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RESEARCH ARTICLE

Strategic Asset Allocation of a Reserves' Portfolio: Hedging Against Shocks

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Abstract

Central bank reserves function as a liquidity buffer to mitigate country exposure and vulnerability to external shocks. Emerging Market Economies are the countries most exposed to the volatility of capital flows and have usually preferred to build up large war-chests of international reserves as a self-insurance mechanism, as it is under their full discretion. Nevertheless, the standard practice of immobilizing large amounts of "cash" to insure against jumps in volatility and risk-aversion could be enhanced. The inclusion of hedging strategies in the strategic asset allocation decision can help to enhance the risk management of the national balance sheet, transferring funds to those scenarios when reserves are most needed. This paper presents a practical approach that we propose to enhance the analysis of the strategic asset allocation of a central bank, and to explore the benefits of including in the construction of the efficient portfolio the analysis of correlations between the reserves' portfolio and the country's main vulnerabilities to external shocks.

Keywords Strategic asset allocation · Portfolio optimization · Reserves · Hedging · Shocks · Macroprudential policies

1 Introduction

Central banks hold reserves for a variety of reasons, but mainly as a liquidity insurance to mitigate country exposure and vulnerability to external shocks.

For Emerging Market Economies (EMEs), the exposure to capital flows is high, as they are more dependent on external savings, resulting in persistent current account

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deficits. The funding of these deficits requires ongoing capital inflows, which can suddenly stop. As soon as a sudden-stop occurs, the country's current consumption capacity is reduced and the marginal value of an extra unit of reserves increases significantly.

Although some insurance arrangements (e.g., contingent credit lines and bilateral swap agreements) have helped to address their precautionary needs, EMEs countries have usually preferred to build up large war-chests of international reserves as a self-insurance mechanism, as it is under their full discretion.

But the standard practice of immobilizing large amounts of "cash" to insure against jumps in volatility and risk-aversion, even when optimally managed, had been gathered as expensive and incomplete. Caballero and Panageas (2004) concluded that this strategy is clearly inferior to one in which portfolios may include assets that are negatively correlated with external shocks.

In an oil-producing country, for example, a sharp drop in the oil price significantly affects the fiscal balance, consumption, and growth of such country. Therefore, the correlation between the changes in the oil price and the changes in the price of the financial assets' portfolio should not be ignored. Between two assets with the same expected return and risk, the strategic asset allocation should choose the asset having the lowest correlation with the main exposure and vulnerability of such country. Moreover, a sound sovereign risk management framework should try to avoid having any significant exposure to those shocks that are more damaging for the economy.

The introduction of external shocks in the strategic asset allocation decision of a central bank´s reserves portfolio may help to enhance the risk management of the national balance sheet, as discretionary portfolio decisions can affect the national risk profile.[1]

Our paper presents a framework that seeks to enhance the strategic asset allocation decision of a central bank. Following the pioneering ideas of Caballero and Panageas (2004) and the model proposed in Gintschel and Scherer (2008), we use a synthetic asset to emulate the most relevant external shocks, which is then included in the optimization process to analyze the immunization provided by the reserves' portfolio to these macroeconomic risks. As a result, the optimization is run in a different risk-return framework, one where risk is not limited to the volatility of financial assets' portfolio but expanded to consider the volatility in the reserves portfolio caused by external shocks.

Once the definition of risk is expanded to include the volatility in the reserves portfolio caused by external shocks, there are very important changes in the composition of the efficient frontier. The optimization tends to give more preference to hedge assets like long-term bonds and, paradoxically, the greater the weight of these assets in the portfolio, the lower the volatility of the reserves portfolio due to the hedge provided.

But the implementation of these strategies in practice is not simple. An efficient strategy in terms of immunization will certainly be sub-optimal in terms of the traditional efficiency observed in the central bank's balance sheet, which may be exposed to greater volatility in the financial asset's portfolio and even to have

[1] Gray and Malone (2008) find that the sovereign has a special role to perform as a manager of sovereign risk: both to manage its own risks, but also to facilitate efficient and effective risk management in other parts of the economy. Indeed, central banks are usually exposed to contingent liabilities as safeguards of financial stability due to the interconnections between the balance sheets of the different sectors (corporates, households, financial sector, government, and the monetary authority).

negative returns. We use a Conditional Value-at-Risk (CVaR) limit to control such concerns and limit the volatility of the financial assets' portfolio.

In the first part of the paper, we review the theoretical framework described in Caballero and Panageas (2004) to better understand the impact of sudden stops in the optimal allocation of central bank reserves (Sect. 2), and we present the framework proposed based on the Gintschel and Scherer´s model (Sect. 3). In the second part of the paper (Sect. 4) we review how the implementation of this framework could impact the asset allocation of emerging market countries in Latin America. We first show the convenience to use this framework to incorporate certain features in the portfolio optimization of a central bank, in terms of currencies, duration, credit ratings and asset classes; and we then show the contrasting results for the strategic asset allocation decision when the definition of risk is expanded to consider the volatility in the reserves' portfolio caused by external shocks. Finally, in the third part of the paper (Sect. 5) we conclude with our final remarks.

2 Theoretical Framework

The microeconomic frictions behind sudden stops and the impact in the optimal allocation of central bank reserves is presented in Caballero and Panageas (2004) through the assumption that there are three types of agents: EMEs, specialist investors, and the world capital markets at large.

EMEs are countries in the pre-development phase that would like to borrow against its post-development income, as its future income is significantly higher than its current income. Therefore, they run persistent current account deficits but have great difficulty in pledging future income to finance these deficits.

Potential financiers are split into world capital markets at large, and specialists. Specialists are risk neutral investors that have developed some expertise and connections in the country. During normal times, they engage in "swap-like" contracts with the country where they commit to provide resources in exchange for receiving a promise to a stream of payments if development arrives. But specialists themselves are subject to shocks that limit their ability to commit to deliver resources. These shocks trigger a period of significantly reduced capital inflows (i.e., risk-off scenarios). The beginning of this period is the sudden stop itself, when specialists are unable to rollover all their explicit or implicit short-term commitments, but it can continue even after specialists recover, as countries have to rebuild their international collateral.

The country would like to insulate its current account financing from these sudden stops, but it cannot do so with its specialists since they are constrained during these events. Resorting to the world capital markets after the sudden stop takes place does not work either, since the country has very limited credibility with non-specialists.

Nevertheless, world capital markets can still be used ex-ante, as long as contracts and investments are made contingent on variables that do not require emerging markets' knowledge.

Caballero and Panageas assume a central bank's objective that has the following form:

$$\max_{R_0,\pi} -\frac{\alpha}{2}E[\left(R_1 - K - 1\{SS\}Z\right)^2]$$

where R_1 denotes total reserves at date 1, $K \geq 0$ is a target level of reserves at date 1, and $1\{SS\}Z$ is a term composed of two terms: an indicator function $1\{SS\}$, that becomes 1 during a sudden stop $\{SS\}$ and is 0 otherwise, and a constant $Z > 0$, that controls the need for funds during the sudden stop.

They solve this problem subject to:

$$R_0 = \pi P_0 + B_0$$

$$R_1 = B_1 + \pi P_1$$

where R_0 is the initial level of reserves, π is the amount of risky securities held by the central bank, P_0 is the price of such securities, P_1 is the (stochastic) payoff of these assets at t=1, and B_0 is the amount of uncontingent bonds held by the central bank, whose interest rate is fixed to 0 for simplicity, so that $B_1 = B_0$ and $R_1 = R_0 + \pi(P_1 - P_0)$

They show that the first order conditions with respect to R_0 and π yield:

$$R_0 = K + \Pr(SS)Z$$

$$\pi = Z\frac{Cov(1\{SS\}, P_1)}{Var(P_1)}$$

Based on these conditions, they discuss three different solutions that are of special interest for central banks:

1. No Hedging:
   The first alternative assumes a no-hedging ($\pi = 0$) decision, which is not far from what central banks do in practice. With no hedging $B_0 = R_0 = K + \Pr(SS)Z$ and, therefore, the possibility of a sudden stop induces the country to hold reserves beyond the target level K.
2. Arrow-Debreu Securities:
   The second alternative is the opposite one. Assuming there were perfect Arrow-Debreu securities[2] (and fair pricing), and/or contracts could be written contingent on the sudden stop events, then perfect hedging would be possible and, therefore, in the special case where $K = 0$ (corresponding to the case where the country finds it optimal to hold no reserves in the absence of sudden stops) a central bank would be induced to invest 100% of its reserve assets in such Arrow-Debreu securities.

[2] An Arrow-Debreu security is an asset that pays:
1 if $SS = 1$.
0 if $SS = 0$.

3. The intermediate case:

   The third alternative is an intermediate one. In reality, as one neither observes Arrow-Debreu securities nor does observe contracts written contingent on the sudden stop (at least in an amount sufficient to insulate the country from it), Caballero and Panageas propose that a proxy hedging, through contracts that are correlated with sudden stops, but not perfectly, could function as good substitutes for the idealized Arrow-Debreu securities (paying 1 when some proxy event happens, and zero otherwise). One of such proxy events found by these authors is the jump of the VIX index,[3] which they show that has a strong correlation with the incidence of sudden stops.

The framework we present in this paper goes in the direction of proxy hedging strategies, seeking to enhance the country's immunization from external shocks through the strategic asset allocation of its central bank. Indeed, central banks could use their strategic asset allocation to enhance the transfer of reserves to sudden stop scenarios, which are those scenarios when reserves are needed the most.

Following the model proposed in Gintschel and Scherer (2008), we consider the volatility of the reserves portfolio in a risk-expanded dimension, where the reserves portfolio fluctuates due to the changes in the market value of the financial assets (traditional scope) but also as a result of external shocks. As a result, we include in the construction of the efficient frontier the risk-reduction benefits of those investment strategies that are negatively correlated with the main external shocks and/or vulnerabilities of the country.

Gintschel and Scherer (2008) show that choosing a portfolio along the efficient frontier, which is typically viewed as the key task in asset allocation, is relatively unimportant compared to the hedge decision. Their work is an example of how risk stemming from nonfinancial assets can be hedged, at least partially, through financial assets. The key is exploiting the correlation between financial and non-financial assets to reduce the overall risk of the portfolio, compared to an allocation that considers only the correlation structure of the financial assets.

The framework we propose uses a synthetic asset to emulate the main shocks that could impact the reserves´ portfolio. Rather than looking at strategies that could generate large payoffs but could also be exposed to some important challenges in terms of cost, size, and the credit risk of such payoffs,[4] it seeks to enhance the risk management framework of the sovereign balance sheet, which can help countries to

[3] The Cboe Volatility Index® (VIX® Index) is considered by many to be the world's premier barometer of equity market volatility. The VIX Index is based on real-time prices of options on the S&P 500® Index (SPX) and is designed to reflect investors' consensus view of future (30-day) expected stock market volatility. The VIX Index is often referred to as the market's "fear gauge" (for further references see http://www.cboe.com/products/vix-index-volatility).

[4] Large payoffs could be challenging for any private insurer and would be triggered during the most unwelcomed scenarios for such insurers, increasing the risks of having further disruptions if such payoff creates a liquidity problem in an insurer that is a systemically important institution.

avoid “wrong-way risks”[5] in their strategic asset allocation of large reserve portfolios and reduce the probability of having “procyclical behaviors”.[6]

3 The Framework Proposed

Reserve assets are usually the first line of defense for those countries that try to smooth the impact of external shocks in the domestic consumption. Foreign exchange intervention is quite common in emerging market countries, especially in those scenarios with high market volatility. Moreover, central banks typically provide explicit or implicit financial support to large financial institutions in the case of serious deposit runs, illiquidity, or insolvency.

Therefore, external shocks are usually impacting the reserves portfolio. As shown in Fig. 1, even if a central bank would be investing 100% of its reserves portfolio in US dollar banknotes to avoid any exposure to market or credit risks (drift = 0), it would end up having a stochastic process and volatility in the reserves portfolio as a result of the foreign exchange intervention and/or other operations performed to safeguard financial stability.

The framework we propose expands the definition of reserves portfolio volatility to include the impact of external shocks and thus to include in the portfolio analysis the correlation between the reserves portfolio and such shocks. As shown in Fig. 1, we propose a strategic asset allocation decision that is based both on the expected returns and risk of the financial assets portfolio, and on the hedging properties and risk-mitigating benefits that some financial assets may have in those scenarios when reserves are most needed.

The impact of external shocks is included through an index that emulates the most common sources of external vulnerability. Figure 2, e.g., shows the index we constructed for Argentina with data from December 1998 to December 2018, where the two most common sources of external vulnerability are real terms of trade and financial shocks.

These shocks are quantified in a time series of cumulative wealth shocks by constructing a synthetic asset. The construction of this synthetic asset shock follows four consecutive steps[7]:

i. The selection of the indices that represent the most common external shocks
ii. Quantify the size and impact of these shocks

[5] Wrong-way risk is defined by the International Swaps and Derivatives Association (ISDA) as the risk that occurs when "exposure to a counterparty is adversely correlated with the credit quality of that counterparty". In short, it arises when default risk and credit exposure increase together. In this paper we use “wrong-way risk” in a different way. We use it to define such scenarios where the risk of a drop in the market value of the reserves’ portfolio increase when reserves are more needed, i.e. when the marginal utility of an extra unit of reserves increases significantly.

[6] Pihlman and van der Hoorn (2010) show the procyclical behavior in central bank reserve management during the 2007–2008 global financial crisis.

[7] See Annex 1.

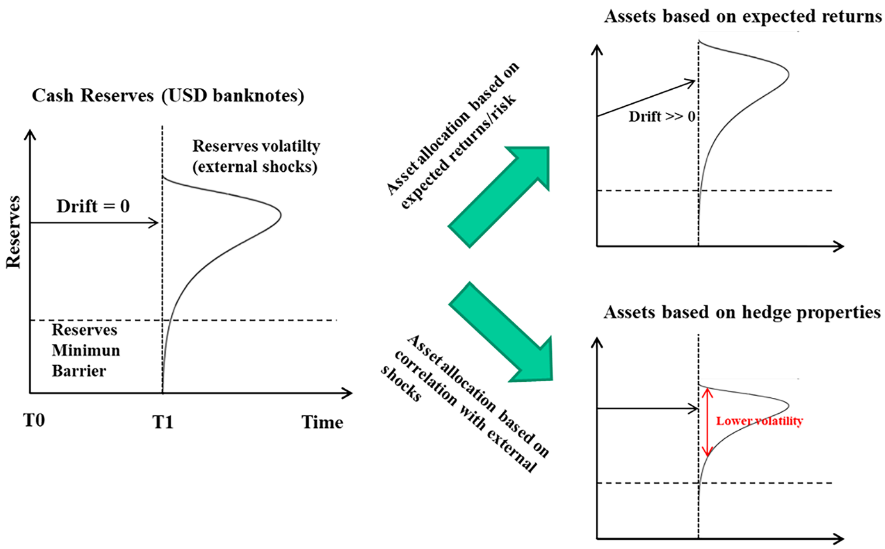

Fig. 1 Reserves' stochastic processes and asset allocation drivers

iii. Normalize shocks by the size of reserves, to convert shocks into "returns" on an asset

iv. Construct an index based on the compounding of asset "returns", which is then detrended to have an expected return of zero for this synthetic asset shock (to focus only on the correlation of this synthetic asset with the portfolio of financial assets).

This synthetic asset is then incorporated into an optimization framework similar to the one proposed in Gintschel and Scherer (2008). In this case, the aim is to minimize the variance of a reserves portfolio $Var(r)$ by allocating an omega ω proportion to a synthetic asset and the remaining $(1-\omega)$ to a portfolio of financial assets whose weights are described by the vector w:

$$min\ Var(r) = \omega^2\sigma^2_{Act.Sint.} + (1-\omega)^2 w^T\Sigma w + 2\omega(1-\omega)\sigma^2_{Act.Sint.} w^T\ \beta$$

The variance to be minimized is composed of a first term that reflects the volatility of the synthetic asset, a second term that reflects the volatility of the financial assets portfolio $w^T\Sigma w$ and a third term $2\omega(1-\omega)\sigma^2_{Act.Sint.} w^T\beta$ that reflects the correlation between the synthetic asset and the portfolio of financial assets. The term β contains the sensitivities of each financial asset in relation to the synthetic asset. The omega ω proportion of this synthetic asset is chosen to be 50%,[8] since we implicitly

[8] The choice of this value (50%) of omega ω (or the scaling of the volatility of the synthetic asset) does not significantly affect the conclusions of what type of assets to avoid or include in the optimization of the portfolio. Since the volatility of the synthetic asset is much higher than the volatility of the financial assets included in the optimization, the attempt to obtain the maximum negative covariance (second term) dominates the traditional portfolio optimization (the third component of the equation is the portfolio variance). Since risk tolerance is also controlled through a Conditional Value-at-Risk limit and short sales are not allowed, the CVaR limit dominates the portfolio's allocation to hedging assets.

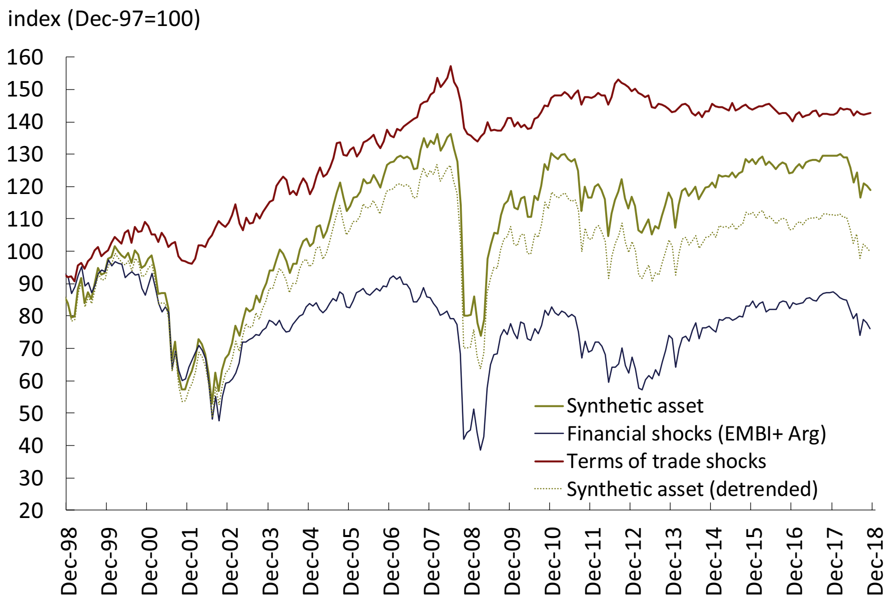

Fig. 2 Synthetic Asset (cumulative external shocks for Argentina). Source: Sturzenegger (2018)

invest an amount equivalent to the foreign exchange reserves invested in an asset that has the shocks modeled as returns.

In the framework we implement, the problem is solved subject to the following restrictions:

$$1^T w = 1$$

$$E(r_i)^T w = \mu$$

$$w_i \geq 0 \; \forall w_i$$

$$CVaR_{95\%}\left(r^T w\right) < CVaR_{limit95\%}$$

That is, the optimization must comply that the sum of the weights assigned to each asset add up to 100%, that the assets have a non-negative weight (short sales are not allowed), that the financial assets have the expected return (μ) that has been projected based on its risk factors, and that the changes in the market value of the financial assets portfolio do not exceed a certain threshold set in terms of its Conditional Value-at-Risk (*CVaR*).[9]

[9] In our experience, these represent the typical constraints that can be found in central bank asset allocation models. Short selling, for example, could be theoretically interesting to model in this case, but it is not allowed in most central banks.

These restrictions highlight two important components that are worth mentioning:

1. Expected returns are estimated based on the projection of risk factors.
2. The eligible portfolios of financial assets are limited to those that comply the market risk tolerance of said portfolios.

Setting a limit in terms of the market risk of such portfolio is a very important element of this framework, since it allows the central bank to keep the volatility of its balance sheet under control.

In fact, central banks usually prefer to focus on their own balance sheet, trying to avoid headline or reputational risks. Even if there are assets (i.e., long-term US Treasuries) that perform well when reserves are most needed, and could be attractive to increase yield and reserve portfolio drift, the market volatility of such financial assets could sometimes be too large for those central banks that prefer not to be exposed to negative returns in short term periods (e.g. during some fiscal year).

Although a market risk limit allows this framework to be implemented without overlooking such concerns, there is a trade-off with the immunization provided. The lower a central bank's tolerance for volatility in its reserves portfolio, the lower the hedge provided to external shocks. Therefore, the higher the market risk limit, the higher the probability of constructing an efficient frontier that is not very different from the one derived from traditional optimizations. Nevertheless, as we will show in the next section, even an optimization run under very strict limits is better than running an optimization without taking into account the correlations between the portfolio of financial assets and external shocks.

4 Implementation in Practice: Traditional Optimization vs Hedging Against Shocks

When implementing a framework as the already described, there are several features that can be analyzed to understand the benefits of enhancing the traditional optimization analysis through the inclusion of external shocks.

In this section we present a practical implementation of this framework for emerging markets in Latin America (Latam). We use an "asset shock index" (ASI) where real terms-of-trade and financial shocks for Latam countries are emulated through the change in the JPMorgan EMBI + Latam Index and the change in an exports-weighted Latam index constructed with the Citi Terms-of-Trade Index for each country.

Although this ASI is slightly different than the synthetic asset we have defined for Argentina, this general example helps to present our main findings without being exposed to the idiosyncratic part of a country. In addition, we use the Black-Litterman reverse optimization framework with no views[10] to show the results without being influenced by subjective or modeled expected returns.

[10] See, e.g., Black and Litterman (1990).

As a first step, we will start by analyzing the correlation between the ASI and different indices in the ICE BofAML Index universe to draw conclusions about the convenience of using this type of analysis to incorporate certain features into the portfolio in terms of currencies, duration, credit ratings and asset classes. We will then show the proposed changes in the optimal asset allocation that are driven by the inclusion of external shocks and how these changes are impacted when market-risk limits are introduced to control balance-sheet concerns.[11]

4.1 Main features to consider when hedging against shocks

4.1.1 Currency Risk

The currency composition of central bank reserves has shown for the last thirty years a dominant role of the US dollar, representing more than 60% of central bank reserves.[12]

Although there is no common framework among central banks to define the currency composition of a reserves portfolio, in most emerging markets it is generally found that Latin and Central American countries typically tend to invest mainly in US dollars, whereas central banks of economies highly integrated with the Eurozone tend to hold most of their reserves in euro-denominated assets (Invesco 2019).

This currency composition shows not only the dominant role of the major reserve currencies, but also how central banks structure their reserves portfolio. Lu and Wang (2019) describe that most central banks usually follow a portfolio optimization strategy where they create a “liquidity tranche" portfolio and an “investment portfolio”. The “liquidity tranche” is designed to finance the day-to-day FX needs (which are mostly in US dollar for most emerging markets), and the “investment portfolio” pursues the highest return subject to risk constraints. As a result, the larger the relative size of the liquidity tranche, the more important the effect of some balance of payments components to define the currency composition of the reserves portfolio. Conversely, the larger the relative size of the investment tranche, the larger the effect of reserve currencies’ expected returns on the currency composition of FX reserves.

This probably helps to explain why the strong accumulation of reserves in recent years (i.e. the increase of the investment portfolios) lead to a widening in the landscape of the reserves’ currency composition to new alternative currencies such as the Aussie (AUD), the Canadian dollar (CAD), the Korean won (KRW), Scandies (NOK, SEK, DKK) and, more recently, the Renminbi (RMB); usually seen as vehicles to increase the “diversification” of the reserves’ portfolio.

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[11] Annex 2 lists the indices included in the analysis. This universe includes data from thirteen countries, in five different horizon groups, and for different asset classes and credit ratings. We use monthly data from December 1998 to December 2018.

[12] See IMF, Currency Composition of Official Foreign Exchange Reserves (COFER).

Nevertheless, from a risk management perspective, it is more important to understand how "diversification" works in relation to a country's own macroeconomic risk factors rather than diversifying the correlation among currency returns, as this can help central banks to mitigate some risk factors at a country level or, at least, to avoid doubling up. Figure 3, for example, shows a dendrogram similar to the one proposed by Invesco (2019) to group currencies that tend to move in tandem and with other factors such as region, commodities, or "flight to safety" during periods of increased financial market volatility.[13]

Not surprisingly, when we look at a group of indices corresponding to government bonds with maturities from 1 to 10 years, we can clearly identify the risk factors that traditional optimizations can miss by focusing only on the diversification of currency returns without considering the covariance with external shocks. Figure 4 shows that since Latam countries tend to have a large exposure to commodity prices, government bond indices exposed to commodity currencies such as the Australian or Canadian dollar tend to show a strong and positive correlation with the ASI, meaning that if they were included in the investment portfolio, they would only intensify the impact of external shocks on the reserves portfolio when reserves are most needed.

However, it is also very interesting to note that when Australian or Canadian government bonds are fully hedged to the US dollar, they become negatively correlated to the ASI and, in some cases they can even show a more negative correlation than US Treasuries, as a sharp drop in commodity prices reduces growth prospects in commodity exposed countries, increasing the likelihood of monetary policy easing, pushing yields lower and thus causing an increase in the price of these government bonds. Therefore, when looking to diversify external risk exposure, some currencies hedged to the US dollar could even work better than clean currency exposure.

Currency analysis covers only one dimension of the decision. The duration decision is another dimension in which the benefits of this analysis can also be assessed.

4.1.2 Duration Risk

In traditional mean–variance optimizations, the duration decision in fixed income portfolios primarily balances the trade-off between higher expected return and higher volatility of such expected return (i.e., a higher return-at-risk). Therefore, under the traditional approach, the volatility of financial assets causes a loss of utility.

[13] Invesco (2019) points out that *"…since the emerging market crisis of 1997–98, EM currencies have tended to move in tandem across countries with distinctly different macro-economic fundamentals. This correlation spiked during the EM crisis of 1997–98, which emerged in East Asia and spread across EM countries through what was tagged as "financial contagion." During the decade of central bank quantitative easing, the correlation amongst EM currencies increased further as the Federal Reserve artificially suppressed interest rates and caused the market to trade in a "risk on/risk off" pattern. This is clearly evident in 2013 when the Federal Reserve announced the tapering of its USD bond purchases during the so-called "taper tantrum" and global investors sold "risk assets" including EM debt. Whilst the correlation of EM currencies increased during quantitative easing, nevertheless the market appears to be better discerning differences amongst countries than was the case in 1997–98. The "financial contagion" during the East Asia crisis of 1997, is less notable in subsequent country crises as, for example, Turkey in 2001 and Argentina in 2001…".*

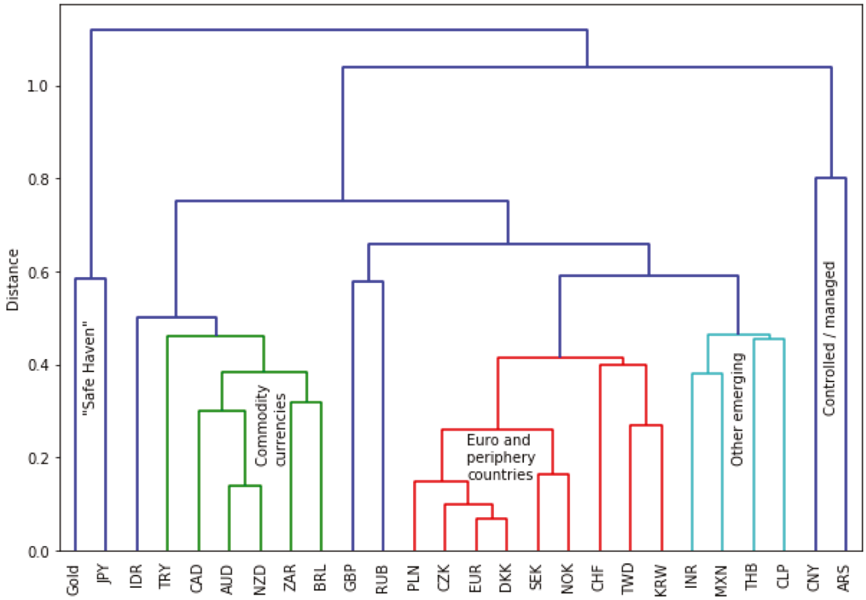


Fig. 3 Currency Clusters and Underlying Risk Factors. Source: author's construction based on Invesco (2019) and Bloomberg data. Distance = 1 – correlation versus USD (period 2006–2018)

Central banks that are generally very risk-averse investors and set "safety" and "liquidity" as primary objectives for the investment of their reserves, when constructing their efficient frontier, they often try to get the highest return to the point where they are confident that the risk of having negative returns during some time horizon (e.g., the fiscal year) is under control.

Only more recently and as a result of the accumulation of FX reserves and the growth of their "investment portfolios", central banks started to be more focused in obtaining higher returns, increasing the duration of their portfolios as a way to achieve this goal.

Although the scenario of low yield and term premium of recent years had not been adequately compensating for taking more duration risk, when hedging properties against external shocks are introduced in the optimization process, the benefits of having a higher duration clearly help central banks to find their compensation.

Indeed, Botte (2020) notes that developed market sovereign bonds are arguably the most canonical example of safe-haven assets. They tend to rally in risk-off scenarios. The longer the duration, the higher the gain, which occurs concurrently when reserves are most needed.

The covariance between the ASI and external shocks clearly shows this extremely important feature that is usually overlooked in traditional optimizations: the most efficient hedge per money invested. Similar results are seen in the covariance between the ASI and the larger government bond market indices.

Covariance Matrix

Assets\Term	Currency	Unhedged				100% Hedged to USD			
		1-3 yr	3-5 yr	5-7 yr	7-10 yr	1-3 yr	3-5 yr	5-7 yr	7-10 yr
United States	USD	-0.0006	-0.0013	-0.0016	-0.0020	-			
Germany	EUR	0.0023	0.0018	0.0014	0.0009	-0.0004	-0.0009	-0.0013	-0.0017
France	EUR	0.0023	0.0018	0.0014	0.0011	-0.0004	-0.0008	-0.0012	-0.0015
Italy	EUR	0.0021	0.0017	0.0014	0.0011	-0.0004	-0.0008	-0.0011	-0.0014
Spain	EUR	0.0020	0.0015	0.0012	0.0009	-0.0005	-0.0010	-0.0014	-0.0017
Japan	JPY	0.0020	0.0017	0.0014	0.0011	-0.00003	-0.0003	-0.0006	-0.0010
United Kingdom	GBP	0.0029	0.0024	0.0019	0.0016	-0.0005	-0.0010	-0.0015	-0.0018
Canada	CAD	0.0067	0.0063	0.0062	0.0060	-0.0003	-0.0006	-0.0008	-0.0010
Australia	AUD	0.0085	0.0076	0.0071	0.0067	-0.0008	-0.0016	-0.0022	-0.0026
Sweden	SEK	0.0052	0.0046	0.0052	0.0038	-0.0002	-0.0008	-0.0009	-0.0016
Switzerland	CHF	0.0009	0.0005	0.0001	-0.0003	-0.0004	-0.0008	-0.0011	-0.0016
India	INR	0.0031	0.0028	0.0028	0.0022	-0.0002	-0.0006	-0.0006	-0.0012
China	CNY	-0.0011	-0.0015	-0.0015	-0.0019	-0.0004	-0.0008	-0.0009	-0.0013

Correlation Matrix

Assets\Term	Currency	Unhedged				100% Hedged to USD			
		1-3 yr	3-5 yr	5-7 yr	7-10 yr	1-3 yr	3-5 yr	5-7 yr	7-10 yr
United States	USD	-0.42	-0.40	-0.38	-0.38	-			
Germany	EUR	0.21	0.16	0.12	0.08	-0.31	-0.33	-0.35	-0.35
France	EUR	0.21	0.16	0.13	0.10	-0.26	-0.29	-0.31	-0.30
Italy	EUR	0.18	0.14	0.11	0.09	-0.20	-0.19	-0.20	-0.20
Spain	EUR	0.18	0.13	0.09	0.07	-0.24	-0.27	-0.26	-0.26
Japan	JPY	0.18	0.16	0.13	0.10	-0.05	-0.27	-0.33	-0.34
United Kingdom	GBP	0.32	0.27	0.21	0.17	-0.30	-0.34	-0.37	-0.34
Canada	CAD	0.76	0.72	0.69	0.65	-0.23	-0.28	-0.26	-0.23
Australia	AUD	0.63	0.58	0.55	0.51	-0.51	-0.54	-0.51	-0.46
Sweden	SEK	0.41	0.37	0.58	0.30	-0.15	-0.27	-0.28	-0.31
Switzerland	CHF	0.09	0.05	0.01	-0.03	-0.36	-0.36	-0.35	-0.36
India	INR	0.47	0.38	0.34	0.25	-0.10	-0.17	-0.14	-0.21
China	CNY	-0.31	-0.37	-0.35	-0.35	-0.25	-0.28	-0.24	-0.25

Fig. 4 Covariance/Correlation between the Asset Shock Index (ASI) and ICE BofAML Government Bond Indices. Source: author's calculations based on Bloomberg data

It is important to note that when the definition of risk is expanded to include the volatility caused by external shocks, a higher volatility in the financial assets portfolio may no longer represent a loss of utility, as this higher volatility includes changes that are offsetting the impact of negative shocks.

Therefore, the duration analysis under this framework shows that when central banks increase the duration of their portfolios, they are contributing to obtain a higher return (when the term-premium is positive) but also to better hedge their macroeconomic risks in risk-off scenarios.

4.1.3 Asset Classes and Credit Risk

HSBC (2019) notes that reserve managers have always remained very committed to government bonds, the mainstay of reserve management. They have also typically added other asset classes to their portfolios: deposits and money market instruments in their "liquidity portfolio", and agencies, supras, mortgage-backed-securities, and corporates (i.e., spread products) in their "investment portfolio".

Figure 5 shows the results of a recent survey. Almost all central banks currently invest in government bonds, and most also invest in agencies, deposits, and gold. It also shows that some 84% of central banks have added a new asset class to their reserves portfolio in recent years, with corporate bonds being the most popular, followed by emerging-market bonds, mortgage-backed securities, exchange-traded funds (ETFs), equities, and inflation-linked bonds.[14]

When analyzing asset classes, some important conclusions can also be drawn by considering hedging properties against external shocks.

First, Fig. 6 shows that US inflation-linked bonds (US TIPS), which have been regarded as good diversifiers for any reserve portfolio, are even more correlated to the ASI than US Corporate bonds, which means that they could increase the procyclicality of the reserves portfolio in Latam countries. The rationale behind this is very simple: the change in commodity prices usually goes hand in hand with the change in US inflation and thus the relative performance of US TIPS.

Second, for assets with a similar duration, US Treasuries are the asset class that diversifies the risk of external shocks the most, ahead of US Corporates, US Agencies, US Supras, and other spread products. This is consistent with the procyclicality usually observed in credit spreads, meaning that adding too many spread products will also add procyclicality to the reserves portfolio, which does not help to construct the kind of countercyclical portfolio that should be constructed to enhance the management of macroeconomic risks.

Third, credit ratings are also impacting the procyclicality of the reserves portfolio. Figure 6 shows that the lower the rating, the higher the covariance with the ASI. This is consistent with the fact that risk-off scenarios and financial shocks usually affect the funding of low-rated companies.[15] Therefore, if reserve managers were investing reserves in low-rated companies, they would be adding a part of the financing risk of those low-rated companies, which face challenges in risk-off scenarios, increasing the risk of their reserves portfolio when reserves are most needed.

4.2 Implementation Results for Latam Countries

All the features presented in the previous section are examples of how portfolios that may be optimal for traditional asset-only investors, may be sub-optimal when

[14] See HSBC (2019), p.39 and 41.

[15] This is also consistent with the Merton model where the same shock applied to the value of a highly-levered enterprise results in a more than proportional increase in default probabilities.

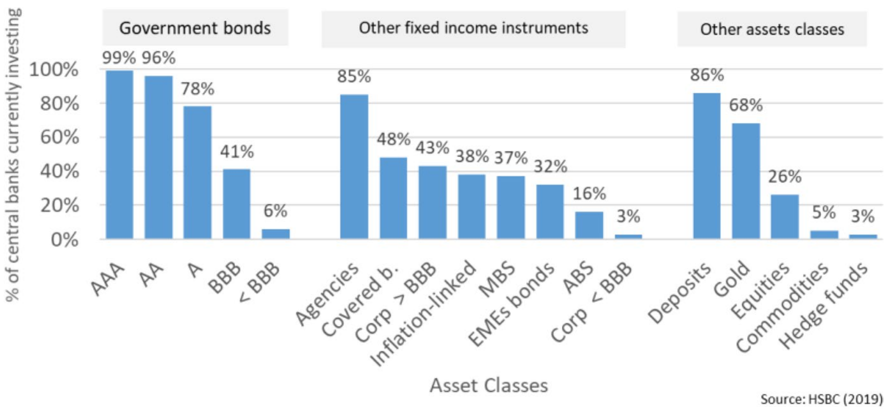


Fig. 5 Asset allocation in central bank's reserves management

the definition of risk is expanded to include the volatility in the reserves portfolio caused by external shocks.

Under traditional mean–variance optimizations, the efficient frontier is constructed by selecting the lowest balance sheet reserves' volatility per unit of expected return. When the definition of risk is expanded to include the volatility in the reserves portfolio caused by external shocks, we introduce the possibility of using financial assets for two different purposes: to hedge the financial risk stemming from another financial asset but also to act as a hedge against macroeconomic risks and vulnerabilities of the national balance sheet.

The inclusion of the hedging decision in the strategic asset allocation can drastically change the optimal composition of the efficient frontier.

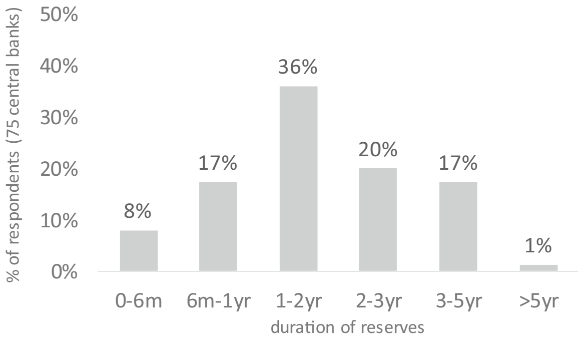
The most important change we found is in the dimension of duration risk. Under the traditional optimizations of fixed income portfolios, the minimum variance portfolio and other low volatility portfolios are predominantly composed of short duration strategies, which is fully consistent with the average duration that we usually find in the reserves portfolios of the central banks, where short-duration strategies predominate over long-duration ones.

	Correlation with ASI			
Asset Class	1-3 yr	3-5 yr	5-7 yr	7-10 yr
US Treasuries	-0.42	-0.40	-0.38	-0.38
US Agency	-0.34	-0.29	-0.26	-0.22
US Corp AAA	0.00	-0.02	-0.01	-0.01
US Corp AA	0.09	0.07	0.13	0.13
US Corp A	0.34	0.27	0.27	0.24
US Corp BBB	0.40	0.37	0.41	0.40
US Supras AAA	-0.19	-0.10	0.00	0.05
US MBS	-0.03	-0.10	-0.07	-0.39
US TIPS	0.61	0.46	0.35	0.28

	Covariance with ASI			
Asset Class	1-3 yr	3-5 yr	5-7 yr	7-10 yr
US Treasuries	-0.0006	-0.0013	-0.0016	-0.0020
US Agency	-0.0005	-0.0008	-0.0010	-0.0011
US Corp AAA	0.0000	-0.0001	0.0000	0.0000
US Corp AA	0.0002	0.0003	0.0007	0.0009
US Corp A	0.0011	0.0013	0.0018	0.0018
US Corp BBB	0.0016	0.0021	0.0031	0.0034
US Supras AAA	-0.0003	-0.0003	0.0000	0.0003
US MBS	-0.0001	-0.0002	-0.0002	-0.0013
US TIPS	0.0014	0.0016	0.0016	0.0017

Fig. 6 Covariance/Correlation between the Asset Shock Index (ASI) and different asset classes. Source: author's calculations based on Bloomberg data

Fig. 7 Duration of the Reserves' portfolio



In fact, for highly risk-averse investors, such as central banks, it is often very difficult to find significant exposures to long duration strategies. HSBC (2019) shows that, indeed, more than 80% of central banks are currently investing in portfolios with an average duration under 3 years (Fig. 7).

However, when the risk dimension is expanded to include the risk of external shocks, there is an important shift in the optimal duration of the reserves portfolio. Long duration strategies start to play a key role in hedging external shocks and the optimal composition for the efficient frontier could be predominantly composed by them.

Figure 8 shows the results we obtained per duration bucket in the optimization problem presented before (using data from December 1998 to December 2018 and the Black-Litterman equilibrium returns). Under the traditional approach, since higher allocations to long-duration strategies generally cause higher volatility for the financial assets portfolio, the efficient portfolios are predominantly composed by short-duration strategies. However, when the risk dimension is expanded to include the risk of external shocks, the hedging properties of long-duration strategies dominate the asset allocation decision: the higher the allocation to these assets, the higher the hedge to external shocks, and the lower the volatility of the reserves portfolio.

Unfortunately one of the drawbacks from the central bank's balance sheet perspective is that these types of long-duration portfolios can lead to more volatile

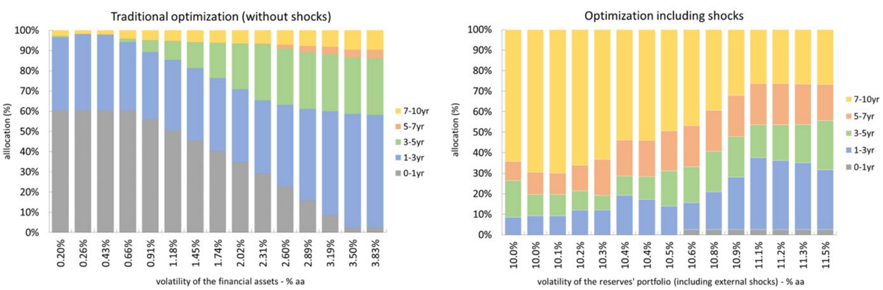


Fig. 8 Efficient portfolios per duration bucket. Source: author's calculations based on data from Bloomberg

balance sheets, if not controlled through market-risk limits. Another possible drawback could be in terms of liquidity, but the impact should not be significant as long-term US Treasuries, one of the most liquid fixed-income assets, will likely dominate the hedging decision. On the other hand, for those central banks looking for higher yields to reduce the cost of carrying foreign exchange reserves, this type of analysis can help them find their justification for increasing the duration of their portfolios, as this will also be consistent with hedging macroeconomic risks.

Regarding the currency composition of a reserves portfolio, Fig. 9 shows the results we obtained per currency bucket when including external shocks. It does have an impact, but mainly in the distribution between US dollar-denominated assets and other assets fully hedged to the US dollar.

Figure 9 also shows that, for Latam countries, the exposure to AUD and CAD suggested by a traditional currency return diversification approach, could even reach zero if shocks were included in the risk dimension (i.e., when underlying risk factors start to influence the asset allocation decision).

The different allocations proposed in the two risk dimensions clearly show that the frontier that is efficient to hedge external shocks may not be efficient in the traditional landscape where hedging properties are ignored and risk is only defined as the volatility of the financial assets portfolio.

Conversely, when the risk dimension is expanded to include the risk stemming from external shocks, the frontier that is efficient in the traditional landscape, may no longer be efficient in the expanded risk dimension.

Although there is a trade-off in the efficiency decision between the two different risk dimensions for low-volatility portfolios, we can see in Fig. 10 that efficient allocations in both risk dimensions tend to converge when we move towards those portfolios of financial assets with the higher volatility, as the investment universe for such high expected returns also tends to shrink.

4.3 Implementation Results with Market-Risk Limits

Central banks have always tried to avoid any reputational concerns. In fact, in surveys like HSBC (2019) it can be found that most central banks have been very reluctant to shift their reserves portfolio to long duration strategies, which have a higher

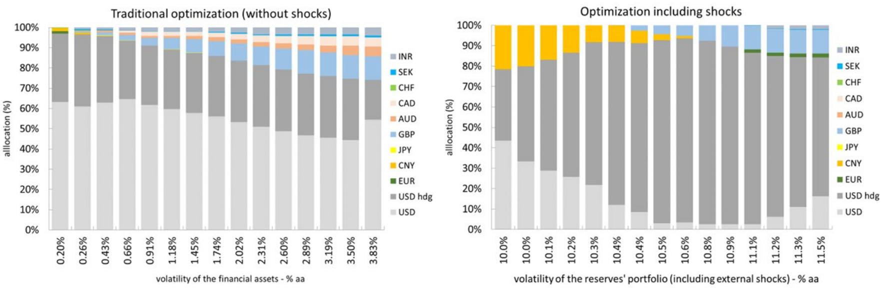


Fig. 9 Efficient portfolios per currency bucket. Source: author's calculations based on data from Bloomberg

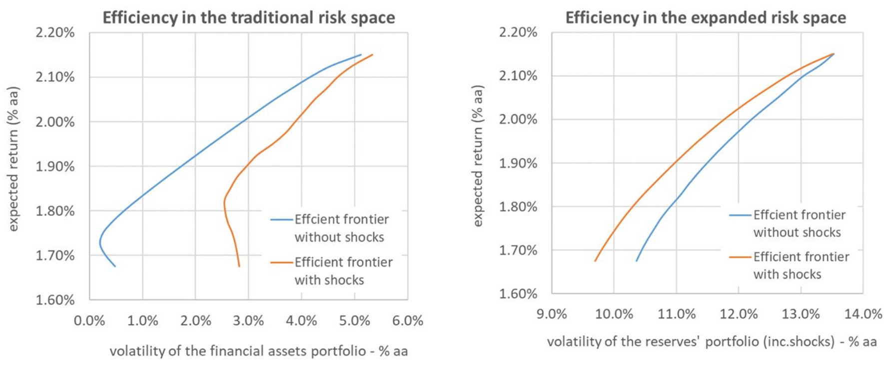


Fig. 10 Efficient frontiers in the different risk dimensions. Source: author's calculations based on data from Bloomberg

yield, but also a higher return-at-risk and can expose the central bank to negative returns.

In our experience, in order to deal with the reputational concerns arising from long duration strategies, some central banks use "Hold-to-Maturity" portfolios, other central banks try to enhance their communication strategy, while many central banks simply prefer not to be exposed to such financial risks.

The use of market-risk limits in the strategic asset allocation process (i.e. those limits placed in the volatility of the financial assets´portfolio) is a common practice that can help to control the volatility of the financial assets portfolio and, therefore, reputational concerns.

Although the use of market risk limits will shift the optimal asset allocation to a suboptimal one, in terms of hedging, it should be better to use these limits and enhance the risk management framework, rather than not considering the immunization provided at all.

When market-risks limits are included in the expanded risk dimension, the higher the limits, the lower the hedge provided to macroeconomic risks and the more similar the efficient allocation will be to the one proposed by the traditional mean–variance framework.

Figure 11 shows the results we obtained for the Latam countries in the minimum-variance portfolio with different market-risk limits. In the traditional approach without shocks (on the left), the efficient frontier suggests an allocation of 96% to 0-3 yr duration strategies. In contrast, if shocks without market-risk limits were included (on the right), the same exercise would suggest only an allocation of 9% to 0-3 yr duration strategies. Between the two, different allocations are suggested depending on the market-risk limit. For example, if shocks were included using a Conditional Value-at-Risk (CVaR) of 300 basis points, the optimal allocation to 0-3 yr duration strategies would increase to 25%. If the CVaR were limited to 100 basis points, the optimal allocation would shift to 50%.

In terms of the optimal currency composition, Fig. 11 shows that the traditional approach without shocks would recommend a 97% exposure to the US dollar for

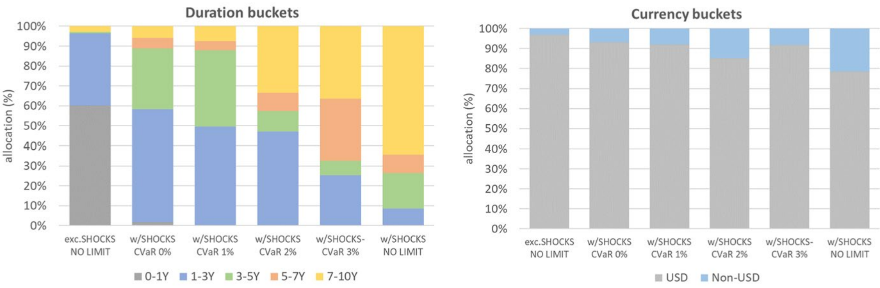


Fig. 11 Optimal allocation with different market-risk limits for minimum-variance portfolios. Source: author's calculations based on data from Bloomberg

those portfolios of minimum variance that use the US dollar as numeraire. The suggested exposure to the US dollar is reduced to 78% if shocks are included without market-risk limits. If shocks were included using a CVaR limit of 100 basis points, the optimal allocation to the US dollar would shift to 90%.

Therefore, even if the introduction of market-risk limits changes the optimal composition to a suboptimal one, where the hedge of macroeconomic risks is reduced, there are significant changes that could be introduced to enhance the risk management of the national balance sheet, especially in the duration dimension, if shocks are considered for strategic asset allocation.

5 Final Remarks

The introduction of external shocks in the analysis of strategic asset allocation leads us to draw some interesting conclusions.

First, it is valuable to include this type of analysis for central banks, as it is a way to better understand the underlying risk factors of the national balance sheet, preventing to duplicate the main vulnerabilities of each country but also having procyclical behaviors that only exacerbate the challenges that they face in risk-off scenarios (i.e., when reserves are most needed).

As Caballero and Panageas (2004) point out, prudent economies are generally forced to incur in a variety of costly precautionary measures in order to mitigate the risk of being impacted by a sudden-stop scenario. Since discretionary portfolio decisions affect the national risk profile, prudent economies should also seek to enhance the risk management of their national balance sheet.

In fact, even if reserves portfolios are tranched into two or more separate portfolios, long-term "investment portfolios" always function as a supplemental buffer to the short-term "liquidity" ones. Therefore, from a risk management perspective, the covariance between the portfolio of financial assets and those shocks that may trigger the probability of transfer funds from the long-term to the short-term portfolio should not be overlooked in the asset allocation decision. Between two financial assets with the same expected return and volatility, the optimizer should choose the asset that has the lowest correlation with the country's main vulnerabilities.

In this sense, there are always “right-way risks” that central banks can take when considering increasing the expected returns on their reserves portfolio. Higher duration risk, for example, goes in the right direction and including the volatility caused by external shocks in the reserves’ volatility risk dimension is key to helping central banks find their compensation for taking on higher duration risk, especially if there is a low yield and term-premium scenario.

The traditional optimization approach generally overlooks the underlying risk factors. There is no difference between advanced and emerging market countries for the strategic asset allocation framework when the efficient frontier is constructed from an “assets only” risk-return perspective. The same allocations are recommended to very different countries, with very different risk profiles and exposures on their national balance sheets. Just as there are currency clusters, there are many other risk factors that are relevant, especially for those countries more vulnerable to external shocks. These factors should play a role in the strategic asset allocation of the reserves portfolio.

Central banks are key players in safeguarding financial stability. They should always try to construct portfolios that are countercyclical or, at least, that are not prone to procyclical behavior that could exacerbate market volatility. The traditional optimization approach does not help to prevent procyclical behavior. The expanded risk dimension does.

The practical approach we show is just a work in progress trying to go in the right direction. There is no framework that gives to any central bank and/or investor the masterpiece to find the best portfolio for all kind of scenarios. Portfolios that perform well in some scenarios, will undoubtedly perform poorly in other scenarios. The hedging decision has, indeed, the intrinsic unintended result that when there is a positive shock to the national balance sheet (e.g., an increase in commodity prices for EMEs), there will be a countercyclical impact in the reserves portfolio, which will cause a poor performance or even a negative return.

However, it is under such scenarios that reserves are less needed and the marginal utility of an extra unit of reserves decreases. The major challenge for central banks is how they manage market expectations and the reputational risks that can arise from underperforming reserves portfolios.

One way we propose to manage these concerns is through the introduction of market-risk limits in the optimization process. As we show, even an implementation with market risk limits is better than having a framework with no shocks at all. Although the higher these limits are, the more similar the optimization will be to a traditional one, there is still a lot of information provided by this framework that is useful to avoid doubling-up risks.

Another way to manage these concerns is through a strong and clear communication policy. This is probably the best way to go, as the hedging provided to macroeconomic risks will not be sub-optimal, but it is certainly the most challenging, especially for those countries that have a closer scrutiny to changes in their reserves portfolio.

Annex 1 Steps in the Construction of the Synthetic Asset

i. The selection of the indices that represent the most common external shocks

The most common sources of external vulnerability for most emerging markets, including Argentina, are typically terms of trade and financial shocks. In this paper we show an index constructed using for terms of trade shocks the Citibank's Terms of Trade indices and for financial shocks the changes in the JPMorgan's EMBI+ spread indices. For Argentina we use Citibank's Terms of Trade Index for Argentina (Bloomberg ticker CTOTARS Index) and the EMBI+ Argentina (Bloomberg ticker JPSSEMAR Index). For Latam we use a GDP-weighted average for Citibank's Terms of Trade Index of the same countries that are included in the EMBI+ Latam (Bloomberg ticker JPSSGDCA Index).[16]

ii. Quantify the size and impact of these shocks

The size of term of trade shocks are quantified through the impact of changes in the terms of trade index in 12 months of exports. For the financial shocks, we consider the change in the EMBI+ indices in relation to the size of each country's debt in foreign currency:

$$Shock_t = ToTPctChg_t * Exports12M_T - SpreadChg_t * ForeignDenominatedDebt_T$$

Although we tested several alternatives to quantify the size and impact of these shocks, while the volatility of the shock index changed the correlation matrix with the portfolio of financial assets did not change significantly, nor the asset weights in risk constrained portfolios. Furthermore, as both shocks tend to correlate between each other, the relative importance of each factor is less important.

iii. Normalize shocks by the size of reserves

$$ShockPctChg_t = \frac{Shock_t}{ForeignExchangeReserves_T}$$

Note: in our estimations, the scale of the shock does not have a significant impact in the asset allocation decision. However, for numerical computation reasons it is better to scale them similarly.

iv. Construct a detrended index

The index is constructed by setting the value at 100 one month before the start of the data and calculating the cumulative product of (1+ShockPctChg).

$$AssetShockIndex_t = 100 * \prod_{j=1}^{t}(1 + ShockPctChg_j)$$

While some shocks may behave as mean reverting processes, we prefer to model shocks as random walks. We also detrend the index to avoid having positive (or negative) expected returns in the asset shock index.

[16] Argentina, Brazil, Uruguay, Paraguay, Dominican Republic, El Salvador, Chile, Colombia, Ecuador, México, Panamá, Perú, Venezuela.

Annex 2 Bank of America-Merrill Lycnh Indices Included in the Analysis

Country=US

Ticker	Index
G1O2	ICE BofAML 1-3 Year US Treasury Index
G2O2	ICE BofAML 3-5 Year US Treasury Index
G3O2	ICE BofAML 5-7 Year US Treasury Index
G4O2	ICE BofAML 7-10 Year US Treasury Index
G1P0	ICE BofAML 1-3 Year US Agency Index
G2P0	ICE BofAML 3-5 Year US Agency Index
G3P0	ICE BofAML 5-7 Year US Agency Index
G4P0	ICE BofAML 7-10 Year US Agency Index
C1A1	ICE BofAML 1-3 Year AAA US Corporate Index
C2A1	ICE BofAML 3-5 Year AAA US Corporate Index
C3A1	ICE BofAML 5-7 Year AAA US Corporate Index
C4A1	ICE BofAML 7-10 Year AAA US Corporate Index
C1A2	ICE BofAML 1-3 Year AA US Corporate Index
C2A2	ICE BofAML 3-5 Year AA US Corporate Index
C3A2	ICE BofAML 5-7 Year AA US Corporate Index
C4A2	ICE BofAML 7-10 Year AA US Corporate Index
C1A3	ICE BofAML 1-3 Year Single-A US Corporate Index
C2A3	ICE BofAML 3-5 Year Single-A US Corporate Index
C3A3	ICE BofAML 5-7 Year Single-A US Corporate Index
C4A3	ICE BofAML 7-10 Year Single-A US Corporate Index
C1A4	ICE BofAML 1-3 Year BBB US Corporate Index
C2A4	ICE BofAML 3-5 Year BBB US Corporate Index
C3A4	ICE BofAML 5-7 Year BBB US Corporate Index
C4A4	ICE BofAML 7-10 Year BBB US Corporate Index
GS01	ICE BofAML 1-3 Year US Supranational Index
GS02	ICE BofAML 3-5 Year US Supranational Index
GS03	ICE BofAML 5-7 Year US Supranational Index
GS04	ICE BofAML 7-10 Year US Supranational Index
M1A0	ICE BofAML 0-3 Year US MBS Index
M2A0	ICE BofAML 3-5 Year US MBS Index
M3A0	ICE BofAML 5-7 Year US MBS Index
M4A0	ICE BofAML 7-10 Year US MBS Index
G1QI	ICE BofAML 1-3 Year US Inflation-Linked Treasury Index
G2QI	ICE BofAML 3-5 Year US Inflation-Linked Treasury Index
G3QI	ICE BofAML 5-7 Year US Inflation-Linked Treasury Index
G4QI	ICE BofAML 7-10 Year US Inflation-Linked Treasury Index

In the optimization, all the indices in currencies different than the US dollar were included unhedged and fully hedged to the US Dollar.

Other countries

Ticker	Index
G1T0	ICE BofAML 1-3 Year Australia Govt Index
G2T0	ICE BofAML 3-5 Year Australia Govt Index
G3T0	ICE BofAML 5-7 Year Australia Govt Index
G4T0	ICE BofAML 7-10 Year Australia Govt Index
G1C0	ICE BofAML 1-3 Year Canada Govt Index
G2C0	ICE BofAML 3-5 Year Canada Govt Index
G3C0	ICE BofAML 5-7 Year Canada Govt Index
G4C0	ICE BofAML 7-10 Year Canada Govt Index
G1CN	ICE BofAML 1-3 Year China Govt Index
G2CN	ICE BofAML 3-5 Year China Govt Index
G3CN	ICE BofAML 5-7 Year China Govt Index
G4CN	ICE BofAML 7-10 Year China Govt Index
G1F0	ICE BofAML 1-3 Year France Govt Index
G2F0	ICE BofAML 3-5 Year France Govt Index
G3F0	ICE BofAML 5-7 Year France Govt Index
G4F0	ICE BofAML 7-10 Year France Govt Index
G1D0	ICE BofAML 1-3 Year German Govt Index
G2D0	ICE BofAML 3-5 Year German Govt Index
G3D0	ICE BofAML 5-7 Year German Govt Index
G4D0	ICE BofAML 7-10 Year German Govt Index
G1IN	ICE BofAML 1-3 Year India Govt Index
G2IN	ICE BofAML 3-5 Year India Govt Index
G3IN	ICE BofAML 5-7 Year India Govt Index
G4IN	ICE BofAML 7-10 Year India Govt Index
G1I0	ICE BofAML 1-3 Year Italy Govt Index
G2I0	ICE BofAML 3-5 Year Italy Govt Index
G3I0	ICE BofAML 5-7 Year Italy Govt Index
G4I0	ICE BofAML 7-10 Year Italy Govt Index
G1Y0	ICE BofAML 1-3 Year Japan Govt Index
G2Y0	ICE BofAML 3-5 Year Japan Govt Index
G3Y0	ICE BofAML 5-7 Year Japan Govt Index
G4Y0	ICE BofAML 7-10 Year Japan Govt Index
G1E0	ICE BofAML 1-3 Year Spain Govt Index
G2E0	ICE BofAML 3-5 Year Spain Govt Index
G3E0	ICE BofAML 5-7 Year Spain Govt Index
G4E0	ICE BofAML 7-10 Year Spain Govt Index
G1W0	ICE BofAML 1-3 Year Sweden Govt Index
G2W0	ICE BofAML 3-5 Year Sweden Govt Index
G3W0	ICE BofAML 5-7 Year Sweden Govt Index
G4W0	ICE BofAML 7-10 Year Sweden Govt Index
G1S0	ICE BofAML 1-3 Year Switzerland Govt Index
G2S0	ICE BofAML 3-5 Year Switzerland Govt Index
G3S0	ICE BofAML 5-7 Year Switzerland Govt Index
G4S0	ICE BofAML 7-10 Year Switzerland Govt Index
G1L0	ICE BofAML 1-3 Year UK Gilt Index
G2L0	ICE BofAML 3-5 Year UK Gilt Index
G3L0	ICE BofAML 5-7 Year UK Gilt Index
G4L0	ICE BofAML 7-10 Year UK Gilt Index

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