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FX Policy When Financial Markets are Imperfect

Matteo Maggiori*

The last fifteen years have witnessed remarkable interventions of governments in financial markets. Central banks have purchased securities at unprecedented levels via quantitative easing and foreign exchange intervention. These interventions have constituted the core policy response to crises such as the global financial crisis of 2008-09, the European sovereign debt crisis of 2011-12, and the ongoing Covid-19 pandemic. In all these episodes, capital and asset prices moved abruptly, often with adverse consequences for the global economy. Traditional monetary policy quickly ran out of power due to the zero lower bound (ZLB) constraint, and policymakers resorted to these alternate policies, previously regarded as unconventional or even heterodox (see BIS (2019)).

My comments today will focus on foreign exchange intervention.[1] Much progress has been made recently in understanding the foundations of this policy and its optimal use (Cavallino (2019); Amador, Bianchi, Bocola and Perri (2020); Fanelli and Straub (2020); Davis, Devereux and Yu (2020); Hassan, Mertens and Zhang (2020)). On the economic theory front, this has required not only new models but also going back to older insights that had been largely forgotten, such as the portfolio balance theories of the 1970s.[2] In models with imperfect financial intermediation, the exchange rate is pinned down by imbalances

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[1] A more extensive version of these comments is available in a recent Handbook of International Economics chapter (Maggiori (2021)).

[2] The intellectual origin of this modeling traces back to the Nurkse (1944) view of capital flows as inducing volatile and destabilizing exchange rate movements. The field has been inspired by the pioneering work of Penti Kouri on the portfolio balance approach to exchange rates (Kouri (1976)). For a review of this early literature see Branson and Henderson (1985).

in the demand and supply of assets in different currencies and, crucially, by the limited risk-bearing capacity of financiers that absorb these imbalances.

On the policy front, the financial frictions view offers a different take on exchange rates compared to their traditional role as shock absorbers. Exchange rates are distorted by financial forces and can be a source of shocks to the real economy rather than a re-equilibrating mechanism. Quantitative easing and FX intervention, the purchase of domestic and foreign currency assets by the central bank, respectively, are ineffective in perfect markets but effective and, if used appropriately, welfare-enhancing policies under imperfect markets. Their ineffectiveness in perfect markets relies on a combination of Modigliani-Miller logic applied to the balance sheet of the central bank and Ricardian equivalence. Under these conditions, if the central bank buys foreign currency assets while selling domestic currency assets, agents in the economy simply take the opposite position since they understand that the central bank is trading on their behalf in an undesired way. Future losses or gains arising from the central bank position are passed through to the agents without distorting their actions.

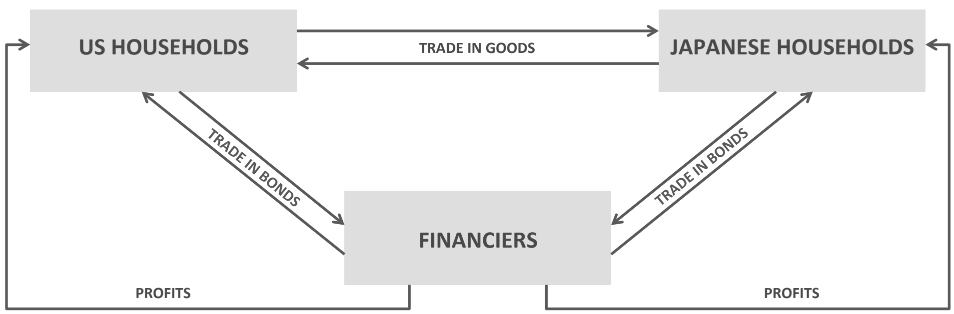
Limited financial intermediation breaks the Modigliani-Miller component because the intervention is a risk transfer between the central bank and constrained financial intermediaries. The presence of financial constraints and/or imperfections in the goods market like sticky prices, are at the core not only of the effectiveness of interventions but also provide a deeper rationale for their optimal use. Private decisions in the presence of pecuniary and/or demand externalities are no longer optimal, thus generating a role for government intervention even under the strict criterion of constrained Pareto optimality.[3]

An intuitive way to visualize the conceptual difference of international macro models with segmented currency markets is illustrated in Figure 1. Let us start with a simple two country model, for concreteness, say the U.S. and Japan. These countries trade in the goods market with each other because they produce heterogeneous goods which they both enjoy consuming

[3] The study of these optimal policies is reviewed extensively in a recent Handbook of International Economics chapter by Bianchi and Lorenzoni (2021).

(in different proportions). Shocks across states of the world and time also generate motives to trade in financial assets. The more traditional setup is to make these countries also face each other in financial markets with a menu of assets that might be complete or incomplete. The financial intermediation view breaks this structure by introducing global financiers at the core of the model. Both countries trade in a limited set of assets, for concreteness, say bonds in dollars and yen, against the financiers. Ultimately, the financiers are owned by the households in each country and receive the profits/losses of intermediation. If the financiers behaved optimally, then they would simply be a veil and the model would be much the same without them. The model, therefore, comes alive when financial frictions limit the ability of the financiers to take on positions.

Figure 1: Basic Structure of a Segmented Currency Market Model



The players and structure of the flows in the goods and financial markets. Reproduced from Gabaix and Maggiori (2015).

A Simple Theoretical Framework. To make ideas concrete, we will sketch here a version of the model in Gabaix and Maggiori (2015). Going back to Figure 1, there are two countries, the US and Japan, and two periods $t = 0, 1$. The setup of households in each country is mostly standard. Households in the US derive utility from the consumption of goods according to:

$$\theta_0 \ln C_0 + \beta \mathbb{E} \left[\theta_1 \ln C_1 \right], \tag{1}$$

where C is a consumption basket defined as:

$$C_t \equiv [(C_{NT,t})^{\chi_t}(C_{H,t})^{a_t}(C_{F,t})^{\iota_t}]^{\frac{1}{\theta_t}}, \tag{2}$$

where $C_{NT,t}$ is the US consumption of its non-tradable goods, $C_{H,t}$ is the US consumption of its domestic tradable goods, and $C_{F,t}$ is the US consumption of Japanese tradable goods. We use the notation $\{\chi_t, a_t, \iota_t\}$ for non-negative, potentially stochastic, preference parameters and we define $\theta_t \equiv \chi_t + a_t + \iota_t$. The non-tradable good is the numéraire in each economy and, consequently, its price equals one in domestic currency ($p_{NT} = 1$).

To sharpen the focus on financial forces, we start with a frictionless goods market across countries and flexible prices. The law of one price holds in the goods market. Financial markets, instead, are incomplete and each country trades a risk-free domestic currency bond that pays one unit of non-tradable goods in all states of the world.

US households' optimization problem is:

$$\max_{(C_{NT,t},C_{H,t},C_{F,t})_{t=0,1}} \quad \theta_0 \ln C_0 + \beta \mathbb{E}\left[\theta_1 \ln C_1\right], \tag{3}$$

$$\text{subject to} \quad (2), \tag{4}$$

$$\text{and} \quad \sum_{t=0}^{1} R^{-t}\left(Y_{NT,t} + p_{H,t}Y_{H,t}\right) = \sum_{t=0}^{1} R^{-t}\left(C_{NT,t} + p_{H,t}C_{H,t} + p_{F,t}C_{F,t}\right). \tag{5}$$

The static utility maximization problem takes the form:

$$\max_{C_{NT,t},C_{H,t},C_{F,t}} \quad \chi_t \ln C_{NT,t} + a_t \ln C_{H,t} + \iota_t \ln C_{F,t} + \lambda_t\left(CE_t - C_{NT,t} - p_{H,t}C_{H,t} - p_{F,t}C_{F,t}\right), \tag{6}$$

where CE_t is consumption expenditure on the basket, which is taken as exogenous in this static optimization problem and later endogenized in the dynamic optimization problem, λ_t is the associated Lagrange multiplier, $p_{H,t}$ is the Dollar price in the US of US tradables, and $p_{F,t}$ is the Dollar price in the US of Japanese tradables. First-order conditions imply:

$\frac{\chi_t}{C_{NT,t}} = \lambda_t$, and $\frac{\iota_t}{C_{F,t}} = \lambda_t p_{F,t}$. Non-tradable goods are produced by an endowment process that for simplicity follows $Y_{NT,t} = \chi_t$, unless otherwise stated. This simplifying assumption, combined with the market clearing condition for non-tradables $Y_{NT,t} = C_{NT,t}$, implies that in equilibrium $\lambda_t = 1$ in all states. The assumption essentially removes marginal utility variation across states, thus sharpening, as we will see below, the focus on imperfect substitutability between currencies coming from financial frictions.

With this assumption in hand, the Dollar value of US imports is $p_{F,t}C_{F,t} = \iota_t$. Japanese households derive utility from consumption according to: $\theta_0^* \ln C_0^* + \beta^* \mathbb{E}\left[\theta_1^* \ln C_1^*\right]$, where starred variables denote Japanese quantities and prices. By analogy with the US case, the Japanese consumption basket is: $C_t^* \equiv \left[(C_{NT,t}^*)^{\chi_t^*}(C_{H,t}^*)^{\xi_t}(C_{F,t}^*)^{a_t^*}\right]^{\frac{1}{\theta_t^*}}$, where $\theta_t^* \equiv \chi_t^* + a_t^* + \xi_t$. The Japanese static utility maximization problem together with the symmetric assumption $Y_{NT,t}^* = \chi_t^*$, leads to a Yen value of US exports to Japan, $p_{H,t}^* C_{H,t}^* = \xi_t$. US net exports, expressed in dollars, are given by: $NX_t = e_t p_{H,t}^* C_{H,t}^* - p_{F,t}C_{F,t} = \xi_t e_t - \iota_t$. The exchange rate e_t is defined as the quantity of dollars bought by 1 yen, i.e. the strength of the Yen. Consequently, an increase in e represents a Dollar depreciation.[4]

The optimization problem (3) for the intertemporal consumption-saving decision leads to a standard optimality condition (Euler equation):

$$1 = \mathbb{E}\left[\beta R \frac{U'_{1,C_{NT}}}{U'_{0,C_{NT}}}\right] = \mathbb{E}\left[\beta R \frac{\chi_1 / C_{NT,1}}{\chi_0 / C_{NT,0}}\right] = \beta R, \tag{7}$$

where $U'_{t,C_{NT}}$ is the marginal utility at time t over the consumption of non-tradables. Given the simplifying assumption that $C_{NT,t} = \chi_t$, the above Euler equation implies that $R = 1/\beta$. This is clearly a crude model of interest rates, but it allows us to sharpen the focus on the exchange rate: any desired changes in equilibrium currency returns have to occur via changes in expected currency appreciation.

[4]In this simple real model, the exchange rate is related to the relative price of non-tradable goods. Gabaix and Maggiori (2015) provides a detailed discussion of different exchange rate concepts in this economy including the nominal and CPI-based real exchange rate. The analogy with the nominal is perhaps the most straightforward by thinking of non-tradable goods as money in the utility function.

The demand and supply of bonds in different currencies by the ultimate holders/issuers rarely balances and a global financial intermediation sector exists to absorb, for a profit, these imbalances in the medium run. The intermediation sector is large but so are the global flows that it needs to absorb. The literature has therefore emphasized the limits to the sector's risk-absorption capacity.

The limits come in various forms ranging from those imposed by regulation, like capital requirements, to those arising from private contracting and the incentives to profitably use the inside capital of intermediaries given costly external financing. Here we follow a simple and tractable specification for the constrained portfolio problem that generates a demand function that captures the spirit of the limits of arbitrage theory. We assume that there is a unit mass of global financial firms, each managed by a financier. Agents from the two countries are selected at random to run the financial firms for a single period. Financiers start their jobs with no capital of their own and can trade bonds denominated in both currencies. Therefore, their balance sheet consists of q_0 dollars and $-\frac{q_0}{e_0}$ yen, where q_0 is the Dollar value of Dollar-denominated bonds the financier is long of and $-\frac{q_0}{e_0}$ the corresponding value in Yen of Yen-denominated bonds. At the end of (each) period, financiers pay their profits and losses out to the households.

We assume that each financier maximizes the expected value of her firm:

$$V_0 = \mathbb{E}\left[\beta\left(R - R^* \frac{e_1}{e_0}\right)\right] q_0 = \Omega_0 q_0. \tag{8}$$

In the absence of frictions our financiers would simply be a veil and the optimality condition in maximization (8) would impose the household optimality criterion: $0 = \mathbb{E}\left[\beta\left(R - R^* \frac{e_1}{e_0}\right)\right]$. After taking positions but before shocks are realized, the financier can divert a portion of the funds she intermediates. If the financier diverts the funds, her firm is unwound and the households that had lent to her recover a portion $1 - \Gamma\left|\frac{q_0}{e_0}\right|$ of their credit position $\left|\frac{q_0}{e_0}\right|$, where $\Gamma = \gamma\left(var\left(e_1\right)\right)^{\alpha}$, with $\gamma \geq 0, \alpha \geq 0$. Since creditors, when lending to the financier, correctly anticipate the incentives of the financier to divert funds, the financier is subject to a credit constraint of the form:

$$\underbrace{\frac{V_0}{e_0}}_{\substack{\text{Intermediary Value}\\ \text{in yen}}} \geq \underbrace{\left|\frac{q_0}{e_0}\right|}_{\substack{\text{Total}\\ \text{Claims}}} \underbrace{\Gamma\left|\frac{q_0}{e_0}\right|}_{\substack{\text{Diverted}\\ \text{Portion}}} = \underbrace{\Gamma\left(\frac{q_0}{e_0}\right)^2}_{\substack{\text{Total divertable}\\ \text{Funds}}}. \tag{9}$$

The constrained optimization problem of the financier is:

$$\max_{q_0} \; V_0 = \mathbb{E}\left[\beta\left(R - R^*\frac{e_1}{e_0}\right)\right] q_0, \qquad \text{subject to} \quad V_0 \geq \Gamma\frac{q_0^2}{e_0}. \tag{10}$$

Intuitively, given any non-zero expected excess return in the currency market, the financier would want to either borrow or lend as much as possible in Dollar and Yen bonds. The constraint limits the maximum position and therefore binds. Substituting the firm's value into the constraint and re-arranging (using $R = 1/\beta$), we find: $q_0 = \frac{1}{\Gamma}\mathbb{E}\left[e_0 - e_1\frac{R^*}{R}\right]$. Integrating the above demand function over the unit mass of financiers yields the aggregate financiers' demand for assets:

$$Q_0 = \frac{1}{\Gamma}\mathbb{E}\left[e_0 - e_1\frac{R^*}{R}\right]. \tag{11}$$

The slope parameter Γ governs the ability of financiers to bear risks. The higher Γ, the lower the financiers' risk bearing capacity, the steeper their demand curve, and the more segmented the asset market.

First consider the simple, but unrealistic, case of imbalances resulting only from trade flows, and then extend the model to imbalances arising from gross portfolio flows. To sharpen the intuition, assume for now that $\beta = \beta^* = 1$ and $\xi_t = 1$ for $t = 0, 1$. The equilibrium exchange rate is then given by:

$$e_0 = \frac{(1+\Gamma)\,\iota_0 + \mathbb{E}[\iota_1]}{2+\Gamma}, \tag{12}$$

$$e_1 = \{\iota_1\} + \frac{\iota_0 + (1+\Gamma)\,\mathbb{E}[\iota_1]}{2+\Gamma}, \tag{13}$$

where $\Gamma = \gamma\ var\,(\iota_1)^{\alpha}$ and $\{\iota_1\}$ is the time-one import shock (i.e. define $\{X\} \equiv X - \mathbb{E}[X]$ to be the innovation to a random variable X).

Depending on Γ, the time-zero exchange rate varies between two polar opposites: the UIP-based and the financial-autarky exchange rates, respectively. Both extremes are important benchmarks of open economy analysis, and the choice of Γ allows us to modulate our model between these two useful benchmarks. $\Gamma \uparrow \infty$ results in $e_0 = \frac{\iota_0}{\xi_0}$, which is the financial autarky value of the exchange rate. Intuitively, financiers have so little risk-bearing capacity that no financial flows can occur between countries and, therefore, trade has to be balanced period by period. When $\Gamma = 0$, UIP holds and we obtain $e_0 = \frac{\iota_0 + \mathbb{E}[\iota_1]}{2}$. Intuitively, financiers are so relaxed about risk taking that they would be willing to take infinite positions in currencies if there was a positive expected excess return from doing so.

Let us now turn to gross portfolio flows. We start by focusing on private flows before introducing official flows (i.e. FX intervention). We focus here on the simplest form of portfolio flows from households, not so much for their realism, but because they allow for the sharpest analysis of the main forces of the model.

Assume that Japanese households have, at time zero, an inelastic demand (e.g. some noise trading) f^* of Dollar bonds funded by an offsetting position $-f^*/e_0$ in Yen bonds. Both transactions face the financiers as counterparties. While we take these flows as exogenous, they can be motivated as a liquidity shock, or perhaps as a decision resulting from bounded rationality or portfolio delegation. The flow equations are now given by:

$$\xi_0 e_0 - \iota_0 + Q_0 + f^* = 0, \qquad \xi_1 e_1 - \iota_1 - RQ_0 - Rf^* = 0. \tag{14}$$

The financiers' demand is still $Q_0 = \frac{1}{\Gamma}\mathbb{E}\left[e_0 - \frac{R^*}{R}e_1\right]$, and maintain that $\xi_t = R = R^* = 1$ for $t = 0, 1$. The exchange rates at times $t = 0, 1$ are now:

$$e_0 = \frac{(1+\Gamma)\,\iota_0 + \mathbb{E}[\iota_1] - \Gamma f^*}{2+\Gamma}; \qquad e_1 = \{\iota_1\} + \frac{\iota_0 + (1+\Gamma)\,\mathbb{E}[\iota_1] + \Gamma f^*}{2+\Gamma}, \tag{15}$$

where $\Gamma = \gamma\ var(\iota_1)^\alpha$. Hence, additional demand f^* for dollars at time zero induces a Dollar appreciation at time zero, and subsequent depreciation at time one. However, the time-average value of the Dollar is unchanged: $e_0 + e_1 = \iota_0 + \iota_1$, independently of f^*.

An increase in Japanese demand for Dollar bonds needs to be absorbed by financiers, who correspondingly need to sell Dollar bonds and buy Yen bonds. To induce financiers to provide the desired bonds, the Dollar needs to appreciate on impact *as a result of the capital flow*, in order to then be expected to depreciate, thus generating an expected gain for the financiers' short Dollar positions. This is a simple example of a deep force of the model: a relative price, the exchange rate, has to move in order to equate the supply and demand of two assets, Yen and Dollar bonds intermediated by a constrained financial sector.

This framework can analyze concrete situations, such as large scale capital flows from developed countries into emerging market local-currency bond markets, say by US investors into Brazilian Real bonds, that put upward pressure on the receiving countries' currencies. While such flows and their impact on currencies have been paramount in the logic of market participants and policy makers, they had for a long time proven elusive in a formal theoretical analysis.[5]

Our last step before focusing on FX intervention is to close the general equilibrium model by specifying the production side. A general equilibrium production setting shows the important role that exchange rates can have in transmitting financial distortions and pressures coming from financial flows to the real economy. Thus providing theoretical support for the argument often articulated by emerging market policy makers that open capital

[5] For related evidence see Pandolfi and Williams (2019) and Broner, Martin, Pandolfi and Williams (2020).

markets and floating exchange rates seldom perform the shock absorption role highlighted by traditional macroeconomic analysis. To build up to this intuition, let us introduce a minimal model of production. We assume that non-tradable goods are given by endowment processes and that tradable goods are produced with a technology linear in labor with unit productivity. In each country, labor L is supplied inelastically and is internationally immobile.

Profit maximization at the firm level yields a Dollar wage in the US of $w_{H,t} = p_{H,t}$. Under flexible prices, goods market clearing then implies full employment $Y_{H,t} = L$ and a US tradable price in dollars of: $p^{\circ}_{H,t} = \frac{a_t + \xi_t e_t}{L}$, where the circle in p° denotes a frictionless quantity. Likewise, for Japanese tradables the equilibrium features both full employment $Y_{F,t} = L$ and a Yen price of: $p^{*\circ}_{F,t} = \frac{a^*_t + \iota_t / e_t}{L}$.

Let us now assume that wages are "downward rigid" in domestic currency at a preset level of $\{\bar{p}_H, \bar{p}^*_F\}$, where these prices are exogenous (see also Schmitt-Grohé and Uribe (2016)). Let us further assume that firms do not engage in pricing to market, so that prices are sticky in producer currency (PCP). Firm profit maximization then implies that: $p_{H,t} = \max\left(\overline{p}_H, p^{\circ}_{H,t}\right)$; or more explicitly: $p_{H,t} = \max\left(\overline{p}_H, \frac{a_t + e_t \xi_t}{L}\right)$. Hence:

$$Y_{H,t} = \min\left(\frac{a_t + e_t \xi_t}{\bar{p}_H}, L\right). \tag{16}$$

If demand is sufficiently low ($a_t + \xi_t e_t < \overline{p}_H L$), then output is demand-determined (i.e., it depends directly on: e_t, ξ_t,and a_t) and there is unemployment: $L - Y_{H,t} > 0$. Notice that in this case the exchange rate has an *expenditure-switching* effect: if the Dollar depreciates ($e_t \uparrow$), unemployment falls and output expands in the US. Intuitively, since US tradables' prices are sticky in dollars, these goods become cheap for Japanese consumers to buy when the Dollar depreciates. In a world that is demand constrained, this expansion in demand for US tradables is met by expanding production, thus raising US output and employment. A similar expression and mechanism apply to Japanese tradables:

$$Y_{F,t} = \min\left(\frac{a_t^* + \iota_t/e_t}{\bar{p}_F^*}, L\right). \tag{17}$$

The expenditure switching role of exchange rates has been central to the Keynesian analysis of open macroeconomics (Dornbusch (1976); Obstfeld and Rogoff (1995)).

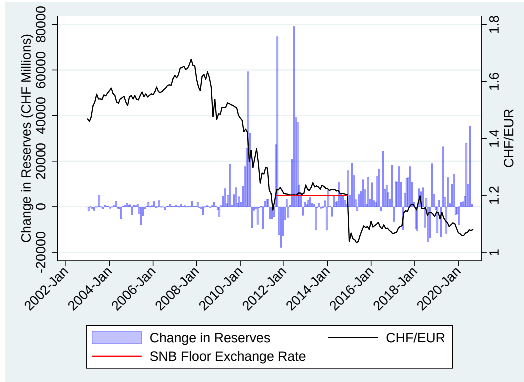
The financial determination of exchange rates has real consequences. Let us reconsider our earlier example of a sudden inflow of capital from US investors into Brazilian Real bonds. The exchange rate in this economy with production and sticky prices is still characterized by equation (15). As previously discussed, the capital inflow in Brazil causes the Real to appreciate and,[6] if the flow is sufficiently strong (f sufficiently high) or the financiers' risk bearing capacity sufficiently low (Γ sufficiently high), the appreciation (the increase in e_0) can be so strong as to make Brazilian goods uncompetitive on international markets; the corresponding fall in world demand for Brazilian output ($\downarrow C_H^* = \frac{\iota_0}{e_0\bar{p}_F^*}$) causes an economic slump in Brazil with both falling output and increasing unemployment.[7]

Foreign Exchange Intervention. Large-scale currency interventions have recently been undertaken by the governments of Switzerland, Israel, and the Czech Republic, in addition to many emerging markets. Figure 2 highlights the grand scale on which these FX operations have been conducted. These governments aimed to relieve their currency appreciation in the face of turmoil in financial markets. The policymakers at the respective institutions expressed the view that interventions successfully weakened the exchange rate and boosted the real economy.

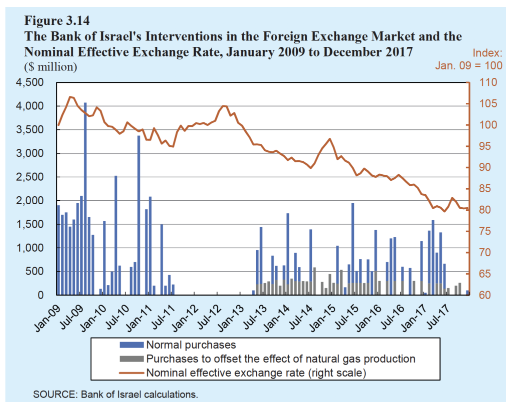
For example, Israels' central bank governor Stanley Fisher remarked: "I have no doubt that the massive purchases [of foreign exchange] we made between July 2008 and into 2010

[6]When $\alpha = 0$, $\frac{\partial e_0}{\partial f} = -\frac{\Gamma}{2+\Gamma} < 0$. More generally, a sufficient condition for this effect is that α is small.

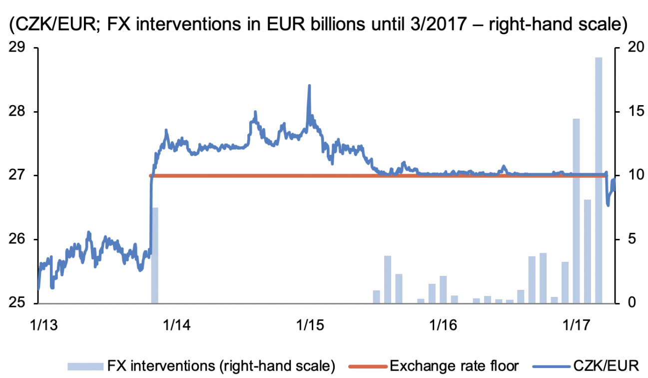
[7]The Brazilian Finance Minister Guido Mantega complained, as reported in Forbes Magazine (2011), that: "We have to face the currency war without allowing our productive sector to suffer. If we allow [foreign] liquidity to [freely] enter [the economy], it will bring the Dutch Disease to the economy."



(a) Swiss National Bank (SNB) Change in Reserves and the CHF/EUR Exchange rate



(b) Bank of Israel (BoI) FX Purchases and the Shekel Exchange Rate



(c) Czech National Bank (CNB) FX Purchases and the CZK/EUR Exchange Rate

Figure 2: **Recent Episodes of FX Intervention.** Panel A plots the CHF/EUR nominal exchange rate (right axis) and the change in reserves held by the Swiss National Bank (SNB). Source: FRED series on Relevant Foreign Currency Positions of the Swiss National Bank. Panel B plots monthly FX purchases by the Bank of Israel (BoI) (left axis) and the Shekel nominal exchange rate (a decrease is a Shekel appreciation). Source: reproduced here courtesy of Bank of Israel. Panel C plots FX interventions by the Czech National Bank (CNB) (right scale) and the CZK/EUR exchange rate. Source: reproduced here courtesy of Czech National Bank.

[...] had a serious effect on the exchange rate which I think is part of the reason that we succeeded in having a relatively short recession." Levinson (2010).[8]

Thomas Jordan, the governor of the Swiss National Bank, remarked in his 2020 Camdessus Lecture at the IMF that: "in Switzerland the upward pressure on the franc was the main reason for the at times very low inflation. Against this backdrop, for us, foreign exchange market interventions were and still are the most direct and thus the most effective instrument besides the negative interest rate. [...] Our experience shows that foreign exchange market interventions and the negative interest rate are essential for a small open economy with a safe-haven currency in a global low interest rate environment. The combination of these two monetary policy instruments is more effective and results in fewer undesirable side-effects overall than concentrating on just one of them." Jordan (2020).[9]

The theoretical literature on FX intervention has recently made much progress in understanding both under which conditions foreign exchange rate intervention can be effective and how it should be used optimally (see: Cavallino (2019); Amador, Bianchi, Bocola and Perri (2020); Fanelli and Straub (2020); Davis, Devereux and Yu (2020); Hassan, Mertens and Zhang (2020)). Here we focus on a sketch illustrating why, in a model of limited risk-bearing capacity, FX intervention is effective and its relation to private flows. The limited risk-bearing capacity of the financiers is at the core of the effects of FX intervention on exchange rates. Indeed, Backus and Kehoe (1989) show that in a general class of models in which currencies are imperfect substitutes due to risk premia, but in which importantly there are no financial frictions, sterilized FX interventions have no effect on the exchange rate.

Returning to our illustrative framework, we set most parameters at 1 for notational

[8]In context the expression "a serious effect on the exchange rate" is understood to mean prevented a strong appreciation of the Shekel.

[9]Governor Jordan's lecture at the IMF symbolizes well how far the policy consensus has moved on the use of FX intervention. The IMF had traditionally advocated the "Washington consensus" prohibiting the use of capital controls and FX intervention. For the governor of a central bank overseeing one of the most liquid currencies in world markets to advocate so clearly the use of FX intervention in an IMF flagship lecture is a significant event.

simplicity: e.g. $\iota_0 = \xi_t = a_t = a_0^* = \beta = \beta^* = 1$. We allow ι_1 to be stochastic (keeping $\mathbb{E}[\iota_1] = 1$, and setting $a_1^* = \iota_1$ for symmetry) so that currency trading is risky.

At time 0, the Japanese government intervenes in the currency market vis-à-vis the financiers: it buys q^* dollars and sells q^*/e_0 yen. The analogy with private flows discussed above shows that we obtain the following result (as the government creates a flow $f^* = q^*$ in the currency market): If the Japanese government buys q^* dollars and sells q^*/e_0 yen at time 0, the exchange rates satisfy $e_0 = 1 - \frac{\Gamma}{2+\Gamma} q^*$, and $e_1 = 1 + \frac{\Gamma}{2+\Gamma} q^* + \{\iota_1\}$, with $\Gamma = \gamma \, var(\iota_1)^\alpha$.

In the absence of frictions, if $\Gamma = 0$, there is no effect of the intervention on the exchange rate. Correspondingly, the potency of the intervention is strictly increasing in the severity of the frictions: the higher the Γ, the more the exchange rate moves for a given size of the intervention. Intuitively, FX intervention is, all else equal, more powerful in shallow markets like emerging economies, or when financial markets are deeply constrained, like in a crisis or flight to safety episode.

One way to give theoretical foundations to the statements by policymakers reported above is to return to the model with production and PCP. Assume that in the short run, i.e. period $t = 0$, Japanese tradables' prices are sticky in domestic currency; prices are flexible in the long run, i.e. period $t = 1$. We postulate that at time zero the price is downward rigid at a level $\overline{p}_F^*$ that is sufficiently high as to cause unemployment in the Japanese tradable sector. US tradable prices are assumed to be flexible. This captures a situation in which one country is in a recession, with high slack capacity and unemployment, so much so that its output is demand driven. A Japanese government currency intervention, whereby the government buys $q^* \in [0, \overline{q}^*]$ worth of Dollar bonds and sells q^*/e_0 yen bonds at time zero, depreciates the Yen and increases Japanese output. $\overline{q}^*$ is the smallest intervention that restores full employment in Japan. The intervention distorts consumption with the consumption shares determined by: $\frac{C_{H,t}^*}{L} = s_t^*$ and $\frac{C_{F,t}}{Y_{F,t}} = 1 - s_t^*$ with $s_t^* = \frac{e_t}{1+e_t}$ for $t = 0, 1$.

There are two preconditions for this intervention analysis. The first one is that prices are sticky (fixed) in the short run at a level that generates a fall in aggregate demand and induces an equilibrium output below the economy's potential. This condition, i.e. being in a *demand driven* state of the world, is central to the Keynesian analysis in which a depreciation of the exchange rate leads to an increase in output via an increase in export demand. If this condition is satisfied, a first order output loss would occur even in a world of perfect finance. The second precondition is that financial markets are imperfect, i.e. $\Gamma > 0$. Recall that the ability of the government to affect the time-zero exchange rate is proportional to Γ. When markets are frictionless ($\Gamma = 0$) the government FX policy has no effect on the time-zero exchange rate, even if prices are sticky, because financiers would simply absorb the intervention without requiring compensation for the resulting risk.

The model suggests that intervention is best used in countries with relatively shallow FX markets, or in those situations in which financial intermediaries are temporarily very constrained. It also clarifies the relevant stock of assets to affect: the balance sheet of financial institutions. The earlier literature on portfolio balance had instead focused on the stock of outstanding assets in different currencies, which is often much bigger than those held by financial players, making it quantitatively less plausible that interventions could be effective. Finally, the model stresses the nature of FXI as a risk transfer from the private sector to the central bank. Since the key point is to transfer the risk, FXI can be implemented with derivatives (like currency swaps and forwards) without necessarily having to have the bonds themselves on the balance sheet of the central bank. Indeed, in recent years interventions in the derivatives market have become commonplace for most central banks.

FX intervention might also be combined with forms of capital controls that increase market segmentation. A simple way to explore this idea is to introduce a proportional (Japanese) government tax on each financier's profits. Recall the imperfect intermediation problem illustrated above, we now assume that the after-tax value of the intermediary is $V_t(1-\tau)$, where τ is the tax rate. The financiers' optimality condition, derived in a manner entirely analogous to the optimization problem in equation (10), is now: $Q_0 = \frac{\mathbb{E}\left[e_0 - e_1 \frac{R^*}{R}\right](1-\tau)}{\Gamma}$.

This is equivalent to changing Γ to an effective $\Gamma^{\text{eff}} \equiv \frac{\Gamma}{1-\tau}$, so that the financiers' demand can be rewritten as $Q_0 = \frac{\mathbb{E}\left[e_0 - e_1 \frac{R^*}{R}\right]}{\Gamma^{\text{eff}}}$. Recall that the effect of currency intervention on the exchange rate is bigger the lower the financiers' risk bearing capacity (the higher the Γ). It follows that a tax on finance or a capital control, by implicitly reducing risk-bearing capacity, increases the potency of FX intervention.

There are, of course, many other rationales for intervening, including at the opposite end of the spectrum preventing contractionary exchange rate depreciations. Intervention might target more complex dynamics of the exchange rate than the level analyzed above; for example, intervention might target inefficiently high volatility of the exchange rate rather than the level. However, the limits to currency market intermediation remain a core foundation for this policy. Recently, the IMF moved its traditional policy stance that discouraged the use of FX intervention. The new Integrated Policy Framework of the IMF includes FX intervention as a stabilization tool to be used jointly with monetary policy, macro-prudential regulation, and capital controls. Basu, Boz, Gopinath, Roch and Unsal (2020) provide a conceptual model as a foundation of the new IMF policy framework in which FX intervention is predicated on the presence of segmented currency markets.

Evidence and Some Practical Considerations. Empirical evidence on the effectiveness of FX intervention is limited by the thorny issue of endogeneity. For example, if central banks intervene to stem appreciation, even successful interventions that prevent (further) appreciation might appear to be counterproductive in an analysis that does not account for the endogeneity. The concern is apparent in Figure 2. In all three cases, the central banks are intervening against currency appreciation and stop or slow the intervention when they perceive the exchange rate to be above their targeted level.[10] A further consideration is the size and duration of the intervention. Small interventions at high frequency might have very different outcomes from the protracted and large interventions observed in recent years by

[10]For Israel and the Czech Republic the figure uses FX purchases by the central bank. For Switzerland, instead, it uses changes in the total value of FX reserves held at the central bank.

Switzerland and Israel, as discussed above.

An early empirical literature, that mostly focused on interventions of smaller size, found mixed results and is summarized by Sarno and Taylor (2001). A classic study by Dominguez and Frankel (1993a,b) finds empirical support for the effect of foreign exchange rate intervention via a portfolio balance channel. More recently, Blanchard, de Carvalho Filho and Adler (2014), Fratzscher, Gloede, Menkhoff, Sarno and Stöhr (2019b), Fratzscher, Menkhoff, Sarno, Schmeling and Stoehr (2019a), and House, Proebsting and Tesar (2021) find evidence that FX intervention is effective.

Ben Bernanke famously said of quantitative easing (QE) that "it works in practice, but not in theory". For FX intervention, a policy in many ways similar to QE, we can say that it works in theory, that many policy makers are convinced it works in practice, but that high quality causal evidence is still missing.

There are many open areas for future work. On the empirical side, more policy evaluation that makes progress on endogeneity is a crucial endeavor. On the theoretical side, many features that are of important practical consideration are mostly absent from the current models. I will highlight below two directions that I find particularly interesting:

(1) The Lucas Critique and FX market deepness. As FX intervention becomes part of the policy toolkit and especially if interventions are predictably sustained over a long period of time, one should expect the structure of the FX market to adapt endogenously. One policy concern is that FX intervention might disincentivize private companies from building up their ability to deal with foreign exchange risk. This concern is particularly present in emerging and frontier economies where it could slow down the development of a local FX market. At the opposite end, one could imagine that central bank interventions that prevent market breakdowns might ensure the necessary conditions for private players to enter the market and deepen its liquidity. In the framework above a number of these considerations could be analyzed by further endogeneizing the financial frictions (Γ) with entry and exit of the financiers.

(2) One particularly important area is the political economy of these new tools and the chance that they might be abused by policymakers. One might conjecture that FX intervention is less likely to be abused than capital controls to generate fiscal revenue since the revenue is uncertain and might even turn out to be negative. The potential losses of FX intervention bring up the possibility that the central bank might lose its independence. Similarly, vast reserve accumulation and management come with issues on how they are allocated, and whether the allocation should include ethical considerations in addition to pure return and risk ones. These are likely to be important themes for future literature.

Conclusions

I have reviewed recent advances in open economy analysis under segmented international markets. This type of analysis has recently boomed as a modeling tool to understand financial crises, the ensuing policy response (i.e., QE and FX intervention), deviations from arbitrage (CIP deviations), and, more generally, the impact of capital flows on exchange rates. It has also shed a different light on classic topics such as the exchange rate disconnect, the Backus and Smith risk-sharing condition, UIP failures, and the carry trade. Much remains to be done on the theoretical side, especially in quantifying the effects of market segmentation and policy intervention. Even more space for progress is available on the empirical side: understanding the positions of global financial institutions and the impact of policy interventions.[11]

References

Amador, Manuel, Javier Bianchi, Luigi Bocola, and Fabrizio Perri, "Exchange Rate Policies at the Zero Lower Bound," *The Review of Economic Studies*, 2020, *87* (4), 1605–1645.

[11] On the positions of global financial institutions see Maggiori et al. (2020, 2019), Coppola et al. (2020), Lilley et al. (2020).

Backus, David K. and Patrick J. Kehoe, "On the Denomination of Government Debt: A Critique of the Portfolio Balance Approach," *Journal of Monetary Economics*, May 1989, *23* (3), 359–376.

Basu, Suman Sambha, Emine Boz, Gita Gopinath, Francisco Roch, and Filiz Unsal, "A Conceptual Model for the Integrated Policy Framework," 2020.

Bianchi, Javier and Guido Lorenzoni, "The Prudential Use of Capital Controls and Foreign Currency Reserves," *Chapter in Handbook of International Economics*, 2021.

BIS, "Monetary policy frameworks in EMEs: inflation targeting, the exchange rate and financial stability," in "Chapter in BIS Annual Report" 2019.

Blanchard, Olivier, Irineu de Carvalho Filho, and Gustavo Adler, "Can Sterilized Foreign Exchange Intervention Stem Exchange Rate Pressures from the Global Financial Cycle?," *Unpublished Manuscript*, April 2014.

Branson, William H and Dale W Henderson, "The specification and influence of asset markets," *Handbook of international economics*, 1985, *2*, 749–805.

Broner, Fernando, Alberto Martin, Lorenzo Pandolfi, and Tomas Williams, "Winners and Losers from Sovereign Debt Inflows," *NBER Working Paper*, 2020, (w27772).

Cavallino, Paolo, "Capital Flows and Foreign Exchange Intervention," *American Economic Journal: Macroeconomics*, 2019, *11* (2), 127–70.

Coppola, Antonio, Matteo Maggiori, Brent Neiman, and Jesse Schreger, "Redrawing the Map of Global Capital Flows: The Role of Cross-Border Financing and Tax Havens," Technical Report, National Bureau of Economic Research 2020.

Davis, Scott, Michael B Devereux, and Changhua Yu, "Sudden Stops and Optimal Foreign Exchange Intervention," *NBER Working Paper*, 2020, (w28079).

Dominguez, Kathryn M and Jeffrey A Frankel, "Does Foreign-Exchange Intervention Matter? The Portfolio Effect," *American Economic Review*, December 1993, *83* (5), 1356–69.

Dominguez, Kathryn M. and Jeffrey A. Frankel, *Does Foreign Exchange Intervention Work?*, Institute for International Economics, 1993.

Dornbusch, Rudiger, "Expectations and Exchange Rate Dynamics," *Journal of Political Economy*, 1976, *84* (6), 1161.

Fanelli, Sebastian and Ludwig Straub, "A Theory of Foreign Exchange Interventions," *NBER Working Paper*, 2020, (w27872).

Forbes Magazine, http://www.forbes.com/sites/afontevecchia/2011/04/18/mantega-inflation-under-control-in-brazil-as-qe2-pressures-real/ 2011.

Fratzscher, Marcel, Lukas Menkhoff, Lucio Sarno, Maik Schmeling, and Tobias Stoehr, "Systematic Intervention and Currency Risk Premia," *Available at SSRN 3119907*, 2019.

Fratzscher, Marcel, Oliver Gloede, Lukas Menkhoff, Lucio Sarno, and Tobias Stöhr, "When is Foreign Exchange Intervention Effective? Evidence from 33 Countries," *American Economic Journal: Macroeconomics*, 2019, *11* (1), 132–56.

Gabaix, Xavier and Matteo Maggiori, "International Liquidity and Exchange Rate Dynamics," *Quarterly Journal of Economics*, 2015, *3*, 1369–1420.

Hassan, Tarek A, Thomas M Mertens, and Tony Zhang, "A Risk-Based Theory of Exchange Rate Stabilization," 2020.

House, Chris, Christian Proebsting, and Linda Tesar, "Czeching out the Effects of an Exchange Rate Intervention," *Working Paper*, 2021.

Jordan, Thomas J., "Small Country — Big Challenges; Switzerland's Monetary Policy Response to the Coronavirus Pandemic," *Speech for the 2020 IMF Michel Camdessus Central Banking Lecture*, 2020.

Kouri, Pentti J. K., "The Exchange Rate and the Balance of Payments in the Short Run and in the Long Run: A Monetary Approach," *Scandinavian Journal of Economics*, 1976, *78* (2), 280–304.

Levinson, Charles, "Interview Transcript: Stanley Fischer," Wall Street Journal. http://online.wsj.com/news/articles/SB10001424052702304510704575562410676436730 (accessed January 15, 2014) 2010.

Lilley, Andrew, Matteo Maggiori, Brent Neiman, and Jesse Schreger, "Exchange Rate Reconnect," *Forthcoming in Review of Economics and Statistics*, 2020, pp. 1–28.

Maggiori, Matteo, "International Macroeconomics With Imperfect Financial Markets," in "Handbook of International Economics," Elsevier, 2021.

Maggiori, Matteo, Brent Neiman, and Jesse Schreger, "The rise of the dollar and fall of the Euro as international currencies," *AEA Papers and Proceedings*, 2019, *109*, 521–26.

Maggiori, Matteo, Brent Neiman, and Jesse Schreger, "International Currencies and Capital Allocation," *Journal of Political Economy*, 2020, *128* (6), 2019–2066.

Nurkse, Ragnar, *International Currency Experience: Lessons of the Interwar Period* number 4, League of Nations, 1944.

Obstfeld, Maurice and Kenneth Rogoff, "Exchange Rate Dynamics Redux," *Journal of Political Economy*, 1995, *103* (3), 624–660.

Pandolfi, Lorenzo and Tomas Williams, "Capital Flows and Sovereign Debt Markets: Evidence from Index Rebalancings," *Journal of Financial Economics*, 2019, *132* (2), 384–403.

Sarno, Lucio and Mark P. Taylor, "Official Intervention in the Foreign Exchange Market: Is It Effective and, If so, How Does It Work?," *Journal of Economic Literature*, 2001, *39* (3), pp. 839–868.

Schmitt-Grohé, Stephanie and Martin Uribe, "Downward nominal wage rigidity, currency pegs, and involuntary unemployment," *Journal of Political Economy*, 2016, *124* (5), 1466–1514.

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