Regulatory Arbitrage and Economic Stability

Sami Alpanda*
University of Central Florida

Uluc Aysun†
University of Central Florida

August, 2020

Abstract

This paper shows that national bank regulation can ensure financial and economy stability only if business cycles are driven by domestic and non-financial global shocks. If global financial shocks are more important, by contrast, national regulatory policies can be destabilizing. These inferences are drawn from a two-country DSGE model with global banking, financial regulation and the financial accelerator mechanism. The results indicate that bank regulation suppresses the amplification effects of the financial accelerator mechanism when countries face domestic and non-financial global shocks. When there is a global financial shock, however, highly-regulated countries are more vulnerable to the ebbs and flows of global bank lending since their firms are more leveraged and externally funded. More generally, the results imply that the financial trilemma is not binding in economies where domestic and non-financial global shocks drive the business cycle.

Keywords: bank regulation, DSGE, financial accelerator, global banks, financial trilemma.

JEL Classification: E32, E44, F33, F44.

*University of Central Florida, Department of Economics, College of Business, 4336 Scorpius Street, Orlando, FL 32816. Phone: +1 (407) 823-1575, e-mail: sami.alpanda@ucf.edu.

†University of Central Florida, Department of Economics, College of Business, 4336 Scorpius Street, Orlando, FL 32816. Phone: +1 (530) 574-3951, e-mail: uaysun@bus.ucf.edu.

1 Introduction

Internationally active banks (IABs) are important conduits for international shock transmission and a major determinant of macroeconomic stability in many nations. Some IABs hold substantial amounts of claims throughout the world and their assets are comparable to the GDP of the country that charters them. These banks, also known as global systematically important banks, shift large amounts of funds across countries by effectively using their internal capital markets. While dynamic pull and push variables are often identified as the drivers of international bank flows (Fratzscher, 2012; Avdjiev et al., 2019), institutional factors such as accounting standards, managerial practices, creditor rights, and government quality that change relatively less often are also related to the cross-country portfolio reallocation of IAB funds (Houston et al., 2012; Laeven and Levine, 2009).

Among different aspects of institutions, bank regulatory stringency is the one that is most commonly associated with IAB flows (Houston et al., 2012; Bremus and Fratzscher, 2015; Ongena et al., 2013). Empirical findings typically reveal that regulatory arbitrage governs the international flow of funds, as banks shift funds away from countries where they are more regulated to those with lax regulation. This arbitrage behavior, combined with the size of IABs, imply the presence of an international financial trilemma since nationalistic regulations with free capital flows may lead to financial instability.[1] A reasonable prediction here would be that countries facing the trilemma would like to defer bank regulation to supranational bodies such as the BIS that could harmonize regulation globally. However, this is at odds with what is observed in data. While some regulatory restrictions apply uniformly throughout the world (e.g., those administered through Basel III), there exists a considerable amount of heterogeneity across countries. It is, therefore, unclear how different degrees of regulation can endure the financial trilemma.

In this paper, we offer one possible explanation for how national bank regulation can coexist with large IABs. We do so by building a model in which regulation, while repelling bank flows due to high costs of compliance can also attract these funds. In particular, we assume that higher regulation reduces the riskiness of banks' assets, and thus an IAB incurring higher regulatory costs can also face less risk in a more regulated country. By capturing the two forces within the context

[1] Financial trilemma refers to the incompatibility between financial stability, financial integration and national financial policies such as regulation (see, Schoenmaker, 2011 and 2013 for a more detailed explanation). Countries that face this trilemma must choose two of the three objectives.

of a two-region, open-economy, dynamic stochastic general-equilibrium (DSGE) model with various structural shocks, we compare and compute the counteracting effects of regulation on IAB flows and the economies of countries. In doing so, we assume that regulatory stringency is an institutional aspect of the economy and that it is much less volatile compared to macroeconomic variables.

The results that are obtained from a reasonable calibration of the model show that the effect of regulation on financial and macroeconomic stability depends on the type of shock. For non-financial shocks common to both countries and for country-specific shocks, regulation fosters stability. By contrast, if shocks originate in global financial markets and they are directly transmitted through the balance sheets of IABs, a country with higher regulation faces higher instability. The unique inference here is that the well-documented destabilizing mechanism of regulation is only observed for global financial shocks (i.e., global push shocks). For countries where other types of shocks are more prevalent, nationalistic regulatory policies can still be effective in promoting stability contrary to the financial trilemma hypothesis.

The disparity in the responses to different shocks is generated by the dynamic and steady state characteristics of our model. When regulation is more stringent in a country, there is a lower degree of asymmetric information and thus a higher share of external (bank) funding at steady state. In terms of dynamics, the sensitivity of lending spreads to the financial leverage of borrowers in this country are also lower as there is a smaller chance of default. Conversely, the less regulated country has a higher share of internal funding and a higher leverage sensitivity of lending spreads. Given these characteristics, if there is a positive global financial shock that increases global banks' net worth or decreases their funding costs then this shock has a disproportionately higher effect on the more regulated country since the entrepreneurs in this country are more leveraged and dependent on external finance. An increase (decrease) in global banks' net worth (funding costs) that is transmitted to the two economies through a drop in lending spreads, therefore, has a stronger positive effect on investment and output in the more regulated economy. The mechanism runs in the other direction for the less regulated country, mitigating the responses to global financial shocks. These can also be said for any other positive shock that is transmitted directly through global bank balance sheets. By contrast, when we measure the responses to country specific shocks and shocks that are common for both countries yet are non-financial in nature (such as a common productivity/technology shock), we find that regulation has a mitigating effect on the responses.

The amplification and mitigation mechanisms for these types of shocks are primarily determined by the leverage elasticity of lending spreads as described by the financial accelerator mechanism of Bernanke et al. (1999). The responses to domestic and non-financial common shocks in the highly regulated country with a lower leverage elasticity are, therefore, smaller in magnitude.

Further tests reveal that the responses to global shocks are amplified when global banks have a higher probability of default, that our baseline inferences are stronger when regulation is more effective in reducing financial market risk, and that regulation has an economically important effect on macroeconomic volatility and welfare. We also find some empirical evidence that supports our model predictions by using a Structural Vector Autoregression (SVAR) model and a unique methodology to capture the relationship between global bank flows and regulation.

There is a general empirical support for a key assumption that we make in our model: bank regulation reduces financial market risk. For example, studies such as Kim and Santomero (1994), Barth et al. (2004), Buch and DeLong (2008) and Ongena et al. (2013) find evidence for less risk taking when regulation is more stringent. This is consistent with the negative relationship between financial market risk and regulatory effectiveness that studies such as Delis and Staikouras (2011) and Klomp and de Haan (2012) uncover. As mentioned, a subset of this literature (Goldberg, 2009; Houston et al., 2012; Ongena et al., 2013; Bremus and Fratzscher, 2015) identifies the asymmetries in regulatory strength as the reason why global banks shift loanable funds across countries. Unlike these studies, we distinguish between the types of shocks when assessing the effects of regulation. More importantly, we not only consider the benefits of regulation (lower financial market risk) but also its adverse effect on banking through higher compliance costs.

The simultaneous analysis of costs and benefits of regulation for business cycles in our paper is also different from the large volume of work on banking stability and regulation that uses general equilibrium models. While most of this literature focuses on closed economy frameworks, we investigate the effects of regulation on global banking and open economies. We should also note that the banks in our model hold bank capital (i.e., bank net worth) based on market funding concerns, similar to Davis (2010) and Meh and Moran (2010), rather than to satisfy capital regulations as in Van den Heuvel (2008) and Gerali et al. (2010). In the latter model, banks pay a penalty if they do not have adequate net worth to satisfy the capital requirement, while in our model they incur larger funding costs. Banks pass these costs onto the lending rates faced by borrowers (i.e., entrepreneurs); hence, both market-based and regulatory costs play a similar role.

One unique feature of our analysis is that we include the financial accelerator mechanism of Bernanke et al. (1999) twice in the same model; one on the lending side of bank subsidiaries and the other on the funding side of global banks. This two-layered approach, different from the standard closed economy financial accelerator mechanism, allows us to demonstrate the importance of global banking for country-specific business cycles. There is a large number of empirical studies that similarly reveal this key role that global banks play through their internal capital markets (e.g., Buch, 2000; Goldberg, 2002; Jeanneau and Micu, 2002; Martinez Peria et al., 2002; Morgan and Strahan, 2004; De Haas and Van Lelyveld, 2006, 2010; Alpanda and Aysun, 2012). Also, there are indications that global banks can generate a common shock transmission mechanism across countries that helps two country open economy models replicate the comovement of macroeconomic variables in the data (e.g., Alpanda and Aysun, 2014).

Our results imply that for countries where domestic shocks are the primary driver of their business cycles regulatory stringency is beneficial as it can mitigate economic fluctuations. This inference is related to the literature on push and pull determinants of business cycles that emerged following the 2008 crisis. While the literature (e.g., Cetorelli and Goldberg, 2012a, 2012b; Schnabl, 2012; Shin, 2012; Bruno and Shin, 2015; Buch et al., 2016; Rey, 2015) identifies push shocks (those that originate in global financial markets) as a key source of business cycles, especially during global financial crisis episodes, there is evidence that for most countries pull effects (macroeconomic shocks/conditions within the country) are the primary drivers of general business cycles (e.g. Houston et al., 2012; Koepke, 2015; Avdjiev et al., 2019). The mechanism that we describe in our paper together with this evidence gives one reason why national regulation can be justified even with global financial integration and that open economy trilemma may not be binding for most countries.

The next section describes the DSGE model, while Sections 3 and 4 discuss the calibration of model parameters and model results respectively. We present some empirical support for our results in Section 5, and Section 6 concludes.

2 The Model

The basic setup that we use is a two-country, large-open economy DSGE model with global banking. Figure 1 presents a bird's eye view of the domestic side of the model. The foreign economy is modeled in an analogous fashion.

Each country is populated by households, local banks, entrepreneurs, capital producers, domestic intermediate and final goods producers, importers, as well as a government and central bank which conduct fiscal, monetary, and regulatory policy. Global banks accept deposits from households in each country, and use the proceeds along with their own bank capital to fund their local subsidiaries. In turn, local banks lend to entrepreneurs, who use the borrowing along with their net worth to finance their capital purchases. There are financial frictions both at the global bank funding level as well as at the level of local bank lending to entrepreneurs. These are modeled similar to the financial accelerator setup of Bernanke et al. (1999), whereby asymmetric information between lenders and borrowers give rise to a risk spread based on the leverage position of the borrowers.

The model also features real and nominal frictions as is standard in DSGE models. The real frictions are in the form of external habit formation in consumption, investment adjustment costs, and cost of capital utilization similar to Christiano et al. (2005) and Smets and Wouters (2007). Nominal rigidities are introduced via adjustment costs in price and wage-setting as in Rotemberg (1982), and through indexation of prices and wages to past inflation. In particular, monopolistically competitive intermediate goods firms are price-setters in the goods market, and households are wage-setters in the labor market. The model also features intermediaries in each country which import consumption and investment goods from abroad, and sell them domestically in the local currency. Adjustment costs in price-setting for these intermediaries result in incomplete exchange rate pass-through as in Gertler et al. (2007) and Justiniano and Preston (2010).

In what follows, we describe the optimization problems of the key agents related to the financial frictions and banking regulations in the model; namely, entrepreneurs and local and global banks. The description of household preferences, intermediate and final goods production, international trade, and monetary and fiscal policy are relatively standard, and are thus deferred to Appendix A. Our exposition for entrepreneurs and local banks focuses on the domestic economy, but the foreign economy is modeled analogously.[2]

2.1 Entrepreneurs and local banks

There is a unit measure of risk-neutral entrepreneurs in the domestic economy who own the capital stock. At the end of period t, an entrepreneur purchases k_t units of capital from capital producers (at a relative price of q_t), financing this purchase using her own net worth, n_t, and funds acquired from local banks, B_t. Borrowing is undertaken in nominal terms; hence entrepreneurs' (end-of-period) balance sheet condition is given by:

$$q_t k_t = n_t + \frac{B_t}{P_t}, \tag{1}$$

where P_t is the aggregate price level.

In the beginning of period $t+1$, entrepreneurs are hit with an idiosyncratic capital quality shock which transforms the capital they brought from the previous period into $\omega_{t+1} k_t$ units of installed capital. As is standard in this literature, we assume ω_t is lognormally distributed with $\log \omega_t \tilde{} N\left(\mu_{\omega,t}, \sigma^2_{\omega,t}\right)$ and $\mu_{\omega,t} = -\sigma^2_{\omega,t}/2$ so that $E\left[\omega_t\right] = 1$ for all t. The standard deviation term for the idiosyncratic shock follows an AR(1) process in its logarithm as

$$\log \sigma_{\omega,t} = (1-\rho_\omega) \log \sigma_\omega(\theta) + \rho_\omega \log \sigma_{\omega,t-1} + \eta_{\omega,t}, \tag{2}$$

where the function $\sigma_\omega(\theta)$ represents the mean of the process with θ denoting the degree of banking regulations. The specification makes it explicit that banking regulations affect the riskiness of local banks' lending book by altering the average standard deviation of the idiosyncratic capital quality shock. In particular, highly regulated economies face lower variation in capital quality shocks. In our simulations, we will assume that the domestic and foreign economies are equivalent in every way except for the degree of regulation θ.

After the idiosyncratic shock hits, entrepreneurs rent their capital to goods producers within period at a rate of mpk_{t+1} (since the rental rate of capital is equal to its marginal product), and after production takes place, they sell their depreciated capital stock back to capital producers at

[2] All foreign variables are denoted with the same name as their domestic economy counterparts, but with an asterisk ($*$) superscript.

a price of q_{t+1}. Thus, in period $t+1$, the realized real return from capital, $r_{k,t+1}$, of entrepreneurs is given by

$$r_{k,t+1} = \frac{(1-\delta)\, q_{t+1} + mpk_{t+1}}{q_t}, \tag{3}$$

where δ is the depreciation rate of capital. In log-linearized form, the above expression can be written in period t as

$$\widehat{r}_{k,t} = \frac{1-\delta}{r_k}\widehat{q}_t + \left(1 - \frac{1-\delta}{r_k}\right)\widehat{mpk}_t - \widehat{q}_{t-1}. \tag{4}$$

2.1.1 Local banks

There is a unit measure of competitive risk-neutral local banks, which fund themselves through their global parent bank and provide lending to domestic entrepreneurs. Local banks are subsidiaries to global banks, but are subject to the regulatory rules of the country where they operate. As discussed above, one aspect of regulation in the model deals with the riskiness of the local banks' loan book. The other key aspect of regulation is related to the local banks' funding rate. Global banks accept deposits from both countries, and fund their local subsidiaries in the domestic and foreign economies at $R_{f,t}$ and $R^*_{f,t}$, respectively, but the cost of funding for the local subsidiaries are multiplied by $\theta, \theta^* \geq 1$ based on the degree of regulatory burden each country imposes on local banks. If the local banks in the foreign economy face a higher regulatory burden (i.e., $\theta^* > \theta$), for example, they will also face higher funding costs, which in turn will be reflected to the lending rate charged to entrepreneurs.

The debt contract between an entrepreneur and a local bank is structured so that the entrepreneur either pays a state-contingent gross nominal interest rate $R_{E,t+1}$ on the loan, or default as in Bernanke et al. (1999) and Fernandez-Villaverde (2010). If the entrepreneur defaults, the bank seizes all its revenue, but loses a proportion μ of this in bankruptcy proceedings. Since the entrepreneur loses everything in default, it will always choose to pay back the bank if it has generated enough revenue to do so. Let $\overline{\omega}_{t+1}$ denote the threshold level of the idiosyncratic asset quality shock ω_{t+1} which would make an entrepreneur indifferent between paying back the bank versus defaulting; this threshold level is given by:

$$R_{E,t+1}B_t = \overline{\omega}_{t+1}P_{t+1}r_{k,t+1}q_tk_t. \tag{5}$$

With a lower realization of the idiosyncratic shock, i.e. $\omega < \overline{\omega}_{t+1}$, the entrepreneur would default, while with a higher realization, it would pay back $R_{E,t+1}$ per unit of borrowing.

To ensure that local banks participate in this contract, $R_{E,t+1}$ is set on an ex-post state-contingent manner to satisfy a zero profit condition for banks:

$$\left[1 - F\left(\overline{\omega}_{t+1}\right)\right] R_{E,t+1} B_t + (1-\mu) \int_0^{\overline{\omega}_{t+1}} \omega dF\left(\omega\right) P_{t+1} r_{k,t+1} q_t k_t = \theta R_{f,t} B_t, \tag{6}$$

where $F\left(\omega\right)$ denotes the cumulative distribution function (cdf) of ω. Let $\Gamma\left(\overline{\omega}_{t+1}\right)$ denote the share of entrepreneur's nominal earnings that accrue to local banks from the contract:

$$\Gamma\left(\overline{\omega}_{t+1}\right) = \left[1 - F\left(\overline{\omega}_{t+1}\right)\right] \overline{\omega}_{t+1} + G\left(\overline{\omega}_{t+1}\right), \text{ where } G\left(\overline{\omega}_{t+1}\right) = \int_0^{\overline{\omega}_{t+1}} \omega dF\left(\omega\right). \tag{7}$$

Using (5) and (1), the participation constraint of the bank (6) can be expressed as

$$\left[\Gamma\left(\overline{\omega}_{t+1}\right) - \mu G\left(\overline{\omega}_{t+1}\right)\right] \frac{r_{k,t+1}}{\theta R_{f,t}/\pi_{t+1}} \frac{q_t k_t}{n_t} = \frac{q_t k_t}{n_t} - 1, \tag{8}$$

which relates entrepreneurial leverage, $q_t k_t / n_t$, with the default threshold value for the idiosyncratic asset quality shock, $\overline{\omega}_{t+1}$.

2.1.2 Entrepreneurs' problem

The problem of the entrepreneur is to choose $q_t k_t / n_t$ and a schedule for $\overline{\omega}_{t+1}$ to maximize the expected return on its net worth given by

$$\max_{q_t k_t / n_t,\, \overline{\omega}_{t+1}} E_t \left[\left[1 - \Gamma\left(\overline{\omega}_{t+1}\right)\right] \frac{r_{k,t+1}}{\theta R_{f,t}/\pi_{t+1}} \frac{q_t k_t}{n_t}\right], \tag{9}$$

subject to the participation constraint of the local bank in (8). The optimality conditions of this problem are given by

$$E_t \left[\left[1 - \Gamma\left(\overline{\omega}_{t+1}\right)\right] \frac{r_{k,t+1}}{\theta R_{f,t}/\pi_{t+1}} + \lambda_{E,t+1} \left(\left[\Gamma\left(\overline{\omega}_{t+1}\right) - \mu G\left(\overline{\omega}_{t+1}\right)\right] \frac{r_{k,t+1}}{\theta R_{f,t}/\pi_{t+1}} - 1\right)\right] = 0, \tag{10}$$

and

$$\Gamma'(\overline{\omega}_{t+1}) = \lambda_{E,t+1}\left[\Gamma'(\overline{\omega}_{t+1}) - \mu G'(\overline{\omega}_{t+1})\right], \tag{11}$$

where $\lambda_{E,t}$ is the Lagrange multiplier on the local bank's participation constraint. Note that $G'(\overline{\omega}_{t+1}) = \overline{\omega}_{t+1}F'(\overline{\omega}_{t+1})$ and $\Gamma'(\overline{\omega}_{t+1}) = 1 - F(\overline{\omega}_{t+1})$, and therefore

$$\lambda_{E,t+1} = \frac{1 - F(\overline{\omega}_{t+1})}{1 - F(\overline{\omega}_{t+1}) - \mu\overline{\omega}_{t+1}F'(\overline{\omega}_{t+1})}. \tag{12}$$

Plugging this into (10) and using the participation constraint (8), we get

$$E_t\left[\left[1 - \Gamma(\overline{\omega}_{t+1})\right]\frac{r_{k,t+1}}{\theta R_{f,t}/\pi_{t+1}}\right]\frac{q_t k_t}{n_t} = E_t\left[\frac{1 - F(\overline{\omega}_{t+1})}{1 - F(\overline{\omega}_{t+1}) - \mu\overline{\omega}_{t+1}F'(\overline{\omega}_{t+1})}\right]. \tag{13}$$

Coupled with the participation constraint, the expression above implies that the leverage of the entrepreneur is inversely related to the expected returns from capital in excess of funding costs, which in log-linearized form can be written as

$$E_t\widehat{r}_{k,t+1} - \left(\widehat{R}_{f,t} - E_t\widehat{\pi}_{t+1}\right) = \chi\left(\widehat{q}_t + \widehat{k}_t - \widehat{n}_t\right) + \varepsilon_{k,t}, \tag{14}$$

where $\chi = \left[\chi_1 + 1 - k/n\right] / \left[(\chi_1 + 1)(k/n - 1)\right]$ determines the elasticity of the lending risk premium to borrower leverage with

$$\chi_1 = \left(\frac{\Gamma'(\overline{\omega})}{1 - \Gamma(\overline{\omega})} + \frac{\Gamma''(\overline{\omega})}{\Gamma'(\overline{\omega})} - \frac{\Gamma''(\overline{\omega}) - \mu G''(\overline{\omega})}{\Gamma'(\overline{\omega}) - \mu G'(\overline{\omega})}\right)\frac{\Gamma(\overline{\omega}) - \mu G(\overline{\omega})}{\Gamma'(\overline{\omega}) - \mu G'(\overline{\omega})}, \tag{15}$$

and the risk-premium shock, $\varepsilon_{k,t}$, is derived from the standard deviation of the idiosyncratic capital quality shock, $\sigma_{\omega,t}$, described above.

At the end of each period, only a time-varying fraction $\gamma_{E,t}$ of entrepreneurs survive to the next period, while the rest die and the value of their capital is transferred over to households. The dead entrepreneurs are replaced by a new cohort of entrepreneurs that receive a lump-sum amount, $\gamma^t N_E$, from households. After some algebra, the aggregate entrepreneurial net worth in real terms can be shown to evolve as

$$n_t = \gamma_{E,t}\left[\left[1 - \mu G(\overline{\omega}_t)\right]r_{k,t}q_{t-1}k_{t-1} - \theta\frac{R_{f,t-1}}{\pi_t}\left(q_{t-1}k_{t-1} - n_{t-1}\right)\right] + (1 - \gamma_{E,t})\gamma^t N_E, \tag{16}$$

which in log-linearized form is given by

$$\widehat{n}_t = \frac{\gamma_E}{\gamma} \left[\begin{array}{c} [1 - \mu G(\overline{\omega})] \frac{r_k k}{n} \left(\widehat{r}_{k,t} + \widehat{q}_{t-1} + \widehat{k}_{t-1} - \frac{\mu G'(\overline{\omega}_t)}{1-\mu G(\overline{\omega}_t)} \overline{\omega} \widehat{\omega}_t \right) \\ -\frac{\theta R_f}{\pi} \left(\frac{k}{n} - 1 \right) \left(\widehat{R}_{f,t-1} - \widehat{\pi}_t \right) - \frac{\theta R_f}{\pi} \frac{k}{n} \left(\widehat{q}_{t-1} + \widehat{k}_{t-1} \right) + \frac{\theta R_f}{\pi} \widehat{n}_{t-1} \end{array} \right] + \varepsilon_{n,t} \tag{17}$$

where the net worth shock, $\varepsilon_{n,t}$, is derived from the exogenous time-variation in $\gamma_{E,t}$, and follows an AR(1) process.

2.2 Global banks

There is a unit measure of identical global banks which raise loanable funds in both regions, but conduct their lending through their local subsidiaries. As local subsidiaries operate in their respective currencies, global banks take all the exchange rate risk on their own balance sheet. Furthermore, global banks face financial frictions similar to those faced by entrepreneurs when raising funds. As a result, global banks pay a spread over the risk free rate for their funding, and this spread depends on the banks' leverage position.

The end-of-period balance sheet position of global banks is given by

$$\frac{B_t}{P_t} + \frac{e_t P_t^*}{P_t} \frac{B_t^*}{P_t^*} = \frac{D_t}{P_t} + \frac{e_t P_t^*}{P_t} \frac{D_t^*}{P_t^*} + n_{B,t}, \tag{18}$$

where B and B^* are the nominal loans extended to domestic and foreign entrepreneurs through the local subsidiaries, D and D^* are domestic and foreign deposits in nominal terms, e_t is the nominal exchange rate (quoted in terms of the domestic currency per unit of foreign currency), and $n_{B,t}$ is the real net worth position of global banks. This balance sheet identity can be written as $bb_t = dd_t + n_{B,t}$, where bb_t denotes total real bank assets, and dd_t denotes total real deposits. Total bank loans, can thus be expressed as

$$bb_t = (q_t k_t - n_t) + rer_t (q_t^* k_t^* - n_t^*), \tag{19}$$

where $rer_t = e_t P_t^* / P_t$ denotes the real exchange rate.

Let $R_{B,t+1}$ denote the state-contingent gross nominal return that global banks will earn on their assets in the next period.[3] This return is given by

$$R_{B,t+1}\left(B_t + e_t B_t^*\right) = \theta R_{f,t} B_t + e_{t+1}\theta^* R_{f,t}^* B_t^*. \tag{20}$$

Note that arbitrage between funding domestic versus foreign subsidiaries implies

$$\theta R_{f,t} = \theta^* R_{f,t}^* E_t\left[\frac{e_{t+1}}{e_t}\right], \tag{21}$$

and therefore $E_t\left[R_{B,t+1}\right] = \theta R_{f,t}$.

Similar to entrepreneurs, global banks face an idiosyncratic asset quality shock at the beginning of period $t+1$, which transforms the assets they brought from the previous period into $\omega_{B,t+1}\left(B_t + e_t B_t^*\right)$ units. $\omega_{B,t}$ is lognormally distributed with $\log\omega_{B,t}\tilde{\ }N\left(\mu_{\omega B,t}, \sigma^2_{\omega B,t}\right)$ and $\mu_{\omega B,t} = -\sigma^2_{\omega B,t}/2$ so that $E\left[\omega_{B,t}\right] = 1$ for all t. The standard deviation term for the idiosyncratic shock follows an AR(1) process in its logarithm as

$$\log\sigma_{\omega B,t} = \left(1-\rho_{\omega B}\right)\log\sigma_{\omega B} + \rho_{\omega B}\log\sigma_{\omega B,t-1} + \eta_{\omega B,t}, \tag{22}$$

where $\sigma_{\omega B}$ is the mean of the process.

The debt contract between global banks and depositors is structured similar to that between entrepreneurs and local banks. In particular, for every state-of-the-world with an associated return on bank assets in period $t+1$, a global bank either pays back a state-contingent gross nominal interest rate $R_{d,t+1}$ per unit of domestic deposits and $R^*_{d,t+1}$ per unit of foreign deposits, or it defaults on its depositors. If the bank defaults, the depositors seize all the bank's revenues, although a proportion μ_B of this is lost in bankruptcy proceedings as monitoring costs. Since the bank loses everything in default, it will always choose to pay back depositors if it has generated enough revenue to do so. Let $\overline{\omega}_{B,t+1}$ denote the threshold level of the idiosyncratic asset quality shock which would make a bank indifferent between paying back depositors versus defaulting; this threshold level is given by:

$$R_{d,t+1}D_t + e_{t+1}R^*_{d,t+1}D^*_t = \overline{\omega}_{B,t+1}R_{B,t+1}\left(B_t + e_t B_t^*\right). \tag{23}$$

[3] The state-contingency is due to the exchange rate risk held by global banks. In our simulations, we assume that global banks hedge this risk, which ensures symmetric responses of global bank variables to country-specific shocks in our baseline calibration with regulatory parity ($\theta = \theta^*$).

With a lower realization of the idiosyncratic shock, i.e. $\omega_B < \overline{\omega}_{t+1}$, the bank would default, while with a higher realization, it would pay back $R_{d,t+1}$ per unit of deposits.

To ensure that domestic and foreign depositors participate in this contract, $R_{d,t+1}$ and $R^*_{d,t+1}$ are set so as to make depositors indifferent between placing funds at the global bank versus receiving their risk-free rate:

$$[1 - F(\overline{\omega}_{B,t+1})]\left(R_{d,t+1}D_t + e_{t+1}R^*_{d,t+1}D^*_t\right) + (1-\mu_B)\int_0^{\overline{\omega}_{B,t+1}} \omega_B dF(\omega_B) R_{B,t+1}(B_t + e_t B^*_t) \tag{24}$$
$$= R_t D_t + E_t[e_{t+1}] R^*_t D^*_t,$$

where R_t and R^*_t are the nominal interest rates on domestic and foreign government bonds, respectively.[4] Note that arbitrage between these bonds implies

$$R_t = R^*_t E_t\left[\frac{e_{t+1}}{e_t}\right]. \tag{25}$$

The participation constraint can thus be written as

$$[1 - F(\overline{\omega}_{B,t+1})]\,\overline{\omega}_{B,t+1} R_{B,t+1} bb_t + (1-\mu_B)\int_0^{\overline{\omega}_{B,t+1}} \omega_B dF(\omega_B) R_{B,t+1} bb_t = R_t dd_t. \tag{26}$$

Let $\Gamma(\overline{\omega}_{B,t+1})$ denote the share of bank's nominal earnings that accrue to depositors from the contract:

$$\Gamma(\overline{\omega}_{B,t+1}) = [1 - F(\overline{\omega}_{B,t+1})]\,\overline{\omega}_{B,t+1} + G(\overline{\omega}_{B,t+1}), \text{ where } G(\overline{\omega}_{B,t+1}) = \int_0^{\overline{\omega}_{B,t+1}} \omega_B dF(\omega_B). \tag{27}$$

(26) can thus be expressed as

$$[\Gamma(\overline{\omega}_{B,t+1}) - \mu_B G(\overline{\omega}_{B,t+1})]\frac{R_{B,t+1}}{R_t}\frac{bb_t}{n_{B,t}} = \frac{bb_t}{n_{B,t}} - 1, \tag{28}$$

which relates bank leverage, $bb_t/n_{B,t}$, and the threshold value of the idiosyncratic asset quality

[4] Here, we are implicitly assuming the existence of risk-neutral participants in depositor households, who sign this contract.

shock, $\overline{\omega}_{B,t+1}$.

The problem of the bank is to pick its level of leverage (and therefore the level of its deposits and assets) and default threshold to maximize the expected return on its net worth subject to the participation constraint of depositors (28). This problem is analogous to the entrepreneurs' problem, and its optimality conditions imply

$$E_t\left[\left[1-\Gamma\left(\overline{\omega}_{B,t+1}\right)\right]\frac{R_{B,t+1}}{R_t}\right]\frac{bb_t}{n_{B,t}}=E_t\left[\frac{1-F\left(\overline{\omega}_{B,t+1}\right)}{1-F\left(\overline{\omega}_{B,t+1}\right)-\mu_B\overline{\omega}_{B,t+1}F'\left(\overline{\omega}_{B,t+1}\right)}\right], \tag{29}$$

along with the depositor participation constraint in (28). Using $E_t\left[R_{B,t+1}\right]=\theta R_{f,t}$, we can write the external finance premium of the global bank (i.e., the funding spread) as a function of bank leverage, which, in log-linearized form is given by

$$\widehat{R}_{f,t}-\widehat{R}_t=\chi_B\left(\widehat{bb}_t-\widehat{n}_{B,t}\right)+\varepsilon_{f,t}, \tag{30}$$

where χ_B determines the elasticity of the funding spread with respect to bank leverage, and $\varepsilon_{f,t}$ is a bank funding shock which is derived from the idiosyncratic shock faced by the global banks.

The bank funding spread derived above can be combined with the lending spread derived from the contract between entrepreneurs and local banks to yield the total credit spread faced by entrepreneurs as

$$spread_t=E_t\widehat{r}_{k,t+1}-\left(\widehat{R}_t-E_t\widehat{\pi}_{t+1}\right)=\chi\left(\widehat{q}_t+\widehat{k}_t-\widehat{n}_t\right)+\chi_B\left(\widehat{bb}_t-\widehat{n}_{B,t}\right)+\varepsilon_{f,t}+\varepsilon_{k,t}. \tag{31}$$

The analogous expression for entrepreneurs in the foreign economy is given by

$$spread_t^*=E_t\widehat{r}_{k,t+1}^*-\left(\widehat{R}_t^*-E_t\widehat{\pi}_{t+1}^*\right)=\chi^*\left(\widehat{q}_t^*+\widehat{k}_t^*-\widehat{n}_t^*\right)+\chi_B\left(\widehat{bb}_t-\widehat{n}_{B,t}\right)+\varepsilon_{f,t}+\varepsilon_{k,t}^*. \tag{32}$$

Accordingly, the credit spread faced by entrepreneurs in each region depend not only on their own leverage position, but also on the leverage position of the global banks and the global funding shock, $\varepsilon_{f,t}$. Since these are common to both countries, they endogenously generate a positive cross-country correlation in risk spreads.

Finally, at the end of each period, only a time-varying fraction $\gamma_{B,t}$ of global banks survive to the next period, while the rest die and their assets are transferred to households. The exiting banks are replaced by a new cohort of banks that receive a lump-sum amount, $\gamma^t N_B$, from households. The aggregate global bank net worth in real terms evolves as

$$n_{B,t} = \gamma_{B,t}\left[\left[1-\mu_B G\left(\overline{\omega}_{B,t}\right)\right]\frac{R_{B,t}}{\pi_t}bb_{t-1} - \frac{R_{t-1}}{\pi_t}\left(bb_{t-1} - n_{B,t-1}\right)\right] + \left(1-\gamma_{B,t}\right)\gamma^t N_B, \tag{33}$$

which, after detrending and log-linearization, can be simplified as

$$\widehat{n}_{B,t} = \frac{\gamma_B}{\gamma\eta}\left[\begin{array}{c} \left[1-\mu_B G\left(\overline{\omega}_B\right)\right]\frac{R_f}{\pi}\frac{bb}{n_B}\left(\widehat{R}_{B,t} + \widehat{bb}_{t-1} - \frac{\mu_B G'\left(\overline{\omega}_{B,t}\right)}{1-\mu_B G\left(\overline{\omega}_{B,t}\right)}\overline{\omega}_B\widehat{\overline{\omega}}_{B,t}\right) \\ -\frac{R}{\pi}\left(\frac{bb}{n_B}-1\right)\left(\widehat{R}_{t-1} - \widehat{\pi}_t\right) - \frac{R}{\pi}\frac{bb}{n_B}\widehat{bb}_{t-1} + \frac{R}{\pi}\widehat{n}_{B,t-1} \end{array}\right] + \varepsilon_{nB,t} \tag{34}$$

where $\frac{b}{bb} = \left(\frac{k}{n}-1\right)\frac{n}{n_B}/\frac{bb}{n_B}$ and the bank net worth shock, $\varepsilon_{B,t}$, is derived from the exogenous time-variation in $\gamma_{B,t}$ and follows an AR(1) process. Note that global banks' subsidiaries make 0 profits; global banks essentially earn the risk-free rate (times the regulatory cost θ) on their net worth, modulo some realized gains or losses from the exchange rate risk they take on their balance sheet.

As noted in the beginning of this section, the model also features households, domestic producers and importers of intermediate goods, final goods aggregators, as well as monetary and fiscal policy rules. These are relatively standard, and are thus presented in Appendix A.

3 Calibrated parameters and steady state

To calibrate the standard parts of our model, we adopt parameter values that are commonly used to match long term data moments for advanced economies. We initially set the parameters to identical values in both countries. For example, we set the time-discount factor, β, to 0.9975, which implies a 1% annualized real interest rate. We assign the value of 0.025 to the depreciation rate of capital, δ, so that annual depreciation rate is 10%. Fixing the capital share parameter, α, to 0.3, implies a steady-state capital income share of 30%. We set the steady state share of government spending , g/y, to 0.18.

The steady-state gross price and wage mark-ups, ϕ_p and ϕ_w, are assigned the values of 1.25 and 1.5, respectively, similar to Smets and Wouters (2007). We set the share of local consumption and investment goods in the corresponding final goods, γ_c and γ_i, to 0.9 so that import and export shares are 10% at steady-state for both countries. When we transition to asymmetric calibrations with different degrees of regulatory stringency, γ_c and γ_i, will also be different across the two countries.[5]

Throughout our simulations, with the exception of those in Section 4.7, we also follow common practice and set the parameters representing persistence and the standard deviation of the *i.i.d.* innovations equal to 0.9 and 0.01, respectively.

To calibrate the country-specific financial and regulatory parts of the model, we first assign the values of 0.85 percent, 0.123 and 0.97 to the entrepreneurs' quarterly default rate, $F(\bar{\omega})$, the monitoring cost coefficient, μ, and the quarterly survival probability of the entrepreneurs, γ_E. These values are similar to the corresponding values commonly-used in the literature (e.g. Bernanke et al, 1999).[6] Setting the variance of the idiosyncratic returns to capital shock, σ_ω^2, to 0.118 implies that the regulatory cost parameter θ and the cut-off value of the idiosyncratic shock $\bar{\omega}$ are equal to 0.0015 and 0.4088 at steady state, respectively.

These parameter values mentioned above allow us to reasonably match data moments. The implied values for credit spreads and financial leverage, for example, closely match the corresponding values in the data.[7] The Moody's Seasoned Baa Corporate Bond yield relative to the yield on 10-Year Treasury bonds, for example, is 2.3 percent between 1986 and 2019. The corresponding steady state value in our model is 2.2 percent. Similarly, our steady state total-debt-to-equity ratio of 1.7

[5] The two sets of parameters will be related as follows: $\gamma_c^* = 1 - (1-\gamma_c)\frac{\frac{c}{y}}{\frac{c*}{y*}\frac{y*}{y}}$, $\gamma_i^* = 1 - (1-\gamma_i)\frac{\frac{i}{y}}{\frac{i*}{y*}\frac{y*}{y}}$

[6] We should note that our steady state annualized default rate, 3.4 percent, matches the rate reported by Standard and Poor's Financial Services for the period between 1999 and 2019 (excluding 2001 and 2009). The corresponding value in Bernanke et al. 1999 is 3%. The value of our monitoring cost coefficient is also slightly higher than the value in Bernanke et al. (1999). This disparity allows us for a closer approximation to the lending spreads in more recent data.

[7] The steady state expressions for credit spreads and leverage for entrepreneurs are given by,

$$r^k/\left(\theta r^f\right) = \frac{\lambda(\bar{\omega})}{(1-\Gamma(\bar{\omega})) + \lambda(\bar{\omega})\left([\Gamma(\bar{\omega}) - \mu G(\bar{\omega})]\right)} \tag{F.1}$$

$$\frac{k}{n} = 1 + \lambda(\bar{\omega})\frac{[\Gamma(\bar{\omega}) - \mu G(\bar{\omega})]}{1-\Gamma(\bar{\omega})} \tag{F.2}$$

where $\Gamma(\bar{\omega}) = \int_0^{\bar{\omega}} \omega dF(\omega) + \bar{\omega}\int_{\bar{\omega}}^{\infty} dF(\omega) = 1 - \Phi\left(\frac{\frac{\sigma_\omega^2}{2} - \log\bar{\omega}}{\sigma_\omega}\right) + \bar{\omega}[1 - F(\omega)]$,

$G(\bar{\omega}) = \int_0^{\bar{\omega}} \omega dF(\omega) = 1 - \Phi\left(\frac{\frac{\sigma_\omega^2}{2} - \log\bar{\omega}}{\sigma_\omega}\right)$, and $\lambda(\bar{\omega}) = \frac{\Gamma'(\bar{\omega})}{[\Gamma'(\bar{\omega}) - \mu G'(\bar{\omega})]} = \frac{1-F(\bar{\omega})}{1-F(\bar{\omega}) - \mu\bar{\omega}f(\bar{\omega})}$. In this formulation, $\Phi(\cdot)$ and $f(\bar{\omega})$ represent the cdf of the standard normal distribution function and the pdf of the lognormal distribution of ω.

is a good approximation for the ratio of 1.8 in IMF, Financial Soundness Indicators (average value between 2005 to 2019). The elasticity of credit spreads to entrepreneurs' financial leverage, χ, is computed by using equation (15). The implied steady state value of this parameter is 0.0298.[8]

We use the same methodology to calibrate the parts of the model related to global banks. We use identical values for the monitoring cost and default probability but we set the variance of the baseline idiosyncratic asset quality shock to 0.00204. This ensures that the financial leverage of the global banks is much higher than that of entrepreneurs. Specifically, the financial leverage of global banks is equal to 10 in our steady state. This value is a reasonable approximation of the bank leverage provisions of Basel III. The leverage elasticity of the global banks' borrowing spread is determined via an expression similar to equation (15) with bb/n_B and $\overline{\omega}_B$ replacing k/n and $\overline{\omega}$ respectively. The steady state value of this parameter is 0.029. Our steady state implies that there is arbitrage across the two funding rates, domestic and foreign, of the global bank such that $R_f = R_f^*$.

We should also note that at the symmetric steady state the net worth of the entrepreneurs in the two countries is equal so that $n/n^* = 1$. This is true for other variables as well. Allowing for regulatory differences, however, also generates a disparity between steady state values. The ratio of domestic to foreign net worth, for example is determined as follows:

$$\frac{n^*}{n} = \frac{\left[1 - \mu G\left(\overline{\omega}\right)\right] r_k \frac{k}{n} - \frac{\theta R_f}{\pi}\left(\frac{k}{n} - 1\right)}{\left[1 - \mu^* G\left(\overline{\omega}^*\right)\right] r_k^* \frac{k^*}{n^*} - \frac{\theta^* R_f^*}{\pi}\left(\frac{k^*}{n^*} - 1\right)} \tag{35}$$

Below we analyze how regulatory stringency affects model dynamics. In doing so, we change the regulatory stringency parameters, θ and θ^*, to gauge how the two economies respond to various shocks. Changing the regulatory stringency parameter affects our steady in two counteracting ways. On the one hand, higher (lower) regulatory stringency, increases (decreases) the regulatory costs of subsidiaries. On the other hand, the default rate of entrepreneurs and the variance of

[8] The expressions for $\lambda'\left(\bar{\omega}\right), \Gamma'\left(\bar{\omega}\right), G'\left(\bar{\omega}\right), F''\left(\omega\right), G''\left(\overline{\omega}\right)$ in equation (15) are as follows:
$\lambda'\left(\bar{\omega}\right) = -\frac{f(\bar{\omega})}{\bar{\omega}}\left[1 + \frac{(\ln(\bar{\omega}) + \sigma_\omega^2/2)}{\sigma_\omega^2}\right]$
$\Gamma'\left(\bar{\omega}\right) = 1 - F(\bar{\omega})$
$G'\left(\bar{\omega}\right) = \bar{\omega} f\left(\bar{\omega}\right)$
$F''\left(\omega\right) = -\frac{1}{\omega} F'\left(\omega\right)\left(1 + \frac{\ln\omega - \mu_\omega}{\sigma_\omega^2}\right)$
$G''\left(\overline{\omega}\right) = F'\left(\overline{\omega}\right) + \overline{\omega} F''\left(\overline{\omega}\right) = -\frac{\ln\omega - \mu_\omega}{\sigma_\omega^2} f\left(\overline{\omega}\right)$

the idiosyncratic shock both fall (increase) proportionally as regulatory stringency parameter θ increases (decreases). The latter feature of regulation can be interpreted as the effectiveness of regulation in enhancing financial stability. For example, it is reasonable to postulate that banks fund low risk investment when regulation is tighter, which in turn decreases default rates and overall investment risk.

While we could not find any empirical study on either the relationship between default rates and investment risk or that between default rates and regulatory stringency, we find evidence from country-level data that the relationships are negative and approximately proportional. We infer these relationships by using data from two sources. The default rates are obtained from the OECD, Timely Indicators of Entrepreneurship statistics and they are measured as the number of enterprise bankruptcies in 19 countries (Australia, Belgium, Brazil, Canada, Germany, Denmark, Spain, Finland, France, United Kingdom, Iceland, Italy, Japan, Netherlands, Norway, New Zealand, Sweden, United States, and South Africa). The regulatory stringency of the same group of countries is approximated by using the Overall Financial Conglomerates Restrictiveness index of Barth et al. (2013). The index is based on the responses to World Bank Surveys of Bank Regulation in years 1999, 2003, 2007, 2011 and it reflects restrictions on securities, insurance and real estate activities of financial conglomerates. We form a panel dataset by matching the regulatory data with the default rates in years, 2000, 2004, 2008, 2012. A fixed effects regression confirms the negative relationship between the two variables and that this relationship is approximately proportional, (a 1 percent increase in regulatory stringency is associated with a 1.17 percent decrease in default rates).

We use the same regulatory index to investigate the relationship between regulation and the variance of the idisyncratic shock. We obtain interest rate spreads (annual bank lending rates minus interest rates on government bonds with similar maturities) from IMF, IFS database for the group of countries mentioned above. In our model, when regulatory costs double, the standard deviation of the idiodyncractic shock is half its baseline value and the borrowing spreads decrease by 0.68%. The corresponding value that we infer from our empirical analysis is 0.4%. This estimate is obtained by using the same fixed effects methodology mentioned above.

In alternative simulations of our model below, we deviate from our default formulation and test how our results change when regulation is less and more effective than the effectiveness implied by a proportional relationship.

4 Results

In this section, we discuss the effects of regulation on our steady state variables and model dynamics, and we report the results from various sensitivity analyses.

4.1 Steady state characteristics

Before we proceed to dynamics, it is useful to observe how regulatory stringency affects some key components of our steady state. To make this observation, we incrementally change the regulatory parameter θ and recalculate steady state values at each iteration. The results from this exercise are displayed for some key variables in Figure 2. The x axis shows the annual costs of regulation as a percentage of the subsidiary's revenue where the former is measured as $100(\theta^4 - 1)$. The x axis value of 0.6 percent corresponds to our baseline calibration.

While the higher degree of regulation increases compliance costs for the subsidiary, it also decreases the amount of risk associated with lending. With lower risk and a fall in default rates, the subsidiary's sensitivity to entrepreneurs' leverage and lending spreads decline. This prompts entrepreneurs to increase their external borrowing and become more leveraged. The higher leverage and lower risk cause the cutoff value of the idiosyncratic shock to increase (as the distribution becomes less flat). The initial sharp decline in lending spreads bring down real borrowing rates despite an increase in regulatory costs. As the decline in lending spreads flatten out, regulatory costs become the primary driver and higher regulatory costs increase borrowing rates. Investment, as a share of output, drops in response to higher borrowing costs and domestic economy shrinks relative to the foreign economy.

4.2 Responses to global financial shocks

In this section, we investigate how our model variables respond to global financial shocks under different degrees of regulatory stringency. For each shock, we measure impulse responses under three scenarios. 1) Regulation is equally stringent in both economies, $\theta = \theta^* = 1.0015$, 2) Regulation is more stringent in the domestic economy and less stringent in the foreign economy, $\theta = 1.0030$, $\theta^* = 1.00075$, 3) Regulation is less stringent in the domestic economy and more stringent in the foreign economy, $\theta = 1.00075$, $\theta^* = 1.003$.

The first shock we introduce is a positive one standard deviation exogenous change in the net worth of the global banks. In response to this shock, the global banks' borrowing spreads decrease and so do the borrowing spreads of subsidiaries as this positive shock is transmitted to both economies. With lower borrowing spreads, cost of capital decreases, and investment and output increase. With higher returns to capital, entrepreneurs accumulate more net worth. Bank loans, nevertheless, increase due to the positive wedge between returns to capital and borrowing rates.

Under the baseline calibration with regulatory parity, the responses of the foreign economy are identical and thus the subplots measuring the relative change in variables (domestic variable response - foreign variable response) are equal to zero at all horizons. In the calibration with a higher degree of domestic regulation, we observe a stronger positive response of output. In the more regulated domestic economy, asset risk is lower and thus entrepreneurs are more leveraged and externally/bank financed. A drop in lending spreads, therefore, has a stronger positive effect on investment, output and net worth in this economy. Also, we observe that with a sharper increase in net worth, there is relatively less demand for bank loans (which further reduces spreads and lending rates) and thus the bank lending grows faster in the less regulated foreign economy. We should note, however, that since the amount of steady state bank lending is much higher in the highly regulated domestic economy, the increase in the volume of loans is still higher in this country. Therefore, the more regulated economy absorbs most of the growth in global bank funds.

The results mentioned above are reversed if the domestic banking is relatively less regulated. Under this calibration, there is less reliance on external finance (entrepreneurs have low leverage) and the decrease in borrowing spreads have a weaker positive effect on entrepreneurs' net worth (as well as investment and output). The higher level of investment, therefore, is financed, to a larger extent, by the subsidiary and bank loans grow faster in the domestic economy compared to the growth rate in the foreign economy. We draw opposite inferences if the bank net worth shock is negative.

The second shock that we investigate is a positive one standard deviation exogenous change in the risk free interest rates (policy rates). We introduce the shock symmetrically so that interest rates rise simultaneously in the two economies. This shock can be interpreted as a global coordination in monetary policy to decrease liquidity in financial markets. This type of shock is different from the first common shock as it affects the two economies both directly, and indirectly through the funding costs of global banks. By contrast the first shock's effects are transmitted only indirectly through the global banks' balance sheet. We should note here that any shock to the global banks' borrowing spreads (a change in the perception of risk in global financial markets for example) serves the same purpose and yields qualitatively similar results.

The responses to a one standard deviation increase in the risk free interest rates of the two countries are displayed in Figure 4. An increase in interest rates raise the cost of funding for the global bank which in turn generates higher lending rates in both economies. In response, there is a retrenchment in loans as investment drops. The negative response of net worth and the resulting hike in spreads suppresses investment further as the financial accelerator mechanism takes effect. This mechanism operates and amplifies the responses not only through entrepreneurs' balance sheets but also through those of the global bank. Higher funding costs and lower returns from the economies increase the global bank's borrowing spreads. These higher spreads get passed on to the banks' subsidiaries and therefore they are transmitted to the two economies.

A more central finding for our analysis is that the more regulated domestic economy suffers a bigger setback in response to the adverse shock. The reason is similar. The more leveraged, external finance dependent entrepreneurs in the highly regulated domestic economy are more negatively affected compared to the less leveraged entrepreneurs in the foreign economy. As a result, investment, output and entrepreneurial net worth in this economy shrink more substantially. Due to the larger drop in net worth in the domestic economy, there is a bigger demand for bank loans relative to the foreign economy. Bank loans, therefore, decrease by a smaller percentage in the more regulated country.

In general, these results show that higher regulation amplifies responses to common shocks, and that banks loans grow faster (slower) in the more regulated economy during market downturns (upswings).

4.3 Responses to country-specific shocks

In this section, we obtain the responses of domestic economic variables to shocks that originate in the domestic economy. The responses are obtained for the seven shocks displayed on the left hand side of Figure 5. Here, investment shock refers to an investment-specific technology shock that is introduced through the capital accumulation equation. This shocks affects the amount of investment that can be successfully converted to capital. The consumption shock represents a preference shock that affects the preference for current consumption over next quarter's consumption. On the supply side, we introduce a disembodied aggregate productivity shock through the production function of intermediate goods producers, and three cost push shocks, an exogenous change in domestic price, foreign price and wage mark-up. Finally, we include a shock to the real net worth of entrepreneurs that originates from an exogenous change in the survival rate of entrepreneurs. This shock, ultimately, affects the demand for loans and investment.

The baseline responses are fairly standard and they demonstrate the financial accelerator mechanism. According to this mechanism, the impact of the shock on output is typically reinforced by countercyclical borrowing spreads. An increase in output and net worth ensuing a productivity shock, for example, decreases borrowing spreads and prompts entrepreneurs to borrow and investment a greater amount.

With a lower degree of regulation, borrowing spreads become more sensitive to entrepreneurs' leverage. Any shock that impacts this leverage, therefore, has a larger effect on borrowing spreads, investment and output in the economy. These results are reversed with a higher degree of regulation and lower default risk as the leverage elasticity of borrowing spreads is lower. The responses for relative loan growth displayed in the last column show that global banking funds grow relatively faster (slower) in the domestic economy when shocks increase (decrease) the demand for loans. There is, however, a positive spillover to the foreign economy as the amplitudes of the relative loan responses are smaller than those for the domestic loan responses.

Comparing the results in this section with those obtained in the previous section reveals a clear disparity. While regulatory stringency amplifies output responses to global financial shocks, it mitigates the responses to domestic shocks. This disparity can be explained by how global banks respond to the two sets of shocks. When a global financial shock improves the global banks' balance sheets, for example, the banks decide to lend more since its borrowing costs are lower than its expected returns. A greater share of these extra amounts of loanable funds flow to the more regulated economy since entrepreneurs in this economy are more leveraged and more dependent on bank loans. The strength of this cross-country allocation of loans is much weaker for a country-specific shock. Global banking funds mostly flow into or out of the economy (depending on the nature of the shock) where the shock originates. As explained above, the strength of the financial accelerator mechanism and the leverage elasticity of borrowing spreads is much higher in the less regulated economy. The overall inference here, therefore, is that bank regulation could promote economic stability only if a country sustains domestic shocks. If global financial shocks are more prevalent then higher regulation could destabilize an economy.

4.4 Responses to other global shocks

The previous section revealed a disparity in the model responses to domestic and global financial shocks. In this section, we further classify global shocks as those that directly affect the borrowing spreads of global banks and those that do not. We do so to determine whether the disparity mentioned above is due to the influence of the global banks' financial condition or the global nature of the shock.

To incorporate non-financial global shocks, we assume that the 7 shocks mentioned in the previous section affect the two economies simultaneously. These common shocks are different from the two other global shocks that we have considered so far, i.e., common interest rate and global bank net worth shock, such that they affect the global banks' borrowing spreads only indirectly. While literature offers different interpretations of the common shocks (Canova and Marrinan,1998; Kwark, 1999; Kose et al., 2008) such as global risk aversion, change in prices of oil and commodities, global production and adoption of new technologies, it is a common observation that these shocks are important drivers of international business cycles.

The responses to one-standard-deviation common shocks are displayed in Figure 6. The main inference from these results is that if common shocks are not directly associated with the global banks' lending capabilities, they generally affect the economies similar to how domestic shocks do. Specifically, common shocks genereally have a bigger impact on output in the less regulated economy. Compared to the more regulated foreign economy, the amplification effect of the financial accelerator mechanism in the less regulated economy is stronger and borrowing spreads are more countercyclical for each shock except a consumption shock. The crowding-out effect of a consumption shock on investment is more pronounced in the less regulated economy since consumption constitutes a larger share of aggregate demand in this economy.

Comparing the amplitude of the responses with those in Figure 5, we also observe that the response of output is smaller when shocks have a simultaneous impact on the two economies. The reallocation of funds to or away from the domestic economy that we observe when it is the only economy that experiences a shock is more muted when both economies are simultaneously hit by the same shock.[9]

4.5 Global bank riskiness

The results from the previous two sections highlighted the importance of the financial accelerator mechanism for country-specific shocks (idiosyncratic and common shocks). In this section, we investigate how this mechanism affects the propagation of global financial shocks solely through the balance sheets of global banks. We do so by determining how the responses to global bank net worth shocks change with different degrees of global bank riskiness. In our baseline calibration, the standard deviation of the idiosyncratic asset quality shock that the global banks face was set equal to 0.0020444 with a corresponding leverage ratio of 10 and a leverage elasticity of borrowing spreads of 0.029. Here, we set the asset shock standard deviation equal to 0.214 and 0.0006 to approximate high and low global bank riskiness, respectively. This implies that banks' leverage elasticity of borrowing spreads is 0.031 and 0.0248, and their leverage ratio is 20 and 1.42 under high and low risk, respectively.

The results obtained with these alternative calibrations are displayed in Table 7. The main observation is that the output responses are larger (smaller) in magnitude when global banks' assets are subject higher (lower) risk. Also, the disparity between the output growth of the more regulated and the less regulated economy is magnified with higher global bank risk.[10] These results imply that country-specific regulation that aims to mitigate local financial market risk has to be accompanied by supranational regulation to be fully effective.

[9] As an alternative test, we allowed shocks to be positively correlated across the two economies. The impulse reponses from this alternative test pointed to similar inferences. We choose to report the results from the common shock specification since when shocks are correlated, shocks are identified by imposing dubious assumption. Specifically, orthogonal shocks are identified via a Cholesky restriction on the contemporaneous correlation matrix. If domestic shocks are ordered first, this implies that domestic economy shocks are not contemporaneously affected by foreign economy shocks. This is an arbitrary assumption for our two-country open economy model.

[10] We find similar results for the common interest rate shock. These results are not reported for brevity.

4.6 Effectiveness of regulation

So far, we assumed that an increase in the degree of regulation prompts a proportional drop in the risk of lending (i.e., lower variance of the idiosyncratic returns to capital shock). In this section, we test how our results change when we allow regulation to be more and less effective than in this baseline formulation. To simplify the analysis, we only consider the asymmetric case with higher domestic and lower foreign regulation. We should, however, note that the inferences are very similar when we use the calibration with lower domestic and higher foreign regulation as we explain below.

To incorporate regulatory effectiveness, we assume that while regulation has the same costs for firms, it may have a larger or a lower impact on the standard deviation of the idiosyncratic shock. At one extreme, we assume that regulation is not effective at all in reducing risk. This assumption generates the results displayed under column header "0" in Table 1. At the other end, we assume that regulation could be twice as effective in reducing risk as it is in the baseline calibration (with corresponding results displayed under column header "2"). We also consider the intermediate cases under which regulation is 50% less and more effective compared to the baseline scenario. For each experiment we assume that the foreign economy's regulatory effectiveness remains fixed to its baseline level.

Table 1 reports the results obtained for the domestic economy. The steady state moments displayed in the first three rows show that the effectiveness of regulation changes our steady state similar to how regulatory costs do. In particular, with higher effectiveness, there is lower risk, higher financial leverage and a lower leverage elasticity of borrowing spreads. The next set of results, the amplitudes of the impulse responses, reveal that the mechanisms that we inferred from our baseline simulations are reinforced with higher regulatory effectiveness. The global banks' net worth and funding shocks (common interest rate shock), for example, generate a higher response in the output growth rate of the more regulated domestic economy similar to our initial results and this disparity between the two growth rates is magnified when regulation is more effective in the domestic economy. Also similar to our earlier results, the shocks that are not directly related to global banks' financial conditions, generate a more muted response in the domestic economy and that this mitigation effect is stronger with higher regulatory effectiveness. The latter set of observations can be made from the last 4 rows of the table. Here we only report the results corresponding to a domestic and a common productivity shock for brevity. The results are similar for all the other shocks.

In alternative simulations, we considered the asymmetric case with lower domestic and higher foreign regulation. The inferences were similar as the results showed that the wedge between the output growth rate of the less and more regulated economies narrows (widens) if regulatory effectiveness in the less regulated economy increases (decreases).

4.7 Volatility costs of regulation

How economically important are the effects of regulation that we detected so far? The impulse responses to global bank net worth and common interest shocks indicate that with higher and lower regulation, output growth responses could be roughly 25 percent higher and lower, respectively. In this section, we investigate these economic effects of regulation in more detail by following four additional steps.

We first obtain model responses to the two global financial shocks (net worth and interest rate shock) and the domestic economy specific net worth and a common net worth shock (see below for an explanation of this choice). Second, we measure the effects of these shocks on the volatility of both output growth and lending rates under the three scenarios for regulation (regulatory parity, high domestic and low foreign regulation, low domestic and high foreign regulation). The two variables allow us to detect whether regulation is effective in promoting real and financial stability. As a third step, we set the standard deviation of our shocks to values estimated by some studies that use a similar two country, medium scale DSGE framework to compare our results across the four different shocks that we consider. In particular, we set the standard deviation of the global bank net worth shock equal to 0.1, the corresponding estimated value in Alpanda and Aysun (2014). We set the common interest, domestic economy specific and common productivity shocks equal to 0.002, 0.071 and 0.075, by adopting the estimates of Aysun (2016).[11] The reason we choose to report results for net worth shocks instead of productivity shocks in this section is that the estimates for the domestic and foreign net worth shock standard deviations were closer to each other relative to the productivity shocks of the two economies (U.S. and the Euro Area) in Aysun (2016). This

[11] Both Alpanda and Aysun (2014) and Aysun (2016) estimate their models by using data from the U.S. and the Euro Area.

shock is, therefore, a better fit for our symmetric two country model (symmetric in every aspect other than regulation).

Finally, we quantify volatility implications of regulation by measuring the effects of shocks on households' expected utility. We measure these effects as the share of their steady state level of consumption that households would be willing to pay to avoid the effects of the shocks that feed through the unconditional variances of the consumption and labor. We denote this welfare cost by u^{var} and measure it as follows:

$$\ln[(1+u^{var})(1-\zeta)C]-\tau = U - \frac{(1+\zeta)}{2(1-\zeta)} var(c_t) - \frac{\tau\nu}{2} var(l_t) - \frac{\zeta}{(1-\zeta)^2} cov(c_t, c_{t-1}) \tag{36}$$

where $U = \ln[(1-\zeta)C] - \tau$ and C are the steady state values of the utility function and consumption, respectively, and $\tau = \frac{(1-\alpha)}{\phi_w(1-\zeta)C/Y}$ ensures that labor supply is equal to one at steady state. u^{var} can be solved as,

$$u^{var} = \exp\left[-\frac{(1+\zeta)\,var(c_t)}{2(1-\zeta)} - \frac{\tau\nu var(l_t)}{2} - \frac{\zeta cov(c_t, c_{t-1})}{(1-\zeta)^2}\right] - 1 \tag{37}$$

We measure u^{var} by using the conditional moments of the simulated model variables and we repeat this exercise for the different regulatory scenarios mentioned above.

The results that we obtain by following these steps are reported in Table 2. The first column reports the interest cost of regulation for the three different scenarios. The main inferences from these results are consistent with our earlier findings. While higher regulation increases the volatility costs of global financial shocks (for both output and lending rate volatility), it decreases these costs when the economy faces domestic and non-financial global shocks. Consistent with this, we find that consumers are willing to give up a higher share of their consumption (0.349% for a global bank net worth shock, for example) when their economy is more regulated compared to the foreign economy and when they face global banking shocks. Conversely, domestic and other common shocks have smaller negative impact on their utility under more stringent regulation.

5 Some empirical evidence

A natural way to proceed would be to take our model predictions to data. An empirical analysis of the relationship between global banking flows, regulation and economic volatility, however, is confounded by the difficulties in relating global bank flows to regulation. In this section, we use a unique set of data and a scheme to provide a simple test for two predictions of our model: in response to an adverse global push shock (an increase in borrowing spreads), there is a larger growth of global banking claims and a sharper drop in output growth in more regulated countries.

We use Baa-Aaa corporate bond spreads (the Moody's Seasoned Baa-Aaa corporate bond spread obtained from the Federal Reserve Bank of St. Louis, FRED database) as our global push factor. This variable is commonly used an indicator of default risk perception, not only for the U.S. economy but also globally. It also provides for a simpler interpretation compared to other commonly used measures of global push effects in the literature such as the Gilchrist and Zakrajsek (2012) credit spread index, and the global factors of Miranda-Agrippino and Rey (2020), while at the same time demonstrating a high degree of correlation with these indices. We should note here that we do not attempt to include any variables that could help us capture the domestic and non-financial shocks in our model for the same reason. While it is possible to incorporate estimated shock series from two country models the interpretation of these shock series and how they relate to the other variables in the empirical model is far from straightforward.

To capture bilateral banking flows, we use the Bank for International Settlements' Consolidated Banking Statistics. This database includes annual data on the country-by-country claims for reporting country banks. To simplify our analysis we only collect the annual data, from 2000 to 2018, reported by banks chartered by U.S., U.K., and Germany. These banks constitute a larger share of the total claims reported in the database, they lend in 113 counterparty countries, and their claims include instruments (such as debt securities, loans and deposits) of all maturities, all currencies, for all sectors.

We approximate the degree of regulatory stringency in countries by using the Overall Financial Conglomerates Restrictiveness index of Barth et al. (2013). This index takes values between 3 and 12 (with higher values indicating higher stringency of regulation) and it is constructed by using responses to World Bank Surveys of Bank Regulation. The surveys are conducted in years

1999, 2003, 2007, 2011, covering 180 countries. We use these 4 surveys to incorporate regulatory stringency into our annual dataset. To do so, we use the indices from the 1999, 2003, 2007 and 2011 surveys for the periods, 2000-2003, 2004-2007, 2008-2011, 2012-2018, respectively.

To determine whether global banking claims grow faster and output grows slower in response to adverse push shocks in highly regulated host-nations, we first construct a regulation weighted relative claim growth variable, denoted by $rwcg_{it}$, as follows:

$$rwcg_{it} = \frac{\sum_{j=1}^{N^i} (r_{jt} cg_{ijt} - cg_{it})}{\sum_{j=1}^{N^i} r_{jt}} \tag{38}$$

where i and j index reporting countries (U.S., U.K., and Germany) and the counterparty/host nations, respectively. r_{jt} and cg_{ijt} represent the regulatory index and the claim growth of reporting country i in host-nation j, and cg_{it} denotes the total claim growth rate of country i. According to this formulation, the relative growth variable, assigns a higher weight to the claim growth of highly-regulated countries in which country i's banks hold claims. By subtracting the total claim growth rate, therefore, we ensure that the direction of the change in $rwcg_{it}$ are determined by the claim growths in highly regulated countries. A reallocation of global bank funds away from the less regulated countries towards those that are more regulated, for example, would generate a positive response of $rwcg_{it}$.

Next, we combine our global push measure, the relative claim growth variable, and real Gross Domestic Product (GDP) growth rate of host-nations to form a Structural Vector Autoregression (SVAR) model. The latter variable is included to capture local pull effects that may also drive global banking flows. When measuring this variable we follow the same formulation above and capture the relative growth rate in highly regulated nations that reporting banks hold claims in. A positive (negative) value of this variable then indicates that real GDP grows faster (slower) in the more regulated countries where reporting banks hold claims.

To identify orthogonal shocks, we use a Cholesky decomposition where the push factor is ordered first, followed by relative GDP growth and the relative claim growth variable. This ordering reasonably implies that the global factor is not contemporaneously affected by host nation specific variables and that GDP growth of nations' is not affected by the relative claim growth within the same period. This also implies that global banks' claim growth is driven by both past and current changes in push and pull conditions.

The responses of the relative claim and GDP growth rate variables to a 1% borrowing spread shock are displayed in Figure 8. These responses are consistent with our earlier findings. Specifically, an adverse push shock prompts a larger growth in global bank claims and a more pronounced decrease in the output growth rate of highly-regulated countries. This observation is made for all three of the reporting countries.[12]

6 Conclusion

This paper demonstrates that national bank regulation can ensure financial and economy stability only if business cycles are driven by domestic and non-financial global shocks. If global financial shocks are more prevalent, by contrast, national regulatory policies can be destabilizing. These inferences are drawn from a two-country DSGE model with global banking and bank regulation. In the model, the country with more strict regulation has less financial market risk. Firms in this country are, therefore, more leveraged with a higher degree of bank borrowing at steady state, and lending rates are less sensitive to firms' leverage. Conversely, the firms in the less regulated country are less leveraged and are more internal finance dependent. The ebbs and flows of global bank lending that are prompted by global financial shocks are then mostly sustained by the more bank-reliant, highly regulated country, which in turn destabilizes its economy. Conversely, if the shocks originate domestically or they are global yet non-financial in nature, regulation promotes stability because the lower elasticity of lending spreads mitigate the amplification generated by the financial accelerator mechanism.

The paper finds that the destabilizing and stabilizing effects of regulation are economically important and that they are magnified when global banks have a higher probability of default and if regulation is more effective in reducing financial market risk. The paper also finds some empirical evidence that is consistent with model predictions.

We believe that there are two extensions to our analysis that could produce interesting infer-

[12] We obtained qualititatively similar result for the remaining 28 reporting countries in the BIS database. We omit these results for brevity but they are available upon request.

ences. Our model does not include endogenous growth. It is plausible to assume that the risk-reduction due to higher regulation could inhibit high-risk, high reward, growth enhancing activities. Specifically, if regulation directs bank lending towards safer low-growth industries/activities, there could be a stability-growth trade-off in economies that predominantly face domestic shocks. It could be interesting to analyze and quantify this trade-off.

Second, we assume that the stringency of regulation is independent of the business cycle. There is, however, evidence indicating that regulation can be more binding and strict during economic downturns (e.g., Albertazzi et al., 2009; Goldstein, 2009; Blinder, 2015; Almasi, et al. 2018; Dagher, 2018; Beatty et al., 2019). While we predict that this potential feature of regulation would reinforce our main inferences as the financial accelerator mechanism becomes stronger, it would be interesting to determine the quantitative significance of countercyclical regulatory stringency.

References

[1] Albertazzi U., P. Angelini, F. Columba, W. Cornacchia, A. Di Cesare, F. Panetta, A. Pilati, C. Salleo, G. Santini, 2009. "Financial sector pro-cyclicality: lessons from the crisis," Questioni di Economia e Finanza (Occasional Papers) 44, Bank of Italy, Economic Research and International Relations Area.

[2] Almasi, P., J. Dagher, C. Prato, 2018. “Regulatory Cycles: A Political Economy Model,” mimeo.

[3] Alpanda, S., and U. Aysun, 2012. “Global Banking and the Balance Sheet Channel of Monetary Transmission,” *International Journal of Central Banking*, 8, 141-175.

[4] Alpanda, S., and U. Aysun, 2014. “International Transmission of Financial Shocks in an Estimated DSGE Model,” *Journal of International Money and Finance*, 47, 21-55.

[5] Avdjiev, S., U. Aysun, R. Hepp, 2019. “What drives local lending by global banks?” *Journal of International Money and Finance*, 90(C), 54-75.

[6] Aysun, U., 2016. “Searching for the source of macroeconomic integration across advanced economies,” Oxford Economic Papers, 68(2), 316-339.

[7] Beatty, A., S., Liao, H. Zhang, 2019. "The effect of banks’ financial reporting on syndicated-loan structures," Journal of Accounting and Economics, 67(2), 496-520.

[8] Barth, J.R., G. Caprio, R. Levine, 2013. "Bank Regulation and Supervision in 180 Countries from 1999 to 2011." National Bureau of Economic Research Working Paper 18733.

[9] Barth, J.R., G. Caprio, R. Levine, 2004. "Bank regulation and supervision: What works best?" Journal of Financial Intermediation 13, 205-248.

[10] Bernanke, B. S., M. Gertler, and S. Gilchrist, 1999. “The Financial Accelerator in a Quantitative Business Cycle Framework.” in *Handbook of Macroeconomics vol. 1C*, ed. by J. B. Taylor and M. Woodford, 1341-93. Amsterdam: Elsevier Science, North-Holland.

[11] Blinder, A.S., 2015. "Financial Entropy and the Optimality of Over-regulation,” The New International Financial System: Analyzing the Cumulative Impact of Regulatory Reform, 48, 3.

[12] Bremus, F., M. Fratzscher, 2015. "Drivers of structural change in cross-border banking since the global financial crisis," Journal of International Money and Finance, 52, 32-59.

[13] Buch, C.M., 2000. “Why Do Banks Go Abroad? Evidence from German Data,” *Financial Markets, Institutions and Instruments*, 9, 33-67.

[14] Buch, C., and G. DeLong, 2008. "Do weak supervisory systems encourage bank risk taking?" Journal of Financial Stability 4, 23-39.

[15] Buch, C., C. Koch, and M. Koetter, 2016. “Crises and rescues: liquidity transmission through international banks,”Bank for International Settlements, Working Paper No: 576, August.

[16] Bruno, V., and H. Shin, 2015. “Capital flows, cross-border banking and global liquidity,” Review of Economic Studies, 82 (2), 535-564.

[17] Cetorelli, N., and L. Goldberg, 2012a. “Liquidity management of U.S. Global Banks: Internal Capital Markets in the Great Recession”, Journal of International Economics, 88, 299-311.

[18] ____________________________, 2012b. “Banking Globalization and Monetary Transmission,” *Journal of Finance*, 67, 1811-1843.*mics*, 11, 155-178.

[19] Christiano, L.J., M. Eichenbaum, and C. L. Evans, 2005. “Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy,” *Journal of Political Economy*, 113, 1-45.

[20] Dagher, J. 2018. "Regulatory Cycles: Revisiting the Political Economy of Financial Crises", IMF Working Paper, WP 18/8.

[21] Davis, J. S., 2010. “The adverse feedback loop and the effects of risk in both the real and financial sectors,” Federal Reserve Bank of Dallas Globalization and Monetary Policy Institute Working Paper No. 66.

[22] De Haas, R., and I. Van Lelyveld, 2006. “Foreign Banks and Credit Stability in Central and Eastern Europe. A Panel Data Analysis,” *Journal of Banking and Finance*, 30, 1927-1952.

[23] De Haas, R., and I. Van Lelyveld, 2010. “Internal Capital Markets and Lending by Multinational Bank Subsidiaries,” *Journal of Financial Intermediation*, 19, 1-25.

[24] Delis, M., and P. Staikouras. 2011. “Supervisory Effectiveness and Bank Risk.” Review of Finance 15, 3, 511–543.

[25] Adjemian, S., H. Bastani, M. Juillard, F. Karamé, F. Mihoubi, G. Perendia, J. Pfeifer, M. Ratto, and S. Villemot, 2011. “Dynare: Reference Manual, Version 4,” Dynare Working Papers, 1, CEPREMAP.

[26] Fernandez-Villaverde, J., 2010. “Fiscal Policy in a Model With Financial Frictions,” *American Economic Review: Papers & Proceedings*, 100, 35-40.

[27] Fratzscher, M., 2012. “Capital flows, push versus pull factors and the global financial crisis," Journal of International Economics, 88(2), 341-356.

[28] Gerali, A., S. Neri, L. Sessa, and F. Signoretti, 2010. “Credit and banking in a DSGE model of the Euro area,” *Journal of Money Credit and Banking*, 42, 107-141.

[29] Gertler, M., S. Gilchrist, and F. M. Natalucci, 2007. “External Constraints on Monetary Policy and the Financial Accelerator,” *Journal of Money, Credit and Banking*, 39, 295-330.

[30] Gilchrist, S., E. Zakrajsek, 2012. “Credit Spreads and Business Cycle Fluctuations,” American Economic Review, 102(4), 1692–1720.

[31] Goldberg, L., 2002. “When Is U.S. Bank Lending to Emerging Markets Volatile?” in *Preventing Currency Crises in Emerging Markets*, ed. S. Edwards and J. A. Frankel, 171-196. Boston: NBER.

[32] Goldberg, L., 2009. "Understanding banking sector globalization," International Monetary Fund, Staff Papers, 56(1), 171-197.

[33] Goldstein, M., 2009. "Reforming financial regulation, supervision, and oversight: What to do and who should do it," VoxEU.org, 24 February.

[34] Houston, J F., C. Lin, Y. Ma, 2012. “Regulatory Arbitrage and International Bank Flows”, Journal of Finance 67(5): 1845-1895.

[35] Jeanneau, S., and Micu, M., 2002. “Determinants of International Bank Lending to Emerging Market Countries,” BIS Working Paper No. 112.

[36] Justiniano, A., and B. Preston, 2010. “Monetary Policy and Uncertainty in an Empirical Small Open Economy Model,” *Journal of Applied Econometrics*, 25, 93-128.

[37] Kim, D., A. Santomero, 1994. "Riks in banking and capital regulation," Journal of Finance, 43, 1219-1233.

[38] Klomp, J., and J. de Haan, 2012. “Banking Risk and Regulation: Does One Size Fit All?” Journal of Banking and Finance 36, 12, 3197–3212.

[39] Koepke, R., 2015. “What Drives Capital Flows to Emerging Markets? A Survey of the Empirical Literature,”MPRA Paper 62770, University Library of Munich, Germany.

[40] Laeven, L., R. Levine, 2009. "Bank governance, regulation and risk taking," Journal of Financial Economics, 93, 259-275.

[41] Martinez Peria, M. S., A. Powell, and I.V. Hollar, 2002. “Banking on Foreigners: The Behavior of International Bank Lending to Latin America, 1985–2000,” World Bank Policy Research Working Paper No. 2893.

[42] Meh, C., and K. Moran (2010). “The Role of Bank Capital in the Propagation of Shocks,” *Journal of Economic Dynamics and Control*, 34, 555-576.

[43] Miranda-Agrippino S., H. Rey, 2020. "US Monetary Policy and the Global Financial Cycle," Review of Economic Studies, https://doi.org/10.1093/restud/rdaa019.

[44] Morgan, D. P., and P.E. Strahan, 2004. "Foreign Bank Entry and Business Volatility: Evidence from U.S. States and Other Countries." in *Foreign Banking Market Structure and Monetary Policy*, ed. Luis Ahumada and J. Fuentes. Santiago: Central Bank of Chile.

[45] Ongena, S., A. Popov, G.F. Udell, 2013. "When the cat's away the mice will play: Does regulation at home affect bank risk-taking abroad?" Journal of Financial Economics, 108(3), 727-750.

[46] Rey, H., 2015. "Dilemma not Trilemma: The global Financial Cycle and Monetary Policy Independence," National Bureau of Economic Research Working Paper No: 21162.

[47] Rotemberg, J. J., 1982. "Monopolistic Price Adjustment and Aggregate Output," *Review of Economic Studies*, 49, 517-31

[48] Schnabl, P., 2012. "International Transmission of Bank Liquidity Shocks: Evidence from an Emerging Market,"Journal of Finance 67, 897-932.

[49] Schoenmaker, D., 2011. "The financial trilemma," Economics Letters, 111(1), 57-59.

[50] Schoenmaker, D., 2013. "Governance of International Banking: The Financial Trilemma," OUP Catalogue, Oxford University Press, no: 9780199971596.

[51] Shin, H. S., 2012. .Global Banking Glut and Loan Risk Premium,.Mundell-Fleming Lecture, IMF Economic Review 60 (2), 155-192.

[52] Smets, F., and R. Wouters, 2007. "Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach," *American Economic Review*, 97, 586-606.

[53] Van den Heuvel, S. J., 2008. "The welfare cost of bank capital requirements," *Journal of Monetary Economics*, 55, 298-320.

A Appendix on the Model

A.1 Households

The economy is populated by a unit measure of infinitely-lived households indexed by j. Household j's intertemporal preferences over consumption, c_t, and labor, l_t, are described by the following expected utility function:

$$E_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \varepsilon_{c,\tau} \left(\log \left[c_\tau (j) - \zeta \bar{c}_{\tau-1} \right] - \frac{l_\tau (j)^{1+\vartheta}}{1+\vartheta} \right), \tag{39}$$

where t indexes time, $\beta < 1$ is the time-discount parameter, $\bar{c}_t$ denotes aggregate consumption, ζ is the external habit parameter, ϑ is the inverse of the Frisch-elasticity of labor supply, and the preference shock, $\varepsilon_{c,t}$, follows an AR(1) process:

$$\log \varepsilon_{c,t} = \rho_c \log \varepsilon_{c,t-1} + \eta_{c,t}, \tag{40}$$

where ρ_c is the persistence parameter and $\eta_{c,t}$ is the i.i.d. innovation with standard deviation equal to σ_c.[13]

Labor services are heterogeneous across the households, and are aggregated into a homogenous labor service by perfectly-competitive labor intermediaries, who in turn rent these labor services to domestic intermediate goods producers. The labor intermediaries use a standard Dixit-Stiglitz aggregator; therefore, the labor demand curve facing each household is given by

$$l_t (j) = \left(\frac{W_t (j)}{W_t} \right)^{-\theta_{l,t}} l_t, \tag{41}$$

where W_t and l_t are the aggregate nominal wage rate and labor supply of households respectively, and $\theta_{l,t}$ is the (time-varying) elasticity of substitution between the differentiated labor services. To capture cost-push shocks on wages, we specify an exogenous AR(1) process on $\varepsilon_{w,t} = \theta_{l,t}/(\theta_{l,t} - 1)$ as:

$$\log \varepsilon_{w,t} = (1 - \rho_w) \log \phi_w + \rho_w \log \varepsilon_{w,t-1} + \eta_{w,t}, \tag{42}$$

[13] In what follows, we denote the persistence of all shocks as ρ, and the standard deviation of shock innovations as σ, with appropriate subscripts corresponding to each shock.

where ϕ_w is the gross mark-up of real wage over the marginal rate of substitution at the steady-state.

The households' period budget constraint is given by

$$c_t(j) + \frac{D_t(j)}{P_t} + \frac{B_{h,t}(j)}{R_t P_t} + \frac{e_t B_{f,t}(j)}{\varepsilon_{d,t} R_t^* P_t} \leq \frac{W_t(j)}{P_t} l_t(j) + R_{t-1} \frac{D_{t-1}(j)}{P_t} + \frac{B_{h,t-1}(j)}{P_t}$$
$$+ \frac{e_t B_{f,t-1}(j)}{P_t} - \frac{T_t}{P_t} + \frac{Tr_t}{P_t} - \frac{\kappa_w}{2} \left(\frac{W_t(j) / W_{t-1}(j)}{\gamma \pi_{t-1}^{\varsigma_w} \pi^{1-\varsigma_w}} - 1 \right)^2 \frac{W_t}{P_t} l_t, \tag{43}$$

where P_t is the consumption price index, D_t is bank deposits, $B_{h,t}$ and $B_{f,t}$ are holdings of home and foreign government bonds, T_t is lump-sum taxes paid to the government, and Tr_t is net lump-sum transfers to households (including profits of monopolistically competitive firms, net worth of dead entrepreneurs minus the startup funds for new entrepreneurs, as well as resources spent on price adjustment costs, capital utilization costs and monitoring costs). Domestic and foreign bonds trade at a discount R_t and $\varepsilon_{d,t} R_t^*$ respectively, where R_t and R_t^* are the policy rates in the domestic and foreign economies, and $\varepsilon_{d,t}$ is an exogenous country-risk premium shock following an AR(1) process. Households also receive interest income from their deposits at the global banks, which, net of defaults, pay at a rate equal to the policy rate. Wage-stickiness is introduced via a quadratic cost of wage adjustment similar to Rotemberg (1982) where κ_w is a level parameter, γ is the growth factor of the economy at the steady-state, $\pi_t = P_t / P_{t-1}$ is the aggregate inflation factor, and ς_w determines indexation of wage adjustments to past inflation.

The households' objective is to maximize utility subject to the budget constraint, the labor demand curve of labor intermediaries, and appropriate No-Ponzi conditions. The households' first-order-conditions with respect to consumption, labor, domestic bonds/deposits, foreign bonds, and the wage rate are given, respectively, by

$$\frac{\varepsilon_{c,t}}{c_t - \zeta c_{t-1}} = \lambda_t, \tag{44}$$

$$\varepsilon_{c,t} l_t^{\vartheta} = \lambda_t \Omega_t \frac{W_t}{P_t}, \tag{45}$$

$$1 = E_t \left[\left(\beta \frac{\lambda_{t+1}}{\lambda_t} \right) \frac{R_t}{\pi_{t+1}} \right], \tag{46}$$

$$1 = E_t \left[\left(\beta \frac{\lambda_{t+1}}{\lambda_t} \right) \frac{\varepsilon_{d,t} R_t^*}{\pi_{t+1}} \frac{e_{t+1}}{e_t} \right], \tag{47}$$

$$\left(\frac{\pi_{w,t}}{\gamma \pi_{t-1}^{\varsigma_w} \pi^{1-\varsigma_w}} - 1 \right) \frac{\pi_{w,t}}{\gamma \pi_{t-1}^{\varsigma_w} \pi^{1-\varsigma_w}} \tag{48}$$

$$= E_t \left[\left(\beta \frac{\lambda_{t+1}}{\lambda_t} \right) \left(\frac{\pi_{w,t+1}}{\gamma \pi_t^{\varsigma_w} \pi^{1-\varsigma_w}} - 1 \right) \frac{\pi_{w,t+1}}{\pi_t^{\varsigma_w} \pi^{1-\varsigma_w}} \frac{\pi_{w,t+1}}{\pi_{t+1}} \frac{l_{t+1}}{l_t} \right] - \frac{\theta_{l,t} - 1}{\kappa_w} \left(1 - \Omega_t \varepsilon_{w,t}\right),$$

where λ_t and Ω_t are the Lagrange multipliers on the budget constraint and the labor demand curve, respectively, and $\pi_{w,t} = W_t / W_{t-1}$ is the nominal wage inflation.

The optimality conditions for consumption and domestic bonds can be combined to yield the consumption demand equation, which, after detrending and log-linearization around the steady-state, is given by[14]

$$\widehat{c}_t = \frac{1}{1 + \zeta/\gamma} E_t \widehat{c}_{t+1} + \frac{\zeta/\gamma}{1 + \zeta/\gamma} \widehat{c}_{t-1} - \frac{1 - \zeta/\gamma}{1 + \zeta/\gamma} \left(\widehat{R}_t - E_t \widehat{\pi}_{t+1} \right) + \varepsilon_{c,t}, \tag{49}$$

where the standard deviation of the consumption shock, $\varepsilon_{c,t}$, is scaled to ensure that it enters the log-linearized expression with a coefficient of 1.[15] Similarly, arbitrage between domestic and foreign bonds (after log-linearization) implies the following uncovered interest-parity condition:

$$\widehat{R}_t - \widehat{R}_t^* = E_t \widehat{d}_{t+1} + \varepsilon_{d,t}, \tag{50}$$

where $d_t = e_t / e_{t-1}$ denotes the nominal depreciation rate of domestic currency. Finally, the optimality conditions with respect to labor and wages can be combined to derive the New-Keynesian wage Phillips curve as

$$\widehat{\pi}_{w,t} - \varsigma_w \widehat{\pi}_{t-1} = \beta E_t \left[\widehat{\pi}_{w,t+1} - \varsigma_w \widehat{\pi}_t \right] - \frac{\theta_l - 1}{\kappa_w} \left[\widehat{w}_t - \left(\vartheta \widehat{l}_t + \frac{1}{1 - \zeta/\gamma} \left(\widehat{c}_t - \frac{\zeta}{\gamma} \widehat{c}_{t-1} \right) \right) \right] + \varepsilon_{w,t}, \tag{51}$$

where $w_t = W_t / P_t$ refers to the real wage, and the cost-push shock $\varepsilon_{w,t}$ is rescaled. The nominal wage inflation and the real wage rate are related as

$$\widehat{\pi}_{w,t} = \widehat{w}_t - \widehat{w}_{t-1} + \widehat{\pi}_t. \tag{52}$$

[14] Note that aggregate variables in the economy grow with a factor of γ along the balanced growth path of the economy. The model variables are appropriately detrended before log-linearization.

[15] This type of scaling is without loss of generality, and will also be applied to other shocks in the model.

A.2 Capital producers

Capital producers are perfectly competitive. After goods production takes place, these firms purchase the undepreciated part of the installed capital from entrepreneurs at a relative price of q_t, and the new investment goods from final goods firms at a price of P_t^i, and produce the capital stock to be carried over to the next period. This production is subject to adjustment costs in the change in investment, and is described by the following law-of-motion for capital:

$$k_t = (1-\delta)\,k_{t-1} + \left[1 - \frac{\kappa_i}{2}\left(\frac{i_t}{\gamma i_{t-1}} - 1\right)^2\right]\varepsilon_{i,t} i_t, \tag{53}$$

where κ_i is the adjustment cost parameter, and $\varepsilon_{i,t}$ captures investment-specific technological change which is assumed to be exogenous and follows an AR(1) process.

After capital production, the end-of-period installed capital stock is sold back to entrepreneurs at the installed capital price of q_t. The capital producers' objective is thus to maximize

$$E_t \sum_{\tau=t}^{\infty} \beta^{\tau-t}\frac{\lambda_\tau}{\lambda_t}\left[q_\tau k_\tau - q_\tau\,(1-\delta)\,k_{\tau-1} - \frac{P_{i,\tau}}{P_t} i_\tau\right], \tag{54}$$

subject to the law-of-motion of capital, where future profits are again discounted using the patient households' stochastic discount factor. The first-order-condition of capital producers with respect to investment goods yields

$$\begin{aligned} q_t\varepsilon_{i,t} - \kappa_i q_t\left(\frac{i_t}{\gamma i_{t-1}} - 1\right)\frac{\varepsilon_{i,t} i_t}{\gamma i_{t-1}} - q_t\frac{\kappa_i}{2}\left(\frac{i_t}{\gamma i_{t-1}} - 1\right)^2 \varepsilon_{i,t} \\ + E_t\left[\left(\beta\frac{\lambda_{t+1}}{\lambda_t}\right)\kappa_i q_{t+1}\left(\frac{i_{t+1}}{\gamma i_t} - 1\right)\frac{i_{t+1}}{\gamma i_t}\frac{\varepsilon_{i,t+1} i_{t+1}}{i_t}\right] - \frac{P_{i,t}}{P_t} = 0, \end{aligned} \tag{55}$$

which, in log-linearized form, yields the following investment demand equation:

$$\widehat{i}_t = \frac{\beta}{1+\beta}E_t\widehat{i}_{t+1} + \frac{1}{1+\beta}\widehat{i}_{t-1} + \frac{1}{(1+\beta)\,\kappa_i}\left(\widehat{q}_t - \widehat{p}_t^i\right) + \varepsilon_{i,t}, \tag{56}$$

where the investment shock is rescaled. After detrending and log-linearization, the law-of-motion for capital can be written as

$$\widehat{k}_t = \frac{1-\delta}{\gamma}\widehat{k}_{t-1} + \left(1 - \frac{1-\delta}{\gamma}\right)\left[\widehat{i}_t + (1+\beta)\,\kappa_i \varepsilon_{i,t}\right], \tag{57}$$

where the investment shock is consistent with the rescaling of this shock in (56).

A.3 Final goods aggregators

The final consumption good, c_t, is a CES (constant elasticity of substitution) aggregate of domestic final goods, $c_{h,t}$, and imported final goods, $c_{f,t}$. Both $c_{h,t}$ and $c_{f,t}$ are themselves aggregates, in Dixit-Stiglitz fashion, of domestic intermediate goods, $c_{h,t}(j)$, and imported intermediate goods, $c_{f,t}(j)$, as will be explained in the next two subsections. In what follows, we describe the consumption goods aggregators, but investment goods aggregators are modeled in an analogous fashion.

Consumption aggregators are perfectly competitive, and they produce the final goods as a CES aggregate of home and foreign final goods, $c_{h,t}$ and $c_{f,t}$:

$$c_t = \left(\gamma_c^{\frac{1}{\lambda_c}} c_{h,t}^{\frac{\lambda_c - 1}{\lambda_c}} + (1-\gamma_c)^{\frac{1}{\lambda_c}} c_{f,t}^{\frac{\lambda_c - 1}{\lambda_c}}\right)^{\frac{\lambda_c}{\lambda_c - 1}}, \tag{58}$$

where γ_c denotes the share of domestic goods, and λ_c is the elasticity of substitution between home and foreign goods in the consumption aggregate. After detrending and log-linearization, this consumption aggregate can be written as

$$\widehat{c}_t = \gamma_c \widehat{c}_{h,t} + (1-\gamma_c)\,\widehat{c}_{f,t}. \tag{59}$$

Since the final goods producers are perfectly competitive, they earn zero profits in equilibrium. For any level of output, their optimal demand for the domestic and imported final goods are thus given by

$$c_{h,t} = \left(\frac{P_{h,t}}{P_t}\right)^{-\lambda_c} \gamma_c c_t \text{ and } c_{f,t} = \left(\frac{P_{f,t}}{P_t}\right)^{-\lambda_c} (1-\gamma_c)\, c_t, \tag{60}$$

where $P_{h,t}$ and $P_{f,t}$ are the prices of the home and foreign goods respectively, while P_t is the price of the final consumption good. Combining these, detrending and log-linearizing yields:

$$\widehat{c}_{h,t} - \widehat{c}_{f,t} = \lambda_c \left(\widehat{p}_{f,t} - \widehat{p}_{h,t} \right). \tag{61}$$

The aggregate price index for consumption goods is given by

$$P_t = \left[\gamma_c P_{h,t}^{1-\lambda_c} + (1-\gamma_c) P_{f,t}^{1-\lambda_c} \right]^{\frac{1}{1-\lambda_c}}, \tag{62}$$

which, in log-linearized form and after first-differencing, can be written as

$$\widehat{\pi}_t = \gamma_c \widehat{\pi}_{h,t} + (1-\gamma_c) \widehat{\pi}_{f,t}, \tag{63}$$

where $\pi_{h,t} = P_{h,t}/P_{h,t-1}$ is the home-goods price inflation, and $\pi_{f,t} = P_{f,t}/P_{f,t-1}$ is the imported-goods price inflation.

The analogous expressions for investment goods aggregators are given by:

$$i_t = \left(\gamma_i^{\frac{1}{\lambda_i}} i_{h,t}^{\frac{\lambda_i - 1}{\lambda_i}} + (1-\gamma_i)^{\frac{1}{\lambda_i}} i_{f,t}^{\frac{\lambda_i - 1}{\lambda_i}} \right)^{\frac{\lambda_i}{\lambda_i - 1}}, \tag{64}$$

$$i_{h,t} = \left(\frac{P_{h,t}}{P_t^i} \right)^{-\lambda_i} \gamma_i i_t \text{ and } i_{f,t} = \left(\frac{P_{f,t}}{P_t^i} \right)^{-\lambda_i} (1-\gamma_i) i_t, \tag{65}$$

$$P_{i,t} = \left[\gamma_i P_{h,t}^{1-\lambda_i} + (1-\gamma_i) P_{f,t}^{1-\lambda_i} \right]^{\frac{1}{1-\lambda_i}}, \tag{66}$$

which in log-linearized form can be written as

$$\widehat{i}_t = \gamma_i \widehat{i}_{h,t} + (1-\gamma_i) \widehat{i}_{f,t}, \tag{67}$$

$$\widehat{i}_{h,t} - \widehat{i}_{f,t} = \lambda_i \left(\widehat{p}_{f,t} - \widehat{p}_{h,t} \right), \tag{68}$$

$$\widehat{p}_{i,t} = \gamma_i \widehat{p}_{h,t} + (1-\gamma_i) \widehat{p}_{f,t}. \tag{69}$$

A.4 Domestic intermediate goods firms

There is a unit measure of monopolistically competitive domestic intermediate goods firms indexed by j. Their technology is described by the following production function:

$$y_t(j) = \varepsilon_{a,t} \left[u_t(j)\, k_{t-1}(j)\right]^{\alpha} \left[A_t l_t(j)\right]^{1-\alpha} - \gamma^t f, \tag{70}$$

where α is the share of capital, u_t is the capital utilization rate, and f is a fixed cost of production.[16] A_t is the deterministic component of the level of total-factor-productivity (TFP), and grows at a constant factor γ. The aggregate productivity shock, $\varepsilon_{a,t}$, follows an AR(1) process.

Domestic goods produced are heterogeneous across firms, and are aggregated into a homogenous domestic final good by perfectly-competitive final goods producers using a standard Dixit-Stiglitz aggregator. The demand curve facing each firm is given by

$$y_t(j) = \left(\frac{P_{h,t}(j)}{P_{h,t}}\right)^{-\theta_{h,t}} y_t, \tag{71}$$

where y_t is aggregate domestic output, and $\theta_{h,t}$ is a time-varying elasticity of substitution between the differentiated goods. To capture cost-push shocks, we specify an exogenous AR(1) process on $\varepsilon_{h,t} = \theta_{h,t}/(\theta_{h,t}-1)$,

$$\log \varepsilon_{h,t} = (1-\rho_h)\log\phi_p + \rho_h \log \varepsilon_{h,t-1} + \eta_{h,t}, \tag{72}$$

where ϕ_p is the gross mark-up of price over marginal cost at the steady-state.

Firm j's profits at period t is given by

$$\begin{aligned}\frac{\Pi_{h,t}(j)}{P_t} &= \frac{P_{h,t}(j)}{P_t} y_t(j) - \frac{W_t}{P_t} N_t l_t(j) - mpk_t k_{t-1}(j) \\ &\quad - \frac{\kappa_u}{1+\varpi}\left[u_t(j)^{1+\varpi} - 1\right] k_{t-1}(j) - \frac{\kappa_{ph}}{2}\left(\frac{P_{h,t}(j)/P_{h,t-1}(j)}{\pi_{h,t-1}^{\varsigma_h}\pi^{1-\varsigma_h}} - 1\right)^2 \frac{P_{h,t}}{P_t} y_t\end{aligned} \tag{73}$$

where mpk_t is the rental rate of capital, and κ_u and ϖ are the level and elasticity parameters for the utilization cost specification, respectively. Similar to wage-stickiness, price-stickiness is introduced

[16] Note that fixed costs increase as the economy grows to preserve the existence of a balanced growth path. Also, the fixed cost parameter f is set equal to $\phi_p - 1$ times the steady-state level of detrended output to ensure that pure economic profits are zero at the steady-state; hence, there is no incentive for firm entry and exit in the long-run.

via quadratic adjustment costs with level parameter κ_{ph}, and ς_h captures the extent to which price adjustments are indexed to past inflation.

A domestic firm's objective is to choose input and output quantities and output price to maximize the present value of profits (using the households' stochastic discount factor) subject to the demand function they are facing with respect to their individual output from the aggregators. The first-order-conditions of the firm with respect to labor, capital and the utilization rate are given by:

$$\Omega_{h,t}\frac{P_{h,t}}{P_t}(1-\alpha)\frac{y_t+(\eta\gamma)^t f}{l_t} = \frac{W_t}{P_t}, \tag{74}$$

$$\Omega_{h,t}\frac{P_{h,t}}{P_t}\alpha\frac{y_t+(\eta\gamma)^t f}{k_{t-1}} = mpk_t + \frac{\kappa_u}{1+\varpi}\left(u_t^{1+\varpi}-1\right), \tag{75}$$

$$\Omega_{h,t}\frac{P_{h,t}}{P_t}\alpha\frac{y_t+(\eta\gamma)^t f}{u_t} = \kappa_u u_t^{\varpi} k_{t-1}, \tag{76}$$

where $\Omega_{h,t}$ is the Lagrange multiplier with respect to the output demand facing each domestic firm. After log-linearization, the first two expressions above can be combined to relate the capital-labor ratio to the relative price of inputs as

$$\widehat{w}_t - \widehat{mpk}_t = \widehat{u}_t + \widehat{k}_{t-1} - \widehat{l}_t, \tag{77}$$

while the last two expressions can be combined to yield[17]

$$\widehat{u}_t = \frac{1}{\varpi}\widehat{mpk}_t.$$

The production function can be log-linearized as

$$\widehat{y}_t = \phi_p\left[\varepsilon_{a,t} + \alpha\left(\widehat{u}_t + \widehat{k}_{t-1}\right) + (1-\alpha)\,\widehat{l}_t\right]. \tag{78}$$

The first-order-condition with respect to price is respectively given by:

$$\left(\frac{\pi_{h,t}}{\pi_{h,t-1}^{\varsigma_h}\pi^{1-\varsigma_h}} - 1\right)\frac{\pi_{h,t}}{\pi_{h,t-1}^{\varsigma_h}\pi^{1-\varsigma_h}}$$

[17] Note that κ_u is set to the steady-state value of mpk_t to ensure that the capital utilization rate, u_t, is equal to 1 at the steady-state. This is without-loss-of-generality, and the first-order-conditions presented in the text reflect this choice.

$$= E_t \left[\left(\beta \frac{\lambda_{t+1}}{\lambda_t} \right) \left(\frac{\pi_{h,t+1}}{\pi_{h,t}^{\varsigma_h} \pi^{1-\varsigma_h}} - 1 \right) \frac{\pi_{h,t+1}}{\pi_{h,t}^{\varsigma_h} \pi^{1-\varsigma_h}} \frac{y_{t+1}}{y_t} \right] - \frac{\theta_{h,t} - 1}{\kappa_{ph}} \left(1 - \Omega_{h,t} \varepsilon_{h,t}\right), \tag{79}$$

which, after log-linearization, and combining with (77) and (78) can be written as:

$$\widehat{\pi}_{h,t} = \frac{\beta}{1+\varsigma_h \beta} E_t \left[\widehat{\pi}_{h,t+1}\right] + \frac{\varsigma_h}{1+\varsigma_h \beta} \widehat{\pi}_{h,t-1} - \frac{\theta_h - 1}{\left(1+\varsigma_h \beta\right) \kappa_{ph}} \left[\widehat{p}_{h,t} + \varepsilon_{a,t} + \alpha \left(\widehat{u}_t + \widehat{k}_{t-1} - \widehat{l}_t\right) - \widehat{w}_t\right] + \varepsilon_{h,t}, \tag{80}$$

where the cost-push shock $\varepsilon_{h,t}$ is rescaled.

A.5 Importers

There is a unit measure of monopolistically competitive importers of intermediate goods indexed by j. They import foreign goods from abroad, differentiate them and mark-up their price, and then sell these heterogenous goods to perfectly competitive import aggregators, who aggregate these into a homogenous imported final good using a standard Dixit-Stiglitz aggregator. The demand curve facing each importer is given by

$$y_{f,t}(j) = \left(\frac{P_{f,t}(j)}{P_{f,t}} \right)^{-\theta_{f,t}} y_{f,t}, \tag{81}$$

where $y_{f,t}$ is aggregate imports, and $\theta_{f,t}$ is a time-varying elasticity of substitution between the differentiated goods. To capture cost-push shocks, we specify an exogenous AR(1) process on $\varepsilon_{f,t} = \theta_{f,t}/(\theta_{f,t} - 1)$,

$$\log \varepsilon_{f,t} = (1 - \rho_f) \log \phi_f + \rho_f \log \varepsilon_{f,t-1} + \eta_{f,t}, \tag{82}$$

where ϕ_f is the gross mark-up of the domestic price of imported goods over its import price at the steady-state.

Importers maximize the present value of profits (using the households' stochastic discount factor) subject to the demand function they are facing from the aggregators with respect to their own output. The importer's profits at period t are given by:

$$\frac{\Pi_{f,t}(j)}{P_t} = \frac{P_{f,t}(j)}{P_t} y_{f,t}(j) - \frac{e_t P_{h,t}^*}{P_t} y_{f,t}(j) - \frac{\kappa_{pf}}{2} \left(\frac{P_{f,t}(j) / P_{f,t-1}(j)}{\pi_{f,t-1}^{\varsigma_f} \pi^{1-\varsigma_f}} - 1 \right)^2 \frac{P_{f,t}}{P_t} y_{f,t}, \tag{83}$$

where importers face quadratic price adjustment costs, which helps generate partial exchange rate pass-through to domestic prices. κ_{pf} and ς_f are the price adjustment cost and indexation parameters respectively.

The first-order condition of importers with respect to price is given by

$$\begin{aligned}
&\left(\frac{\pi_{f,t}}{\pi_{f,t-1}^{\varsigma_f}\pi^{1-\varsigma_f}} - 1\right)\frac{\pi_{f,t}}{\pi_{f,t-1}^{\varsigma_f}\pi^{1-\varsigma_f}} \\
&\quad = E_t\left[\left(\beta\frac{\lambda_{t+1}}{\lambda_t}\right)\left(\frac{\pi_{f,t+1}}{\pi_{f,t}^{\varsigma_f}\pi^{1-\varsigma_f}} - 1\right)\frac{\pi_{f,t+1}}{\pi_{f,t}^{\varsigma_f}\pi^{1-\varsigma_f}}\frac{\pi_{f,t+1}}{\pi_{t+1}}\frac{y_{f,t+1}}{y_{f,t}}\right] - \frac{\theta_{f,t}-1}{\kappa_{pf}}\left(1 - \frac{e_t P_{h,t}^*}{P_{f,t}}\varepsilon_{f,t}\right), \quad (84)
\end{aligned}$$

where $\pi_{f,t} = P_{f,t}/P_{f,t}$ is the import-price inflation factor. After log-linearization, the imported-price New Keynesian Phillips curve can be written as:[18]

$$\widehat{\pi}_{f,t} = \frac{\beta}{1+\varsigma_f\beta}E_t\left[\widehat{\pi}_{f,t+1}\right] + \frac{\varsigma_f}{1+\varsigma_f\beta}\widehat{\pi}_{f,t-1} - \frac{1}{\left(1+\varsigma_f\beta\right)\kappa_{pf}}\left(\widehat{p}_{f,t} - \widehat{rer}_t - \widehat{p}_{h,t}^*\right) + \varepsilon_{f,t}, \tag{85}$$

where the cost-push shock $\varepsilon_{f,t}$ is rescaled. The real exchange rate, $rer_t = e_t P_t^*/P_t$, after log-linearization and first-differencing can be written as

$$\widehat{rer}_t - \widehat{rer}_{t-1} = \widehat{d}_t + \widehat{\pi}_t^* - \widehat{\pi}_t. \tag{86}$$

A.6 Monetary and fiscal policy

The central bank targets the yield on government bonds using a Taylor rule

$$\log R_t = \rho\log R_{t-1} + (1-\rho)\left[\log R + a_\pi\log\frac{\pi_t}{\pi} + a_y\log\frac{y_t}{\gamma^t y} + a_{\Delta y}\log\frac{y_t}{\gamma y_{t-1}}\right] + \varepsilon_{R,t}, \tag{87}$$

where R is the steady-state value of the (gross) nominal policy rate, ρ determines the extent of interest rate smoothing, and the parameters a_π, a_y, and $a_{\Delta y}$ determine the importance of inflation, output gap and output growth in the Taylor rule. y is the detrended steady-state level of output. $\varepsilon_{R,t}$ is a monetary policy shock which follows an AR(1) process. In log-linearized form, the Taylor rule can be written as

$$\widehat{R}_t = \rho\widehat{R}_{t-1} + (1-\rho)\left[a_\pi\widehat{\pi}_t + a_y\widehat{y}_t + a_{\Delta y}\left(\widehat{y}_t - \widehat{y}_{t-1}\right)\right] + \varepsilon_{R,t}. \tag{88}$$

[18] Note that we assume the existence of subsidies that correct the inefficiency created by importer price mark-ups. This allows us to set the relative price of imports equal to 1 at the steady-state.

Government expenditure is given by $g_t = \gamma^t \widetilde{g}_t$, where detrended government expenditure, $\widetilde{g}_t$, follows an exogenous AR(1) process:

$$\log \widetilde{g}_t = (1 - \rho_g) \log g + \rho_g \log \widetilde{g}_{t-1} + \varepsilon_{g,t}, \tag{89}$$

and g is the steady-state value of detrended government expenditure. The government runs a balanced budget with

$$g_t = \frac{T_t}{P_t}, \tag{90}$$

and government bonds are in zero supply with $B_{h,t} = B^*_{f,t} = 0$.

A.7 Market clearing conditions

The domestic final goods, y_t, are used by consumption and investment aggregators as well as for government expenditure and exports:

$$c_{h,t} + i_{h,t} + g_t + y^*_{f,t} = y_t. \tag{91}$$

The imported final goods, $y_{f,t}$, are used only by consumption and investment aggregators; hence,[19]

$$c_{f,t} + i_{f,t} = y_{f,t}. \tag{92}$$

Combining these yields (after detrending and log-linearizing)

$$\widehat{y}_t = \gamma_c \frac{c}{y} \widehat{c}_{h,t} + \gamma_i \frac{i}{y} \widehat{i}_{h,t} + \frac{g}{y} \widehat{g}_t + (1 - \gamma_c) \frac{y^*}{y} \frac{c^*}{y^*} \widehat{c}^*_{f,t} + (1 - \gamma_i) \frac{y^*}{y} \frac{i^*}{y^*} \widehat{i}^*_{f,t}, \tag{93}$$

where the steady-state expenditure shares are given by

$$\frac{i}{y} = (\gamma - 1 + \delta) \frac{k}{y} \text{ and } \frac{c}{y} = 1 - \frac{i}{y} - \frac{g}{y}, \tag{94}$$

[19] We thus assume that government expenditure and export goods do not have imported components. Note also that utilization costs and financial monitoring costs are modeled as transfer payments to households.

and

$$\frac{i^*}{y^*} = (\gamma - 1 + \delta)\,\frac{k^*}{y^*} \text{ and } \frac{c^*}{y^*} = 1 - \frac{i^*}{y^*} - \frac{g^*}{y^*}. \tag{95}$$

The model's equilibrium is defined as prices and allocations such that households maximize discounted present value of utility, and banks, entrepreneurs, and firms maximize discounted present value of profits, subject to their constraints, and all markets clear.

		High domestic, low foreign regulation				
		Regulatory effectiveness				
		0.0	0.5	1.0	1.5	2.0
Standard deviation of the idiosyncratic shock		0.344	0.243	0.172	0.121	0.086
Leverage of entrepreneurs		1.714	2.124	2.695	3.482	4.566
Leverage elasticity of spreads		0.030	0.025	0.021	0.018	0.015
Maximum/minimum amplitudes						
Global bank net worth shock	output	0.093	0.106	0.118	0.129	0.140
	relative output	0.021	0.032	0.044	0.055	0.065
Common interest rate shock	output	-5.572	-6.023	-6.479	-6.984	-7.483
	relative output	-1.012	-1.592	-2.178	-2.741	-3.255
Productivity shock	output	0.796	0.761	0.730	0.701	0.676
	relative output	0.739	0.729	0.715	0.700	0.684
Common productivity	output	0.312	0.253	0.194	0.136	-0.099
	relative output	-0.107	-0.172	-0.237	-0.300	-0.357

Table 1. Effectiveness of regulation

This table reports the steady state moments and the maximum/minimum amplitudes of variable responses under different degrees of regulatory effectiveness. The values displayed in the columns correspond to the degree of regulatory effectiveness relative to the baseline calibration. A value of 2, for example, implies that regulation is twice as effective in reducing financial market risk.

		Standard deviation		
	Domestic regulatory costs	Output	Lending rates	u-var
Global bank net worth shock				
Baseline	0.6%	1.139	0.672	0.247
High domestic, low foreign regulation	1.2%	1.388	0.750	0.349
Low domestic, low foreign regulation	0.3%	0.911	0.614	0.163
Common interest rate shock				
Baseline	0.6%	1.717	1.152	0.080
High domestic, low foreign regulation	1.2%	1.923	1.224	0.161
Low domestic, low foreign regulation	0.3%	1.557	1.116	0.028
Domestic net worth shock				
Baseline	0.6%	0.780	0.295	0.084
High domestic, low foreign regulation	1.2%	0.498	0.178	0.034
Low domestic, low foreign regulation	0.3%	1.050	0.405	0.157
Common net worth shock				
Baseline	0.6%	2.839	0.847	1.637
High domestic, low foreign regulation	1.2%	0.841	0.849	0.094
Low domestic, low foreign regulation	0.3%	5.987	2.137	5.828

Table 2. Regulation and volatility

This table reports the standard deviations of output growth and lending rates and the utility costs of consumption and labor volatility (u-var) that are obtained from the simulations with the shocks displayed in the first column.

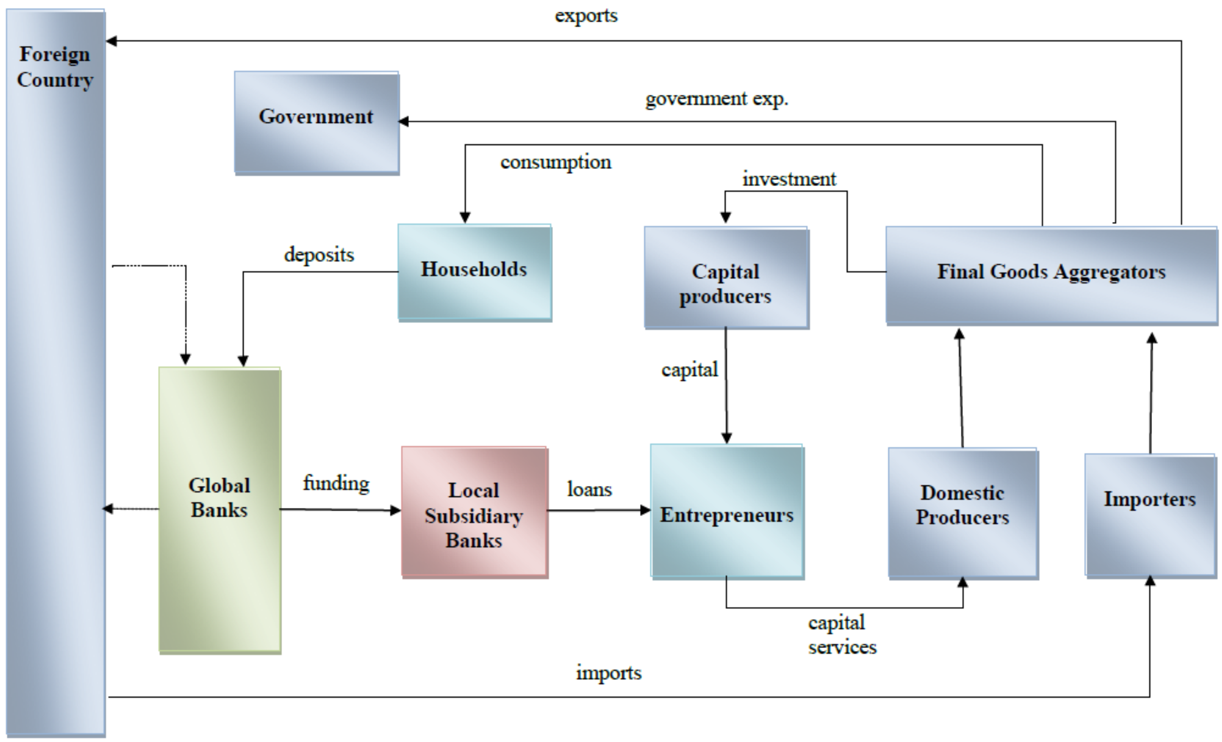

Figure 1: Bird's eye view of the domestic side of the model. The Foreign economy is modeled in an analogous fashion, except for the global banks, which are assumed to be under the domestic country's jurisdiction.

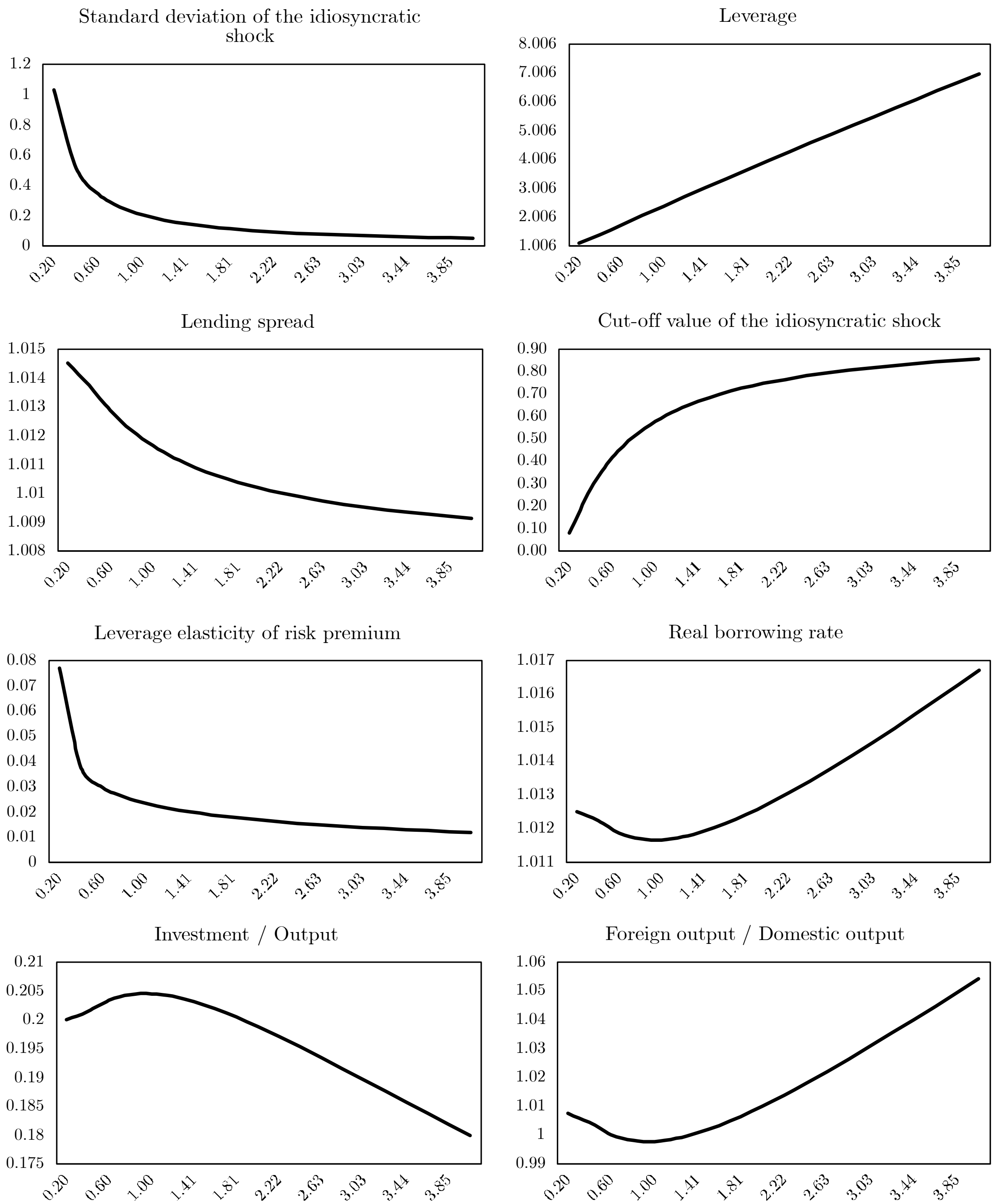

Figure 2: Steady state values.

The figure shows how the steady state values of some key variables change as the stringency of regulation increases. Regulatory stringency, the $x-$axis variable, is expressed as the regulatory costs incurred by the subsidiary (as a percentage of the revenue from lending on an annual basis).

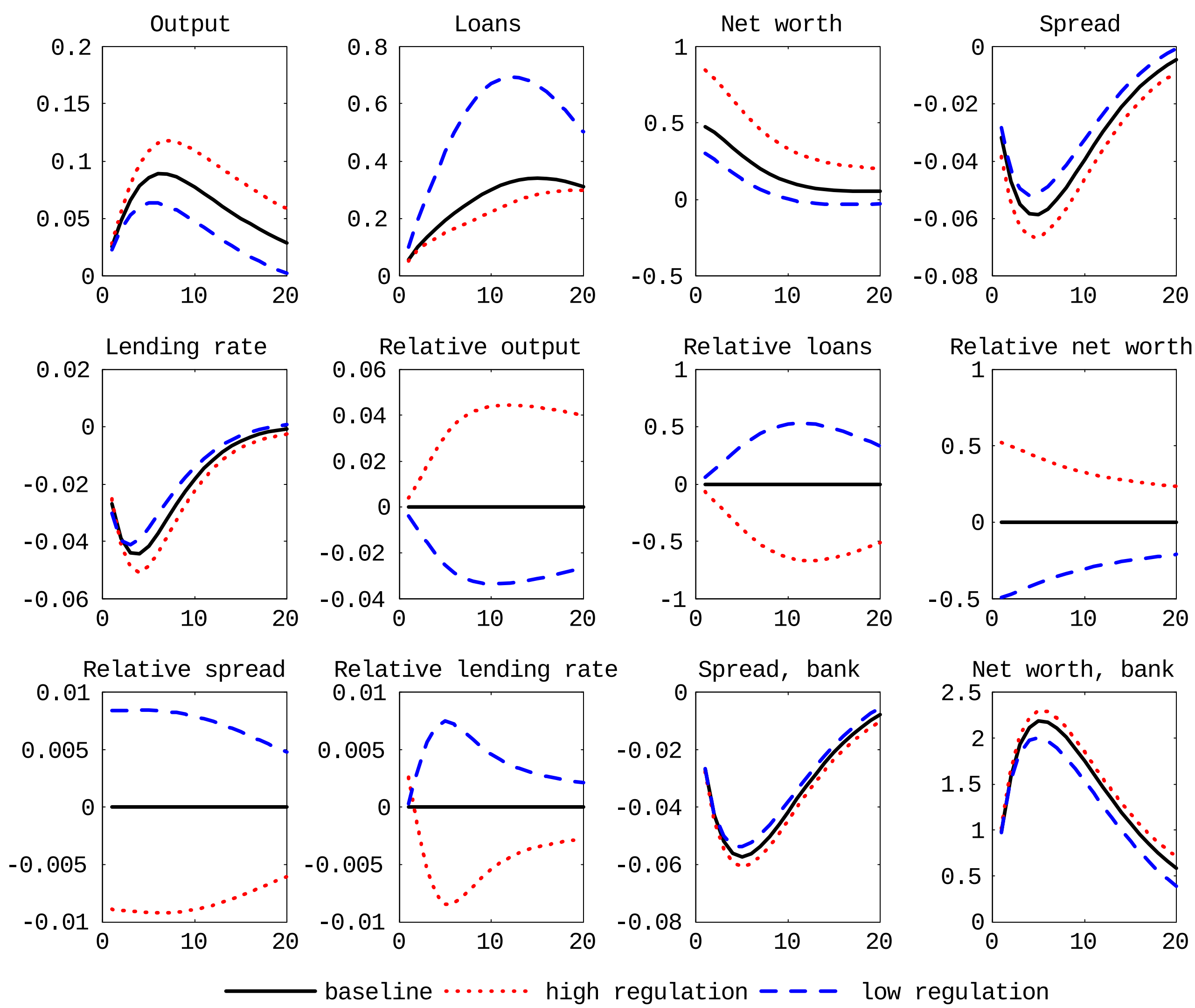

Figure 3: Responses to a 1 standard deviation positive global bank net worth shock.

Variables designated with "relative" are measured as the difference between domestic variable responses and the corresponding foreign variable responses.

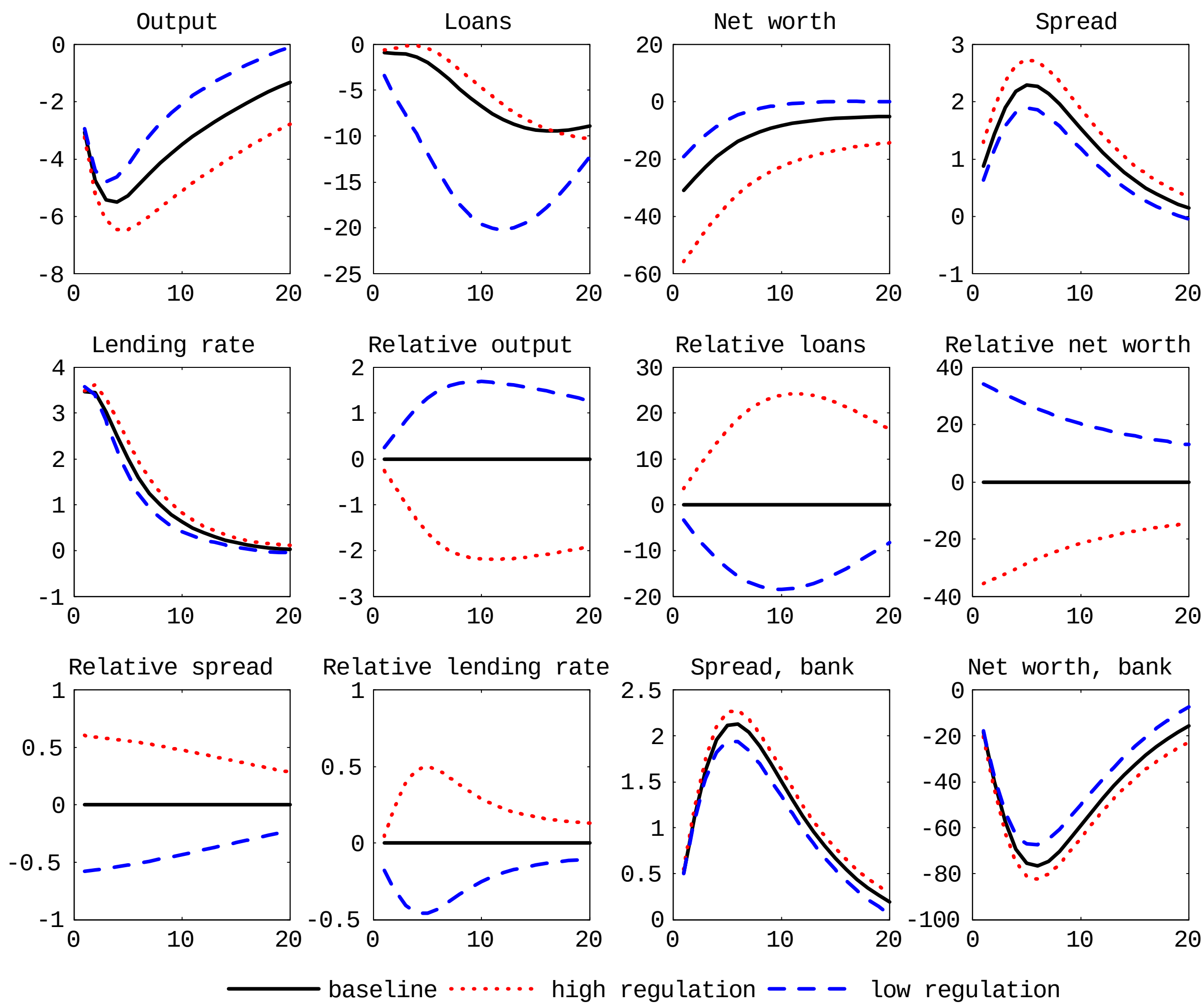

Figure 4: Responses to a 1 standard deviation positive common interest rate shock.

Variables designated with "relative" are measured as the difference between domestic variable responses and the corresponding foreign variable responses.

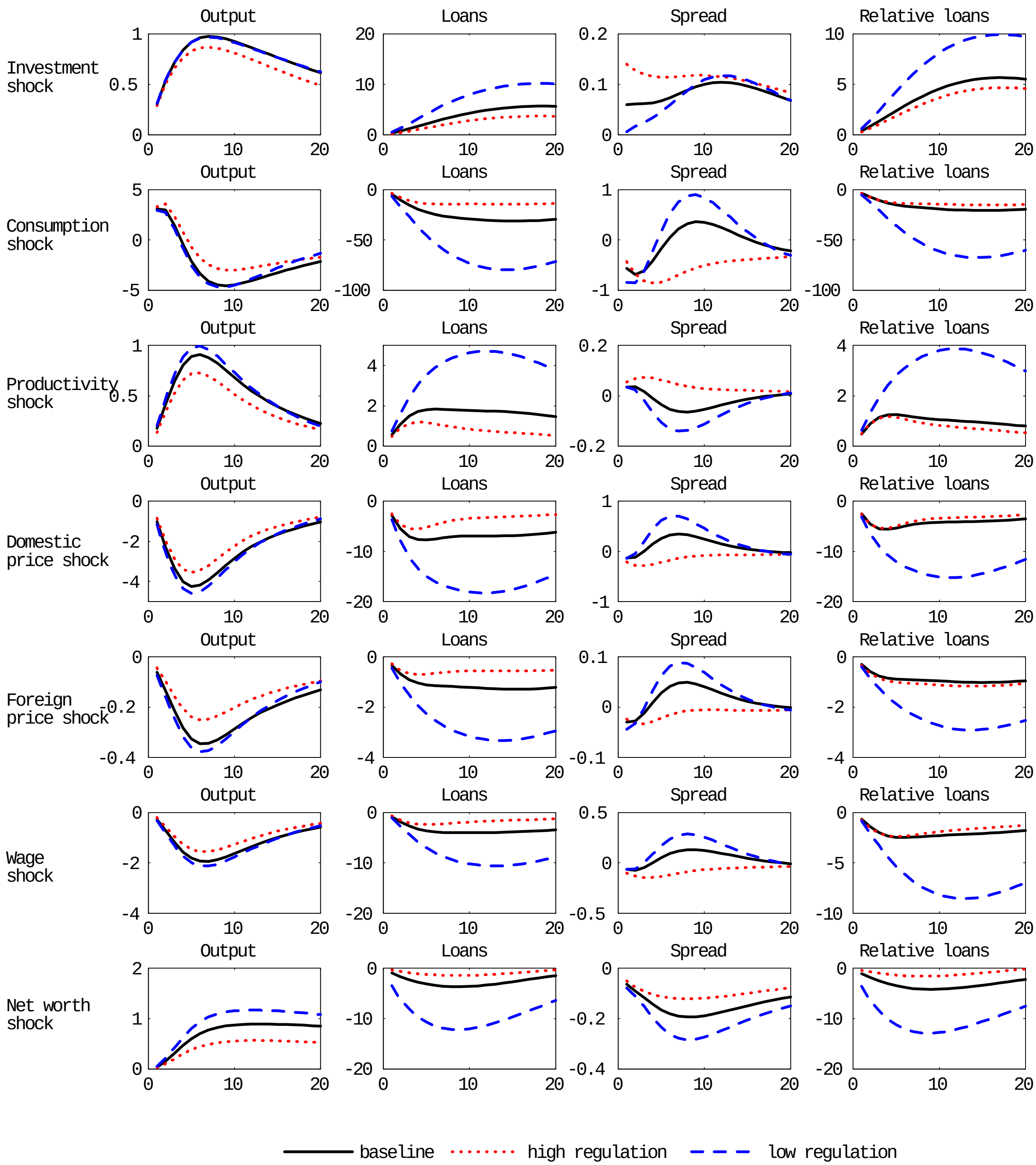

Figure 5: Domestic variable responses to 1 standard deviation positive domestic shocks.
The variable designated with "relative" is measured as the difference between domestic variable responses and the corresponding foreign variable responses.

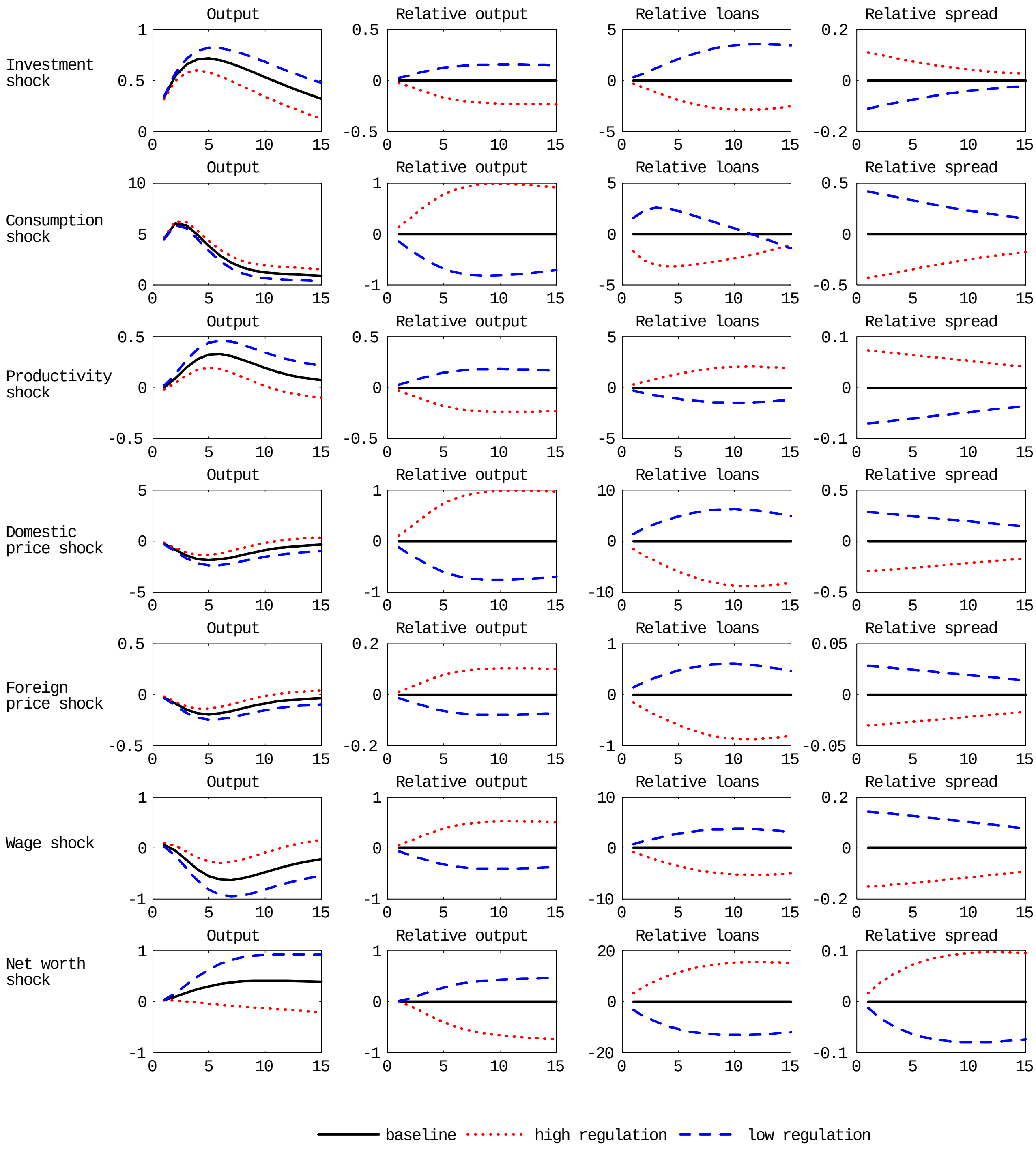

Figure 6: Responses to a 1 standard deviation positive common shock.

Variables designated with "relative" are measured as the difference between domestic variable responses and the corresponding foreign variable responses.

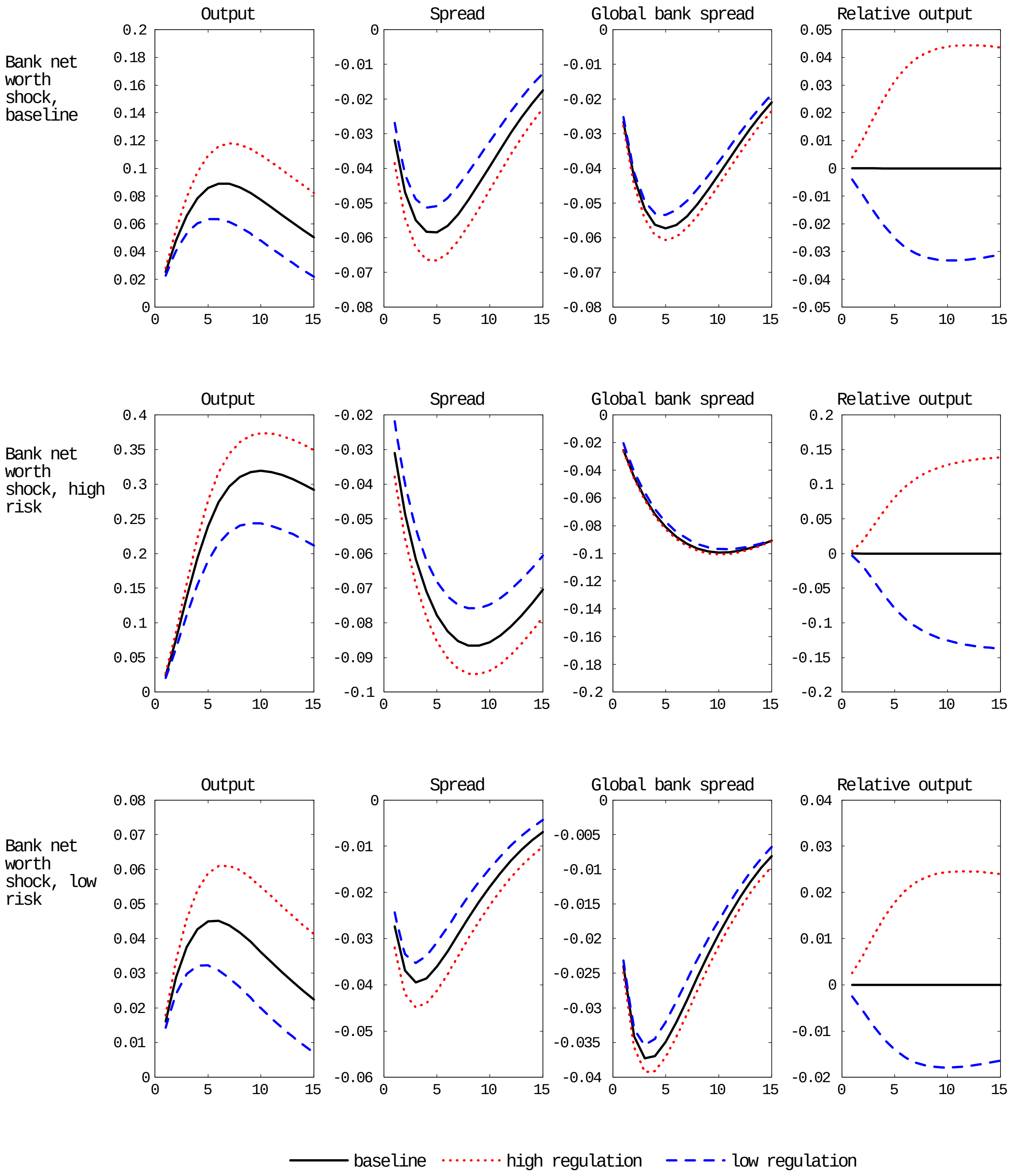

Figure 7: Responses with high and low global bank risk.

The figure displays the responses to a 1 standard deviation positive shock. Relative output is measured as the difference between domestic and foreign output growth. High/low risk responses correspond to a higher/lower standard deviation of the asset shock that the global banks face.

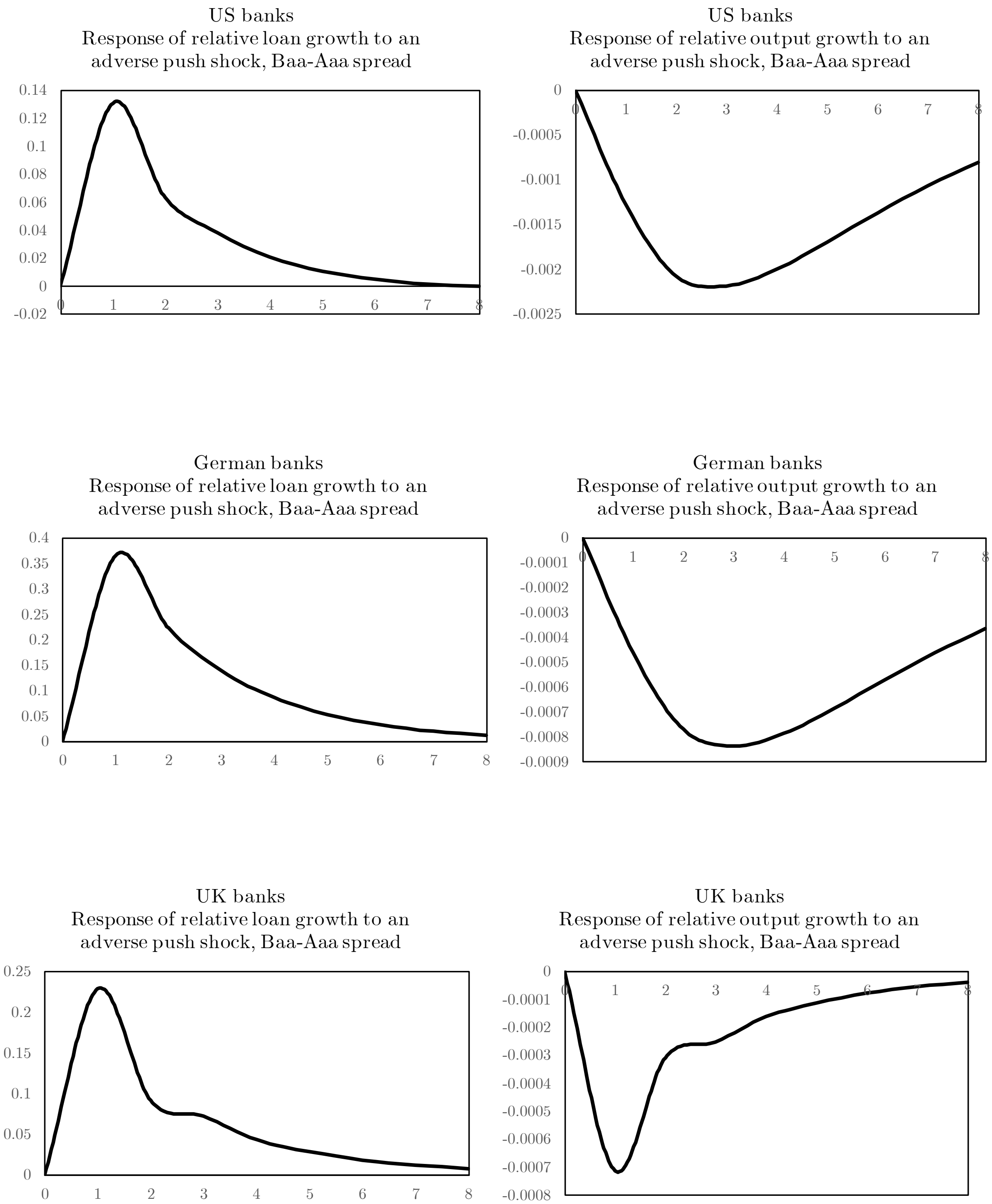

Figure 8: SVAR model responses. This figure shows the responses of US, German and UK global banks' cross country lending and the GDP growth rates of local economies to an adverse push shock (an increase in the Baa-Aaa bond spread).