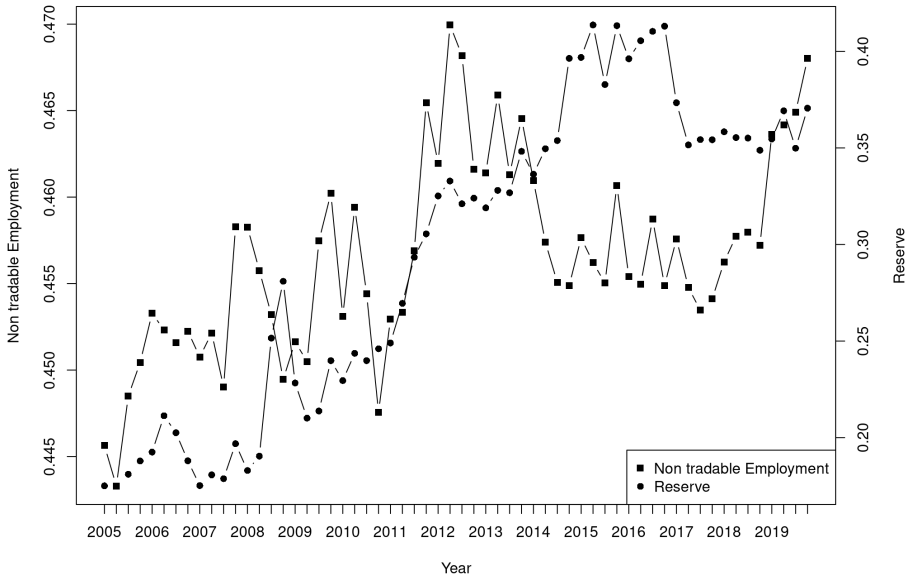
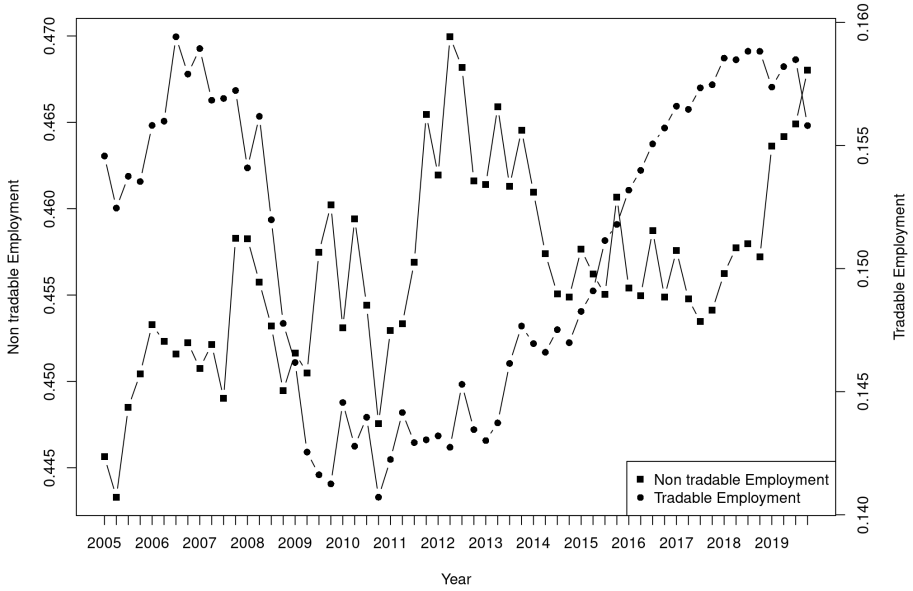


Figure 4: Tradable and Non tradable Employment



4.2 Calibration

I assume that the world interest rate follows an exogenous markov transition matrix. In the data, it varies from 0.11 to 6.73. To calibrate the transition matrix, I create 8 bins. Now, element $\{ij\}$ of the matrix is equal to the number of transitions $i \to j$ divided by total transitions originating from i.

$$\Pi = \begin{bmatrix} 0.974 & 0.026 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0.040 & 0.920 & 0.040 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0.048 & 0.905 & 0.048 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0.111 & 0.778 & 0.111 & 0 & 0 & 0 \\ 0 & 0 & 0.083 & 0.167 & 0.667 & 0.083 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0.074 & 0.926 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0.167 & 0.667 & 0.167 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0.143 & 0.857 \end{bmatrix}$$

The remaining parameters are calibrated to match a set of moments for Mexico. The results are presented in Table 5. I set the discount factor β to 0.91 so that the mean of $\frac{1}{R_t}$ is 0.981, tradable expenditure share $\alpha = 0.28$ so that the mean non tradable employment is 0.45, and Frisch elasticity $\psi = 0.63$ to get mean employment is 0.61. I use adjusted data to calibrate parameters corresponding to the forex reserve. $\mu = 0.295$ is the mean reserve level, $\rho = 0.961$ corresponds to the AR1 process presented in Table 4, and $\sigma_\epsilon = 0.022$ is used to match the standard deviation of adjusted reserve level in data.

4.2.1 Calibration of Γ

To calibrate Γ, I use data on net international investment position from Balance of Payments and International Investment Position Statistics from IMF for Brazil and Mexico. Selic interest rate target, obtained from Banco Central Do Brasil, is used as domestic interest rate for Brazil and short term rate for Mexico is obtained from OECD. Both rate are expressed in % p.a. at quarterly frequency from 2014-Q1 to 2019-Q4.

Noting that the aggregate investment in the economy is $b_{I,t+1} = \frac{1}{\Gamma}(R_{t+1} - R^*_{t+1})$, we get

$$\Gamma_M = \frac{b_{IB}}{b_{IM}} \left(\frac{R_M - R^*}{R_B - R^*} \right) \Gamma_B,$$

where $\Gamma_B = 9$[3]. The average value for Γ_M turns out to be 7.64.

Table 4: AR1 process for adjusted forex data.

	Dependent variable:
	forex(+1)
forex	0.961^{***}
	(0.030)
Constant	0.015
	(0.009)
Observations	59
R^2	0.947
Adjusted R^2	0.946
Residual Std. Error	0.018 (df = 57)
F Statistic	$1{,}010.058^{***}$ (df = 1; 57)
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 5: Calibration

Parameter	Value	Target
β	0.91	mean $\frac{1}{1+r}$
α	0.28	mean ℓ_N
ψ	0.63	mean ℓ
ρ	0.961	AR1 process
μ	0.295	mean Forex
σ_ϵ	0.022	std.dev. of forex
Γ	8	See description

4.3 Simulation

After discretizing reserve level by tauchen's method, the model can be solved using value function iteration. Table 6 depicts the result of simulating the calibrated version of the model

[3] Fanelli and Straub (2021) uses evidence from Chamon et al. (2017) to calibrate Γ for Brazil to be 9.

specified in (6). From the results we can see that the correlation between reserve level and employment; reserve level and household saving; and household saving and employment are of same sign in simulation and data. It should also be pointed out that household saving was not used for calibration.

Table 6: Results

Variable	Model	Data
$cor(forex, emp)$	0.98	0.42
$cor(forex, HHsav)$	0.98	0.92
$cor(HHsav, emp)$	0.98	0.45
$cor(forex, empN)$	-0.98	0.53
$cor(forex, empT)$	0.98	0.022
$cor(emp, R^*)$	-0.06	0.24
$cor(forex, R)$	-0.95	-0.51
$cor(forex, Welfare)$	-0.96	

4.3.1 Time Series Simulation

In order to further test the model performance, I simulate the time series for foreign reserve and world interest rate; and plot the response of employment in the model and employment data. The comparison of employment in the model and data is shown in Figure 5. Figure 6, and Figure 7 show the counterfactual simulation with constant world interest rate (1.0075) and constant reserve level (0.175) respectively. In these simulations, I keep variables fixed at their initial value. The statistical results from the simulations are presented in Table 7[4].

The simulation indicates that the statistical properties of employment when only reserve level is allowed to vary is close to those in data i.e. mean of 0.607 and std. dev. of 0.0075. But the employment trend in data and model are closer when we allow both reserve level and world interest rate to vary.

4.4 Robustness

Since it is difficult to obtain precise value of Γ from data, I report results for a variety of values of $\Gamma \in \{5, 10, 15\}$ to be sure that the mechanism proposed in this paper remains valid for a

[4] emp_1 indicates simulation with world interest rate held fixed at its initial value; emp_2 indicates simulation with reserve level held fixed at its initial value.

Figure 5: Time series simulation.

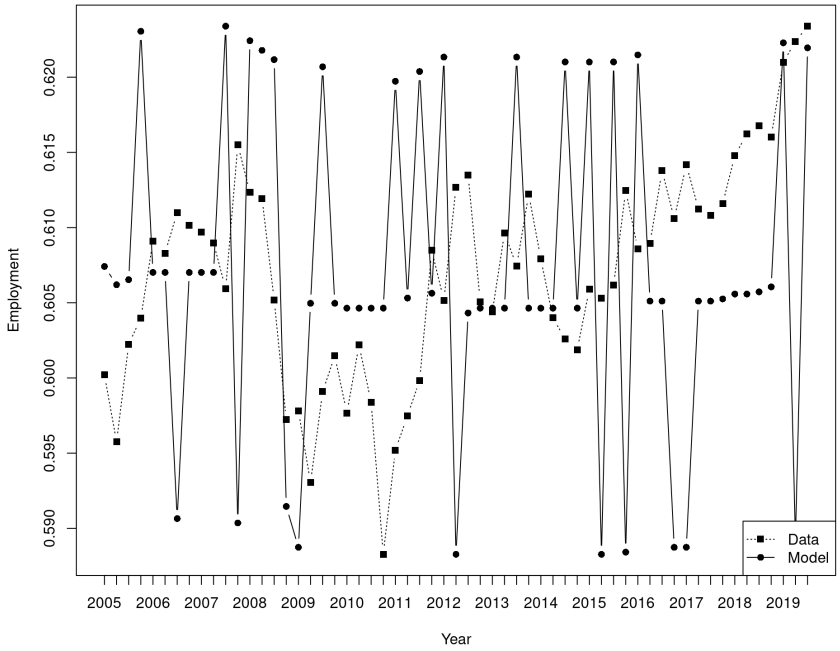


Figure 6: Time series simulation with constant world interest rate at 1.0075.

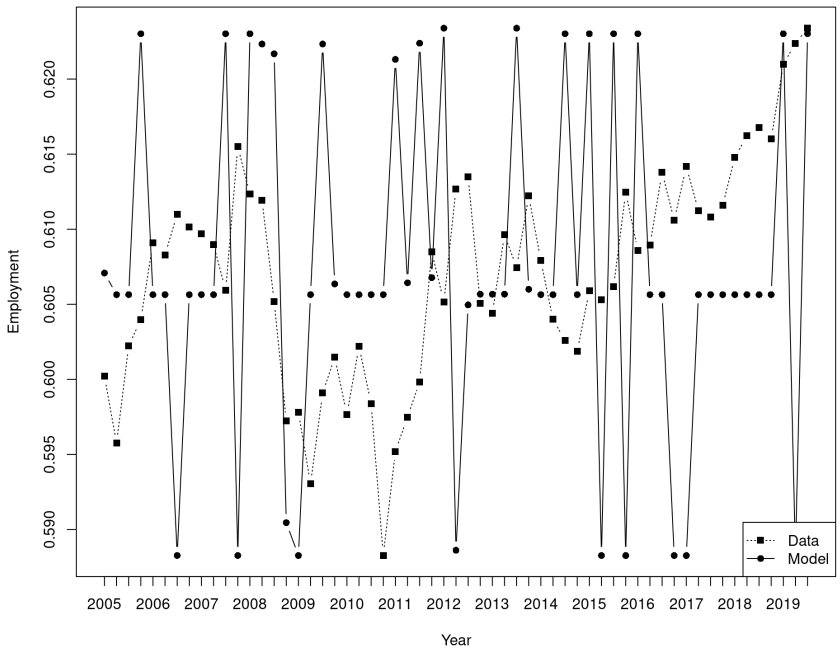


Figure 7: Time series simulation with constant reserve level at 0.175.

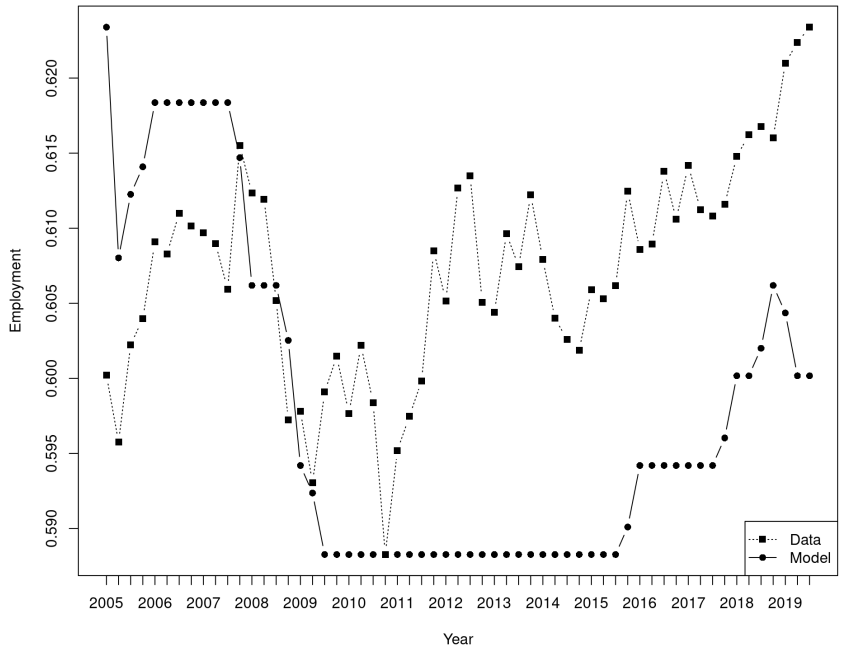


Table 7: Statistics for time series simulation

Variable	Simulation
$mean(emp)$	0.62
$sd(emp)$	0.01
$mean(emp_1)$	0.624
$sd(emp_1)$	0.0086
$mean(emp_2)$	0.618
$sd(emp_2)$	0.0057

Table 8: Results

Variable	Model	Data
$cor(forex, emp)$	0.064	0.42
$cor(forex, HHsav)$	1	0.92
$cor(HHsav, emp)$	0.065	0.45

reasonable range of Γ. The results of this exercise are reported in Table 9.

Table 9: Results

Variable	$\Gamma = 5$	$\Gamma = 10$	$\Gamma = 15$	Data
$cor(forex, emp)$	0.97	0.99	0.99	0.42
$cor(forex, HHsav)$	1	1	1	0.92
$cor(HHsav, emp)$	0.97	0.99	0.99	0.45
$cor(forex, empN)$	-097	-0.99	-0.99	0.53
$cor(forex, empT)$	0.97	0.99	0.99	0.022
$cor(emp, R^*)$	-0.02	-0.001	-0.07	0.24
$cor(forex, R)$	-0.97	-0.95	-0.94	-0.51
$cor(forex, Welfare)$	-0.98	-0.96	-0.96	

4.4.1 Results for time series simulation

Next, I simulate the the time series for forex reserves and world interest rate for different values of capital closedness Γ. The correlation between variables are computed and signs are compared with those in data. The results of this exercise is documented in Table 10. From

Table 10: Results

Variable	$\Gamma = 5$	$\Gamma = 10$	$\Gamma = 15$	Data
$cor(forex, emp)$	0.03	0.07	0.09	0.42
$cor(forex, HHsav)$	1	1	1	0.92
$cor(HHsav, emp)$	0.03	0.07	0.09	0.45

the quantitative exercise it can also be observed that the correlation between reserve level and employment increases as I increase Γ. This is expected as the more the economy is closed the more real variables can be affected by government actions.

5 Conclusion

This paper studies the effect of reserve accumulation on employment. I build a two sector model that features reserve accumulation by the government, and foreign intermediaries that are subject to exogenous capital control and financial friction. The imperfect capital mobility makes reserve accumulation by the government effective.

The main contribution of the paper is to propose a mechanism through which reserve accumulation can effect employment. Government sterilizes reserve accumulation by issuing debt in domestic financial market. The debt so issued crowds out household borrowing which increases employment via income effect. Note that the proposed mechanism does not rely on externality like learning by doing or any market failure.

To validate the mechanism, I calibrate the model using data on Mexico. On simulating the calibrated model I find that correlation between forex reserve and employment, forex reserve and household saving, and household saving and employment have same sign in the model and in the data.

The computation and analysis of the model is complicated due to the appearance of quadratic term in balance of payments equations. The future research plan is to develop a model that can be log linearized and hence is analytically tractable.

Bibliography

Joshua Aizenman and Jaewoo Lee. International reserves: precautionary versus mercantilist views, theory and evidence. *Open Economies Review*, 18:191–214, 2007.

Joshua Aizenman and Jaewoo Lee. Real exchange rate, mercantilism and learning by doing externality. *Pacific Economic Review*, 15:324–335, 2010.

Fernando Alvarez, Andrew Atkeson, and Patrick J. Kehoe. Time-Varying Risk, Interest Rates, and Exchange Rates in General Equilibrium. *Review of Economic Studies*, 76:851–878, 2009.

Fernando Arce, Julien Bengui, and Javier Bianchi. A Macroprudential Theory of Reserve Accumulation. 2022.

David K. Backus and Patrick J. Kehoe. On The Denomination of Government Debt - A critique of Portfolio Balance Approach. *Journal of Monetary Economics*, 23:359–376, 1989.

Tamim Bayoumi, Joseph Gagnon, and Christian Saborowski. Official Financial Flows, Capital Mobility, and Global Imbalances. *IMF Working Paper 13/11*, 2014.

Jaromir Benes, Andrew Berg, Rafael A. Portillo, and David Vavra. Modelling Sterilized Intervention and Balance Sheet Effects of Monetary Policy. *IMF Working Paper 13/11*, 2012.

Gianluca Benigno, Luca Fornaro, and Martin Wolf. Reserve accumulation, growth, and financial crises. *Journal of International Economics*, 139, 2022.

Javier Bianchi and Guido Lorenzoni. *The prudential use of capital controls and foreign currency reserves*. 2022.

Javier Bianchi and Cesar Sosa-Padilla. Reserve Accumulation, Macroeconomic Stabilization, and Sovereign Risk. *Review of Economic Studies*, 2023.

Javier Bianchi, Juan Carlos Hatchondo, and Leonardo Martinez. International Reserves and Rollover Risk. *American Economic Review*, 2018.

Olivier Blanchard, Gustavo Adler, and Irineu de Carvalho Filho. Can Foreign Exchange In-

tervention Stem Exchange Rate Pressures from Global Capital Flow Shocks? *IMF Working Paper 15/159*, 2015.

Guillermo Calvo, Alejandro Izquierdo, and Rudy Koo-Lung. Optimal Holding of International Reserves: Self Insurance Against Sudden Stop. *NBER Working Paper 18219*, 2012.

Marcos Chamon, Marcio Garcia, and Laura Souza. FX Intervention in Brazil: A Synthetic Control Approach. *Journal of International Economics*, 108:154–191, 2017.

Marcos Chamon, David J Hoffman, Nicolas E Magud, and Alejandro M Werner. *Foreign Exchange Intervention in Inflation Targeters in Latin America*. International Monetary Fund, 2019.

Woo Jin Choi and Alan M. Taylor. Precaution versus Mercantilism: Reserve Accumulation, Capital Control, and Real Exchange Rate. *Journal of International Economics*, 139, 2022.

Sebastian Fanelli and Ludwig Straub. A Theory of Foreign Exchange Interventions. *Review of Economic Studies*, 88:2857–2885, 2021.

Xavier Gabaix and Matteo Maggiori. International Liquidity and Exchange Rate Dynamics. *Quaterly Journal of Economics*, 130, 2015.

Joseph Gagnon. The Elephant Hidding in the Room: Currency Intervention and Trade Imbanlances. *Peterson Institute for International Economics, WP No. 13-2*, 2013.

Atish R. Ghosh, Jonathan D. Ostry, and Marcos Chamon. Two Targets, Two Instruments: Monetary and Exchange Rate Policies in Emerging Market Economies. *Journal of International Money and Finance*, 2015.

Jonathan Kearns and Roberto Rigobon. Identifying the efficacy of central bank interventions: evidence from Australian and Japan. *Journal of International Economics*, 66:31–48, 2005.

Lukas Menkhoff. High Frequency Analysis of Foreign Exchange Interventions: What Do We Learn? *Journal of Economic Surveys*, 24(1):85–112, 2010.

Lukas Menkhoff. Foreign Exchange Interventions in Emerging Markets: A Survey of Empirical Studies. *Leibniz University Hannover DP No 498*, 2012.

Reza Moghadam, Jonathan D. Ostry, and Robert Sheehy. Assessing Reserve Adequacy. *International Monetary Fund*, 2009.

Christopher J. Neely. An Analysis of Recent Studies of the Effect of Foreign Exchange Intervention. *Federal Reserve Bank of St. Louis Review*, 87:685–717, 2005.

Roamin Ranciere and Olivier D. Jeanne. The Optimal Level of International Reserves for Emerging Market Countries: Formulas and Applications. *International Monetary Fund*, 2006.

Dani Rodrik. The Real Exchange Rate and Economic Growth. *Brookings Paper and Economic Activity*, 39:769–797, 2008.

Agustin Samano. International Reserves and Central Bank Independence. *Journal of International Economics*, 2022.

Lucio Sarno and Mark Taylor. Official Intervention in the Foreign Exchange Market: Is it Effective and, If So, How Does It Work? *Journal of Economic Literature*, 39:839–868, 2001.

A Reserve Intervention in Mexico

In this appendix, I describe foreign exchange intervention in Mexico. The description is based on Chamon et al. (2019). The purpose of providing details of reserve intervention is to provide justification for assuming exogenous reserve intervention by emphasizing the fact that there are various objectives and mechanism for intervention which are independent of macroeconomic variables like employment.

Mexico adopted floating exchange rate in 1995. Since then interventions were made to manage the stock of international reserve or reduce exchange rate volatility, but they were never used to set the exchange rate level.

The state owned oil company, Pemex, was the only institution that subject to restrictions on operating in foreign exchange market. The reason for restricting Pemex was that its large trade surplus could distort the exchange rate and Pemex would have influenced foreign exchange policy.

From Table 8, we see that for many years Pemex was a major source of international reserve for Mexico, thus changes in oil price is one of the factors which could exogenously influence reserve level in the economy.

A.1 Various metrics

One of the primary goals of reserve intervention is to accumulate/ decumulate the reserve. There are different metrics that are used to assess the sufficiency of reserve level. These include 1) the ratio of reserve to GDP, compared with the ratio in other emerging markets; 2) the reserve adequacy metric proposed by Moghadam et al. (2009); 3) the cost-benefit approach proposed by Calvo et al. (2012); and 4) utility maximization approach by Ranciere and Jeanne (2006).

A.2 Intervention mechanisms

Some of the mechanisms used for reserve accumulation are outlined.

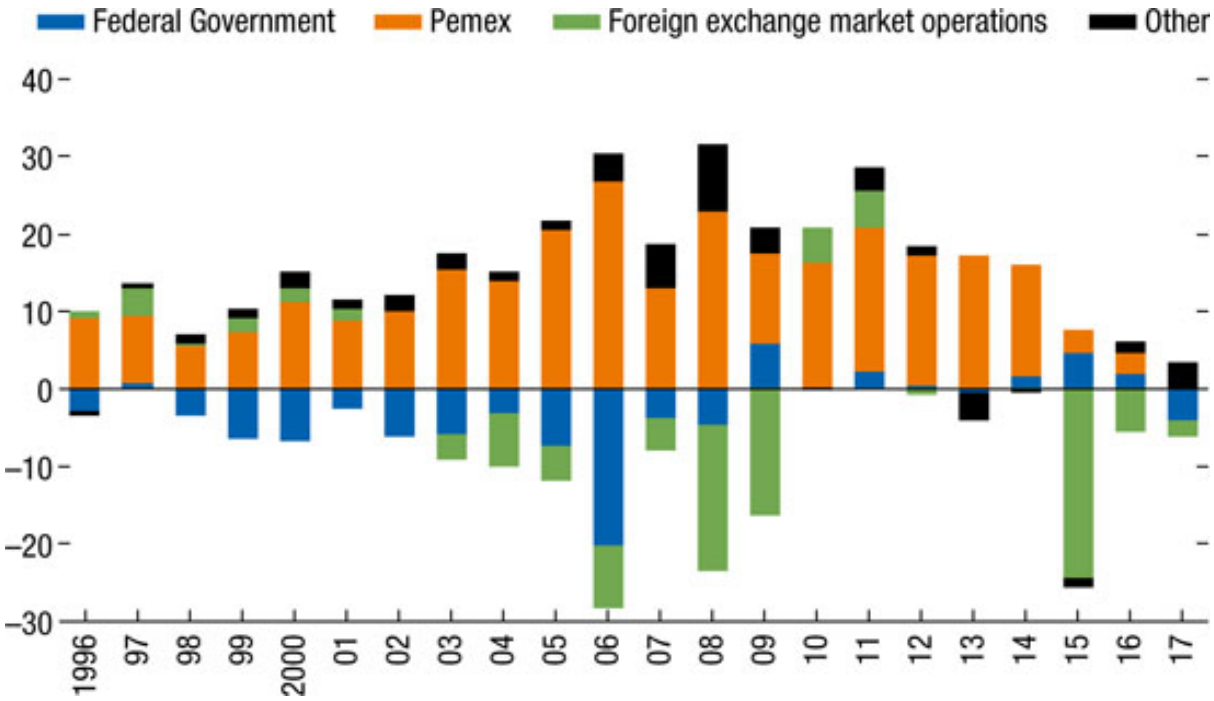


Figure 8: Source: Chamon et al. (2019). Sources of reserve accumulation.

A.2.1 Accumulation through Put Options

Under this mechanism, the central bank sells US dollar put options to the market through monthly auctions. These options give financial institutions right to sell US dollars to the central bank during the following month. However the sale is subject to two conditions. The first was that the strike price was determined by the central bank one business day before. Secondly the option can be executed only when exercise exchange rate was below its 20-day moving average.

A.2.2 Foreign exchange sales

In a given quarter, half the amount accumulated during the previous quarter, was sold. To smooth the sale, the moving average of accumulation during previous four quarters is used.

A.2.3 Auction with minimum bid price

The US dollar daily auction with minimum bid price is used to limit exchange rate volatility. The central bank auctions prespecified amount of dollars and sets the minimum bid price. Hence the trigger to sell is predetermined by market conditions.

A.2.4 Auction without minimum bid price

If the demand for dollars and exchange rate volatility is expected to persist, then a determined amount of dollars are auctioned without a minimum price.

A.2.5 Other mechanisms

In addition to the above, there are several other mechanisms that can be used to accumulate reserves. These are extraordinary US dollar auctions, US dollar discretionary outright sales, US dollar credit auctions, foreign exchange hedge auction program, and flexible credit lines with IMF.

B Data Sources

Variable	Source	Unit
Forex reserve	International Financial Statistics	Mn USD
GDP	FRED	Nominal Mn Pesos
Exchange rate	FRED	Pesos in USD
Employment	OECD	Ratio*
Employment (Agriculture)	OECD	Thousand persons
Employment (Manufacturing)	OECD	Thousand persons
Employment (Services)	OECD	Thousand persons
Domestic interest rate	OECD	% p.a.
World interest rate	OECD	% p.a.

*Ratio of employed to working age population (15 to 64 years).

C Simplified Recursive Problem

In this section I simplify the Recursive problem mentioned in the main text of the paper.

$$V(R^*, b_H, b_G^*, R'^*, \varepsilon) = \max_{\substack{c_N, c_T, b'_H, \ell, \\ \ell_N, \ell_T, b'_G, t \\ p_N, w, R'}} \log c + \psi \log(1-\ell) + \beta \mathbb{E}_{R''^*, \varepsilon'} V(R'^*, b'_H, b'^*_G, R''^*, \varepsilon'),$$

where

$$c = c_N^{1-\alpha} c_T^{\alpha}, \tag{8a}$$

$$p_N c_N + c_T + b'_H = w\ell + Rb_H + t, \tag{8b}$$

$$b'_G + b'^*_G + t = Rb_G + R^* b^*_G, \tag{8c}$$

$$b'_G + b'^*_G = 0, \tag{8d}$$

$$b'^*_G - \mu = \rho(b^*_G - \mu) + \varepsilon, \tag{8e}$$

$$b'_H = -b'_G - \frac{1}{\Gamma}(R' - R'^*), \tag{8f}$$

$$p_N = w = 1, \tag{8g}$$

$$c_N = \ell_N, \tag{8h}$$

$$\ell = \ell_N + \ell_T. \tag{8i}$$

From households' first order condition, we get

$$p_N c_N = (1-\alpha)c,$$

$$c_T = \alpha c,$$

$$w(1-\ell) = \psi c.$$

So, c_N, c_T, and ℓ can be eliminated from the household budget constraint (8b) to get

$$(1+\psi)c = 1 + Rb_H + t - b'_H,$$

where $w = 1$ has also been substituted.

Notice that b'_G can be determined from (8d) and b'_H can be determined from (8f). Also once we know c, we can also compute $\ell_N = c_N$, $\ell = 1 + \psi c$, and $\ell_T = \ell - \ell_N$.

Hence the only free variable remaining is R' which can determined from the simplified recursive problem. Combining the simplified recursive problem with transition matrix for R^*, the model can then be solve on a computer.

D Two period version

Table 11: Employment is positively correlated with forex-gdp ratio and R^*

	Dependent variable:		
	Employment		
	(1)	(2)	(3)
FbyG	1.706^{***}	1.509^{**}	
	(0.590)	(0.612)	
r_star	0.061^{**}		0.049^{**}
	(0.025)		(0.025)
Observations	2,404	2,404	2,404
R^2	0.005	0.003	0.002
Adjusted R^2	−0.049	−0.060	−0.053
F Statistic	6.116^{***} (df = 2; 2278)	6.077^{**} (df = 1; 2260)	3.848^{**} (df = 1; 2279)
Note:			*p<0.1; **p<0.05; ***p<0.01

D.1 Household

The optimization problem of the household is as follows:

$$\max_{c_t,\ell_t} \sum_{t=0}^{1} \beta^t \log(c_t) + \psi \log(1-\ell_t)$$

$$c_0 + b_{H1} = w_0\ell_0 + R_0 b_{H0} + t_0,$$

$$c_1 = w_1\ell_1 + R_1 b_{H1} + t_1.$$

The household saving in terminal period is set to 0.

D.2 Government

The government's constraints are same as in the main text, but it exists only for two periods. Further, it does not accumulate reserve or issue debt in the terminal period.

$$b_{G1} + b^*_{G1} + t_0 = R_0 b_{G0} + R^*_0 b^*_{G0},$$

$$t_1 = R_1 b_{G1} + R_1^* b_{G1}^*,$$

$$b_{G0} + b_{G0}^* = b_{G1} + b_{G1}^* = 0.$$

As, assumed previously, the level of reserve, b_{G1}^*, and the world interest rate, R_1^*, are assumed to be given exogenously.

D.3 Firms

The optimization problem of tradable and non tradable firms will give $w_t = 1$.

D.4 Foreign intermediaries

The foreign intermediaries' behavior is as described in the main test, from which we get: $b_{I1} = \frac{1}{\Gamma}(R_1 - R_1^*)$, and $b_{I2} = 0$.

D.5 Solution

From household's problem we get

$$c_0 = \frac{1}{(1+\psi)(1+\beta)}\left[\left(1 + \frac{1}{R_1}\right) + R_0 b_{H0} + \left(t_0 + \frac{t_1}{R_1}\right)\right],$$

$$b_{H1} = \frac{\beta}{1+\beta}\left(1 + R_0 b_{H0} + t_0\right) - \frac{1+t_1}{(1+\beta)R_1} \tag{9}$$

Combined with domestic financial market condition,

$$b_{H1} = b_{G1}^* - \frac{1}{\Gamma}(R_1 - R_1^*) \tag{10}$$

and, the government budget constraint

$$t_1 = (R_1^* - R_1) b_{G1}^*. \tag{11}$$

we can solve for R_1, using the equilibrium value of R_1 we can solve for employment $\ell_0 = 1 - \psi c_0$. Figure 9 shows the variation of employment (ℓ_0) for different reserve levels (b_{G1}^*).

And the variation of employment (ℓ_0) for different world interest rates (R_1^*) is shown in Figure 10. These plots agree with the results presented in Table 11.

Table 12: Parameter for two period version.

Parameter	Value
β	0.91
ψ	0.63
Γ	8
R_0	1.04
R_0^*	1.04
R_1^*	1.04
b_{G0}^*	0

Figure 9: Two period version of the model.

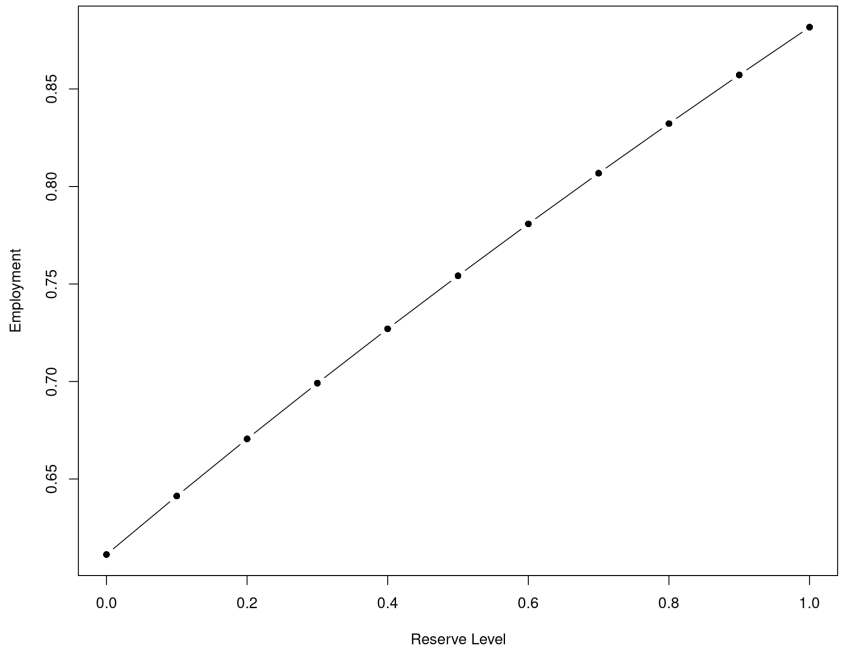


Figure 10: Two period version of the model.