Money Matters: Global Banks, Safe Assets and Monetary Autonomy*

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Abstract

I propose a theory where the demand for global safe assets plays a critical role in the occurrence of various types of monetary policy spillovers. Monetary shocks of a hegemon currency issuer country determine portfolio allocation of risk-averse global banks, international capital flows, and by this way (1) production, (2) aggregate risk and (3) optimal monetary policy within a non-hegemon economy. Because of general equilibrium effects, (4) non-hegemon's monetary policy responses indirectly affect global bank's incentives to hold hegemon's goverment debt –i.e. the global safe asset– as well as the hegemon country's welfare. This theory provides a novel framework that rationalizes and integrates various types of empirically documented monetary policy spillovers. Moreover, by shedding light on two-way spillovers, going both from the hegemon to the non-hegemon economy as well as the other way around, it also provides a headway on how to think about potential gains of monetary policy cooperation. Understanding how the international demand for safe assets affects the international transmission of shocks is important for understanding the optimal design of monetary policy in an open economy.

JEL Codes: E42, E44, E52, E63, F42, F44

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1 Introduction

Debates around non-traditional monetary policy transmission channels have been on the rise for the last three decades. Work as early as Gertler and Gilchrist (1993), Bernanke and Gertler (1995), Bernanke et al. (1999) as well as recent work from Gertler and Kiyotaki (2010) highlight that, by omitting banking and financial intermediaries in conventional monetary policy models, neoclassical transmission mechanisms have often overlooked the important relation between monetary policy, credit cycles and business cycles.

More recently, an important strand of this literature has highlighted 1) that monetary policy plays an important role in risk-taking behaviour of banks, with considerable consequences for aggregate macroeconomic risks (Borio and Zhu, 2012; Borio et al., 2019; Coimbra and Rey, 2017; Bruno and Shin, 2015); 2) that there exists a Global Financial Cycle, closely intertwined with the widespread use of the U.S. dollar as the hegemon global currency, that raises questions on international monetary policy autonomy as stated by traditional Mundellian arguments (Miranda-Agrippino and Rey, 2015; Gerko and Rey, 2017; Rey, 2015; Jordà et al., 2018; Rey, 2016); as well as 3) the fact that U.S. debt plays a special role in safe assets' provision that confers an 'exorbitant privilege' to their treasury bonds in the form of lower debt costs (Gourinchas and Rey, 2007; Gourinchas et al., 2010, 2012; Jiang et al., 2020a; Engel and Wu, 2022; Kekre and Lenel, 2020a). My paper explores the interaction of these three channels. As these phenomena may change the nature in which monetary policy transmission channels operate, it is of paramount importance to have a theoretical structure that can integrate these concerns.

The purpose of this paper is to address the issues raised by this emerging macro-finance evidence, studying how global funding needs by risk-averse global banks affect conventional knowledge on monetary policy transmission channels as well as its repercussions in open economies with free capital flows. To do so, I propose a simple theoretical model where the demand for global safe assets plays a central role in the dynamics of monetary policy spillovers. I call this the safety-appetite mechanism of transmission of monetary policy. The model highlights four results:

First, production spillovers of monetary policy: Monetary policy tightening by global currency issuers –referred as global monetary policy shocks– are associated with a decrease in global bank's incentives to create global loans. In a setting where loans are an essential element of production, negative credit shocks triggered by contractive global monetary shocks reduce production in other 'local' economies.

Second, risk-taking spillovers of monetary policy: Changes in loan allocations imply a rebalancing of banker's portfolio holdings between safe and risky assets. In this sense, monetary shocks also induce changes in aggregate risk. The model suggests that global monetary expansions increase portfolio risk and aggregate consumption volatility of agents internationally.

Third, responses of local monetary authorities to global monetary spillovers entail a trade-off between boosting production and reducing consumption volatility: Monetary authorities in 'local' countries may take actions that offset negative welfare effects of global monetary policy shocks. Following a global monetary policy contraction that reduces local production and aggregate welfare, local monetary authorities may respond by relaxing their monetary policy, increasing loan creation, production and aggregate welfare. However, as loans are risky, a rise in loan creation also generates increased local consumption volatility.

Fourth, monetary policy conditions alter the budget constraint of the monopolist issuer of global safe assets: Monetary policy determines global bank's portfolio allocation, and in this way, global safe asset demand. Global monetary policy contractions increase the demand for global safe assets, decreasing the price that global investors charge the safe asset issuer for its debt and increasing this agent's consumption. Local monetary policy expansions have the opposite effect, decreasing the demand for global safe assets as well as consumption levels of the global safe asset issuer. This last point may constitute a source of local monetary policy spillovers over the economy of the global safe asset issuer.

The contributions of this paper are threefold. First, it provides a rationalization for a commonly ignored mechanism by which monetary policy may be determining credit cycles as well as business cycles, namely safety appetite. It appears surprising to learn that monetary policy has been historically entwined with the effects of liquidity provision on risk perceptions of financial intermediaries (Warburg, 1930; Gorton, 1984; Miron, 1986; Gorton and Huang, 2006)[1], while only very recent work has focused on the possible consequences of this fact on business cycles dynamics.

[1]As a matter of fact, the Aldrich-Vreeland Act, which finally lead to the creation of the Federal Reserve and set the road for modern central banking way-of-doing-things, was a response to the 1907 panic that allowed banking associations –a primitive private-form of Federal Reserve Board– to increase previously banned note issuance in emergency situations, just when financial markets liquidity is low and risk perceptions intensify (Laughlin, 1908).

Second, it proposes a simple model that allows to rethink conventional Mundellian wisdom and the relation between capital flows and monetary policy autonomy. Traditional open economy macro arguments have consistently highlighted that floating exchange rates may be enough to isolate an open economy from foreign shocks, including international monetary policy shocks (Mundell, 1963; Fleming, 1962; Galí and Monacelli, 2005). Incorporating monetary policy effects over safe asset markets with risk-averse investors may raise questions on this widespread tenet, as recent empirical macro finance literature suggests.[2] Furthermore, this work places local monetary policy reactions to global monetary spillovers at the center of the discussion on monetary autonomy.

Third, this model re-addresses the policy debate regarding the desirability of international monetary policy cooperation as well as current discussions developed at the heart of the International Monetary Fund on the adequacy of an integrated policy framework for open economies (Basu et al., 2020). Under the presumption that exchange rate variation is empirically disconnected from traditional macroeconomic fundamentals (Meese and Rogoff, 1983) and that exchange rate flexibility is sufficient to isolate economies from foreign shocks, it arises as a natural conclusion that gains of monetary policy cooperation are negligible (Rogoff, 1985). In this model, the existence of both foreign and local monetary policy spillovers could lead to potential welfare benefits from international monetary policy cooperation, just as suggested by Keynes (1936), Caballero et al. (2015) and Ocampo (2017).

Model: The general equilibrium model here proposed depicts how monetary policy affects portfolio allocations of risk-averse global investors and gives rise to monetary policy spillovers in open economies. It features one local or non-hegemon economy where firms have working capital requirements that force them to use both local and foreign loans to pay for their factors of production,[3] as well as one foreign or hegemon economy that, lacking firms, gets all its consumption from credit services provided to the local economy. In this milieu, credit creation is at the core of production.

Global as well as local commercial banks supply local firms with the credit needed to pay for factors. Credit creation is a risky endeavour, as it requires banks to hold assets

[2] Gopinath et al. (2020) have addressed a different facet of the relation between foreign shocks isolation and floating exchange rates by studying how does dominant currency pricing in international trade affects the adjustment mechanism of the terms of trade highlighted by traditional open economy models.

[3] Recent work that integrates financial concerns to macro models through working capital requirements may be found in Borio et al. (2019), Hill and Perez–Reyna (2017) and Jiang et al. (2020a).

–namely equity holdings used as funding for loans– that are subject to an idiosyncratic shock to their value. I refer to these assets as risky bank equity holdings. As banks are risk-averse, they hedge this risk by buying safe debt from governments, which I refer to as safe assets. In this sense, banks choose their optimal portfolio holdings, between risky bank equity holdings and safe government debt purchases, by weighting expected returns with perceived risks associated with these assets. Monetary policy determines the funding cost of banks which, as a result of the implied loan pricing structure within the model, affects the returns on risky equity holdings. In the model, as monetary conditions tighten, funding costs rise and risky equity returns diminish, creating incentives for banks to reduce their risky bank equity holdings as well as loan creation while increasing their safe debt purchases. In turn, this entails a reduction both in production and in aggregate consumption volatility. This is the way in which the safety-appetite mechanism of transmission works.

While global monetary policy controls funding costs of global banks, local monetary policy controls funding costs of local banks. Global and local loan markets are segmented such that, due to imperfect substitution between these two sources of firm financing,[4] global loan shocks triggered by a global monetary tightening are able to reduce factor contracting by the local firm. This element is the key cornerstone underlying the existence of monetary spillovers of global currency issuers within the local economy.

In the previous setting, monetary policy conditions determine the demand of safe government debt. By modeling the debt issuance problem of the hegemon economy's treasury –which acts as a monopolist supplier of global safe assets–, this paper follows the work of Farhi and Maggiori (2017) and studies how does monetary policy affects what previous literature has called 'the exorbitant privilege'. The pompous term was originally devised by former French finance minister and president Valéry Giscard d'Estaing around the 1960s (Eichengreen, 2010), being used in recent times to identify the liquidity-safety premium enjoyed by the debt of countries that issue hegemon international currencies –in particular U.S. Tresuries' safety premium–. Within the model, the hegemon government enjoys a monopoly premium that changes with monetary policy conditions. In particular, monetary policy tightening increase the demand of global safe assets, reducing the price that investors –in this case, global banks– charge the hegemon government for its debt. This reduction in the cost of the hegemon's debt

[4] Sheng Shen (2019) places specialization in abilities to solve information asymmetries by global and local banks at the core of this segmentation.

generates a rise in its monopoly premium as well as its consumption.

Literature: Initially, this paper builds upon recent contributions on real monetary policy effects on funding costs of banks (Drechsler et al., 2017) and risk-premia[5]. In the framework here proposed, I suppose ex-ante that monetary policy has direct control over real funding costs of banks to see how changes in these costs alter the equilibrium risk-liquidity premia enjoyed by the hegemon government in the form of the exorbitant privilege. My approach is then very similar in spirit to recent work by Kekre and Lenel (2020a), where U.S. debt enjoys an inherent premium associated with its liquidity properties that changes with monetary policy shocks. The model framework hereby presented presupposes real effects of monetary policy, so that this work is also related to the traditional discussions on monetary neutrality originally set by Lucas (1972), Barro (1976) and Sargent and Wallace (1975), which are at the heart of monetary economics.

Secondly, it approaches a new set of macro models that study monetary policy effects on risk-taking behavior of financial intermediaries –the risk-taking channel of monetary policy–. There are two differences between the model here proposed and previous work on this research strand. 1) While previous work has mainly targeted monetary policy effects on risk-taking by financial intermediaries in closed economy settings (Borio and Zhu, 2012; Coimbra and Rey, 2017; Borio et al., 2019), this work extends the argument to open economies with free capital flows. 2) Within the less abundant literature that has studied this subject in open economies (Bruno and Shin, 2015), there are no theoretical papers that shed light on the mechanisms that underlie banks' international risk-taking.

Thirdly, it builds on a wide range of works highlighting the paramount importance of global currencies in trade and international denomination of debt,[6] which appears to be the reason underpinning the emergence of monetary policy spillovers (Rey, 2015), as well as the exorbitant privilege.[7] While extensive empirical research has been done on each individual issue, less theoretical work has been developed on the key elements that knit them together.

[5] Kekre and Lenel (2020b) study how premiums vary as nominal policy rates change heterogeneous marginal propensities of households to take risks. Lenel (2017) also establishes variations in the availability of safe assets that occur in episodes of non-conventional monetary policy as potential drivers risk-premia.

[6] See Gopinath (2015), Goldberg and Tille (2009), Gourinchas et al. (2019), Gourinchas (2019), Maggiori et al. (2019), Maggiori et al. (2020), and Gabaix and Maggiori (2015).

[7] See Gourinchas et al. (2010), Gourinchas and Rey (2007), Du et al. (2018), Krishnamurthy and Lustig (2019), Jiang et al. (2020b) and Farhi and Maggiori (2017).

Finally, the cornerstone mechanism here proposed draws on the latest works concerning the macroeconomic implications of safe asset shortages. Low supply of safe assets relative to their demand gives rise to risk premiums that alter the connection between monetary policy and economic activity (Caballero, 2006; Caballero et al., 2016; Gourinchas and Jeanne, 2012). Caballero and Farhi (2017) refer to this phenomenon as the Safety Trap. The model presented in this paper may be thought of as modeling an economy which is already at the Safety Trap. It is in this sense that monetary policy may affect safe asset holdings of investors as well as equilibrium safe return rates.

The recent papers of Gourinchas et al. (2020), Jiang et al. (2020a) and Kekre and Lenel (2020a) are the most closely related to this work, proposing a model where global investors are willing to pay currency and bond risk-premiums in order to explain how monetary policy may transmit internationally via safe asset markets. However, none of them address the possible interactions between global and local monetary policy as this paper does. As previously explained, the results of this paper suggest that, when responding to hegemon monetary policy spillovers, local monetary authorities face a trade-off between boosting production and reducing consumption volatility. Moreover, local monetary policy responses affect the hegemon's government welfare, which may be the source of potential benefits of monetary policy cooperation. To the best of my knowledge, this work is the first paper that includes this element as a theoretical possibility underlying the international financial architecture.

Outline: The rest of the paper will be organized as follows. Section 2 describes the model. Section 3 presents the main results. Section 4 concludes.

2 Model

The paper presents a general equilibrium two period model composed by a unique local firm with working capital constraints –so that the firm needs loans to pay for its factors of production–, global and local risk-averse bankers that supply loans to these firms, households that supply labor to firms and savings to banks in the form of deposits, and governments that issue safe debt. There is an idiosyncratic shock on equity value of banks, in such way that these agents will hedge themselves by buying safe assets to governments. By altering the returns on bank loans, monetary policy alters risk pricing of banks as well as their asset composition. Local economy variables and agents will be identified by h, while foreign ones will be identified by f.

2.1 Households

The representative local household is characterized by a representative worker with CRRA preferences that lives both periods. In the first period, this agent finances its purchases with labor income obtained by supplying labor hours to firms. One may think the first period as the moment in which this individual is young and can work. In the second period, he does not work but consumes the returns on its first period savings. Taking the previous analogy, one may think the second period as the moment when the representative worker is too old to work. There is only one financial instrument available for this agent to save for old-age, namely local banks deposits. The paper only models the behaviour of local households, while supposing that there exists a foreign household that elastically supplies deposits to global banks.

Denote the local household by superscript wh. Local household's problem may be written as follows

$$\begin{aligned} \max_{\{d_h, N\}} \quad & \mathcal{W}^{wh} = \left[\frac{{C_1^{wh}}^{1-\sigma}}{1-\sigma} + \rho \frac{{C_2^{wh}}^{1-\sigma}}{1-\sigma} - \phi \frac{N^{1+\eta}}{1+\eta} \right] \\ \text{s.t.} \quad & C_1^{wh} = WN - d_h \\ & C_2^{wh} = R_h^d d_h \end{aligned} \tag{2.1}$$

where $\mathcal{W}^{wh}$ denotes the welfare of worker w in local economy h, C_t^{wh} identifies this agent's consumption in period t, d_h local deposits, N local labor hours, W is the real wage per unit of labor and R_h^d is the real return on deposits. σ and η are consumption and labor substitution parameters that determine the curvature of the utility of consumption and the disutility of labor. ρ characterizes the discount factor while ϕ is a labor disutility parameter.

2.2 Firms

There is one unique standard representative local firm with Cobb-Douglas technology, that uses both capital and labor as inputs to produce. This firm pays for its factors of production upfront, in the first period of the economy. However, it receives its final produce only at the beginning of the second period. In this setting, working capital requirements arise such that the firm needs loans to pay for its factors of production. As will be clear when defining the concept of equilibrium used within the model, first period consumption goods come from banks' wealth endowments and from wholesale funding supply given by central banks.

The model assumes that each type of bank –local or global– only finances one specific factor of production. Concretely, local banks only finance the local factor –labor N– while global banks only finance the foreign factor –capital K–. This is assumption is equivalent to segmentation between global and local financial markets. In this model, I construct over an extreme case segmentation where neither local banks lend for the foreign factor, nor global banks lend for the local factor. In the real world, one may expect an intermediate scenario where there may be some substitution between local and global loans when financing either locally-produced factors or foreign-produced ones.

Denote the firm by superscript F. Firm's problem is

$$\begin{aligned} \max_{\{N,K\}} \quad & \Pi_2^F = F(K,N) - R_h^L W N - R_f^L K \\ \text{s.t.} \quad & F(K,N) = Z K^{\alpha} N^{1-\alpha} \end{aligned} \tag{2.2}$$

where Π_2^F indicates firm's profits received in the second period, K is capital, R_h^L denotes real return on local loans and R_f^L the real return on foreign loans. Z and α denote total factor productivity and capital share parameters. Local loans L_h demanded by the firm should be equal to total value of labor contracting WN, while total foreign loans L_f demanded by the firm should be equal to total value of capital contracting K.

2.3 Bankers

There exist two types of risk-averse commercial bankers, one local and one global, each of whom owns a bank that allows them to generate income. Each bank intermediates deposits. Global banks intermediate elastically supplied global deposits, while local banks intermediate deposits supplied by local households. Banks face regular leverage constraints[8] that force them to raise internal funds in order to get deposit funding.

Banks may also access wholesale money markets, that provide funding at a spread ψ from deposits. Global banks make use of global currency wholesale funding markets, while local banks use local currency wholesale funding markets. As in the case of deposits, wholesale funding is subject to capital requirements that limit the amount

[8] See Hill and Perez–Reyna (2016).

that these agents may borrow.

Finally, bankers face a shock that reduces the value of their equity holdings between period 1 and 2. As these agents are risk-averse, they hedge themselves against the shock by buying safe low-return assets to governments. The model assumes that global banks only consider foreign or hegemon government debt as safe, while local banks only consider non-hegemon or local government debt safe, and that the reason behind this preference lies in the currency of issuance of each debt. This is consistent with empirical evidence set by Maggiori et al. (2020), according to which local investors' security holdings are biased towards safe debt denominated in their own currency, while global investors are towards safe debt denominated in global currency.[9]

Each banker (local or global) is characterized by an agent with mean-variance preferences that obtains income from its asset purchases. When the economy begins, in period 1, these agents are endowed with wealth resources that they distribute between high-risk/high-yielding assets –namely equity capital destined to fund their banks – and low-risk/low-yielding government debt. Let subscript $j \in \{h, f\}$ denote domestic (h) and foreign (f) prices and quantities, and superscript $bj \in \{bh, bf\}$ denote domestic (bh) and foreign (bf) bankers. Bankers' problem may be written as

$$\begin{aligned} \max_{\{s_j, b_j\}} \quad & \mathcal{W}^{bj} = \mathrm{E}\left[C_2^{bj}\right] - \frac{\chi}{2}\mathrm{Var}\left[C_2^{bj}\right] \\ \text{s.t.} \quad & \omega = s_j + b_j \\ & \Lambda_{j,2} = \pi_j + R_j b_j - \Omega \delta s_j \\ & C_2^{bj} = \Lambda_{j,2} \end{aligned} \tag{2.3}$$

where $\mathcal{W}^{bj}$ denotes the welfare of the banker in economy j (b in j) and C_2^{bj} indicates this agent's consumption which takes place in period 2. First restriction indicates the budget constraint of bankers in period 1, where initial wealth endowments ω should be distributed between equity holdings s_j –directed to fund their banks– and government debt purchases b_j –where global (local) bankers only buy global (local) government debt–. $\Lambda_{j,2}$ is the real value of bankers' portfolio in the second period. π_j are the profits that the bankers obtain from their bank, R_j identifies the return rate that bankers

[9]Numerous work including Krishnamurthy and Vissing-Jorgensen (2012), Greenwood et al. (2015), as well as Nagel (2016) place high liquidity services of the hegemon government debt –the U.S.– in international financial markets at the center of this phenomenon. Borio et al. (2016) have also shown how post-2008 financial regulations that aim to improve global banks' foreign exchange exposures have put pressures on the demand of safe assets denominated in dollars, amplifying this currency denomination bias.

charge the government of each economy for their debt, Ω is a random dichotomic variable that assumes the value of 1 if the equity shock realizes, $\delta \in (0,1)$ is the loss of equity value in the case that the shock occurs, while χ is a risk-aversion parameter.

Bank profits π_j are determined by the following profit maximization problem

$$\begin{aligned} \max_{\{L_j,d_j,l_j\}} \ & \pi_j = R^L_j L_j - R^d_j d_j - R^d_j(1-\psi_j) l_j \\ \text{s.t.} \quad & L_j = d_j + l_j + s_j \\ & \frac{d_j}{s_j} \leq \lambda_1 \\ & \frac{l_j}{s_j} \leq \lambda_2. \end{aligned} \tag{2.4}$$

Bank profits π_j are equal to the net return on given loans L_j of price R^L_j, after subtracting funding costs of deposits d_j of price R^d_j, as well as costs of wholesale funding l_j of cost $R^d_j(1-\psi_j)$. The model supposes that that central banks act as deep-pocketed institutions that elastically supply all wholesale funding demanded by commercial banks at prevalent interest rates.[10] Variable $\psi_j \in (0,1)$ denotes the spread of deposits costs over wholesale funding costs, and will be assumed to be controlled directly by central banks. In particular, expansive global (local) monetary policy –or cheaper global (local) currency wholesale funding– will be associated with increases in the spread ψ_f (ψ_h).

First restriction in problem (2.4) indicates banks' balance sheet constraint, where loans should be financed either by deposits, by raising wholesale funds, or by raising internal funds s_j –equity holdings of banks–. Second restriction denotes the exogenous leverage constraint that limits the amount of deposits that banks may borrow from households. According to this constraint, the ratio between deposits and bank equity is capped at λ_1. Similarly, banks must fulfill capital requirements in order to access to wholesale funds. Capital requirements are identified by the third restriction, so that the ratio between wholesale funds and bank equity is capped at λ_2.

2.4 Governments

The paper supposes the existence of one foreign and one local government that issue public debt to banks in order to finance public expenditure. Their debt is safe. Gov-

[10] See Coimbra and Rey (2017).

ernments have a technology of public investments with fixed returns that determines their equilibrium consumption levels. Constructing on Farhi and Maggiori (2017), the exorbitant privilege is introduced as a monopoly rent of which the foreign or hegemon government enjoys as a monopolist issuer of global safe assets. This allows for a spread to appear between the marginal benefit and the cost of global safe debt issuance, that will in turn be modified as monetary policy conditions change.

Each government issues debt in period 1, allocating the entirety of raised funds to a public investment technology with fixed returns, that lasts 1 period to produce final output. Both governments receive the proceeds of their investments and consume in period 2. As before, let subscript $j \in \{h, f\}$ denote domestic (h) and foreign (f) prices and quantities, and superscript $gj \in \{gh, gf\}$ denote domestic (gh) and foreign (gf) governments. Governments' problem may be characterized as

$$\begin{aligned} \max_{\{b_j\}} \quad \mathcal{W}^{gj} &= C_2^{gj} \\ &= \mathcal{F}(b_j) - R_j(b_j) \cdot b_j \quad : \quad \mathcal{F}(b_j) = \gamma b_j \end{aligned} \tag{2.5}$$

where $\mathcal{W}^{gj}$ characterizes the welfare of the government of economy j (g in j), C_2^{gj} denotes this agent's consumption –which takes place in period 2–, $\mathcal{F}$ identifies public investment technology with constant return γ, b_j accounts for the level of public debt issuances of the government in j and $R_j(b_j)$ identifies the debt cost function for this agent. The local government is supposed to issue its debt on competitive markets, so that it will take debt costs R_h as given. By contrast, the foreign government is assumed to be a monopolist issuer of global safe debt such that it internalizes the effects of its debt issuance over its costs. In this sense, debt cost function $R_f(b_f)$ is equivalent to the inverse demand function of foreign public debt. Monopoly power will give rise to a monopoly-risk premium on foreign government's debt.

2.5 Equilibrium

Definition 1 presents the general concept of equilibrium used in this work.

Definition 1. Equilibrium: *Given exogenous monetary conditions set by central banks* $\psi = \{\psi_f, \psi_h\}$*, an equilibrium in this economy will be identified by allocations* $x^{wh} \equiv \{d_h^{wh}, N^{wh}\}$, $x^F \equiv \{K^F, N^F\}$, $x^{bj}(\psi) \equiv \{s_j^{bj}(\psi), b^{bj}(\psi), L_j^{bj}(\psi), d_j^{bj}(\psi), l_j^{bj}(\psi)\}$, $x^{gj} \equiv \{b_j^{gj}\}$*, and prices* $p \equiv \{W, R_h^d, R_f^d, R_h^L, R_f^L, R_h, R_f\}$ *such that*

1. *given p, x^{wh} is a solution to (2.1);*
2. *given p, x^{F} is a solution to (2.2);*
3. *given p, $x^{bj}(\psi)$ is a solution to (2.3) and (2.4) for each $j \in \{h, f\}$;*
4. *given p, x^{gj} is a solution to (2.5);*
5. *All markets clear:*
   (a) *labor: $N^{wh} = N^F$;*

   (b) *capital or global loans: $L_f^{bf}(\psi) = K^F$;*

   (c) *local loans: $L_h^{bh}(\psi) = WN$;*

   (d) *global deposits: $d_f^{bf}(\psi)$ (elastically supplied to global bankers);*

   (e) *local deposits: $d_h^{wh} = d_h^{bh}(\psi)$;*

   (f) *safe assets: $b_j^{gj} = b_j^{bj}(\psi)$ for each $j \in \{h, f\}$;*

   (g) *wholesale funding: $l_j^{bj}(\psi)$ for each $j \in \{h, f\}$ (elastically supplied to global and local banks);*

   (h) *goods:*

$$\begin{aligned} t = 1: \qquad \omega + l_h &= \left[\, C_1^{wh} + b_h + K \,\right] \\ &\quad - \left[\, \omega + l_f + d_f - b_f \,\right], \end{aligned}$$

$$\begin{aligned} t = 2: \qquad F(K, N) + \mathcal{F}(b_h) - \Omega \delta s_h &= \Big[\, C_2^{wh} + C_2^{bh} + C_2^{gh} + R_h^d (1 - \psi_h) l_h \,\Big] \\ &\quad + \Big[\, R_f^d d_f + C_2^{bf} + C_2^{gf} + R_f^d (1 - \psi_f) l_f - (\mathcal{F}(b_f) - \Omega \delta s_f) \,\Big]. \end{aligned}$$

In definition 1, left hand side of goods markets' clearing equations for both periods depict local supply of goods. In this first period, this amounts to local banker's wealth endowmens ω plus the wholesale funds given by the deep-pocketed central bank. In the second period, this amounts to the sum of private and public local production, less the loss in product in the case the shock Ω occurs. First term of the right hand side of both equations shows domestic absorption, while the second term shows the trade balance. In the first period, there are only imports as local firms need capital that can only be payed with foreign inflows. In the second period, outflows –or exports– are used to compensate foreign agents for their loan services. Appendix A demonstrates that general equilibrium in goods markets holds for both periods 1 and 2.

3 Results

This section presents the main results of the paper. First, I characterize the equilibrium to explain the economics behind the dynamics portrayed in the model: optimal asset allocation of banks, optimal debt issuance by governments and aggregate consumption volatility. Thereupon, I define monetary policy shocks and solve the model numerically to draw conclusions on general equilibrium.

3.1 Characterizing the Equilibrium

Optimal asset allocation: I proceed to characterize banks' optimal asset allocation. I will uniquely focus on the interesting case where $R_j^L > R_j^d$, in which case both leverage and capital requirements –constraints 2 and 3 in equation (2.4)– hold with equality as stated in lemma 1.

Lemma 1. *For banks to demand positive deposits and wholesale funds, it must happen that $R_j^L \geq R_j^d$. In the interesting case where $R_j^L > R_j^d$, both leverage and capital requirement constraints are binding.*

$$\frac{d_j}{s_j} = \lambda_1 \qquad \textit{and} \qquad \frac{l_j}{s_j} = \lambda_2.$$

Proof: See appendix B.

Using results from lemma 1, in conjunction with bank's balance sheet constraint and banks profits in equation (2.4), one may obtain expressions for L_j, d_j, l_j and π_j that only depend on bank capital s_j and prices, such that *bank* allocations –this is, demanded loans and wholesale funding, and supplied loans– are completely determined by *bankers* optimal risky equity allocation s_j.

$$d_j(s_j) = \lambda_1 s_j \tag{3.1}$$
$$l_j(s_j) = \lambda_2 s_j \tag{3.2}$$
$$L_j(s_j) = (1 + \lambda_1 + \lambda_2)s_j \tag{3.3}$$
$$\pi_j(s_j) = \left(R_j^L - R_j^d\right)\lambda_1 s_j + \left[R_j^L - R_j^d(1 - \psi_j)\right]\lambda_2 s_j + R_j^L s_j. \tag{3.4}$$

Note that loans L_j are increasing in the holdings of s_j, such that global/local loans will rise as risky global/local equity holdings by banks increase. In this sense, leverage constraints and capital requirements bind loan creation to equity allocations. This last assertion is formally stated in proposition 1.

Proposition 1. *Leverage and capital requirement constraints bind loan creation to internal-funding equity allocation of banks. Without constraints on funding sources, total loan levels would not be determined by internal-funding equity allocations, but on supply of external-funding of deposits and wholesale funds.*

Proof: See appendix C.

Proposition (1) highlights the importance that capital regulations play in determining asset allocation dynamics of investors, what will ultimately enhance the safety-appetite transmission mechanism presented in this work. In fact, this element has been a persistent feature in recent literature highlighting how changes in banking regulations after the Great Financial Crisis may have altered the nature of monetary policy transmission channels.[11]

By replacing equation (3.4) in the second constraint of banker's problem –equation (2.3)–, one may easily solve the maximization problem, obtaining the following optimality condition underlying bank's optimal asset allocation[12]

$$\pi_j{}'(s_j) = R_j + \delta \mathrm{E}(\Omega) + s_j \chi \delta^2 \mathrm{Var}(\Omega). \tag{3.5}$$

Left hand side of equation (3.5) corresponds to the marginal benefit that bankers earn by allocating an extra unit of equity capital into their banks, while right hand side identifies the marginal costs of these investments. The first term of the marginal cost corresponds to renounced returns of safe debt, the second one to the marginal expected loss of equity capital associated with an increase in risky equity holdings, while the third one corresponds to the increase in portfolio volatility caused by the increase in holdings of these risky assets.

Equation (3.5) depicts the trade-offs that bankers face when deciding how much equity to allocate as internal funding to their banks, while this ultimately determines equilibrium supply of global loans as stated by equation (3.3). Main intuition may be stated as follows: contractive monetary policy is associated with reductions in the

[11]See Borio and Zhu (2012) for a discussion on their role on the *risk-taking* channel. Fornaro and Romei (2019) discuss their effects on the eventual rise of liquidity-safety traps with recessionary effects, as suggested by Keynes (1936) original paradox of thrift.

[12]See appendix D for complete derivation of bankers' first order condition.

spread between deposit funding and wholesale funding ψ_j, so that the marginal benefit of equity investments $\pi_j{}'(s_j)$ decreases. This is evident by recalling that equation (3.4) decreases as ψ_j declines. Ceteris paribus, as the marginal benefit of equity investments falls, investors will prefer to allocate their wealth into safe assets of return R_j, which have no expected losses and are not associated with portfolio volatility. In the previous scenario, official liquidity costs set by global central banks ψ_f are a key determinant of risk pricing of global investors.[13]

Optimal safe asset issuance: Optimal safe asset issuance is determined by the market power of governments when issuing safe debt. The local government issues its debt in competitive debt markets, such that it takes debt costs as given. Hence, optimality condition for local debt issuance is

$$R_h = \gamma.$$

This comes from the fact that local government problem is linear in debt issuance b_h, such that the marginal cost of debt should equal marginal productivity of public investments. Recall that this condition results in fixed local government consumption (equal to zero).

$$\begin{aligned} C_2^{wh} &= \gamma\, b_h - R_h\, b_h \\ &= 0. \end{aligned} \tag{3.6}$$

By contrast, the foreign government will be a monopolist issuer of global safe debt such that it internalizes the effect of its debt issuance over the demand of safe assets and over debt costs. This gives rise to a monopoly-risk premium on foreign government debt. First order condition for this agent is then

$$\gamma \;=\; R_f{}'(b_f)\cdot b_f \;+\; R_f(b_f), \tag{3.7}$$

where left hand side of equation (3.7) is the marginal return that the foreign government obtains from its investments, while the right hand side denotes the marginal costs that this agent faces when deciding its optimal issuance. Note that there exists a spread

[13]This characteristic has been recently highlighted by Cohen et al. (2017), who suggest that the ability of market participants to raise global currency cash is a key determinant of their perceived risks. In this sense, by setting the cost of global liquidity in wholesale funding markets, hegemon currency issuers are in a convenient position to 'lean against the wind' of global financial markets safety perceptions, and in this way, influence risk-appetite and balance sheets of lenders internationally (Avdjiev et al., 2016).

equal to $R_f'(b_f) \cdot b_f$ between returns obtained by the hegemon government for its investments γ and the returns payed by the foreign government to global banks $R_f(b_f)$. This term is positive as it comes from the inverse demand for global safe assets. Recall that increases in the supply of an asset –in this case, government bonds– should be accompanied, ceteris paribus, by an increase in the return of that asset that foster investors to accept the excess supply.[14] The positive spread $R_f'(b_f) \cdot b_f$ characterizes then the monopoly-safety rent of the global safe asset issuer, namely the exorbitant privilege.

Aggregate Volatility: Let C_2^h be total consumption of the local economy's agents in period 2, C_2^h may be expressed as

$$\begin{aligned} C_2^h &= C_2^{wh} + C_2^{bh} + C_2^{gh} \\ &= R_h^d\, d_h + \Lambda_{h,2}, \end{aligned} \tag{3.8}$$

where local government consumption C_2^{gh} is equal to zero –see equation (3.6)–. Departing from equation (3.8), and recalling that there is no uncertainty on loans, deposits nor on local safe asset return rates $\{R_g^L, R_h^d, R_h\}$ one may define aggregate local consumption volatility as

$$\begin{aligned} \mathrm{Var}(C_2^h) &= \mathrm{Var}(\Lambda_{h,2}) \\ &= s_h^2\, \delta^2\, \theta\, (1-\theta). \end{aligned} \tag{3.9}$$

Local consumption volatility is then equal to local banker's portfolio volatility. This is in fact a consequence of the modeling strategy that assumes that all risk in the model is bore by banks. As basic economic intuition may suggest, aggregate volatility is positively correlated with the levels of risky equity holdings of local banks s_h.

3.2 Monetary Policy Shocks

In what follows, I proceed to present the numerical results of the paper, by analyzing how global and local monetary policy shocks affect the equilibrium of the model. Monetary policy determines the spread between deposit and wholesale funding, as stated in definition 2.

[14] It is possible to see this formally by finding the demand of global safe assets (from global banker's solution), isolating R_f and derivating with respect to asset issuance b_f.

Definition 2. Monetary Policy: *Monetary policy of hegemon currency issuers will set the spread ψ_f between global currency wholesale funding and global deposits funding. Global monetary expansions will be associated with increases in the spread ψ_f while contractions will cause reductions in this spread. Hegemon currency issuers will supply all wholesale funding demanded by global banks at prevalent prices. Monetary policy of local currency issuers will set the spread ψ_h between local currency wholesale funding and local deposits funding. Local monetary expansions will be associated with increases in the spread ψ_h while contractions will cause reductions in this spread. Local currency issuers will supply all wholesale funding demanded by local banks at prevalent prices.*

In definition 1, monetary policy conditions $\psi = \{\psi_f, \psi_h\}$ were defined as exogenous variables within the equilibrium. I start by analyzing the effect of a reduction in ψ_f, while leaving local monetary policy spread ψ_h fixed at an arbitrary level. I refer to this scenario as a global monetary contraction. I subsequently depart from the global monetary contraction scenario and characterize a stylized local monetary policy rule to study the effects of local monetary policy responses to global monetary contractions. I refer to this scenario as the optimal local monetary response. The global monetary contraction scenario may be thought of as a first stage within the timing of the model, and the local monetary response as a second stage. For the following exercises, I suppose Ω is Bernoulli-distributed with parameter $\theta = 0.5$. Table 1 shows predetermined parameters used in the numerical analysis.[15]

3.2.1 Global Monetary Policy Shocks

Figure 1 depicts the markets of the model before and after the contractive global monetary policy shock. Panel (a) identifies the direct effect of this shock over conceded loans by global banks. As global wholesale funding becomes more expensive, global loan supply drops causing a raise in global loan price R_f^L.

Panel (b) represents the indirect effects of global monetary policy over the local factor market –labor–. Labor demand diminishes due to complementarity between factors of production. Less capital contracted leads to excess capacity so that labor contracting is less appealing to firms. In general equilibrium, there will also be a

[15]In global monetary contraction exercise, $\psi_h = 0.5$, while ψ_f decreases from 0.5 to 0.3. For local monetary response exercise, ψ_f stays at 0.3 while ψ_h goes from 0.5 to it's optimal value, according to a stylized monetary policy rule presented in section 3.2.2. Interest rates on global deposits R_f^d should also be defined as a parameter. This is not problematic as the paper assumes that global deposits are supplied elastically at any deposit rate.

Table 1: Predetermined parameters

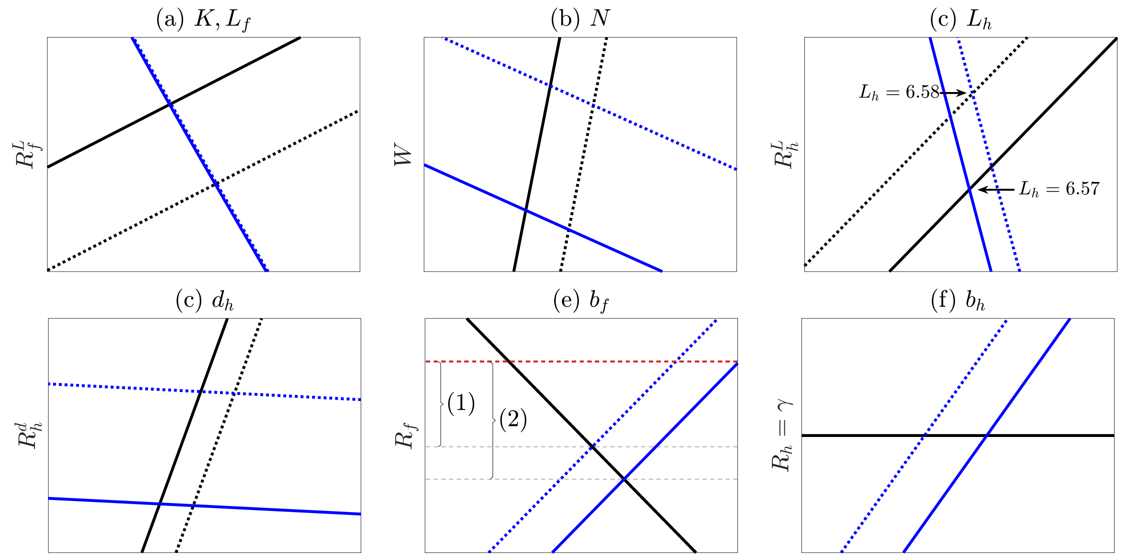
Parameter	Value	Description
ρ	0.995	Household discount factor
σ	0.7	Intertemporal consumption substitution parameter
η	1.1	Labor substitution parameter
ϕ	0.8	Labor disutility parameter
α	0.53	Capital participation
Z	4	Total factor productivity
χ	20	Banker's risk-aversion parameter
ω	1.2	Banker's initial wealth
δ	0.5	Equity loss in case of shock realization
θ	0.5	Bernoulli parameter of shock Ω
λ_1	6	Leverage requirements
λ_2	0.4	Capital requirements
γ	1.06	Public investment productivity
R_f^d	$1/\rho = 1.005$	Global deposits return rate

reduction in labor supply. In the aggregate, both effects generate a fall in effective labor contracted as well as in wages.

Panel (c) shows the local loans market before and after the shock. Local loans market acts as the payments counterpart to the labor market just explained above. As wages and labor levels fall, labor payments WN decrease and less local loans are demanded by firms. This is consistent with a left movement of the local loans demand that pushes local loans price R_h^L downwards. It also appears that, in equilibrium, local loans supply increases. This is in fact a consequence of the curvature of deposits demand function around selected equilibria. To see this, note that drops in local loans demand should also imply less funding needs by local banks, what entails less local deposits demand. As panel (d) shows, this results in a reduction in deposit costs R_h^d. To sum up, both loan returns and deposit funding costs decrease following the drop in labor demand. The fact that local loan supply in panel (c) increases after the global monetary policy shock suggests that, in equilibrium, marginal deposit costs are decreasing faster than marginal loan returns, what increases local banks incentives to create local loans. However, this minor particularity would not be fundamental to the main results of the paper. Thus, further discussion on the issue is sidelined.

Panel (e) illustrates global monetary policy effects over the global safe asset market/hegemon government debt market. The red dashed line identifies the value of the

Figure 1: Global monetary policy shock: Effects of contraction in funding spread ψ_f over markets



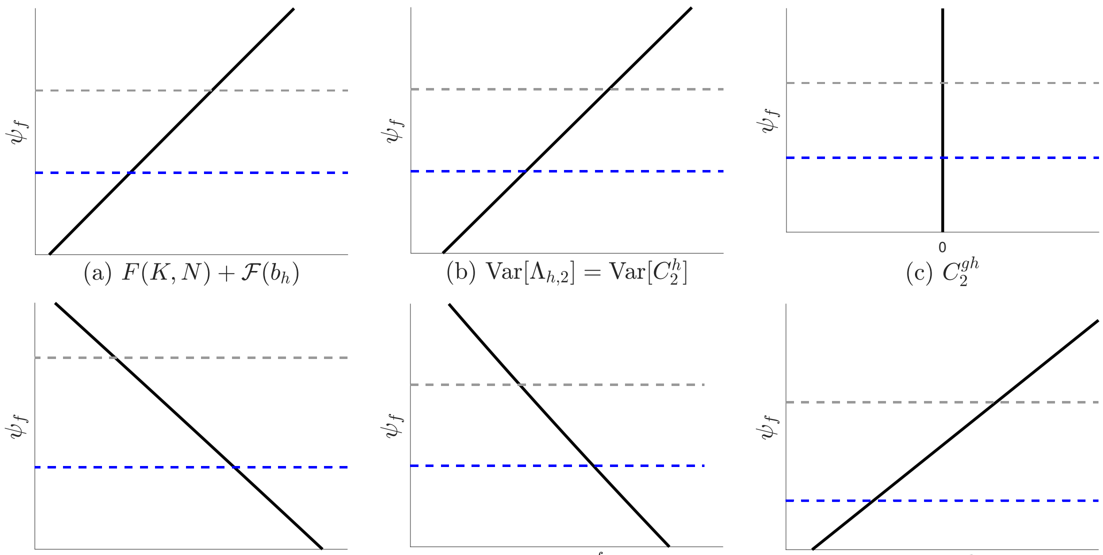
Note: Figure shows market plots. Black curves identify supplies. Blue curves identify demands. Dotted lines identify equilibrium before hegemon monetary shock while solid lines identify equilibrium after the shock. The red dashed line in panel (e) identifies public investment return γ.

fixed marginal return on public investments γ, while brackets (1) and (2) identify the premium of public investment returns over equilibrium debt costs for the foreign government –or the exorbitant privilege–, which widens as a result of the global monetary tightening. As will be seen in figure 2, this also leads to a rise in foreign government consumption levels. Global contractive monetary policy caused a reduction in risky global loan returns –recall equation (3.4)–, inducing global bankers to modify their portfolio holdings by increasing their purchases of safe assets and displacing the demand for this asset rightwards. After the global monetary shock, bankers are willing to accept higher holdings of safe hegemon debt, even if it comes at the price of lower returns on its debt.

Panel (f) shows the dynamic of the local safe asset market. Global monetary contractions causes an increase in this asset's demand. This the counterpart of the reduction in local loans due to the cutback of labor payments depicted in panels (b) and (c). Panel (f) also evidences the fact that local safe debt is elastically supplied at price $R_h = \gamma$. This the main difference between hegemon and non-hegemon processes of debt issuance, and is the main reason underlying the fact that foreign government consumption is positive (and dependent on monetary policy conditions) while local government consumption is always zero, independently of its debt issuance level.

Figure 2 illustrates equilibrium relations between global monetary policy levels and

Figure 2: Global monetary policy shock: Effects of contraction in funding spread ψ_f over interesting variables



(a) $F(K,N)+\mathcal{F}(b_h)$ (b) $\mathrm{Var}[\Lambda_{h,2}]=\mathrm{Var}[C_2^h]$ (c) C_2^{gh}

(d) f risk premium $=\gamma-R_f$ (e) C_2^{gf} (f) $\mathcal{W}^h$

Note: Black solid lines identify general equilibrium relations between referenced variables. Grey dashed lines identify global currency wholesale funding spread ψ_f before the shock while blue dashed lines identify the spread after the shock.

interest variables of the model, where the grey dashed lines indicate the funding spread ψ_f before the monetary shock while blue dashed lines indicate the value of this parameter after the shock. Panel (a) states that global monetary contractions cause a reduction in total local production, as less capital and less labor is contracted –as shown in panels (a) and (b) of figure 1–. These are the *production* spillovers of monetary policy of global currency issuers.

Panel (b) shows that these contractions are also associated with reductions in local banker's portfolio volatility. This comes from the fact that there is an increase in holdings of safe local debt –as shown in panel (f) of figure 1– with a corresponding reduction in risky local equity holdings by banks. From equation (3.9), local consumption volatility rises hand in hand with local banker's portfolio volatility. These are the *risk-taking* spillovers.

Panel (c) identifies local government's consumption as global monetary conditions change. As shown in equation (3.6), this agent's consumption is always constant and equal to zero, as the local government issues its debt in competitive local safe asset markets so that its debt costs always equal the returns obtained by reinvesting the debt in the public investment technology.

Panel (d) and (e) are extensions of what was shown in panel (e) of figure 1, portraying the way in which the exorbitant privilege and global monetary conditions interplay. As global monetary conditions tighten, the safety premium on hegemon's government debt as well as its consumption increase.

Finally, panel (f) shows the effect of global monetary policy contractions over aggregate welfare in the local economy $\mathcal{W}^h$. Intuitively, as global monetary conditions tighten and local production falls, so does available consumption goods for agents, thus reducing aggregate local welfare.

3.2.2 Local Monetary Policy Response

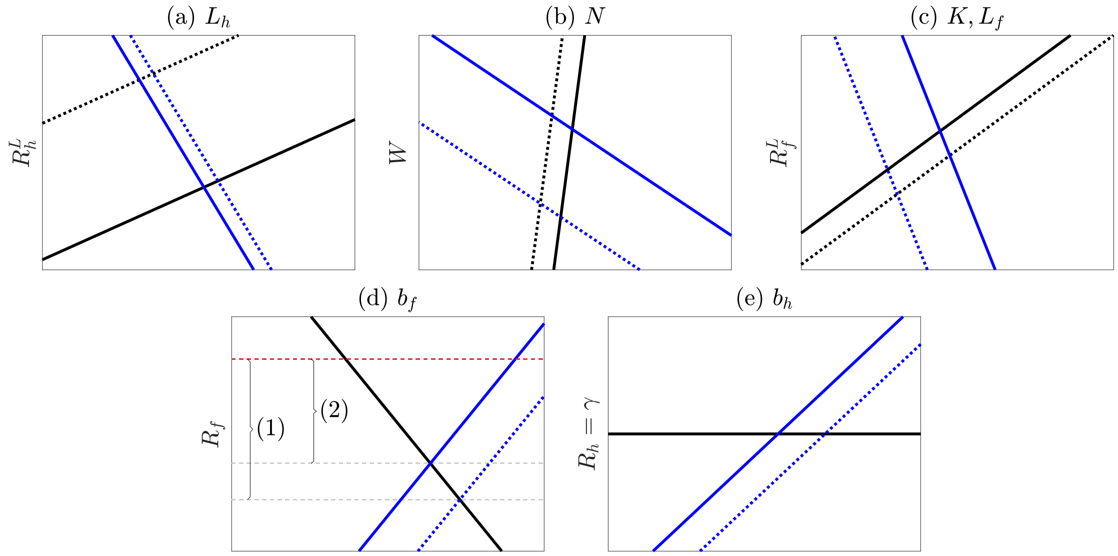
I proceed to define a stylized monetary policy rule under which local monetary authorities respond to global monetary policy contractions –that reduce local production and welfare– with local monetary expansions –that once again increase both local production and welfare–. This rule is introduced in definition 3. Then, I present numerical results when this monetary policy rule is included.

Definition 3. Local Monetary Policy Rule: *Let $\{\psi_f, \psi_h\}$ be the vector of exogenous prevalent monetary policy conditions, $\mathcal{W}^{wh}(\psi_f, \psi_h)$ local household's welfare, $\mathcal{W}^{bh}(\psi_f, \psi_h)$ local banker's welfare, $\mathcal{W}^{gh}(\psi_f, \psi_h)$ local government's welfare and $\mathcal{W}^h(\psi_f, \psi_h)$ the aggregate welfare of the local economy associated with monetary conditions $\{\psi_f, \psi_h\}$. Given an arbitrary state 0 with monetary policy conditions $\{\psi_{f0}, \psi_{h0}\}$, and a subsequent exogenous global monetary policy shock $\psi_{f1} \neq \psi_{f0}$, local monetary authorities will set local monetary conditions $\widetilde{\psi}_{h1}$ according to the following problem*

$$
\begin{aligned}
&\min_{\{\widetilde{\psi}_{h1}\}} \quad \left| \, \mathcal{W}^h(\psi_{f1}, \widetilde{\psi}_{h1}) - \mathcal{W}^h(\psi_{f0}, \psi_{h0}) \, \right| \\
&\textit{where} \quad \mathcal{W}^h(\psi_f, \psi_h) = \mathcal{W}^{wh}(\psi_f, \psi_h) + \mathcal{W}^{bh}(\psi_f, \psi_h) + \mathcal{W}^{gh}(\psi_f, \psi_h).
\end{aligned}
$$

Definition 3 states that the main objective of local monetary policy responses is to leave the welfare levels of the local economy at a fixed value of a given arbitrary initial state 0. As a matter of fact, this rule permits local monetary policy to fully counteract the effects of global monetary shocks over local welfare. That said, local monetary policy responses will have heterogeneous effects over the two elements that determine local aggregate welfare: production (that ultimately determines consumption levels) and consumption volatility. To see this, recall that total local welfare $\mathcal{W}^h$ is the sum

Figure 3: Local monetary policy shock: Effects over markets of local response to hegemon's spillovers



Note: Figure shows market plots. Black curves identify supplies. Blue curves identify demands. Dotted lines identify previous equilibrium after hegemon monetary contraction, while solid lines identify new equilibrium after non-hegemon monetary expansion that increases funding spread ψ_h (response). The red dashed line in panel (d) identifies public investment return γ.

of the welfare levels of local workers $\mathcal{W}^{wh}$, local bankers $\mathcal{W}^{bh}$ and the local government $\mathcal{W}^{gh}$

$$\mathcal{W}_h = \underbrace{C_1^{wh} + C_2^{wh}}_{\mathcal{W}^{wh}} + \underbrace{\mathrm{E}\left[C_2^{gh}\right] - \mathrm{Var}\left[C_2^{gh}\right]}_{\mathcal{W}^{bh}} - \underbrace{C_2^{gh}}_{\mathcal{W}^{gh}},$$

which finally depend both on consumption levels and on consumption volatility.

Following the simple monetary policy rule proposed in definition 3, I take the situation before the hegemon monetary policy shock as the benchmark state –state 0 in definition 3– and study how does the local monetary response to the hegemon monetary contraction affects the equilibrium.

The effect of monetary policy response over main markets of the model is shown in figure 3. Panel (a) and (b) identify the direct effect of local monetary responses over local loans and local factor markets. As local liquidity conditions relax, local loans supply rises and the price of local loans declines. This generates an increase in local factor demand –labor N– as cheaper local loans can be used to pay for labor services. In equilibrium, there are also both a small reduction in the loans demand curve triggered by higher salaries and an increase in labor supply due to labor substitution effects, which are not paramount in the model and thus, will be sidelined.

As happened with global monetary policy shocks, increases in labor contracting of one factor of production rise demand for the other factor due to complementarity. When labor contracting increases, firms seek to contract higher levels of capital, causing capital demand to shift to the right and driving global loans return rate up. This is shown in panel (c). In equilibrium, there is a small drop in global loan supply so that this curve is pushed to the left. This result will be sidelined as is not the main focus of the paper. However, it is possible to make an educated guess and affirm that this phenomenon is a result of the fact that not only global loan rates, but also global safe rates are rising. As safe rates increase, the opportunity cost of creating global loans is higher so that global loan supply shifts to the left.

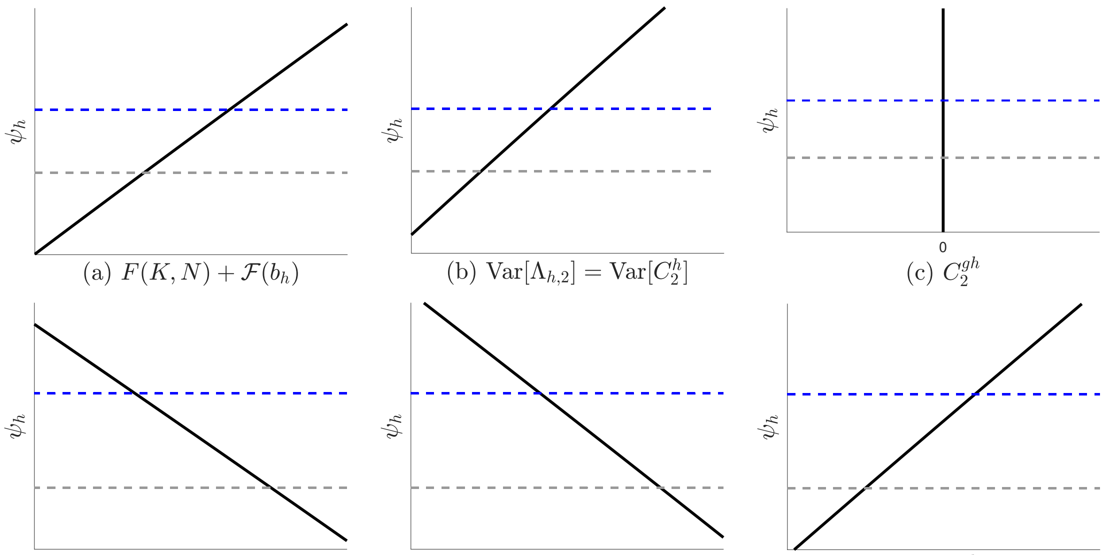
Panel (d) illustrates the way in which local monetary expansions affect global safe assets market equilibrium. As easier local liquidity conditions increase capital demand as well as its price, global banks are willing to divert funds from safe hegemon government debt to risky equity destined to create global loans. This reduces the demand of global safe assets, displacing its curve leftwards and rising the costs that the hegemon government should pay investors so that they are willing to accept holdings of its debt. This brings down the difference between the red dashed line –which as before identifies public investment return γ– and equilibrium debt cost, which is equivalent to a reduction in the exorbitant privilege.

Panel (e) identifies the effects of the shock over the local safe asset market. As local bank's funding costs decrease and its incentives to create local loans increase, equilibrium local safe debt levels decrease. This happens as local banks are only able to increase local loans as long as they increase their equity holdings, what entails a reduction their local goverment debt holdings. As previously discussed, the cost of local government debt R_h remains constant.

Figure 4 illustrates equilibrium relations between local monetary policy levels and interest variables of the model, where the grey dashed lines indicate the funding spread ψ_h before the monetary shock while blue dashed lines indicate the local response to the hegemon's monetary contraction.

Following panel (a), local monetary response increases production levels. As discussed at the beggining of this section, this is consistent with the idea that local monetary authorities use their policy rates to counteract hegemon's production spillovers. Panel (b) shows that production boosting comes at the cost of increased local banker's portfolio volatility and consumption volatility as higher local loans are accompanied by

Figure 4: Local monetary policy shock: Effects over interesting variables of local response to hegemon's spillovers



(a) $F(K, N) + \mathcal{F}(b_h)$ (b) $\text{Var}[\Lambda_{h,2}] = \text{Var}[C_2^h]$ (c) C_2^{gh}

(d) f risk premium $= \gamma - R_f$ (e) $C_{gf,2}$ (f) $\mathcal{W}^h$

Note: Black solid lines identify equilibrium relations between referenced variables. Grey dashed lines identify local currency wholesale funding spread ψ_h before the shock while blue dashed lines identify the spread after the shock.

an increase in risky local equity holdings by local banks. In this sense, the local monetary response leads to a trade-off between boosting local production and reducing local consumption volatility. In closed economy settings, a similar dilemma between output boosting and financial vulnerabilities has been recently highlighted both by the works of Coimbra and Rey (2017) and Borio et al. (2019). In open economy settings, this phenomenon may support the idea pointed out by Bordo and James (2017) whereby a new dimension should be added to the traditional Mundellian trilemma, namely financial stability. For this reason, even if local monetary policy is autonomous in the sense of independent setting of funding costs, it is not autonomous in the sense of foreign shock isolation, as formerly suggested by traditional Mundellian arguments[16].

Panel (c) shows the dynamics of local government consumption which, as already discussed, is fixed at zero. Panels (d) and (e) depict local monetary policy effects over the exorbitant privilege. Local monetary shocks are associated with a decrease in hegemon's debt demand, so that the cost on this agent's debt will increase. The counterpart of this would be a reduction in risk premium, that in turn reduces the for-

[16]See Mundell (1963) and Fleming (1962) for the traditional Mundellian interpretation of monetary autonomy in open economies and Galí and Monacelli (2005) for New Open Economy Models interpretation of Mundellian arguments.

eign government's monopoly/safety rent and its consumption levels. This last element highlights a possible source of local monetary spillovers over the hegemon's economy, and may underlie potential gains of international monetary cooperation, both for the local/non-hegemon economy and for the global/hegemon economy.

Finally, panel (f) exhibits local monetary policy response effects over local welfare. As local monetary conditions relax and production increases, aggregate local welfare rises too, returning to its initial levels before the hegemon monetary policy shock. This is in fact consistent with the way in which the local monetary policy rule presented in definition 3 works.

4 Conclusions

This paper develops a novel framework that integrates monetary policy spillovers in an open economy model through safe asset market dynamics, characterizing the way in which the *safety-appetite* mechanism of transmission of monetary policy operates internationally, as well as its repercussions on international monetary policy spillovers.

Monetary policy acts by changing the relation between risky asset returns and perceived risks, what alters portfolio decisions of risk-averse investors. In turn, this determines credit creation and factor contracting. Global currency funding needs by global banks confer a special role to the monetary policy of global currency issuers, so that monetary policy shocks of these authorities –referred as global monetary shocks– have repercussions over aggregate conceded loans by global banks. In a world with segmented local and foreign loan markets –i.e. with no perfect substitution between local and foreign loans–, where loans are an essential element of production, global loan shocks triggered by global monetary shocks have real effects over production. These are the *production* spillovers of monetary policy.

As global monetary shocks change portfolio composition of bankers, they also change the risks taken by these agents, what has consequences over aggregate risk. The repercussions over risk-taking of banks lie beyond countries' borders. These are the *risk-taking* spillovers of monetary policy.

The existence of international monetary spillovers drives local monetary policy to respond to foreign monetary shocks, what entails an inherent trade-off between increasing production and reducing consumption volatility. As global monetary conditions tighten, local welfare as well as local production declines leading local monetary authorities to run expansive monetary policy that increases welfare and production again by enhancing local loan creation. However, this will cause risky equity holdings of local agents –namely local banks– to increase, rising aggregate consumption volatility in the local economy.

Monetary conditions, both global and local, determine risk-averse investors' willingness to hold safe debt. In a setting where a particular government –the hegemon government– is a monopolist issuer of safe debt, changes in willingness to hold its debt modify its equilibrium levels of consumption, or its exorbitant privilege.

Finally, hegemon's monetary spillovers over local production and risk-taking, in tandem with local monetary spillovers over hegemon's government consumption, may give rise to potential welfare benefits associated with international monetary policy cooperation. Still, the rigorous characterization of the costs and gains of this proposal lie outside the scope of this work. Research strands on this particular area appear to be an attractive area of growing research (Agénor and Pereira da Silva, 2019; Matschke, 2020).

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Appendix

Appendix A Market Clearing in Goods Markets

Market clearing condition in period 1 implies

$$\underbrace{\omega + l_h}_{\text{domestic goods supply}} = \underbrace{C_1^{wh} + b_h + K}_{\text{domestic absorption}} - \underbrace{(\omega + l_f + d_f - b_f)}_{\text{net imports}}.$$

As there is no production in this period, resources come either from banker's wealth endowments ω, from local/global wholesale funding –funds which are provided elastically by central banks–, and from global deposits –provided elastically in the international capital markets–. Local aggregate supply equals local banker's wealth and local wholesale funding, as shown in the left hand side of the previous equation. Domestic absorption equals local household's goods purchases, local banker's safe asset purchases and capital. Governments and bankers only consume in the second period. All foreign resources that fund the local economy are grouped in the net imports term.

Replacing (3.1), (3.2), (3.3), the first period constraint of (2.1) and the first period constraint of (2.3) we get

$$\omega + \lambda_2 s_h = WN - d_h + \omega - s_h + (\lambda_1 + \lambda_2 + 1)\, s_f - \big[\, \omega + \lambda_2 s_f + \lambda_1 s_f - (\omega - s_f) \,\big]\,,$$

canceling terms

$$\lambda_2 s_h = WN - d_h - s_h.$$

Recall that equation (3.1) states that $d_h = \lambda_1 s_h$, such that one may reorganize the previous expression as

$$(1 + \lambda_2 + \lambda_1)\, s_h = WN,$$

where $WN = L_h$ as local loans are equal to total labor payments. Thus,

$$(1 + \lambda_2 + \lambda_1)\, s_h = L_h,$$

which is true[17], such that first period budget constraint holds.

[17] See equation (3.3).

For the second period, market clearing requires that

$$F(K,N)+\mathcal{F}(b_h)-\Omega\delta s_h=\Big[C_2^{wh}+C_2^{bh}+C_2^{gh}+R_h^d(1-\psi_h)l_h\Big]$$
$$+\Big[R_f^d d_f+C_2^{bf}+C_2^{gf}+R_f^d(1-\psi_f)l_f-(\mathcal{F}(b_f)-\Omega\delta s_f)\Big].$$

Local aggregate supply –left hand side– is equivalent to firms and local government production, less the local equity random shock. Domestic absorption –first term of right hand side– equals local workers', bankers' and government's consumption plus local wholesale funding payments. Net exports –second term of the right hand side– account for foreign demand for goods –the sum of payments to foreign deposits, global bankers' consumption, foreign goverment's consumption and payments for foreign wholesale funding– less foreign aggregate supply –which equals foreign government production less global equity random shock–. Replacing by firm's production function, household's second period constraint shown in (2.1), bankers' consumption/portfolio value shown in (2.3) and governments' production function shown in (2.5) we get

$$ZK^\alpha N^{1-\alpha}+\gamma b_h-\Omega\delta s_h=\left[\,R_h^d\,d_h+\pi_h+R_hb_h-\Omega\delta s_h+\gamma b_h-R_hb_h+R_h^d(1-\psi_h)l_h\,\right]$$
$$+\left[\,R_f^d d_f+\pi_f+R_fb_f-\Omega\delta s_f+\gamma b_f-R_fb_f+R_f^d(1-\psi_f)l_f-\gamma b_f+\Omega\delta s_f\,\right],$$

canceling terms

$$ZK^\alpha N^{1-\alpha}=\left[\,R_h^d\,d_h+\pi_h+R_h^d(1-\psi_h)l_h\,\right]$$
$$+\left[\,R_f^d d_f+\pi_f+R_f^d(1-\psi_f)l_f\,\right].$$

Replacing bank's benefits depicted in equation (3.4)

$$ZK^\alpha N^{1-\alpha}=\left[\,R_h^d\,d_h+\left(R_h^L-R_h^d\right)\lambda_1 s_h+\left(R_h^L-R_h^d(1-\psi_h)\right)\lambda_2 s_h+R_h^L s_h+R_h^d(1-\psi_h)l_h\,\right]$$
$$+\left[\,R_f^d d_f+\left(R_f^L-R_f^d\right)\lambda_1 s_f+\left(R_f^L-R_f^d(1-\psi_f)\right)\lambda_2 s_f+R_f^L s_f+R_f^d(1-\psi_f)l_f\,\right],$$

replacing d_j and l_j for equations (3.1) and (3.2)

$$ZK^\alpha N^{1-\alpha}=\left[\,R_h^d\,\lambda_1 s_h+\left(R_h^L-R_h^d\right)\lambda_1 s_h+\left(R_h^L-R_h^d(1-\psi_h)\right)\lambda_2 s_h+R_h^L s_h+R_h^d(1-\psi_h)\lambda_2 s_h\,\right]$$
$$+\left[\,R_f^d\lambda_1 s_f+\left(R_f^L-R_f^d\right)\lambda_1 s_f+\left(R_f^L-R_f^d(1-\psi_f)\right)\lambda_2 s_f+R_f^L s_f+R_f^d(1-\psi_f)\lambda_2 s_f\,\right],$$

and by canceling terms we get

$$ZK^{\alpha}N^{1-\alpha} = (\,\lambda_1 s_h + \lambda_2 s_h + s_h\,)\, R_h^L + (\,\lambda_1 s_f + \lambda_2 s_f + s_f\,)\, R_f^L. \tag{A.1}$$

Prices R_h^L and R_f^L in (A.1) should be consistent with a solution for firms' problem. Solution to (2.2) gives the following first order conditions

$$\begin{aligned} R_h^L &= \frac{(1-\alpha)Z}{W}\left(\frac{K}{N}\right)^{\alpha} \\ R_f^L &= \alpha Z\left(\frac{N}{K}\right)^{1-\alpha}, \end{aligned}$$

both of which can be replaced in (A.1), obtaining

$$ZK^{\alpha}N^{1-\alpha} = (\,\lambda_1 s_h + \lambda_2 s_h + s_h\,)\left[\frac{(1-\alpha)ZK^{\alpha}}{WN}\cdot\frac{1}{N^{\alpha-1}}\right] + (\,\lambda_1 s_f + \lambda_2 s_f + s_f\,)\left[\frac{\alpha Z N^{1-\alpha}}{K}\cdot\frac{1}{K^{-\alpha}}\right].$$

Equation (3.3) states that $L_h = (\,\lambda_1 s_h + \lambda_2 s_h + s_h\,)$ and $L_f = (\,\lambda_1 s_f + \lambda_2 s_f + s_f\,)$. Total labor (capital) payments should equal local (foreign) loans, such that one may simplify the previous expression as

$$\begin{aligned} ZK^{\alpha}N^{1-\alpha} &= \left[(1-\alpha)ZK^{\alpha}\cdot\frac{1}{N^{\alpha-1}}\right] + \left[\alpha Z N^{1-\alpha}\cdot\frac{1}{K^{-\alpha}}\right], \\ &= ZK^{\alpha}N^{1-\alpha} \end{aligned}$$

proving that second period budget constraint holds. ■

Appendix B Proof of Lemma 1

Replacing banks' balance sheet constraint in banks' profits, one obtains

$$\begin{aligned} \pi_j &= R_j^L\,(d_j + l_j + s_j) - R_j^d d_j - R_j^d(1-\psi_j)l_j \\ &= \left(R_j^L - R_j^d\right) d_j + \left(R_j^L - R_j^d(1-\psi_j)\right) l_j + R_j^L s_j. \end{aligned}$$

If $R_j^L < R_j^d$, bank's profits will be decreasing in the number of deposits demanded, so that bank's demand of deposits will be zero. In the interesting case where $R_j^L > R_j^d$, bank's profits are increasing both in deposits and on wholesale funding. The case for deposits is trivial. For wholesale funding, note that spread $\psi_j \in (0,1)$ such that $R_j^d > R_j^d(1-\psi_j)$, what indicates that $R_j^L > R_j^d(1-\psi_j)$. As a corollary, bank profits are increasing in wholesale funding l_j.

Banks will then demand deposits and wholesale funds up to the maximum limit they are allowed, so that their leverage and capital requirements constraints bind. ■

Appendix C Proof of Proposition 1

Without leverage constraints and capital requirements, the problem of bank $j \in f, h$ becomes

$$\max_{\{L_j, d_j, l_j\}} \pi_j(s_j) = R_j^L L_j - R_j^d d_j - R_j^d(1-\psi_j)l_j \tag{C.1}$$

subject to the balance sheet constraint

$$L_j = d_j + l_j + s_j. \tag{C.2}$$

Replacing equation (C.2) in (C.1) and reorganizing terms, one obtains the following expression for the bank's problem

$$\max_{\{d_j, l_j\}} \pi_j(s_j) = \left(R_j^L - R_j^d\right) d_j + \left(R_j^L - R_j^d(1-\psi_j)\right) l_j + R_j^L s_j. \tag{C.3}$$

The analysis will only focus on the interesting case in which $R_j^L \geq R_j^d(1-\psi_j)$, as cases in which wholesale fund rates are higher to loan rates are uncommon.

Lemma C.1. *In the case in which monetary policy sets $\psi_j > 0$, for an equilibrium to exist, it should be the case that $R_j^L = R_j^d(1-\psi_j)$ and banks will elastically demand wholesale funds while demanding zero deposits.*

Proof: If $R_j^L > R_j^d(1-\psi_j)$, banks will demand infinite amount of wholesale funding, as profits –depicted in equation (C.3)– will be increasing in this variable. This is not consistent with an equilibrium.

By contrast, if $R_j^L = R_j^d(1-\psi_j)$, banks will be indifferent in the amount of wholesale funds that they demand. Given this fact, equilibrium in wholesale funding markets indicates that these agents should demand all wholesale funds supplied at prevalent return rates. This is consistent with an elastic demand for wholesale funding. Equality between loan return rates and wholesale funding rates implies that $R_j^L < R_j^d$. This is evident by recalling the initial assumption in lemma C.1 according to which $\psi_j > 0$. In this case, bank's profits denoted by equation (C.3) are decreasing in deposits levels, so that banks will demand zero deposits.

In the case in which there exists a positive spread between deposits' cost and wholesale funding costs, one can draw conclusions on the effective supply of loans by using lemma C.1 in conjunction with bank's budget constraint, equation (C.2). Let l_j^s denote the supply of wholesale funds (which do not depend on bank's decisions), loan supply in the case where $\psi_j > 0$ will be equal to

$$L_j = l_j^s + s_j$$

Note that, in this case, loan supply is not entirely determined by banker's equity allocations s_j. In this sense, portfolio decisions, and specially risk-aversion of bankers, is not a fundamental driver of loan creation an credit.

Lemma C.2. *In the case in which monetary policy set $\psi_j = 0$, for an equilibrium to exist, it should be the case that $R_j^L = R_j^d$ and banks will elastically demand both wholesale funds and deposits.*

Proof: Analogous to the case depicted in lemma C.1. If $R_j^L > R_j^d$, banks will demand both infinite amount of deposits and infinite amount of wholesale funds, as profits – depicted in equation (C.3)– will be increasing in both variables. This is not consistent with an equilibrium. If $R_j^L = R_j^d$, banks will be indifferent both in the amount of deposits and in the amount of wholesale funds that they demand. Given this fact, equilibrium in deposits and wholesale funding markets suggests that these agents should demand all deposits and all wholesale funds supplied at prevalent return rates. This is consistent with both an elastic demand of deposits and of wholesale funding.

Conclusions on the effective supply of loans when the spread between deposits and wholesale funding is zero can be drawn by using lemma C.2 in conjunction with bank's budget constraint, equation (C.2). Let d_j^s denote the supply of deposits (which do not depend on bank's decisions), loan supply in the case where $\psi_j = 0$ is equal to

$$L_j = d_j^s + l_j^s + s_j, \tag{C.4}$$

such that loans are not entirely determined by equity allocations s_j nor by banker's portfolio decisions and risk-aversion. ■

Appendix D Banker's Optimality Condition

Replacing banker's portfolio value in its utility function –see equation (2.3)–, one may express banker's welfare $\mathcal{W}^{bj}$ as

$$\begin{aligned}\mathcal{W}^{bj} &= \mathrm{E}\left[\Lambda_{j,2}\right] - \frac{\chi}{2}\mathrm{Var}\left[\Lambda_{j,2}\right] \\ &= \mathrm{E}\left[\pi_j(s_j) + R_j b_j - \Omega\delta s_j\right] - \frac{\chi}{2}\mathrm{Var}\left[\pi_j(s_j) + R_j b_j - \Omega\delta s_j\right],\end{aligned} \tag{D.1}$$

such that banker's utility ultimately depends on both the expected value and the variance of its portfolio holdings.

Equation (3.4) states that

$$\pi_j(s_j) = \left(R_j^L - R_j^d\right)\lambda_1 s_j + \left[R_j^L - R_j^d(1-\psi_j)\right]\lambda_2 s_j + R_j^L s_j.$$

The model assumes that loans, public debt and deposits contracts are enforceable, such that there is no uncertainty on private loans return rates R_j^L, public debt return rates R_j, nor on deposit interest rates R_j^d. This also implies that there is no uncertainty in bank's profits $\pi_j(s_j)$ such that one may simplify equation (D.1) as

$$\begin{aligned}\mathcal{W}^{bj} &= \pi_j(s_j) + R_j b_j - \mathrm{E}\left[\Omega\delta s_j\right] - \frac{\chi}{2}\mathrm{Var}\left[\Omega\delta s_j\right] \\ &= \pi_f(s_j) + R_j b_j - \delta s_j \mathrm{E}(\Omega) - \frac{\chi}{2}\,\delta^2\, s_j^2\,\mathrm{Var}(\Omega).\end{aligned}$$

Replacing b_j using banker's first period budget constraint, we obtain an expression for $\mathcal{W}^{bj}$ that uniquely depends on banker's equity allocations s_j

$$\mathcal{W}^{bj} = \pi_j(s_j) + R_j(\omega - s_j) - \delta s_j \mathrm{E}(\Omega) - \frac{\chi}{2}\delta^2 s_j^2 \mathrm{Var}(\Omega),$$

so that global bankers problem may be written as

$$\max_{\{s_j\}} \quad \mathcal{W}^{bj} = \pi_j(s_j) + R_j(\omega - s_j) - \delta s_j \mathrm{E}(\Omega) - \frac{\chi}{2}\delta^2 s_j^2 \mathrm{Var}(\Omega).$$

Random equity shock Ω is independent of equity allocations, such that first order condition of the previous problem is

$$\pi_j{}'(s_f) = R_f + \delta s_f \mathrm{E}(\Omega) + s_f \chi \delta^2 \mathrm{Var}(\Omega),$$

which is equivalent to equation (3.5). ■