International Shadow Banking and Macroprudential Policy*

Job Market Paper

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Abstract

The Great Recession featured a global collapse in real and financial economic activity that was highly synchronized across countries. Two unique precursors to the crisis were the rise in the shadow banking sector and increased securitization. I develop a model that is the first to explain the extent to which these factors contributed to the international transmission of the crisis that mostly originated in the United States. Using a two-country model with commercial and shadow banking sectors, I show that a country-specific financial shock leads to a simultaneous decline in real and financial aggregates in both countries. My model is the first to include both shadow and commercial banking in an open-economy framework. While commercial banks transfer funds from borrowers to lenders, shadow banks securitize loans and sell them to intermediaries internationally as asset-backed securities. Transmission occurs through a balance sheet channel, which is stronger when intermediaries hold more securities from abroad. I also consider the implications of capital controls on the transmission of a financial crisis. In general, I find that capital controls can reduce transmission.

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1 Introduction

The Great Recession featured a global collapse in economic activity with an abnormal level of international comovement. In the United States and Europe, there was a synchronized downturn in both real and financial aggregates. Two unique precursors to the Great Recession were the rise in the shadow banking sector and increased securitization. Securities backed by subprime mortgages, or mortgage-backed securities, originated in the United States and were held by well-established commercial and investment banks around the world. When the housing bubble in the United States burst, these mortgage-backed securities collapsed in value, resulting in a "bank run" on the shadow banking system. While the trigger was relatively localized in the United States, the ensuing crisis was felt internationally. With lessons from the Great Depression in mind, fiscal and monetary policy was heavily utilized to reduce the severity of the crisis across many countries. However, shadow banking remains a concern to policymakers. Due to the increased size of the shadow banking system leading up to the Great Recession, the Financial Stability Board (FSB) has conducted an annual monitoring exercise to assess global trends and risks in the shadow banking system. Until now, the extent to which shadow banking and securitized lending contributed to international transmission during the Great Recession has been left unexplained. I develop a model that is the first to address this issue in an open-economy framework.

Recessions accompanied by banking crises tend to be deeper and more difficult to recover from compared to other recessions. The Great Recession was different in the sense that the crisis originated in the shadow banking system. I build a model that is the first to incorporate shadow banking in parallel with commercial banking in an open-economy framework. I find that the inclusion of shadow banking produces a synchronized downturn in global economic activity when a financial crisis originates in one country. Similar to the Great Recession, this simultaneous downturn occurs not only in real aggregates, but also financial aggregates. When considering the experience of the Great Recession between the United States and Euro Area, my model is able to produce 99 percent of the transmission of a financial crisis in investment and 20 percent in real GDP. Furthermore, 33 percent of the transmission in the bank capital-to-asset ratio can be explained within my framework. I also show that capital controls can help reduce the transmission of a financial crisis originating in one country by reducing contagion within intermediary balance sheets.

Critical to the results of my framework is a balance sheet channel that exists within the supply-side mechanisms governing credit growth. Each country has its own banking sector, each consisting of their own commercial banks and shadow banks. Commercial banks specialize in monitoring their borrowers, so they serve as the economy's primary intermediaries as they channel funds from lenders to borrowers. The lenders in question are households, who deposit funds with commercial banks, who then make loans to firms. Shadow banks specialize in securitization, as they transform pools of bank loans into collateralized assets, or asset-backed securities (ABS).[1] These ABS are then sold to commercial banks

[1]A literature review on shadow banking by Adrian & Ashcraft (2016) define the shadow banking system as "a web of specialized financial institutions that conduct credit, maturity, and liquidity transformation without direct access to public backstops." I focus on the role of

both domestically and abroad. Unlike commercial banks, shadow banks do not take deposits.

I incorporate shadow banking into my framework due to its pivotal importance leading up to the Great Recession and in its aftermath. According to Gorton & Metrick (2012), assets of the shadow banking system just before the crisis were at least as large as the assets of commercial banks.[2] Shadow banking is also as vulnerable to panics as traditional banking since they are subject to similar risks. When non-bank financing involves bank-like activity, including liquidity and maturity transformation along with the creation of leverage, systemic risk is increased both directly and through its interconnectedness with the traditional banking system. The growth of shadow banking has continued well-past the events of the Great Recession. The MUNFI measure of all non-bank financial intermediation grew in 2016 to an aggregate 160 trillion USD (FSB (2017)).[3] Additionally, the MUNFI share within the global financial assets was reported to be 48 percent and has increased for the fifth consecutive year. Shadow banking is not only relevant in a discussion of the last global financial crisis, as it may play a role in future crises due to its continued growth. It is therefore of first-order importance for policymakers to understand the various channels by which shadow banking increases systemic risk.

Financial market frictions in my model are endogenized by introducing an agency problem between borrowers and lenders. This friction exists for both types of intermediaries in the economy, but with varying degrees. The friction introduced for commercial banks limits their ability to obtain funds from depositors, which introduces a wedge between the loan and deposit rates. Similarly, the friction introduced for shadow banks limits their ability to obtain funds from commercial banks via ABS purchases, which introduces a wedge between the loan and ABS rates. Thus, the agency problem produces an external finance premium, which is defined as a wedge between the cost of external finance and the opportunity cost of internal finance. A financial crisis in my framework occurs when balance sheets of intermediaries deteriorate, causing the external finance premium to jump. The feedback from the international financial market to the real economy produces an "international financial accelerator" in the presence of a crisis.[4]

The balance sheet channel in my framework depends critically on the composition of commercial bank assets, which include loans, domestically-originated ABS, and foreign-originated ABS. This portfolio composition depends on two primary factors: financial market frictions and risk. Financial market frictions for commercial banks are represented by a funding constraint in two competing ways. On one hand, while commercial banks specialize at monitoring their borrowers (domestic firms), they are not as effective at monitoring borrowers of intermediaries abroad (foreign firms). ABS originated abroad are derived from loans to foreign firms. Depositors recognize a commercial bank's limitations at monitoring the underlying loans of these securities, so they reduce their deposits as com-

liquidity transformation of shadow banks.

[2]According to the authors, this is likely an underestimation, as the comparison involves assets of only a fraction of the shadow banking system.

[3]The Monitoring of Non-bank Financial Intermediation (MUNFI) includes 21 jurisdictions and the euro area as a whole.

[4]The term "financial accelerator" was first coined in Bernanke, Gertler, & Gilchrist (1994).

mercial banks increase their portfolio share of ABS originated abroad. This will discourage commercial banks from holding foreign-originated ABS. On the other hand, ABS both domestic and foreign can be advantageous to hold due to their value as collateral. Loans held by banks are opaque and idiosyncratic, whereas ABS are standardized, tradeable, and backed by broad pools of collateral. This will encourage commercial banks to hold ABS. The determination of intermediary balance sheets will also depend on risk. I follow the method by Coeurdacier, Rey, & Winant (2011) of utilizing a risky steady state to account for uncertainty and pin down the determinate portfolio structure of intermediaries. This allows for second-order moments to play a role in international risk-sharing.

Fiscal and monetary policy was thoroughly utilized in many countries as the events of the 2007-2009 financial crisis unfolded internationally. Many of these policies in the US were imposed by the US Federal Reserve, who used their powers as a lender of last resort to facilitate credit flows. The domestic aspect of credit policy has been considered by Reis (2009), Cúrdia & Woodford (2009), Curdia & Woodford (2010), and Gertler & Kiyotaki (2010). Among the arsenal of domestic credit policies are lending facilities, discount window lending, and equity injections. While these policies could be implemented in my model, I instead consider policies that have explicit international implications. In particular, I suppose each country can impose capital controls in the form of a tariff on ABS originated abroad. I find that capital controls can reduce transmission of a financial crisis originating in one country. However, the effectiveness of capital controls at reducing international transmission depends on the degree of balance sheet exposure. To illustrate this more specifically, consider the following hypothetical scenario: European officials are contemplating capital controls on US-originated securities. If European commercial banks are holding a relatively large share in US-originated securities, then imposing a sufficiently large tariff on US-originated securities will reduce these shares. When a shock hits the US and a financial crisis ensues, European commercial banks will be less exposed to contagion on their balance sheets. As a result, Europe experiences a less severe downturn than they would have if capital controls were not imposed. This result is consistent with the findings of Ostry, Ghosh, Chamon, & Qureshi (2012), whose econometric analyses suggest in general that countries which deployed capital controls during the boom prior to the global financial crisis were more resilient during the bust.[5]

The remainder of this paper is organized as follows. Section 2 summarizes the related literature, including those on financial intermediation along with international business cycle comovement. Section 3 describes the model, which contains a global banking sector, households, goods-producing firms, capital-producing firms, and government sectors. A calibration exercise is documented in Section 4. The results for crisis simulations and policy experiments are then reported in Section 5. Section 6 concludes the paper.

[5]For further discussion on the effectiveness of capital controls, see Grilli & Milesi-Ferretti (1995), Edwards (1999), and Montiel & Reinhart (1999).

2 Related Literature

2.1 Financial Intermediation

The financial sector of my model features endogenous frictions introduced by an agency problem between creditors and debtors, as pioneered by Benanke & Gertler (1989) and Kiyotaki & Moore (1997). Much of the early literature focused on credit constraints faced by non-financial borrowers, or the demand side. However, disruptions in financial intermediation played a key role in the events leading up to the Great Recession. As in Gertler & Karadi (2011) and Gertler & Kiyotaki (2010), the focus in my model is on financial intermediaries, or the supply-side. In these papers, bank balance sheets provide a channel for financial crisis transmission that exhibits an improvement over standard DSGE models in matching the economy's response to shocks.

Securitization has been a financial market phenomenon at the forefront of discussion regarding the Great Recession. Adrian & Shin (2008) describe broker-dealers as playing market-making and underwriting roles in securities markets. Broker-dealers in my model are shadow banks, who carry out the process of securitization. Models of shadow banks are particularly scarce. Closed economy models with shadow banks can be found in Meeks, Nelson, & Alessandri (2017) and Moreira & Savov (2017). A three-period model of shadow banking can be found in Gennaioli, Shleifer, & Vishny (2013), who find that the shadow banking system is stable and welfare-improving under rational expectations, but susceptible to dry-ups in liquidity when investors ignore tail risks.

Within the financial sector of my framework, there are both commercial and shadow banks in each country. Meeks, Nelson, & Alessandri (2017) also considers this heterogeneity in intermediaries, but do so in a closed economy. In their model, shadow banks sell both debt-like and pass-through ABS to commercial banks, where the portfolio of ABS is exogenously chosen in a steady state.[6] Since international risk-sharing is a centerpiece of my model, I instead focus exclusively on pass-through ABS, which in essence serve as risk-sharing securities. Additionally, the portfolios in my model are determinate.

The agency problem I utilize is such that commercial and shadow banks may divert a fraction of their assets off of their balance sheets, which induces creditors to reduce their lending to these entities. Gertler, Kiyotaki, & Queralto (2012) considers the endogenous determination of bank outside equity by having the fraction of divertible assets depend on the liability structure of intermediaries. In particular, they assume that the fraction of divertible bank assets is increasing the fraction of assets funded by outside equity. This results in less funding via outside equity, in favor of deposit and inside equity funding. In my model, shadow banks sell outside equity to commercial banks in the form of ABS. In addition, the divertibility of commercial bank assets depends on the asset structure of their balance sheets. Specifically, the fraction of commercial banks' divertible assets is increasing in the ABS share of assets.

[6]Pass-through securities involve cash flows from the underling collateral pool that are "passed through" to the security holder. Examples of debt-like securities are government bonds, corporate bonds, certificates of deposit, municipal bonds, and preferred stock.

2.2 International Business Cycles

The literature on international business cycles with financial intermediation is relatively new. Mendoza & Quadrini (2010) consider an open-economy model with financial intermediaries to show that financial integration leads to a sharp rise in net credit in the country with the most financial development, leading to large asset price spillovers over country-specific shocks to bank capital.[7] Kollmann, Enders, & Müller (2011) describe the international transmission of a loan shock using a global bank in a two-country model with a binding bank capital requirement.[8] In contrast to the previous two papers described, Olivero (2010) does not consider capital requirements on banks. These early models on financial intermediation in an open economy framework treat intermediaries as global entities, rather than country-specific. While there is a global aspect to intermediation, most banks are region-specific. In addition, the Great Recession featured shadow banking as a pivotal channel of transmission during the Great Recession, which is not addressed by the early literature.

The Gertler & Karadi (2011) style of intermediation has been incorporated in an international context only recently. Gabaix & Maggiori (2015) use a two-period model with financiers, who serve as intermediaries, to provide a theory of exchange rate determination based on capital flows in imperfect financial markets. Intermediaries in their model are credit constrained, as creditors recognize the possibility that financiers may divert funds. Maggiori (2017) considers a two-country model in continuous time with banks that shows equilibrium risk-sharing between countries with varying financial development.[9] They find that the most financially-developed country takes on a higher level of risk and suffers heavier losses during a global crisis. The financially-developed country's currency also emerges as the reserve currency.

While much of the international business cycle literature has abstracted from banks, financial frictions have played an increasingly critical role. For example, Devereux & Yetman (2010) describe the international transmission of productivity shocks with international portfolio holdings by investors who face leverage constraints. They show that with binding leverage constraints and diversified portfolios, there is a powerful transmission channel, resulting in a positive co-movement of production. Dedola & Lombardo (2012) incorporate a financial accelerator and endogenous portfolio choice to study how the international transmission of asymmetric shocks is affected when levered investors hold foreign assets. They find a similar result to mine in that real and financial interdependence can be strong, despite low balance sheet exposure to foreign assets. More recently in the literature, Perri & Quadrini (2018) consider an interdependence between the value of collateral and liquidity in a two country model, which results in multiple self-fulfilling

[7]While the global bank in their model faces a capital requirement, intermediaries in my model face an agency problem which reduces their external funding.

[8]The global bank in their model operate by maximizing a utility function, whereas intermediaries in my model operate by maximizing expected lifetime franchise value. Critically, the global bank also consumes its dividends each period, whereas intermediaries in my model retain their earnings, only using dividends for consumption if they exit the market.

[9]The use of continuous time is often needed for endogenous determination of portfolio composition. While my model is in discrete time, the portfolio composition is still endogenously determined in a steady state. The structure of the incentive constraint intermediaries face allows for this.

equilibria. A global liquidity shortage results from pessimistic self-fulfilling expectations, and economic activity contracts in both countries. A key theme across these papers without financial intermediation is international co-movement in the face of shocks of the following forms: country-specific, asymmetric, and common. I consider both country-specific and asymmetric financial shocks, which both result in international co-movement of real and financial variables across countries.

3 The Model

3.1 The Global Banking Sector

There are two countries, Home and Foreign, each with their own banking sectors. Within each banking sector are two types of banks: commercial and shadow banks. The roles of commercial banks are threefold: delegated monitoring, maturity transformation, and liquidity provision. Commercial banks are experts at monitoring borrowers, so they act as conduits that channel funds from households (lenders) to firms (borrowers). Maturity transformation occurs through this intermediation, as commercial banks hold short-term liabilities in the form of deposits, and long-term assets in the form of loans to firms.

Shadow banks on the other hand specialize in securitization. While commercial banks specialize in originating loans, shadow banks have a comparative advantage in holding them. In order to fund the purchase of these loans, shadow banks issue asset-backed securities (ABS) to commercial banks. Commercial banks desire to hold ABS because they serve as high-quality collateral and they increase portfolio diversification. While loans are originated domestically, ABS can be sold overseas to foreign commercial banks. To this end, while a commercial bank specializes in monitoring its borrowers, it is less effective at monitoring a foreign bank's borrowers overseas. As a result, a commercial bank will limit the amount of foreign ABS it will hold due to this informational asymmetry. On the other hand, since commercial banks originate the loans that domestic shadow banks securitize, they are able to monitor the underlying loans of domestic ABS more effectively than those originating abroad. This induces a bias in a commercial bank's portfolio composition in favor of domestic ABS.

A shadow bank in my model can be interpreted as a special purpose vehicle (SPV) setup by a commercial bank. One motivation for a commercial bank to establish an SPV is to offload assets from its balance sheets in order to meet a regulatory capital requirement. An alternative explanation could be for liquidity purposes, as bank loans are relatively illiquid. Without loss of generality, I abstract from microfoundations for establishing an SPV. [10]

A visualization of the global financial system is featured in Figure 1. In this visualization, I consider US and European Area (EA) financial markets that are integrated via the shadow banking system. US shadow banks sell ABS derived from US loans to both US and EA commercial banks, while EA shadow banks

[10] An example of a microfoundation can be found in Gertler & Kiyotaki (2010), who use the capital requirement motivation for establishing an SPV. It should be noted that in their model, the SPV does not act independently of the commercial bank. Instead, the commercial bank and SPV act as a consolidated bank. In my model, shadow banks makes their decisions independently of commercial banks.

sell ABS derived from EA loans to both US and EA commercial banks. US and EA commercial banks are indirectly linked through this ABS channel in a circular fashion. In a reduced version of the framework without securitization, shadow banks cease to exist and so financial market integration is broken. The model without securitization will serve as a benchmark in the crisis simulations.

In the subsections that follow, I will describe the modeling of commercial and shadow banks. I will focus on the Home country throughout, as the banking sectors are symmetric across countries.

3.1.1 Return Structure on Assets

The two primary types of assets in the financial market are bank loans and ABS. The loans in question are made to firms and are state-contingent. Firms use these loans to fund their purchases of capital for production. Let Z_t be the dividend payment at t on the loans funded at $t-1$ by a Home commercial or shadow bank. Furthermore, let Q_t be the price of a loan at t. The period t return on a loan funded at $t-1$ is

$$R_{st} = \psi_t \frac{Z_t + (1-\delta)Q_t}{Q_{t-1}} \tag{1}$$

ψ_t is a capital quality shock in the Home country faced by firms and δ is the depreciation rate on capital. The capital quality shock serves as an exogenous trigger of asset price variation.

Asset-backed securities are derived from pools of bank loans. These securities are pass-through in that their income payments are identical to the loans they are collateralized from. An ABS from Home is sold at t for a price q_{ht}. The resulting period t return on an ABS purchased at $t-1$ is

$$R_{ht} = \psi_t \frac{Z_t + (1-\delta)q_{ht}}{q_{ht-1}} \tag{2}$$

ABS are exposed to the same shock as the loans they are derived from. Hence, Foreign commercial banks' balance sheets are directly exposed to fluctuations in Home asset price dynamics if they hold Home ABS. The Foreign counterparts to loan and ABS returns are

$$R^*_{st} = \psi^*_t \frac{Z^*_t + (1-\delta)Q^*_t}{Q^*_{t-1}} \tag{3}$$

$$R_{ft} = \psi^*_t \frac{Z^*_t + (1-\delta)q_{ft}}{q_{ft}} \tag{4}$$

where q_{ft} is the price of a Foreign ABS and ψ^*_t is the Foreign capital quality shock. The two capital quality shocks may not necessarily be correlated.

3.1.2 Commercial Banks

Commercial banks serve as the primary financial intermediaries in the economy. Each country is populated by a continuum of commercial banks of measure one. A commercial bank is managed by a domestic household member. In order to limit a commercial bank's ability to save to overcome financial constraints, I assume that a banker exits the market with probability $1-\sigma$. This implies that the average survival time of a bank is $1/1-\sigma$. Without loss of generality, I assume shadow banks have the same survival probabilities.

Each period t, commercial banks raise funds by taking one-period riskless deposits d_t from domestic households at the rate R_{t+1}. These funds are used to finance a portfolio of domestic and foreign assets. In the domestic market, banks offer perfectly state-contingent loans s_{ct} to firms at a price Q_t. They may also purchase a quantity m_{ht} of ABS from domestic shadow banks at a price q_{ht}. In the international market, commercial banks purchase a quantity m_{ft} of ABS from foreign shadow banks at a price q_{ft}.

A commercial bank's period t flow of funds constraint equates the sum of expenditures on assets to its liabilities, including its net worth n_{ct}:

$$Q_t s_{ct} + q_{ht} m_{ht} + q_{ft} m_{ft} = n_{ct} + d_t \tag{5}$$

Net worth of a commercial bank at t is the gross payoff of assets funded at $t-1$ minus net borrowing costs at $t-1$:

$$n_{ct} = R_{st} Q_{t-1} s_{ct-1} + R_{ht} q_{ht-1} m_{ht-1} + R_{ft} q_{ft-1} m_{ft-1} - R_t d_{t-1} \tag{6}$$

A commercial bank retains all earnings until the time it exits the market, at which point it pays out its accumulated retained earnings as dividends to its manager's household. The objective function of a commercial bank at the end of period t is the expected present value of the future terminal dividends,

$$V_{ct} = \mathbb{E}_t \sum_{\tau=t+1}^{\infty} (1-\sigma)\sigma^{\tau-t-1} \Lambda_{t,\tau} n_{c\tau} \tag{7}$$

where $\Lambda_{t,\tau}$ is the domestic household stochastic discount factor between dates t and τ.

An agency problem is introduced in order to motivate an endogenous constraint on the bank's ability to obtain funds from households. Suppose that after a bank obtains funds, its manager may transfer a fraction of assets to his or her family. Recognizing this possibility, depositors may limit their funding to commercial banks. The fraction of funds a commercial bank may divert also depends on its asset composition. In particular, on the margin, a bank may divert a larger fraction of its assets the higher its holdings of foreign assets are relative to domestic assets. While loans are originated by commercial banks domestically, ABS purchased from abroad are more difficult for outsiders to monitor. Creditors recognize a commercial bank's specialty in monitoring its borrowers, but they also recognize a commercial bank's inability to do the same with a foreign intermediary's borrowers.

After a bank has obtained funds, it may divert the fraction $\Theta(x_t)$ of its assets, where x_t is the ratio of the value of foreign ABS to loans.

$$\Theta(x_t) = \theta_c \left(1 + \varepsilon x_t + \frac{\kappa}{2} x_t^2\right) \tag{8}$$

$$x_t = \frac{q_{ft} m_{ft}}{Q_t s_{ct}} \tag{9}$$

This functional form of Θ allows for the possibility that there may be some efficiency gains in a commercial bank's ability to monitor foreign borrowers by holding some foreign ABS, i.e., ε may be negative. Notice that ABS purchased from domestic shadow banks do not enter the function Θ. Since domestic commercial banks originate the loans that domestic ABS are derived from, they have a comparative advantage at monitoring the underlying loans of these ABS. Depositors recognize this and do not limit their funding.

If a commercial bank diverts assets, it defaults on its debt and shuts down. Its creditors may reclaim the remaining fraction $1 - \Theta(x_t)$ of funds. Since depositors recognize a commercial bank's incentive to divert funds, they limit their deposits. It is assumed that a commercial bank's decision to divert funds must be made at the end of period t, but before the realization of aggregate uncertainty in the following period. The intuition here is that if a commercial bank is going to divert funds, it takes time to position the assets, which must be done in-between periods.

Let $V_{ct}(s_{ct}, m_{ht}, x_t, n_{ct})$ be the maximized value of a commercial bank's objective function V_{ct}, given a portfolio of assets and net worth $(s_{ct}, m_{ht}, x_t, n_{ct})$ at the end of period t. In order to ensure that a commercial bank does not divert funds, the incentive compatibility constraint (ICC) must hold:

$$V_{ct} \geq \Theta(x_t)\big[Q_t s_{ct} + \omega(q_{ht}m_{ht} + q_{ft}m_{ft})\big] \tag{10}$$

The ICC states that in order for creditors to be willing to fund a commercial bank, the bank's franchise value must be at least as large as its surplus from diverting funds. The parameter $\omega \in [0, 1]$ captures an element of divertibility of ABS. In particular, values strictly less than one capture the notion that ABS are superior forms of collateral relative to bank loans. Intuitively, while loans held by banks are opaque and idiosyncratic, ABS are standardized, tradeable, and backed by broad pools of collateral. While the function Θ reduces the incentive to hold ABS, the parameter ω improves the incentive. In most cases, the function Θ will dominate due to its nonlinearity in x_t. This results in a bias in favor of domestic assets, which include loans and domestic ABS.

Combining the flow of funds constraint (5), the law of motion for net worth (6), and the ratio of foreign to home assets (9) yields period t net worth n_{ct} as a function of the state variables $(s_{ct-1}, m_{ht-1}, x_{t-1}, n_{ct-1})$:

$$n_{ct} = \big[(R_{st} - R_t) + x_{t-1}(R_{ft} - R_t)\big]Q_{t-1}s_{ct-1} + (R_{ht} - R_t)q_{ht-1}m_{ht-1} + R_t n_{ct-1} \tag{11}$$

From this, it follows that the franchise value of a commercial bank at the end of period $t - 1$ satisfies the Bellman equation

$$V_{ct-1}(s_{ct-1}, m_{ht-1}, x_{t-1}, n_{ct-1}) = \mathbb{E}_{t-1}\Lambda_{t-1,t}\big\{(1-\sigma)n_{ct} + \sigma \max_{s_{ct}, x_t}[V_{ct}(s_{ct}, m_{ht}, x_t, n_{ct})]\big\} \tag{12}$$

The right-hand side takes into account that a commercial bank exits with probability $1 - \sigma$ or continues to operate with probability σ. Based on (12), a commercial bank's problem is reduced to choosing the triple (s_{ct}, m_{ht}, x_t) to maximize its franchise value $V_{ct}(s_{ct}, m_{ht}, x_t, n_{ct})$ subject to its incentive constraint (10). The approach used to solve this problem involves conjecturing a value function and later verifying it. Specifically, I conjecture that the value function has the form

$$V_{ct}(s_{ct}, m_{ht}, x_t, n_{ct}) = (\mu_{st} + x_t\mu_{ft})Q_t s_{ct} + \mu_{ht}q_{ht}m_{ht} + \upsilon_t n_{ct} \tag{13}$$

The variables μ_{st}, μ_{ht}, μ_{ft}, and υ_t are part of the conjecture and are nonnegative. In Appendix A, I provide a detailed derivation of this conjectured value function and verify its validity.

Let λ_t be the Lagrangian multiplier associated with the ICC. Then, the interior first-order conditions with respect to s_{ct}, m_{ht}, and x_t are

$$\mu_{st} + x_t \mu_{ft} = (1 + \omega x_t)\Theta(x_t)\frac{\lambda_t}{1 + \lambda_t} \tag{14}$$

$$\mu_{ht} = \omega\Theta(x_t)\frac{\lambda_t}{1 + \lambda_t} \tag{15}$$

$$\mu_{ft} Q_t s_{ct} = \left[\omega\Theta(x_t)Q_t s_{ct} + \Theta'(x_t)[(1 + \omega x_t)Q_t s_{ct} + \omega q_{ht} m_{ht}]\right]\frac{\lambda_t}{1 + \lambda_t} \tag{16}$$

These conditions equate the marginal benefit through increasing franchise value to the marginal cost of tightening the incentive constraint. The first-order condition with respect to the Lagrangian multiplier λ_t is

$$Q_t s_{ct} + \frac{\omega}{1 + \omega x_t} q_{ht} m_{ht} = \phi_{ct} n_{ct} \tag{17}$$

where

$$\phi_{ct} = \frac{\upsilon_t}{(1 + \omega x_t)\Theta(x_t) - (\mu_{st} + x_t \mu_{ft})} \tag{18}$$

Note that this corresponds to a binding incentive constraint. The variable ϕ_{ct} has the form of a leverage ratio, although the right-hand side of 17 is not exactly the sum of asset expenditures. This term is increasing in the excess value of bank loans $\mu_{st} + x_t \mu_{ft}$ and in the saving in deposit costs from a unit of net worth υ_t. Recall from (13) that these terms raise the franchise value of a commercial bank, which reduces the incentive for a diversion of assets. On the other hand, this "quasi-leverage-ratio" is decreasing in the fraction of loans a commercial bank can divert $(1 + \omega x_t)\Theta(x_t)$.

By plugging (17) back into the Bellman equation (12) and utilizing the law of motion for net worth (11), the conjectured value function can be verified, with the variables μ_{st}, μ_{ht}, μ_{ft}, and υ_t satisfying

$$\mu_{st} = \mathbb{E}_t \Lambda_{t,t+1}\Omega_{ct+1}(R_{st+1} - R_{t+1}) \tag{19}$$

$$\mu_{ht} = \mathbb{E}_t \Lambda_{t,t+1}\Omega_{ct+1}(R_{ht+1} - R_{t+1}) \tag{20}$$

$$\mu_{ft} = \mathbb{E}_t \Lambda_{t,t+1}\Omega_{ct+1}(R_{ft+1} - R_{t+1}) \tag{21}$$

$$\upsilon_t = \mathbb{E}_t \Lambda_{t,t+1}\Omega_{ct+1} R_{t+1} \tag{22}$$

with

$$\Omega_{ct} = 1 - \sigma + \sigma\left[\upsilon_t + \phi_{ct}(\mu_{st} + x_t \mu_{ft})\right] \tag{23}$$

The variable Ω_{ct} is the shadow value of a unit of net worth to a commercial bank at t. The product $\Lambda_{t,t+1}\Omega_{t+1}$ is referred to as a commercial bank's augmented stochastic discount factor between t and $t+1$. The expected discounted value of the credit spread with respect to bank loans is μ_{st}, as represented by (19). μ_{ht} and μ_{ft} have analogous interpretations, but with respect to domestic and foreign ABS, respectively.

The Home commercial bank flow of funds can be aggregated to yield

$$Q_t S_{ct} + q_{ht} M_{ht} + q_{ft} M_{ft} = N_{ct} + D_t \tag{24}$$

where S_{ct} is the aggregate demand for commercial bank loans, M_{ht} and M_{ft} are the aggregate demand for Home and Foreign ABS, respectively, N_{ct} is the aggregate net worth of the Home commercial banking sector, and D_t is the aggregate supply of deposits. Since ϕ_{ct} does not depend on commercial bank specific factors, (17) can be also be aggregated:

$$Q_t S_{ct} + \frac{\omega}{1+\omega x_t} q_{ht} M_{ht} = \phi_{ct} N_{ct} \tag{25}$$

Aggregating across Foreign commercial banks yield analogous results:

$$Q_t^* S_{ct}^* + q_{ht} M_{ht}^* + q_{ft} M_{ft}^* = N_{ct}^* + D_t^* \tag{26}$$

$$Q_t^* S_{ct}^* + \frac{\omega^*}{1+\omega^* x_t^*} q_{ft} M_{ft}^* = \phi_{ct}^* N_{ct}^* \tag{27}$$

Aggregate net worth in the Home commercial banking sector is the sum of the net worth of existing commercial banks N_{ct}^o and entering commercial banks N_{ct}^y:

$$N_{ct} = N_{ct}^o + N_{ct}^y \tag{28}$$

Aggregate net worth of existing commercial banks at t is equal to the returns on total assets of existing bankers held in $t-1$ net the cost of deposit finance, multiplied by the fraction that survive until t, σ:

$$N_{ct}^o = \sigma(R_{st} Q_{t-1} S_{ct-1} + R_{ht} q_{ht-1} M_{ht-1} + R_{ft} q_{ft-1} M_{ft-1} - R_t D_{t-1}) \tag{29}$$

I assume that households transfer a fraction $\xi_c/(1-\sigma)$ of assets from commercial banks exiting the market, where ξ_c is assumed to be sufficiently small. It follows that aggregate net worth of entering commercial banks is

$$N_{ct}^y = \xi_c(R_{st} Q_{t-1} S_{ct-1} + R_{ht} q_{ht-1} M_{ht-1} + R_{ft} q_{ft-1} M_{ft-1}) \tag{30}$$

Aggregate net worth of commercial banks is thus

$$N_{ct} = (\sigma + \xi_c)(R_{st} Q_{t-1} S_{ct-1} + R_{ht} q_{ht-1} M_{ht-1} + R_{ft} q_{ft-1} M_{ft-1}) - \sigma R_t D_{t-1} \tag{31}$$

Recall from (1) through (4) that the return on assets are subject to capital quality shocks. In particular, loans and domestic ABS are subject to domestic shocks, whereas ABS are subject to foreign shocks. Deterioration in capital quality at t directly reduces returns and commercial bank net worth. The Foreign analogue to (31) is

$$N_{ct}^* = (\sigma + \xi_c)(R_{st}^* Q_{t-1}^* S_{ct-1}^* + R_{ht} q_{ht-1} M_{ht-1}^* + R_{ft} q_{ft-1} M_{ft-1}) - \sigma R_t^* D_{t-1}^* \tag{32}$$

As long as a commercial bank holds ABS from abroad, their net worth is directly vulnerable to capital quality shocks overseas. This is the primary channel for transmission of a financial crisis originating in one country.

3.1.3 Shadow Banks

While commercial banks are experts in monitoring their borrowers, this ability degenerates when the borrowers in question are in an entirely different country. Thus, commercial banks in my model do not engage in lending to firms abroad. Still, some commercial banks may want to diversify their portfolios and expose themselves to foreign financial markets. A secondary market with shadow banks as intermediaries exists to satisfy this possibility. Shadow banks specialize in securitization, which involves pooling loans and selling their related cash flows to third party investors as securities. In this case, third party investors are commercial banks, both domestic and foreign.

Each country is populated by a continuum of shadow banks of measure one. Like commercial banks, shadow banks are managed by domestic households. Shadow bankers exit the market with a probability $1 - \sigma$, which is identical to that of a commercial bank.

Aside from securitization, a key heterogeneity between commercial and shadow banks is that while commercial banks take deposits from households, shadow banks do not. Shadow banks use the proceeds from the sale of ABS and inside equity in order to purchase loans "left over" from domestic commercial banks. A shadow bank's flow of funds constraint at t is

$$Q_t s_{st} = n_{st} + q_{ht} m_t \tag{33}$$

where n_{st} is a shadow bank's net worth at and m_t is the supply of ABS. The ABS in question are based off of Home loans to firms and are sold to both Home and Foreign commercial banks. ABS in my model are assumed to be pass-through, in that the stream of payments are identical to that of the underlying pool of loans. The key difference between these securities is pricing, which is q_{ht} for Home ABS and Q_t for the underlying loans. Generally, the price of ABS will be no less than the price of the underlying loans.

Net worth of a shadow bank at t is the gross payoff of loans held at $t-1$ net payments to ABS holders:

$$n_{st} = R_{st} Q_{t-1} s_{st-1} - R_{ht} q_{ht-1} m_{t-1} \tag{34}$$

A shadow bank retains all earnings until the time it exits the market, at which point it pays out its accumulated retained earnings as dividends to its manager's household. The objective function of a shadow bank at the end of t is the expected present value of future terminal dividends,

$$V_{st} = \mathbb{E}_t \sum_{\tau=t+1}^{\infty} (1-\sigma)\sigma^{\tau-t-1} \Lambda_{t,\tau} n_{s\tau} \tag{35}$$

An agency problem exists for shadow banks, in which their sale of ABS to commercial banks is endogenously constrained. Once a shadow bank has obtained funds and made its decision on how many loans to hold, the bank manager may divert a fraction θ_s of these loans to his or her household. If a shadow bank manager decides to divert loan holdings, the bank defaults on its debt and shuts down. ABS holders may reclaim the remaining fraction $1 - \theta_s$ of loans. Since

ABS holders recognize a shadow bank's incentive to divert loans, they limit their purchase of ABS.

Let $V_{st}(s_{st}, m_t, n_{st})$ be a shadow bank's maximized value of its objective V_{st}, given an asset and liability composition (s_{st}, m_t, n_{st}) at the end of period t. The ICC for a shadow bank is then

$$V_{st} \geq \theta_s Q_t s_{st} \tag{36}$$

This incentive constraint states that in order for commercial banks to purchase ABS, the shadow bank's enterprise value must be no less than the fraction of its assets it can divert. I will only consider equilibria in which this constraint is binding.

Substituting a shadow bank's flow of funds constraint (33) for $q_{ht}m_t$ into its law of motion for net worth (34) results in

$$n_{st} = (R_{st} - R_{ht})Q_{t-1}s_{st-1} + R_{ht}n_{st-1} \tag{37}$$

Note that substituting the flow of funds constraint (5) for $q_{ht}m_t$ also modifies the shadow bank's enterprise value to a function of the pair (s_{st}, n_{st}). The enterprise value of a shadow bank at the end of period $t-1$ satisfies the Bellman equation

$$V_{st-1}(s_{st-1}, n_{st-1}) = \mathbb{E}_{t-1}\Lambda_{t-1,t}\big\{(1-\sigma)n_{st} + \sigma \max_{s_{st}}[V_{st}(s_{st}, n_{st})]\big\} \tag{38}$$

As seen in the Bellman equation, a shadow bank's problem is reduced to choosing a quantity of loan holdings s_{st} to maximize its franchise value $V_{st}(s_{st}, n_{st})$ subject to the incentive constraint (36). A conjecture and verify methodology on the value function is utilized. I hypothesize the shadow bank's value function to have the form

$$V_{st}(s_{st}, n_{st}) = \left(\mu_t - \frac{\upsilon_{ht}}{q_{ht}}\right)Q_t s_{st} + \frac{\upsilon_{ht}}{q_{ht}}n_{st} \tag{39}$$

where μ_t and υ_{ht} are variables to be determined explicitly. Appendix A provides the derivation of this conjectured value function, along with verification of its validity.

From solving the shadow banker's problem, the binding incentive constraint can be rewritten as

$$Q_t s_{st} = \phi_{st} n_{st} \tag{40}$$

with

$$\phi_{st} = \frac{\upsilon_{ht}/q_{ht}}{\theta_s - \mu_t} \tag{41}$$

The variable ϕ_{st} is interpreted as a shadow bank's maximum permissible leverage ratio. It is increasing in the excess value of bank loan holdings μ_t and in the saving in ABS costs from a unit of inside equity υ_{ht}/q_{ht}. In contrast, it is decreasing in the fraction of divertible assets θ_s.

The conjecture and verify method produces the values for μ_t and υ_{ht}/q_{ht}:

$$\mu_t = \mathbb{E}_t\Lambda_{t,t+1}\Omega_{st+1}(R_{st+1} - R_{ht+1}) \tag{42}$$

$$\frac{\upsilon_{ht}}{q_{ht}} = \mathbb{E}_t\Lambda_{t,t+1}\Omega_{st+1}R_{ht+1} \tag{43}$$

Ω_{st} is the period t shadow value of a unit of net worth to a shadow bank and is given by

$$\Omega_{st} = 1 - \sigma + \sigma\left(\frac{\upsilon_{ht}}{q_{ht}} + \phi_{st}\mu_t\right) \tag{44}$$

The product $\Lambda_{t,t+1}\Omega_{st+1}$ is a shadow bank's augmented stochastic discount factor. According to (42), the excess value of loan holdings μ_t is the expected discounted value of the spread between the return on loans and the return on ABS. (43) states that the saving in ABS costs from a unit of inside equity υ_{ht}/q_{ht} is equal to the expected discount value of ABS returns.

Aggregation of the flow of funds for Home shadow banks produces

$$Q_t S_{st} = N_{st} + q_{ht} M_t \tag{45}$$

where S_{st} is the aggregate demand for shadow bank loan holdings, N_{st} is aggregate net worth in the shadow banking sector, and M_t is the aggregate supply of Home ABS. Aggregation of the flow of funds for Foreign shadow banks yields

$$Q_t^* S_{st}^* = N_{st}^* + q_{ft} M_t^* \tag{46}$$

The interpretations of Foreign aggregate shadow bank variables are analogous to their Home counterparts. Since the maximum permissible leverage ratio of a shadow bank ϕ_{st} does not depend on bank-specific factors, (40) can be aggregated for Home and Foreign shadow banks as

$$Q_t S_{st} = \phi_{st} N_{st} \tag{47}$$

$$Q_t^* S_{st}^* = \phi_{st}^* N_{st}^* \tag{48}$$

Aggregate net worth in the Home shadow banking sector is the sum of net worth of existing shadow banks N_{st}^o and entering shadow banks N_{st}^y:

$$N_{st} = N_{st}^o + N_{st}^y \tag{49}$$

Aggregate net worth of existing shadow banks at t is equal to the return on loan holdings from $t-1$ net the returns paid to ABS holders, multiplied by the fraction of surviving shadow banks at t, σ:

$$N_{st}^o = \sigma(R_{st} Q_{t-1} S_{st-1} - R_{ht} q_{ht-1} M_{t-1}) \tag{50}$$

Similarly to commercial banks, I assume that households transfer a fraction $\xi_s/(1-\sigma)$ of assets from shadow banks exiting the market. Aggregate net worth of entering shadow banks is then

$$N_{st}^y = \xi_s R_{st} Q_{t-1} S_{st-1} \tag{51}$$

It follows that the aggregate net worth of the Home shadow banking sector is

$$N_{st} = (\sigma + \xi_s) R_{st} Q_{t-1} S_{st-1} - \sigma R_{ht} q_{ht-1} M_{t-1} \tag{52}$$

The Foreign counterpart to (52) is analogous:

$$N_{st}^* = (\sigma + \xi_s) R_{st}^* Q_{t-1}^* S_{st-1}^* - \sigma R_{ft} q_{ft-1} M_{t-1}^* \tag{53}$$

Aggregate net worth of shadow banks are directly exposed to domestic capital quality shocks. While a capital quality downturn at t negatively affects shadow bank net worth through the return on loan holdings, the sale of ABS reduces the impact.

3.2 The Real Economy

The global real economy is composed of three primary entities: households, goods-producing firms, and capital-producing firms. These entities are identical across countries due to my assumption of symmetry. In what follows, I will focus the description of the real economy on the Home country, as the description of the Foreign real economy is analogous.

3.2.1 Households

A representative household exists in each country with a continuum of members of measure one. The representative household contains three types of agents: a fraction f_c of commercial bankers, a fraction f_s of shadow bankers, and a fraction $1-f_c-f_s$ of goods-producing workers. The role of commercial and shadow bankers is to optimally manage their respective franchises, as described in sections 3.1.2 and 3.1.3, respectively. Workers on the other hand supply labor to good-producing firms and return their wages to the household.

Each period t, the representative household must decide its final good consumption C_t, labor supply to goods producers L_t, and supply of deposits to domestic commercial banks D_t. The preference structure features additive separability in consumption utility and labor disutility, as in Greenwood, Hercowitz, & Huffman (1988):

$$\mathbb{E}_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \frac{1}{1-\gamma} \left(C_\tau - hC_{\tau-1} - \frac{\chi}{1+\varphi} L_\tau^{1+\varphi} \right)^{1-\gamma} \tag{54}$$

A household funds its period t expenditure on consumption and commercial bank deposits with its wages from supplying labor, return on deposits supplied at $t-1$, and net distributions of ownership of commercial banks, shadow banks, and capital-producing firms:

$$C_t + D_t = W_t L_t + R_t D_{t-1} + \Pi_t \tag{55}$$

W_t is the wage rate and Π_t are the net distributions from ownership of both financial and non-financial firms. In particular,

$$\Pi_t = \Pi_{ct} + \Pi_{st} + \Pi_{kt} \tag{56}$$

where Π_{ct} and Π_{st} are dividends transferred to the household from commercial and shadow banks exiting the market, respectively, and Π_{kt} is profit from capital producers. Based on the aggregation of commercial bank net worth (31) and of shadow bank net worth (52), dividends transferred to households are

$$\Pi_{ct} = (1-\sigma-\xi_c)(R_{st}Q_{t-1}S_{ct-1} + R_{ht}q_{ht-1}M_{ht-1} + R_{ft}q_{ft-1}M_{ft-1}) - (1-\sigma)R_t D_{t-1} \tag{57}$$

$$\Pi_{st} = (1-\sigma-\xi_s)R_{st}Q_{t-1}S_{st-1} - (1-\sigma)R_{ht}q_{ht-1}M_{t-1} \tag{58}$$

The functional form of Π_{kt} will be described in section 3.2.3.

The representative household's first-order conditions are

$$\mathbb{E}_t(u_t^{-\gamma} - \beta h u_{t+1}^{-\gamma})W_t = \chi L_t^{\varphi} u_t^{-\gamma} \tag{59}$$

$$\mathbb{E}_t \Lambda_{t,t+1} R_{t+1} = 1 \tag{60}$$

with

$$u_t \equiv C_t - hC_{t-1} - \frac{\chi}{1+\varphi} L_t^{1+\varphi} \tag{61}$$

$$\Lambda_{t,t+1} \equiv \beta \frac{u_{t+1}^{-\gamma} - \beta h u_{t+2}^{-\gamma}}{u_t^{-\gamma} - \beta h u_{t+1}^{-\gamma}} \tag{62}$$

(59) equates the intratemporal marginal utility of consumption to the disutility of labor. International risk sharing via consumption can be derived by combining (60) with its Foreign counterpart to yield

$$\mathbb{E}_t \Lambda_{t,t+1} R_{t+1} = \mathbb{E}_t \Lambda_{t,t+1}^* R_{t+1}^* \tag{63}$$

Recall that each period, a commercial or shadow bank exits the market with i.i.d. probability $1-\sigma$. At this point, the manager of the franchise becomes a worker. This finite bank lifetime is critical to the tractability of the model, as it avoids the possibility that a bank may retain enough earnings over time to overcome financial constraints. Furthermore, I assume that in each period, $(1-\sigma)f_c$ workers become commercial bankers and $(1-\sigma)f_s$ workers become shadow bankers. This keeps the number in each occupation constant.

3.2.2 Final Goods Producers

There exists a continuum of final goods producers of measure one. Each firm produces output using an identical constant returns to scale Cobb-Douglas production function with labor and capital as inputs. Aggregate output Y_t can thus be described as a function of aggregate capital stock K_t and aggregate labor hours L_t:

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha} \tag{64}$$

where A_t is aggregate total factor productivity and follows a Markov process. Given a wage rate W_t and rental rate of capital Z_t, a firm's profit-maximizing conditions are

$$W_t = (1-\alpha)\frac{Y_t}{L_t} \tag{65}$$

$$Z_t = \alpha \frac{Y_t}{K_t} \tag{66}$$

Let S_t be aggregate capital stock "in process" for period $t+1$, which is the sum of undepreciated capital $(1-\delta)K_t$ and investment I_t.

$$S_t = (1-\delta)K_t + I_t \tag{67}$$

At $t+1$, capital stock in process from t is transformed into capital for production after being subject to the capital quality shock ψ_{t+1}.

$$K_{t+1} = \psi_{t+1} S_t \tag{68}$$

The utilization of a capital quality shock in the model follows the literature pioneered by Merton (1973). It should be noted that the capital quality shock captures some form of economic obsolescence in capital.[11]

[11] For a specific motivation of the capital quality shock, see the companion working paper associated with Gertler, Kiyotaki, & Queralto (2012).

Goods producers fund investment of new capital with state-contingent bank loans. Since banks specialize in monitoring their borrowers, goods producers can frictionlessly obtain funds for investment in new capital production. Each unit of funding in new capital production is sold to banks at a price Q_t, where these funds are used to buy new capital goods from capital producers. Each unit of the state-contingent loan is a claim to future returns from one unit of investment:

$$\psi_{t+1}Z_{t+1}, (1-\delta)\psi_{t+1}\psi_{t+2}Z_{t+2}, (1-\delta)^2\psi_{t+1}\psi_{t+2}\psi_{t+3}Z_{t+3}, ...$$

Due to perfect competition, the price of new capital goods is equal to Q_t. In addition, goods producers earn zero residual profits in every state.

3.2.3 Capital Producers

Capital-producing firms create new capital using the final output good as an input, subject to adjustment costs. Capital is sold to firms at the price Q_t. The capital producer chooses I_t for each t to solve

$$\max E_t \sum_{i=t}^{\infty} \Lambda_{t,i} \left\{ Q_i I_i - \left[1 + f\left(\frac{I_i}{I_{i-1}} \right) \right] I_i \right\} \tag{69}$$

where the stochastic discount factor is used because households own capital-producing firms. Physical adjustment costs at t are represented by $f(I_t/I_{t-1})I_t$, where $f(1) = f'(1) = 0$ and $f''(I_t/I_{t-1}) > 0$. The first-order condition is

$$Q_t = 1 + f\left(\frac{I_t}{I_{t-1}} \right) + \frac{I_t}{I_{t-1}} f'\left(\frac{I_t}{I_{t-1}} \right) - \mathbb{E}_t \Lambda_{t,t+1} \left(\frac{I_{t+1}}{I_t} \right)^2 f'\left(\frac{I_{t+1}}{I_t} \right) \tag{70}$$

which equates the price of capital goods to the marginal cost of investment. Note that profits are zero in a steady state. Outside of a steady state, profits are redistributed lump sum to households. In particular, net transfers to households from capital producers are

$$\Pi_{kt} = Q_t I_t - \left[1 + f\left(\frac{I_t}{I_{t-1}} \right) \right] I_t \tag{71}$$

3.3 Capital Controls

Capital controls can be imposed by the domestic government sector to reduce the quantity of foreign ABS purchased in an attempt to reduce the transmission of a financial crisis. I model capital controls as a tariff on ABS purchased from abroad. Let τ_t be the per-unit tariff on Foreign ABS purchased by Home commercial banks in period t. The aggregate Home commercial bank flow of funds constraint at t then becomes

$$Q_t S_{ct} + q_{ht} M_{ht} + (1 + \tau_t) q_{ft} M_{ft} = N_{ct} + D_t \tag{72}$$

The tariff changes (14), (16), (18), and (23) as follows:

$$\mu_{st} + x_t(\mu_{ft} - \tau_t \upsilon_t) = (1 + \omega x_t)\Theta(x_t) \frac{\lambda_t}{1 + \lambda_t} \tag{73}$$

$$\mu_{ft} - \tau_t \upsilon_t = \left[\omega\Theta(x_t) + (1+\omega x_t)\Theta'(x_t)\right]\frac{\lambda_t}{1+\lambda_t} \tag{74}$$

$$\phi_{ct} = \frac{\upsilon_t}{(1+\omega x_t)\Theta(x_t) - [\mu_{st} + x_t(\mu_{ft} - \tau_t\upsilon_t)]} \tag{75}$$

$$\Omega_{ct} = 1 - \sigma + \sigma\left[\upsilon_t + \phi_{ct}[\mu_{st} + x_t(\mu_{ft} - \tau_t\upsilon_t)]\right] \tag{76}$$

The term $\tau_t\upsilon_t$ represents the reduction in the ABS spread resulting from the tariff. I choose a tariff that keeps the reduction in the spread constant. Specifically, I set τ_t to a constant rate τ divided by the shadow cost of deposits υ_t:

$$\tau_t = \frac{\tau}{\upsilon_t} \tag{77}$$

As a result the marginal benefit of holding loans at t becomes $\mu_{st} + x_t(\mu_{ft} - \tau)$. I assume that the revenue from tariffs are redistributed lump sum to domestic households.

A description of capital controls imposed by the Foreign government on their commercial banks is analogous. Let the tax rate on ABS purchased by Foreign commercial banks from Home shadow banks be τ_t^*, where

$$\tau_t^* = \frac{\tau^*}{\upsilon_t^*} \tag{78}$$

The rate τ^* need not be identical to τ, as I will consider different policy combinations for crisis simulations.

3.4 Equilibrium

Aggregate final goods produced must equal aggregate consumption and investment, where the latter is subject to adjustment costs.

$$Y_t + Y_t^* = C_t + C_t^* + \left[1 + f\left(\frac{I_t}{I_{t-1}}\right)\right]I_t + \left[1 + f\left(\frac{I_t^*}{I_{t-1}^*}\right)\right]I_t^* \tag{79}$$

Market clearing in Home and Foreign loans is such that the aggregate loans in each country are equal to domestic commercial bank loan holdings and domestic shadow bank loan holdings:

$$S_t = S_{ct} + S_{st} \tag{80}$$

$$S_t^* = S_{ct}^* + S_{st}^* \tag{81}$$

In addition, the aggregate demand for ABS must equal the aggregate supply in both Home and Foreign securities:

$$M_{ht} + M_{ht}^* = M_t \tag{82}$$

$$M_{ft} + M_{ft}^* = M_t^* \tag{83}$$

Finally, the aggregate demand for overseas ABS for Home and Foreign commercial banks satisfy

$$q_{ft}M_{ft} = x_t Q_t S_{ct} \tag{84}$$

$$q_{ht}M_{ht}^* = x_t^* Q_t^* S_{ct}^* \tag{85}$$

To close the model, I will describe the exogenous processes for the productivity shocks A_t and A_t^*, as well as the capital quality shocks ψ_t and ψ_t^*. The log deviations from the steady state satisfy

$$\begin{pmatrix} \hat{A}_t \\ \hat{A}_t^* \end{pmatrix} = \begin{pmatrix} \pi_{11} & \pi_{12} \\ \pi_{21} & \pi_{22} \end{pmatrix} \begin{pmatrix} \hat{A}_{t-1} \\ \hat{A}_{t-1}^* \end{pmatrix} + \begin{pmatrix} \varepsilon_{at} \\ \varepsilon_{at}^* \end{pmatrix} \tag{86}$$

$$\begin{pmatrix} \hat{\psi}_t \\ \hat{\psi}_t^* \end{pmatrix} = \begin{pmatrix} \rho_{11} & \rho_{12} \\ \rho_{21} & \rho_{22} \end{pmatrix} \begin{pmatrix} \hat{\psi}_{t-1} \\ \hat{\psi}_{t-1}^* \end{pmatrix} + \begin{pmatrix} \varepsilon_{pt} \\ \varepsilon_{pt}^* \end{pmatrix} \tag{87}$$

where hats denote log deviations from the steady state. In a steady state, I assume the productivity and capital quality shocks to be equal to unity. The disturbances satisfy $(\varepsilon_{at}, \varepsilon_{at}^*) \sim \boldsymbol{N}(\boldsymbol{0}, \boldsymbol{\Sigma}_a)$ and $(\varepsilon_{pt}, \varepsilon_{pt}^*) \sim \boldsymbol{N}(\boldsymbol{0}, \boldsymbol{\Sigma}_p)$, where

$$\boldsymbol{\Sigma}_i = \begin{pmatrix} 1 & \varsigma_i \\ \varsigma_i^* & 1 \end{pmatrix}, i = a, p \tag{88}$$

I will consider two separate calibrations: one in which shocks are correlated across countries and one in which shocks are isolated. This amounts to placing restrictions on the off-diagonal entries of the matrices in (86), (87), and (88).

Appendix B lists all equations of the model for each period t, along with a list of all endogenous variables, state variables, and exogenous processes. Note that I exclude the Foreign household flow of funds equation, as it is not independent by Walras' Law.

4 Calibration

There are eight non-bank parameters, including the capital share of production α, the subjective discount factor β, the disutility of labor χ, the capital depreciation rate δ, the habit parameter for consumption h, the inverse Frisch elasticity of labor supply φ, the coefficient of relative risk aversion γ, and the steady state second-order adjustment cost $f''(1)$. The parameter values chosen are conventional to the DSGE literature and reported in Table 1.

The remaining parameters are bank-specific: the quarterly survival rate of commercial and shadow banks σ; the fraction of assets transferred to new commercial and shadow banks ξ_c and ξ_s, respectively; the divertibility of ABS for Home and Foreign commercial banks ω and ω^*, respectively; the fraction of divertible loan holdings for shadow banks θ_s; and three parameters that are part of the function describing the fraction of divertible commercial bank assets Θ: ϵ, κ, and θ_c. I target an average lifetime for commercial and shadow banks of eight years by setting $\sigma = 0.968$. I consider a symmetric steady state equilibrium across countries, so $\omega = \omega^*$. This reduces the remaining parameter count to seven, which will be chosen to satisfy seven targets.

The first target is an average credit spread of one hundred basis points per year, which is based on an average of the following pre-2007 spreads: mortgage rates versus government bond rates, commercial paper rates versus T-Bill rates, and BAA corporate bond rates versus government bonds. This target translates to a Home credit spread of $R_s - R$ of twenty-five basis points due to the quarterly time denomination. The Foreign credit spread is identical, but due to the symmetry of the steady state in question, it is not a separate restriction. The second target is an ABS spread of fifty basis points, which is based on a rough midpoint between 2000-2007 average ABS spreads over comparable swap rates for high-quality securities. This amounts to a Home ABS spread $R_h - R$ of 12.5 basis points per quarter. Again, due to symmetry, $R_f - R^*$ is identical.

The third target is the ratio of ABS holdings to loans for commercial banks of 30 percent in both countries, which amounts to $(M_h + M_f)/S_c = 0.3$. This target is based on call report data on bank assets sold and securitized. The fourth target is a shadow bank leverage ratio of ten. Various papers in the literature have used varying values of leverage ratios to average across many sectors. However, the worldwide average leverage ratios of banks from 2000-2009 was measured to be approximately twelve by Kalemli-Ozcan, Sorensen, & Yesiltas (2012). I choose to target a slightly lower leverage ratio, as shadow banks in my model are limited to a role as an SPV rather than a multi-faceted investment bank. The fifth target is an aggregate ratio of commercial bank loans to net worth S_c/N_c of 4.5. This target is close to the median ratio of total loans and leases to the sum of tier 1 and 2 capital at commercial banks in call report data.

The fraction of assets a commercial bank can divert Θ is nonlinear and includes three parameters: θ_c, ϵ, and κ. One is already pinned down with one of the previous targets. The remaining two parameters require targets involving the function Θ. This segment of the calibration is critical to the composition of Home and Foreign ABS in commercial bank balance sheets. Recall that I assumed that ϵ is negative, which implies there are efficiency gains in monitoring the underlying loans of ABS from abroad. The larger these efficiency gains are relative to the parameters θ_c and κ, the larger the holdings of ABS originated abroad. Therefore, I consider two calibrations: one in which commercial bank holdings of ABS originated abroad are high and one where these holdings are low.

The first target involving Θ is relatively intuitive, as it amounts to targeting a bank leverage ratio in a reduced version of the model where securitization does not exist. This implies $x = x^* = 0$, and so $\Theta(0) = \theta_c$. I consider two possible values for the leverage ratio in this economy: three and four. These ratios capture economy-wide leverage, which in general will be much lower than bank-specific leverage. I calibrate two values to yield two portfolio holdings of ABS from abroad: one with a relatively large share of these ABS and one with a relatively small share.

The final target involves the following equation:

$$\frac{\Theta'(0)}{\Theta(0)} = \epsilon \tag{89}$$

This equation is derived from evaluating the first-order derivative of Θ at zero and noting that $\Theta(0) = \theta_c$. The left-hand side of (89) has the form of an elasticity. As a first-pass, I target a value $\epsilon = -2$, which provides a sufficient level of efficiency gains from holding ABS from abroad in order to produce the two portfolio compositions described previously. It should be noted that these portfolio holdings could also be produced by choosing one value for θ_c and two values for ϵ. The goal here is simply to calibrate two different steady states that vary in the composition of commercial bank portfolios.

5 Results

5.1 Crisis Simulations

Central to this paper is showing the endogenous international transmission of a financial crisis originating in one country. To replicate the comovements exhibited during the Great Recession, it is not enough to show a synchronized decline in real activity. Critically, there was a sharp and simultaneous decline in financial markets as well, especially in aggregates related to intermediation. Foreign holdings of US-originated securities was on the rise leading up to the Great Recession. Therefore, I will consider three economies for crisis simulations. The first is one in which securitization does not exist. In such a setting, financial market integration is broken and shadow banks do not exist. This will serve as a benchmark case. The second economy is one in which securitization and shadow banking exists, but steady state holdings in each country of ABS originated abroad are relatively low. The third economy is identical to the second, except steady state holdings in each country of ABS originated abroad are relatively high. These last two environments will illustrate the importance of balance sheet composition in the international transmission of a financial shock.

I first consider a persistent Home capital quality shock with an impact of -2.5 percent and autocorrelation of 0.8. Figure 2 illustrates the impulse responses of key real and financial aggregates for both countries. The primary narrative here is that the economy with securitization and shadow banking exhibits a synchronized downturn in all real and financial variables, whereas the benchmark economy fails to produce any transmission at all. Additionally, transmission is greater when a larger share of Home ABS are held by Foreign commercial banks prior to the shock. This is consistent with that narrative that countries holding relatively larger shares of US-originated securities suffered larger downturns than those that held relatively smaller shares.

The interplay between Home and Foreign aggregates depends critically on the strength of the balance sheet channel of international transmission. Home aggregate output, investment, capital, and consumption suffer large, instantaneous downturns in all three hypothetical economies following the capital quality shock, but with varying degrees. The worst downturn in Home real aggregates occurs in the economy without securitization and shadow banking, which is due to the lack of international risk sharing in financial markets. As a result, Foreign real aggregates are left unaffected. In contrast, real aggregates fall simultaneously in both countries when securitization and shadow banking exist. Larger holdings of Home ABS by Foreign commercial banks result in a sharper downturn of Foreign real aggregates, but a smaller downturn in Home real aggregates. The balance sheet channel of international transmission is stronger when Foreign commercial banks hold more Home ABS, thus Foreign real aggregates share a larger burden of the shock. This is directly the result of commercial bank balance sheet exposure being greater, as Home ABS returns depend on the capital quality shock.

While the impulse responses of real aggregates move in the same direction as seen during the Great Recession, the degree of transmission is also reminiscent to what was seen between the US and Euro Area. For example, the ratio of the trough of Foreign investment to the trough of Home investment is almost identical to the ratio of the trough of Euro Area investment to the trough of US investment, as seen in the data.[12] Using an analogous comparison for real output, I find that my model explains twenty percent of transmission between the US and Euro Area during the Great Recession.[13]

Financial aggregates do not exhibit the same degree of interplay as their real aggregate counterparts. For example, while Foreign commercial bank net worth suffers a larger downturn when more Home ABS are held, the downturn of Home commercial bank net worth is not sensitive to Foreign commercial bank portfolio structure. While Foreign commercial banks are more exposed to the Home capital quality shock as they hold more Home ABS, Home commercial banks are already highly exposed since they are loan originators and holders. A similar result follows for Home and Foreign shadow bank net worth. It should be noted that while Home and Foreign commercial bank balance sheets are only directly exposed to the capital quality shock on the asset-side, Home shadow banks are directly exposed on both the asset and liability-side. The capital quality shock negatively affects Home shadow bank net worth by reducing the return on loan holdings, but positively affects it by reducing payouts to ABS holders. The former dominates the latter in this case, as Home shadow bank net worth falls over thirty percent on impact in both initial steady state portfolio scenarios. In contrast, Foreign shadow bank balance sheets are not directly exposed to the Home capital quality shock. Instead, the dynamics of Foreign shadow bank net worth depends on the supply of Foreign loans and the demand for Foreign-originated ABS by commercial banks.

The commercial bank capital-to-total-assets ratio when there are large ABS holdings accounts for 33 percent of the transmission when compared to the data.[14] I compare the ratios of the troughs again. It should be noted that the only trade in assets across borders is in ABS, so this transmission result could potentially be improved by adding more asset trade, such as commercial banks making direct loans overseas or considering more volatile securities, such as credit default swaps.

The international securities market faces a downturn upon impact of the shock, as seen by the impulses of both Foreign ABS purchased by Home commercial banks and Home ABS purchased by Foreign commercial banks. It should be noted that ABS markets as a whole do not suffer a downturn. In fact, while commercial banks' demand for ABS originated overseas decrease, their demand for ABS originated domestically increase. As a result of this increase in domestic ABS demand, shadow bank net worth recovers more quickly than commercial bank net worth. This result can be seen as a "flight-to-collateral," as domestically-originated ABS are seen as a better source of collateral than loans via the incentive constraint faced by commercial banks. While commercial bank credit falls following the sock, domestic shadow bank credit rises. This result is consistent with the credit cycle behavior of the last three US recessions documented in Meeks, Nelson, & Alessandri (2017).

[12] I use annual gross fixed capital formation (GFCF) from OECD (2018) as a proxy for investment.

[13] Quarterly real GDP for the Euro Area and US during the downturn are utilized from Eurostat (2018) and BEA (2018), respectively.

[14] I use annual bank capital-to-total-assets for both the US and Euro Area from World Bank (2018b) and World Bank (2018a) , respectively. This includes data collected from the respective countries' banking sectors. Shadow banking is likely not fully represented here, so I treat this data as a proxy for commercial banks.

On the commercial ban k liability side, both Home and Foreign deposits fall following the shock. As exhibited by real aggregates, the downturn in Home deposits is at its greatest when Foreign commercial banks hold more Home ABS, whereas the downturn in Foreign deposits is at its greatest when Foreign commercial banks hold less Home ABS. As Foreign commercial banks hold more Home ABS, their incentive constraint tightens. When the shock hits, the tighter incentive constraint induces households to reduce their deposits even more.

The last impulses of interest involve the relevant spreads faced by commercial and shadow banks. The loan-deposit spread increases in both countries upon impact of the shock, but to a greater degree on the Home spread. This is due to the direct impact of the Home capital quality shock on the Home return rate on loans. The loan-ABS spread also increases in both countries, but again to a greater degree at Home. Again, the capital quality shock directly affects Home returns on loans and ABS. The loan-ABS spread has implications for shadow banks, as the widening of this spread allows shadow banks to expand their holdings of loans by taking on increased leverage.

Figure 3 illustrates a negative Home capital quality shock of five percent with no persistence. The overall impulse response behavior to real and financial aggregates is similar to a persistent shock, but with a few caveats. First and foremost, Foreign aggregate output increases upon impact of the shock, then decreases, even though this shock is greater on impact than in the previous case. Persistence of the shock appears to play a critical role on the initial transmission to Foreign output. Thus, in order to replicate a completely synchronized decline in economic activity in both countries, the Home capital quality shock must be persistent. I also include impulse responses for correlated capital quality shocks with no persistence for the sake of completeness in Figure 4. With correlated shocks, the economy without securitization exhibits a decline in Foreign real and financial aggregates. It becomes increasingly more difficult to tell the impulse responses of the three initial economies apart in the case of correlated shocks. This is not surprising, as risk-sharing becomes less relevant in the case of common shocks.

5.1.1 Policy Experiment: Capital Controls

Foreign policymakers may be interested in reducing transmission of a Home financial crisis by reducing their commercial banks' balance sheet exposure. I thus consider a policy experiment with capital controls in the form of a tariff on ABS purchased from abroad. I focus on a persistent Home capital quality shock and two capital control environments: one in which Foreign policymakers impose capital controls and one in which both Home and Foreign policymakers impose capital controls. In the latter, without loss of generality, I assume the capital controls are identical in both countries. The Home and Foreign capital controls are tariffs on ABS from abroad, expressed by (77) and (78), respectively. The case in which there are only Foreign capital controls sets $\tau = 0$ and $\tau^* = 0.001$, whereas the case in which there are both Home and Foreign capital controls sets $\tau = 0.001$ and $\tau^* = 0.001$.

The effectiveness of capital controls will depend critically on the quantity of Home ABS held by Foreign commercial banks in a no-policy steady state. I first consider a no-policy steady state in which Foreign commercial bank holdings of Home ABS are relatively high. This corresponds to the calibration in which $\Theta_c = 0.4331$ and $\kappa = 7.5924$, i.e., the efficiency gains of Foreign commercial banks holding Home ABS are relatively large. I then consider the dynamics centered at a steady state with the same parameter values, but with capital controls. The resulting impulse responses are illustrated in Figure 5. When Foreign policymakers impose tariffs on Home-originated ABS, transmission is reduced across all real and financial aggregates. In absence of capital controls, steady state ABS holdings are high and the response to Foreign aggregates would have followed Figure 2. Foreign capital controls reduce the steady state Home-originated ABS holdings of Foreign commercial banks in a steady state, which results in less balance sheet exposure and thus less transmission of the shock.

In addition to reducing transmission, Foreign capital controls have a negligible impact on Home impulse responses. Home real and financial markets don't absorb more of the shock in response to this Foreign policy. It follows that the decline in global aggregates is reduced in the presence of Foreign capital controls. If Home policymakers decide to impose capital controls on Foreign-originated ABS in parallel with Foreign policy, then the results become mixed across both Home and Foreign aggregates. For example, while the impulse response of Home aggregate output remains mostly unchanged, Home deposits fall by more than they would have if Home policymakers didn't impose capital controls. Additionally, commercial bank loans in both countries decline significantly more when capital controls are imposed in both countries. Global capital controls may not be the optimal policy decision if policymakers are concerned with reducing the severity of a financial crisis.

Consider now a no-policy steady state in which Foreign commercial banks hold a relatively small share of Home ABS. This corresponds to the calibration in which $\Theta_c = 0.3604$ and $\kappa = 17.4065$, i.e., the efficiency gains of Foreign commercial banks holding Home ABS are relatively small. Using this calibration, I consider the dynamics around a steady state with capital controls. The impulse responses for this case are illustrated in Figure 6. While there is still a reduction in international transmission of the Home capital quality shock, the reduction is smaller in magnitude compared to the previous case. The justification for this result is that Home-originated ABS holdings of Foreign commercial banks would have already been small in absence of policy. When exposure is small to begin with, capital controls will barely reduce transmission versus free trade. Furthermore, if Home policymakers also impose capital controls, the change to the impulse responses are mostly negligible. In this environment, policymakers may want to consider domestic credit policy, such as discount window lending or equity injections.

It should be emphasized that the policy experiments documented in this section were not taking welfare into consideration. The welfare implications of commercial banks holding ABS are among the various topics one could consider for future research within this framework. Since the primary concern of this paper is international transmission, I abstract from welfare analysis.

6 Concluding Remarks

I have developed a two-country model with financial intermediation that illustrates a simultaneous decline in real and financial aggregates in both countries following a financial shock in one country. This result is reminiscent of the Great Recession and depends critically on the shadow banking sector. Increased shadow bank credit along with larger holdings of ABS held outside of the originating country lead to increased systemic risk through commercial bank balance sheets. When a shock hits one country, intermediaries' balance sheets deteriorate and a financial accelerator emerges, leading to a decline in real economic activity. Without shadow banking and securitization, transmission is nonexistent in my framework, further illustrating the importance of the shadow banking sector. According to my framework, capital controls can reduce the transmission of a financial crisis, but the magnitude of transmission reduction depends on how exposed commercial banks are to the securities most vulnerable to negative shocks. The effectiveness of capital controls can become obscure if the country where the shock originates also imposed capital controls. The welfare implications of capital controls in my framework are a topic for future research.

The open-economy literature on transmission of country-specific shocks have largely abstracted from financial intermediation. Models that have incorporated banks into their model have mostly focused on global banks rather than country-specific banks. My model only considers country-specific intermediaries, but banks owned and operated globally could also be included and would likely increase transmission. For example, a commercial bank owned and operated by both Home and Foreign households that lend to firms and take deposits in both countries would be exposed to both Home and Foreign uncertainty without even considering the channel explored in my framework via ABS holdings.

The growing importance of shadow banking in both domestic and international financial markets cannot be emphasized enough. Much of the closed and open macroeconomic literatures have abstracted from these entities. I have provided the first framework to incorporate shadow banking alongside commercial banking in an open-economy framework with the experiences of The Great Recession in mind. This should serve as a first pass at considering the role of shadow banking in global real and financial markets. The shadow banking industry is not just large in scope, but it is composed of a diverse set of entities. Some of these entities include securitization vehicles, asset-backed commercial paper conduits, money market funds, markets for repurchase agreements, mortgage companies, and investment banks. The shadow banks in my framework resembled securitization vehicles that operated independently of commercial banks. There is clearly a lot more of the shadow banking system to consider for future research.

References

Adrian, T., & Ashcraft, A. B. (2016). Shadow banking: a review of the literature. In *Banking crises* (pp. 282–315). Springer.

Adrian, T., & Shin, H. S. (2008). Liquidity and financial cycles.

BEA. (2018). *Real gross domestic product [gdpc1].* (retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/GDPC1)

Benanke, B., & Gertler, M. (1989). Agency costs, net worth, and business fluctuation. *American Economic Review*, *79*(1), 14–31.

Bernanke, B., Gertler, M., & Gilchrist, S. (1994). *The financial accelerator and the flight to quality* (Tech. Rep.). National Bureau of Economic Research.

Coeurdacier, N., Rey, H., & Winant, P. (2011). The risky steady state. *American Economic Review*, *101*(3), 398–401.

Cúrdia, V., & Woodford, M. (2009). Conventional and unconventional monetary policy.

Curdia, V., & Woodford, M. (2010). Credit spreads and monetary policy. *Journal of Money, credit and Banking*, *42*, 3–35.

Dedola, L., & Lombardo, G. (2012). Financial frictions, financial integration and the international propagation of shocks. *Economic Policy*, *27*(70), 319–359.

Devereux, M. B., & Yetman, J. (2010). Leverage constraints and the international transmission of shocks. *Journal of Money, Credit and Banking*, *42*, 71–105.

Edwards, S. (1999). How effective are capital controls? *Journal of Economic Perspectives*, *13*(4), 65–84.

Eurostat. (2018). *Real gross domestic product (euro/ecu series) for euro area (19 countries) [clvmeurscab1gqea19].* (retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/CLVMEURSCAB1GQEA19)

FSB. (2017). *Global shadow banking monitoring report.* Financial Stability Board Basel.

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

Gennaioli, N., Shleifer, A., & Vishny, R. W. (2013). A model of shadow banking. *The Journal of Finance*, *68*(4), 1331–1363.

Gertler, M., & Karadi, P. (2011). A model of unconventional monetary policy. *Journal of monetary Economics*, *58*(1), 17–34.

Gertler, M., & Kiyotaki, N. (2010). Financial intermediation and credit policy in business cycle analysis. In *Handbook of monetary economics* (Vol. 3, pp. 547–599). Elsevier.

Gertler, M., Kiyotaki, N., & Queralto, A. (2012). Financial crises, bank risk exposure and government financial policy. *Journal of Monetary Economics*, *59*, S17–S34.

Gorton, G., & Metrick, A. (2012). Securitized banking and the run on repo. *Journal of Financial economics*, *104*(3), 425–451.

Greenwood, J., Hercowitz, Z., & Huffman, G. W. (1988). Investment, capacity utilization, and the real business cycle. *The American Economic Review*, 402–417.

Grilli, V., & Milesi-Ferretti, G. M. (1995). Economic effects and structural determinants of capital controls. *Staff Papers*, *42*(3), 517–551.

Kalemli-Ozcan, S., Sorensen, B., & Yesiltas, S. (2012). Leverage across firms, banks, and countries. *Journal of international Economics*, *88*(2), 284–298.

Kiyotaki, N., & Moore, J. (1997). Credit cycles. *Journal of political economy*, *105*(2), 211–248.

Kollmann, R., Enders, Z., & Müller, G. J. (2011). Global banking and international business cycles. *European Economic Review*, *55*(3), 407–426.

Maggiori, M. (2017). Financial intermediation, international risk sharing, and reserve currencies. *American Economic Review*, *107*(10), 3038–71.

Meeks, R., Nelson, B., & Alessandri, P. (2017). Shadow banks and macroeconomic instability. *Journal of Money, Credit and Banking*, *49*(7), 1483–1516.

Mendoza, E. G., & Quadrini, V. (2010). Financial globalization, financial crises and contagion. *Journal of monetary economics*, *57*(1), 24–39.

Merton, R. C. (1973). An intertemporal capital asset pricing model. *Econometrica: Journal of the Econometric Society*, 867–887.

Montiel, P., & Reinhart, C. M. (1999). Do capital controls and macroeconomic policies influence the volume and composition of capital flows? evidence from the 1990s. *Journal of international money and finance*, *18*(4), 619–635.

Moreira, A., & Savov, A. (2017). The macroeconomics of shadow banking. *The Journal of Finance*, *72*(6), 2381–2432.

OECD. (2018). *Investment (gfcf) (indicator).* doi: 10.1787/b6793677-en.

Olivero, M. P. (2010). Market power in banking, countercyclical margins and the international transmission of business cycles. *Journal of International Economics*, *80*(2), 292–301.

Ostry, J. D., Ghosh, A. R., Chamon, M., & Qureshi, M. S. (2012). Tools for managing financial-stability risks from capital inflows. *Journal of International Economics*, *88*(2), 407–421.

Perri, F., & Quadrini, V. (2018). International recessions. *American Economic Review*, *108*(4-5), 935–84.

Reis, R. (2009). Where should liquidity be injected during a financial crisis? *Columbia University*, 2007–09.

World Bank. (2018a). *Bank capital to total assets for euro area [ddsi03eza156nwdb].* (retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/DDSI03EZA156NWDB)

World Bank. (2018b). *Bank capital to total assets for united states [ddsi03usa156nwdb].* (retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/DDSI03USA156NWDB)

7 Appendix

7.1 Appendix A

In this subsection of the appendix, I solve the optimization problems of commercial and shadow banks in detail. In what follows, I focus on Home franchises. The Foreign bank optimization problems are analogous.

7.1.1 A Commercial Banker's Problem

I conjecture a value function for a commercial bank that is linear in the quadruple $(s_{ct}, m_{ht}, m_{ft}, d_t)$:

$$V_{ct}(s_{ct}, m_{ht}, m_{ft}, d_t) = \frac{\upsilon_{st}}{Q_t} Q_t s_{ct} + \frac{\upsilon_{ht}}{q_{ht}} q_{ht} m_{ht} + \frac{\upsilon_{ft}}{q_{ft}} q_{ft} m_{ft} - \upsilon_t d_t \tag{A1}$$

where the quadruple $(\upsilon_{st}, \upsilon_{ht}, \upsilon_{ft}, \upsilon_t)$ are unknown coefficients. To simplify the problem, I substitute the flow of funds constraint (5) and the ratio of foreign ABS to loan expenditures (9) into the conjectured value function:

$$V_{ct}(s_{ct}, m_{ht}, x_t, n_{ct}) = (\mu_{st} + x_t \mu_{ft}) Q_t s_{ct} + \mu_{ht} q_{ht} m_{ht} + \upsilon_t n_{ct} \tag{A2}$$

where $\mu_{st} \equiv \frac{\upsilon_{st}}{Q_t} - \upsilon_t$, $\mu_{ht} \equiv \frac{\upsilon_{ht}}{q_{ht}} - \upsilon_t$, and $\mu_{ft} \equiv \frac{\upsilon_{ft}}{q_{ft}} - \upsilon_t$. The commercial bank's problem has been reduced to maximizing franchise value by choosing (s_{ct}, m_{ht}, x_t) subject to the incentive constraint (10). The corresponding Lagrangian is

$$\begin{aligned}\mathcal{L}_{ct}(s_{ct}, m_{ht}, x_t, \lambda_t) =& (1+\lambda_t)[(\mu_{st} + x_t \mu_{ft}) Q_t s_{ct} + \mu_{ht} q_{ht} m_{ht} + \upsilon_t n_{ct}] \\ & - \lambda_t \Theta(x_t) \big[(1 + \omega x_t) Q_t s_{ct} + \omega q_{ht} m_{ht}\big]\end{aligned} \tag{A3}$$

where λ_t is the Lagrangian multiplier with respect to the incentive constraint. The first-order necessary conditions for s_{ct}, m_{ht}, x_t, and λ_t yield

$$(1+\lambda_t)(\mu_{st} + x_t \mu_{ft}) = \lambda_t (1 + \omega x_t) \Theta(x_t) \tag{A4}$$

$$(1+\lambda_t)\mu_{ht} = \omega \lambda_t \Theta(x_t) \tag{A5}$$

$$(1+\lambda_t)\mu_{ft} Q_t s_{ct} = \lambda_t \big[\omega \Theta(x_t) Q_t s_{ct} + \Theta'(x_t)[(1+\omega x_t) Q_t s_{ct} + \omega q_{ht} m_{ht}]\big] \tag{A6}$$

$$(\mu_{st} + x_t \mu_{ft}) Q_t s_{ct} + \mu_{ht} q_{ht} m_{ht} + \upsilon_t n_{ct} = \Theta(x_t) \big[(1 + \omega x_t) Q_t s_{ct} + \omega q_{ht} m_{ht}\big] \tag{A7}$$

Note that I only consider interior solutions. The left-hand side of (A4) is the marginal benefit from increasing loans, whereas the right-hand side is the marginal cost of tightening the incentive constraint. The interpretation of (A5) is identical, but with respect to domestic ABS. The left-hand side of (A6) is the marginal benefit of increasing foreign ABS purchases, whereas the left-hand side is the marginal cost of increasing the fraction of assets a commercial bank may divert. Finally, (A7) is the incentive constraint, which can be rewritten to obtain (17).

Substituting (17) into the conjectured value function (A2) for $Q_t s_{ct}$ yields

$$V_{ct}(x_t, n_{ct}) = [\upsilon_t + \phi_{ct}(\mu_{st} + x_t \mu_{ft})] n_{ct} \tag{A8}$$

The Bellman equation at t can be written shorthand as

$$V_{ct} = \mathbb{E}_t \Lambda_{t,t+1} [(1-\sigma) n_{ct+1} + \sigma V_{ct+1}] \tag{A9}$$

Plugging (A8) evaluated at $t+1$ into the Bellman equation for V_{ct+1} produces

$$V_{ct} = \mathbb{E}_t \Lambda_{t,t+1} \Omega_{ct+1} n_{ct+1} \tag{A10}$$

where

$$\Omega_{ct+1} = 1 - \sigma + \sigma[\upsilon_{t+1} + \phi_{ct+1}(\mu_{st+1} + x_{t+1}\mu_{ft+1})] \tag{A11}$$

Finally, in order to verify the conjectured value function for the commercial bank, plug the law of motion for net worth (11) for n_{ct+1} and (A2) for V_{ct} in (A10):

$$\begin{aligned}(\mu_{st} + x_t\mu_{ft})Q_t s_{ct} + \mu_{ht} q_{ht} m_{ht} + \upsilon_t n_{ct} = \mathbb{E}_t \Lambda_{t,t+1}\Omega_{ct+1}\big\{\big[(R_{st+1} - R_{t+1}) \\ + x_t(R_{ft+1} - R_{t+1})\big] Q_t s_{ct} + (R_{ht+1} - R_{t+1}) q_{ht} m_{ht} + R_{t+1} n_{ct}\big\}\end{aligned} \tag{A12}$$

This implies the unknown coefficients $(\mu_{st}, \mu_{ht}, \mu_{ft}, \upsilon_t)$ are

$$\mu_{st} = \mathbb{E}_t \Lambda_{t,t+1} \Omega_{ct+1}(R_{st+1} - R_{t+1}) \tag{A13}$$

$$\mu_{ht} = \mathbb{E}_t \Lambda_{t,t+1} \Omega_{ct+1}(R_{ht+1} - R_{t+1}) \tag{A14}$$

$$\mu_{ft} = \mathbb{E}_t \Lambda_{t,t+1} \Omega_{ct+1}(R_{ft+1} - R_{t+1}) \tag{A15}$$

$$\upsilon_t = \mathbb{E}_t \Lambda_{t,t+1} \Omega_{ct+1} R_{t+1} \tag{A16}$$

This confirms the validity of the conjectured value function for a commercial bank.

7.1.2 A Shadow Banker's Problem

The conjecture and verify method for a shadow bank's value function is similar to that of a commercial bank. I conjecture a value function for a shadow bank that is linear in the double (s_{ct}, m_t):

$$V_{st}(s_{st}, m_t) = \frac{\upsilon_{st}}{Q_t} Q_t s_{st} - \frac{\upsilon_{ht}}{q_{ht}} q_{ht} m_t \tag{A17}$$

The double $(\upsilon_{st}, \upsilon_{ht})$ contains unknown coefficients.

Plugging the shadow bank's flow of funds constraint (33) for $q_{ht} m_t$ into (A17) yields

$$V_{st}(s_{st}, n_{st}) = \mu_t Q_t s_{st} + \frac{\upsilon_{ht}}{q_{ht}} n_{st} \tag{A18}$$

where $\mu_t \equiv \frac{\upsilon_{st}}{Q_t} - \frac{\upsilon_{ht}}{q_{ht}}$. The shadow banker's problem has been reduced to choosing loan holdings s_{st} to maximize franchise value subject to the incentive constraint (36). The period t Lagrangian of a shadow bank is

$$\mathcal{L}_{st}(s_{st}, \eta_t) = (1 + \eta_t)(\mu_t Q_t s_{st} + \frac{\upsilon_{ht}}{q_{ht}} n_{st}) - \eta_t \theta_s Q_t s_{st} \tag{A19}$$

where η_t is the Lagrange multiplier associated with the shadow bank's incentive constraint. The first-order necessary conditions for s_{st} and η_t are

$$(1 + \eta_t)\mu_t = \theta_s \eta_t \tag{A20}$$

$$\mu_t Q_t s_{st} + \frac{\upsilon_{ht}}{q_{ht}} n_{st} = \theta_s Q_t s_{st} \tag{A21}$$

The left-hand side of (A20) is the marginal benefit of holding loans, whereas the right-hand side is the marginal cost of tightening the incentive constraint. The binding incentive constraint is (A21), which can be rewritten as (40).

Plugging the (40) for $Q_t s_{st}$ into the conjectured value function (A18) produces

$$V_{st}(n_{st}) = \left(\frac{\upsilon_{ht}}{q_{ht}} + \phi_{st}\mu_t\right) n_{st} \tag{A22}$$

The Bellman equation for a shadow bank can be written shorthand as

$$V_{st} = \mathbb{E}_t \Lambda_{t,t+1}[(1-\sigma)n_{st+1} + \sigma V_{st+1}] \tag{A23}$$

Plugging (A22) evaluated at $t+1$ into (A23) for V_{st+1} gives

$$V_{st} = \mathbb{E}_t \Lambda_{t,t+1} \Omega_{st+1} n_{st+1} \tag{A24}$$

where

$$\Omega_{st+1} = 1 - \sigma + \sigma\left(\frac{\upsilon_{ht+1}}{q_{ht+1}} + \phi_{st+1}\mu_{t+1}\right) \tag{A25}$$

Finally, to verify the conjectured value function, plug (A8) into the right-hand side of (A24) and the law of motion for net worth (37) at $t+1$ into the left-hand side to obtain

$$\mu_t Q_t s_{st} + \frac{\upsilon_{ht}}{q_{ht}} n_{st} = \mathbb{E}_t \Lambda_{t,t+1}[(R_{st+1} - R_{ht+1}) Q_t s_{st} + R_{ht+1} n_{st}] \tag{A26}$$

This implies the values of the unknown coefficients μ_t and υ_{ht} satisfy

$$\mu_t = \mathbb{E}_t \Lambda_{t,t+1} \Omega_{st+1}(R_{st+1} - R_{ht+1}) \tag{A27}$$

$$\frac{\upsilon_{ht}}{q_{ht}} = \mathbb{E}_t \Lambda_{t,t+1} \Omega_{st+1} R_{ht+1} \tag{A28}$$

Therefore, the conjectured value function for a shadow bank is verified.

7.2 Appendix B

The this section of the appendix, I describe the no-policy equilibrium equations for the model.

7.2.1 Home Commercial Banks

$$\mu_{st} = \mathbb{E}_t \Lambda_{t,t+1} \Omega_{ct+1}(R_{st+1} - R_{t+1}) \tag{B1}$$

$$\mu_{ht} = \mathbb{E}_t \Lambda_{t,t+1} \Omega_{ct+1}(R_{ht+1} - R_{t+1}) \tag{B2}$$

$$\mu_{ft} = \mathbb{E}_t \Lambda_{t,t+1} \Omega_{ct+1}(R_{ft+1} - R_{t+1}) \tag{B3}$$

$$\upsilon_t = \mathbb{E}_t \Lambda_{t,t+1} \Omega_{ct+1} R_{t+1} \tag{B4}$$

$$\Omega_{ct} = 1 - \sigma + \sigma\big[\upsilon_t + \phi_{ct}(\mu_{st} + x_t \mu_{ft})\big] \tag{B5}$$

$$\phi_{ct} = \frac{\upsilon_t}{(1+\omega x_t)\Theta(x_t) - (\mu_{st} + x_t\mu_{ft})} \tag{B6}$$

$$\mu_{st} + x_t \mu_{ft} = (1+\omega x_t)\Theta(x_t)\frac{\lambda_t}{1+\lambda_t} \tag{B7}$$

$$\mu_{ht} = \omega\Theta(x_t)\frac{\lambda_t}{1+\lambda_t} \tag{B8}$$

$$\mu_{ft}Q_tS_{ct} = \big[\omega\Theta(x_t)Q_tS_{ct} + \Theta'(x_t)[(1+\omega x_t)Q_tS_{ct} + \omega q_{ht}M_{ht}]\big]\frac{\lambda_t}{1+\lambda_t} \tag{B9}$$

$$Q_tS_{ct} + \frac{\omega}{1+\omega x_t}q_{ht}M_{ht} = \phi_{ct}N_{ct} \tag{B10}$$

$$Q_tS_{ct} + q_{ht}M_{ht} + q_{ft}M_{ft} = N_{ct} + D_t \tag{B11}$$

$$\begin{aligned} N_{ct} = (\sigma+\xi_c)(R_{st}Q_{t-1}S_{ct-1} + &R_{ht}q_{ht-1}M_{ht-1} + R_{ft}q_{ft-1}M_{ft-1}) \\ &- \sigma R_tD_{t-1} \end{aligned} \tag{B12}$$

$$q_{ft}M_{ft} = x_tQ_tS_{ct} \tag{B13}$$

7.2.2 Home Shadow Banks

$$\mu_t = \mathbb{E}_t\Lambda_{t,t+1}\Omega_{st+1}(R_{st+1} - R_{ht+1}) \tag{B14}$$

$$\frac{\upsilon_{ht}}{q_{ht}} = \mathbb{E}_t\Lambda_{t,t+1}\Omega_{st+1}R_{ht+1} \tag{B15}$$

$$\Omega_{st} = 1 - \sigma + \sigma\left(\frac{\upsilon_{ht}}{q_{ht}} + \phi_{st}\mu_t\right) \tag{B16}$$

$$\phi_{st} = \frac{\upsilon_{ht}/q_{ht}}{\theta_s - \mu_t} \tag{B17}$$

$$Q_tS_{st} = \phi_{st}N_{st} \tag{B18}$$

$$Q_tS_{st} = N_{st} + q_{ht}M_t \tag{B19}$$

$$N_{st} = (\sigma+\xi_s)R_{st}Q_{t-1}S_{st-1} - \sigma R_{ht}q_{ht-1}M_{t-1} \tag{B20}$$

7.2.3 Foreign Commercial Banks

$$\mu^*_{st} = \mathbb{E}_t\Lambda^*_{t,t+1}\Omega^*_{ct+1}(R^*_{st+1} - R^*_{t+1}) \tag{B21}$$

$$\mu^*_{ht} = \mathbb{E}_t\Lambda^*_{t,t+1}\Omega^*_{ct+1}(R_{ht+1} - R^*_{t+1}) \tag{B22}$$

$$\mu^*_{ft} = \mathbb{E}_t\Lambda^*_{t,t+1}\Omega^*_{ct+1}(R_{ft+1} - R^*_{t+1}) \tag{B23}$$

$$\upsilon^*_t = \mathbb{E}_t\Lambda^*_{t,t+1}\Omega^*_{ct+1}R^*_{t+1} \tag{B24}$$

$$\Omega^*_{ct} = 1 - \sigma + \sigma\big[\upsilon^*_t + \phi^*_{ct}(\mu^*_{st} + x^*_t\mu^*_{ht})\big] \tag{B25}$$

$$\phi^*_{ct} = \frac{\upsilon^*_t}{(1+\omega^*x^*_t)\Theta(x^*_t) - (\mu^*_{st} + x^*_t\mu^*_{ht})} \tag{B26}$$

$$\mu^*_{st} + x^*_t\mu^*_{ht} = (1+\omega^*x^*_t)\Theta(x^*_t)\frac{\lambda^*_t}{1+\lambda^*_t} \tag{B27}$$

$$\mu^*_{ft} = \omega^*\Theta(x^*_t)\frac{\lambda^*_t}{1+\lambda^*_t} \tag{B28}$$

$$\mu_{ht}Q^*_tS^*_{ct} = \big[\omega^*\Theta(x^*_t)Q^*_tS^*_{ct} + \Theta'(x^*_t)[(1+\omega^*x^*_t)Q^*_tS^*_{ct} + \omega^*q_{ft}M^*_{ft}]\big]\frac{\lambda^*_t}{1+\lambda^*_t} \tag{B29}$$

$$Q^*_tS^*_{ct} + \frac{\omega^*}{1+\omega^*x^*_t}q_{ft}M^*_{ft} = \phi^*_{ct}N^*_{ct} \tag{B30}$$

$$Q_t^* S_{ct}^* + q_{ht} M_{ht}^* + q_{ft} M_{ft}^* = N_{ct}^* + D_t^* \tag{B31}$$

$$N_{ct}^* = (\sigma + \xi_c)(R_{st}^* Q_{t-1}^* S_{ct-1}^* + R_{ht} q_{ht-1} M_{ht-1}^* + R_{ft} q_{ft-1} M_{ft-1}^*) - \sigma R_t^* D_{t-1}^* \tag{B32}$$

$$q_{ht} M_{ht}^* = x_t^* Q_t^* S_{ct}^* \tag{B33}$$

7.2.4 Foreign Shadow Banks

$$\mu_t^* = \mathbb{E}_t \Lambda_{t,t+1}^* \Omega_{st+1}^* (R_{st+1}^* - R_{ft+1}) \tag{B34}$$

$$\frac{\upsilon_{ft}^*}{q_{ft}} = \mathbb{E}_t \Lambda_{t,t+1}^* \Omega_{st+1}^* R_{ft+1} \tag{B35}$$

$$\Omega_{st}^* = 1 - \sigma + \sigma \left(\frac{\upsilon_{ft}^*}{q_{ft}} + \phi_{st}^* \mu_t^* \right) \tag{B36}$$

$$\phi_{st}^* = \frac{\upsilon_{ft}^* / q_{ft}}{\theta_s - \mu_t^*} \tag{B37}$$

$$Q_t^* S_{st}^* = \phi_{st}^* N_{st}^* \tag{B38}$$

$$Q_t^* S_{st}^* = N_{st}^* + q_{ft} M_t^* \tag{B39}$$

$$N_{st}^* = (\sigma + \xi_s) R_{st}^* Q_{t-1}^* S_{st-1}^* - \sigma R_{ft} q_{ft-1} M_{t-1}^* \tag{B40}$$

7.2.5 Asset Returns

$$R_{st} = \psi_t \frac{Z_t + (1-\delta) Q_t}{Q_{t-1}} \tag{B41}$$

$$R_{ht} = \psi_t \frac{Z_t + (1-\delta) q_{ht}}{q_{ht-1}} \tag{B42}$$

$$R_{st}^* = \psi_t^* \frac{Z_t^* + (1-\delta) Q_t^*}{Q_{t-1}^*} \tag{B43}$$

$$R_{ft} = \psi_t^* \frac{Z_t^* + (1-\delta) q_{ft}}{q_{ft-1}} \tag{B44}$$

7.2.6 Home Firms and Households

$$(u_t^{-\gamma} - \beta h \mathbb{E}_t u_{t+1}^{-\gamma}) W_t = \chi L_t^{\varphi} u_t^{-\gamma} \tag{B45}$$

$$u_t = C_t - h C_{t-1} - \frac{\chi}{1+\varphi} L_t^{1+\varphi} \tag{B46}$$

$$\mathbb{E}_t \Lambda_{t,t+1} R_{t+1} = 1 \tag{B47}$$

$$\Lambda_{t,t+1} = \beta \frac{u_{t+1}^{-\gamma} - \beta h u_{t+2}^{-\gamma}}{u_t^{-\gamma} - \beta h u_{t+1}^{-\gamma}} \tag{B48}$$

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha} \tag{B49}$$

$$W_t = (1-\alpha) \frac{Y_t}{L_t} \tag{B50}$$

$$Z_t = \alpha \frac{Y_t}{K_t} \tag{B51}$$

$$Q_t = 1 + f\left(\frac{I_t}{I_{t-1}}\right) + \frac{I_t}{I_{t-1}} f'\left(\frac{I_t}{I_{t-1}}\right) - \mathbb{E}_t \Lambda_{t,t+1} \left(\frac{I_{t+1}}{I_t}\right)^2 f'\left(\frac{I_{t+1}}{I_t}\right) \tag{B52}$$

$$K_t = \psi_t S_{t-1} \tag{B53}$$

$$S_t = (1-\delta)K_t + I_t \tag{B54}$$

7.2.7 Foreign Firms and Households

$$(u_t^{*-\gamma} - \beta h \mathbb{E}_t u_{t+1}^{*-\gamma}) W_t^* = \chi L_t^{*\varphi} u_t^{*-\gamma} \tag{B55}$$

$$u_t^* = C_t^* - hC_{t-1}^* - \frac{\chi}{1+\varphi} L_t^{*1+\varphi} \tag{B56}$$

$$\mathbb{E}_t \Lambda_{t,t+1}^* R_{t+1}^* = 1 \tag{B57}$$

$$\Lambda_{t,t+1}^* \equiv \beta \frac{u_{t+1}^{*-\gamma} - \beta h u_{t+2}^{*-\gamma}}{u_t^{*-\gamma} - \beta h u_{t+1}^{*-\gamma}} \tag{B58}$$

$$Y_t^* = A_t^* K_t^* \alpha L_t^{*1-\alpha} \tag{B59}$$

$$W_t^* = (1-\alpha)\frac{Y_t^*}{L_t^*} \tag{B60}$$

$$Z_t^* = \alpha \frac{Y_t^*}{K_t^*} \tag{B61}$$

$$Q_t^* = 1 + f\left(\frac{I_t^*}{I_{t-1}^*}\right) + \frac{I_t^*}{I_{t-1}^*} f'\left(\frac{I_t^*}{I_{t-1}^*}\right) - \mathbb{E}_t \Lambda_{t,t+1}^* \left(\frac{I_{t+1}^*}{I_t^*}\right)^2 f'\left(\frac{I_{t+1}^*}{I_t^*}\right) \tag{B62}$$

$$K_t^* = \psi_t^* S_{t-1}^* \tag{B63}$$

$$S_t^* = (1-\delta)K_t^* + I_t^* \tag{B64}$$

7.2.8 Market Clearing

$$Y_t + Y_t^* = C_t + C_t^* + \left[1 + f\left(\frac{I_t}{I_{t-1}}\right)\right] I_t + \left[1 + f\left(\frac{I_t^*}{I_{t-1}^*}\right)\right] I_t^* \tag{B65}$$

$$S_t = S_{ct} + S_{st} \tag{B66}$$

$$S_t^* = S_{ct}^* + S_{st}^* \tag{B67}$$

$$M_{ht} + M_{ht}^* = M_t \tag{B68}$$

$$M_{ft}^* + M_{ft} = M_t^* \tag{B69}$$

$$C_t + D_t = W_t L_t + R_t D_{t-1} + \Pi_t \tag{B70}$$

$$\Pi_t = \Pi_{ct} + \Pi_{st} + \Pi_{kt} \tag{B71}$$

$$\begin{aligned} \Pi_{ct} = (1-\sigma-\xi_c)(R_{st}Q_{t-1}S_{ct-1} + R_{ht}q_{ht-1}M_{ht-1} + R_{ft}q_{ft-1}M_{ft-1}) \\ - (1-\sigma)R_t D_{t-1} \end{aligned} \tag{B72}$$

$$\Pi_{st} = (1-\sigma-\xi_s)R_{st}Q_{t-1}S_{st-1} - (1-\sigma)R_{ht}q_{ht-1}M_{t-1} \tag{B73}$$

$$\Pi_{kt} = Q_t I_t - \left[1 + f\left(\frac{I_t}{I_{t-1}}\right)\right] I_t \tag{B74}$$

7.2.9 Exogenous Processes

$$A_t = e^{\varepsilon_{at}} A_{t-1}^{\pi_{11}} A_{t-1}^{*\pi_{12}} \tag{B75}$$

$$A_t^* = e^{\varepsilon_{at}^*} A_{t-1}^{\pi_{21}} A_{t-1}^{*\pi_{22}} \tag{B76}$$

$$\psi_t = e^{\varepsilon_{pt}} \psi_{t-1}^{\rho_{11}} \psi_{t-1}^{*\rho_{12}} \tag{B77}$$

$$\psi_t^* = e^{\varepsilon_{pt}^*} \psi_{t-1}^{\rho_{21}} \psi_{t-1}^{*\rho_{22}} \tag{B78}$$

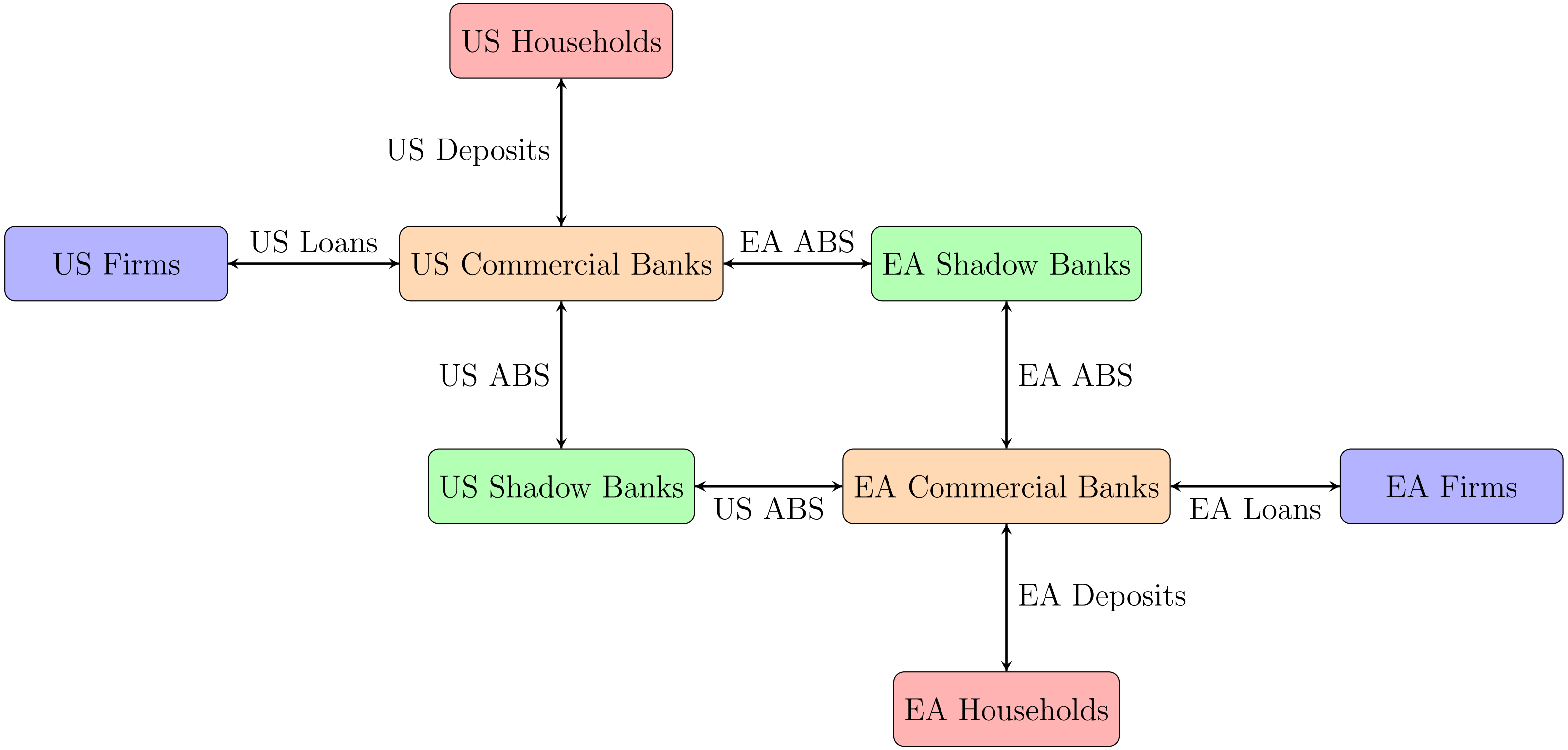

Figure 1: The Global Financial Market

Table 1: Parameter values used in simulations

Parameter	Value	Description
α	0.3000	Capital share of production
β	0.9900	Subjective discount factor
χ	0.2500	Disutility of labor
δ	0.0250	Capital depreciation rate
h	0.75	Habit parameter for consumption
φ	0.3333	Inverse Frisch elasticity of labor
γ	2.0000	Relative risk aversion
$f''(1)$	2.0000	Elasticity of investment
σ	0.9680	Survival probability for banks
ε	-2.0000	Parameter in Θ
κ	17.4065	Parameter in Θ
	7.5924	
θ_c	0.3604	Parameter in Θ
	0.4331	
ξ_c	0.0016	Fraction of assets transferred to commercial banks
ω	0.5000	Home recoverability of ABS
ω^*	0.5000	Foreign recoverability of ABS
θ_s	0.1723	Divertibility of shadow bank loans
ξ_s	0.0008	Fraction of assets transferred to shadow banks

Two values for κ and θ_c are given, corresponding to two calibrations. The green values correspond to the calibration associated with relatively small commercial bank holdings of ABS from abroad. The blue values correspond to the calibration associated with relatively large commercial bank holdings of ABS from abroad.

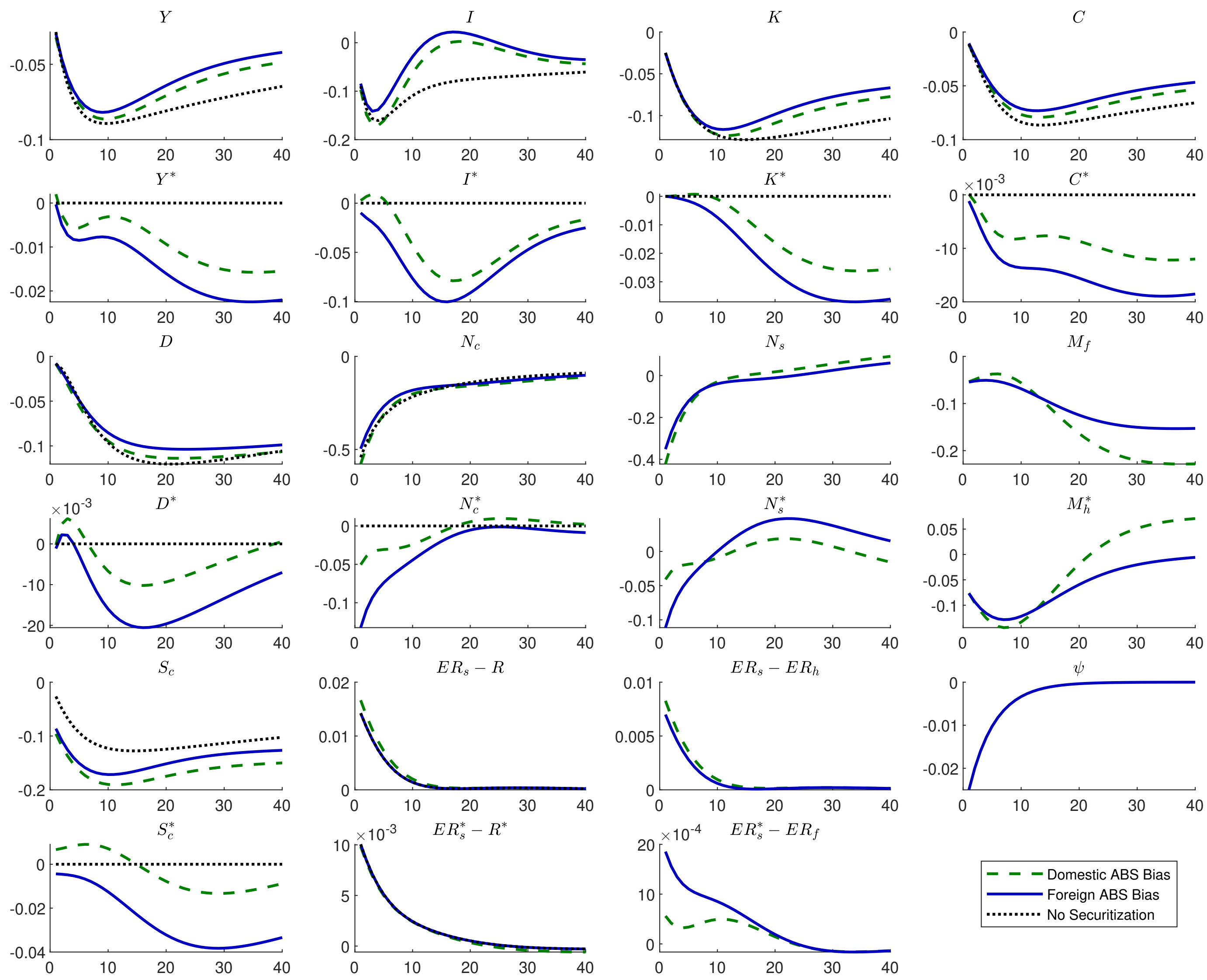

Figure 2: Persistent Home Financial Shock

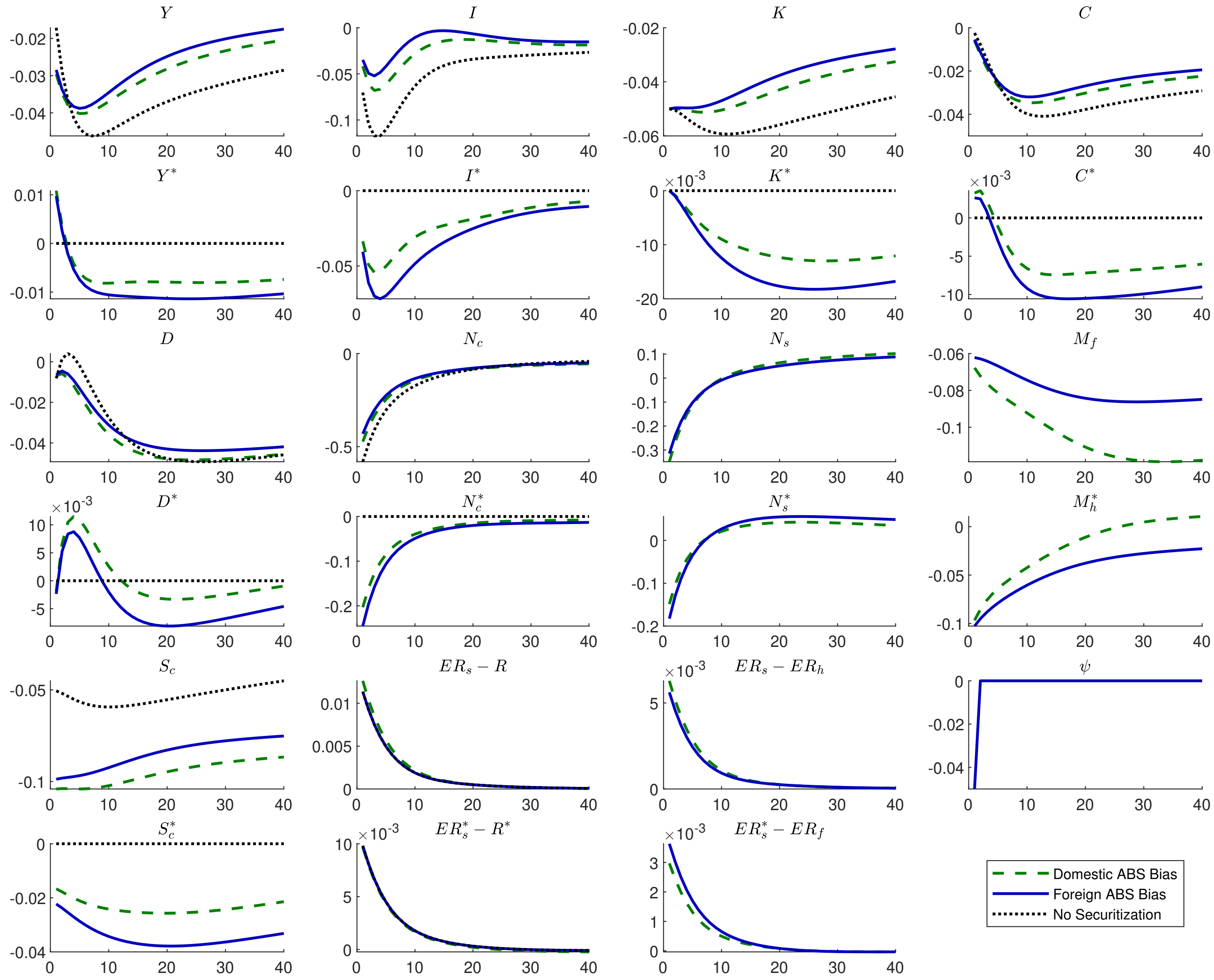

Figure 3: One-Time Home Financial Shock

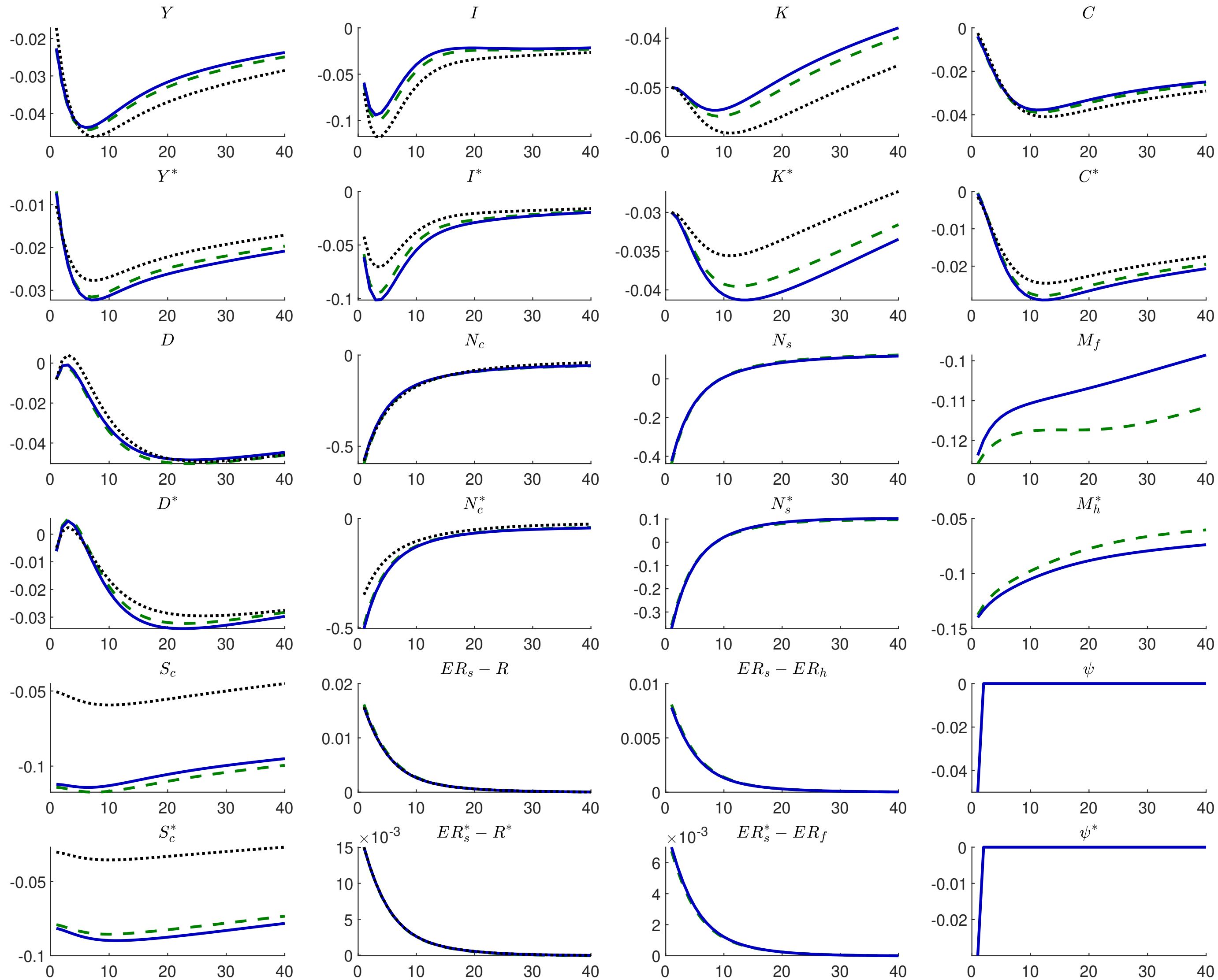

Figure 4: Correlated Financial Shocks

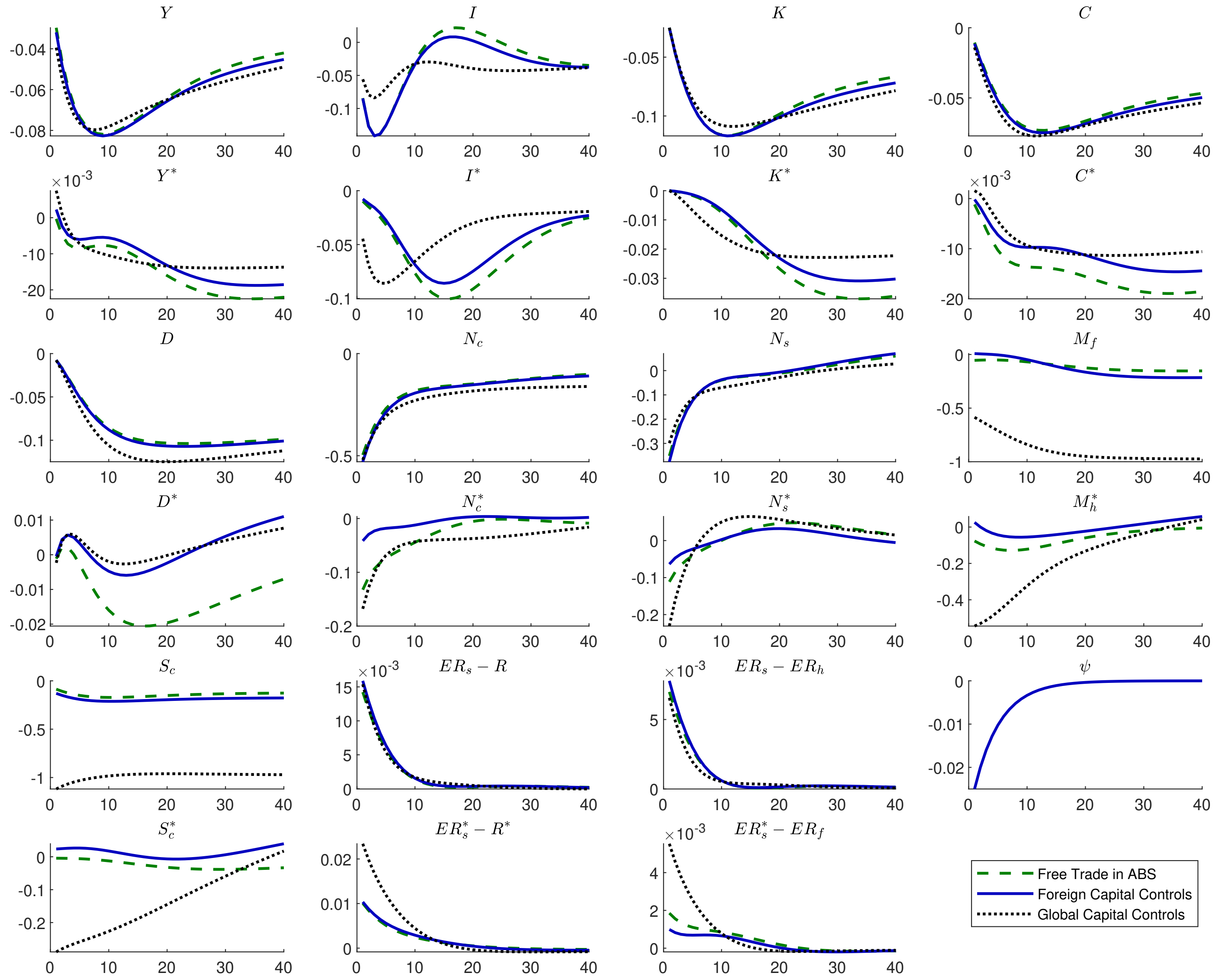

Figure 5: Policy Experiment: Capital Controls (Large Foreign Holdings of Home ABS)

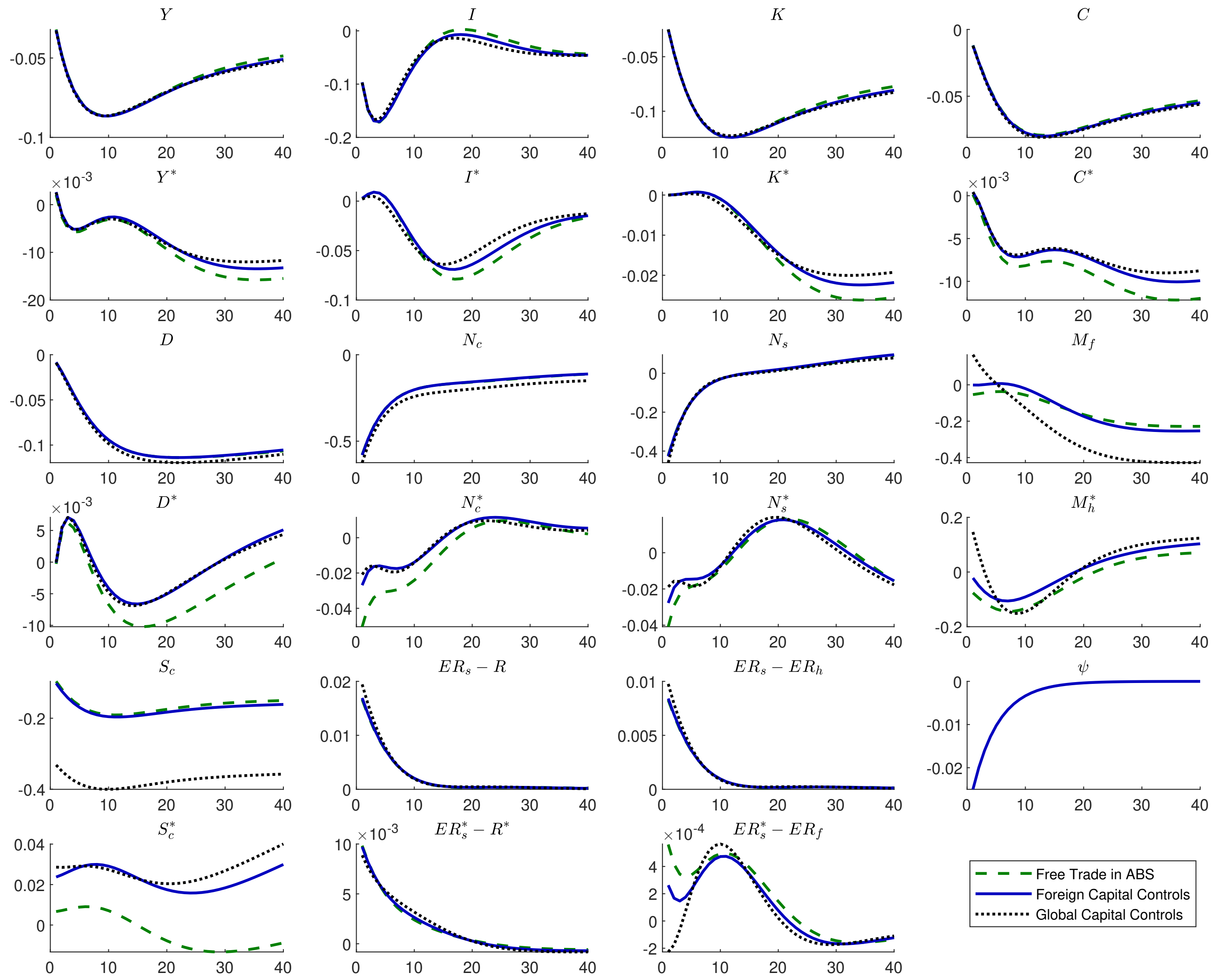

Figure 6: Policy Experiment: Capital Controls (Small Foreign Holdings of Home ABS)