

Foreign Exchange Intervention

A Survey of the Literature

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Summary

The practice of central bank intervention for a time ran ahead of either compelling theoretical explanations of its use or persuasive empirical evidence of its effectiveness. Research accelerated when the emerging economy crises of the 1990s and the early 2000s brought fresh data in the form of urgent experimentation with intervention and related policies, and the financial crisis of 2008 propelled serious treatment of financial frictions into models of intervention.

Current intervention models combine financial frictions with relevant externalities: with the aggregate demand and pecuniary externalities that now inform macroeconomic models more broadly, and with the trade-related learning externalities that are particularly relevant for developing and emerging economies. These models characteristically allow for normative evaluation of the use of intervention, though most (but not all) do so from a single economy perspective.

Empirical advances reflect the advantages of more variation in the use of intervention, better data, and novel approaches to addressing simultaneity. Intervention is now widely seen as influencing exchange rates at least to some extent; and sustained one-sided intervention and its corresponding reserve accumulation appears to play a role in moderating exchange rate fluctuations, and in reducing the likelihood and damaging consequences of financial crises.

Key avenues for future research include sorting out which frictions and externalities matter most, and where intervention—and perhaps international cooperation—properly fits (if at all) into the blend of policies that might appropriately address the externalities.

Keywords: central bank intervention, sterilized intervention, exchange rates, currency crisis, foreign exchange reserves, international reserves, currency manipulation, currency wars, financial crises, uncovered interest parity

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1 Introduction

Foreign exchange market intervention, at its simplest, is the exchange of foreign currency-denominated assets for domestic currency by a monetary authority.^{1, 2} The main challenge of research in foreign exchange intervention is to elucidate the real effects of that asset exchange.

For a long time, many scholars, such as Bordo, Humpage, and Schwartz (2018), restricted the definition of foreign exchange intervention solely to episodes intended to influence exchange rates.³ Central banks routinely used foreign exchange intervention to maintain exchange rates during the Bretton-Woods era, and their use of it to target or manage exchange rates has continued since then—episodically in some countries and continually (sometimes one-sidedly, and controversially) in others.^{4, 5} However, central banks also enter the foreign exchange market for other reasons.⁶ They intervene to provide liquidity during market disruptions or to reduce exchange rate volatility.⁷ Or, particularly in emerging economies, they intervene to buffer the effects of capital flow reversals.⁸ They intervene in pursuit of inflation targets or to

¹ This definition excludes the sort of ‘intervention’ in the foreign exchange market that is undertaken through taxes on tradable or nontradable consumption, though such taxes do indeed affect the real exchange rate.

² The phrase ‘at its simplest’ sidesteps three issues. First, as will be discussed below, intervention is often combined with other transactions to yield an exchange of foreign assets for domestic interest-bearing assets rather than simply for domestic currency. Second, monetary authorities also intervene through derivatives markets. (See footnote 59 for additional discussion and related citations.) Third, in some countries, it is the Ministry of Finance or the Department of the Treasury that has the authority to make intervention decisions.

³ See also Neely (2011) and Humpage (2003); and, for a subtler—but still similarly limiting—definition, see Benes, Berg, Portillo, and Vavra (2013).

⁴ The term ‘central bank’ is used throughout this article, but here and in subsequent instances the statements about central bank intervention are applicable to monetary authorities in general, and sovereign wealth funds and other governmental entities are also sometimes relevant.

⁵ One-sided purchases of foreign exchange lead to the accumulation of foreign reserves and are discussed in the ‘Foreign Reserve Accumulation’ section below.

⁶ BIS surveys of central banker officials provide some insight into the motivations for intervention; see, for example, Moreno (2005), Mohanty and Bat-el Berger (2013), and Patel and Cavallino (2019).

⁷ See, for example Neely (2011) who documents intervention by the G7 in response to “excess volatility and disorderly movements” following the Tohoku earthquake of 2011.

⁸ Ghosh, Ostry, and Qureshi (2017) document the emerging economy use of foreign exchange intervention (among other policies) to offset capital flow reversals. See also Domanski, Kohlscheen, and Moreno (2016), and Frankel (2019).

meet other domestic objectives—as was demonstrated when interest rates neared effective lower bounds after the 2008 financial crisis and again during the pandemic, and central banks intervened to make the foreign exchange market a fresh arena for unconventional monetary policy.

Whatever the motivations that lie behind intervention, it is an often-used tool of policy. Yet, it has been a practice that for a long time ran ahead of either compelling theoretical explanations of its use or persuasive empirical evidence of its effectiveness.⁹

Both theory and empirics are now making strides. Substantial theoretical advances have occurred in tandem with the post-2008 surge of research exploring the interplay between financial frictions and central bank policies more broadly. And, since the emerging economy crises of the 1990s and early 2000s, large increases in the scale of intervention (combined with new empirical approaches) have made its effects more evident. The new work has begun to illuminate the uses of intervention and to clarify its underlying mechanisms and their welfare implications. Before discussing that new work, some aspects of the implementation of intervention and the earlier literature may be worth reviewing.

2 Sterilized and Unsterilized Intervention

The implications of intervention depend in large part on how it is mixed with other policy tools, such as domestic monetary operations, capital account regulations, and macroprudential policies. Importantly, intervention’s effects depend on how it is combined—even in just a mechanical sense—with the other balance sheet operations of monetary policy.

Foreign exchange intervention is operationally comparable to a central bank’s domestic balance sheet transactions: It is similar to domestic open market operations,

⁹ See Bordo, Humpage, and Schwarz (2012) for a skeptical discussion of the U.S. experience with intervention between 1973 and 1995.

which exchange the central bank’s currency for a limited range of short-term securities. Likewise, it is similar to unconventional monetary policy operations, which exchange central bank liabilities for longer-term bonds and risky assets.¹⁰ Just as a central bank’s domestic balance sheet operations affect the money supply, foreign exchange intervention, when it is used on its own, also affects the money supply and (in usual times) the corresponding policy rate.

However, intervening central banks often use countervailing open market operations (or unconventional monetary policy operations) to undo the effect of the foreign exchange intervention on their domestic monetary conditions. These offsetting domestic balance sheet operations ‘sterilize’ the intervention’s impact on the money supply and the central bank’s policy rate, leaving both unchanged. Sterilized intervention then changes only the composition of the central bank’s assets. That is, unsterilized intervention changes both the money supply and the policy rate. Sterilized intervention changes neither. For some central banks, the primacy of their domestic monetary targets means they automatically—endogenously—sterilize fully.

The effect of unsterilized intervention on the nominal exchange rate, like that of other money supply changes, has been taken for granted; but it has not been seen as a distinct monetary tool. Only sterilized intervention—divorced as it is from changes in the money supply—seemed to hold out the promise of a policy tool that might allow the central bank more scope to pursue additional objectives. Thus, research into foreign exchange market intervention, as distinct from monetary policy in general, chiefly explored (and much of it still explores) sterilized intervention.

Early theoretical research on sterilized intervention focused almost exclusively on how it affected the exchange rate, and two approaches dominated. One approach

¹⁰ Some authors, such as Céspedes, Chang, and Velasco (2017), and Chang (2019), go further: they characterize foreign exchange intervention as a constituent part of unconventional monetary policy. Lízal and Schwarz (2013) describe this in the context of Czech monetary policy. Carrasco and Hoyle (2021) note that foreign exchange intervention in emerging economies differs from unconventional policy in that it may be relevant more often because of additional financial constraints that bind in emerging economies even in periods where the effective lower bound is irrelevant.

emphasized financial frictions and the other emphasized incomplete information. In the first, exemplified by Kouri (1976), Kouri and de Macedo (1978), Henderson and Rogoff (1982), and Branson and Henderson (1985), researchers explored how the then modestly sized (relative to foreign exchange market turnover) interventions could affect the exchange rate by inducing portfolio rebalancing in the private sector in the presence of various forms of market segmentation.¹¹ In the second approach, researchers studied sterilized intervention’s informational role—mainly in terms of its provision of a signal of future monetary policy, as suggested by Mussa (1981), but also in terms of how it played out within the microstructure of the foreign exchange market, as described in Dominguez (2003) and in Lyons (2001).¹²

Much current theoretical research on sterilized intervention follows up on the earlier work on portfolio rebalancing (and some follows up on informational imperfections). However, research now examines the mechanisms in the context of richer models of the economy. These richer models capture deeper motivations for using intervention to influence the exchange rate and other variables, and they make it possible to derive some (albeit, model-specific) welfare implications of sterilized intervention.

Alongside these richer models of sterilized intervention, an interest in unsterilized intervention has entered the mix. The emerging interest in understanding the role of unsterilized intervention largely reflects the prevalence of two central bank practices: foreign reserve accumulation and unconventional monetary policy. Both practices make the distinction between sterilized and unsterilized intervention less salient than in other contexts.

Purchases of foreign exchange cause foreign reserves to accumulate regardless of whether or not the purchases are sterilized. So, research into foreign reserve

¹¹ For early background on the portfolio balance approach, see Tryon (1983).

¹² For an early microstructural approach to modeling the welfare effects of a signaling role, see Popper and Montgomery (1999), who endogenized the central bank’s informational advantage; and see Peiers (2012) for related empirical work.

accumulation (discussed in its own section below) can encompass a consideration of both sterilized and unsterilized intervention.

Regarding unconventional monetary policy: as with other asset purchases, neither sterilized nor unsterilized foreign exchange purchases can lower a policy rate that is already at its lower bound. So, the idea that only unsterilized, not sterilized, purchases of foreign exchange affect the policy rate becomes an irrelevant distinction under such conditions. Perhaps more importantly, much research on unconventional monetary policy—particularly the research exploring its welfare implications—focuses on the interplay between financial frictions and the composition of the asset side of the central bank’s balance sheet. Both sterilized and unsterilized intervention alter the asset composition, and the welfare implications of both likewise depend on their interplay with financial frictions.

3 Models of Intervention with Financial Frictions

The 2008 financial crisis marked a watershed in the approach to modeling financial frictions and their relevance for international macroeconomics in general and for foreign exchange intervention in particular.¹³ Prior to the crisis, central bankers practiced foreign exchange intervention, but academics struggled to adequately explain it. Intervention research took place against the backdrop of the macroeconomic progeny of Modigliani and Miller, where infinitely lived, rational agents without credit constraints viewed central bank swaps of assets as indistinguishable from their own. Wallace’s (1981) aptly titled, ‘A Modigliani-Miller Theorem for Open-Market Operations’ was eventually followed by Backus and Kehoe’s (1989) irrelevance proposition for sterilized intervention.¹⁴

¹³Related insights came earlier to scholars and policy makers exploring the issues surrounding capital market regulations in emerging economies, particularly after the Asian Crisis of the 1990s and amid waves of emerging economy capital flows in the naughts. See Korinek (2011) for a review of the related literature on the prudential use of capital market regulations. For an early survey of the broader impacts of the crisis on macroeconomic modeling, see, for example, Caballero (2010).

¹⁴ See also Sargent and Smith (1987).

The flurry of work in the 1970s and the 1980s on intervention's portfolio balance mechanism had drawn its conclusions from models of agents' asset demands. That work, with its focus on market segmentation and asset preferences, presaged the recent close attention to financial frictions. But, by and large, the empirical evidence for intervention's effectiveness at the time was weak;¹⁵ and Backus and Kehoe compellingly argued that the work on asset demands was one sided: it failed to adequately model the government's budget constraints. Putting together both sides with the models of the day yielded Backus and Kehoe's result that without changes in monetary or fiscal policy, intervention had no effect.

Today's richer models include both a private sector, as in the earlier portfolio balance literature, and the government sector, as in Backus and Kehoe; but they also include a specification of the financial intermediation that links the two in new and meaningful ways.¹⁶ While the *raison d'être* of the financial sector is to enhance risk sharing, explicit models of financial intermediation make it possible to characterize the frictions that can arise in that sector and to study their implications for the economy as a whole.¹⁷ Models of intervention now characterize such frictions, show how they affect real variables, and explain how they might provide scope for intervention's effectiveness.

Key to these models is limited risk sharing. The models capture such things as limited participation in domestic and international financial markets, collateral constraints by households, banks, and other intermediaries, informational imperfections, or inflexible and distortionary taxes. Limited risk sharing renders domestic and foreign assets (and, private and public assets) imperfect substitutes. The imperfect substitutability of domestic and foreign assets often shows up in models as endogenous

¹⁵ For a survey, see Edison (1993).

¹⁶ In related approaches, Chang, Liu, and Spiegel (2015) and Prasad (2018) find a role for sterilized intervention when international capital markets are closed, and Devereux and Yetman (2014) rely on imperfectly integrated goods markets.

¹⁷ For a detailed survey of the role of financial frictions in the macroeconomy, see Brunnermeier, Eisenbach and Sannikov (2013). Also note that these research changes are not restricted to the monetary side of macroeconomic policy: Valerie Ramey (2019) describes how attention to heterogeneous agents and financial market frictions has altered our understanding of the efficacy of fiscal policy.

deviations from uncovered interest parity. With such frictions in international portfolio adjustments and between private and public assets, returns then depend on the relative asset supplies. By changing those relative supplies, a central bank’s foreign exchange intervention can have real effects.

Current intervention research emphasizes various aspects of the financial frictions. Collateral constraints or other balance sheet size constraints that limit intermediaries’ ability to bear risk feature prominently in Céspedes, Chang, and Velasco (2017), Gabaix and Maggiori (2015), Chang and Velasco (2017), Chang (2019), and Cavallo (2019).¹⁸ These collateral constraint-based models are particularly useful in providing insights into the episodic use and effectiveness of intervention in the presence of external capital flow changes, including sudden stops.¹⁹

Other work emphasizes—and variously characterizes—portfolio adjustment costs. Liu and Spiegel (2015), for example, derive intervention’s role when private agents incur costs when adjusting the shares of domestic and foreign assets in their portfolios. In early work, Ho (2008) derives intervention’s effects in a model where households’ bank deposits cannot be adjusted dynamically. In Benes, Berg, Portillo, and Vavra (2013), it is the costly adjustment of households’ bank borrowing that is relevant. Focusing on the financial implications of related frictions in the government sector, Kumhof and Van Nieuwerburgh (2007) and Kumhof (2010) show how fiscal rigidities give rise to an intervention effect.

Still others focus on informational imperfections. Carrasco and Hoyle (2021) examine intervention in a model where bankers have an incentive to secretly divert funds to their own private use.²⁰ Building on the earlier microstructure literature, Montoro

¹⁸ This approach builds on Greenwald and Stiglitz (1986), Bernanke and Gertler (1990) and the subsequent closed-economy literature that emphasized the aggregate importance of balance sheet effects.

¹⁹ They are also related to the literature on the conversion of ‘original sin’ vulnerability to a local currency bond market vulnerability, called ‘original sin redux’ by Carstens and Shin (2019). See also Aizenman (2019) and Hofmann, Patel, and Wu (2022).

²⁰ The model of Carrasco and Hoyle (2021) is closely related to Gabaix and Maggiori (2015) and similar to the collateral constraint models in that the relevant constraint is not always binding, and foreign exchange intervention is only effective when it does bind.

and Ortiz (2016) describe how intervention's effect arises in a model with noise traders and risk averse market makers. Fernholz (2015) examines how the effectiveness of intervention is related to the transparency of central bank interventions and market depth, particularly during crisis periods. Adler, Lama, and Medina (2016) examine intervention's role when agents only gradually learn about the central bank policy rules. Iovino and Sergeyev (forthcoming) build on recent work on the formation of higher order beliefs to understand intervention's effects.

While there is not yet a consensus regarding which frictions matter most, and in which countries and time periods they matter, these approaches have begun to clarify the potential theoretical underpinnings of the practice of foreign exchange intervention, and they provide guidance for promising new approaches to empirical work. Importantly, the models are now built on microeconomic foundations that allow for normative evaluations of the use of intervention.

4 Welfare Effects of Foreign Exchange Intervention

The evaluation of the welfare effects of foreign exchange intervention in these models is tied to the same kinds of distortions that are relevant for monetary policy, for macroprudential policy, and for capital account policies in the economy as a whole.²¹ Key to the distortions are risk-averse households and financial frictions, with related externalities. The externalities largely fall into two broad categories: aggregate demand externalities and welfare-relevant pecuniary externalities. In both sets of externalities, what may seem to individual agents like small costs and risks can ultimately have large, endogenous spillovers to the rest of the economy. Some models of intervention focus on positive externalities from the trade sector.²² However, intervention

²¹ The distortions are also relevant for fiscal policy, of course; but fiscal policy is less prominent in the related literature. That said, fiscal policy has a role in several important models of foreign reserve accumulation (sustained, one-sided intervention), as discussed in that section below; and it matters in intervention models with fiscal constraints.

²² For example, Benigno and Fornaro (2012) focus on knowledge spillovers from the imports of intermediary products that lead to a positive externality from traded goods production. In related work, Lama and Medina (2012) also describe a learning-by-doing in the trade sector. Likewise, Guzman, Ocampo, and Stiglitz (2018) provide a related, simplified model with learning externalities that may vary across potentially many sectors.

to promote the trade sector typically must be sustained and one-sided, so these types of models are discussed in the later section on foreign reserve accumulation.

In the first category, aggregate demand externalities, the distortions stem from nominal rigidities in goods and labor markets.²³ In open economy models, these nominal rigidities—and the corresponding aggregate demand externalities—often work at least in part through the trade sector. These rigidities result in the traditional aggregate demand-driven underemployment. In the second category, welfare-relevant pecuniary externalities, it is the effect of price changes, rather than price rigidities, that are problematic. These welfare-relevant pecuniary externalities are described and categorized in Dávila and Korinek (2017).²⁴ In the absence of complete markets, the pecuniary externalities typically result in excessive exchange rate appreciation and overborrowing in periods when consumption is high (for example, when foreign capital inflows are high), but they result in both subsequent excessive depreciation and subsequent excessive deleveraging in what sometimes turn out to be financial crises.²⁵

The usefulness of foreign exchange market intervention in addressing these externalities depends not only on the precise nature of the financial frictions, but also on the implementation of the other macroeconomic, prudential, and capital account policies. Thus, evaluations of the welfare effects of foreign exchange intervention are intertwined with the uses of those other policies. Unifying assortments of distortions with assortments of policies to draw compelling welfare conclusions is an area of ongoing research.

²³ These nominal rigidities are detailed in the models of Farhi and Werning (2016), though they do not focus on foreign exchange intervention per se.

²⁴ Dávila and Korinek divide the pecuniary externalities into what they call distributional externalities and collateral externalities. In the absence of complete markets, the distributional externalities prevent agents from equating their marginal rates of substitution. Thus, the distribution of wealth is particularly salient in normative models of this kind, and representative agent models can be particularly problematic. With financial frictions, the collateral externalities always lead to overborrowing and subsequent destabilizing deleveraging.

²⁵ Such crises represent a form of Fisher's (1933) debt-deflation spiral, as reprised in Bernanke (1983) and Mendoza (2002 and 2006), among others.

That said, some broad themes come to the surface in these models. First, in the presence of financial frictions and aggregate demand related distortions, flexible nominal exchange rates do not fully insulate economies from external financial factors. Instead, nominal exchange rate fluctuations can exacerbate the distortions, and foreign exchange intervention can in principle at least partly offset the distortions to improve welfare. This feature of nominal exchange rates and the corresponding role for foreign exchange intervention arises most naturally in models with dominant currency pricing, but it is present in many other models as well. Second, the financial frictions provide both part of a rationale for intervention and simultaneously a vehicle for its effectiveness. Indeed, both the rationale and the scope for intervention are greater when the frictions are greater (and when the asset markets are shallower). Third, the timing of foreign exchange intervention matters: intervention can play a role *ex ante*, during tranquil periods to reduce the risk of a subsequent downturn; and it can play a role *ex post*, to mitigate the damage of a downturn once it occurs.

These themes can be made more concrete by considering the models' implied optimal responses to foreign capital inflows (which the models typically treat as exogenous) in the context of other, related policies.²⁶ Models relying on some form of segmentation between domestic and foreign assets (with some additional private sector frictions) usually lead to the conclusion that the optimal foreign exchange intervention should at least partly offset capital inflows. The inflows would otherwise result in an excessive currency appreciation and excessive borrowing, which would ultimately contribute to problematic downturns.^{27, 28} While the policy mix implied by various models differs, foreign exchange intervention is useful in all of them.

²⁶ A number of papers conceive of exogenous changes in foreign capital flows as shocks to the 'foreign appetite for domestic currency'. See, for example, in Ilzetzi (2011), Daude Levy-Yeyati and Nagengast (2016) and Basu, Boz, Gopinath, Roch, and Unsal (2020).

²⁷ Rebucci and Ma (2019), and Erten, Ocampo, and Korinek (2019) summarize the closely related work on capital account regulations. Many authors formally model capital account regulation as a state contingent tax on capital inflows.

²⁸ The private sector frictions are needed to preclude the private sector from fully offsetting the intervention à la Ricardian equivalence.

In Cavallino’s (2019) model, with international financial intermediation frictions, the optimal foreign exchange intervention absorbs some of the capital flows, so it reduces their exchange rate impact. He shows that intervention of this type complements monetary policy. Liu and Spiegel (2015) provide a related, early example. In their model, sterilized intervention to offset the flows complements capital account regulations, making those regulations more effective. Other models include: Basu, Boz, Gopinath, Roch, Unsal (2020), where intervention, along with capital account regulations, make monetary policy more effective; Davis, Fujiwara, Huang, and Wang (2020), whose model yields an equivalency between foreign exchange intervention and capital account regulation (an important equivalency if continual changes to capital account regulations are called for but impractical to implement); and, Fanelli and Straub (2021), whose model includes an externality related to income distribution and implies that the usefulness of intervention requires central bank credibility.^{29, 30}

In these types of models, domestic financial crises (or potential crises) associated with capital outflows in turn call for central bank sales of foreign assets in exchange for domestic assets.³¹ At that point, the intervention often improves welfare by lessening or preventing excessive deleveraging. However, the expectation of that intervention creates a moral hazard that exacerbates excessive risk taking during the periods of capital inflow. Thus, ex post sales of foreign assets call for additional ex ante purchases. The combination of ex ante purchases and ex post sales also addresses a

²⁹ Relatedly, Benigno, Chen, Otrok, Rebucci, and Young (2016) carefully evaluate both *ex ante* capital account regulation that is used during tranquil times to prevent excessive borrowing, and *ex post* policies used to support the exchange rate during crises to prevent collateral collapse. They find that when there are costs to supporting the exchange rate, both policies should be used. (Without costs to exchange rate supports, those *ex post* supports should be used exclusively.) However, they model their exchange rate support as a tax on tradable or non-tradable consumption (which are rebated through lump sum transfers to prevent their bringing about other distortions) rather than—as defined throughout this review—as a change in the composition of the assets held by the central bank.

³⁰ See also Choi (2020), who emphasizes the interplay of intervention and the exchange rate regime.

³¹ The parenthetical ‘or potential crises’ is relevant both in models of sudden stops, where the intervention prevents a sudden stop by keeping the economy in a region where borrowing constraints do not bind, and in more continuous frameworks, where the intervention simply mitigates the impacts of capital flow changes.

practical matter: without the ex ante accumulation of reserves, ex post foreign exchange intervention usually becomes infeasible.³²

5 Challenges to Practical Implementation

Among these models, a particularly comprehensive one is that of Basu, Boz, Gopinath, Roch, and Unsal (2020), a team of authors from the International Monetary Fund. Their model brings together pieces from many other models, and it highlights several policy tradeoffs and their interactions under conditions that are most relevant for emerging and small open economies. Like the other models, theirs implies that the use of foreign exchange intervention can improve welfare; but they show that the prescriptions for intervention's use are not general. The implied optimal use of intervention needs to be tailored to each country's circumstances. It depends not only on a country's other policies, but—importantly—on a wide range of shocks and country characteristics, including such things as a country's trade invoicing paradigm, the depth of its foreign exchange markets, and its initial levels of domestic and foreign debt. This wide-ranging, micro-founded model helps to rationalize the variety of intervention policies observed in practice.

The outer bounds of the model's scope also hint at the remaining challenges to the implementation of such models.³³ The challenges are both formal and practical. At a formal level, implementation calls for more complete treatments of interactions among countries, of intervention's longer-term implications, and of its policy constraints. In practical terms, implementation of the normative prescriptions would require a great deal of information. It would also require coordination within a

³² The 'usually' is here to reflect the important caveat that central banks at times can use derivatives, including swap lines, to have a similar effect without explicitly changing their holdings of foreign reserves. Baba and Shim (2010) discuss the effectiveness of the Bank of Korea's use of the U.S. Federal Reserve's swap line during the 2008 financial crisis. Obstfeld, Shambaugh, and Taylor (2009) discuss the uses of swap lines more broadly at that time, as do Rose and Spiegel (2012). For more recent discussions of swap lines, see Bahaj and Reis, (2021), McCauley and Schenk (2020), Choi, Goldberg, Lerman, and Ravazzolo (2021), and—particularly with regard to their use during the pandemic—Aizenman, Ito, and Pasricha (2021). For further discussions of the use of derivatives in implementing intervention, see footnote 59.

³³ Many authors of such studies (including Basu, Boz, Gopinath, Roch, and Unsal, 2020) themselves touch on a number of these challenges.

country’s own governmental agencies, and communication with the private sector to establish and maintain credibility and to address broader, related political issues.

In terms of international interactions, small economy models per se are not equipped to incorporate the treatment of international spillovers. Korinek (2017) provides a general framework for consideration of such international spillovers and enumerates the requisite conditions for cooperation to be potentially beneficial. Fanelli and Straub (2021) demonstrate one approach to extending a small open economy model to incorporate foreign exchange intervention’s spillover effects to the rest of the world.³⁴ In their extended model, countries buy foreign exchange when world interest rates are low; and those purchases cause world interest rates to fall further, which induces additional intervention. In equilibrium, countries over-purchase reserves through beggar-thy-neighbor interventions. This effect alters overall normative evaluations, and it is not captured in pure small open economy models. Two-country models, such as Adler, Lama, and Medina (2019) can also capture these spillovers. In practical terms, by missing such international implications, small open economy models uncomfortably sidestep the recurring political concerns around ‘currency wars’, such as those described in Dooley, Folkerts-Landau, and Garber (2004), Aizenman and Lee (2007), Bergsten and Gagnon (2012 and 2017), Gagnon and Sarsenbayev (2021), Hassan, Mertens, and Zhang (2016), and those regularly evident in U.S. Treasury reports to Congress.³⁵ A sustained real depreciation requires substantial, one-sided intervention, and the section below on foreign reserves provides additional discussion of accumulated intervention’s international spillovers.

In terms of intervention’s longer-term implications and policy constraints, there are layers of endogeneity that are largely outside the formal scope of many current

³⁴ Jeanne (2021) provides a multi-country model with (among many things) taxes on capital flows, which he interprets as corresponding to foreign exchange intervention—rather than the more typical interpretation that such taxes correspond to capital account regulation. (Indeed, the two are equivalent in his model.) In Jeanne’s model, ‘intervention’ has a zero-sum effect, but it is not welfare reducing. Other aspects of his model are discussed in the ‘Foreign Reserve Accumulation’ section below. For a detailed and comprehensive model that allows for policy spillovers but is not explicitly microfounded, see Adrian, Gaspar and Vitek (2022). For a more traditional model, see Blanchard (2021).

³⁵ See, for example, the discussion of currency manipulation in U.S. Treasury (2021).

models. Yet those layers of endogeneity ultimately will matter for intervention’s appropriate implementation over time. Model’s assumed parameters, a central bank’s constraints, and a country’s susceptibility to what might seem at a single point in time to be fundamental shocks may all be endogenous to that country’s regular use of intervention. That is, numerous model characteristics that are treated as exogenous plausibly change over time in response to the conditions brought about by intervention.³⁶ In a number of models, for example, a single exogeneous parameter ultimately captures a country’s foreign exchange market depth. That depth reflects such things as the development of debt instruments and hedging instruments. By smoothing exchange rate volatility, intervention can alter the pace of the development of those instruments over time. It would thereby change the future path of foreign exchange market depth. Likewise, intervention might affect the propensity for a country to be subjected to various seemingly exogeneous shocks.³⁷ Finally, while several models capture the carrying cost of foreign exchange intervention, fewer models explain why (and for how long) the central bank is able to circumvent the kinds of financial constraints the private sector faces.³⁸

In practice, sustained policies also require political support. Complex policies—with state-contingent implementation that varies based on shocks and parameters that are not directly and widely observable—are challenging to communicate and verify.³⁹ So, they do not naturally engender support. Implementation of such policies requires establishing and maintaining credibility, particularly in the presence of

³⁶ See, for example, Kim, Mano, and Mrkaic (2020) and Tong and Wei (2021) for empirical evidence of the effect of intervention on foreign exchange debt and corporate leverage.

³⁷ Of course, models vary in terms of what additional aspects they endogenize. Céspedes and Chang (2020), for example, endogenize the probability of a crisis. Additionally, as discussed below in the section on foreign reserve accumulation, empirical evidence suggests that sustained intervention does affect the probability of a crisis.

³⁸ Models in which the central bank incurs a cost when intervening do at least implicitly touch on such issues in that the cost may be interpreted in part as representing potential harm to central bank credibility and independence.

³⁹ Gelos, Gornicka, Koepke, Sahay, and Sgherri (2019) note that central bank transparency, itself, provides some protection from capital flow volatility.

broader, related political issues.^{40, 41} Practical implementation of foreign exchange intervention may require trading off some theoretical efficiency for simplicity or observability.⁴²

6 Empirical Studies of Intervention

While micro-founded analytical models do not themselves offer much immediate quantitative guidance to policy makers, they do provide fresh insights for empirical researchers. Importantly, they have implications for which countries and, in some cases, which time periods we should expect intervention to be effective. In addition, by specifying the nature of frictions, the new models deliver distinctive testable implications. Finally, by providing structure, the current models offer potential alternatives to the reduced form empirical approaches that have been particularly vulnerable to simultaneity bias.⁴³ Empirical work has been increasingly incorporating this needed structure as well as attending more carefully to appropriate measurement of intervention.⁴⁴

⁴⁰ Much of the literature discussed here is in the spirit of the concerns about emerging economy credit discussed in Calvo and Reinhart (2002); however, this particular concern about policy complexity instead represents a reprise of that paper's other explanation of countries' 'fear of floating': namely, a concern about policy credibility.

⁴¹ Implementation may also entail potentially challenging cooperation among the multiple governmental units typically authorized to implement the interwoven policies; and, as noted by Rodrik and Subramanian (2009), government capacities are themselves constrained, and this resource-demanding implementation has opportunity costs.

⁴² The tradeoff may not always be stark. That is, optimal policies in some cases may be close to simple rules of thumb. Jeanne and Rancière (2011), for example, show that their model's optimal level of reserves is close to (in one case, it is identical to) that implied by the Guidotti-Greenspan Rule. Likewise, Arce, Bengui, and Bianchi (2019) show that a simple rule based on observable variables corresponds in several ways to their optimal reserve accumulation policy. The central banks of a number of emerging economies have adopted transparent, rule-based intervention policies. (Two are discussed in the empirical section below.) Lafarguette and Veyrune (2021) describe some of the key issues. Examining the tradeoffs for such rules in the context of specific micro-founded models would be informative.

⁴³ Like so much other empirical work examining the effects of macroeconomic policies, estimates of the effect of foreign exchange intervention must address the problem of simultaneity. Intervention is both intended to affect and affected by the exchange rate and related variables. Thus, naïve estimates will be biased and typically will mask intervention's effect.

⁴⁴ For discussions of some approaches to appropriate measurement, see Dominguez, Hashimoto, and Ito (2012), Fratzscher, Heidland, Menkhoff, Sarno and Schmeling (2020), and Adler, Chang, Mano, and Shao (2021).

6.1 Advanced Economy Empirics

For many years, evidence of the effectiveness of foreign exchange intervention was unpersuasive. The initial, post-Bretton Woods empirical work focused on the exchange rate effect in advanced economies. The findings through the 1980s seemed to indicate that under most circumstances, intervention had only a short-lived effect on exchange rates. A measurable effect only appeared to be sustained when intervention was concerted among central banks, and when it was in some sense consistent with their other policies.⁴⁵ Work by Dominguez (1990), Ghosh (1992), and Dominguez and Frankel (1993) provided early counterpoints to that view; and the findings of empirical studies throughout the remainder of the decade were increasingly mixed as the range of approaches widened.

By the naughts, the problem of simultaneity was being more consistently addressed, and many central bankers expressed the view that intervention was effective.⁴⁶ Nevertheless, the conclusion that sterilized intervention in advanced economies had only limited effects on exchange rates prevailed in empirical studies published prior to the 2008 financial crisis. For example, using an event study to identify the effect of Japanese intervention, Fatum and Hutchison (2006) found that the Bank of Japan's intervention had only short-term exchange rate effects, though the effects were strengthened when intervention was undertaken in concert with the Federal Reserve. Kearns and Rigobon (2005) used changes in Australian and Japanese operational policies as an identification strategy; and they also found intervention to have a short-lived effect. Brandner, Grech and Stix (2006) used a Markov Switching model to capture the effects of intervention among a set of EMS countries, where they also found intervention's effect to be limited. More recent approaches to the simultaneity problem continue to provide conflicting results for advanced economies.⁴⁷

⁴⁵ See the 'Jurgensen Report' (Jurgensen, 1983) for a policy-focused assessment of the evidence at the time. For some of its empirical underpinnings see Henderson and Sampson (1983) and Rogoff (1984). See also the period surveys of Humpage (1991) and Edison (1993).

⁴⁶ See Neely (2000) for results from his survey of central bankers.

⁴⁷ For example, Dominguez, Fatum and Vacek (2013) take advantage of a sustained policy of selling foreign reserve by the Czech National Bank, and they find the impact on the Czech koruna depends on the operational aspect of the sales—whether they are discretionary and infrequent, or nondiscretionary and daily. Naef (2020)

Other empiricists, motivated by the microstructural aspects of foreign exchange intervention, use high-frequency data to study intervention's intra-day effects on the foreign exchange market conditions of (mainly) advanced economies. While these studies do not address intervention's persistent effects, they find that intervention affects the very short-term dynamics of the foreign exchange market.⁴⁸ In keeping with the model of Popper and Montgomery (2001), Peiers (1997) finds that intervention appears to be known by major traders up to an hour ahead of when it is known by the general public.⁴⁹ Likewise, with U.S. data, Dominguez (2003) finds that some traders appear to know of Federal Reserve intervention ahead of newswire reports of its occurrence. As predicted by the models of Vitale (1999) and Fernholz (2015), Beine, Bénéassy-Quéré, Dauchy and MacDonald (2007) find that intervention works through rumors in the euro-dollar market. Scalia (2008) finds that intervention increases the impact of order flow in the euro-koruna market. Chen and Gau (2015) find that intervention affects price discovery in the yen-dollar market. One might expect the very short-term market dynamics of intervention to be somewhat more pronounced in emerging economies, where liquidity is typically lower. Yet, even to date, there has been little work studying intervention's microstructural impacts in these economies, though interest in other aspects of foreign exchange intervention in emerging economies has grown.⁵⁰

6.2 *Emerging Economy Empirics*

relies for identification on Bank of England officials' own descriptions of market conditions for identification and finds their intervention to be ineffective. Menkhoff, Rieth and Stöhr (2021) rely for identification on differences in the endogeneity of initial and subsequent interventions, and they find that U.K., U.S., Euro, and Japanese intervention have substantial effects. Fratzscher, Gloede, Menkhoff, Sarno and Stöhr (2019) use a matching algorithm and find large interventions to be successful when publicly known.

⁴⁸ Dominguez, Fatum and Vacek (2013), discussed in the footnote above, is one cross-over exception: it uses intra-day data, and it has both microstructural implications, but it also captures somewhat longer term effects of intervention.

⁴⁹ See also Vitale (1999).

⁵⁰ Important exceptions include Canales-Kriljenko (2003), who describes the foreign exchange market microstructures of developing and transition economies, and Kuersteiner, Phillips, and Villamizar-Villegas (2018), discussed below in the section on 'Emerging Market Economy Empirics', who look at a range of channels of effectiveness in Columbia. See also Wu (2012), who estimates the impact of intervention in his broader study of the micro structure of the foreign exchange market in Brazil.

The development of modern, micro-founded international macroeconomic models with financial frictions has been driven since the 2008 financial crisis by the consequences of that crisis. However, the importance of financial frictions to the macroeconomy had already become salient before then in many emerging economies. Correspondingly, serious empirical work on foreign exchange intervention in those countries (along with antecedent theoretical modeling) had already begun. The East Asian Crisis of 1997 and subsequent emerging economy crises around the turn of the century involved sudden capital outflows and reductions of inflows that led to large, rapid depreciations and destructive deleveraging in many emerging economies. The crises highlighted the recurring conflict between a policy of defending the exchange rate to prevent further destructive deleveraging and a policy to stimulate the economy as the contractionary consequences of deleveraging unfolded.

Central banks in emerging economies used a range of tools to address this policy conflict during the crises. In particular, emerging economy central banks increased their use of foreign exchange intervention (with intervention sizes that were larger relative to their domestic bond markets than in advanced economies), and they accelerated their accumulation of foreign exchange reserves. (Research focusing on the effects of accumulated reserves—the result of sustained, one-sided intervention—is discussed in a separate section below.) Their experience with intervention motivated new empirical research to understand intervention’s emerging economy consequences, and it simultaneously provided data to facilitate that research.⁵¹ The empirical work has explored intervention’s effects on the exchange rate, as well as its broader countercyclical effects and the effects of reserve accumulation and corresponding concerns about global imbalances.

⁵¹ As episodes of intervention have increased, substantial progress in the provision of cross-sectional intervention data has also been made. For a long time, empirical work relied on changes in central banks’ reported holding of foreign exchange reserves. Those measures are affected by valuation and other changes unrelated to active intervention. See Adler, Chang, Mano, and Shao (2021) for a detailed discussion of measures of foreign exchange intervention and their dataset; and see Fratzscher, Heidland, Menkhoff, Sarno, and Schmeling (2020), for an intervention database constructed using a training algorithm in combination with confidentially provided intervention data and intervention-related news accounts.

The most basic empirical question about foreign exchange intervention is whether it can affect the exchange rate substantially, and for a meaningful period of time. While the results are not uniform in terms of size and longevity, the evidence of intervention's effectiveness in emerging economies is more persuasive than what had been observed earlier in studies of advanced economies alone. Still, findings vary with differing definitions and samples, as well as with differing approaches to addressing simultaneity and other challenges.⁵²

Several studies use panels that include emerging economies either exclusively or in a mixture with advanced economies. Daude, Levy Yeyati, and Nagengast (2014) use a panel that includes only emerging economies. Noting that the effects of intervention can be obscured by the desire to accumulate reserves for precautionary purposes, they adopt an unusual definition of intervention. Specifically, they use changes in the ratio of reserves to M2 in an attempt to purge from intervention the portion that is motivated by precautionary concerns.⁵³ Using that definition of intervention in a panel of 18 emerging economies from 2003 to 2011, they find intervention to be effective under several alternative specifications, including one specification that addresses simultaneity using instrumental variables.⁵⁴

Blanchard, Adler, and Filho (2015) are particularly interested in the ability of intervention to mitigate the effects of external capital flow shocks, and they address the simultaneity problem by identifying the portion of capital flow changes that are plausibly exogenous to each country.⁵⁵ In a panel of dozens of advanced and emerging economies from 1990 to 2013, they find that intervention affects exchange rates and is helpful in mitigating the effects of capital flow changes. Fratzscher, Gloede,

⁵² The empirical work summarized here for emerging economies appeared after the 2000s. See Menkhoff (2013) for an extensive survey of earlier work, much of which found more limited effectiveness than the later studies.

⁵³ Their definition of reserves is related to Adler, Lisack and Mano's (2019) instrumental variable approach. Both papers attempt to separate the precautionary purchases of foreign exchange from purchases more immediately directed at the exchange rate. The precautionary motive should reflect the size of the banking sector, hence the ratio of M2 to reserves is used both here and as an instrument in Adler, Lisack and Mano (2019).

⁵⁴ A key instrument is the ratio of M2 to GDP.

⁵⁵ Treating each country as a small, open economy, they estimate a vector autoregression for each county to derive the exogeneous shocks. They are then able to exploit the cross-sectional variation in the intervention responses to estimate a causal link between intervention and the exchange rate.

Menkhoff, Sarno and Stöhr (2019) address simultaneity by using a matching approach to construct counterfactuals.⁵⁶ Also using a panel of dozens of advanced and emerging economies (though comprised of a surprisingly different set) over roughly the same period, they find that large, well-communicated intervention appears to be effective. Using a larger sample (more than fifty countries), still over roughly the same period, Adler, Lisack and Mano (2019) address simultaneity using instrumental variables that are related to various intervention motives. They too find intervention to be effective. Additionally, their methods (using an error correction model) enable them to quantify the persistence of intervention’s effect. Notably, they find the effect to have a long half-life, one lasting approximately one to two years.

Many other emerging economy studies focus on a single country or a small set of countries. Of particular interest are the several studies that cleanly address the simultaneity issue or that compare the effectiveness of different intervention instruments. Among these are Chamon, Garcia, and Souza (2017) and Nedeljkovic and Saborowski (2019), who examine Brazilian intervention, and Kuersteiner, Phillips, Villamizar-Villega (2018), who examine Columbian intervention.

Chamon, Garcia, and Souza (2017) examine the effects of the announcement of a large Brazilian intervention program that followed the ‘taper tantrum’ of 2013. They take advantage of this sequence—an event study framework combined with an earlier shock shared by many other countries—to construct a synthetic control group as a way around the usual simultaneity problem.⁵⁷ They find that the Brazilian intervention program, executed via swaps, had a substantial effect on the Brazilian real. Notably, they emphasize a reassuring aspect of their results: the large intervention effects they observed—when scaled properly—are roughly comparable to that found in other Brazilian studies using more standard approaches to address endogeneity.⁵⁸

⁵⁶ This approach is related to the propensity scoring matching approach used by Fatum and Hutchison (2010), and to the synthetic control approach used in Chamon, Garcia and Souza (2017) and in Dominguez (2020).

⁵⁷ This approach uses the period prior to Brazil’s intervention operations to estimate the degree of financial openness and turn other countries into “controls” for counterfactual comparison after the Brazil’s announcement.

⁵⁸ From intervention that amounted to about 30 percent of Brazil’s foreign exchange reserves, the exchange rate change—relative to what it would have been—was close to 20 percent.

Nedeljkovic and Saborowski (2019) address the problem of simultaneity by using the most standard of methods: they use instrumental variables comprised of lagged values of exchange rates and closely related variables. What is particularly interesting about their study is that they directly compare the effectiveness of intervention via derivatives (as in Chamon, Garcia, and Souza) with intervention via standard, spot instruments.⁵⁹ While the standard spot intervention changes the central bank's holdings of foreign reserves, intervention in the derivatives market does not do so. Despite this difference, and despite the authors' finding that central bank uses the spot and derivatives markets for different reasons, the authors find both modes of intervention to be effective.⁶⁰

Kuersteiner, Phillips, Villamizar-Villega (2018) examine Colombian intervention.⁶¹ They, too, are able to more cleanly address the endogeneity problem. They begin with the observation that the Central Bank of Columbia had a fixed and observable intervention rule with a clear, discrete threshold for intervention.⁶² While the threshold is known to all market participants, it is not known each day whether the threshold will be met. Thus, with tick-by-tick order book data, the authors are able to use a regression discontinuity design to identify the causal effects of the intervention. They find that this intervention, which was largely aimed at reducing exchange rate volatility, had a significant, though short-term effect. They also note that the effects are asymmetric, and that interventions have a larger effect when—as measured by deviations from covered interest parity—capital controls and other frictions are most relevant. Several other central banks, most of them in Latin America, use pre-

⁵⁹ Central banks, particularly in Latin America, are increasingly relying on the use of derivatives to intervene in foreign exchange markets. Domanski, Kohlscheen, and Moreno (2016), and Chamon, Hofman, Lanau, Rawat and Vari (2019) catalogue the instruments used in foreign exchange intervention and provide examples of the central banks that use them. Keefe and Rengifo (2019) discuss the practice of using of currency option trading strategies in intervention.

⁶⁰ Kohlscheen and Andrade (2014) also document the effectiveness of the Bank of Brazil's swap interventions.

⁶¹ See also Echavarría, Melo-Velandia, and Villamizar (2018) who compare pre-announced and unannounced intervention in Columbia, and Keefe and Rengifo (2015), who find that Colombian intervention via derivatives is effective in reducing short-term exchange rate volatility.

⁶² Several other central banks, most of them in Latin America, use pre-specified intervention rules. See the articles in Chamon, Hofman, Magud, and Werner (2019) for detailed descriptions of Latin American intervention operations.

specified intervention rules. Chamon, Hofman, Lanau, Rawat and Vari (2019) provide detailed descriptions of such rules, along with many other aspects of Latin American use of foreign exchange intervention as a countercyclical policy tool.

7 Foreign Reserve Accumulation

As the central banks of emerging economies have intervened, they have purchased foreign exchange more often than not; in the process, they have accumulated foreign reserves.⁶³ Foreign exchange reserves grew in emerging economies from about five percent of GDP in 1990 to close to 30 percent of GDP by 2018;⁶⁴ and by mid-2021, emerging economies' reserves were nearing \$13 trillion.⁶⁵

The benefits of such reserve accumulation, of course, reflect the benefits of intervention: In the face of foreign capital inflows, a country's purchases of foreign exchange are thought to inhibit excessive leverage; and access to the resulting reserves, once accumulated, may reduce the likelihood of sudden capital flow reversals and enable a country to further smooth consumption in the face of such capital flow reversals or sudden stops.⁶⁶ In addition, the accumulation of foreign exchange reserves, while entailing some costs, is often seen as promoting a country's trade sector and future growth.⁶⁷

Whatever the net benefits of reserves to an individual country, sustained, one-sided interventions and their resultant reserve accumulation are not always viewed

⁶³ As noted by Cheung and Ito (2009), the surge in reserve accumulations since the 1990s has been essentially an emerging economy phenomenon; advanced economy reserves as a fraction of GDP have been relatively stable since then.

⁶⁴ See Arslan and Cantú (2019).

⁶⁵ IMF: <https://data.imf.org/?sk=E6A5F467-C14B-4AA8-9F6D-5A09EC4E62A4>

⁶⁶ For early work in this area, see Heller (1966), Clark (1970), and when the focus was on 'balance of payments' rather than 'capital flows', or Ben-Bassat and Gottlieb (1992) who tie reserves to sovereign risk.

⁶⁷ In another approach that is also (at least somewhat) distinct from macroprudential trade motivations, Jung and Pyun, (2016) provide a model in which accumulated reserves provide liquidity needed for the functioning of decentralized international financial markets.

favorably by other countries. Reserve accumulation is often pejoratively referred to as hoarding; and, intervention (particularly when seen as promoting the trade sector) is correspondingly branded as mercantilist, beggar-thy-neighbor currency manipulation—emblematic of a currency war. In this vein, the home country’s benefits are perceived as coming mainly at the expense other countries,⁶⁸ particularly its trading partners.⁶⁹

These two opposing faces of reserve accumulation—the potential net benefits to the accumulating country and the potential costs to others—are reflected in the ongoing theoretical and empirical research exploring the motivations, conduct, and implications of reserve accumulation. And, since foreign reserve accumulation entails ongoing intervention, studies of reserve accumulation are entwined with the studies of two-sided intervention. Like their two-sided intervention counterparts, small open economy models of foreign reserve accumulation typically bypass multilateral spillovers to explore particular internal benefits and costs in detail, while multi-country models capture the spillovers. As for empirical work, it has—like the empirical research on two-sided intervention—largely (though not exclusively) focused on emerging economies.

7.1 Models of Reserve Accumulation

⁶⁸ Of course, the same has been said of countries’ inward-focused monetary (and fiscal) policies, and the literature on such spillovers is large. Bodenstein, Corsetti, and Guerrieri (2020) model negative monetary spillovers and show that they can be large, especially when the magnitudes of countries’ net foreign asset positions are large. Interestingly, Jeanne (2021), discussed in more detail below, provides a model in which monetary stimulus has positive spillovers in general equilibrium despite negative spillovers in partial equilibrium. For a focused, careful empirical study of how monetary spillovers work through one particular channel—bank subsidiaries—see Spiegel (2022). For a broad overview, see Ammer, De Pooter, Erceg, and Kamin (2016). Other related examples of empirical studies providing evidence of monetary spillovers include: Aizenman, Chinn, and Ito (2016), Dekle and Hamada (2015), and Kalemli-Özcan (2019). For a general framework for consideration of international spillovers, see Korinek (2017), mentioned above in the section on challenges.

⁶⁹ As mentioned in the challenges section, such views are described by (among others): Dooley, Folkerts-Landau, and Garber (2004), Aizenman and Lee (2007), Bergsten and Gagnon (2012 and 2017), Gagnon and Sarsenbayev (2021), Hassan, Mertens, and Zhang (2016). 16And, as Dominguez (2020) has emphasized, it is the combination of large reserves and current account balances that prompt such accusations.

Several of the small economy models of reserve accumulation emphasize the growth externality in the trade sector. The externality stems from learning by doing or learning by investing in the trade sector; and its relevancy arises in models that (perhaps motivated by international agreements precluding trade subsidies) omit a mechanism to directly address the trade externality. In one such model, Begnigno and Fornaro (2012), the accumulation of foreign reserves depreciates the real exchange rate and shifts production to the trade sector, and the related benefits are magnified by the ability of the central bank to use reserves during crises. Importantly, in their model, the benefits are quite large. Korinek and Servén (2016) also focus on the trade-related externality in a small economy model. They combine a learning externality with capital account restrictions to flesh out the tradeoff between the short-term losses from reserve accumulation and the longer-term gains from the growth externality.⁷⁰ Faltermeier, Lama, and Medina (2022) generate a role for reserve accumulation by combining learning by doing with commodity prices disturbances. Also using a small economy model, Choi and Taylor (2017) let two parameters capture the trade externality and the crisis externality. They then show how these parameters affect the optimal accumulation of foreign reserves. It is worth noting that in many of the trade-promoting models of reserve accumulation, the promotion of trade comes at the expense of current consumption, either by households or by the government.

Eschewing the trade sector externality, the small, open economy models of Jeanne and Rancière (2011), Bocola and Lorenzoni (2020), Céspedes and Chang (2020), Davis, Devereux, and Yu (2021), and Arce, Bengui, and Bianchi (2019) focus on the usefulness of a country's reserve accumulation in addressing financial crises, either *ex ante*, *ex post*, or both. In Jeanne and Rancière (2011), the optimal level of reserves depends on the probability of a sudden stop.⁷¹ In Bocola and Lorenzoni (2020) reserves enhance central bank credibility, which in turn supports domestic credit markets, reduces foreign liabilities, and improves financial stability. In Céspedes and

⁷⁰ See also Stiglitz and Greenwald (2014), where reserves always accumulate, and Guzman, Ocampo, and Stiglitz (2018).

⁷¹ Arslan and Cantú (2019) note that the Central Reserve Bank of Peru adopted a version of the optimal reserve rule derived in Jeanne and Rancière (2011).

Chang (2020), the probability of a crisis is endogenous, and reserves enable the central bank to provide liquidity when financial constraints would otherwise bind. Likewise, in Davis, Davis, Devereux, and Yu (2021), reserve accumulation reduces the risk of sudden stops. In Arce, Bengui, and Bianchi (2019), reserves rise after financial liberalization, and they are procyclical. By emphasizing such things as the magnitudes of reserves, their relationship to private capital flows, and their behavior during crises periods, each of these small economy models provides distinct insight into the observed behavior of foreign exchange reserves.

To the extent that a country’s reserve accumulation has any real effect on an international variable, such as the real exchange rate, it has international spillovers. Whether those spillovers are problematic is another question—one that is currently explored in models that examine more than one country.

In the model of Fanelli and Straub (2021), mentioned above in the ‘welfare’ and ‘challenges’ sections, those spillovers are inefficient. In their model, financial frictions combine with an income distribution based pecuniary externality; and, from the home country’s point of view, the use of foreign exchange intervention can be welfare improving. However, rather than only treating each small open economy in isolation, the authors go on to consider a continuum of small economies. As they illustrate, an exogenous increase in, say, the global preference to save leads each individual country to engage in foreign exchange purchases that amplify the change, and those interventions ultimately lead to a costly ‘reserve war’. That result is consistent with low global interest rates and the familiar notion of a savings glut.

In a different vein, Jeanne (2021) explores reserve accumulation in the context of a range of policy instruments in a multicountry model.^{72, 73} He finds that a rationale for reserve accumulation in some countries arises during economic downturns despite low returns on their reserves. At the same time, other countries benefit from that reserve

⁷² In this model, the policy instrument leading to the reserve accumulation is a tax on capital inflows.

⁷³ See also Adler, Lama, and Medina (2019), introduced above, who examine reserve accumulation in the context of quantitative easing.

accumulation by being able to borrow at a low cost; and, importantly, there are no gains from coordination. The model presents a sharp contrast between this situation and the situation of a classic trade war with tariffs on imports that can entail substantial welfare losses. Notably, the reserve accumulation motives in both Fanelli and Straub (2021) and Jeanne (2021) are unrelated to the trade externality.

7.2 Reserve Accumulation Empirics

While the empirical work on two-sided intervention focuses largely on its influence on the exchange rate, the empirical work on reserve accumulation is more wide ranging. Much of the work in the early 2000s explored the pattern of reserve accumulation and its determinants.^{74, 75} That line of research often also examined the costs of reserves and compared countries reserve levels to a variety of benchmarks.⁷⁶ (In the background of some of that work lurked the idea—sometimes an accusation—that the level of reserves was too large.) Dominguez (2010) provides an excellent discussion of the issues most relevant for emerging economies at that time.

The 2008 financial crisis marked a change in the empirical landscape. Because the onset of the crisis was considered to be unexpected, the level of foreign exchange reserves prior to the crisis was not seen as an endogenous response to the challenging

⁷⁴ Various more recent studies also examine the patterns of reserves. See, for example, Aizenman, Chung, and Ito (2014), who find (among other things) that commodity price volatility induces reserve accumulation along the lines of the model of Faltermeier, Lama, and Medina (2022). Others address reserves' rise in the early stages of capital market opening and their macroprudential cyclicalities. Still others—for example, Ito and McCauley (2020), Aizenman, Cheung, and Qian (2020), Chinn, Ito, and McCauley (2022), and Schanz (2019)—examine the composition of reserves. Questions about reserve compositions are often raised in conjunctions with concerns about the cost of reserves, but they are also raised in the context of considerations of dollar hegemony.

⁷⁵ Dominguez, Fatum and Vacek (2013) provide a notable exception to studies of pre-crisis foreign reserves both in that they study decumulation and in that they examine its effect on the exchange rate. As mentioned above in the earlier empirical discussion, they find that reserve decumulation by the Czech National bank led to a significant appreciation of the Czech koruna when the reserve sales were carried out daily. Adler and Tovar (2014) provide another exception: while they write after the 2018 financial crisis, they exclude the crisis period from their sample. They examine reserve accumulation in Latin American countries and find that it reduces appreciations, particularly among countries with limited international financial openness.

⁷⁶ See, among many others, Bird and Mandilaras (2005), Rodrik (2006), Aizenman and Lee (2007), Cheung and Ito (2009), and Obstfeld, Shambaugh and Taylor (2010). In more recent work, Arslan and Cantú (2019) carefully consider the use of various reserve adequacy benchmarks; and they and Aizenman and Jinjark (2021) evaluate the costs of reserves.

circumstances that the crisis engendered. Thus, the crisis mitigated the usual simultaneity problem; so it provided a fresh opportunity for empirical work to examine the effects, rather than the patterns, of reserve accumulation. The post-crisis work explores the effect of a country's reserves on its exchange rate and also on its trade, on its balance sheets, and—importantly—on its resilience to crises. Overall, the evidence appears to be mounting that official reserves do matter for various aspects of economic performance.⁷⁷

Several papers used the 2008 crisis to examine reserve's effect on the exchange rate. In one of the first of these, Obstfeld, Taylor and Shambaugh (2009) find that both emerging and advanced economies with large (relative to a banking sector benchmark) pre-crisis reserves experience less depreciation than those with relatively low reserves. Likewise, examining non-Eurozone European countries, Dominguez (2014) finds that having—and using—reserves moderates depreciations during a crisis. Aizenman and Hutchison (2012) and Aizenman and Sun (2012) both examine emerging economies, and they find that countries refraining from using their reserves during the crisis experience depreciations. These last two papers also describe what appeared to be an emerging economy reluctance to use foreign reserves to forestall depreciation; however, Dominguez (2012) shows that the reluctance is no longer apparent once one adjusts foreign reserves for interest income and valuation changes to capture active reserve changes. The adjusted reserves data suggest that many emerging economies—especially those with ample pre-crisis reserves—actively sold reserves during the crisis.⁷⁸

Choi and Taylor (2017) examine the exchange rate effect in a pre-2008 panel that extends back into the 1970s and includes developing, emerging, and advanced economies (but excludes many Eastern European countries since the data for those

⁷⁷ Tong and Wei (2019), citing a portion of early work by Blanchard, Das, and Faruquee (2010), read the literature as more mixed. Relatedly, Rose and Spiegel (2011 and 2012) also find scant evidence of reserve effects.

⁷⁸ Relatedly, Alfaro and Kanczuk (2019) emphasize that valuation effects contribute significantly to consumption smoothing and suggest (in their informal empirical work) that this consumption-smoothing aspect of reserves explains much of what otherwise would appear to be reserve hoarding.

countries does not extend back into the Soviet era).⁷⁹ In keeping with many of the 2008 crisis papers, they too find the level of foreign reserves to be important for the exchange rate; but they find that the importance depends on the degree of financial openness. Specifically, larger accumulations of reserves imply weaker real exchange rates—but only in countries without open capital accounts. Their finding is strongest for developing countries, and they also find that the effects of official foreign reserve holdings differ from the effects of private foreign asset holdings. Looking directly at the implications for current accounts, rather than the exchange rate in multi-decade panels, Bayoumi and Saborowski (2014), Bayoumi, Gagnon, and Saborowski (2015), and Steiner (2014) all find that reserve increases are strongly linked to current account increases;⁸⁰ and Bayoumi and Saborowski (2014), Bayoumi, Gagnon, and Saborowski (2014) find that the links depend on degree of financial openness.

Several studies use the financial crisis to examine the links between reserves and the severity of a crisis. Dominguez, Hashimoto, and Ito (2012), Frankel and Saravelos (2012), and Bussiere, Cheng, Chinn, and Lisack (2015), and Joyce (2018) look at the 2008 crisis all document that ex ante large foreign reserve accumulations are indicative in some way of less severe crises or more rapid recoveries. In keeping with Choi and Taylor (2017), Bussière, Cheng, Chinn, and Lisack (2015) document that the link they find is stronger for those countries with less open capital accounts.

Joyce’s (2018) work explores the role of reserves in the context of a favorable “long debt, short” equity position going into the crisis. However, the issue of a country’s net (private plus public) position—which remains central to the precautionary motive for reserve accumulation—is not settled. In a large, emerging economy panel extending from the late 1990s to 2015, Amstad, Packer, and Shek (2020) find that the larger reserves contribute to improved emerging economy credit worthiness. And, in an advanced economy three-decade panel, Joyce (2019) documents that large foreign exchange reserves are associated with greater portfolio equity and less debt. However,

⁷⁹ In a robustness check, they also find the same result for the crisis and follow-on period, 2008-2011.

⁸⁰ Moreover, they find that the current account increases are met in large part by opposite changes in the current account of the main reserve currency issuer, the United States.

using emerging economy, firm-level data to help address endogeneity in the pre-crisis 2000s, Tong and Wei (2021) report that reserve increases lead to significant increases in firm leverage. Further empirical work in this area would illuminate the potential of reserves to reduce the likelihood and mitigate the effects of financial crises.

Research over other periods explores additional aspects of vulnerability and stability. In examining the consequences of the 2013 news of the Federal Reserve’s imminent asset purchase tapering (the ‘taper tantrum’), Ahmed, Coulibaly, and Zlate (2017) find that several measures of emerging country financial performance are stronger in those countries with greater reserves. Looking at the ability of countries to maintain stable international monetary regimes from the 1980s through 2010 in a large panel of countries, Popper, Mandilaras, and Bird (2013) find that reserve accumulation is predictive of greater policy stability; and the effect they find, like that of Choi and Taylor’s (2017), is strongest among developing countries. Gourinchas and Obstfeld (2012) look at the overall probability of a crisis over roughly the same time period and find that, among emerging economies, the accumulation of foreign exchange reserves appears to substantially reduce the probability of a crisis.

Overall (though not uniformly),⁸¹ the empirical research on foreign reserve accumulation suggests that it has real and lasting effects. The extant studies indicate that ex ante reserve holdings appear to allow central banks to resist currency depreciations during crises. And—whether through the exchange rate mechanism or through others—those holdings also appear to reduce the probability and severity of crises. Less clear are the implications of official foreign reserve accumulation for public and private saving, and for the underlying patterns of private asset accumulation and private leverage. Less clear still is an empirical sense of its normative implications, either globally or even simply within the accumulating country itself.

8 Conclusions

⁸¹ See, for example, Rose and Spiegel (2011) and the cites therein.

For a long time, central banks intervened in foreign exchange markets for a variety of stated reasons, while academics (and even many central bankers) struggled to discover any theoretical justifications or see much empirical relevance. However, the emerging economy crises of the 1990s and the early 2000s brought fresh data in the form of urgent experimentation with intervention and other policies; and the financial crisis of 2008 propelled serious treatment of financial frictions into macroeconomic models. Now, theorists are building models that clarify the rationales for intervention, and empiricists are finding ways to identify its relevance.

The current models of intervention wed financial frictions to relevant externalities. Those externalities include the aggregate demand and pecuniary externalities that now inform macroeconomic models more broadly, and the trade-related learning externalities that are particularly relevant for developing and emerging economies. Empirical advances reflect more variation in intervention, better data, and novel approaches to circumventing the perennial problem of simultaneity.

With these beginnings, the next challenges include learning which frictions and externalities matter most; when and for whom they matter; and where intervention, and perhaps international cooperation, properly fits (if at all) into the blend of policies that might appropriately address the externalities.

References

- Adler, G., Chang, K. S., Mano, R., and Shao, Y. (2021). “Foreign Exchange Intervention: A Dataset of Public Data and Proxies”, IMF Working Papers (No. 2021/047).
- Adler, G., Lama, R., and Medina, J. (2016). “Foreign Exchange Intervention under Policy Uncertainty”. IMF Working Papers (2016/67).
- Adler, G. and Lama, R., and Medina, J.P. (2019). “Unconventional Policies and Exchange Rate Dynamics”. *Journal of International Money and Finance*, 95, 402-423.
- Adler, G., Lisack, N., and Mano, R. C. (2019). Unveiling the effects of foreign exchange intervention: A panel approach. *Emerging Markets Review*, 40, 100620.
- Adler, G., and Tovar, C. (2014). “Foreign exchange interventions and their impact on exchange rate levels”, *Monetaria*, 2(1), 1-48.
- Adrian, T., Gaspar, V., and Vitek, F. (2022). A Medium-Scale DSGE Model for the Integrated Policy Framework. IMF Working Papers, 2022(015).
- Ahmed, S., Coulibaly, B., and Zlate, A. (2017). International financial spillovers to emerging market economies: How important are economic fundamentals?. *Journal of International Money and Finance*, 76, 133-152.
- Aizenman, J. (2019). International reserves, exchange rates, and monetary policy: From the trilemma to the quadrilemma. In *Oxford Research Encyclopedia of Economics and Finance*.
- Aizenman, J., Cheung, Y. W., & Qian, X. (2020). The currency composition of international reserves, demand for international reserves, and global safe assets. *Journal of International Money and Finance*, 102, 102120.
- Aizenman, J., Chinn, M. D., and Ito, H. (2016). Monetary policy spillovers and the trilemma in the new normal: Periphery country sensitivity to core country conditions. *Journal of International Money and Finance*, 68, 298-330.
- Aizenman, J., Cheung, Y. W., & Qian, X. (2020). The currency composition of international reserves, demand for international reserves, and global safe assets. *Journal of International Money and Finance*, 102, 102120.

Aizenman, J., & Hutchison, M. M. (2012). Exchange market pressure and absorption by international reserves: Emerging markets and fear of reserve loss during the 2008–2009 crisis. *Journal of International Money and Finance*, 31(5), 1076-1091.

Aizenman, J., Ito, H., and Pasricha, G. K. (2022). Central bank swap arrangements in the covid-19 crisis. *Journal of International Money and Finance*, 122, 102555.

Aizenman, J., Jinjark, Y., Park, D., and Zheng, H. (2021). Good-bye original sin, hello risk on-off, financial fragility, and crises?. *Journal of International Money and Finance*, 117, 102442.

Aizenman, J., and Lee, J. (2007). International reserves: precautionary versus mercantilist views, theory and evidence. *Open Economies Review*, 18(2), 191-214.

Aizenman, J., & Sun, Y. (2012). The financial crisis and sizable international reserves depletion: From ‘fear of floating’ to the ‘fear of losing international reserves’?. *International Review of Economics & Finance*, 24, 250-269.

Alfaro, L., and Kanczuk, F. (2019). Debt redemption and reserve accumulation. *IMF Economic Review*, 67(2), 261-287.

Ammer, J., De Pooter, M., Erceg, C. J., and Kamin, S. B. (2016). International spillovers of monetary policy (No. 2016-02-08-1). Board of Governors of the Federal Reserve System (US).

Amstad, M., Packer, F., and Shek, J. (2020). Does sovereign risk in local and foreign currency differ?. *Journal of International Money and Finance*, 101, 102099.

Arce, F., Bengui, J., and Bianchi, J. (2019). A macroprudential theory of foreign reserve accumulation (No. w26236). National Bureau of Economic Research.

Arslan, Y., and Cantú, C. (2019). The size of foreign exchange reserves. *BIS Paper*, (104a).

Baba, N., and Shim, I. (2010). Policy responses to dislocations in the FX swap market: the experience of Korea. *BIS Quarterly Review*, June.

Backus, D. K., and Kehoe, P. J. (1989). On the denomination of government debt: a critique of the portfolio balance approach. *Journal of Monetary Economics*, 23(3), 359-376.

Bahaj, S., and Reis, R. (2021). Central bank swap lines: Evidence on the effects of the lender of last resort. *Review of Economic Studies*.

Basu, Mr Suman S., Ms Emine Boz, Ms Gita Gopinath, Mr Francisco Roch, and Ms Filiz D. Unsal. (2020). A conceptual model for the integrated policy framework. International Monetary Fund.

Bayoumi, T., Gagnon, J., and Saborowski, C. (2015). Official financial flows, capital mobility, and global imbalances. *Journal of International Money and Finance*, 52, 146-174.

Bayoumi, T., and Saborowski, C. (2014). Accounting for reserves. *Journal of International Money and Finance*, 41, 1-29.

Beine, M., Bénassy-Quéré, A., and MacDonald, R. (2007). The impact of central bank intervention on exchange-rate forecast heterogeneity. *Journal of the Japanese and International Economies*, 21(1), 38-63.

Ben-Bassat, A., and Gottlieb, D. (1992). Optimal international reserves and sovereign risk. *Journal of international Economics*, 33(3-4), 345-362.

Benes, J., Berg, A., Portillo, R. A., and Vavra, D. (2015). Modeling sterilized interventions and balance sheet effects of monetary policy in a New-Keynesian framework. *Open Economies Review*, 26(1), 81-108.

Benigno, G., Chen, H., Otrok, C., Rebucci, A., and Young, E. R. (2016). Optimal capital controls and real exchange rate policies: A pecuniary externality perspective. *Journal of monetary economics*, 84, 147-165.

Benigno, G., and Fornaro, L. (2012). Reserve accumulation, growth and financial crises. *Growth and Financial Crises* (November 2012).

Bergsten, C. F., and Gagnon, J. E. (2012). Currency manipulation, the US economy, and the global economic order (pp. 12-25). Washington, DC: Peterson Institute for International Economics.

Bergsten, C. F., and Gagnon, J. E. (2017). *Currency conflict and trade policy: A new strategy for the United States*. Columbia University Press.

Bernanke, B. (1983). Nonmonetary Effects of the Financial Crisis in the Propagation of the Great Depression. *The American Economic Review*, 73(3), 257-276.

Bernanke, B., and Gertler, M. (1990). Financial fragility and economic performance. *The quarterly journal of economics*, 105(1), 87-114.

Bird, G., & Mandilaras, A. (2005). Reserve accumulation in Asia. *World Economics*, 6(1), 85-99.

Blanchard, O. (2021). Currency wars, coordination, and capital controls. In *The Asian Monetary Policy Forum: Insights for Central Banking* (pp. 134-157).

Blanchard, O. J., Adler, G., and de Carvalho Filho, I. (2015). Can Foreign Exchange Intervention Stem Exchange Rate Pressures from Global Capital Flow Shocks?. *IMF Working Papers*, 2015(159).

Blanchard, O. J., Das, M., and Faruqee, H. (2010). The Initial Impact of the Crisis on Emerging Market Countries. *Brookings Papers on Economic Activity*, 2010(1), 263-307.

Bocola, L., and Lorenzoni, G. (2020). Financial crises, dollarization, and lending of last resort in open economies. *American Economic Review*, 110(8), 2524-57.

Bodenstein, M., Corsetti, G., and Guerrieri, L. (2020). The Elusive Gains from Nationally-Oriented Monetary Policy. *FRB International Finance Discussion Paper*, (1271).

Bordo, M. D., Humpage, O. F., & Schwartz, A. J. (2011). *The federal reserve as an informed foreign exchange trader: 1973-1995* (No. w17425). National Bureau of Economic Research.

Bordo, M. D., Humpage, O. F., and Schwartz, A. J. (2018). The Federal Reserve as an Informed Foreign Exchange Trader: 1973-1995. 28th issue (March 2011) of the *International Journal of Central Banking*.

Brandner, P., Grech, H., and Stix, H. (2006). The effectiveness of central bank intervention in the EMS: The post 1993 experience. *Journal of International Money and Finance*, 25(4), 580-597.

Branson, W. H., and Henderson, D. W. (1985). The specification and influence of asset markets. *Handbook of international economics*, 2, 749-805.

Bussière, M., Cheng, G., Chinn, M. D., and Lisack, N. (2015). For a few dollars more: Reserves and growth in times of crises. *Journal of International Money and Finance*, 52, 127-145.

Brunnermeier, M. K., Eisenbach, T. M., and Sannikov, Y. (2013, May). A Survey. In *Advances in Economics and Econometrics: Volume 2, Applied Economics: Tenth World Congress* (Vol. 50, p. 3). Cambridge University Press.

Caballero, R. J. (2010). Macroeconomics after the crisis: time to deal with the pre-tense-of-knowledge syndrome. *Journal of Economic Perspectives*, 24(4), 85-102.

Calvo, G. A., and Reinhart, C. M. (2002). Fear of floating. *The Quarterly journal of economics*, 117(2), 379-408.

Canales-Kriljenko, J. I. (2003). Foreign Exchange Intervention in Developing and Transition Economies: Results of a Survey. International Monetary Fund.

Carrasco, A., and Florián Hoyle, D. (2021). External shocks and FX intervention policy in emerging economies (No. IDB-WP-1243). IDB Working Paper Series.

Carstens, A., and Shin, H. S. (2019). Emerging markets aren't out of the woods yet. *Foreign Affairs*.

Cavallino, P. (2019). Capital flows and foreign exchange intervention. *American Economic Journal: Macroeconomics*, 11(2), 127-70.

Céspedes, L. F., and Chang, R. (2020). Optimal foreign reserves and central bank policy under financial stress (No. w27923). National Bureau of Economic Research.

Céspedes, L. F., Chang, R., and Velasco, A. (2017). Financial intermediation, real exchange rates, and unconventional policies in an open economy. *Journal of International Economics*, 108, S76-S86.

Chamon, M., Garcia, M., and Souza, L. (2017). FX interventions in Brazil: a synthetic control approach. *Journal of International Economics*, 108, 157-168.

Chamon, M., Hofman, D., Lanau, S., Rawat, U., and Vari, M. (2019). The effectiveness of intervention. In *Foreign Exchange Intervention in Inflation Targeters in Latin America*. Eds: Chamon, M., Hofman, D. J., Magud, N. E., and Werner, A. M., Chapter, 4, 43-61, International Monetary Fund.

Chamon, M., Hofman, D. J., Magud, N. E., and Werner, A. M. (2019). Foreign Exchange Intervention in Inflation Targeters in Latin America. International Monetary Fund.

Chang, R. (2019). Foreign Exchange Intervention Redux. *Central Banking, Analysis, and Economic Policies Book Series*, 26, 205-247.

Chang, C., Liu, Z., and Spiegel, M. M. (2015). Capital controls and optimal Chinese monetary policy. *Journal of Monetary Economics*, 74, 1-15.

Chang, R., and Velasco, A. (2017). Financial frictions and unconventional monetary policy in emerging economies. *IMF Economic Review*, 65(1), 154-191.

Chen, Y. L., and Gau, Y. F. (2015). Foreign exchange market intervention and price discovery. *Journal of the Japanese and International Economies*, 38, 214-227.

Cheung, Y. W., and Ito, H. (2009). A cross-country empirical analysis of international reserves. *International Economic Journal*, 23(4), 447-481.

Chinn, M. D., Ito, H., & McCauley, R. N. (2022). Do central banks rebalance their currency shares?. *Journal of International Money and Finance*, 122, 102557.

Choi, J. (2020). Capital Controls and Foreign Exchange Market Intervention. *Journal of International Money and Finance*, Vol 101, ISSN 0261-5606.

Choi, M., Goldberg, L. S., Lerman, R. I., and Ravazzolo, F. (2021). The Fed's central bank swap lines and FIMA repo facility (No. 983). Staff Report.

Choi, W. J., and Taylor, A. M. (2017). Precaution versus mercantilism: Reserve accumulation, capital controls, and the real exchange rate (No. w23341). National Bureau of Economic Research.

Clark, P. B. (1970). Optimum international reserves and the speed of adjustment. *Journal of political economy*, 78(2), 356-376.

Daude, C., Yeyati, E. L., and Nagengast, A. J. (2016). On the effectiveness of exchange rate interventions in emerging markets. *Journal of International Money and Finance*, 64, 239-261.

Dávila, E. and Korinek, A. (2017) Limited Pecuniary Externalities in Economies with Financial Frictions, *The Review of Economic Studies*, 01, 1–44.

Davis, S., Devereux, M., and Yu, C. (2020). Sudden Stops in Emerging Economies: The Role of World Interest Rates and Foreign Exchange Intervention. *Globalization and Monetary Policy Institute Working Paper*, (405).

Davis, J. S., Fujiwara, I., Huang, K. X., and Wang, J. (2021). Foreign exchange reserves as a tool for capital account management. *Journal of Monetary Economics*, 117, 473-488.

Dekle, R., and Hamada, K. (2015). Japanese monetary policy and international spillovers. *Journal of International Money and Finance*, 52, 175-199.

Devereux, M. B., and Yetman, J. (2014).. Globalisation, pass-through and the optimal policy response to exchange rates. *Journal of International Money and Finance*, 49, 104-128.

Domanski, D., Kohlscheen, E., and Moreno, R. (2016). Foreign exchange market intervention in EMEs: what has changed?. *BIS Quarterly Review* September.

Dominguez, K.M. (1990). Market responses to coordinated central bank intervention. *Carnegie-Rochester Conference Series on Public Policy*. Vol. 32. North-Holland.

Dominguez, K. M. (2003). The market microstructure of central bank intervention. *Journal of International economics*, 59(1), 25-45.

Dominguez, K. M. (2010). International reserves and underdeveloped capital markets. In *NBER International Seminar on Macroeconomics* (Vol. 6, No. 1, pp. 193-221). Chicago, IL: The University of Chicago Press.

Dominguez, K. M. (2012). Foreign reserve management during the global financial crisis. *Journal of International Money and Finance*, 31(8), 2017-2037.

Dominguez, K. M. (2014). Exchange rate implications of reserve changes: how non-EZ European countries fared during the great recession. *Comparative Economic Studies*, 56(2), 229-252.

Dominguez, K. M. (2020). Revisiting Exchange Rate Rules. *IMF Economic Review*, 68(3), 693-719.

Dominguez, K. M., Fatum, R., and Vacek, P. (2013). Do sales of foreign exchange reserves lead to currency appreciation?. *Journal of Money, Credit and Banking*, 45(5), 867-890.

Dominguez, K. M., and Frankel, J. A. (1993). Does foreign-exchange intervention matter? The portfolio effect. *The American Economic Review*, 83(5), 1356-1369.

Dominguez, K. M., Hashimoto, Y., and Ito, T. (2012). International reserves and the global financial crisis. *Journal of International Economics*, 88(2), 388-406.

Dooley, M. P., Folkerts-Landau, D., and Garber, P. (2004). The revived bretton woods system. *International Journal of Finance and Economics*, 9(4), 307-313.

Daude, C., Yeyati, E. L., & Nagengast, A. (2014). On the effectiveness of exchange rate interventions in emerging markets.

Echavarría, J. J., Melo-Velandia, L. F., and Villamizar-Villegas, M. (2018). The impact of pre-announced day-to-day interventions on the Colombian exchange rate. *Empirical Economics*, 55(3), 1319-1336.

Erten, B., Korinek, A., & Ocampo, J. A. (2019). Capital controls: Theory and evidence (No. w26447).

Edison, H. J. (1993). The effectiveness of central-bank intervention: a survey of the literature after 1982 (Vol. 18). International Finance Section, Department of Economics, Princeton University.

Faltermeier, J., Lama, R., and Medina, J. P. (2022). Foreign exchange intervention for commodity booms and busts. *European Economic Review*, 104018.

Fanelli, S., and Straub, L. (2021). A Theory of Foreign Exchange Interventions. *The Review of Economic Studies*, 88(6), 2857-2885.

Farhi, E., and Werning, I. (2016). A theory of macroprudential policies in the presence of nominal rigidities. *Econometrica*, 84(5), 1645-1704.

Fatum, R., & Hutchison, M. (2006). Effectiveness of official daily foreign exchange market intervention operations in Japan. *Journal of International Money and Finance*, 25(2), 199-219.

Fatum, R., & Hutchison, M. M. (2010). Evaluating foreign exchange market intervention: Self-selection, counterfactuals and average treatment effects. *Journal of International Money and Finance*, 29(3), 570-584.

Fernholz, Ricardo T. (2015). Exchange rate manipulation and constructive ambiguity." *International Economic Review* 56, no. 4: 1323-1348.

Fisher, I. (1933). The debt-deflation theory of great depressions. *Econometrica: Journal of the Econometric Society*, 337-357.

Frankel, J. (2021). Systematic managed floating. In *The Asian Monetary Policy Forum: Insights for Central Banking* (pp. 160-221).

Frankel, J., and Saravelos, G. (2012). Can leading indicators assess country vulnerability? Evidence from the 2008-09 global financial crisis. *Journal of International Economics*, 87(2), 216-231.

Fratzscher, M., Gloede, O., Menkhoff, L., Sarno, L., and Stöhr, T. (2019). When is foreign exchange intervention effective? Evidence from 33 countries. *American Economic Journal: Macroeconomics*, 11(1), 132-56.

Fratzscher, M., Heidland, T., Menkhoff, L., Sarno, L., and Schmeling, M. (2020). Foreign exchange intervention: A new database.

Gabaix, X., and Maggiori, M. (2015). International liquidity and exchange rate dynamics. *The Quarterly Journal of Economics*, 130(3), 1369-1420.

Gagnon, J. and Sarsenbayev, M.(2021). Fiscal and exchange rate policies drive trade imbalances: New estimates. Peterson Institute for International Economics Working Paper, (21-4).

Gelos, M. R., Gornicka, L., Koepke, M. R., Sahay, M. R., and Sgherri, M. S. (2019). Capital flows at risk: Taming the ebbs and flows. International Monetary Fund.

Ghosh, A. R. (1992). Is it signalling? Exchange intervention and the dollar-deutschmark rate. *Journal of International Economics*, 32(3-4), 201-220.

Ghosh, M. A. R., Ostry, M. J. D., and Qureshi, M. S. (2017). Managing the tide: How do emerging markets respond to capital flows?. International Monetary Fund.

Gourinchas, P. O., and Obstfeld, M. (2012). Stories of the twentieth century for the twenty-first. *American Economic Journal: Macroeconomics*, 4(1), 226-65.

Greenwald, B. C., and Stiglitz, J. E. (1986). Externalities in economies with imperfect information and incomplete markets. *The quarterly journal of economics*, 101(2), 229-264.

Guzman, M., Ocampo, J. A., and Stiglitz, J. E. (2018). Real exchange rate policies for economic development. *World Development*, 110, 51-62.

Hassan, T. A., Mertens, T. M., and Zhang, T. (2016). A Risk-based Theory of Exchange Rate Stabilization (No. 22790). National Bureau of Economic Research, Inc.

Heller, H. R. (1966). Optimal international reserves. *The Economic Journal*, 76(302), 296-311.

Henderson, D. W., and Rogoff, K. (1982). Negative net foreign asset positions and stability in a world portfolio balance model. *Journal of International Economics*, 13(1-2), 85-104.

- Henderson, D., and Sampson, S. (1983). Intervention in foreign exchange markets-A summary of ten staff studies. Fed. Res. Bull., 69, 830.
- Ho, W. M. (2008). The welfare implications of foreign exchange intervention. Journal of International Money and Finance, 27(8), 1360-1382.
- Hofmann, B., Patel, N., and Wu, S. P. Y. (2022). Original sin redux: a model-based evaluation. BIS Working Paper 1004.
- Humpage, O. F. (1991). Central Bank Intervention: Recent Literature. Continuing Controversy. Federal Reserve Bank of Cleveland Economic Review, 27(2), 12-26.
- Humpage, Owen F. *Government intervention in the foreign exchange market*. Working paper No. 0315. Federal Reserve Bank of Cleveland, 2003.
- Ilzetzki, E. (2011). Fiscal policy and debt dynamics in developing countries. World Bank Policy Research Working Paper, (5666).
- Iovino, L. and Sergeyev, D., (forthcoming). Central Bank Balance Sheet Policies Without Rational Expectations, The Review of Economic Studies.
- Ito, H., & McCauley, R. N. (2020). Currency composition of foreign exchange reserves. Journal of International Money and Finance, 102, 102104.
- Jeanne, O. (2021). Currency Wars, Trade Wars, and Global Demand (No. w29603). National Bureau of Economic Research.
- Jeanne, O., and Ranciere, R. (2011). The optimal level of international reserves for emerging market countries: A new formula and some applications. The Economic Journal, 121(555), 905-930.
- Joyce, J. P. (2018). External balance sheets as countercyclical crisis buffers. International Economics and Economic Policy, 15(2), 305-329.
- Joyce, J. P. (2019). Partners, not debtors: The external liabilities of emerging market economies. Journal of Economic Behavior and Organization, 157, 320-337.
- Jung, K. M., and Pyun, J. H. (2016). International reserves for emerging economies: A liquidity approach. Journal of International Money and Finance, 68, 230-257.
- Jurgensen, P. (1983). Report of the working group on exchange market intervention. US Department of the Treasury.

Kalemli-Özcan, Ş. (2019). US monetary policy and international risk spillovers (No. w26297). National Bureau of Economic Research.

Kearns, J., and Rigobon, R. (2005). Identifying the efficacy of central bank interventions: evidence from Australia and Japan. *Journal of International Economics*, 66(1), 31-48.

Keefe, H. G., and Rengifo, E. W. (2015). Options and central bank currency market intervention: The case of Colombia. *Emerging Markets Review*, 23, 1-25.

Keefe, H. G., & Rengifo, E. W. (2019). Currency Option Trading Strategies as an Alternative Tool for Central Bank Foreign Exchange Interventions. 58th issue (June 2019) of the *International Journal of Central Banking*.

Kim, M., Mano, R. C., and Mrkaic, M. (2020). Do FX interventions lead to higher FX debt? Evidence from firm-level data.

Kohlscheen, E., and Andrade, S. C. (2014). Official FX interventions through derivatives. *Journal of International Money and Finance*, 47, 202-216.

Korinek, A. (2011). The new economics of prudential capital controls: A research agenda. *IMF Economic Review*, 59(3), 523-561.

Korinek, A. (2017). Currency wars or efficient spillovers? A general theory of international policy cooperation (No. w23004). National Bureau of Economic Research.

Korinek, A., and Serven, L. (2016). Undervaluation through foreign reserve accumulation: Static losses, dynamic gains. *Journal of International Money and Finance*, 64, 104-136.

Kouri, P. J. (1976). The Exchange Rate and the Balance of Payments in the Short Run and in the Long Run: A Monetary Approach. *The Scandinavian Journal of Economics*, 280-304.

Kouri, P. J., and Braga de Macedo, J. (1978). Exchange Rates and the International Adjustments Process. *Brookings Papers on Economic Activity*, 9(1), 111-158.

Kuersteiner, G. M., Phillips, D. C., and Villamizar-Villegas, M. (2018). Effective sterilized foreign exchange intervention? Evidence from a rule-based policy. *Journal of International Economics*, 113, 118-138.

Kumhof, M. (2010). On the theory of sterilized foreign exchange intervention. *Journal of Economic Dynamics and Control*, 34(8), 1403-1420.

- Kumhof, M., and Van Nieuwerburgh, S. (2007). Monetary policy in an equilibrium portfolio balance model.
- Lafarguette, R., and Veyrune, M. R. M. (2021). Foreign Exchange Intervention Rules for Central Banks: A Risk-based Framework. International Monetary Fund.
- Lama, Ruy, and Juan Pablo Medina. (2012). Is Exchange Rate Stabilization an Appropriate Cure for the Dutch Disease? International Journal of Central Banking.
- Liu, Z., and Spiegel, M. M. (2015). Optimal monetary policy and capital account restrictions in a small open economy. IMF Economic Review, 63(2), 298-324.
- Lízal, L., & Schwarz, J. (2013). Foreign exchange interventions as an (un) conventional monetary policy tool. BIS Paper, (73i).
- Lyons, R. K. (2001). The microstructure approach to exchange rates (Vol. 333). Cambridge, MA: MIT press.
- McCauley, R., and Schenk, C. R. (2020). Central bank swaps then and now: swaps and dollar liquidity in the 1960s (No. 851). Bank for International Settlements.
- Mendoza, E. G. (2002). "Credit, Prices, and Crashes: Business Cycles with a Sudden Stop. Edwards, S., Frankel, J. A. (Eds.), Preventing Currency Crises in Emerging Markets". University of Chicago Press, 335-392.
- Mendoza, E.G (2006). Lessons from the Debt-Deflation Theory of Sudden Stops, The American Economic Review, vol. 96, no. 2, 411-416.
- Menkhoff, L. (2013). Foreign exchange intervention in emerging markets: A survey of empirical studies. The World Economy, 36(9), 1187-1208
- Menkhoff, L., Rieth, M., and Stöhr, T. (2021). The dynamic impact of FX interventions on financial markets. Review of Economics and Statistics, 103(5), 939-953.
- Mohanty, Madhusudan S. "Bat-el Berger. 2013." " Central Bank Views on FX Intervention." in: Bank for International Settlements (2013a): 55-74.
- Montoro, C., and Ortiz, M. (2016). Foreign exchange intervention and monetary policy design: a market microstructure analysis. Banco Central de Reserva des Perú Working Paper, 8.
- Moreno, Ramon. "Motives for intervention." BIS Papers chapters 24 (2005): 4-18.

Mussa, M. (1981). Sticky prices and disequilibrium adjustment in a rational model of the inflationary process. *The American Economic Review*, 71(5), 1020-1027.

Naef, A. (2020). Blowing Against the Wind? A Narrative Approach to Central Bank Foreign Exchange Intervention. A Narrative Approach to Central Bank Foreign Exchange Intervention. *European Historical Economics Society Working Paper*.

Nedeljkovic, M., and Saborowski, C. (2019). The Relative Effectiveness of Spot and Derivatives-Based Intervention. *Journal of Money, Credit and Banking*, 51(6), 1455-1490.

Neely, C. J. (2000). The Practice of Central Bank Intervention: Looking Under the Hood. *Central Banking*, 11(2), 24-37.

Neely, Christopher J. "A Foreign Exchange Intervention in an Era of Restraint." *Federal Reserve Bank of St. Louis Review* 93.5 (2011): 303-24.

Obstfeld, M., Shambaugh, J. C., and Taylor, A. M. (2009). Financial instability, reserves, and central bank swap lines in the panic of 2008. *American Economic Review*, 99(2), 480-86.

Patel, N., and Cavallino, P. (2019). FX intervention: goals, strategies and tactics. *BIS Paper*, (104b).

Peiers, B. (1997). Informed traders, intervention, and price leadership: A deeper view of the microstructure of the foreign exchange market. *The Journal of Finance*, 52(4), 1589-1614.

Popper, H., Mandilaras, A., and Bird, G. (2013). Trilemma stability and international macroeconomic archetypes. *European Economic Review*, 64, 181-193.

Popper, H., and Montgomery, J. D. (2001). Information sharing and central bank intervention in the foreign exchange market. *Journal of International Economics*, 55(2), 295-316.

Prasad, N. (2018). Sterilized interventions and capital controls. *Journal of International Money and Finance*, 88, 101-121.

Ramey, V. A. (2019). Ten years after the financial crisis: What have we learned from the renaissance in fiscal research?. *Journal of Economic Perspectives*, 33(2), 89-114.

Rebucci and Ma (2019). "Capital Controls: A Survey of the New Literature". Oxford Research Encyclopedia of Economics and Finance.

Rodrik, D. (2006). The social cost of foreign exchange reserves, *International Economic Journal*, 20:3, 253-266.

Rodrik, D., and Subramanian, A. (2009). Why did financial globalization disappoint?. *IMF staff papers*, 56(1), 112-138.

Rogoff, K. (1984). On the effects of sterilized intervention: An analysis of weekly data. *Journal of Monetary Economics*, 14(2), 133-150.

Rose, A. K., and Spiegel, M. M. (2011). Cross-country causes and consequences of the crisis: An update. *European economic review*, 55(3), 309-324.

Rose, A. K., and Spiegel, M. M. (2012). Cross-country causes and consequences of the 2008 crisis: early warning. *Japan and the world Economy*, 24(1), 1-16.

Sargent, T. J., and Smith, B. D. (1987). Irrelevance of open market operations in some economies with government currency being dominated in rate of return. *The American Economic Review*, 78-92

Scalia, A. (2008). Is foreign exchange intervention effective? Some microanalytical evidence from the Czech Republic. *Journal of International Money and Finance*, 27(4), 529-546.

Schanz, J. F. (2019). Reserve management in emerging market economies: trends and challenges. *BIS Paper*, (104c).

Spiegel, M. M. (2022). Monetary policy spillovers under COVID-19: Evidence from lending by US foreign bank subsidiaries. *Journal of International Money and Finance*, 122, 102550.

Steiner, A. (2014). Current account balance and dollar standard: Exploring the linkages. *Journal of International Money and Finance*, 41, 65-94.

Stiglitz, J. E., & Greenwald, B. (2014). *Creating a learning society*. Columbia University Press.

Tong, H., and Wei, S. J. (2021). Endogenous corporate leverage response to a safer macro environment: The case of foreign exchange reserve accumulation. *Journal of International Economics*, 132, 103499.

Tryon, R. W. (1983). Small empirical models of exchange market intervention: A review of the literature. *Staff Studies*, (134).

U.S. Department of the Treasury, Office of International Affairs (2021, December). *Macroeconomic and Foreign Exchange Policies of Major Trading Partners of the United States*. Report to Congress.

Vitale, P. (1999). Sterilised central bank intervention in the foreign exchange market. *Journal of International Economics*, 49(2), 245-267.

Wallace, N. (1981). A Modigliani-Miller theorem for open-market operations. *The American Economic Review*, 71(3), 267-274.

Wu, T. (2012). Order flow in the South: Anatomy of the Brazilian FX market. *The North American Journal of Economics and Finance*, 23(3), 310-324.