CHARLES UNIVERSITY
FACULTY OF SOCIAL SCIENCES
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Should Central Banks Try to Make Profit on their FX Reserves?

Bachelor's thesis

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Declaration of Authorship

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Prague, February 23, 2022

Jakub Tabášek

Abstract

The first part of the thesis uses vector autoregressions to examine the influence of foreign reserves on macroeconomic variables. The results suggest an economically significant influence on both household consumption and gross capital formation in Brazil, Chile, Argentina, and Indonesia, while in the Philippines and South Korea the influence seems rather weak. However, there is some uncertainty surrounding the results and the relationships may be unstable through time, suggesting that the question is worth revisiting in the future.

The second part deals with the management of foreign reserves and investigates whether the long-term management by the Monetary Authority of Singapore, which entails the objective of providing a regular income stream to the government budget, could be an option for other central banks. Given the similarity of objectives, the discussion builds on a comparison with the management practices of large U.S. university endowments and suggests that the comparison seems to yield interesting insights pertaining to asset allocation. However, constraints stemming from the size of central bank portfolios and challenges having to do with expertise and management may have implications for the overall stability of investment returns. Given the specific character of a central bank, three potential threats to central bank independence are discussed: the issue of accountability for running the portfolio, risks to central bank equity and the problem of "quasi-fiscal dominance". These suggest the usefulness of shared decision-making between central bank and governments, the need for an "equity buffer", and strict spending rules and ring-fencing of proceeds. Under those conditions, the objective does not interfere with the traditional objectives of a central bank.

JEL Classification	E21, E22, E44, E58, F31, G11, G15
Keywords	central banks, monetary policy, foreign reserves, asset management, VAR model, consumption, investment
Title	Should Central Banks Try to Make Profit on their FX Reserves?

Abstrakt

První část práce zkoumá vliv devizových rezerv na makroekonomické proměnné pomocí vektorových autoregresí na vybraném vzorku zemí. Výsledky naznačují ekonomicky relativně výrazný vliv na spotřebu domácností a investice pro Brazílii, Chile, Argentinu a Indonésii, naopak pro Filipíny a Jižní Koreu se vliv zdá velmi slabý. Existuje ovšem nejistota ohledně robustbosti a stabilitě vztahu v čase a studovaný vztah by si zasloužil budoucí zkoumání.

Druhá část práce se zabývá správou devizových rezerv a jejím cílem je prozkoumat, zda by dlouhodobá správa rezerv Singapurskou Měnovou Autoritou, jejíž součástí je generovace pravidelého příspěvku do vládního rozpočtu, mohl být variantou pro další centrální banky. S ohledem na výraznou podobnost cíle je použito srovnání s velkými americkými univerzitními fondy a diskuze naznačuje, že z tohoto srovnání plynou zajímavé poznatky ohledně alokace aktiv. V praxi lze však očekávat, že omezení plynoucí z velikosti investičních portfolií společně s vyššími nároky na expertízu mohou mít za následek nižší stabilitu výnosnosti portfolia. S ohledem na specifický charakter centrální banky jsou diskutovány tři potenciální hrozby pro nezávislost centrální banky: zodpovědnost za správu portfolia, rizika pro jmění centrální banky a problém "kvazi-fiskální dominance". Z toho vyplývá vhodnost sdílené zodpovědnosti za správu portfolia mezi centrální bankou a vládou, nutnost trvalého zadržení určitého procenta zisku ("equity buffer") a potřeba striktních pravidel pro nakládání s výnosy. Za těchto podmínek není tento cíl v rozporu s tradičními cíly centrální banky.

Klasifikace JEL	E21, E22, E44, E58, F31, G11, G15
Klíčová slova	centrální banky, měnová politika, devizové rezervy, investiční management, VAR model, spotřeba, investice
	Měly by se centrální banky snažit generovat zisk ze svých devizových rezerv?

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Bachelor's Thesis Proposal

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Motivation In my thesis, I propose to explore the possibility that central bank reserves (more specifically, a percentage of them) could be actively deployed with a specific view to generating profits and thus be used as state revenue to ameliorate the ever growing long-term commitments faced by many governments today. I propose to consider whether inspiration could be drawn from Sovereign Wealth Funds or even university endowments.

As the basis for my discussion, I intend to examine data on central bank reserves. However, I am not interested in currency composition; rather, to the extent that availability of data permits me, I propose to try to identify trends in reserve composition by asset class. I am especially interested in such questions as:

- Have central banks recently moved to a more active reserve management?
- How have they gone about it?
- Are there any specific trends?
- Are the findings limited to specific classes of central banks?
- Are some groups central banks more conservative or aggressive? Why may that be?
- To what extent does past experience bear on central banksÂ´ decisions?

I further intend to examine and highlight the differences in management practices between central banks and Sovereign Wealth Funds. I seek to ascertain in which areas these practices coincide (or can be made to coincide) as opposed to in which areas they are inherently incompatible due to differing goals and mandates. I will examine in detail the case of the Monetary Authority of Singapore; as it turns out, the MA is a pioneer in deploying reserves for generating revenue (Menon (2019)). I am thus interested to find out to what extent Singapore can (or cannot) be looked to as a role model.

My motivation for exploring the topic is simple: many governments around the world are faced with sluggish growth, tight budget deficits, rising debt-to-GDP ratios and mounting long-term commitments (of which entitlements are only one, but very important example). While these challenges have been more apparent since the Global Financial Crisis and the

subsequent Great Recession, many of them seem likely to deteriorate in the aftermath of the ongoing pandemic. At the same time, central banks in countries across seem to have largely run out of policy options, either reaching ZLB or diminishing returns to their unconventional policies. Acutely aware of the fact that they are running out of ammunition, some central bankers have even started to muse about alternative kinds of stimulus (e. g. Yellen (2016)).

On the other hand, some central banks have accumulated large reserves, which could be managed with the explicit objective of profit generation. Note that this is also the case for central banks which have managed to make their way down the path of normalization, but for some reason (e. g. an exchange rate commitment) have nevertheless seen a large expansion of their balance sheets. The Czech National Bank is a case in point. I propose to explore more active (or perhaps aggressive) reserve management as a way of reinvigorating the contribution of central banks to economic recovery as well as a remedy for the more long-term concerns.

Since such a relatively large recalibration of a central bank's policies and behavior would necessarily involve certain costs and probably more substantial institutional changes, I want to explore each of these carefully in turn. I will discuss the implications for central banks with substantial exchange rate management duties/commitments and discuss ways to address them. I also intend to comment extensively on the legal/political/institutional implications view a specific view to issues of central banks independence, transparence, and accountability. Likewise, I propose to discuss the implications for the conduct of monetary policy in order to determine whether such a new responsibility would be compatible with, or possibly in conflict with, the current central bank responsibilities. I will attempt to sketch out the contours of a framework which may satisfactorily address all these issues.

The proposed topic inevitably entails the need to touch upon a wide range of political, economic, legal, or institutional considerations. It is thus obviously beyond the scope of a bachelor thesis to debate each in enough depth. Therefore, I propose to conclude with a brief summary of issues I believe need to be explored further.

Methodology My aim will be to construct a more comprehensive dataset on levels and asset class composition on central bank reserves than is commonly found in litarature. That is, rather than focus predominantly on currency composition, as is common, I propose to more closely analyze data with a view to determining trends and changes in asset allocation (e. g. mainly among bonds, equities, real estate, and possibly other alternative asset classes). I then plan to carry out econometric analysis using the data to try to answer my research questions. I assume that much of the analysis of the behavior of reserves composition with respect to major macroeconomic variables can likely be done using standard regression analysis. In case variables of interest may be judged to respond to explanatory variables with a lag, an appropriately structured autoregressive distributed lag (ARDL) model could be constructed and estimated. Alternatively, if a cointegrating relationship is determined, an error correction model (ECM) could be deployed. Lastly, subgroups of data could be analyzed separately to test for the presence of idiosyncacies (e. g. whether certain central banks seem to behave substantially differently in case of past turbulent or traumatic events).

Expected Contribution As stated above, while there is literature and data on currency composition of CB reserves, much less discussed is the composition of reserves by asset class. To the extent that academic literature studies central bank reserve management, this is largely done in general terms, with a view to discussing best practices (such as in Nugee (2015)) or from a practitioner's viewpoint (such as in Nugee (2015) or in Sleeper (2005). A common denominator in all these streams is the treatment of reserve management as a by-product of central bank operations, more of an after-thought than an equally worthy pursuit. However, with recent increases of reserves held by many central banks, it may be worthwhile to start to treat active reserve management with a view to generating profit as one of the objectives of a central bank. As motivation I present the pressing need for many economies to identify alternative sources of revenue to meet growing long-term commitments. In the same vein, with many central banks effectively trapped in a corner, I identify reserve management as an alternative tool with which to contribute to stimulating their economies, their conventional tools (or even unconventional) having largely hit the limits of their efficacy. However, I believe even central banks who have arguably been successful in their policies may consider using their reserves more active. The Czech National Bank certainly appears to be a candidate.

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Chapter 1

Introduction

Central banks and monetary policy have been at the center of spotlight in countries throughout the world for more than a decade. Since the Global Financial Crisis, central banks have been instrumental in stabilizing financial markets and supporting subsequent economic recovery. While their often novel and unconventional policies have not been entirely uncontroversial, they have generally been judged favorably, especially on occasions when fiscal policy was not supportive. After the start of the COVID-19 pandemic, which as of this writing is still not over, central banks have once again responded forcefully, cutting interest rates, providing liquidity and reassuring markets and the broader public of their readiness to keep their accommodative measures in place and provide maximum support for the post pandemic recovery.

At the same time, voluminous academic literature has sought to analyze the efficacy and implications of the novel monetary policies. While monetary policy had already been a very fruitful research field for some time (especially during the so-called Great Moderation), the post-GFC period has given it renewed impetus, with sizeable literature devoted to issues such as the efficacy of monetary policy at the zero lower bound, and much more.

By contrast, while foreign exchange reserves held by central banks attracted a lot of attention during the 2000s, mainly in the face of rapidly growing holdings by some emerging economies, the focus seems to have decreased somewhat in recent years. However, as detailed in the following chapter, holdings of foreign reserves have continued to grow and even some developed economies, whose need for reserves is arguably much lower, have acquired large amounts of reserves. At the same time, the prevailing low-interest rate environment has made the task of managing large holdings somewhat more difficult and

made the opportunity cost of conventional conservative reserve management more pronounced. In fact, except for very few countries, such as Switzerland or Singapore, whose Monetary Authority manages a substantial percentage of its reserves in a long-term equity-oriented portfolio with a view of generating consistent returns and providing a regular income stream to the government budget, the vast majority of central banks do not treat consistent return generation as an explicit objective.

This thesis offers a two-pronged contribution to the topic of central bank foreign exchange reserves. First, Chapter 3 presents an econometric examination on the effect of foreign reserve holdings on macroeconomic variables, a relationship that so far seems not to have been substantially explored in the literature. Second, in Chapter 4 I consider and how the management of reserves as practiced in Singapore, with the focus on return and regular payouts to the government, could be emulated by other central banks. While I discuss the problem in general terms and the discussion is therefore applicable to any central bank, my motivation is primarily the case of the Czech National Bank, which recently accumulated extraordinarily high levels of foreign reserves as a percentage of Czech GDP. While the public debate on the management of foreign reserves in the Czech Republic is still fledgling, the opening shots have already been fired in Havránek (2022) and Král & Schmidt (2022) and it is reasonable to assume that the debate will continue. However, a comprehensive discussion of what such a process would look like, as well as what are the potential risks and threats to the central bank, has not yet been offered.

This thesis is organized as follows: in Chapter 2, I trace the context in which the accumulation of reserves by central banks worldwide has taken place; I go on to discuss the precautionary motives for holding reserves and also some costs associated with reserve holdings. Chapter 3 follows up with an econometric examination of the influence of reserves on macroeconomic variables, a topic that seems somewhat underexplored in the literature so far. Drawing on a recent contribution of Sula & Oguzoglu (2021), who provide evidence on data spanning 1981 and 2010 that countries with larger reserves have tended to enjoy higher economic growth, I show on a sample of selected countries that this relationship seems to develop through the positive effect on both household consumption and gross capital formation. Moreover, the results suggest that the relationship can be quite economically significant, though there seems to be a degree of heterogeneity among various countries, with some exhibiting very little of the studied relationship, and the estimates are surrounded by

uncertainty.

Chapter 4 starts off by reviewing the main trends in the management of foreign reserves by central banks to illustrate its conservative nature and also set the stage for the rest of the chapter. I then proceed to consider what a more aggressive, return-driven management of foreign reserves could look like. Since the problem of investment management is, in this circumstance, akin to the challenge of asset management as faced a private endowment (such as a university endowment), I draw on Swensen (2009) to illustrate the problem of endowment management, emphasizing those aspects especially pertinent to a central bank. While my main objective is not to dwell on the investment process itself, I devote a few pages to the question of asset allocation, namely the pros and cons of only investing in public equity markets as opposed to expanding into less liquid asset classes, in part because asset allocation will likely have implications for the return pattern as well as for management and accountability. I also briefly discuss asset allocations of selected major U.S. university endowments since the experience of major endowments can, with some limitations, yield useful lessons for hypothetical central bank portfolios while offering potentially useful insights into how these may be expected to perform.

However, while running an investment portfolio would effectively transform central banks into institutional investors in some ways similar to pension funds or university endowments, central banks are no ordinary institutions and their unique role gives rise to certain considerations not necessarily important to typical institutional investors. Given the fact that the overriding objective of a central bank is the conduct of monetary policy, it is critical to ensure that the task of running a long-term equity-oriented investment portfolio would not interfere with the core mandate. As I show, there are three main (in many ways interconnected) challenges: those of more active management and accountability (a reputational risk), the risks to central bank equity (a threat to independence and a reputational risk) and the problem of "quasi-fiscal dominance" (again, a threat to independence). While the discussion in Chapter 4 makes clear that the overall objectives and the investment process of an endowment are perfectly congruent with the need to minimize the main risks facing a central bank, the need to safeguard central bank independence and its capacity for unrestrained conduct of monetary policy likely requires more. Specifically, addressing the problem of accountability for investment decision should probably involve some form of shared and cooperative decision-making between a

central bank and its government, while the risks to central bank equity may require the build-up of an "equity buffer" to provide additional protection in the event of black-swan events. Similarly, the problem of "quasi-fiscal dominance" suggests the need for strict spending rules and ring-fencing of proceeds.

In sum, while the task of setting up and running a large portfolio is certainly not an easy one, I show in detail that addressing the risks and threats peculiar to a central bank is very feasible and actually almost surprisingly simple, at least in theory. At the end of Chapter 4, I also speculate whether some central banks could adopt the objective of return generation in a foreseeable future. Chapter 5 concludes. Appendix A provides a non-technical overview of monetary policy and issues related to central bank independence.

Chapter 2

The Accumulation of FX Reserves

In this chapter, I trace the reasons for the accumulation of large holdings of foreign reserves by many central banks. Since this phenomenon is inextricably linked to the financial history of the last quarter century, I begin with a short digression on that history. Thus the point of Section 2.1 is not so much to be comprehensive as to illustrate some of the risks faced (especially emerging) economies in order to better illustrate the context in which the accumulation of reserves has been taking place. In Section 2.2, I take a closer look at the role of FX reserves both as a precautionary measure and a residual of monetary policy. Finally, Section 2.3 discusses the costs associated with large holdings of foreign exchange reserves.

2.1 The Accumulation of Reserves: Some Context

The most plausible explanation for the hoarding of large amounts of foreign exchange reserves by many central banks is the increased risk and occurrence of periods of financial instability since the demise of the Bretton-Woods system. This is not to say that crises did not occur prior to the era of financial globalization and liberalization in which the world has operated for the past few decades; instances of financial instability prior to that include the famous "dollar shortage", which was ultimately only resolved by the Marshall Plan, or famous sterling devaluations of 1949 and 1967.

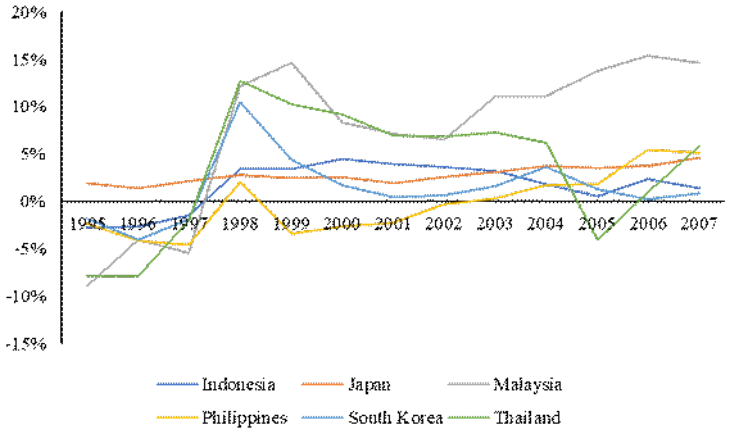
The decades following the closing of the gold window have presented new challenges and new periods of instability. The first notable cluster of "modern" financial crises occurred in Latin America in the early 1980s, when a period

of benevolent lending by U.S. banks to the region' s governments came to an abrupt end following the severe tightening by Paul Volcker's Federal Reserve. The inability of some Latin American governments to service large amounts of debt and the resulting economic turmoil led to the (in)famous "lost decade". At the same time, European economies also struggled to tame the tide of financial instability. While Europe did have some success in devising substitutes for the abandoned quasi-gold standard (like the adoption of the European Exchange Rate Mechanism), some European capitals found it difficult to reconcile a fixed exchange rate with the needs of their economies. Thus, the early 1990s witnessed speculation against the currencies of the United Kingdom and Italy and their hasty expulsion from the ERM. Meanwhile, some Latin American economies went through another round of instability, with the economies of Mexico, Argentina and Brazil going through protracted periods of economic and financial turmoil, see Krugman (2000) ch.2.

However, the Asian Financial Crisis of late 1990s was probably the most significant driver for the accumulation of foreign reserves. Earlier in that decade, many emerging economies in the region had rapidly liberalized their markets and opened up to foreign capital. The result was a rapid period of economic growth, but the stockpile of (often foreign-denominated and short-term) lending by mainly Japanese banks to private entities in South East Asia led to a gradual accumulation of various risks: private balance sheets became burdened by large debt obligations; at the same time, the ability to meet those obligations hinged on the success of long-term (and often rather speculative) investment projects and the continued willingness of foreign lenders extend new credit, or at least not recall the loans already provided. Moreover, the constant inflow of capital from abroad put upward pressure on local exchange rates, hurting competitiveness and leading to dangerous current account vulnerabilities (Figure 2.1) while creating concerns over possible devaluations. Some economies, primarily Thailand, experienced what appeared to be unsustainable real estate booms.

All of these risks manifested themselves in their full ugliness after Thailand's failed battle to avoid a rapid devaluation of its currency in the summer of 1997. Within a matter of weeks and months, many economies in the region were swept in an economic (and in the case of Indonesia, also political) tsunami as foreign creditors hastily withdrew their money and some of the region's currencies faced speculative attacks, leading Malaysia's then-prime minister to famously rail against "an international Jewish conspiracy". While the exact share of

Figure 2.1: Current Account Balance, Selected East Asian Countries (1995-2007)



Source: World Bank

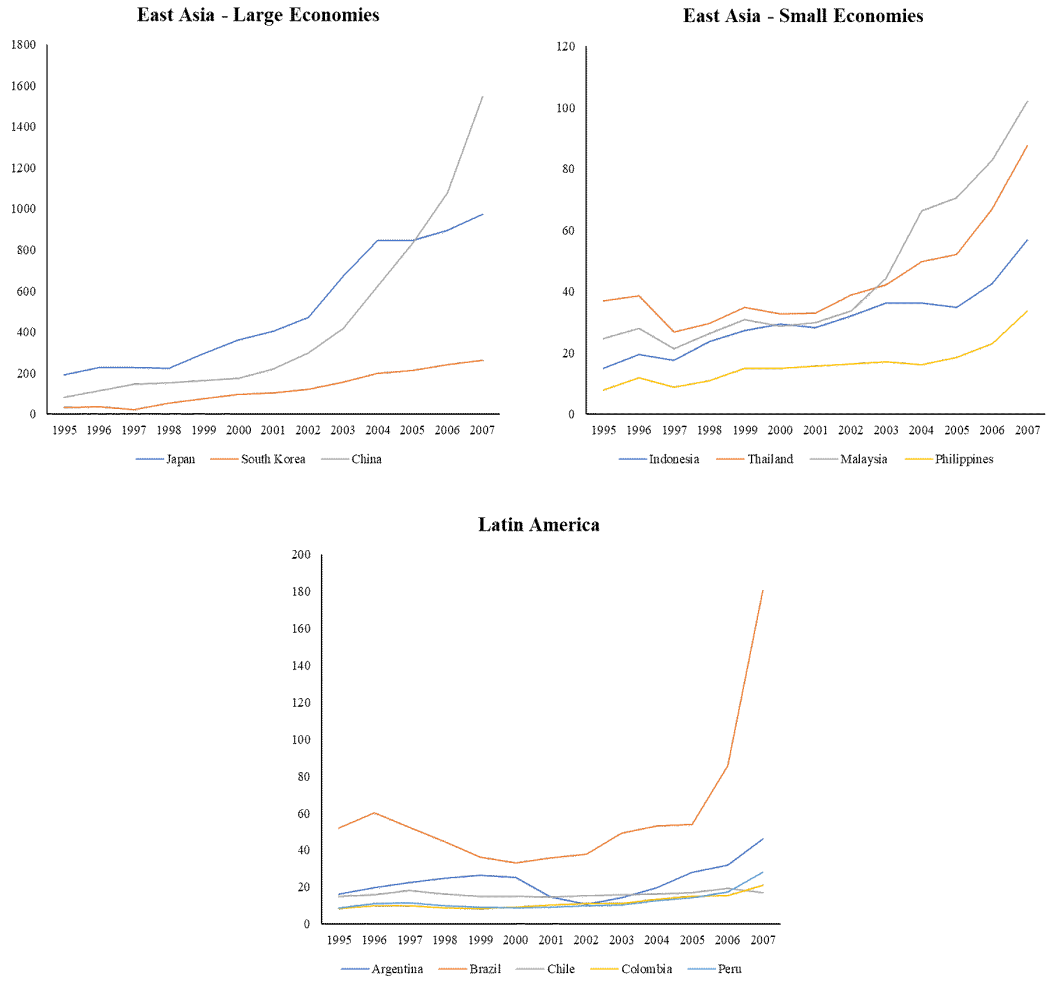
Note: The first years in the graph show CA deficits prior to the sudden stop of 1997. It is worth noting that while the sudden stop of 1997 is to a large extent responsible for the sharp shift into surplus by the countries hit most by the crisis in the immediate aftermath of 1997, the later years are likely more a reflection of the export-driven growth strategy and concern over the repeat of CA vulnerability.

blame is hard to apportion, a widespread perception at the time held that the crisis was probably more virulent than the economic vulnerabilities would have suggested, see Corsetti *et al.* (1998).

Emerging economies drew two main lessons from the tumult of the 1990s. To begin with, while financial globalization has unquestionable benefits in the form of access to foreign capital and a greater integration into the world economy, the financial and economic risks associated with the build-up of vulnerabilities (be it stock market or real estate bubbles or balance-sheet vulnerabilities) could produce potentially cataclysmic events, especially in the event of a "sudden stop" such as the one that occurred in the summer of 1997. At the same time, the existing global safety net turned out to be insufficient. First, the bailouts required by economies like Thailand or South Korea were far greater than any previously extended. Second, the "conditionality" attached to IMF-led bailouts provoked outrage and criticism for being too harsh and driven more by ideology than economic sense.

While EMEs were internalizing these lessons, they also made the choice not to turn back the clock to the pre-liberalization era, and with the brief exception of Malaysia, decided to keep their economies and markets open. In the absence of an adequate safety net, they also adopted a two-pronged insurance strategy, which consisted of running much healthier current account balances

Figure 2.2: Holdings of FX Reserves, Selected Economies (1995-2007)

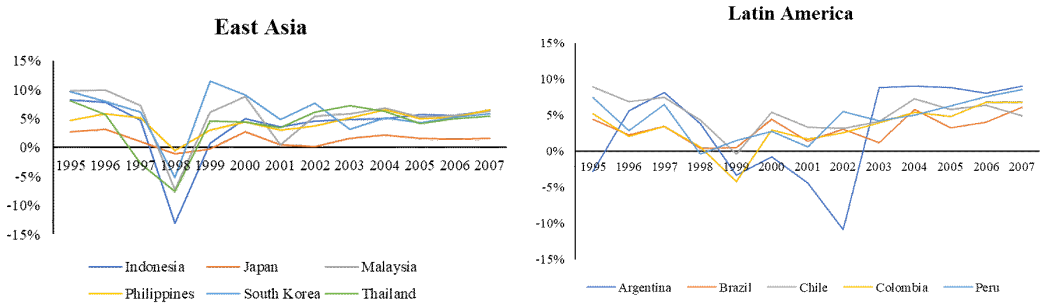


Source: World Bank
Note: The vertical axes are in billions of today's dollars. Holdings of FX reserves include gold valued at year end.

(see again Figure 2.1) and building up substantial war chests in the form of foreign exchange reserves (Figure 2.2).

Conditions prevailing in the early to mid-2000s turned out to be favorable to emerging economies. The period between 2003 and 2007 was a period of relative calm and the Federal Reserve maintained easy monetary policy by following the 9/11 attacks. Emerging economies benefited from the expansion of global trade and record amounts of foreign direct investment. The result was high economic growth for many EMEs (Figure 2.3). Interestingly, many central banks increased their stockpiles of reserves to such a large extent that the growth of reserves outpaced GDP growth (Figure 2.4).

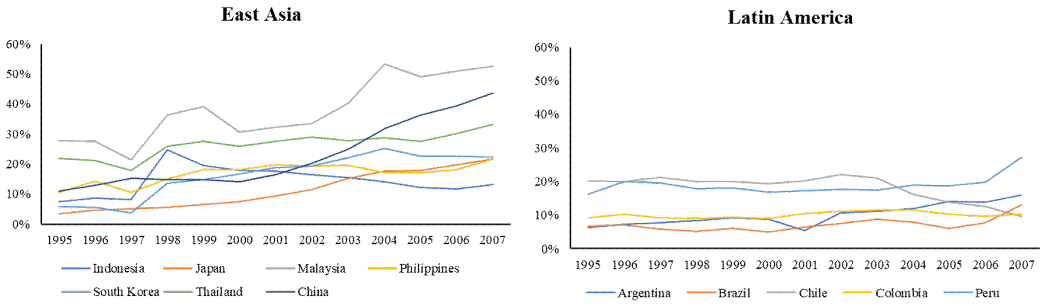
Figure 2.3: Rate of Real Growth, Selected Emerging Economies (1995-2007)



Source: World Bank

Note: The recessionary periods in the two samples are the Asian Financial Crisis and the economic implosions in Brazil and Argentina at the turn of the millennium.

Figure 2.4: FX reserves as a Percentage of GDP, Selected Emerging Economies (1995-2007)



Source: World Bank

Note: Holdings of FX reserves include gold valued at year end. While the growth in reserves outpaced GDP growth by a much smaller margin than in East Asia (with the exception of Indonesia), the overall trend seems rather similar across both regions.

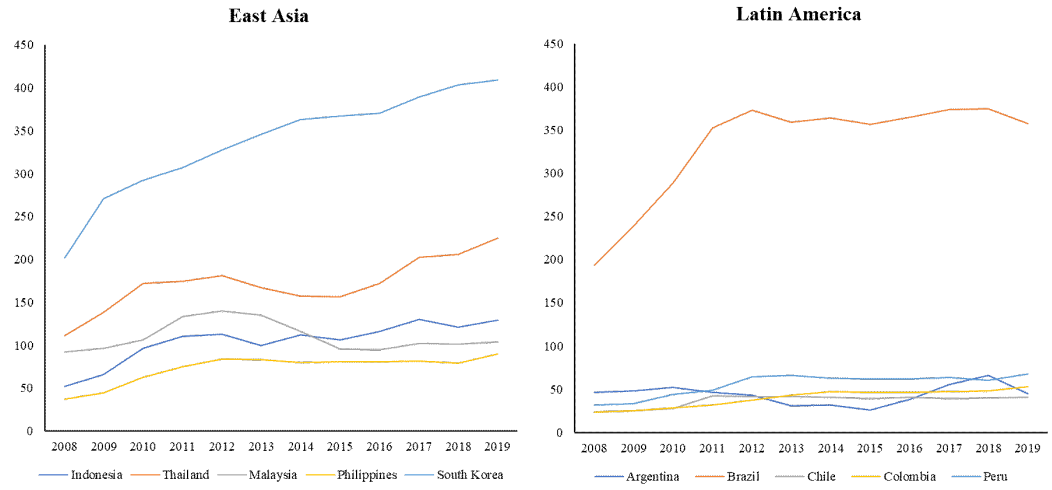
However, the period of calm came to an end with the failure of Lehman Brother and the ensuing Global Financial Crisis that. The uncertainty prompted investors to pull capital from EMEs. The capital flight triggered a lot of turbulence in exchange rates of many EMEs and threatened to damage their financial systems. Most notably, South Korea was forced to appeal to the Federal Reserve for an emergency swap line to restore confidence. At the same time, the collapse in global trade and the onset of the first worldwide recession since 1945 posed a risk to the future growth of developing countries (see Prasad (2015) ch.4 for an account).

Despite the turbulence of the Global Financial Crisis, most developing countries weathered the 2007-2009 period rather well (though some, for example the Baltic countries, paid heavily for the risks they had allowed to build up). In the absence of a quick recovery in the advanced world and with predictions of lackluster recovery becoming more and more common, they even started being described as the engines of future growth (the excitement over the "BRICS" economies being a case in point). On the other hand, the ultra-easy monetary policy pursued by the world's most important central banks created a new set of challenges for developing countries.

First, the rock-bottom interest rates, along with the promise to keep them that way for some time to come, caused some emerging market currencies to appreciate against the dollar (and also other reserve currencies), giving rise to accusations that the pursuit of low interest rates in fact amounted to a currency war in disguise; Brazil's then-president, seeing her country's currency appreciate rapidly, even accused the U.S. of unleashing a "monetary tsunami" on the world (see again Prasad (2015) ch.7 for an account). Second, successive rounds of QE and the efforts by central banks to flatten the yield curve (in other words, keep long-term interest rates low) prompted a "search for yield" by investors. The fact that low U.S. interest rates served as a trigger for inflows into EMEs was not really new, see Ghosh *et al.* (2018) ch.3; however, this time it occurred against the backdrop of an ultra-easy monetary policy which appeared poised to remain so for a long time. Moreover, the amounts of capital crossing borders freely and at short notice, dubbed "tourist dollars" in El-Erian (2017) ch.9, seemed more mobile than in past periods and greater than what could easily be explained by the "pull" factors, see Sahay *et al.* (2014).

On closer inspection, the concerns voiced by developing countries seem to have been justified. For one, literature has repeatedly documented the adverse effects of a rapidly strengthening currency on a country's exports (even

Figure 2.5: Holdings of FX Reserves, Selected Economies (2007-2019)



Source: World Bank
Note: The vertical axes are in billions of today's dollars. Holdings of FX reserves include gold valued at year end.

if followed by a subsequent weakening), giving credence to the "fear of appreciation".[1] Second, sizeable inflows of hot money (i.e. those invested in equity markets and other "runnable" funds) gave rise to fears of rapid outflows in the event of a change in sentiment and the potential knock-on effects. At the same time, and as if to guard against such a scenario, some central banks once again started increasing their holdings of foreign reserves (Figure 2.5).

The events of the summer of 2013 seemed to confirm the fears of policy-makers in developing economies. In May of that year, Fed chairman Bernanke hinted in a speech at a possible "tapering" of asset purchases by the Federal Reserve, see Fed (2013). Taking the hint as a signal that the world's most powerful central bank weighed gradually reducing its support, many investors were spooked by the prospect. The next weeks saw a period of rapid retrenchment as nervous investors pulled their money and some EMEs, not so long ago darlings of investors searching for yield, grappled with volatile currencies and stock markets as the search for yield turned into the flight to safety.

The experience of the "taper tantrum" led some policy-makers to air some vocal criticism of the advanced-economy central banks. Speaking on behalf of EMEs, Rajan (2014) criticized what he perceived as a disregard by the Federal Reserve and other important central banks for the spillover effects of their monetary policy on financial stability in other countries, while Eichengreen *et al.*

[1]See Ghosh *et al.* (2018) ch.4 for an investigation as well as a literature review.

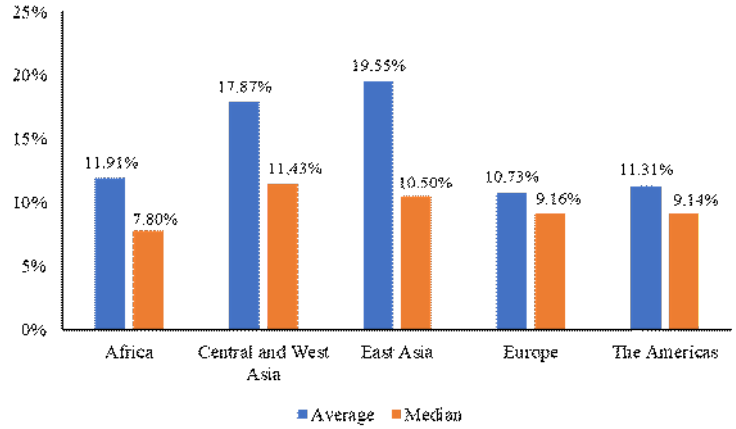
(2011) called for a "greater coordination" of monetary policy among central banks. Responding from the other side of the isle, Svensson *et al.* (2011) flatly dismissed concerns over any spillover effects, instead blaming the failure of central banks in EMEs to "allow their exchange rate to adjust" and counter other risks (such as equity market overheating) through standard tools of monetary policy.

Leaving the debates over monetary policy coordination (and its feasibility) aside, there are two lessons that can be drawn from episodes such as the taper tantrum: number one, in an interconnected world, developing economies are unavoidably impacted by monetary policy decisions in the world's strongest economies, and number two, the increasing mobility and amounts of capital crossing the borders can have very destabilizing effects if triggered by sudden shifts in sentiment. These factors, the experience of past crises, and the inability or unwillingness to rely on outside support such as the IMF, likely account for a great share of the accumulation of foreign reserves observed over the past quarter century.

Figure 2.6 on the next page plots the median and average values for foreign reserves as a percentage of GDP in 1995 for five world regions. The median country in East Asia, Europe and Central and Latin America had reserve holdings of around 10% of GDP, while the median country in Central and West Asia had reserves amounting to roughly 11.50% of GDP. Only in Africa was the median figure substantially lower, at 7.80%. At the same time, only the two Asian regions show the presence of outliers, manifested by substantially greater average figures. The total amount of reserves stood at 1.716 trillion in current U.S. dollars.

Compared to the 1995 levels, Figure 2.7 below shows the average and median holdings of foreign reserves as a percentage of GDP at the end of 2019. Even a cursory look at the charts shows that while the figures presented earlier in the chapter only documented the growth in reserves for selected countries (mainly due to expositional reasons and also the fact the patterns in reserve accumulation have simply been too heterogenous to capture in a concise manner), the trend seems to have held true overall. In none of the five regions was the average or median figure lower in 2019 than it had been in 1995; moreover, the medians have grown faster than the averages in all five regions, suggesting that rather than being driven by a few isolated outliers, the increase in reserves has really been relatively widespread. At the end of 2019, the total amount of reserves worldwide was 13.98 trillion in current U.S. dollars.

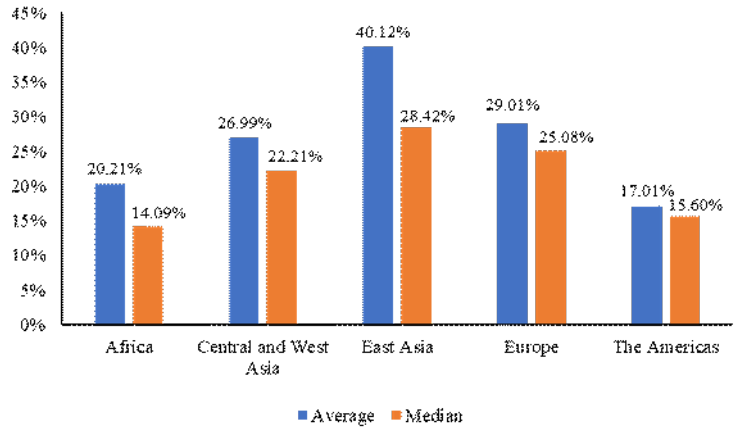
Figure 2.6: Foreign Reserves as a Percentage of GDP (1995)



Source: World Bank

Note: The FX reserve holdings include gold valued at year end. "East Asia" includes economies in the region impacted by the Asian Financial Crisis and is shown separately since the dynamics of reserve accumulation have often been described as different due to the history of financial turbulence in the region. "Europe" includes economies that later became members of the Eurozone; in their absence, the average and median would have been 10.32% and 8.54%, respectively. "The Americas" include the economies of Latin and Central America, excluding dollarized economies. "Africa" does not include members of the African monetary unions.

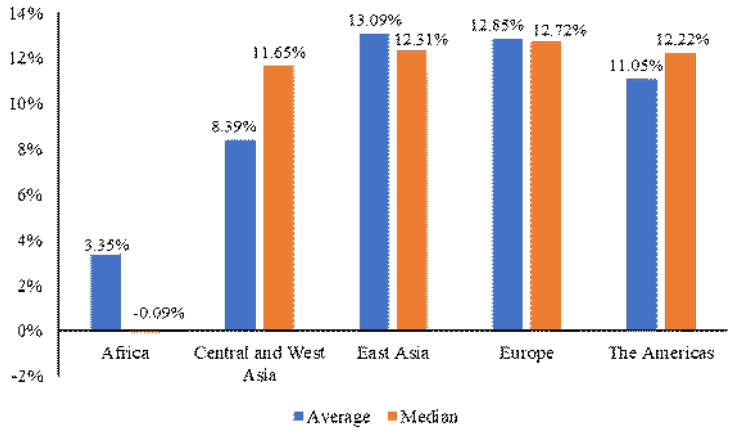
Figure 2.7: Foreign Reserves as a Percentage of GDP (2019)



Source: World Bank

Note: The FX reserve holdings include gold valued at year end. "East Asia" includes economies in the region impacted by the Asian Financial Crisis and is shown separately. "Europe" does not include members of the Eurozone. "The Americas" include the economies of Latin and Central America, excluding dollarized economies. "Africa" does not include members of the African monetary unions.

Figure 2.8: Percentage Changes in Foreign Reserves (2019-2020)



Source: World Bank

Note: The FX reserve holdings include gold valued at year end. "East Asia" includes economies in the region impacted by the Asian Financial Crisis and is shown separately. "Europe" does not include members of the Eurozone. "The Americas" include the economies of Latin and Central America, excluding dollarized economies. "Africa" does not include members of the African monetary unions. Unlike previous two figures, this figure only plots differences in absolute changes, rather than changes in reserves as a percentage of GDP since plotting changes as a percentage of GDP would have been very deceptive given the economic disruption of 2020.

It is interesting to also take a look at how countries' holdings of reserves have fared during the COVID-19 pandemic. While the still ongoing medical emergency has already claimed millions of lives and had far-reaching social consequences, it has also had substantial implications for economic and financial stability. In March 2020, the Dow Jones Index saw its largest day-drop since the Black Monday of 1987 and emerging economies faced some of the largest outflows of capital on record, see Brooks & Fortun (2020). However, as Figure 2.8 above shows, there seems to have been no overall depletion of reserve holdings; if anything, both the average and median figures were greater at the end of 2020 than at the end of 2019, and the increase has been far from insignificant. The only exception is Africa, where the average has grown only modestly while the median has remained essentially unchanged (decreasing by a negligible 0.09%). The total amount of reserves held worldwide was 15.24 trillion dollars as of the end of 2020. It is worth noting, however, that forceful responses of central banks, along with the fact that the U.S. stock market not only reclaimed the losses from the March 2020 sell-off and has actually fared rather handsomely since, have so far helped the world avoid a wave of defaults and widespread financial crises that many feared in the spring of 2020.

2.2 FX Reserves: A Precautionary Measure or a Residual of Monetary Policy?

2.2.1 Reserves as a Precautionary Measure

Having surveyed the patterns in the accumulation of reserves in the historical context, I now zoom in on the precautionary motives for holding FX reserves. These include paying for imports, defending against currency instability and speculative attacks, and backstopping the domestic financial system.

Paying for Imports

The first, one might say "traditional", motive for holding reserves is so that they can be deployed to finance imports of (essential) items from abroad in times of severe shortage of foreign exchange (in modern times, usually the U.S. dollar). If private agents do not have sufficient access to "hard" currency with which to pay their foreign counterparts, the central bank can step in and provide the needed foreign exchange.

Concerns over shortages of foreign exchange in post-WW2 period were quite common even among industrialized countries, most notably during the "dollar shortage" of the late 1940s or Britain's episodic balance of payments crises and often led to substantial trade restrictions or restrictions on currency convertibility. However, in recent decades it has been mostly developing economies that have had to resort to such restrictions, which in some cases have been quite peculiar. For example, in the spring of 2021, Nigeria imposed a preventive ban on importing items ranging from tomatoes to private jets in order to conserve its stock of foreign reserves, see Toromade (2021). Similarly, in 2015, while Argentina was hemorrhaging reserves due to inability to access world markets and the need to use some of its reserves to pay down debt, Argentinian importers of Porsches struck a deal with the government which granted them exception from an import ban in exchange for agreeing to export a specified amount of Argentinian-produced olives and wine, while importers of BMWs were allowed to do the same for agreeing to export rice, see AutomotiveNewsEurope (2015). The occasional need for such restrictions at times of reserve shortage gave rise to an informal "three month rule" for reserve adequacy, which states that a country should seek to maintain enough reserves to cover three monthsâ€™ worth of its imports. Imports have also become a popular determinant of a country's reserve stock, see Edison (2003).

Figure 2.9 on the next page plots countries' reserves as a percentage of GDP (on the horizontal axis) against imports as a percentage of GDP for five world regions for the period 2010-2019. Imports seem to explain roughly a quarter of variation in reserves in Africa and Central and West Asia and nearly a half in East Asia, while in Europe the amount decreases to about a sixth. Interestingly, in The Americas the proportion is a negligible 2%. The plots also suggest that a substantial majority of countries satisfied the three month rule (at least on ex post analysis); only in Africa does the proportion of countries in violation of the rule seem greater than in the other regions. It is worth noting, however, that this rule of thumb may be deceptive, since a country where importers have easy access to foreign exchange can presumably afford to hold little reserves. This seems to be the case for some developed economies.

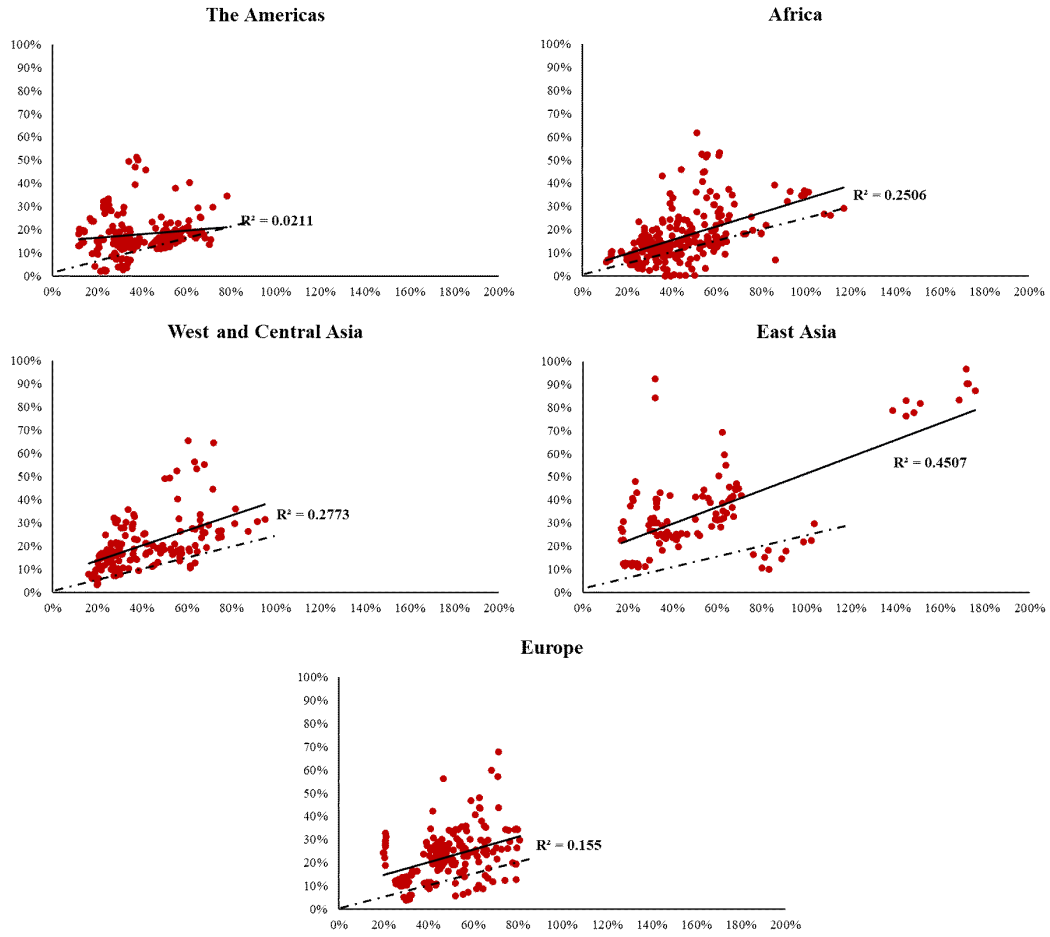
Defending the Exchange Rate

Another precautionary motive for maintaining sizeable foreign reserves is so that they can be used to counter depreciation pressures on the exchange rate or defend against a speculative attack. This motive gained in importance as a number of countries confronted currency crises in the decades following the demise of the Bretton-Woods system, and especially after the wave of currency crises and speculative attacks that occurred in the 1990s. Of course, central banks sometimes combine other tools (mainly interest rate hakes to slow capital outflows or restricts capital outflows outright) with selling reserves in exchange for their currency in open market to prop up its value. The question pertinent here is whether reserves are of any use.

Interestingly, central banks do not really seem to have theoretical literature on their side. In an early contribution, Krugman (1979) models a central bank that maintains a currency peg and is simultaneously forced to finance government deficit through issuance of new currency. This inevitably leads to higher inflation and pressure on the currency peg, which is ultimately abandoned once the central bank runs out of reserves with which to defend the fixed exchange rate. Thus, reserves can only postpone the inevitable denouement.

Of course, while some countries have historically shown to be adept at running "crazy policies", they are not always that crazy. Moreover, currency attacks in the 1990s featured and important self-fulfilling element, which caused imprudent (but not necessarily crazy) combinations of policies to end in a surprising currency crisis. A model in this vein is developed in Obstfeld *et al.* (1996), who use a variation on the dynamic-inconsistency problem to model

Figure 2.9: Imports as an Explanatory Variable for FX Reserves (2010-2019)



Source: Author's calculations based on data from the World Bank
Note: FX reserves as a percentage of GDP are plotted on the vertical axis, while imports to GDP are plotted on the horizontal axis. The (full) regression line and the associated R^2 correspond to a simple regression of FX reserves on imports. Thus, it does not take into account country or year effects or other variables and needs to be interpreted with a grain of salt. Another issue is the potential for reverse causality, where lower reserves could theoretically force a contraction in imports; this could be especially true for countries that violate the "three month rule". However, empirical literature usually treats imports as exogenous in this setting, see Edison (2003). Note that the three month rule is represented by the dotted line; countries above it satisfy the three month rule.

the behavior of a central bank that again maintains a fixed exchange rate while seeking to prop up output at the cost of reneging on its inflation target. In such a setup, the status quo is likely to become harder to maintain as the problem grows in magnitude (among other things, higher prices at home can hollow out exports in the absence of the exchange rate adjustment). The central bank can either renege on its currency peg or double down on its inconsistent policy, defend the peg and pay the cost, which consists of continuing with imprudent policies and risking the loss of reserves and taking a potential capital loss once a devaluation occurs. Importantly, Obstfeld *et al.* (1996) show that to the extent that the dynamic inconsistency problem (and by extension, expected inflation), is serious enough (and the costs of defending the peg are perceived to be high enough), the central bank's choice can be skewed quite heavily toward devaluation. In other words, with enough pressure, the central bank can be forced to abandon its fixed exchange rate (instead of using reserves or other tools to defend it) sooner than may otherwise have been the case.

It is worth noting that dynamic inconsistency is not the only set of assumptions that can give rise to a self-fulfilling currency crisis. A case in point is the United Kingdom in 1992, which battled a weak economy while trying to keep the pound in the ERM. One could make the case that the situation may have ended with the UK's exit from the ERM sooner or later, but the fact that the pound became a target for speculators who dared Bank of England to either put up fight (and in the process risk losing its reserves in an effort to save an unhealthy status quo) or abandon the peg probably brought the whole episode to an end sooner.

An interesting conclusion that follows from the discussion above is that there generally does not seem to be much space for using reserves as a defense against an attack, or at the very least, reserves are no guarantee of success. Even more importantly, even when a central bank "wins", it is still stuck in a fundamentally unhealthy position, which could easily become worse down road. To the extent that speculators "help" a central bank to abandon such a position, their help can even be considered a favor, leaving aside the associated embarrassment.

However, the scenarios discussed above require necessarily require an underlying set of "inconsistencies" in order to work. The decision-making becomes more complex if depreciation pressures result from a temporary dislocation in the currency markets (most commonly, imbalances between supply and demand due to a sudden spike in selling pressure). An example of such a situation is the

case of Thailand, which faced an unexpected depreciation pressure on the bath in 2005 when remarks by a high ranking official caused fears that the country weighed imposing capital restrictions, sending foreign capital scrambling for the exit. A similar dynamic is often at play when a financial crisis originating in one country causes fearful investors to pull their money either from a whole region, as in the case of the Asian Financial Crisis and the famous "sudden-stop" discussed in Chang & Velasco (1998), or from developing economies in general (as in the case of the Global Financial Crisis or, to a lesser extent, during the "taper tantrum" selloff). Farrell *et al.* (2020) document that much of trading activity during the "taper tantrum" could be attributed to a handful of large institutional investors, suggesting that the coming of the "tourist dollar" may present similar challenges again in the future. It is also worth noting that these considerations can be equally valid even for central banks that pursue inflation targeting or other mandate, not necessarily for countries that maintain various forms of a fixed exchange rate (although, as Obstfeld *et al.* (2010) document, countries with fixed regimes have tended to maintain higher levels of reserves).

In contrast to the previous instances, intervening in support of a country's currency can be considered legitimate and can end up in a successful outcome. However, there is again no guarantee of success; sometimes, a mere commitment by a central bank do deploy its reserves can be enough while in other situations even ferocious intervention by a central bank may not be enough (an example can be recent periodic attempts by the Central Bank of Turkey to slow down lira's slide).

The problem that complicates a central bank's risk calculus is that some cases of past sharp depreciations have proven remarkably ugly. This was especially true in situations where sudden currency slumps combined with other economic vulnerabilities, such as liquidity or maturity mismatches on private-sector balance sheets. This lesson was very painful during the Asian Crisis, giving rise to a "contractionary depreciation" as discussed in Krugman (1999), as opposed to an "expansionary depreciation", in which a weaker exchange rate boosts a country's exports and helps speed up the post-crisis recovery. In fact, central banks sometimes get rather creative when it comes to defending their currencies. For instance, Lee (2011) ch.23 recounts the Singaporean Monetary Authority being asked to intervene on behalf of Thailand's currency (with Thailand's own reserves!) so as to create an illusion of coordinated support in the spring of 1997, while just a few months later, South Korea's central bank was caught lying about the true available level of its foreign reserves, see Kim

(2000). Even more spectacularly, Hong Kong's Monetary Authority intervened directly in both exchange rate markets and Hong Kong's stock market in the summer of 1998 to successfully thwart the famous "double market play", see Jao & Yeung (2001) ch.4.[2]

On the other hand, countries often show reluctance to step in to defend their currencies against depreciation pressures. For example, both Singapore and Taiwan refused to intervene on behalf of the dollars during the Asian Crisis, choosing instead to accept a drop in their currency value, despite having some of the largest stockpiles in the world Jao & Yeung (2001) ch.1. There are two possible rationales for such a choice. First, a country feels it can weather a sudden currency weakness without too much pain. Second, it prefers to conserve reserves, perhaps because it feels that the chances of currency defense are not high enough or because it fears that reserves used in exchange rate interventions may be missed if they need to be deployed in back-stopping the domestic financial system, a question I explore below.

Backstopping the Domestic Financial System

The third and final precautionary motive is directly related to the developments discussed earlier in the chapter and could be considered the most important driver behind the ever-rising stockpiles of reserves.

As already discussed, the need to backstop a domestic financial system in the event of a large external drain gained widespread attention during the Asian Financial Crisis, when a tsunami of capital flight left many private balance sheets in negative numbers as short-term funding of long-term projects was withheld and sharp depreciations simultaneously made it difficult to honor foreign-denominated loans. Concurrently, IMF-organized bailouts left a legacy of bitterness. Instead of relying on an "international lender of last resort", central banks seemed to choose to rely on themselves to supply such a role and in the wake of Lehman bankruptcy a decade later, some of them used their

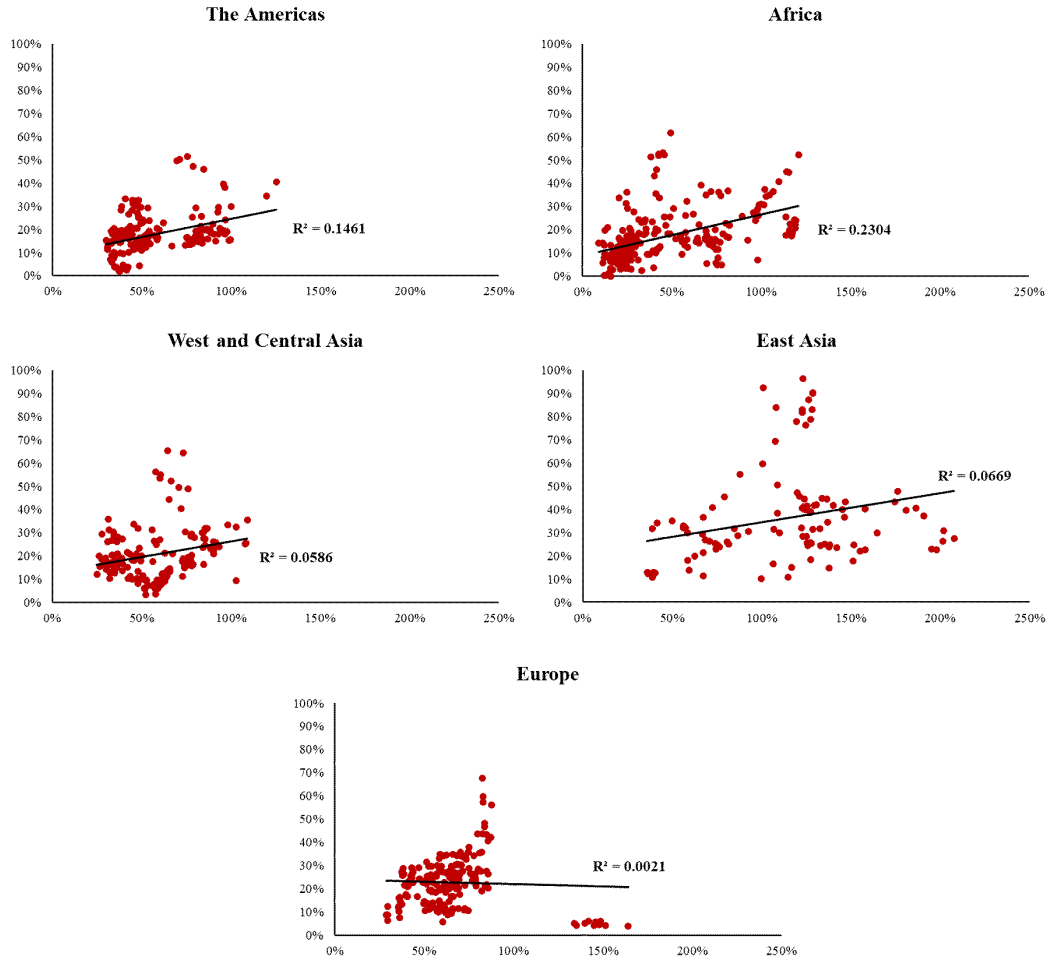
[2]The case of Hong Kong is a rather special one. On the one hand, the country has maintained a currency board since 1983, which would have only allowed an attack on the Hong Kong dollar to be successful if the currency board had been jettisoned. On the other hand, since Hong Kong's dollar is freely convertible, concerted shorting of the currency and the need to use reserves could, in time, have soaked liquidity out of the financial system, which in turn could have triggered a sharp correction in the equity market. The "double market play" was thus as much as (if not more) an attack on the equity market as on the currency. A discussion of Hong Kong's defense and the question of whether speculators actually knew what they were doing can be found in Jao & Yeung (2001) ch.4 and Yam (1998).

reserves to act as a LOLR in foreign currencies, see Arslan & Cantú (2019) ch.1.

Literature did not take long to catch up. The first in this line of thinking about foreign reserves was the so-called Guidotti-Greenspan rule, which stated that a country's reserves ought to cover all short-term foreign-denominated debt. However, the foundational contribution is Obstfeld *et al.* (2010), which followed-up on the G-G rule but extended it substantially. Instead of fixating on short-term external debt, Obstfeld *et al.* (2010) consider a situation in which a central bank faces a simultaneous attack on its currency and a domestic capital flight. Left as the only remaining "forex market maker", the central bank can only forestall exchange rate depreciation by absorbing all domestic liquidity that wishes to be converted into foreign currency and leave the country. Crucially, such a drain can happen much faster than a "traditional" drain where a depletion of reserves results from a collapse in exports and the need to keep financing imports. As a measure of "runnable" capital, the authors proposed broad money (M2) and showed that M2 was in fact a significant determinant of reserve holdings, especially when coupled with financial openness. Using a slightly newer set of data spanning 1999-2010, Benecka *et al.* (2014) arrived at a similar result, although they find financial development seems to render reserves less important.

Similar to imports, Figure 2.10 below plots ratio of FX reserves to GDP against the ratio of broad money to GDP for the period 2010-2019. Note that there is no hard-and-fast rule for reserve adequacy, as the three-month rule for imports. Somewhat surprisingly, broad money seems to explain very little variation in reserves in both Asian regions and virtually none in Europe. The only regions where the proportion seems significant are Latin and Central America (roughly 15%) and Africa (roughly 25%). It is worth noting, however, that broad money is not necessarily sufficient to capture this precautionary motive as the risk of a large scale capital flight is probably more fluid and harder to capture using a simple metric, especially in a world of continuous financial innovation In fact, studies have shown reserves to be a mitigating factor in periods of capital outflows, see for example Ghosh *et al.* (2018) ch.4. Using a more granular perspective, Alberola *et al.* (2016) show that reserves seem to discourage outflows by residents (although, their evidence also seems to suggest that reserves can be procyclical in attracting greater flows by nonresidents in times of calm). A similar view treating reserves as a way of creating a credible backstop for private financial flows is offered in Mehrling (2015).

Figure 2.10: Broad Money as an Explanatory Variable for FX Reserves (2010-2019)



Source: Author's calculations based on data from the World Bank
Note: FX reserves to GDP are plotted on the vertical axis while M2 to GDP is plotted on the horizontal axis. As in the case of the previous figure, the (full) regression line and the associated R^2 correspond to a simple regression of FX reserves on M2. Thus, it does not take into account country or year effects or other variables and needs to be interpreted with a grain of salt. Another issue is again the potential for reverse causality, where higher reserves could filter into an increase in broad money in case of insufficient sterilization by the central bank or perhaps through more optimistic lending by lenders who perceive higher reserves as a buffer against financial shocks. Again however, this possibility seems to be discounted in literature (see Obstfeld *et al.* (2010) for a discussion).

2.2.2 Reserves as a Residual of Monetary Policy

An important part of the debate about the rising levels of reserves has been the controversy surrounding the use of the exchange rate to gain a competitive advantage. This followed from the fact that econometricians have sometimes struggled to "explain" the hoarding of reserves by central banks purely on precautionary motives. At the same time, many countries whose central banks were accumulating ever growing war chests in the 2000s (including China) ran consistent trade surpluses, giving rise to accusations that new reserves were more a derivative of exchange rate fixing than a precautionary move. At the same time, the notion that countries with "cheap" real exchange rates grew faster gained popularity, as in Rodrik (2008).

Even in the decade since the GFC, reserve patterns seemed to suggest that the "mercantilist" motive, as well as the â€śfear of appreciationâ€ť continued to gain in importance. In a very recent paper, Adler *et al.* (2021) document that interventions countering appreciation (i.e. consisting of selling domestic currency and accumulating foreign reserves) was widespread, increasingly also among developed countries.[3] This is consistent with the fact that many EMEs (and also some AEs, notably Denmark and Japan), complained of the adverse effects of large inflows on their exchange rates.

However, there are three main problems with distinguishing between "mercantilist" and "precautionary" accumulation. First, the impact of interventions on exchange rates is notoriously hard to recognize (see d Chamon *et al.* (2019) for a discussion of the methodological issues). Second, central banks are usually not very forthcoming about their motives; sometimes, they announce their intention to accumulate new reserves, citing precautionary motives; sometimes, they choose to do so stealthily. Third, it is not clear that the distinction between reserves as a precaution and reserves as a residual of monetary policy makes sense; to give an example discussed earlier, reserves accumulated by Latin American countries in the aftermath of the GFC, when the same countries complained loudly about the "monetary tsunami" (and the motive to counter exchange rate appreciation may have been a motive behind their increasing reserve holdings) could be considered a residual of monetary policy but could have come in handy as a precautionary tool if the sell-offs in the summer of 2013 had produced more threatening consequences. (The fact that

[3]Note that since most central banks do not regularly publish data regarding their interventions, the authors rely on "carefully derived proxies" to obtain their results. See the original paper for a discussion.

they did not and that reserves held in the region did not decrease substantially does not rule out the possibility that a similar sequence of events could play out more disastrously in a different place at a different time.)

There are, of course, a handful of cases where the motive can be attributed more definitively. The Swiss National Bank accumulated staggering amounts of reserves in the post-GFC period as a result of its commitment to counter franc appreciation, which threatened to decimate Swiss exports. (The persistent growth in SNB's reserves since the violent exit from the commitment in 2015 suggests that interventions may have continued.) Similarly, the Czech National Bank quadrupled its own foreign exchange reserves when it used exchange rate as an unconventional instrument of monetary policy between 2013 and 2017 in order to reach its inflation target, see Franta *et al.* (2014). However, the unconventional nature of such pursuits suggests that they remain more of an exception rather than a rule.

2.3 The Costs of Large Reserve Holdings

To conclude the discussion of foreign reserves, I briefly discuss various costs associated with growing FX holdings. These costs include (in no specific order of importance) sterilization, currency risk, default risk, global spillovers and opportunity cost.

Sterilization Cost

An accumulation of new reserves by a central bank is usually "financed" by creating new currency on the liability side of a central bank's balance sheet. However, the newly created liquidity generally needs to be sterilized out of the economy or else an expansion in money supply may interfere with a central bank's inflation target. Given that this is usually done through reverse repo operations, a central bank pays interest on its sterilization bonds. Given that interest rates in many economies (especially emerging) economies tend to be higher than in the U.S., and central banks are generally understood to deposit their reserves in U.S. Treasuries (or perhaps other advanced-economy debt instruments, the cost of sterilization can be higher than the yield on reserves. While this can theoretically be "solved" by forcing the financial sector to buy sterilization bonds at concessional terms, as seems to have happened for example in China - see Eichengreen *et al.* (2011) - this is hardly a market-based approach. Note, however, that exact sterilization cost can be hard to mea-

sure without knowing the exact composition of a central bank's balance sheet (for example, if reserves are invested in 10-year bonds and sterilization is done through shorter-term bonds, the picture can be very different). On the other hand, the need for the financial system can potentially divert credit from other uses, a concern occasionally cited in literature.

Currency Risk

As much as reserves can serve as protection against exchange-rate-induced risks, the fact that foreign-denominated assets are not matched by foreign-denominated liabilities gives rise to the risk that a central bank may take a capital loss due to a change in valuation of reserves. A prime example would be the Swiss National Bank, which suffered a loss on its FX reserves in 2010, see Amador *et al.* (2016). This type of loss can occur naturally (for example as a result of gradual exchange rate appreciation commonly observed in catching-up economies) or as a result of macroeconomic adjustment; for example, the fact that the U.S. dollar is understood to make up roughly 65% of central bank reserves on average,[4] (with the median being as high as 76% according to a recent survey in Anasashvili *et al.* (2020)) coupled with the fact that the U.S. has run persistent trade deficits for decades, has form time to time had central banks worried about a capital loss if the U.S. dollar were to depreciate and the U.S. trade balance were to close. On the other hand, there is no guarantee that the traditional adjustment mechanism will do its work in the foreseeable future, given the unique position of the U.S. economy and the fact that capital flows are largely divorced from trade flows in the modern economy; in any case, predictions about the inevitable adjustment in the value of the dollar and the closing of the U.S. trade imbalance have become a bit of a cottage industry, with not much vindication. However, there is some indication that some central bankers are concerned about the political repercussions should this risk materialize, see Arslan & Cantú (2019).

Default Risk

This type of risk is rather exotic due to the conservative nature of central bank reserve management. However, reserves need to be invested somewhere, and a certain amount of counterparty risk (however small) may still exist. For example, large investments by central banks in U.S. treasuries and difficult

[4]Note that the IMF only reports the overall percentage figures pertaining to currency composition of central bank reserves, while individual-country data are kept strictly confidential.

rounds of budget negotiations on Capitol Hill in the post-GFC period led to some concerns that exploding U.S. debt may tempt Washington to renege on its obligations, potentially threatening a huge capital loss for central banks. Speaking at a university in China in 2011, U.S. Treasury Secretary Geithner famously faced questions as to whether investments in U.S. Treasuries were in fact safe, see Prasad (2015) ch.6. Given the recent spending bills enacted by the U.S. Congress, such concerns could theoretically surface again, though the likelihood of a default by the U.S. government is likely very small. On the other hand, as central banks slowly begin to diversify into "non-traditional" asset classes such as corporate bonds, counterparty exposure could start to become more of a concern (see Chapter 4).

Global Spillovers

The dramatic increase in reserves worldwide coincided with overall decrease in U.S. interest rates and an overall flattening of the yield curve. Given that U.S. treasuries are a known destination for central bank reserves, it could be argued that the hoarding of reserves might have contributed to the global "savings glut" as central banks become increasingly involved in the global competition for safe assets. However, such a hypothesis is a matter of dispute and hard to (dis)prove. See Arslan & Cantú (2019) for a discussion.

Opportunity Cost

The concept of the opportunity cost of reserves was popularized by Rodrik (2006). In this context, I prefer to define the term narrowly as the costs stemming from the decision by central banks to restrict their investments of reserve into very safe assets (see Chapter 4). Even in this context, the cost can be far from negligible; for a country with reserves amounting to roughly 30% of GDP (the 2019 median for East Asia), each 1% in foregone investment opportunities equals 0.3% of GDP in foregone yield every year. One could go further and incorporate secondary costs, such as the costs of failing to invest the hypothetical yield in education or infrastructure, but the discussion obviously becomes more speculative.

In conclusion, as foreign reserves have grown, so has the attention paid to some of the costs. Of course, one should not lose sight of the fact that there are substantial advantages associated with holding those, and these have been discussed above. On the other hand, while benefits accrue to the whole economy, losses generally need to be absorbed by central banks, a fact that has

seemed to cause some concern among central bankers. I discuss the question of central bank losses in greater detail in Chapter 4.

Chapter 3

Do Reserves Help Drive Investment and Consumption? Evidence from Selected Countries

This chapter follows on the discussion above by examining the interplay between foreign reserves and macroeconomic variables. Interestingly, this question seems somewhat underexplored. The only published contribution I am aware of is Sula & Oguzoglu (2021), who find on a panel spanning the period between 1981 and 2010 that countries with more reserves tend to enjoy higher economic growth, though the effect is weaker as the cost of holding reserves increases. Here I take a more indirect approach, examining the channels through which the effect of reserve holdings on growth is likely to develop.

There are two obvious channels through which higher reserves could translate into faster growth: the more obvious one is investment, and the other (perhaps less obvious one) is household consumption. Why higher reserves might drive greater investment is not hard to imagine; likely the most important motive behind the accumulation of reserves by (mainly emerging) economies is the need for an "insurance" against financial shocks that can significantly disrupt economic development (see literature review in the previous chapter). It is therefore reasonable to assume that from the viewpoint of an investor considering an investment project in a country that could suffer a period of such disruption, the level of reserves could be an important criterion by which to judge the riskiness of a project. To a domestic entrepreneur, the experience of a past crisis may provide further reason for cation. However, reserves could be potentially important even in an economy which has not previously

gone through a financial crisis, since outside investors often seem to treat all emerging economies as similarly risky. At the same time, â€śinsuranceâ€ť in forms of reserves could potentially make new projects easier to finance if the perception of greater stability eases domestic lending conditions. (On the flip side, incomplete sterilization of new reserve could potentially have the same effect, but this distinction likely cannot be captured in an econometric model.)

As for household consumption, the effect of reserves could be similar; in countries that experienced painful crises in the past, a perception of higher reserves could serve as a psychological inducement for greater consumption as opposed to the need to save income to live through periods of economic hardship. The contribution of Alberola *et al.* (2016) documenting the role of reserves as a factor mitigating the tendency of residents to shift assets abroad in times of stress is an example of how greater comfort could encourage similar behavior. At the same time, easier lending conditions could potentially encourage greater consumption, just as in case of investment. On the other hand, it seems reasonable to assume that while the consumption channel could be potentially significant in countries with tumultuous past, consumption should overall be expected to be less volatile than investment. It is also important to note that this channel can work less obviously in situations where higher reserves cause increased demand for foreign goods, rather than for domestic goods.

3.1 Estimation Strategy

The discussion above leads to the following economic model:

$$household\ consumption = f\{foreign\ reserves,\ X\}$$

$$investment = f\{foreign\ reserves,\ X\}$$

where f is a presumably increasing function and X is a vector of other variables influencing consumption and investment. The next step is to translate an economic model into an econometric model. The most basic choice would be to use panel regressions to test for the presence of a relationship. However, there are several reasons why a regression-based approach is likely suboptimal. First, the causal relationship may only manifest itself with a lag, requiring the inclusion of lagged values and possibly involving the need to guess the appropriate lag. Second, the nature of the relationship is likely to be country-specific. Third, the relationship between reserves and consumption/investment

cannot be studied in a single model, necessitating a special model for each of the two macro variables. Consequently, I opt for a vector autoregression, which since its introduction in Sims (1980) has become a standard tool in macroeconometrics and is more suited to the task at hand for the reasons discussed above.

A vector autoregressive model (VAR) of order n is defined as follows:

$$y_t = a + A_1 y_{t-1} + ... + A_n y_{t-n} + u_t \tag{3.1}$$

where $y_t = (y_{1t}, ..., y_{kt})^T$ is a vector of endogenous variables, $u_t = (u_{1t}, ..., u_{kt})^T$ is a vector of white noise terms, a is a Kx1 vector of constants and A_i for i = {1,...,n} is a K x K matrix of parameters to be estimated. A VAR model thus allows a system of variables to be modeled as a system of equations where each variable is a function of its own lagged values as well as the lagged values of all other variables while treating all variables in the system as endogenous.

As is common in literature, I utilize orthogonalized impulse response functions (IRFs) and forward error variance decompositions (FEVDs) to isolate the effect of the shocks to one variable on the other variables. Impulse response functions indicate the response of a variable (i.e. its magnitude and direction) in response to an orthogonalized one-standard-deviation shock to another variable in periods after an intervention. Forward error variance decompositions indicate the percentage of the variation of a variable that can be explained by shocks to other variables.

A well-known identification issue in VAR modeling is the need to impose a sufficient number of parameter restrictions in order for the IRFs and FEVDs to be uniquely identified. As is common, I opt for Cholesky decomposition, which requires the assumption that variables in a system can only have a contemporaneous impact on variables placed after them. My model is specified in the following way:

$$OIL \rightarrow FXR \rightarrow HC \rightarrow GCF$$

Apart from foreign exchange reserves, household consumption and gross capital formation (denoting investment), I also include the price of oil as a proxy for global conditions, as is common in VAR models. The ordering of the variables deserves a brief discussion. Placing the oil price in the first place is rather easy, since no economy is likely to significantly influence the price of oil except perhaps the United States, see Bussière *et al.* (2009). Likewise,

it makes sense to place gross capital formation (investment) behind household consumption since while increased investment can certainly influence consumption (most obviously, through higher GDP and greater disposable income), this influence is highly unlikely to occur immediately.

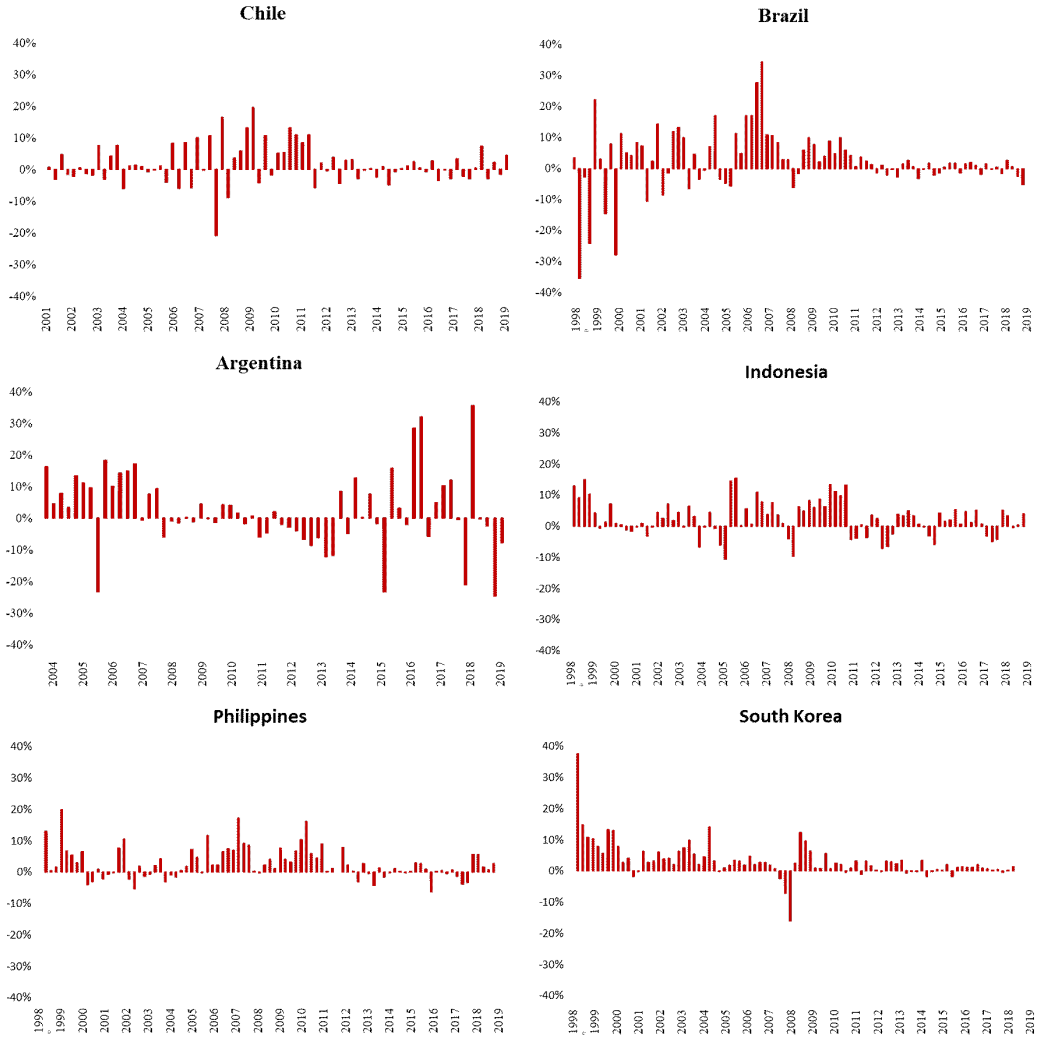
Foreign reserves are placed before consumption and investment, since it is highly unlikely that consumption or investment should have an immediate effect on foreign reserves. By contrast, shocks to foreign reserves could theoretically have a contemporaneous impact on consumption or investment, since data on reserves are generally available on monthly basis and unexpected shocks could, based on the discussion above, have a more immediate influence. Having also estimated the models with reserves placed last and obtained essentially identical results, I feel reasonably confident of the presented ordering.

While VAR models have the advantage of allowing the interaction among variables to be studied for each country individually, the drawback is that I can only provide evidence for a limited sample. In this chapter, I present evidence from Chile, Brazil, Argentina, Indonesia, South Korea and Philippines. However, the choice is not completely random. Brazil and Argentina are economies that have suffered crises in the past and it is reasonable to expect that reserves could play a role in influencing macro variables. Likewise, while Chile has arguably not suffered as grave a crises as the other two, it also has experience with economic instability. Indonesia and South Korea were among the epicenters of the Asian Financial Crisis and while South Korea certainly represents a more mature economy, it still required an emergency swap line in 2008; both countries thus seem worth taking a look at. Finally, Philippines is a small emerging economy that has not seen as dramatic crises as other countries, but is located in a potentially one of the most geopolitically volatile regions.

I work with quarterly data spanning the period of 1998-2019 for Brazil, Indonesia, Philippines and South Korea. For Chile and Argentina, the available series are shorter, 2001-2019 and 2004-2019, respectively. Data for household consumption and gross capital formation are retrieved from respective central banks or statistics offices, for oil I use the Global Brent price from FRED. Figure 3.1 on the next page plots quarterly percentage changes in reserves for all six economies.

An important issue in VAR modeling is the stationarity of variables as non-stationary data could potentially decrease the reliability of the estimated coefficients. However, Sims *et al.* (1990) suggest that inference with data series that are non-stationary is legitimate as long as the model is not used for

Figure 3.1: Quarterly Changes in Foreign Reserves



Source: Author's calculations based on data from respective central banks

Table 3.1: Augmented Dickey-Fuller Tests

	ARG	**BRL**	**CHL**	**IND**	**PHI**	**SKR**
Log-diff OIL	0.0354**	0.235	0.401	0.235	0.235	0.235
Log-diff FXR	0.075*	0.51	0.53	0.213	0.554	<0.01***
Log-diff HC	<0.01***	0.449	0.26	0.022**	0.141	0.033**
Log-diff GCF	<0.01***	0.494	0.024**	0.614	0.024**	0.019**

Source: Author's calculations
Note: The ADF test tests the null of a unit root in a series against the alternative of no unit root. "*", "**", and "***" denote significance at 10%, 5%, and 1% level respectively. P-values differ for oil since time series are of different length for various countries

forecasting and is stable . In the case of my models, estimation with untransformed data produced unstable results. I thus proceeded with estimating the models in log differences, which can for reasonably small values be taken as approximate percentage changes in the variables. However, running Augmented Dickey-Fuller tests indicated that many of the series are non-stationary even after log differencing (Table 3.1) and I consequently rely only on stability.

Another crucial part of specifying a VAR model is lag selection: a model that contains too few lags may be misspecified and fail to capture the underlying process properly, while including too many lags decreases the number of degrees of freedom and could translate into too wide confidence band. I rely on the Akaike Information Criterion for lag selection but impose a maximum of 4 for all countries except Argentina, where I cap the number of lags at 3 as my series are relatively short. I thus have VAR(4) models for all countries except for Argentina, for which I present a VAR(3) model.

I also conduct the standard diagnostic tests for residuals form my models - the Portmanteau test for autocorrelation, the ARCH test for heteroscedasticity and the Jarque-Bera test for normality. Ideally, residuals should be normally distributed and there should be no autocorrelation and heteroscedasticity. The opposite could indicate that residuals still contain information not captured in the model and that the model may be misspecified. Unfortunately, I struggled to remove autocorrelation and heteroscedasticity in some models (see Table 3.2). This could be due to the restrictions imposed on lag selection or perhaps due to weaker performance of the tests (the time series are relatively short and tests produce conflicting results for some countries). In any case, the results should be treated with caution.

Before proceeding to the results of the VAR models, I provide a brief exploratory analysis of the relationship between percentage changes in reserves

Table 3.2: Diagnostic Tests

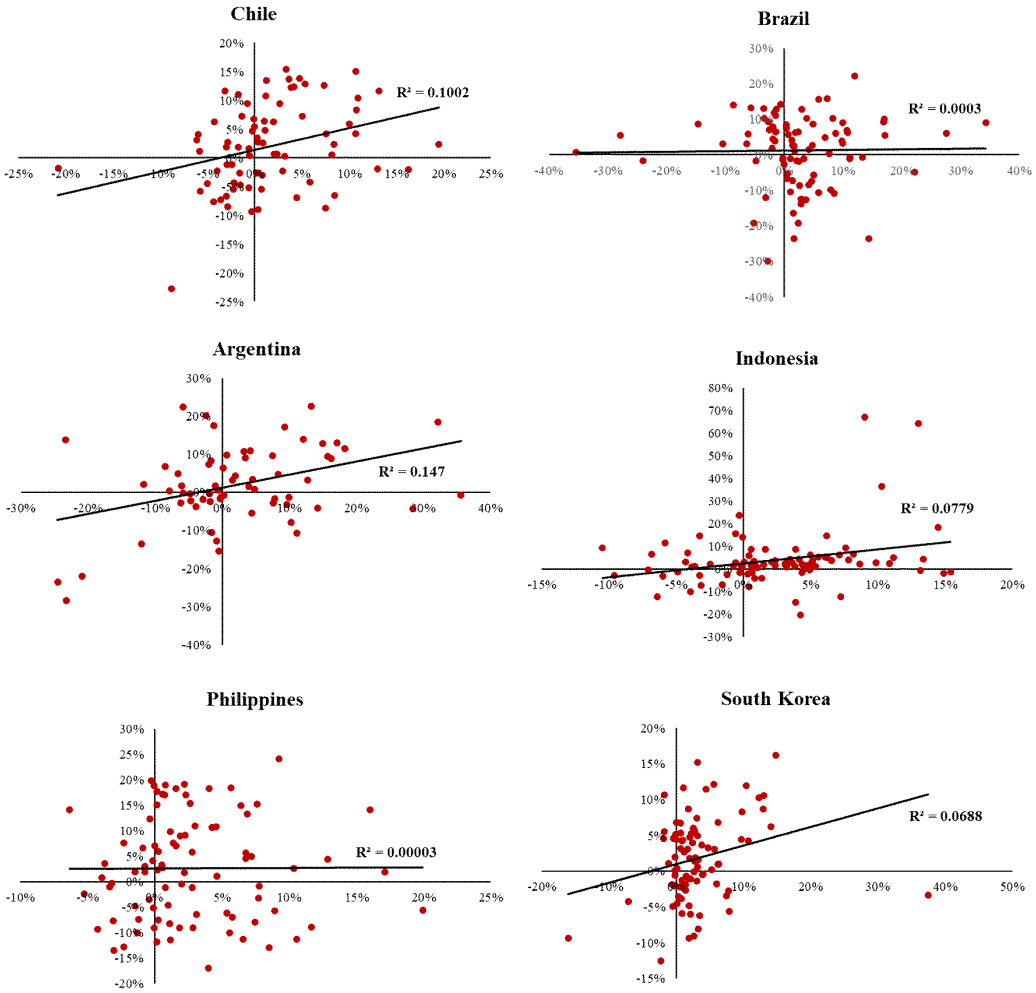
	ARG	BRL	CHL	IND	PHI	SKR
Port. Test	0.49	0.013**	0.094*	<0.01***	0.043**	0.799
ARCH Test	0.37	0.22	0.417	0.173	0.115	0.69
JB Test	<0.01***	0.51	<0.01***	<0.01***	0.39	0.29

Source: Author's calculations

Note: Portmanteau and ARCH tests test the null hypothesis of no autocorrelation/no heteroscedasticity in residuals against the alternative. JB test tests the null of normality of residuals against the alternative. "*", "**", and "***" denote significance at 10%, 5%, and 1% level respectively.

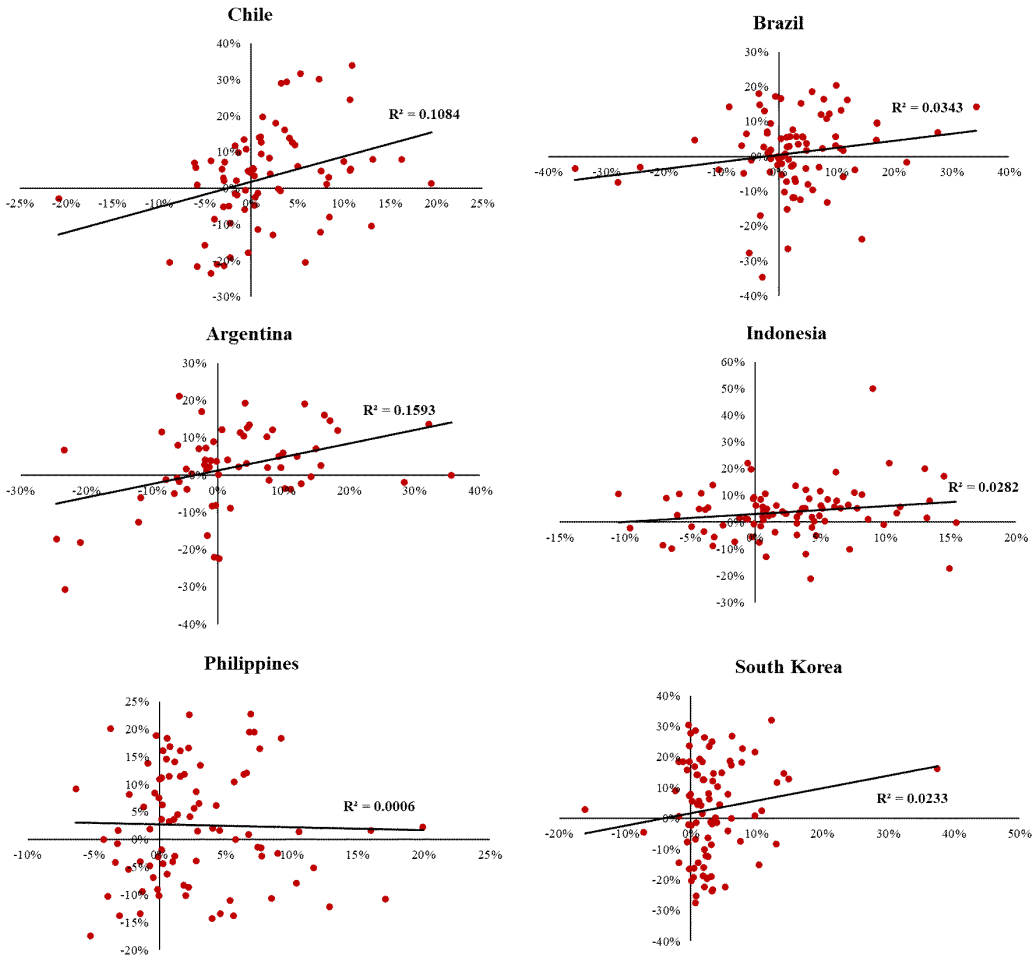
and household consumption (Figure 3.2) and gross capital formation (Figure 3.3). It would appear that percentage changes in reserves (and by, extension, log differences as a rough approximation) could have some exploratory power for household consumption (Chile, Argentina or Indonesia) and investment (Chile or Argentina).

Figure 3.2: Quarterly Changes in Reserves and Consumption



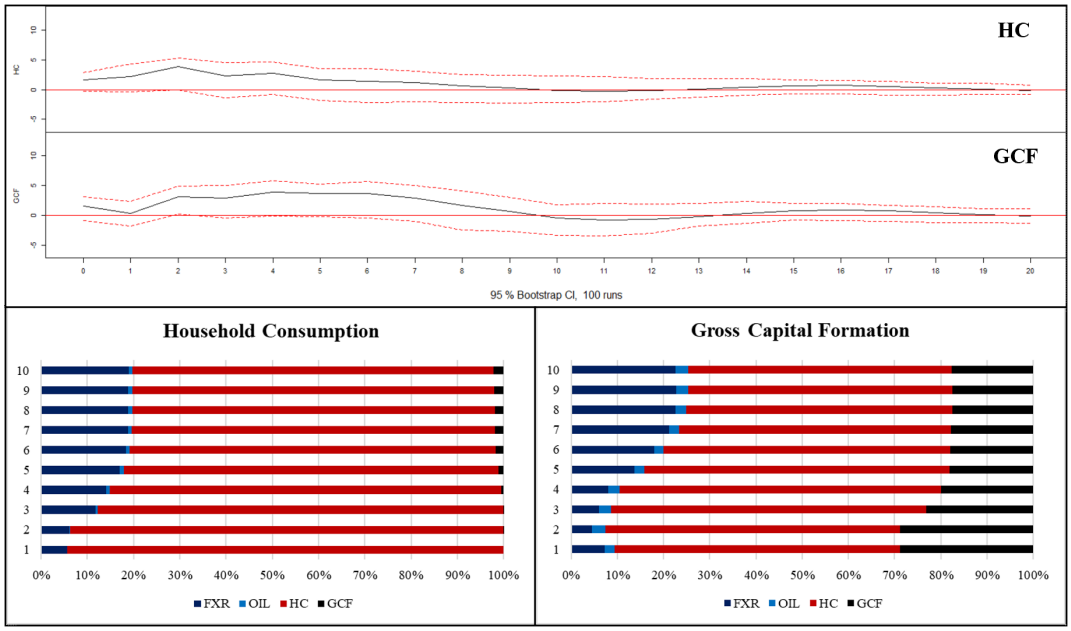
Source: Author's calculations based on data from respective central banks
Note: Household consumption as the dependent variable is plotted on the vertical axis and FX reserves are plotted on the horizontal axis.

Figure 3.3: Quarterly Changes in Reserves and Investment



Source: Author's calculations based on data from respective central banks
Note: Gross capital formation as the dependent variable is plotted on the vertical axis and FX reserves are plotted on the horizontal axis.

Figure 3.4: Chile - IRFs and FEVDs



Source: Author's calculations

3.2 Results

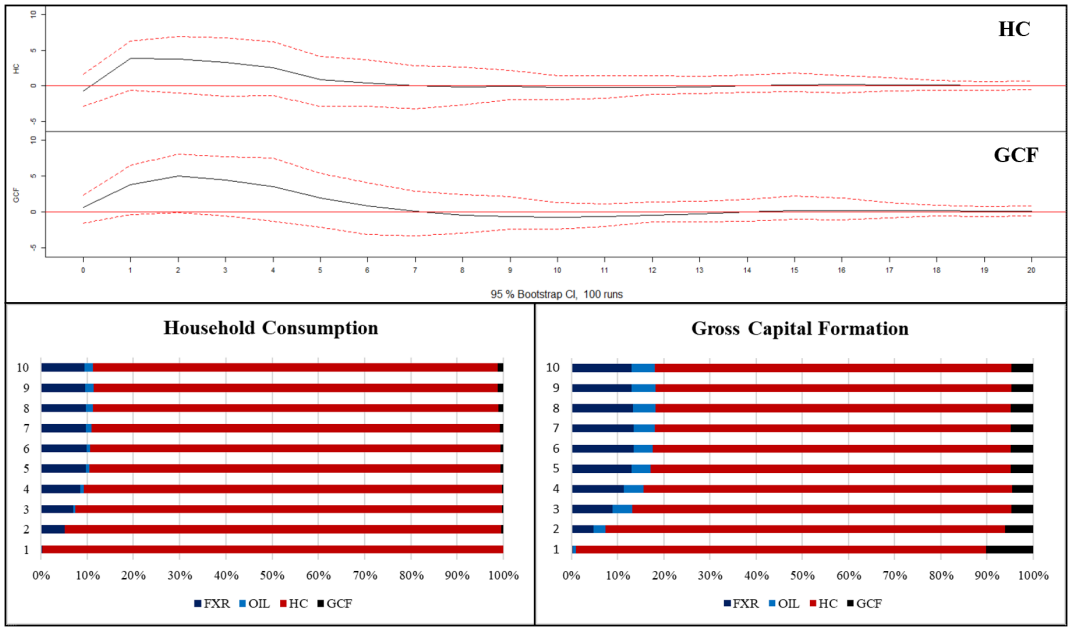
Below I report the orthogonalized IRFs to shocks in foreign exchange reserves for household consumption and gross capital formation and the FEVDS for both variables. I also comment on the results for each country separately.

Latin America

In Chile, both consumption and investment seem to respond positively to a shock to reserves; consumption seems to respond faster, with an almost instantaneous response, though the response is only borderline significant. The peak seems to occur around the fourth lag, with the magnitude of roughly 4%. While there seems to be some persistence until the tenth quarter after a shock, it is not statistically significant. Overall, reserves seem to explain up to 20% of variation. By contrast, there seems to be a small immediate uptick in investment, though not statistically significant. Again, the response is borderline statistically significant between the fourth and sixth lags, peaking at approximately 4%. Variance decomposition seems to indicate that reserves explain a little over 20% of variation in investment around the sixth lag.

In the case of Brazil, both consumption and investment show a pronounced response starting one quarter after a shock, with the magnitude of around 5% at the peak. However, the response of consumption is not statistically significant

Figure 3.5: Brazil - IRFs and FEVDs

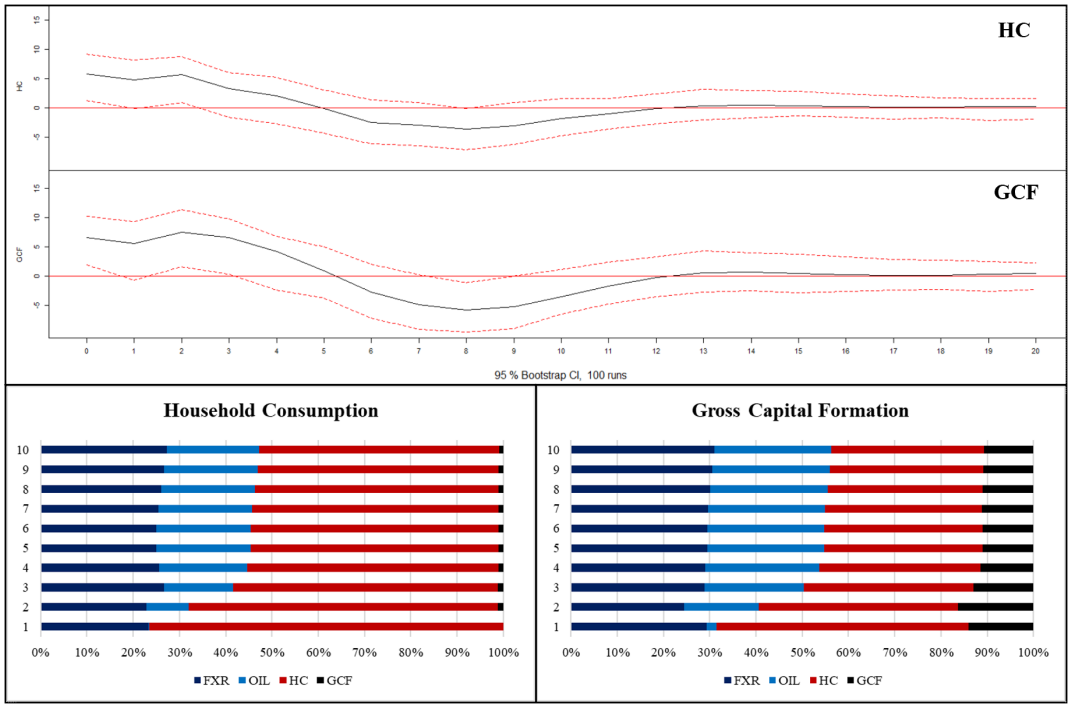


Source: Author's calculations

from zero while the IRF for investment is only borderline significant around the second lag. The character of both responses should thus be treated with caution. Both responses seem to wear off relatively quickly, with the point estimates being back to zero around the seventh lag. Overall, reserves seem to explain a smaller percentage of variation for both consumption and investment (10% and 13%, respectively) two to three quarters after a shock.

The results for Argentina need to be treated with extra caution. Both consumption and investment seem to produce a significant and immediate response (around 6% for each after a shock to reserves). Likewise, variance decompositions for both suggest that a high percentage of variation in both variables is explained by shocks to reserves (over 20% for consumption and up to 30% for investment) and the effects seem very persistent. While this is not very surprising (at least given the notorious economic troubles experienced by Argentina and the fact that Figure 3.1 shows high fluctuations in its reserves), the effects are likely magnified by the fact that Argentina had import restrictions in place repeatedly during the surveyed period (see section 2.2); it is therefore likely that exogenous restrictions make the observed causal relationship appear stronger than it may have been if events had been allowed to develop on their own. For example, households or entrepreneurs may have needed to adjust their consumption of imported goods (whether consumption goods or goods needed to launch new projects) according to restrictions put in place at

Figure 3.6: Argentina - IRFs and FEVDs



Source: Author's calculations

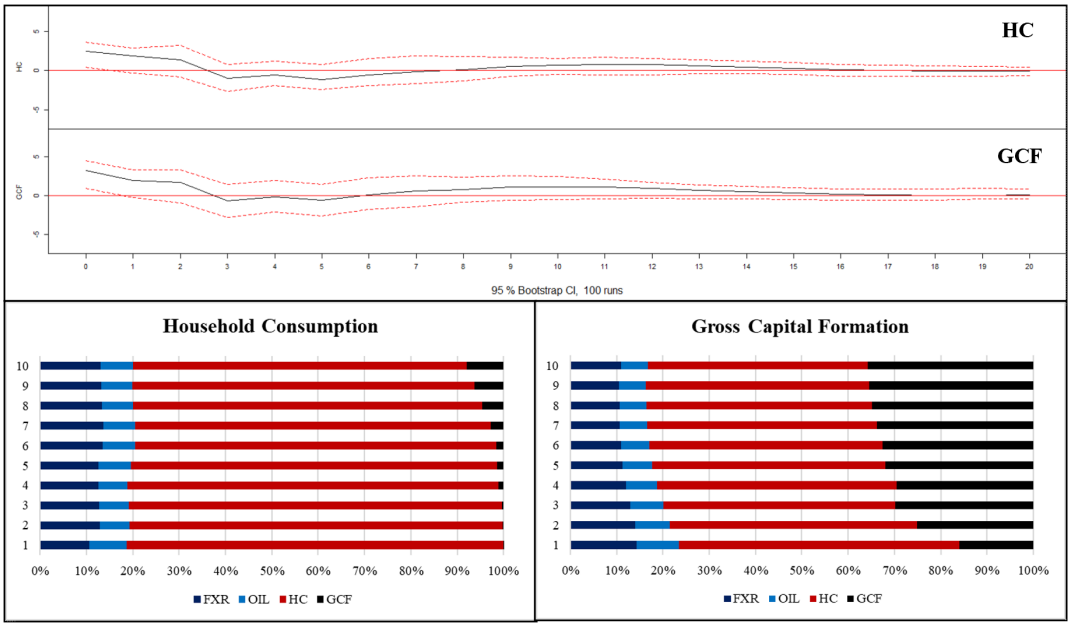
any given moment (In other words, there may have been some "frontloading" of consumption or investment if temporary availability of reserves or suspension of trade restrictions allowed it, especially if restrictions were expected to be reintroduced in the future; the fact that both impulse responses turn significantly negative around the eight lag seems to be consistent with that assumption.)

Southeast and East Asia

In the case if Indonesia, both consumption and investment seem to produce significant immediate responses to a shock to reserves of around 3% and 4%, respectively. However, both impulse responses die down relatively fast (around the third quarter after the shock) and hover closely around zero ever after. Similarly, reserves seem to explain a relatively modest 12% and 10% of the overall variation in consumption and investment, respectively. Overall, the effects of shocks to reserves seem less pronounced and their immediacy may have more to do with the overall fragility of the Indonesian economy and its frequently tenuous current account position, see Chandrasekhar (2021).

The results for both the Philippines and South Korea are a little confusing. In the case of the Philippines, both consumption and investment show a significant positive response of around 2% to a shock to reserves. While for

Figure 3.7: Indonesia - IRFs and FEVDs

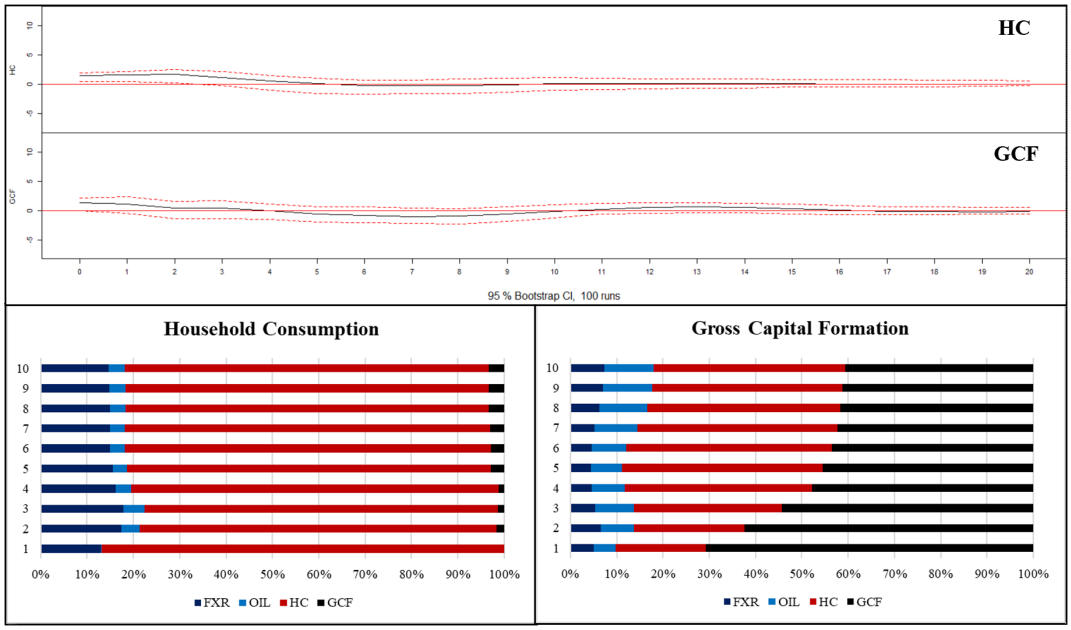


Source: Author's calculations

investment the impulse response returns to zero almost immediately, consumption seems to show a positive response at least until the second quarter after a shock, with variance decomposition indicating that reserves explain around 15% of variation in consumption. While the responses could certainly reflect the theoretical relationship motivating my model, the fact that the responses are rather timid and that reserves held by the Philippines seem to almost always go up (Figure 3.1) could suggest that some of the effect may be driven by improper sterilization of reserves (although the effect is hard to ascertain).

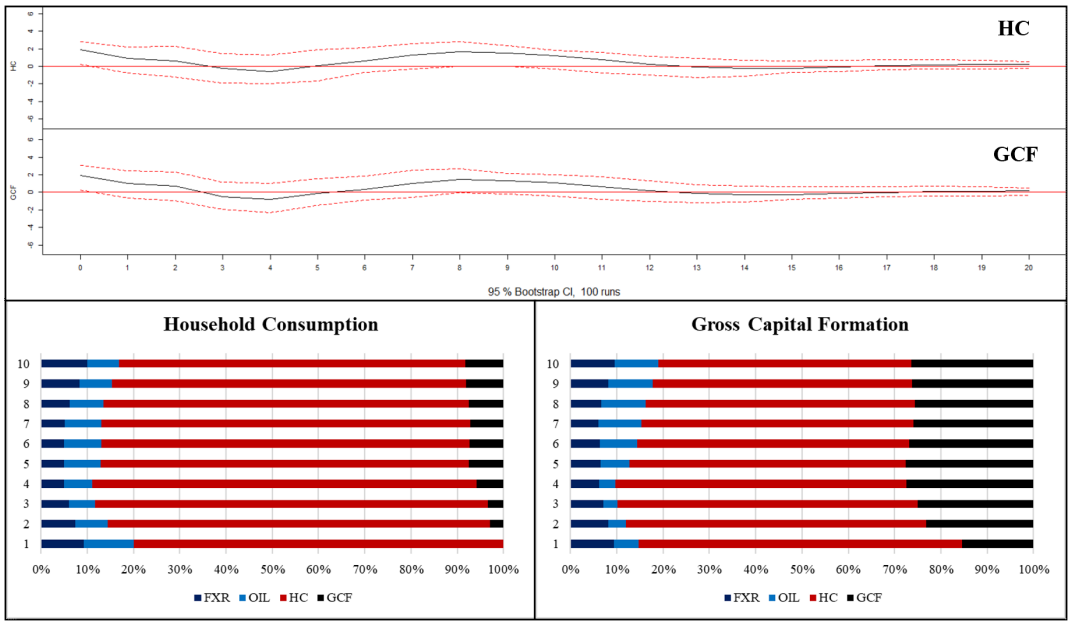
Similarly, consumption and investment in South Korea show a short-lived instantaneous response to a shock to reserves but the shocks do not persist beyond the first quarter. While that could reflect a similar dynamic as that hypothesized in the Philippines (the magnitude of both responses is below 2%), the responses oddly turn just about significant again around the eight lag. Similarly, variance decompositions show almost identical patterns, with more variation explained by reserves around the first and the tenth lag than in between - something for which I cannot really offer a compelling economic explanation other than that the results could potentially be driven by a failure of the model to properly capture the underlying dynamics (see below).

Figure 3.8: Philippines - IRFs and FEVDs



Source: Author's calculations

Figure 3.9: South Korea - IRFs and FEVDs



Source: Author's calculations

3.3 Discussion

The presented results seem to suggest that there likely is a potentially interesting dynamic between foreign reserves and household consumption/gross capital formation in some economies, though the interplay seems heterogenous and the results need to be treated with caution, as in any VAR model. This is especially true given that the span of available time series does not allow for any meaningful robustness checks.

The analysis presented above could be extended at least in two directions. First, it may be interesting to study the interactions in a model that allows for a richer structure and the inclusion of a greater number of exogenous forces (such as commodity prices, regional economic environment, or the monetary policy of major central banks). A natural, though a lot more complex option would be a global VAR model along the lines of Bussière *et al.* (2009).

Similarly, a simple VAR model may not optimally capture the underlying economic dynamic due to the fact that it by definition assumes that the nature of the interaction among the variables in a system remains constant throughout. However, this assumption is likely too stringent for at least two reasons. First, the patterns in the behavior of reserves seems to change over time - for instance, reserves held by Chile and Brazil seemed rather volatile in the 2000s, but much less so in the 2010s and it is likely that lower volatility may have caused reserves to be less important to economic agents. At the same time, the simple fact of economic development should render reserves gradually less important since the main point of holding reserves is as insurance against instability and a greater degree of economic development should presumably go hand in hand with greater resilience. A time-varying VAR model may therefore be a more appropriate tool.

In sum, the question could be worth revisiting in the future. While it is unlikely that central banks would tinker with their reserves to achieve a desired level of consumption and investment, studying the relationship between reserves and investment could be a useful tool to gauge their overall importance as a stabilizing factor.

Chapter 4

Chasing Return: What Might a More Aggressive Management of Reserves Look Like?

"Asset management, when stripped down to its bare essentials, is a simple business."

David Swensen (2008)

This chapter deals with the question of management of FX reserves by central banks. I start off by briefly reviewing the main trends in this arena, mostly zooming in on the general themes such as asset allocation and the overall objectives as defined by central banks. The general focus of the discussion partly flows from the fact that central banks are generally not keen on advertising their management practices (probably for understandable reasons, as discussed later) and partly from the purpose of the discussion, which is to set the stage for the later part of the chapter, where I consider the challenges that would be faced by a central bank that chose to expand the scope of its management by explicitly incorporating the objective of managing part of its portfolio on a very long-term basis and providing a regular income stream to the government. For ease of exposition, I first discuss the problem in general terms (Section 4.2) and defer some considerations important to a central bank to Section 4.3. In Section 4.4., I speculate whether such a novel objective is a realistic option for central banks.

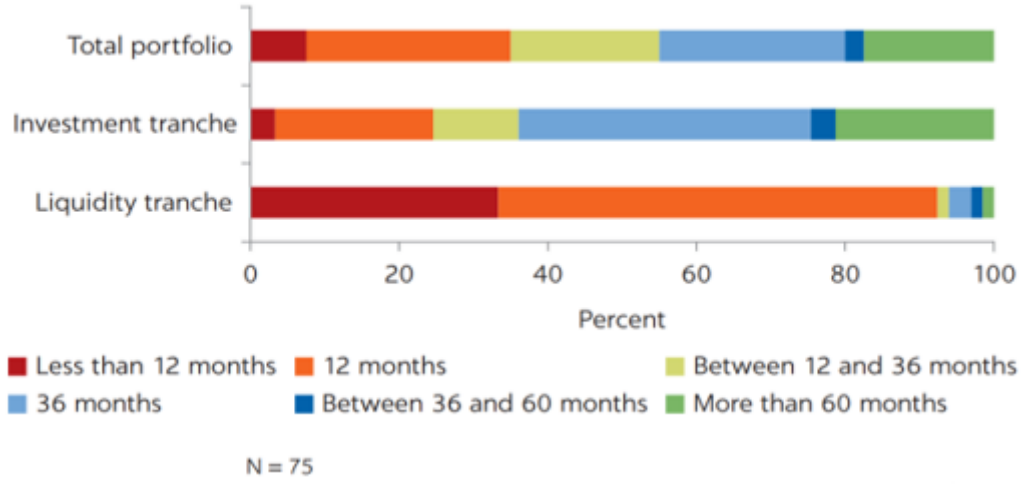
4.1 The Setting

As already alluded to, granular data pertaining to central bank practices when it comes to foreign reserves are not easy to come by. However, for the purposes of the following discussion, it is more than enough to rely on the results of a survey of more than a hundred central banks presented in Anasashvili *et al.* (2020). For the sake of brevity, I restrict the discussion only to the results pertinent for the main goal of the chapter. For further details, see the original study.

A majority of central banks use tranching in their reserve management; in other words, they tend to separate their reserve holdings mostly into the following three portions (tranches):

- **The working capital tranche:** This tranche includes reserves required for short-term central bank operations. The investment horizon is typically under 90 days.
- **The liquidity tranche:** This refers to reserves that the central bank anticipates will/may need to be deployed over the short/medium-term to cover transaction needs or foreign exchange market interventions or potentially replenish the working capital tranche in the event of a larger drawdown. The investment horizon for this tranche is typically 90 days to 1 year.
- **The investment tranche:** Reserves allocated to this tranche are not used in normal central bank operations and only called upon in the event of major emergencies (presumably, this would include crises in which a central bank needed to step in to provide emergency liquidity in foreign currency). The investment horizon for the investment tranche is typically over 1 year and its upper limit depends heavily on the overall size of reserves held by a central bank and the income-group, (with 80% of central banks capping the horizon at three years and only a minority of central banks, especially in higher-income countries, allowing longer horizons). See Figure 4.1 for a summary.

Figure 4.1: Investment Horizon by Tranches



Source: Anasashvili *et al.* (2020)

As seen from Figure 4.1, even the investment tranche tends to be capped at relatively short periods. As discussed later, the limited horizon is quite closely connected with the question of asset allocation and the range of available asset classes. Figure 4.2 on the next page summarizes the asset classes in which central banks are permitted to invest.

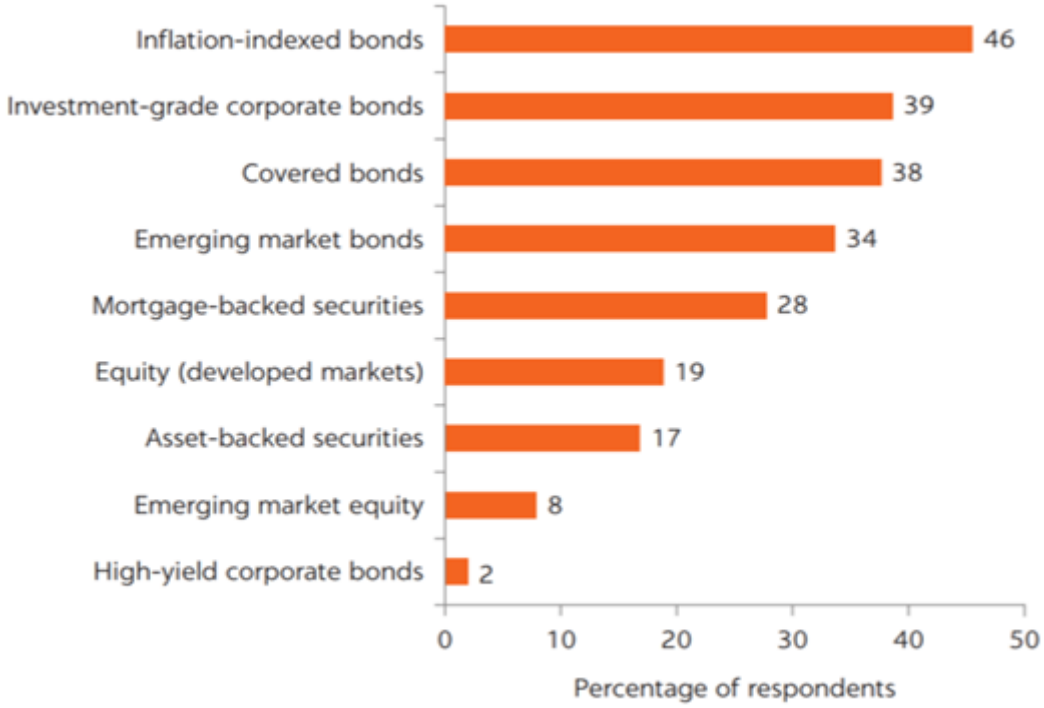
Not surprisingly, all central banks are permitted to invest in developed-market government bonds, and these have historically tended to be the most popular investment destinations for central banks. A corollary of that tradition is the fact that the percentage of central banks permitted to invest in individual asset classes shrinks progressively as one moves down the list, with only 72% of central banks being allowed to invest in "non-traditional" asset classes. These "non-traditional" asset classes have become more popular with central banks as stockpiles of foreign reserves held by many central banks have steadily grown and interest rates (both nominal, and importantly, real) have reached record lows over the past decade. Figure 4.3 on the next page provides an overview.

The list of eligible non-traditional investments predictably includes (among others) inflation-protected instruments, investment-grade corporate obligations or mortgage-backed securities. Still, it is worth noting that even inflation-indexed bonds are an option to less than a half of central banks surveyed. Importantly, investments in equities (in both advanced and developing economies) can only be entertained by less than a fifth (and less than a tenth, respectively) of central banks. However, the formal eligibility of an investment

Figure 4.2: Eligible Asset Classes for Central Bank Foreign Reserves

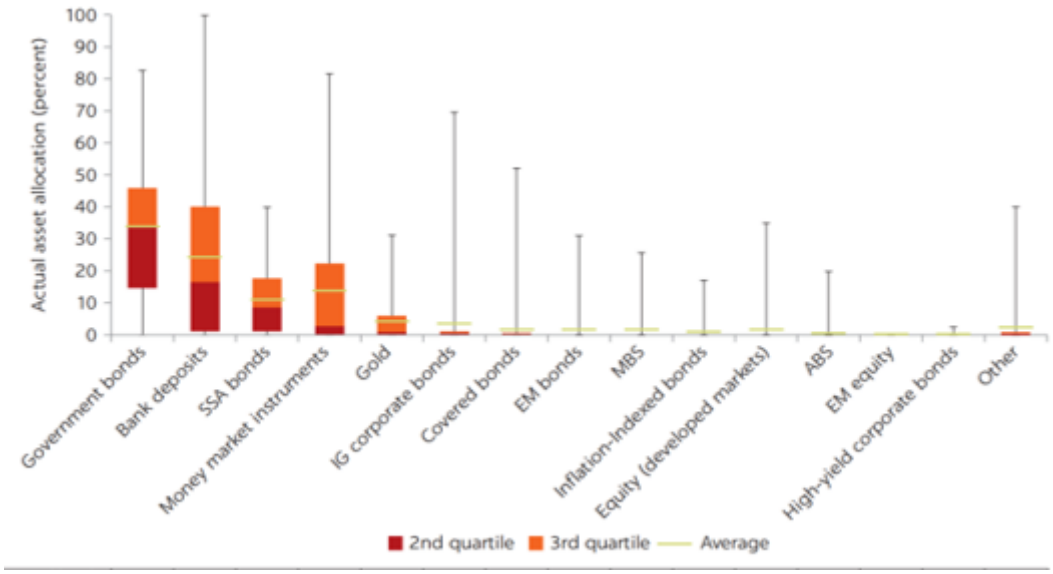
Source: Anasashvili *et al.* (2020)

Figure 4.3: Eligible Higher-Risk Financial Instruments



Source: Anasashvili *et al.* (2020)

Figure 4.4: Distribution of Allocations to Individual Asset Classes



Source: Anasashvili *et al.* (2020)
Note: The figure shows the distribution for a whole sample of central banks surveyed and thus includes central banks without exposure to individual classes. For results pertaining only to central banks with actual exposure, see the original study.

is not the same as an actual decision by a central bank to exercise the prerogative. Figure 4.4 shows the distribution of allocations for individual asset classes.

As Figure 4.4 shows, despite roughly 20% of central banks indicating a mandate to expand beyond fixed-income instruments and into equities, central banks on average do not seem to take advantage of their maneuvering room, with the median exposure to equities equal to zero. Even for those central banks with actual exposure to equities, advanced-economy equity investments account for a very small percentage of the overall allocation, with the average and median at 8.7% and 6.3%, respectively. For equity investments in developing economies, both the average and median allocations are negligible (see the original study for further details).

Overall, central banks seem to continue exercising caution and remain rather conservative in their strategic asset allocation. Furthermore, their caution is also reflected in their risk management, such as emphasis on limiting the overall duration of their portfolios (that is, the sensitivity of their holdings to changes in interest rates). Crucially, while there seems to have been some relaxation in the strict emphasis on safety, mainly due to the prevailing trends in interest rates, the emphasis still overwhelmingly centers on liquidity, with only capi-

tal preservation, rather than explicit return generation, being the overriding objective.

That said, there are a few central banks who have ventured further in recent years. For example, Israel's central bank responded to a tripling of its reserves in the last decade and rock-bottom interest rates by allocating up to 15% of its reserve portfolio to equities Benita *et al.* (2019). Similarly, the Swiss National Bank currently holds 23% of its reserves in equities, pursuing a purely passive investment strategy based on "broad market indices of advanced and emerging economies", see SNB (2020) p. 93-100.

The one central bank which seems to have gone farthest in terms of how it manages its foreign reserves is the Monetary Authority of Singapore, which manages its $400 billion+ Official Foreign Reserves[1] in a "geographically diverse portfolio made up of cash, bonds, and equities" while allocating a percentage of the proceeds to the government budget, see Menon (2020). Alongside the Official Foreign Reserves, part of Singapore's foreign reserves are managed by Temasek Holdings (a government-owned investment entity) and the Government of Singapore Investment Corporation (essentially a sovereign wealth fund), both of which include non-listed investments, such as real estate, in their portfolios. The reserves deposited in these two funds are off the balance sheet of the MAS, but MAS regularly transfers excess Official Foreign Reserves to the government for longer-term purposes.[2] Pages 48 and 49 provide an overview of the portfolios.[3]

As hinted at earlier in the chapter, my objective for what follows is to investigate whether other central banks could replicate Singapore's practice and make the "leap" from a very conservative management of its reserves to a

[1] $417,904.4 million as of end of 2021, excluding SDR, gold and reserve position at IMF. See mas.gov.sg

[2] The transfers have typically occured against a corresponding reduction of the government's deposits with the MAS. However, the growth in reserves has recently outpaced the growth in the government's deposits such that this process is no longer adequate. At the same time, reserves are judged to be well in excess of what is needed. As of now, the MAS will be allowed to accept special non-marketable Reserves Management Government Securities (RMGS) in exchange for reserves transferred to the government which redeemed on par before maturity schould events require it. See Choo (2022) for details. It is worth noting that while this is a perfectly reasonable way of facilitating a transfer of reserves (in terms of the accounting implications) that has the added advantage of insulating the MAS from the investment risk, its acceptance is obviously dependent on the extent to which the government can be trusted not to renege on its obligations to the central bank. It is also worth noting that the aggressive management of reserves by MAS preceeded the founding of GIC. See madeofbold.sg for details.

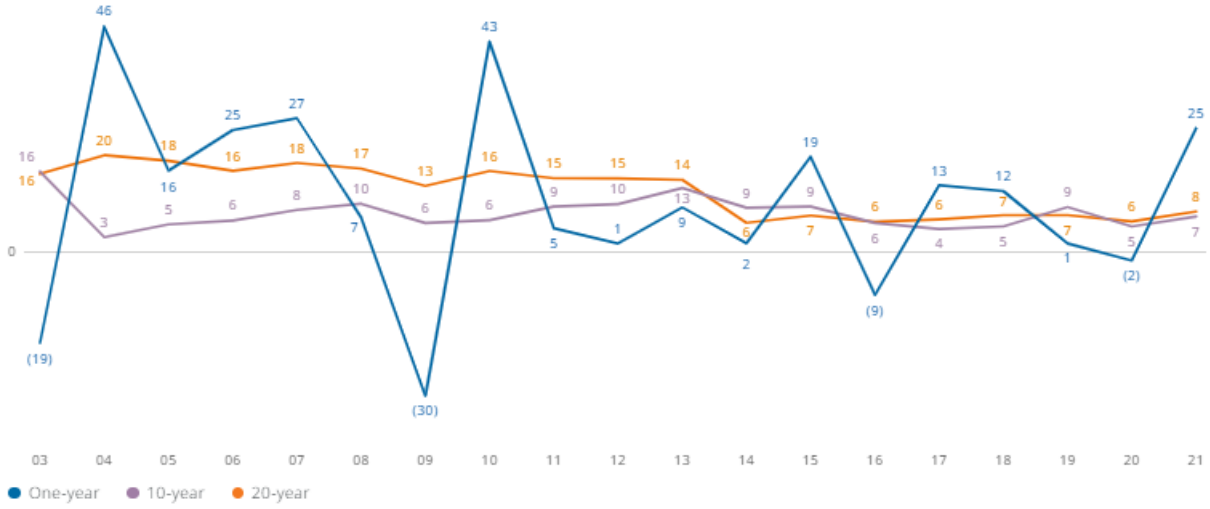
[3] Page 48 only provides information pertaining the GIC and Temasek Holdings since the allocations for the Official Foreign Reserves are not disclosed.

Table 4.1: Temasek Holdings - Asset Allocation as of March 2021

Sector	% of total	Asset Class	% of total
Financial Services	24%	Unlisted assets	45%
Telecom, Media & Technology	21%	Listed, above 50% share	10%
Transportation & Industrials	19%	Listed, 20-50% share	7%
Consumer & Real Estate	14%	Liquid, below 20% share	38%
Life Sciences & Agri-food	10%		
Multi-sector Funds	8%		
Other (including credit)	4%		

Source: temasek.com.sg
Note: The value of the portfolio stood at S$381 billion (US$283 billion) as of March 31, 2021. For further details, see temasek.com.sg

Figure 4.5: Temasek Holdings - Rolling S$ Total Shareholder Return



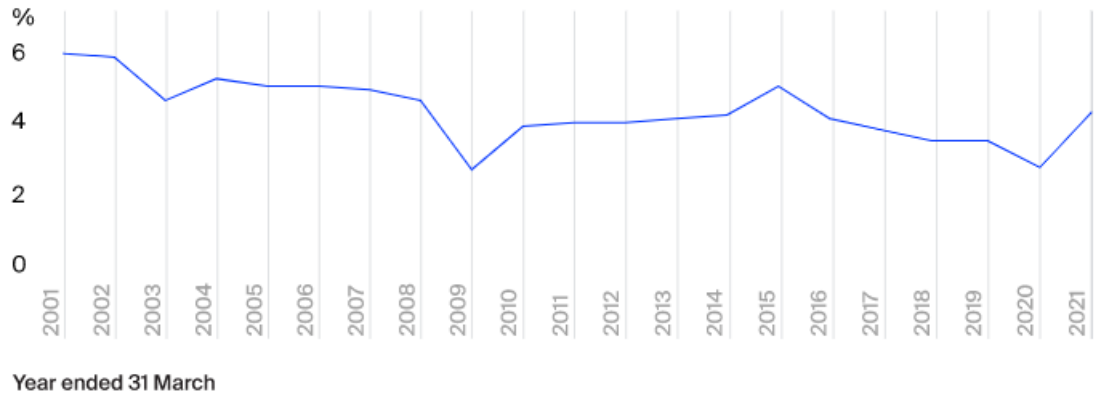
Source: temasek.com.sg

Table 4.2: GIC - Asset Allocation as of March 2021

Region	% of total	Asset Class	% of total
United States	34%	Developed Mkt. Equities	15%
Latin America	3%	Emerging Mkt. Equities	15%
United Kingdom	5%	Nominal Bonds & Cash	44%
Eurozone	9%	Inflation-Linked Bonds	6%
M. East, Africa & r. of Europe	5%	Real Estate	7%
Japan	8%	Private Equity	13%
Asia excl. Japan	26%		
Global	10%		

Source: temasek.com.sg
Note:GIC does not disclose the value of its holdings, but estimates put the figure at about US$744 billion as of March 2021. See BT (2022)

Figure 4.6: GIC - Annualized Rolling 20-year Real Rate of Return since 2001



Source: gic.com.sg

more long-term oriented one while also incorporating the objective of using the proceeds to provide regular (or at least predictable) income stream to their government's budget. Note that the purpose here is not to focus on the minutiae of the investment process or even propose an "optimal" portfolio for a central bank's reserves. I have neither the inclination nor the qualification to engage in such a discussion, which in any case would likely be of limited value since the investment process is a continuously-evolving exercise. Rather, I am interested in investigating what risks are associated with adopting such a new objective and what measures can be taken to ensure that central banks can pursue it successfully. However, I spend time on the question of strategic asset allocation as I believe that it is a crucial part of that discussion, due to potential implications for expected return patterns and management and accountability issues. An obvious problem is the fact that any such discussion is inevitably a little speculative. The best defense I can offer is that the questions I ponder are ones that I would like to see answered if I were on the board of a central bank that considered embarking on such a project. If some of the answers seem subjective, it is largely due to the fact that by the nature of the question, they just are.

4.2 The Problem

A natural first step is to define the objective before discussing the individual steps in pursuit of the goal. I abstract for a moment from certain considerations specific to a central bank and defer an investigation of those to Section 4.3. I

mainly do this for ease of exposition since the linear nature of a written text would make it hard to intelligibly discuss multiple issues at the same time.

The question I am trying to answer is how a central bank could:

- manage part of its foreign exchange reserves (presumably those or part of those deposited in the investment tranche) on a long-term basis with a view of generating return, rather than "mere" capital preservation
- use the proceeds to provide a regular, and if possible, reasonably predictable, income stream to the government;
- achieve both of these objectives without compromising its core objectives (mainly the conduct of monetary policy, its reputation and independence).

Two clarifications are in order. First, the emphasis in the second objective is on the word regular (and preferably predicable). There is nothing that prevents central banks from transferring gains from their operations to their government if/when gains are realized, and central banks in fact tend to be required to do so. On the other hand, such transfers typically tend not to be articulated as an explicit objective of a central bank, and my objective here is precisely to investigate the implications of making regular transfers an explicit goal. Moreover, it makes little sense to adopt a more aggressive (and more risky) investment philosophy without having something to show for it, and it is hard to imagine a different avenue through which to justify the risk and distribute the proceeds other than through reasonably predictable and stable payouts.[4]

Second, when I discuss asset allocation below, I really restrict my attention to equity investments or other investments farther out in the investment spectrum. Of course, even in this "story", central banks will still hold a very substantial part of their reserves in fixed income securities, but it makes no sense to only consider fixed income. One reason is that fixed income securities are by virtue of their limited upside not very suited to long term investments.

[4]Unlike in the case of individual investments, it makes little sense for investments to be held for decades and than liquidate at once for a retirement. Similarly, setting an investment horizon of several years and making lump-sum payments to the government at the end of each period effectively amounts to a potentially large fiscal stimulus, which may not be optimal (assuming away the option to pay down national debt, which again may not be a priority). Trying to systematically relax the government's budget constraint by more modest amounts seems to be the most reasonable objective.

Another reason is that as discussed before, central banks already hold the vast majority of their reserves in fixed income securities, and were I to only consider fixed income investments, I might as well end the discussion here.

It is easy to see the first two goals articulated above are identical to an endowment, such as a university endowment. Interestingly, the same can be said of the third, since the threats to a central bank seem to stem largely from risks to central bank reputation and independence, which in turn are directly tied to risks to a central bank's equity. (I discuss the question of central bank equity in detail in Section 4.3. For now, I treat its importance as a fact.) Given the apt analogy, I closely follow Swensen (2009) ch.5 to lay out "an endowment's problem".

4.2.1 An Endowment's Problem

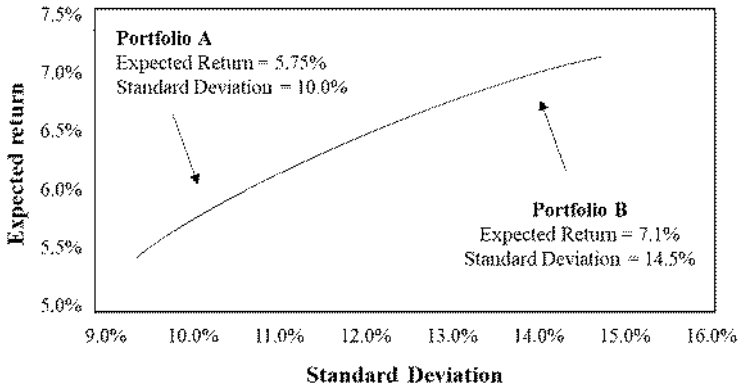
The purpose of an endowment is twofold: to grow the endowment over time through largely equity-oriented long-term investment[5] (in other words, preserve and if possible enhance the purchasing power of the endowment) and at the same time seek to provide stable, reliable and consistent income stream to support operations of the endowed institution. It is thus apparent that the management of an endowment entails making continuous trade-offs between the two main objectives, since any payout executed today automatically reduces the purchasing power of an endowment and in turn the future gains, in effect privileging today's needs over the needs of the future. (To be exact, the value of the trade-off is actually infinite, if one assumes an infinite horizon.) Furthermore, the equity-oriented character of an endowment's portfolio translates directly into the need to accept a degree of volatility of the portfolio's value over time, which is fundamentally in conflict with the desire to maintain maximum predictability in the payout policy.

To better illustrate the problem, consider two portfolios shown in Figure 4.7 on page 52. Portfolio A offers a lower expected return while its lower standard deviation should serve to limit the downside risk. By contrast, portfolio B offers a higher upside but at the cost of higher volatility.

An investor could make use of the standard portfolio optimization techniques to decide which portfolio better suits their perception of risks and rewards. However, an endowment manager also needs to take into account the

[5]The following obviously does not apply to an endowment that only invests in fixed-income, but this is not a variant I consider here.

Figure 4.7: The Choice between Two Portfolios

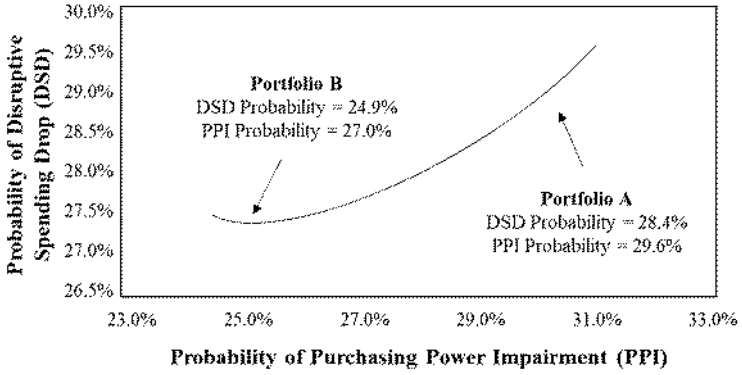


Source: Swensen (2009) ch.5
Note: Since the point of the graphic is to illustrate the differences between two different portfolios and the implications, the exact values are for illustration only. However, since I closely follow Swensen's exposition, I keep the same figures as those presented in Swensen (2009) ch.5.

need to select the portfolio that allows the endowment to produce a regular and hopefully stable income stream. It is easy to see that with the greater the volatility of a portfolio, the greater the risk of having to make a trade-off between a "disruptive spending drop" (in other words, the risk of a forced payout reduction) and a "purchasing power impairment" (or the need to cover the shortfall in the payout by reaching into the endowment and thus reducing its purchasing power). This trade-off can be better visualized through simulations or scenario analysis, as shown in Figure 4.8 on page 53. Such an analysis also allows an investor to hopefully minimize both risks and to express a view on the residual trade-off through selecting a portfolio with a specific set of characteristics.

Of course, in situations where a greater volatility coincides with a greater realized return, the trade-off described above is a rather pleasant one (on some level, it is not really a trade-off at all). It is in the opposite case, i.e. if volatility causes the realized return to be very low or even negative, that the need to make a tough decision arises. In such a scenario, a private endowment weighs the prospect of a (potentially drastic) reduction in spending versus a painful reduction in the value of the endowment. Similarly, since a portfolio of foreign reserves is (potentially a very large) part of a central bank's balance sheet, a negative return would have a central bank weigh the objective of "honoring" its payout to the government against the need to safeguard its balance sheet and, in turn, its equity. Of course, while a private endowment would likely have no

Figure 4.8: The Trade-off between a Spending Drop and a Purchasing Power Impairment for Two Portfolios



Source: Swensen (2009) ch.5

Note: As is the case with Figure 4.5, the exact values are for illustrative purposes. The respective probabilities would obviously differ for different sets of portfolios. Again, since I base my discussion closely on Swensen (2009) ch.5, I keep the values same as in the original study.

choice but to maintain spending at the cost of a "purchasing power impairment", a central bank would almost definitely prioritize its balance sheet at the expense of maintaining a payout, as discussed later. Despite the difference, however, there is an objective common to both an endowment and a central bank: the need to limit downside risk is paramount.

While it makes little sense at this point to discuss spending rules in greater detail, one can still make the following few observations: first, the definition of a spending rule is dependent on the goal of maintaining needed payouts consistent with the capacity of the endowment and is thus always context-dependent. Of course, since dividends paid by a central bank are highly unlikely to make up a very substantial percentage of a government budget (certainly compared to what is often the case for private endowments); the weight attached to the risk of a disruptive spending drop is therefore somewhat lower. At the same time, constraints stemming from the need to safeguard the balance sheet of a central bank require that a heavier weight be placed on the prevention of a purchasing power impairment. Consequently, it is natural to expect a somewhat more volatile payout pattern. This could be especially true if limits (whether exogenous, such as those stemming from a limited capacity to allocate a sufficient percentage of the portfolio to certain asset classes, or self-imposed) were placed on the degree of diversification that is achievable. This does not mean that any efforts at having a spending rule and a target rate of return should be abandoned, but it drives home the fact that both may need to be

defined more flexibly to reflect the above constraints (and potentially adjusted on a regular basis as the investment portfolio matured).

4.2.2 Asset Allocation: Liquidity or Beyond?

The discussion above leads directly to the question of strategic asset allocation (i.e. the choice of asset classes in which to invest). In principle, the following options are available:

- **cash and fixed-income instruments:** cash, money-market instruments, government bonds, corporate bonds, mortgage-backed securities, and the like;
- **public equity:** publicly traded ownership stakes in companies, or indices tracking wider market performance or industry sectors;
- **real assets:** direct investments in real estate, or natural resources (such as oil, gas, or timber);
- **absolute return:** various hedge-fund-type strategies seeking to produce returns uncorrelated with market movements;
- **private equity and venture capital:** direct investments in private companies seeking to generate abnormal returns through substantial value creation.

As mentioned before, I automatically assume that part of the long-term investment tranche will be invested in equities or equity indices. Given that public equities are generally considered a lot more liquid than other assets on the list, the question is whether to stop there or expand into illiquid asset classes. In other words, the question is whether liquidity should be considered as an important factor. There are at least two reasons why emphasis on liquidity might not be optimal:

First, while equity markets generally produce superior returns over fixed-income investments over reasonably long periods of time,[6] they tend to be notoriously volatile. As Figure 4.10 on page 58 shows, periods of handsome returns sometimes give way to periods of sharp losses or lackluster performance; some, such as those in the aftermath of the dot-com bubble or during 2008

[6]See Dimson *et al.* (2002) and CreditSuisse (2021) for a discussion of long-term returns and detailed information about the performance of various markets.

tend to occur over periods of months or even years, some (such as those in March 2020) do not even register in yearly data. While central banks could theoretically hold their equity investments for a long time and thus keep their losses from being "realized", they would still need to deal with a serious prospect of those losses becoming real (with the attendant risk of an equity impairment).[7] Hence, fear of such losses could limit the percentage of portfolio that a central bank could afford to allocate to equities.[8] Furthermore, diversification in the form of investments to other equity markets may only be of limited value during times of stress, due to correlations of equity markets worldwide, which tend to increase in periods of stress (Figure 4.9).

To be fair, the risk of losses can, in the case of equity investments, be mitigated using options (at some cost), so that even substantial adverse movements may not be disastrous.[9] On the other hand, it may be very hard to maintain payouts in periods of negative market returns. While maintaining payouts is relatively easy in a period of a rising market (most obviously, by realizing part of the return), no such option is available in a declining market.[10] This is true even if hedging prevents the investment portfolio (and by extension, the central bank balance sheet) from being impaired. While even occasional payouts can certainly be worth it, relying simply on returns from public equities may translate into a less than stable return pattern. A visual inspection of Figure 4.10 suggests that pursuing such a strategy in the past quarter century would

[7]The magnitude of those losses obviously depends on circumstances, for example, assuming a 25% allocation to equities on a reserve portfolio and the loss suffered by the equity tranche of the Norwegian SWF in 2008 of roughly 40% translates to a loss of 10% (ignoring for the moment the potential effect of increased value of "safe" investments). Such a loss would be felt differently by a central bank whose balance was dominated by foreign reserves (such as the Czech National Bank), in whose case the equity impairment may be close to 10%, and the Banco Central Do Brazil (with reserves making up a little under 50% of the balance sheet), in whose case the impairment would be under 5% (still a possibly substantial number). See the 2020 balance sheets for both central banks for details.

[8]This could be exacerbated by the fact that the traditional hedge in the form of "safe" assets, mostly government bonds (whose value should increase in periods of market stress as "flight to safety" increases demand for them) may not offer as much protection, since rock-bottom interest rates likely place a limit on such an increase in value.

[9]Not surprisingly, that is effectively what the Swiss National Bank has been doing, see SNB (2020).

[10]The only alternative, aside from reaching into the portfolio (an unlikely proposition, as discussed above), would be to rely on the distribution of proceeds from fixed income investments. However, this would only be a responsible option if those proceeds exceeded inflation (in order to preserve the purchasing power of the portfolio), which is not necessarily guaranteed given the prevailing low interest rates - see CreditSuisse (2021). Technically, a more appropriate hurdle than inflation would be the nominal rate of growth of the economy, since the portfolio should ideally keep up with the size of the economy for the process to be truly sustainable in the long-term.

Figure 4.9: Rolling Three-Year Correlations with Morningstar US Market Index

Source: Morningstar (2008)

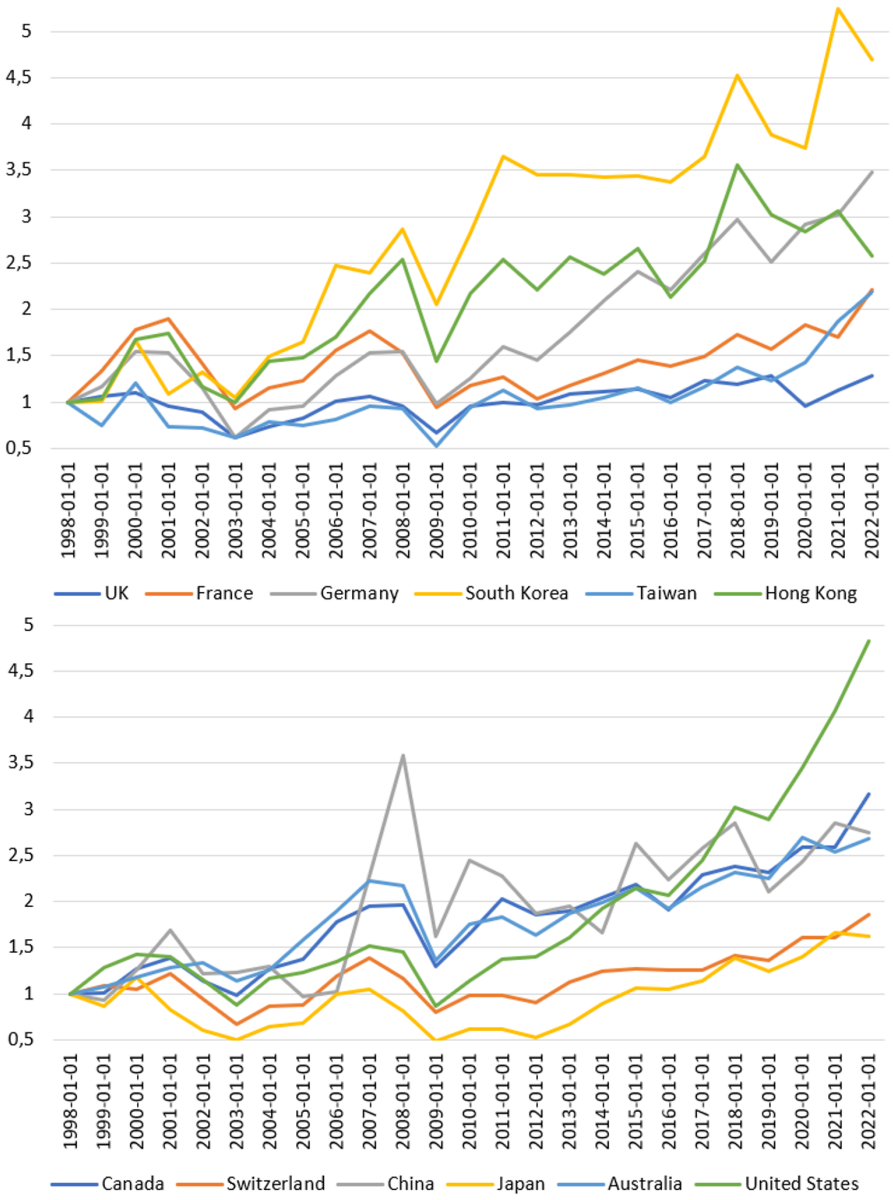
have at a minimum required strong international diversification.[11]

Second, it is not clear that emphasis on liquidity for its own sake makes sense. The most obvious reason why the emphasis on liquidity may make sense is that it could offer space for equity investments even to central banks who may face the need to rapidly liquidate their investments when faced with an emergency. Of course, there is no way to say with certainty that such an approach could not work, though whether any central bank would feel comfortable doing this is another matter.[12] However, in the case of central banks which do

[11]This effectively assumes that central banks would hold passively managed investments. But that is a reasonable assumption since these would likely be easiest to implement, cheap, and relatively easy to hedge.

[12]This would probably occur in situations in which a central bank needed to free up some of its reserves invested in equities to act as a lender of last resort in foreign currency. However, it is not clear that this liquidation could occur smoothly and without cost; for example, if the need to step in as a lender of last resort came in the face of massive capital flight (which would presumably would be a textbook example of such an event), the "run for the exit" may coincide with increased volatility in the U.S. equity market - see Ghosh *et al.* (2018) ch.4 - and given the tendency for correlations worldwide to increase during periods of stress (see above), even other equity markets. It is of course impossible to say if central banks would suffer losses on their portfolio (or how painful those would be), but the possibility cannot be discounted. Even in the absence of increased volatility or in case of a homegrown disturbance (as opposed to an exogenous shock), the central bank may be forced into a typical "buy high, sell low" situation. Needless to say, any losses suffered in an episode such as the one just described would likely kill all appetite for any return-seeking for years to come. Once again,

Figure 4.10: Performance of Major Equity Markets Worldwide, 1998-2021



Source: Yahoo.com

Note: The figure presents indices for major equity markets worldwide, which represent the bulk of the investable universe. Since the indices are not directly comparable, I normalize all to 1 as at Jan 1, 1998. Note that the end values are thus dependent on the choice of the initial date; for instance, the relatively handsome performance of the South Korean equity market since Jan 1, 1998 is likely influenced by the previous substantial drop in the wake of the Asian Crisis. The main point of the figure is to illustrate the differing performance of various markets during various periods since 1998. The indices used are Russell 1000 for the United States, Nikkei 225 for Japan, FTSE 100 for the UK, DAX for Germany, CAC 40 for France, SP/TSX for Canada, TAIEX for Taiwan, KOSPI for South Korea, Hang Seng Index for Hong Kong, SMI for Switzerland, SP/ASX 200 for Australia, and Shanghai Composite Index for China.

not face that need, the emphasis on liquidity seems rather self-defeating from the perspective of investment management. First off, to the extent that liquidity should matter at all, this should only be in the context of the need to maintain spending goals. Note that this may or may not require investments to be very liquid; for example, real estate investments tend to provide regular income despite not being as liquid.[13] At the same time, the emphasis on liquidity reduces the universe of available investments, including the opportunity to exploit longer-term, potentially higher-yielding opportunities (due to lesser efficiency of illiquid markets, private equity or real estate being obvious examples) and, equally importantly, a chance to achieve a greater degree of diversification and reduce the magnitude of downside risk (in case of real estate or absolute return).[14] More generally, reluctance to accept illiquidity also effectively amounts to a lower degree of commitment to a long-term investment process. On the other hand, navigating the landscape of non-listed investments requires more experience and may present additional accountability issues. At the same time, more diversified portfolios may underperform in periods of outstanding equity market returns (see below). I discuss some of the implications in section 4.3.

4.2.3 University Endowments as a Natural Experiment? The Lessons and the Limits

It is worth exploring if the analogy with university endowments can be exploited further. Table 4.3 on the next page shows asset allocations for four of the largest U.S. university endowments. The one thing that should be most striking is the surprisingly small exposure to public equity markets (whether domestic or international) compared to "alternative asset classes" - absolute return, private equity/venture capital or real estate. I only show the allocations for the four endowments, but substantial reliance on alternative investments has really become a norm among U.S. university endowments over $1 billion, see NACUBO-TIAA (2020).

the downside risk could probably be mitigated using options, but trying to generate return while accepting the risk of potentially having to liquidate quickly should a crisis hit may not be an attractive proposition as a matter of principle.

[13] Furthermore, even less liquid investments, such as those with hedge funds, tend to provide options for redemptions in regular intervals, while those with private equity firms typically tend to last years.

[14] For a more detailed discussion of individual asset classes and their role in a portfolio, see again Swensen (2009) ch.7 and ch.8.

Table 4.3: Selected University Endowments, Target Asset Allocation as of 2020

	Yale	Harvard	Stanford	MIT
Absolute Return	21.6%	36.4%	21%	14%****
Domestic (U.S.) Equity	2.3%	18.9%	6%	11%
Foreign Equity	11.4%		19%	24%
Leveraged Buyouts	15.8%	23%	30%	25%
Venture Capital	22.6%			
Natural Resources	3.9%	3.9%*	6%	3%***
Real Estate	8.6%	7.1%	8%	12%
Cash & Fixed Income	13.7%	10.7%**	10%	11%

Note: Allocations are retrieved from respective annual reports. Figures used are valid as of 2020 since annual reports for 2021 were not yet available as of the time of writing. Note that some universities do not provide a breakdown of private equity between leveraged buyouts and venture capital or of public equities into U.S. equities and foreign equities.
*The figure includes natural resources and "other real assets"
**The figure includes "cash & other" and "bonds/TIPS"
***Denoted as "real assets"
****Denoted as "marketable alternatives", but essentially hedge-fund-type investments

Table 4.4: Selected University Endowments, Size as of 2010, 2020 and 2021

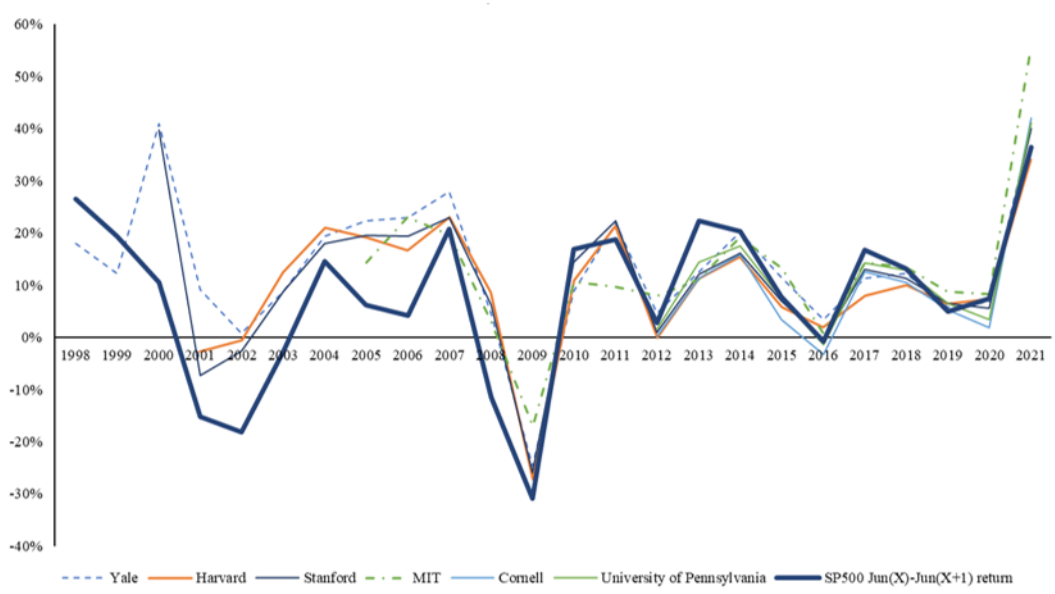
	Yale	Harvard	Stanford	MIT
2010	$16.7 billion	$27.4 billion	$13.8 billion	$7.9 billion
2020	$31.2 billion	$41.9 billion	$28.9 billion	$18.4 billion
2021	$42.3 billion	$53.2 billion	$41.9 billion	$27.4 billion

Note: Figures come from press releases of respective endowments. Figures are valid as of June 30, 2010, June 30, 2020 and June 30, 2021, respectively. Note that the growth in endowment values is also impacted by withdrawals and new donations, and not just the returns presented in Figure 4.11.

Interestingly, some endowments have maintained such diversified allocations even as their size has grown into tens of billions of dollars (Table 4.4).

Figure 4.11 on the next page shows the annual returns produced by the four endowments above plus two more smaller ones against the performance of the SP 500 since 1998 for June-June periods (for some, the series is shorter due to the unavailability of annual reports). Several observations are of interest: first, the outperformance of the three (four) largest endowments over the index in the wake of the dot-com meltdown (the years leading up to the crash of 2008). Second, despite the 20-25% drop in 2008, none of the major en-

Figure 4.11: Selected University Endowments vs. SP 500, Annual Return 1998-2021



Source: Author's calculation based on data from the annual reports of respective university endowments and Robert Shiller

Note: Data on annual returns of respective endowments are compiled from annual financial reports. Data on SP 500 come from Robert Shiller, who uses monthly averages of the value of the index to smooth out potential intra-month fluctuations. Note that since university endowments follow financial years starting July 1 and ending on June 30, annual returns on SP 500 are calculated using June values to ensure maximum comparability.

dowments underperformed the SP 500.[15] Finally, despite underperforming the index for some post-crisis years, the returns seem to have generally been more stable.[16]Moreover, in FY 2021 the endowments substantially outperformed an above-average return on the U.S. equity market, driven largely by investments in private markets.[17]

Several remarks are in order. While the strong orientation toward alternative asset classes has been a hallmark of most large U.S. college endowments, the allocations presented above should of course not be construed as offering a strict "template" for central bank portfolios. Strategic asset allocation is always a function of at least several variables: the spectrum of available opportunities, risk appetite, individual preferences, expertise, projected needs (for example, the spending goals), willingness to acccept illiquidity, etc. Moreover, the key component (or the "art") of any successful portfolio is identifying the "right mix" of individual classes such that the resulting portfolio best addresses the critical trade-off between a "spending drop" and a "purchasing power impairment" (or, if applied to a central bank, an "equity impairment") while offering opportunities for return generation.[18] As such, it is a continuously evolving process, as shown in Figure 4.12.

Put differently, the point of discussing asset allocation as done by large endowments is not that central banks should go out looking to buy timber (to borrow one of the investments famously associated with the Yale Investment Office), but that building a portfolio consisting in great part of investments beyond public equities is actually achievable even for a large eleven-figure pool of money (though it is of course far from easy).[19] Moreover, the fact that

[15]Note that the need to show the SP 500 returns on June-June basis obscures may obscure certain important points: for example, the SP 500 dropped 37% in calendar year 2008, a substantially worse return than the 25% drop experienced by the endowments. On the other hand, the June-June record-keeping obscures the 30.43% return posted by the SP 500 in 2019. On the other hand, the June-June periods likely offer the most "honest" comparison.

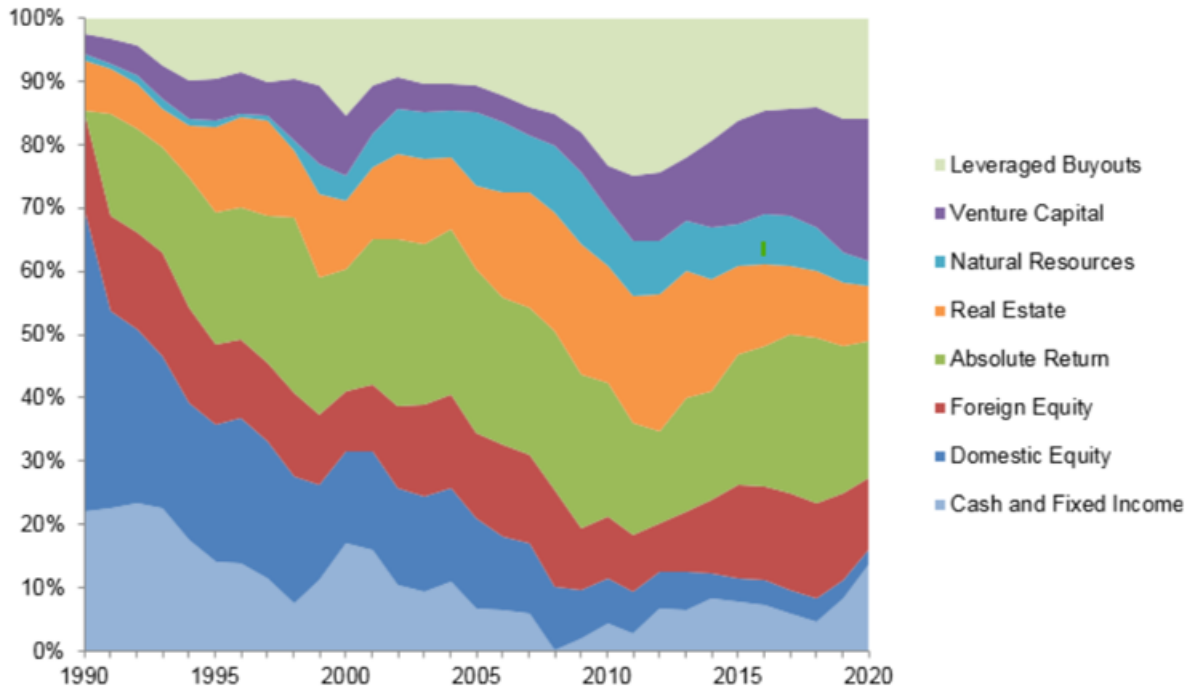
[16]For example, Yale's 20-year return has totaled 11.3% as of June 2021, while a broad index of U.S. equities has returned 9.1%, though Yale's 12.4% 10-year return has trailed the 14.8% 10-year return posted by U.S. equities. Note that stability of returns over long periods obviously does not guarantee results for any future endowments, but rather shows how diversified endowments are "supposed" to perform if successfully managed.

[17]See the press releases of major university endowments (MIT, Yale, etc.) for details.

[18]An accessible discussion is offered in Swensen (2009, ch.5)

[19]The emphasis is on the word achievable. There is no way to say how "easy" or "hard" it would be to emulate such a feat. Therefore, the discussion of allocations and past returns for several of the largest endowments really serves only as an illustration. A "statistically stronger" analysis may involve broadening the pool to include many other smaller endowments. However, the challenges of running a portfolio of $5 billion and a portfolio of $30 billion or more are probably very different, so there is likely limited value in studying returns

Figure 4.12: Yale Investment Office, Asset Allocation through Time



Source: Yale Investment Office

the overall objective of an endowment is the heavy emphasis on protecting downside, which is conveniently congruent with the objective a central bank, seems to offer the experience of large endowments as an interesting natural experiment. At the same time, it is interesting to compare the returns posted by the major endowments with those achieved in the public equity market: In periods of highly negative public market performance, the endowments shown above seem to have done a better job of minimizing their losses (as they were supposed to if executed successfully). At the same time, reliance on alternative assets proved very useful in the decade prior to 2008, when the U.S. stock

and asset allocations by endowments with only several billion under management. In fact, Ennis (2020) finds that the bulk of the performance of U.S. university endowments and pension funds, which also heavily invest in "alternatives", is largely explained by a handful of public market indices. At the same time, endowments and pensions funds on average failed to outperform public markets for the past decade, which the author ascribes to increased efficiency of private markets and the attendant reduction in the diversifying power of the alternatives. On the other hand, it is fair to point out that the performance of the U.S. equity market has been above long-run average since 2009, quite unlike the very disappointing returns realized in the decade prior to 2008. In any case, the main value of this discussion really lies in there being at least a "precedent" that offers several interesting lessons. While it may not seem to be much, this really is as far as this analysis can go since the experience of each portfolio is unique and the future is largely unknowable.

market produced very lackluster returns (see again Figure 10). On the flip side, the relative performance of highly diversified portfolios can be less impressive during prolonged bull markets (such as the one seen since 2009), although timely exposure to private markets offers a chance to reap even greater returns (such as those realized by some large endowments in 2021).

That said, while the experience of endowments yields interesting lessons, there are several important limits to the endowment-central bank analogy. First, even superb diversification may not be enough to avoid short-term fluctuations in the value of the portfolio or prevent potentially large losses in truly cataclysmic times, as exemplified by the endowments' performance in 2008, and I address this below as I discuss central bank equity. Second, the task of managing such a portfolio would probably present challenges to a central bank in terms of expertise and accountability. Third, a portfolio consisting in large part of alternative investments would take longer to build from scratch (although starting with a smaller size may minimize the overall amount of risk and make central banks gradually more comfortable as they gained the required experience and expertise).

A final challenge may have to do with the size of central bank portfolios, both in absolute terms and relative to GDP. First, a portfolio targeting asset classes beyond fixed income and public equities needs to be large enough in absolute terms for it to work.[20] Second, the portfolio needs to be large enough relative to a country's GDP to make potential gains even worthwhile. This is even more true assuming that a central bank would only feel comfortable investing a certain percentage of its reserves in a long-term portfolio. Third, a portfolio must be "small enough" such that there are enough available opportunities to absorb all the money, since allocating portions of a portfolio to alternative asset classes such that the portions are large enough to make a reasonable difference and the allocations offer an attractive value proposition may become more and more difficult as a portfolio grows bigger.[21] For instance, should the Swiss National Bank try to diversify its portfolio of equities (23%

[20]The main reason being that a diversified portfolio involves the need to diversify not just across asset classes, but also within individual classes - large university endowments typically have relationship with dozens of external money managers. At the same time, an institutional investor looking to invest with the top money managers would probably need to "offer" large commitments to make themselves attractive as a client. Another issue are the expenses associated with running and monitoring large diverse portfolios, which again may be a bigger hurdle for smaller pools of money.

[21]Markets for alternative investments small compared to public markets, hence the risk of too much money chasing too few opportunities may substantially decrease the potential for reward and make markets more efficient. See Ennis (2020) for a discussion.

share of reserves, a little under $250 billion), allocating sufficient amounts to other asset classes (be it real estate, private equity or absolute return) to achieve a meaningful level of diversification (or value added) may be challenging to say the least (simply because these allocations would need to amount to tens of billions). Hence, it is perhaps no coincidence that the SNB's portfolio more closely resembles that of the Norway's sovereign wealth fund, which consists of equity investments (up to 70%), fixed-income (up to 30%), real estate (up to 7%) and unlisted renewable energy infrastructure (up to 2%).[22] The logical conjecture is that central banks whose reserves are "too large" may be restricted to pursuing a more aggressive investment strategy mostly through investments in public equities, potentially with the implications discussed above.

4.3 The Challenges

So far, I have only discussed the question of longer-term return-driven investment in terms of the overall objective and asset allocation, while abstracting from certain risks peculiar to a central bank. The three most important ones are the challenges associated with more active management and risks to central bank independence (specifically, risks to central bank equity and what I term the problem of "quasi-fiscal dominance"). I go through each of these in turn.

4.3.1 The Challenges of More Active Management

It is easy to see that branching out beyond fixed-income investments would involve challenges along several fronts. First, running portfolios composed of fixed-income securities can be viewed as a relatively mechanical process (assuming away reinvestment risk). Furthermore, defining guidelines for choosing

[22]This is admittedly not the main argument why an analogy with sovereign wealth funds would be deficient and probably less useful than that with university endowments. To be fair, certain sovereign wealth funds are much smaller in size. However, sovereign wealth funds are not necessarily set up to provide regular income streams to the government budget, which translates into reduced need to smooth out the flucuations of long-term investments, though they are occassonally called on in times of need. Moreover, sovereign wealth funds are not really concerned about their independence (at least not in the manner that central banks are) and certainly not concerned about their equity (at least in the short- to medium-term). Third, sovereign wealth funds are often entrusted with strategic objectives (for instance, in developing domestic economy or conducting strategic acquisitons), instead of being focused exclusively on return. While there is in principle no reason why central banks could not do the same (perhaps down the road, once the investment portfolio is up and running) and such an option could be interesting option for countries that do not have, or could not easily set up, their own SWF, this variant could present further challenges having to do with evaluation of individual investments or political independence and I do not discuss this futher.

specific investments can also be defined rather simply (for instance, based on ratings or geography). Obviously, investments in public equities involve more complicated decision-making as regards the choice of particular investments (not to mention the need to actively enter and exit positions). An issue related to that concerns the question of the behavior of a central bank as a shareholder; they could either choose to be an actively-voting shareholder, as is the case for Norway's SWF - see NBIM (2021) - or they could choose to remain passive, which however does not make much sense from the viewpoint of investment management.[23] Of course, this dilemma goes away if equity investments are done through market indices (as has been done by central banks in Switzerland and Israel).

Even more complex is managing a portfolio comprising in large part non-listed investments. Such a task would almost inevitably involve the need to rely on external managers, though there is some precedent for that, as discussed just below.[24] Second, reliance on a diverse set of asset classes and a potentially large number of external money managers would involve the central bank continually monitoring the overall portfolio to ensure that it satisfies the overall objective (see previous subsection).[25] At the same time, reliance on external managers (especially in non-public markets) entails the process of seeking out and developing relationships (which may be time-consuming, but could potentially result in very long-term fruitful partnerships) and simultaneously selecting the "best in the herd", which is especially critical in private markets.[26] Since central banks have traditionally not been entrusted with such tasks, it would likely take time for a central bank to develop the expertise re-

[23]One reason may have to do with central banks' reluctance to become "players" in financial markets. However, this would likely not pose a problem for central bank neutrality since most central banks would likely choose not to invest in domestic markets, both due to their size (compared, say, to the U.S. stock market) and out of fear of economic overheating, as is again the case for the Norwegian SWF.

[24]This may not necessarily be true in real estate and private equity, where some central banks could theoretically develop their own in-house capabilities.

[25]Essential, though trivial on surface, is the need to understand the individual strategies, which can be particularly challenging in the field of absolute return, where strategies can range from computer-driven trading to merger arbitrage, activist investing, speculative attacks against weak currencies or (in the infamous case of Amaranth Advisors) to betting on the weather.

[26]For instance, venture capital and leveraged buyouts firms typically show a high degree of persistence in relative performance (though the persistence is less pronounced in buyouts). On the other hand, Harris *et al.* (2020) show that data on past performance available in real time do not serve as a reliable predictor for buyout funds, complicating matters for investors. At the same time, many newcomers to the industry seemed to perform well, suggesting investors may have been rewarded for being more courageous in their allocation decisions. Similarly, the potential for long-term fruitful partnerships is confirmed by Nanda

quired (even though at least some of them would likely have more than enough resources required for this pursuit as well as sufficiently large reserves to make it worthwhile). Last but not least, legal changes may be required to allow a central bank to expand beyond fixed-income.

An understandable concern for central bankers stems from the fact that were they to be the ones making such decisions, they may face reputational damage if some investments were to go awry. This would be especially true in the case of "alternative" (or non-listed) investments, where a lot depends on judgement, no recourse exists to ratings and other "objective" criteria are generally hard to come by.[27] On the other hand, the experience of Central Bank of Italy, which in the 1990s famously invested with LTCM and lost money in wake of the hedge fund's demise suggests that even relying on Nobel laureates may not be enough, see WSJ (1998). The experience of Israel's central bank, which has maintained a percentage of its reserves in equity indices, suggests that the understandable fear of "blame" for investments gone awry (arguably reduced by tracking a broad market, rather than "picking" individual stocks) could be a very real hurdle, see Benita *et al.* (2019).

An interesting approach to alleviating the problem could be to delegate investment decisions to an independent panel composed of representatives of both the central bank and the government, such that the responsibility for investment decisions and the blame for potential losses could be evenly shared. On the flip side, while that may take some pressure off a central bank's shoulders, it may entail an even greater loss of control since the central bank may cease to be the only actor making all the decisions. Moreover, the central bank would still need to deal with the consequences of a potential loss, which suggests that this step may not be a sufficient condition and such concerns would likely be best addressed by protecting the central bank's equity, as suggested below.

A further potential challenge may arise should investment decisions themselves become a matter of public controversy. For instance, a central bank may face demands that it should refrain from real estate investments since rising property prices and the growing popularity of real estate with institutional investors seem to be a widespread concern in many parts of the world. Similarly, a central bank may be under pressure to steer clear of "dirty" investments and focus on "clean" investments to contribute to the fight against climate change.

et al. (2020), who find that venture capital firms tend to benefit from past successes and gain network advantages for relatively long periods of time.

[27]Reliance on ratings as a means to filter out acceptable investments seem widespread among central banks. See again Anasashvili *et al.* (2020)

While such concerns are certainly legitimate, the flip side of such restrictions may be a narrowing of the spectrum of available investment opportunities. Furthermore, regardless of the "moral" dimension of the question, a public controversy could further complicate the entire investment process (which should probably be kept out of public view to the greatest extent possible). In fact, a recent announcement by Banque de France, which decided to eliminate investments in fossil fuels from their balance sheets, suggests that this would likely be an issue other central banks may need to consider (whether out of their own initiative or in response to outside calls), see FT (2021). A reasonable way to address the issue would be to issue transparent guidelines and only review them in regular intervals, as is done by Norway's SWF - see NBIM (2020) - rather than making such adjustments on an ad-hoc basis.

4.3.2 Risks to Central Bank Equity

Central bank equity likely represents the most esoteric and most important consideration for a central bank. As such, I first review its importance and discuss available ways to address the risks to it.

On the one hand, central banks theoretically do not need to operate in accordance with standard accounting rules. Moreover, given their monopoly on money creation, it would arguably be hard for them to become illiquid, unless for some reason central bank money ceases to be accepted as money. At the same time, the essence of central banks' operations makes them "structurally" profit-making due to the positive differential between the cost of creating new money and the resulting income earned as a result of securities held on the asset side of the balance sheet as a counterpart to new money (this can be especially advantageous in emerging economies as money supply tends to grow faster in line with the growth of the economy). However, there have been instances of relatively large central bank losses, usually as a result of adverse revaluation affects (in the case of a large part of a central bank's balance sheet being denominated in foreign currencies) or as a result of quasi-fiscal operations (for example, bank bailouts or valuation adjustments of ownership stakes in banks previously rescued by the central bank). A collection of case studies is offered in Dalton & Dziobek (2005).

Central bank losses are important for several reasons. First, they have clear fiscal implications in that negative central bank net worth would likely make fiscal transfers to the government budget impossible, both for economic

and legal reasons (a point pertinent in the context of this discussion). Second, negative central bank net worth can have adverse consequences for central bank independence and the conduct of monetary policy.

The most straightforward channel through which losses could cause a central bank to become incapable of fully carrying out monetary policy is if a negative net worth were to force a central bank to renege on its inflation target in order to reap greater seigniorage income (in other words, a central bank's inflation target may cease to be "financeable").[28] This temptation could be greater for a central bank that could not (or did not want to) rely on a potential recapitalization by the government). Empirical investigations have so far seemed to offer mixed evidence on the importance of the relationship between inflation and central bank finances, with some indications of potentially strong non-linearities (i.e. mildly negative equity may not matter as much as grossly negative equity), for example in Benecká *et al.* (2012). Pinter (2017) provides evidence that a potentially crucial distinction could arise between cases in which a central bank may count on de facto recapitalization guarantee (in which case the temptation to pursue seigniorage may not be as great) and cases where only a de jure recapitalization commitment exists. Overall, it seems that the question of central bank financial strength is taken seriously by central banks and many governments, and many central banks seem to be guaranteed recapitalization in times of need, for example as a result of revaluation losses, see Anasashvili *et al.* (2020). On the other hand, some central banks, such as the Czech National Bank have a long history of operating with negative equity.[29]

Fear of (potential) losses can influence central bank behavior can also manifest itself in less straightforward ways. For example, a fear of potentially large future losses seems to have been a factor in the decision by the Swiss National Bank to suddenly abandon its one-sided exchange-rate commitment in 2015.[30] Another potential concern is that central bank losses and the need for a capital injection by the government may force a central bank to accept an unpleasant quid pro quo (perhaps in terms of adjusting monetary policy to the government's liking) or potentially serve as an excuse to remove central bank officials.

It is thus easy to see how losses sustained as a result of more aggressive

[28]See Benecká *et al.* (2012) for a literature review as well as a discussion of methodological issues.

[29]See annual reports of the Czech National Bank.

[30]For a case study as a well as a theoretical discussion of a "reverse" speculative attack, see Amador *et al.* (2016)

investment decisions (whether "realized" or "unrealized" since it is not clear that the latter would be less threatening) could negatively impact a central bank's position. However, certain factors may make such losses more painful. First, they could be substantially larger than other types of losses (for example those sustained due to sterilization costs). Note that in such a case, relying on a capital injection by the government may well be impossible due to the loss being just too big. Second, they could be more sudden, rather than accumulate gradually (and thus more akin to losses sustained as a result of a sharp revaluation). Third, they could potentially involve a greater reputational cost to a central bank since they would likely be easier to comprehend by the general public (for example, losses suffered as a result of sterilization would likely be harder to communicate and may be less headline-grabbing). Finally, even if losses suffered were relatively small relative to a central bank's balance sheet, they could still be very large in absolute terms; to take (an admittedly extreme) example of the Swiss National Bank, even losses amounting to, say 5% of the SNB's balance sheet would still be equal to tens of billions of dollars in absolute terms (however, even losses far smaller would still likely carry a substantial reputational cost). In the worst case scenario, a central bank may theoretically suffer a double whammy of an equity impairment (with the attendant problems laid out above) and a reputational damage, while facing an additional challenge to its independence, for example if losses were used by the government as a wedge against an unpopular central bank governor.

The most straightforward solution to the need to insulate central bank independence against such potential threats would be to develop an "equity buffer". This could be done by only introducing a payout policy after a certain period of time, or once the central bank accumulated a certain percentage of its equity in gains. The exact size of the buffer would presumably be determined by the central bank depending on its assessment of the needed size of the buffer and as such would depend heavily on the size of the reserve portfolio relative to the whole central bank balance sheet and the maximum estimated loss on the portfolio. [31] The simplest way to develop such a buffer would likely entail only investments in public equities (effectively hoping to "ride" a rising equity market while protecting the downside with put options); expansion into other asset classes could follow after that. At the end of the day, one has to start

[31] An open question is whether the investment portfolio would be treated in isolation or whether losses potentially sustained by the central bank as a result of other operations would be factored in.

somewhere.

Afterward, a spending rule could be designed such that only proceeds above a specified threshold could be transferred. Of course, this does not remove all risk, especially in the early stages of the process, when the "equity buffer" may be small or even nonexistent. One way (in fact, likely the only way, at least in the absence of some early-stage recapitalization guarantee) around that problem would be to start "small" and only gradually increase the percentage of the central bank's portfolio committed, while accepting the likely lengthening of the process. Furthermore, it is worth noting that this involves a potentially politically difficult trade-off between the benefit of protecting central bank equity (which, despite its importance, may seem somewhat less tangible) and the cost of foregoing (or at least delaying) very real transfers to the government budget. On the other hand, that might have to be the cost of persuading a justifiably reluctant central bank. On the flip side, an "equity buffer" could make the investment process slightly less uncomfortable by expanding the margin for error, which could otherwise be unpleasantly close to nonexistent.

It is worth emphasizing that while concerns pertaining to central bank losses and equity are quite easy to understand theoretically, there seems to be substantial uncertainty regarding how important they actually are in reality. This is not only due to less than bullet-proof empirical evidence, but also due to the fact that certain risks (for example, mainly the fear of a quid pro quo discussed above) are probably empirically untestable. In the absence of certainty (one way or the other), the only bullet-proof option is likely to treat central bank equity as more or less sacrosanct, and I proceed accordingly. However, even in the absence of that constraint, the fundamental objective of managing an endowment - that of minimizing even short- to medium-term losses and the overall emphasis on defense - remains in place and so the investment process would not change very dramatically even in the event that the central bank decided that losses to its equity did not matter (as long as kept to a reasonable level). On the other hand, the need to pay attention to central bank equity certainly represents a much more binding constraint and is likely to cause the whole process to be more time-consuming.[32]

[32]An interesting question to consider is to what extent such concerns apply to the Monetary Authority of Singapore: after all, MAS does not really "do" monetary policy as commonly understood. Rather, its main monetary policy instrument is the management of its exchange rate, which is allowed to fluctuate against a trade-weighted basket of currencies within a band that can be adjusted biannually. At the same time, the extreme openness of Singaporean economy means domestic conditions are largely determined exogenously, with interest rates

4.3.3 The Problem of "Quasi-Fiscal Dominance"

Textbook definitions of a "fiscal dominance" typically refer to situations where the conduct of monetary policy becomes subordinate to the fiscal needs of the government. With a government facing budgetary problems or high indebtedness, this could occur through the need to keep interest rates low to reduce government debt service or by pumping up seigniorage income to alleviate the government's budget constraint. This situation is of course very unlikely to occur in this context. However, the expectation of regular dividends could theoretically bring about a degree of fiscal dependence or place a central bank in an uncomfortable position in other ways.[33]

At first sight, such fiscal dependence seems to have developed in Singapore, where income from invested reserves [34] makes up a substantial percentage of the government's budget (up to 20%). This is coupled with the fact that Singapore has tended to run structural budget deficits around 1% of its GDP, making income generated from the reserve portfolio critical, see Menon (2020). On the other hand, the potential for imprudent use of reserves is limited by strict caps on the use of the proceeds with a constitutional bar on debt-financed

more or less determined by global conditions. Given that context, it is not clear how potential losses suffered by the MAS would give rise to concerns surrounding the "financeability" of the inflation target, partly since MAS does not have an inflation target and partly due to its reliance on exchange rate management as a policy tool as far as domestic inflation and inflation expectations are concerned. At the same time, flooding the economy with money to reap seigniorage while keeping a managed exchange rate (and a reputation for stability and ease of doing business) does not seem very reasonable. Perhaps most importantly, given the absence of the policy rate as the main instrument of monetary policy, the potential for quarrels with the government regarding the direction of monetary policy (say, regarding the trade-off between inflation or unemployment, which is presumably what could give rise to demands for a quid pro quo in the event of central bank losses or the need for a recapitalization) also seems substantially diminished. While it is hard to judge to what extent that influences actual decision-making, at least on the theoretical level the concerns over central bank losses seem to be less significant. Of course, they still matter for fiscal reasons, and that is more than enough of a reason to avoid them. But the specific nature of Singaporean monetary policy regime gives the impression of perhaps making things somewhat easier.

Another important factor may be the well-known strength of political institutions in Singapore, especially now with the introduction of the RMGS (see page 47). While RMGS transfer the risk associated with the investment process off the balance sheet of the MAS, they theoretically expose the MAS to a capital loss should the government renege on its obligations. One does not need to subscribe to the supremacy of the "Asian values" to wonder if a similar modus vivendi would be tenable elsewhere.

[33] I want to emphasize that I do not use this term to sound fancy but because I just need a term that draws the parallel between this problem and the concept of fical dominance as traditionaly understood.

[34] Specifically, combined income from Official Foreign Reserves and the other two government investment funds.

government spending. [35] Of course, such stringent restrictions would likely be hard to implement in other countries, nor is it necessarily clear that they would be desirable. At the same time, Singapore's ability to depend on the proceeds from reserves to such a degree is a function of the reserves being extremely large in proportion to GDP and the government's small size relative to GDP (well under 20%). Given this unique combination, a risk of substantial fiscal dependence would probably be limited for other countries.

However, the temptation to draw on proceeds from reserves for political purposes could still put a central bank under undue pressure. A typical example that comes to mind is that proceeds could be used by the government to fund "pre-election presents". To the extent that the central bank were forced to "deliver", this interference could jeopardize the functioning of the investment process and impair central bank independence. For example, in a period of high stock market gains, a central bank may find itself pressured to allocate a larger part of its investment portfolio into equity investments in order to reap "easy" returns (potentially even beyond the amount that it would feel it could comfortably allocate while both safeguarding its independence and having enough reserves for other needs). If such an episode ended badly, the short-term gains could easily come at the expense of longer-term losses, but that may be of little consequence to the current government if the gains went to favored groups and the losses, conveniently, did not materialize until after the next election. However, even in the absence of such a "bad" scenario, the central bank could be placed in a very awkward position and see its independence eroded.

The natural way to address this risk is to place strict legal limits on how proceeds from invested reserves could be used. For instance, a cap could be imposed on the percentage of proceeds that could be used in any given year. Second, the proceeds could be ring-fenced such that they could be only deployed for uses that could not be easily exploited for political purposes, such as education or health-care. The risk of abuse could potentially be another argument why it might be beneficial to try "smooth out" spending to maintain payouts even in "less prosperous" years [36] - if the public perceive that they benefit (however modestly) even in years when gains are not high overall, public

[35] The limit is known as Net Investment Returns Contribution.

For details see: https://www.mof.gov.sg/policies/reserves/what-comprises-the-reserves-and-who-manages-them

[36] This "smoothing" could for example be done by "artificially" retaining a portion of earnings that could have been paid out in "good" years so as to be able to keep spending in "less good" years.

support may make it politically harder to justify a "plundering of the portfolio" like the one discussed above. At the same time, it could be offered as evidence that even investments in "risky" assets (such as those less understandable to general public than equities) serve to reduce the risk of losses in years of bad investment performance, and in turn alleviate pressure on the central bank to run the risk of losses down the road in pursuit of higher short-term gains.[37] On the other hand, even though putting in place a sound legal framework for addressing the risks is a bare minimum that can be done, whatever limits are imposed can only be as strong as a country's institutions. In sum, this is probably the greatest risk that a central bank may confront.[38]

More generally, the above discussion points to the need for the central bank to aggressively communicate - and for the government and the public to accept - the projected capacity of the portfolio for return generation as well as the risks associated with the investment process, be it the uncertainty surrounding expected returns as well as the risk of occasional losses. At the same time, while it is undesirable to divulge too many details of the investment process to the public (simply because the public are unlikely to be in a position to properly evaluate it), the exact opposite applies to communicating the gains and the uses to which the gains are put. This is not only logical since the public would be the ultimate beneficiaries, it is also the most logical way to ensure public support for the process and hopefully also tolerance for the inevitable bumps in the road.

4.3.4 Summing Up

Could it all work? On the one hand, potential gains could be interesting for some countries. On the flip side, the potential risks to central bank reputation and independence are not to be underestimated. Consequently, most central bank would understandably be wary of pursuing such an objective; this could be especially true as today's complicated economic environment has central bank fighting the effects of supply chain dislocations (and the attendant inflationary

[37] Obviously, quite possibly at the cost of lower returns in years of extraordinary performance of equity markets, but that is the price. Some solace could at least be found in the usefulness of this approach as a tool of management of expectations.

[38] In an ironic twist, this problem effectively turns on its head one of the basic issues in the realm of investment management, the principal-agent problem. In this set-up, the central bank effectively acts as a fiduciary to the government as its client, except that here it is not the client that faces the risk of being harmed in the event that there is a misalignment of interests between the fiduciary and the client. In fact, it really is the fiduciary who needs to worry about a potentially misbehaving client.

pressures) and the potentially conflicting objective to keep interest rates low to support the post-pandemic recovery. This dilemma could easily expose central banks to pressure from their governments and thus leave little appetite for any experimentation.

Aside from the risks discussed above, central bankers could be concerned about a possibly lopsided effect on the overall role of a central bank of managing a portfolio "on top of" conducting normal monetary policy. It is a legitimate worry that the process of managing a nation's investment portfolio could potentially divert more and more attention from monetary policy (which should of course always take primacy) to the investment process.[39] On some level, the acceptance of a certain shift in the role of a central bank would likely be unavoidable. On the other hand, assuming the issues threatening the central bank were addressed, that need not prove prohibitive.[40]

Of course, any such project will always require a close cooperation between the central bank and its government. Even more so, this is essentially a two-way street: while governments could in principle always force central banks' hand by legislation, this would likely create little goodwill between the two parties and could have potentially ugly side-effects, as discussed above. On the other hand, it is hard to see central banks doing this purely on their own - while certain decisions should always be left to the central bank (primarily the question of what percentage of reserves to allocate to the investment portfolio or questions pertaining to central bank equity), some steps could be made easier by shared (or at least collaborative) decision-making (the obvious example being strategic asset allocation).

In the end, the challenges are certainly real and any such endeavor would require multi-year effort and probably also a dose of luck, especially since gov-

[39] An imperfect, though perhaps still useful, analogy that comes to mind is what happened to Wall Street investment banks in the 1980s and 1990s, when these institutions started setting up their own trading floors and those practicing the art of traditional investment banking suddenly discovered that their activities became somewhat less important in the face of substantial revenues produced by proprietary trading.

[40] On a more "personal" level, to the extent that those managing the portfolio were to be brought from outside (possibly even from abroad) both for reasons having to do with expertise or experience, remuneration of such managers may well need to be a multiple of that of the central bankers themselves, likely contributing little to personal chemistry. Again, these issues do not seem to be pertinent in Singapore, which seems to have a tradition of home-grown pool of asset management professionals and compensation is not likely to be much of an issue in a country where high-ranking government officials routinely receive seven-figure salaries. However, it once again illustrates that while remedying potential risks involved in the process is relatively conceptually simple, the practical implementation could easily be less so, and many seemingly small issues could potentially interfere with the process beyond the obvious ones discussed in detail in here.

ernments and central banks would only get one shot at this and any debacle along the way would likely "kill" any similar idea for years to come. But the basic road map, when "stripped down to its bare essentials", actually seems to be conceptually quite simple:

- determine what space is available in terms of reserves that can be invested;
- figure out if the expected reward sufficiently compensates for the effort and the risk undertaken;
- define and lay down strict and clear legal framework to minimize the threats to central bank independence;
- just do it.

4.4 The Outlook

Implicit in the discussion so far has been the assumption that central banks actually have the luxury of allocating part of their reserves to a long-term investment tranche or in other words, that a line can be drawn between reserves that could be needed in the future (for any of the three precautionary reasons discussed in Chapter 2) and those that will not. However, finding that line is far from trivial. For starters, there really is no useful universal metric (especially for situations where the central banks acts as lender of last resort in foreign currency). Likewise, the precautionary motives may be hard to separate from other motives (i.e. it is generally hard to say which reserves were accumulated for precautionary reasons and which purely as a by-product of central bank policy).

Moreover, it is not clear if central banks' own distinctions between the "liquidity tranche" and the "investment tranche" can be a useful gauge. The crucial point to note is that for a large majority of central banks, the investment tranche tends to be capped at three years (which almost certainly rules out investments in classes such as real estate or private markets, which tend to require at least 4-7 years) and equally importantly, even reserves deposited in the investment tranche tend to be mostly invested in fixed-income securities. It is easy to see that going from government bonds to corporate bonds or mortgage backed securities is very different from making the leap to equities or even to less liquid investments. On the one hand, considerations stemming

from greater risk exposure associated with more volatile investments could be the main motive discouraging central banks from venturing beyond fixed income. On the other hand, the fact that even mortgage-backed securities or corporate bonds could still likely be liquidated at acceptable costs (or possibly used as collateral in repo transactions) in an emergency may be the main factor. Thus, in practice it may be very hard to infer whether the still very conservative allocations in central banks' investment tranches are driven by risk-aversion or if the investment tranches are really "liquidity plus" tranches.[41] In the former case, expansion into more long-term and aggressive investments is still a challenge, but at least could be solvable. In the latter case, the maneuvering room could be very limited.

On the other hand, there are probably a few cases where the line could be drawn. An obvious case is the Swiss National Bank, whose reserves have grown exponentially as a result of exchange rate interventions in the last decade and are now in the neighborhood of $1 trillion. Coupled with the fact that the Swiss franc is a widely considered a safe haven, it is rather hard to see a large chunk of SNB's reserves ever being used. Similarly, the reserves accumulated by the Czech National Bank as a result of its unconventional monetary policy in 2013-2017 likely fall in that category (since CNB's reserves as a percentage of GDP were quite steady before 2013 and the CNB does not seem to have a history of deploying its reserves in emergencies). Similarly, Bank of Japan's $1.4 trillion in reserves seem rather sufficient. On the other hand, history shows that even a country like South Korea can get into a situation where an appeal for help may be required (as in the case of a hastily arranged swap line with the Federal Reserve in 2008, see Chapter 2), though Bank of Korea's reserves are now double their 2008 level.

An interesting case is the case of Singapore, whose official foreign reserves (OFR) amount to over 100% of GDP.[42] On the other hand, it is an extremely open economy with gross capital flows amounting to over three quarters of its GDP, see Menon (2020). Moreover, its location in a region whose geopolitics seem to be potentially very volatile (see below) together with the absence of strategic depth and a dearth of natural resources would seem to leave it very

[41]The fact that many central banks seem to adjust the size of their tranches in response to many variables, including overall levels of economic volatility worldwide, would seem to support the latter version. See again Anasashvili *et al.* (2020) for a discussion.

[42]Not counting those deposited in GIC and Temasek Holdings or those set to be allocated to GIC. The MAS seems to target a level of reserves of roughly 65-75% of GDP going forward, see again Choo (2022)

little margin for error. At the same time, its finance and insurance industries contribute nearly 15% of its GDP and establishing itself as a regional financial center has been one of its primary goals since independence, see Lee (2011) ch.5. It follows that the emphasis on the exchange rate (which is usually allowed to fluctuate against a trade-weighted basket of currencies within a band) is critical to maintaining the country's credibility (though, as noted in Chapter 2, the SGD was allowed to slide at the height of the Asian Crisis). Similarly, its extreme openness leaves it vulnerable to potential massive outflows (be they driven by economic disturbance halfway across the world or by geopolitical upheaval closer to home). The fact that Singapore is able to draw that line is thus likely a reflection of several factors: One, it feels that its reserves are large enough (given their steady growth, this being a derivative of the fact that its Monetary Authority generally intervenes to suppress appreciation pressures, which are in turn a reflection of positive interest rate differentials). Second, the gains from more aggressive investment justify the reduction in its buffer. Third, it feels it could likely draw on external help if truly needed (for example, the MAS has had a liquidity swap agreement with the Federal Reserves to the tune of $60 billion).[43]

The gradually expanding global network of central bank liquidity swaps could potentially create more space for central banks. While original swap lines between select economies date back to the Bretton-Woods era, a new round of lines began to appear after the Asian Crisis of 1997 and the frustration at IMF-led bailouts. However, despite several rounds of initiatives, an early framework of bilateral swaps centering around Japan failed before ever being drawn on, mostly due to reasons having to do with geopolitical concerns and the residual effects of East Asia's difficult history.[44] On the other hand, the global swap network has continued to grow into dozens of individual swap agreements, though again, many seem to have gone unutilized so far (Figure 4.13).

As is also apparent from Figure 4.13, the one country especially active in the global swap network has been China, with the PBOC entering numerous swap lines with other central banks both inside and outside of Asia. Given China's growing economic and geopolitical importance within East Asia, this

[43]https://www.mas.gov.sg/news/media-releases/2020/mas-announces-swap-facility-with-the-us-federal-reserve

[44]For a detailed account of the early rounds of negotiations, especially the Chiang Main initiative, and the role played by concerns over their Japanese-centric character, see Chandrasekhar (2021). For a comprehensive review of East Asia's "history wars", see McGregor (2017)

Figure 4.13: Global Network of Central Bank Liquidity Swaps (2017)

Source: Council for Foreign Relations Central Bank Currency Swaps Tracker
Note: Data are valid as of 2017, when the Tracker was last updated. Gray lines indicate unused swaps.

is hardly surprising. As explored in detail in Chandrasekhar (2021), thanks to China's growing network, coupled with the PBOC's gargantuan reserves (over $3 trillion), such a regional-wide liquidity backstop could be a potential game-changer. On the other hand, there are potential problems with China's overtures: first, the swaps are denominated in renminbi, potentially necessitating their conversion into dollars (an especially important consideration if the need to draw on the line were motivated by, say, the need to backstop a bank tottering in the wake of outflows driven by a large-scale retrenchment of Western lenders). Second, China's habit of deploying economic tools as coercion in diplomatic disputes could potentially cast doubt on the extent to which the PBOC could be counted on to deliver should the need arise. If not, regional central banks could still theoretically rely on each other for support when needed, but likely to a much smaller extent.[45] The one change that could resolve the problem for good would be for the Federal Reserve to "offer" similar swap lines,

[45]The important point to note is that dollar swap lines not involving the Fed only involve existing reserves being moved around, rather than creating new ones, which by definition limits the amount potentially available. Second, the risk of default by a partner central bank, if coupled with an adverse exchange movement, could expose the lending central bank to losses, which would likely be greater as a percentage of its balance sheet than in the case of the PBOC. Third, such swap lines do not address the question of what to do if multiple countries in a given region face reserve drains simultaneously. A similar criticism can be levelled at the concept of "pooling reserves" suggested by Prasad (2015) ch.11.

though whether it would be willing to do that is an open question.[46] Furthermore, despite the enormous COVID-induced economic disruption, East Asia's swap network has yet to be tested in a protracted large-scale crisis. While such may or may not occur in the foreseeable future, the region's numerous fault lines suggest the potential for a such protracted crisis cannot be underestimated (to name only a few, a confrontation over the South China Sea, a potential escalation in the Taiwan Strait, or a blockade of the Strait of Malacca; the list could probably go on).

[46]While the Federal Reserve reactivated its swap lines in the spring of 2020 to the tune of nearly $300 billion, direct access to the Fed "pipeline" remains limited Chandrasekhar (2021). The Fed generally limits the extension of swap lines to economies where "an intensification of stresses in one or more of these countries could trigger unwelcome spillovers for both the U.S. economy and the international economy more generally", potentially ruling out swaps to less systemically important countries, see Fed (2008). On the flip side, a "standing" extension of dollar swap lines directly from the Fed could be and interesting bargaining chip in the U.S.-Chinese geopolitical competition, but likely at the cost of potential independence issues.

Chapter 5

Conclusion

This thesis has dealt with central bank foreign exchange reserves. Chapter 2 discussed the context for the steady accumulation of reserve holdings, the motives for maintaining reserves and some of the costs associated with their management. Chapter 3 provided evidence from selected countries on the interaction between reserve holdings and household consumption and gross capital formation. While the findings from some countries seem to confirm an economically important causal relationship and are thus in line with earlier findings (such as those identifying reserves as a stabilizing factor in times of financial stress), the lack of a pronounced and statistically strong relationship for other countries suggests a likely heterogeneity of the effects of reserves on macro variables. Moreover, the degree of overall development and the changing patterns of reserve levels could weaken the robustness of the findings through time and the question may be worth revisiting.

Chapter 4 examined the feasibility of incorporating return generation as an explicit objective of the management of foreign reserves. After laying out the "endowment's problem", I discussed in general terms the question of asset allocation, namely the issue of liquidity, and briefly examined the experience of selected university endowments as a source of potential lessons for central bank portfolios. Equally importantly, I have extensively surveyed the potential risks to central banks' independence and reputation, namely the challenges associated with active management, risks to central bank equity, and the problem of "quasi-fiscal dominance". While neither of the hurdles seems unsolvable and can be remedied, the success or failure would ultimately depend on the degree of cooperation (and also trust) between the central bank, the government, and perhaps even the public. Furthermore, acquiring the expertise needed to

successfully navigate the investment landscape would of course represent a challenge in its own right and a simple enumeration of the prerequisites needed to make it a success likely makes the whole process look easier than it would be. At the same time, constraints stemming from the size of central bank portfolios coupled with the difficulty to achieve sufficient levels of diversification may have consequences for the stability of returns over time and in turn, for the overall gains. It also bears repeating that any such endeavor would never be entirely free of risks. However, these are issues that every institutional investor needs to grapple with. By contrast, the discussion in Chapter 4 makes it clear that there is nothing inordinately complex about the extra steps that a central bank would need to take to reconcile its special status with the task of managing a long-term portfolio.

Finally, it is obviously important to be realistic about the possible gains. While proceeds from a successful return-driven management would likely total numbers staggeringly high from the perspective of the average individual, it is unlikely they would ever make up more than a few percent of a country's GDP and are likely not a panacea to the budgetary problems facing many governments today. Therefore, the process should best be viewed as a long-term pursuit, rather than a "quick fix". On the other hand, few would likely question the extra utility of having a GDP growth of, say, 4%, as opposed to a GDP growth of 3%, suggesting that the discussion in Chapter 4 is not just an intellectual fad.

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Appendix A

Central Banks and Monetary Policy

While virtually all modern central banks have as their central task the formulation of monetary policy and safeguarding of price stability, the list of their functions does not end there and includes a variety of other roles; some of them, such as regulation of financial system and support of financial stability (with a heavy emphasis on macroprudential policies) have gained in importance in recent years. This section provides only a selective overview: first, I briefly discuss inflation targeting as this policy regime has become increasingly the regime of choice for (especially industrialized) countries; I then go on to consider alternative policy regimes centered around management of the exchange rate. The last subsection focuses on the topic of central bank independence, reviewing both the traditional literature on the topic and recent threats to central bank independence.

A.1 Inflation Targeting

Historically, monetary policy tended to revolve around controlling money supply and various monetary aggregates as a means of keeping inflation in check; however, such an approach became impractical and was gradually abandoned - see McLeay *et al.* (2014) - giving way to the short-term nominal interest rate as the primary instrument of monetary policy.

Starting in the 1990s, inflation targeting has gained increasing acceptance as the preferred monetary regime for many advanced (and also some emerging)

economies. As a starting point for a discussion of inflation targeting, it is useful to borrow the following five-point characterization offered in Mishkin (2004):

Inflation targeting can be thought of as a series of the following steps:

- the public announcement of a medium-term inflation target,
- a commitment to the inflation target as the primary goal of monetary policy,
- an information inclusive strategy in which many variables, and not just monetary aggregates or the exchange rate, are used for the setting of policy instruments,
- increased transparency regarding the monetary policy strategy as well as the plans, objectives, and decisions of the monetary authorities;
- increased accountability of the central bank for attaining its inflation objectives.

Announcing an inflation target

The natural first step is the announcement of an inflation target by a central bank. In most advanced economies, the target tends to be 2% annually, though some central banks have historically tried to slightly undershoot the target (for example, the European Central Bank for a long time maintained a target of close to, but slightly below, 2%). However, some central banks, for example those in economies with inflationary history or more fragile economies may opt for a slightly higher inflation target; Reserve Bank of India recently announced its intention to keep its target in the 2-6% range. It is worth noting that no intermediate targets are usually announced, only the final objective. However, as discussed below, central banks tend to take care in communicating their strategy for achieving the final objective.

Commitment to the target as the primary goal

An important tenet of an inflation targeting regime is the subordination of other objectives to maintenance of a stable inflation rate: In practice however, central banks tend to preserve some flexibility in their decision making. Consider, for example, the following loss function:[1]

$$L_t = (\pi - \pi^*)^2 + \lambda(y^{gap})^2 \tag{A.1}$$

[1]Note that the loss function takes on a quadratic form since the central bank presumably wants to minimize deviations from its desired values in both directions.

Here, beside trying to minimize deviations from its inflation target (π^*), a central bank may also wish to give certain priority (denoted by λ) to minimizing deviations from the potential (or desired) level of output (this might be especially true if there is a potentially painful cost in terms of output). In the case of purely inflexible inflation targeting, the second term would obviously disappear. This point is thus best understood as underscoring the risks that occur when a central bank pursues objectives incompatible with its main goals. A typical example is the pursuit of an exchange rate policy incompatible with the inflation target, as occurred in the oft-cited case of Hungary in the early 2000s. On the other hand, Ghosh *et al.* (2018) ch.6 derive and calibrate a model showing the utility of exchange rate interventions even for inflation targeters; it is worth noting, however, that this only applies as long as these interventions are done solely as a tool in support of the overall objective.

An inclusive strategy for setting the policy instruments

As discussed above, the main instrument in a central bank toolbox is the short-term interest rate. However, there is a long way from the short-term nominal interest rate to the end objective - the desired level of inflation. Therefore, while inflation targeting has the advantage of not relying on any intermediate goals, (such as a particular level of a monetary aggregate), a deep and accurate understanding of the transmission mechanism is still needed.

The transmission mechanism in a modern economy can be fairly complex: for example, an increase in nominal interest rate pushes up the real interest rate (at least assuming stable inflation), in turn depressing aggregate demand; alternatively, an increase in interest rates reduces the amount of credit in the economy, leading to the same result; yet another view is to interpret an increase in interest rates as a reduction in investment (by making production more expensive), leading to reduced aggregate supply. In a small open economy, a change in interest rates may filter into a change in the exchange rate, which in turn may influence domestic conditions due to expenditure switching.

Increased transparency regarding the monetary policy strategy

Crucially, all of the channels discussed above may influence economic activity - and by extension the inflation rate â€“ simultaneously (although perhaps in different horizons) and in potentially conflicting directions, necessitating the need to take account of a large number of variables. Thus, in order to be successful, a central bank needs to set its objectives in accordance with its assessment of the transmission mechanisms and ought to communicate its ob-

jectives transparently. This is a very crucial point since the credibility of a central bank and the inflation target itself derives both from how serious the central bank is about its inflation target as well as how realistic its target is. Consequently, central banks tend to communicate their decisions in a high level of detail and go to great lengths to make sure that their road map is understood and trusted by economic agents.

Increased accountability of the central bank

The need for communication and transparency is closely connected to central bank accountability. This also explains the popularity of various policy rules, such as the one proposed in Taylor (1993), in which the actions of a central bank are captured by a simple reaction function (capturing the response of the interest rate to innovations in inflation and output) and its calibrated parameters. Despite the popularity of such rules (and their use in theoretical models), central banks do occasionally deviate from such rules (most notably during the Global Financial Crisis). However, while exercising discretion when needed, it is important that they be transparent about why they do so. Similarly, a central bank may choose not to respond to a supply shock that causes unwanted disturbance in a price level as long as it feels that this is not indicative of a broader trend in the economy. Thus, temporarily missing an inflation target in a "well-explained" way need not diminish the credibility of a central bank provided the overall strategy is sound and credible.

Overall, inflation targeting has gained increased acceptance among most reputable central banks, while many emerging economy central banks have also adopted the regime. It is thus likely that inflation targeting will continue to become a monetary policy regime of choice among an increasing number of central banks.

A.2 Exchange Rate Management and Monetary Policy

It will be apparent from the above discussion that apart from a few exceptions, there is not much room within the inflation targeting framework for exchange rate management. However, due to various reasons, monetary policies centered around exchange rate management seem to be popular with some central banks. While an important disadvantage of these frameworks is the so-called

"impossible trinity" - the principle that a country that tries to â€śmanageâ€ť its exchange rate while allowing unimpeded flow of capital may need to surrender some of its control over domestic monetary policy, the upside of a fixed exchange rate may be worth the cost if it serves as a stabilizing factor.

Typical examples of countries that maintain their currencies fixed (specifically, pegged to the U.S. dollar) are the oil producers of the Persian Gulf, such as Saudi Arabia or United Arab Emirates. Given the importance of oil exports (priced in U.S. dollars) to these economies, such a choice of an exchange rate policy is hardly surprising. Similarly, small open economies heavily dependent on international trade such as Hong Kong are also famous for managing their currencies carefully (in the case of Hong Kong, the monetary authority actually operates a currency board).

However, it is worth noting that a managed exchange rate may not need to involve keeping a currency completely fixed all the time; another popular exchange rate regime is the so-called "target zone", where a central bank announces its preferred exchange rate parity within a certain corridor (hence the term "target zone") and only pledges to intervene if the spot exchange rate deviates outside of the allowed territory. The European Exchange Rate Mechanism (now in its second generation) is an example of such an arrangement.

An interesting case of a managed exchange rate regime is the so-called crawling peg - a regime in which a central bank is reluctant to let the currency fully float and instead "leans against the wind" - in other words, only intervenes in the spot market to prevent temporary fluctuations in the exchange rate while allowing only gradual readjustments to underlying fundamentals. As Calvo & Reinhart (2002) famously document, this "fear of floating" has been a consistent feature of international financial system, with many countries intervening despite claiming to be nominal floaters. An obvious danger with adjustable pegs lies in the fact that the adjustment may not be as smooth as a central bank may like, and if the market's assessment of the needed adjustment is at variance with the central bank's, it may actually be destabilizing. An example is the attempted "controlled" devaluation by Mexican officials in 1994, when a correction in the pesoâ€™s exchange rate was widely judged insufficient and led to a period of instability and the so-called "Tequilla crisis".

Finally, a central bank may also attempt to peg its currency to another currency (preferably to a low-inflation one) to "import" lower inflation and thus enhance its own credibility. A notorious instance of such an attempt is the effort of European countries in 1980s to peg their currencies to the Deutsche

mark. However, this "import of credibility" can only happen at the cost of a significantly lower policy space. Moreover, there is in general no guarantee that domestic conditions will be consistent enough with the exchange rate commitment to make the currency peg credible - in the case of Europe in the early 1990s, it turned out not to be. While some extreme version of this (such as a currency board or more irreversibly, and monetary union) may go some way toward increasing credibility, the cost paid is once again the need to give up the option to adjust monetary policy to unexpected shocks (or in the case of a monetary union, to shocks that affect various members of the currency union differently).

Despite the costs and risks, Ilzetzki *et al.* (2019) document that a surprisingly wide range of regimes continues to be pursued (with varying degrees of success) by many countries, suggesting that exchange rate management will likely remain part of central bank toolbox for quite some time.

A.3 Central Bank Independence

One of the most important topics in central banking literature is the question of central bank independence. Since the costs and dangers associated with monetary mismanagement have tended to be quite substantial in the past, this is hardly surprising. This subsection offers a brief review.

Literature on Central Bank Independence

Some of the most destructive instances of monetary mismanagement are past hyperinflationary periods connected to efforts to pay for government expenditure through seigniorage (or the positive differential between the income generated from issuing new currency and the cost of new issuance); Cagan (1956) shows how a government may be tempted to coerce a central bank into issuing more and more currency to cover its fiscal needs, causing hyperinflation as a by-product. Even in less extreme circumstances, however, a central bank may find itself in a situation dubbed as fiscal dominance, where the conduct of monetary policy may need to subordinate the pursuit of price stability to fiscal considerations (most typically, the need to keep cheap financing for a government facing a large debt burden). An interesting example of fiscal-dominance is the pursuit of low government bond rates by the Federal Reserve during and shortly after World War II. To guard against such risks, respectable central banks tend to be expressly prohibited from direct monetary financing.

Moreover, the inflationary experience in the 1970s made it clear that monetary policy can produce suboptimal results if a central bank is unable (or unwilling) to combat inflationary pressures at the cost of destabilizing (or lowering) output, or more generally, tries to pursue the two in an inconsistent fashion. In a classic paper, Kydland & Prescott (1977) consider a situation in which a central bank, though nominally committed to fighting inflationary pressures, also attempts to stimulate output by discreetly allowing some inflation (or even privileges output stimulation over controlling inflation). However, economic agents pick up on this inconsistency and start calling the central bank's bluff, causing the economy to wind up in a suboptimal long-run equilibrium with higher inflation and no higher real output. A similar result - that the perception of the inconsistency in monetary policy leads to an expectation of greater inflation by the public - is derived by Barro & Gordon (1983). The logical response is to make sure that the central bank is granted enough autonomy to prioritize control of inflation; a typical example is the notion of a "conservative central banker" (that is, one who implicitly has a strong anti-inflation bias) offered by Rogoff (1985) or an "optimal contract with the public" as argued for by Walsh (1995).

It is worth noting that while the principle of central bank independence has gained widespread acceptance, that independence has typically extended only to operational independence; by contrast, central bank mandates have typically been set by legislation; while central bank mandates usually center around the management of the price level, central banks can be entrusted with other objectives, too (for example, a dual mandate of the Federal Reserve, or the simultaneous pursuit of low inflation and full employment). Over the last few decades, the principle of central bank independence has gained widespread acceptance and while even reputable central banks occasionally struggled to guard themselves against political interference (for example, Volcker & Harper (2018) recounts being pressured by the Reagan administration not to increase interest rates in the run-up to the 1984 presidential election, while Bank of England was not granted full operational autonomy until 1997), a strong degree of independence is now an important tenet of central banking.

Recent Threats to Central Bank Independence

As just noted, the principle of central bank independence is now widely recognized. However, even in recent times, there have been violations of this rule; for example, Argentina removed its central bank governor at the height of

its 2001-2002 crisis, while disputes over policy probably led governor of India's central bank Rajan to resign in 2016 after just one term in office. Most recently, Turkey fired its central bank governor after a long argument between the central bank and the government over how best to respond to the country's multiple economic problems.

However, even central banks in advanced economies have become embattled as they have increasingly found themselves forced to be more and more creative since the onset of the Global Financial Crisis. While their unconventional responses have likely helped the world economy avoid some of the worst fallout of the crisis, concerns have also been raised regarding the costs and permissibility of certain unconventional policies. Examples of those are the concerns over central bank liquidity swaps expressed by some U.S. lawmakers, controversies over successive rounds of quantitative easing (be it the distributional effects, worries about increased risk-taking or even the international spillovers of ultra-loose monetary policy) or possible "mission creep" - the risk that central banks may be straying outside of the realm of monetary policy. The ongoing court battle in Europe over the ECB's bond purchases is a prime example of the often murky boundaries between monetary and fiscal policy (and especially on the former's effect on the latter). Concerns also arise regarding the mechanics of a future exit of these policies - see for example Yellen (2016) for a discussion. Needless to say, with the COVID-19 pandemic still ongoing, these concerns are sure to persist.

Another issue that central banks will likely need to grapple with in the future is the question of climate change. Given the likely impacts of global warming on economic and financial stability, central banks will likely need to take climate considerations into account anyway. In fact, invocations of climate warnings seem to appear more and more frequently in central bankers' statements - see Mateos Y Lago (2021). With increasing public concern over climate change, central banks may find themselves pressured to be more proactive to counter risks associated with climate disruption. While it is far too early to say whether climate considerations may compromise central banks' independence, the possibility cannot be easily discounted. See Boneva *et al.* (2021) for a discussion,