Financial Globalization, Financial Crises and Contagion

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Abstract

Two observations highlight the central role that financial globalization has played in the ongoing world financial crisis. First, net credit from the rest of the world has been the source of financing for more than half of the rise in net credit of the U.S. nonfinancial sectors since the mid 1980s. Second, the collapse of the U.S. housing and mortgage-backed-securities markets has had worldwide effects on financial institutions and asset markets. We propose an open-economy model with financial markets frictions where financial intermediaries play a central role. Due to capital requirements based on mark-to-market accounting, credit shocks have large effects on global asset prices. The impact of credit shocks is significantly smaller under a capital requirement rule for financial intermediaries which is based on historical values.

1 Introduction

The global financial crisis that started with the meltdown of the U.S. subprime mortgage market in 2007 was preceded by a twenty-year period of substantial growth in debt and leverages, in an environment of increasing world financial integration, low real interest rates and growing U.S. external deficits. During this period of widening "global imbalances" we also observed large financial crises in emerging economies with cross-country contagion that in some cases did not appear to be motivated by fundamental forces. Some of these crises affected the capital markets of the industrial world (particularly the LTCM crisis in the aftermath of the 1998 Russian crash).

These events have generated a large body of research with well-established contributions. Until now, however, the study of global imbalances and the study of financial crises and contagion have remained somewhat separate subjects. In particular, the study of financial or currency crisis has mostly been focused on emerging economies in a small economy set-up. In contrast, this paper addresses the question of whether the ongoing global financial crisis and the process of financial globalization are related. In particular, we study two key issues. First, we study how financial globalization contributed to the buildup of very high leverages in some industrialized countries, especially the U.S. Second, we study how credit frictions can amplify the effects of credit shocks on asset prices and how these effects are transmitted across countries in a world that is financially integrated.

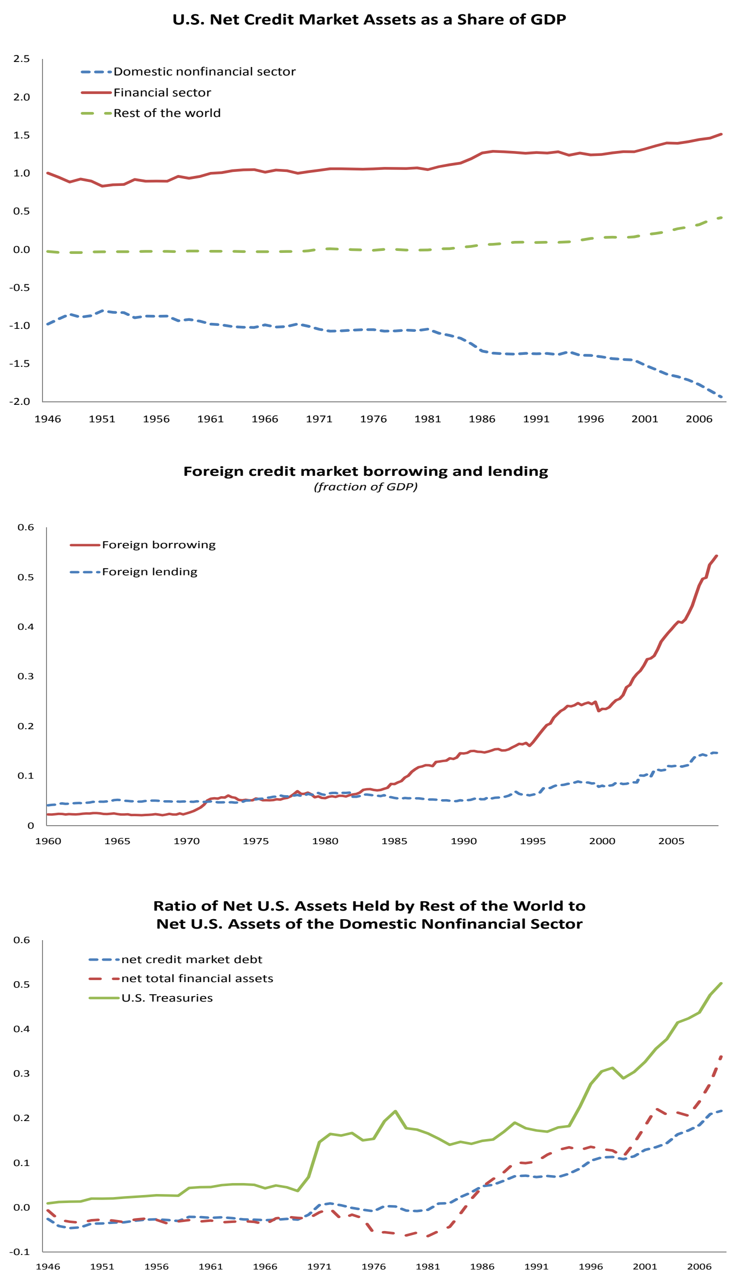
The motivation for this project derives from the evidence provided by Figure 1 showing that the U.S. credit boom was largely fueled by foreign lending.

1. The first panel of Figure 1 shows that the net debt-income ratio of the U.S. nonfinancial sectors doubled between 1982 and 2008 (net credit market assets as a ratio of GDP of these sectors fell from -1 to about -2). A surge in net debt of this magnitude, which affected all three broad U.S. nonfinancial sectors (households, nonfinancial businesses, and the government), is unprecedented in the data available since 1946.[1]

2. Starting in the mid 1980s, the integration of world capital markets that resulted from the removal of capital controls and innovations in financial markets produced significant changes in gross and net foreign asset positions worldwide (see Lane & Milesi-Ferretti (2006)). In the United States, both gross and net foreign borrowing rose sharply. Regarding net foreign credit, about half of the increase in the net debt-income ratio of the nonfinancial sectors mentioned above was financed by a

[1]Data is from the Flow of Funds of the Federal Reserve Board. Net credit is defined as credit market assets minus credit market liabilities. Credit market assets and liabilities exclude all non-debt financial instruments, particularly equity holdings.

Figure 1: Net credit before and after financial integration.



rise in net credit assets held by the rest of the world (see again the top panel of Figure 1), and this was also an unprecedented phenomenon in the post-war period. Before the mid 1980s, the U.S. fitted well the definition of financial autarky: The net debt of the domestic nonfinancial sectors was almost identical to the net credit assets of the financial sector, with a zero net credit position for the rest of the world.[2] In terms of gross positions, the second panel of Figure 1 shows that the foreign credit claims on U.S. nonfinancial sectors grew sharply since 1985, while U.S. lending to foreigners (i.e. claims of the U.S. nonfinancial sectors on foreign agents) experienced a relatively modest increase. As a result, net credit assets held by the rest of the world grew by 50 percent of U.S. GDP since 1982.

3. The above trends identified in net credit assets are even more pronounced for net total financial assets and net Treasury securities, as shown in the bottom panel of Figure 1. The plot shows the net asset positions of the U.S. vis-a-vis the rest of the world as a ratio of the corresponding net asset positions held by the domestic nonfinancial sectors for three asset categories: credit market assets (as in the top two panels), total financial assets, which include non-credit assets like equity, and U.S. Treasury bills. The ratios for credit assets and total financial assets hover near zero before the mid 1980s, reflecting again the fact that before financial globalization the U.S. was effectively in financial autarky. By the end of 2008, however, net credit assets held by the rest of the world amounted to 1/5 of U.S. net credit liabilities of the nonfinancial sectors, and for total financial assets the ratio was even higher at about 1/3. For T-bills, the rest of the world increased its positive net position sharply with the collapse of the Bretton Woods system in the early 1970s, but even that increase dwarfs in comparison with the surge observed since the mid 1980s. By 2008, the rest of the world was a net holder of about one in every two T-bills held outside of the U.S. financial sectors.

The fact that a large fraction of the credit expansion experienced by the

[2]Note that the data for financial sectors combines domestic and international components, and hence it is not accurate to associate the financial sectors data with domestic financial sectors. Before financial integration, the international components were negligible, so the association was valid. After the mid 1980s, however, part of the rise in net credit of financial sectors reflects also the effects of financial globalization.

U.S. economy was financed by foreign borrowing raises a key question: Did the globalization of financial markets contribute to the current crisis? In particular, we are interested in understanding how financial globalization contributed to the surge in debt in the United States, how it might have influenced the volatility of asset prices and the spillover of the crisis across countries.

In order to address these issues, we start with a model that can rationalize both the expansion in domestic credit within the United States and the growth of its liabilities, vis-a-vis the rest of the world, following financial integration. The model extends the framework of Mendoza, Quadrini, & Ríos-Rull (2007) which has proven useful for explaining these two features of the data. Our setup differs in two important respects. The first difference is that our model features three sets of economic agents within each country: savers (or wage earners), producers (or capital owners), and financial intermediaries, with financial intermediaries playing a central role in the analysis. In Mendoza et al. (2007) savers and producers are merged in a single agent and financial intermediaries do not play a crucial role in the analysis. The second difference respect to Mendoza et al. (2007) is that their analysis is limited to steady states and transitions from a steady state with financial autarky to one with full financial integration. In this paper we focus instead on the effects of unanticipated (and hence non-diversifiable) credit shocks that hit the net worth of financial intermediaries.

In our model, savers receive endowment incomes that are subject to idiosyncratic shocks. Savers can trade state-contingent claims with financial intermediaries but there are constraints to the set of feasible claims. These constraints derive from incentive-compatibility conditions imposed by limited enforceability of financial contracts, which differs across countries. Countries with higher enforcement systems allow for better insurance of the idiosyncratic risks and lower propensity to save. As a results, these countries tend to accumulate large negative net foreign asset positions.

Producers do not face idiosyncratic uncertainty, so effectively we assume a representative producer. They also trade with financial intermediaries, but in their case limited enforcement of contracts take the form of a collateral constraint. Financial intermediaries take state-contingent deposits from savers, make loans to producers and own a fixed amount of physical capital. They face a capital requirement constraint that limits the loan portfolio to a fraction of their equity valued at market prices (mark-to-market). Many conjecture that the mark-to-market accounting principle is playing an important role in the current financial crisis.[3]

In our setup, the financial constraint faced by financial intermediaries implies that a "small" shock that reduces the value of their equity (between 1/10 of a percent and 1 percent of the value of loans), induces a large reduction in the equilibrium prices of assets (as much as 40 percent on impact). Moreover, it takes a long period of time for asset prices to fully recover (up to 20 years). Since asset prices are global, the asset price decline is the vehicle for international contagion of the financial crisis. Asset price declines are smaller than they would be in the presence of the same shock under financial autarky, but this is precisely because the shock affects the asset prices worldwide, and not just the country where the shock originated.

We examine the quantitative implications of shifting form a capital requirement for intermediaries based on the mark-to-market principle to a system based on historical book values. Our results indicate that the response of asset prices to credit shocks under this alternative system is significantly weaker.

The financial mechanisms at work in our model are related to several mechanisms studied in the literature on 'credit channels' and 'financial accelerators'. Classic references include Fisher (1933), Bernanke & Gertler (1989) and Kiyotaki & Moore (1997). Similar mechanisms have also been used to study Sudden Stops and the financial contagion in emerging economies during the 1990s (see, for example, Caballero & Krishnamurthy (2001), Calvo (1998), Cook & Devereux (2006), Gertler & Gilchrist (2007), Mendoza & Smith (2006), Mendoza (2008) and Paasche (2001)). Finally, our work is also related to the recent studies examining the implications of financial integration among countries that are heterogenous in the degree of domestic financial development (see Aoki, Benigno, & Kiyotaki (2007), Caballero, Farhi, & Gourinchas (2008) and Mendoza et al. (2007)).

The rest of the paper is organized as follows. Section 2 describes the structure of the model. Section 3 explores its quantitative predictions, both for the effects of financial integration on asset positions and for the effects of shocks to the equity of financial intermediaries. Section 4 examines the implications of changing the mark-to-market rule. Section 5 concludes.

[3]The claim is that marking to market worsen the deflation of asset prices, because as asset prices began to decline, financial intermediaries were required to lower the valuation of their assets, hence forcing them to sell assets to protect their capital, which worked to add downward pressure to asset prices.

2 Analytical Framework

We extend the basic structure of the economy studied in Mendoza et al. (2007) by adding a more structured financial intermediation sector. The goal is to study how the behavior of financial intermediaries in response to financial/credit shocks affects the propagation these shocks to the economy.

There are two countries, indexed by $i \in \{1, 2\}$, each inhabited by a continuum of agents of total mass μ^i. Agents are of two types: producers and savers, each of mass $\mu_i/2$. They all have the same preferences and maximize the lifetime utility $E \sum_{t=0}^{\infty} \beta^t U(c_t)$, where c_t is consumption at time t and β is the intertemporal discount factor. The utility function is strictly increasing and concave with $U(0) = -\infty$ and $U'''(c) > 0$.

Each country is endowed with a fixed per-capita supply $\bar{k}$ of a non-reproducible, internationally immobile asset, traded at price P_t^i. This asset is used in production as specified below. We now describe the specific aspects of the two types of agents.

2.1 Savers

Savers are very similar to the agents described in Mendoza et al. (2007) except that they do not have the managerial ability to generate income through the use of the productive asset. They receive income in the form of an *idiosyncratic* stochastic endowment w_t. The Markov conditional probability distribution of w is denoted by $g(w_t, w_{t+1})$.

Savers can buy contingent claims, $b(w_{t+1})$, that depend on the next period's realizations of the endowment. In absence of aggregate uncertainty, the price of one unit of consumption goods contingent on the realization of w_{t+1} is $q_t^i(w_t, w_{t+1}) = g(w_t, w_{t+1})/(1+r_t^i)$, where r_t^i is the equilibrium interest rate.[4] The budget constraint for an individual saver is:

$$w_t + b(w_t) = c_t + \sum_{w_{t+1}} b(w_{t+1}) q_t^i(w_t, w_{t+1}). \tag{1}$$

Market incompleteness on the side of savers is modeled by assuming limited enforcement. Contracts are not perfectly enforceable due to the limited (legal) verifiability of shocks. Because of this, savers can divert part of their endowment, but they lose a fraction ϕ^i of the diverted income. The parameter ϕ^i characterizes the degree of enforcement of financial contracts in country

[4] The contingent claims are sold by competitive intermediaries as described below.

i. Agents cannot be excluded from financial markets after defaulting. Under these assumptions, we show in Appendix A that incentive compatibility imposes the following two constraints:

$$b(w_1) - b(w_j) \;\leq\; \phi^i \cdot \Big(w_j - w_1\Big) \tag{2}$$

$$w_j + b(w_j) \geq 0 \tag{3}$$

for all $j \in \{1, ..., J\}$. Here J denotes the number of all possible realizations of the endowment and w_1 is the lowest (worse) realization.

The first condition requires that insurance received through contingent claims, $b(w_1) - b(w_j)$, cannot be bigger than the variation in income, scaled by ϕ^i. When ϕ^i is sufficiently large, savers are able to get significant insurance which guarantees constant consumption. When $\phi^i = 0$, only non-state-contingent claims are feasible. A key assumption is that ϕ^i pertains to the country of residency of the savers. Cross-country differences in financial development are captured by differences in ϕ^i. The second constraint derives from limited liability. The assumption is that a saver can always default on a contract at the beginning of next period. At this point the intermediary can only recover the endowment w_j.

Let $\{q^i_\tau(w_\tau, w_{\tau+1})\}_{\tau=t}^{\infty}$ be a (deterministic) sequence of prices in country i. The optimization problem of an individual saver can be written as:

$$V^i_t(w, b) \;=\; \max_{c, b(w')} \left\{ U(c) + \beta \sum_{w'} V^i_{t+1}\Big(w', b(w')\Big) g(w, w') \right\} \tag{4}$$

subject to

(1), (2) and (3)

The solution to the saver's problem yields decision rules for consumption, $c^i_t(w, b)$ and contingent claims $b^i_t(w, b, w')$. The decision rules determine the evolution of the distribution of savers over w and b. We denote the distribution by $M^i_t(w, b)$.

We show in Appendix B that, by properly redefining the stochastic process for the endowments, the problem can be reformulated as if savers choose non-contingent claims, that is,

$$V^i_t(\tilde{w}, \bar{b}) \;=\; \max_{c, \bar{b}' \geq -\tilde{w}_1} \left\{ U(c) + \beta \sum_{w'} V^i_{t+1}\Big(\tilde{w}', \bar{b}'\Big) g(\tilde{w}, \tilde{w}') \right\} \tag{5}$$

subject to

$$\tilde{w} + \bar{b} = c + \frac{\bar{b}'}{1+r}$$

where $\tilde{w}$ is a transformation of w. The solution can then be characterized by the first order condition:

$$U'(c_t) \geq \beta(1+r_t)EU'(c_{t+1}) \tag{6}$$

which is satisfied with equality if $\bar{b}' > -\tilde{w}_1$.

2.2 Producers

Differently from Mendoza et al. (2007), we assume that the owners and users of the productive asset—the producers—are different from other agents (savers). This separation makes the model more tractable when we consider unanticipated financial shocks.

Producers generate income $y_{t+1} = F(k_{t+1}) = Ak^{\nu}_{t+1}$, where k_{t+1} is the quantity of the productive asset purchased at time t. The parameter ν is smaller than one due to limited managerial capital that each producer has. Managerial capital is internationally mobile. Therefore, with capital mobility producers can choose to operate at home, buying the domestic productive asset, or abroad, buying the foreign productive asset. But they cannot do both. To keep the problem simple we have deliberately assumed that producers do not face idiosyncratic uncertainty so that we can focus on a 'representative' producer.

As in the case of savers, producers can enter in contractual arrangements with financial intermediaries. Because producers do not face idiosyncratic uncertainty, their financial contracts are not state contingent. Denote by l_t the loan borrowed from a financial intermediary (or the amount lent to an intermediary if $l_t < 0$). Limited enforcement constraints the amount that the intermediary is willing to lend. This leads to the following constraint:

$$l_t \geq \psi \cdot P_t k_{t+1} \tag{7}$$

This constraint derives from the assumption that the producer can always default on a contract at the end of the period, after consumption. At this point the intermediary can only recover a fraction ψ of the productive asset.

The last assumption about producers is that they are shareholders of the financial intermediaries. Therefore, in any period they receive non-negative dividends d_t from the intermediaries. The problem solved by the producer reads:

$$V_t^i(k,l) = \max_{c,k',l'} \left\{ U(c) + \beta V_{t+1}^i\Big(k',l'\Big) \right\} \tag{8}$$

subject to

$$kP_t + F(k') + \frac{l'}{1+r_t} + d_t = c + l + k'P_t$$

$$l_t \geq \psi k' P_t$$

Given a deterministic sequence of prices $\{r_\tau, P_\tau\}_{\tau=t}^{\infty}$, the solution to the producer's problem can be easily characterized by the following first order conditions:

$$U'(c_t) = \beta U'(c_{t+1})(1+r_t) + \mu_t \tag{9}$$

$$U'(c_t) = \beta U(c_{t+1}) \left(\frac{P_{t+1} + F_k(k_{t+1})}{P_t} \right) + \psi \mu_t \tag{10}$$

where μ_t is the Lagrange multiplier associated with the collateral constraint (7). The multiplier is positive if the constraint is binding.

Assuming that all producers start with the same initial states, k and l, and they have the same shares of financial intermediaries, they all choose the same quantity of the productive asset, k', and the same loan, l'. Therefore, they will all enter the next period with the same states. Conditions (9) and (10), together with the budget and enforcement constraints, determine the whole sequence of consumption for a given sequence of prices. Of course, the prices must satisfy the general equilibrium conditions that we will describe below.

It is important to note that conditions (9) and (10) imply that the equity premium in our model reduces to the following expression:

$$R_{t+1}^q - (1+r_t) = (1-\psi)\mu_t \tag{11}$$

where $R_{t+1}^q \equiv \left(P_{t+1} + F_k(k_{t+1})\right)/P_t$. Thus, equity returns exceed the risk free rate by a fraction $(1-\psi)$ of the shadow value of the producers' credit constraint. These higher returns imply that equilibrium asset prices will be lower than in the absence of the constraint, and in particular, if shocks to credit markets tighten constraint (7), this will put additional downward pressure on asset prices. Notice also that limited enforcement is crucial for this result. If $\psi = 1$ there is no equity premium, and shocks that affect financial intermediaries will have no effect on the equity premium.[5]

2.3 Financial intermediaries

Financial intermediaries are profit maximizing firms whose shares are owned by producers. The assumption that the shares of the financial intermediaries are owned only be producers is without loss of generality.[6]

Financial intermediaries sign financial contracts with savers and producers. They own a fixed quantity $\bar{k}^f$ of the productive capital. We can think of $\bar{k}^f$ as the physical capital that is necessary to run the intermediation activity. For simplicity we assume that this capital is in the balance sheet of the intermediary but it does not generate any income directly. What is important for the analysis we are going to conduct is that the balance sheet of financial intermediaries depend on the market price of the asset. The consolidated budge constraint for the financial intermediation sector is:

$$\bar{k}^f P_t + \frac{L_{t+1}}{1+r_t} + d_t = \frac{B_{t+1}}{1+r_t} + e_t \tag{12}$$

The left-hand-side represents the uses of funds. These are given by the value of the productive assets, $\bar{k}^f P_t$, the loans made to the producers, $L_{t+1}/(1+r_t)$, and the payment of dividends. The right-hand-side includes the source of funds given by deposits from savers, B_t, and the equities before the payment of dividends, e_t. The deposits from savers are the value of all contingent claims determined as $B_{t+1} = \int_{w,b,w'} \sum_{w'} b_t^i(w,b,w') g(w,w') M_t(w,b)$.

So far, the description of financial intermediation sector is standard, except for the assumption that intermediaries own $\bar{k}^f$. We now introduce some frictions that will make the intermediation sector central to our analysis.

The first assumption is that intermediaries cannot issue new shares. This simply means that dividends cannot be negative, that is, $d_t \geq 0$. We could

[5] Mendoza (2008) derives a similar result for a representative agent model of a small open economy with a collateral constraint limiting foreign debt to a fraction of the market value of domestic capital.

[6] The ownership if financial intermediaries by savers would not change the results.

extend the model by allowing for costly shares issuance. However, for the time being, we keep the model simple and assume that $d_t \geq 0$ (or equivalently that the issuance cost is extremely high).

The second assumption is that the volume of loans must be backed by bank equities. More specifically we assume that L_{t+1} cannot be bigger than a multiple of the bank's equity after the payment of dividends, that is,

$$L_{t+1} \leq \alpha(e_t - d_t) \tag{13}$$

This is a capital requirement constraint which can be interpreted as being imposed by means of institutional regulations.

The problem of the financial intermediary can be written as follows:

$$V_t(B, L) = \max_{d, B', L'} \left\{ d + \left(\frac{1}{1 + r_t} \right) V_{t+1}\Big(B', L'\Big) \right\} \tag{14}$$

subject to

$$L - B = \frac{L'}{1 + r_t} - \frac{B'}{1 + r_t} + d$$

$$L' \leq \alpha \left(\bar{k}^f P_t + \frac{L'}{1 + r_t} - \frac{B'}{1 + r_t} \right)$$

In writing this problem we limit the analysis to equilibria in which the interest rate on loans is equal to the interest rate on deposits. The discount rate for a financial intermediary is the relevant discount factor for its shareholders, that is, the producers. Under the assumption that there is no aggregate uncertainty, this is equal to the interest rate.

At this point we are in a condition to understand the role that asset prices play in the financial decision of intermediaries. A fall in asset prices P_t reduces the equity of the financial intermediary. Because of the capital requirement (13), lower equity forces the intermediary to cut on loans. This, in turn, reduces the demand for the productive assets and leads to a further decline in asset prices. Through this mechanism, a small decline in the balance sheet of the financial sector can lead to large asset price deflations.

2.4 Unexpected credit shock

Starting from a steady state equilibrium, we consider a shock that reduces the equity of the financial intermediaries. For example, this could be caused by an unexpected loss in the loans made to producers. For example, because some of the producers default on the debt. Alternatively we can think of an unexpected depreciation in $\bar{k}^f$. This is a one time unanticipated shock. The shock leads to a transition dynamics that is fully deterministic and converging to a steady state equilibrium. The exact nature of the experiment will be described in the quantitative analysis.

2.5 General equilibrium

First we define the general equilibrium without mobility of capital (financial autarky). We will then describe how the definition can be adjusted for the case with capital mobility.

The sufficient aggregate states are given by the distribution of savers, $M_t^i(w,b)$, the value of loans made to producers in the previous period, L_t^i, and the stock of productive capital owned by producers, K_t^i. Once we know the distribution of savers we know the liabilities of the financial intermediaries and, given their loans and prices of assets, we can determine the net worth of producers and the equities of banks. We have the following definition:

Definition 1 (Financial autarky) *Given the financial development parameter, ϕ^i, initial distributions of savers, $M_t^i(w,b)$, banks' loans, L_t^i, productive capital owned by producers, K_t^i, for $i \in \{1,2\}$, an equilibrium without international mobility of capital is defined by sequences of: (i) savers' policies, $\{b_\tau^i(w,b,w')\}_{\tau=t}^\infty$; (ii) producers' policies, $\{l_\tau^i(k,l)\}_{\tau=t}^\infty$ and $\{k_\tau^i(k,l)\}_{\tau=t}^\infty$ (iii) intermediaries' policies, $\{d_\tau^i(B,L)\}_{\tau=t}^\infty$, $\{L_\tau^i(B,L)\}_{\tau=t}^\infty$ and $\{B_\tau^i(B,L)\}_{\tau=t}^\infty$; (iv) prices $\{P_\tau^i, r_\tau^i, q_\tau^i(w,w')\}_{\tau=t}^\infty$; (v) distributions $\{M_\tau^i(w,k,b)\}_{\tau=t+1}^\infty$. Such that: (i) the policy rules solve problems (4), (8) and (14); (ii) prices satisfy $q_\tau^i = g(w,w')/(1+r_t^i)$; (iii) asset markets clear, $\int_{w,b,w'} b_\tau^i(w,b,w')M_\tau^i(w,b)g(w,w_\tau'^i(B,L)$ and $k_\tau^i(K,L)/2 = \bar{k} - \bar{k}^f$ for each $i \in \{1,2\}$ and $\tau \geq t$; (iv) the sequence of distributions of savers is consistent with the initial distributions, the individual policies and the stochastic processes for the idiosyncratic shocks.*

The definition of the equilibrium with globally integrated capital markets is similar, except for the prices and market clearing conditions (ii) and (iii). With financial integration there is a global market for assets and asset prices are equalized across countries. Therefore, condition (ii) becomes $q_\tau^1 = g(w,w')/(1+r_t^1) = g(w,w')/(1+r_t^2) = q_\tau^2$ and $P_\tau^1 = P_\tau^2$. Furthermore, asset markets clear globally instead of country by country.

Therefore, the market clearing condition for the productive assets becomes $\sum_{i=1}^{2} k_\tau^i \mu^i = \bar{k} - \bar{k}^f$ and the market clearing condition for contingent claims becomes $\sum_{i=1}^{2} \int_{w,b,w'} b_\tau^i(w,b,w') M_\tau^i \mu^i(w,b) g(w,w') = \sum_{i=1}^{2} B_\tau^i(B,L)\mu^i$.

3 Quantitative application

The parametrization of the model is as follows. We interpret the first country as the United States and the second country as the rest of the world. Therefore, we calibrate the model so that the economic size of the US is 30 percent the size of the world economy. This can be obtained in two ways: by choosing the population size and/or the per-capita quantities (endowment and productive asset) of the two countries. However, what matters for the quantitative results is the total economic size of the country, not the sources of the size differences. Therefore, to simplify the presentation we simply assume that countries only differ in population size. Accordingly we set $\mu^1 = 0.3$.

Preferences takes the standard form $U(c) = c^{1-\sigma}/(1-\sigma)$. We will consider the case of log-utility, that is, $\sigma = 1$. The intertemporal discount rate is set to $\beta = 0.94$.

We interpret the endowment of savers as labor income and the income generated by producers as capital income. Based on this interpretation we set average per-capita endowment, $\bar{w}$, to 0.85 and the producers' income to $y = Ak^\nu = 0.15$. Given the normalization $k = 1$ this is obtained by setting $A = 0.15$. Notice that the capital income is only 15 percent (and correspondingly the labor income is 85 percent) because this is net of depreciation.

The stochastic endowment of savers takes two values, $w = \bar{w}(1 \pm \Delta_w)$, with symmetric transition probability matrix. We follow recent estimates of the U.S. earnings process and set the persistence probability to 0.95 and $\Delta_w = 0.6$. This is consistent with the process estimated by Storesletten, Telmer, & Yaron (2004).

Next we choose the parameters of the financial structure. We assign $\phi^1 = 0.35$ and $\phi^2 = 0$. This implies that contingent claims are partially available in country 1 and unavailable in country 2.[7] The collateral constraint for producer is set to $\psi = 0.5$.

[7]The assumption that $\phi^1 = 0.35$ implies that the equilibrium allocation in country 1 is similar to the one we would obtain if contingent claims were not available (*i.e.* $\phi^1 = 0$) but the volatilities of all shock was 35 percent lower than in country 2.

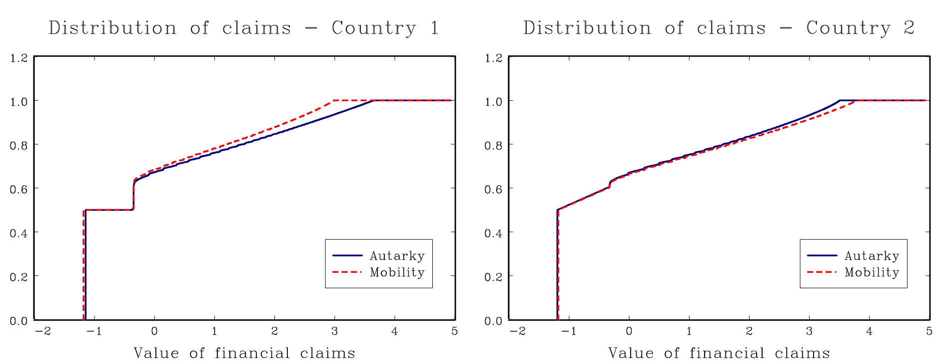
At this point we are left with the parameters characterizing the intermediation sector. The per-capita physical capital is set to $\bar{k} = 1.05$ and the one held by financial intermediaries is set to $k^f = 0.05$. Therefore, the productive capital owned by financial intermediaries is only 5 percent the capital owned by the rest of the economy. The capital requirement for loans is set to $\alpha = 8$. This implies that loans must be backed by 12.5 percent of equity.

3.1 Steady state properties

First we show that the model generates an increase in leverages as a result of financial liberalization in the most developed country. Figure 3 plots the cumulative distribution of agents (savers and producers) over the value of financial claims toward the financial intermediaries in the two steady states with autarky and capital mobility. For producers the financial claims are negative as they borrow from the financial sector. For savers they are mostly positive.

As shown by the figure, after liberalization, the distribution of agents over financial claims in country 1 (the US) becomes more concentrated over negative values. In other words, agents become more indebted on average. The opposite arises in country 2 (the rest of the world).

Figure 2: Distribution of financial claims

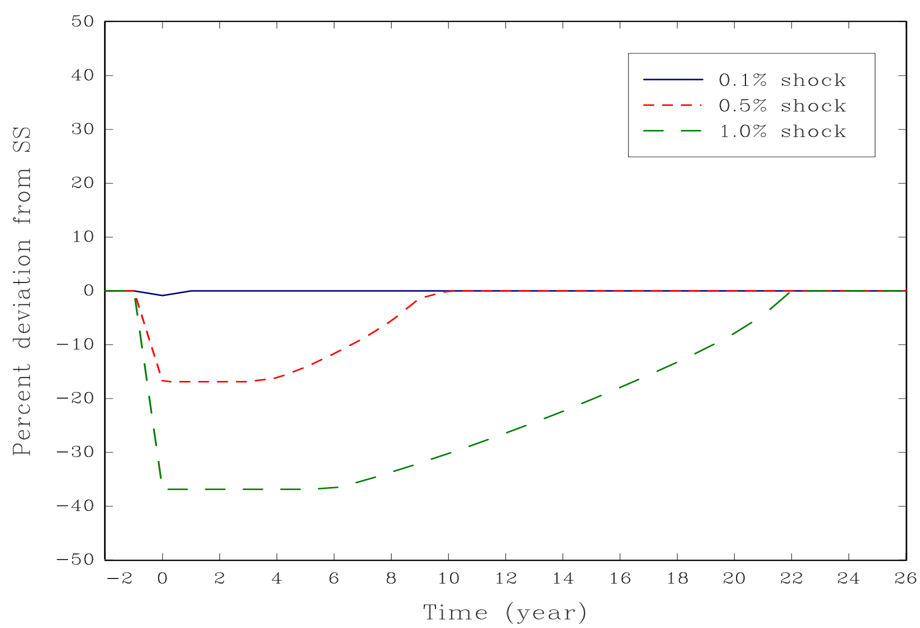


The increase in leverage in country 1 follows from the fact that this country has a better opportunity to insure against the investment risk (given more advanced financial markets). Consequently, after liberalization it takes a positive net position in the foreign productive asset and finances this position with foreign borrowing. Therefore, the model can capture the increase in leverage observed in the US following the international liberalization of capital markets.

3.2 Shock to bank equity

We start considering the impulse response of asset prices to a shock that decreases the bank equity of country 1 by a certain percentage of outstanding loans. This can be interpreted as unexpected loss due to unrecoverable loans made to producers. Figure 3 plots the response of prices for losses of 0.1, 0.5 and 1 percent.

Figure 3: Impulse response of asset prices to credit shocks in the regime with capital mobility

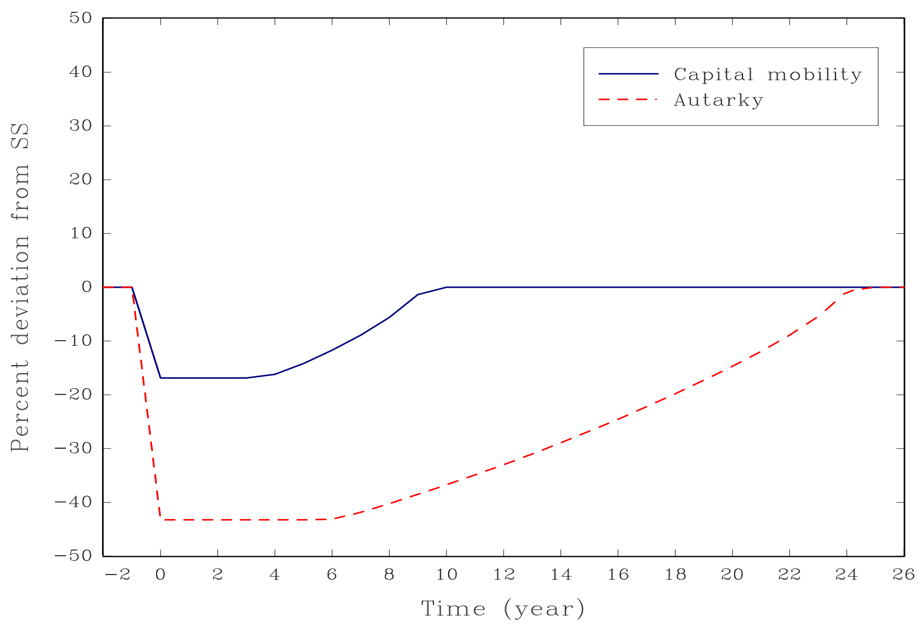


As can be seen, the drop in price is quite large. After a loss of 0.5 percent the value of loans, the price drops initially by 18 percent and it takes ten periods before returning to the initial level. When the losses are 1 percent the value of loans, the drop in price is almost 40 percent and it takes more than 40 periods before going back to the initial value.

Next we consider the asset price response to the same type of shock but in the regime without mobility of capital. Suppose that the initial shock considered in the regime with capital mobility derives from losses made on country 1 loans. In the environment with mobility of capital it does not matter whether the losses come from loans made in country 1 or country 2. In the regime without capital mobility, however, whether the losses are in country 1 or 2 matters. Only the country in which the losses are realized faces the type of consequences we have shown in Figure 3.

Figure 4 considers the case in which country 1 faces the same shock but in a regime without capital mobility. For comparison, the figure also reports the case with capital mobility we have seen in the previous figure. As can be seen, the response of asset prices is much larger in the autarky regime.

Figure 4: Impulse response of asset prices to a credit shock in the regimes with and without capital mobility. The shock is 0.5 percent the value of loans.



Why is the asset price drop larger in the autarky version of the economy? The main point is that globalization creates larger financial markets. While in a closed economy borrowing is limited to the funds supplied by domestic intermediaries, in a globalized economy producers can also borrow from foreign intermediaries. As a result, the credit contraction and the impact on aggregate prices is spread among all countries who are financially integrated. The effect on country 1 is then smaller. Although the impact on the originating country is smaller, other countries will be affected by the shock even if the shock originated abroad. Therefore, although the effect of a financial shock is smaller in the originating country, with globalized markets such a shock gets propagated to other countries with a worldwide drop in asset prices.

4 Mark-to-market accounting

One issue that has been widely debated during the current financial crisis is the role played by the accounting principle known as 'mark-to-market'. This is the accounting standard of assigning a value to a position held in a financial instrument based on the current market price. Because of this principle, the current asset price drop has determined a large drop in the equity value of banks, impairing their ability to make loans. Because of that, many academics and practitioners have proposed the suspension of this principle given the widespread financial difficulties. In this section we explore how the change in this accounting principle modifies the response of the economy to the initial shock.

In the previous simulations we have assumed that the 'equity' of financial intermediaries relevant for capital requirement were determined by valuing assets at market prices. More specifically, the capital $\bar{k}$ was valued at price P_t. Therefore, we assumed a mark-to-market approach.

Now suppose that we change the accounting principle relevant for capital requirement. Instead of using the market price, we use the steady state price $\bar{P}$. The bank equities, before paying dividends, are given by:

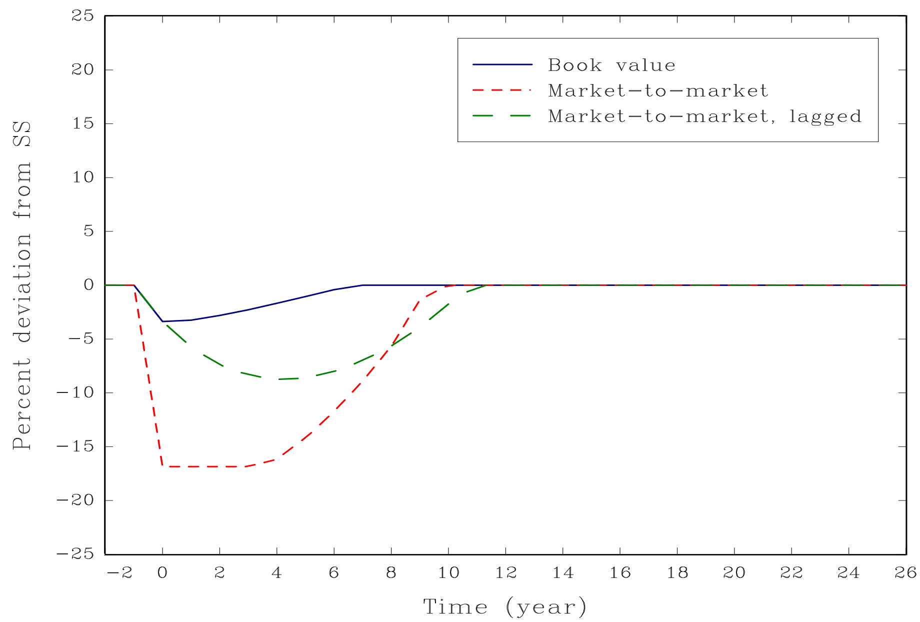
$$e_t = \bar{k}\bar{P} + L_t - B_t \tag{15}$$

Given the non-negativity of dividends, the volume of loans that can be made in the period is restricted by:

$$L_{t+1} \leq \alpha e_t \tag{16}$$

Condition (15) makes clear the importance of using $\bar{P}$ instead of P_t in determining the bank equity. Even if there is a drop in the market price, the 'book value' of equities do not fall and financial intermediaries maintain their ability to make loans. On the other hand, when the bank equities are valued at market prices, a drop in P_t generates a drop in e_t and, according to (16), it reduces the bank ability to make loans. If the drop in P_t is small, banks may not be forced to cut in lending because they can reduce dividends. However, if the drop is large, the non-negativity of dividends binds and the banks are forced to cut on lending. What we want to show is that the change in the accounting principle has a large impact on the response of the economy to the same shock considered above.

Figure 5: Impulse response of asset prices to a credit shock for different accounting rules for capital requirement. The shock is 0.5 percent the value of loans.



As can be seen from Figure 5, the use of a 'book-value' approach, as opposed to the 'mark-to-market' approach, reduces significantly the impact of the shock on the price of assets. The drop in asset prices is much smaller and short living.

The figure also reports the response when we apply a third approach, which is also based on market prices. However, the valuation of current equity is based on the market price in the previous period. The goal of this assumption is to capture some lag between the realization of prices and the actual decision to make loans. Also in this case the impact of the shock on asset prices is significantly amplified when compared to the book-value approach. Under this approach, the model generates a gradual decline in asset prices before the recovery starts instead of a drastic drop in the initial period.

5 Conclusion

Financial integration among countries that differ in domestic financial development produces a significant increase in net credit for the most financially developed country. In this paper we examined the connection between this phenomenon, the effects of credit shocks on asset prices and the cross-country contagion of financial turbulence. We proposed a setup in which financial constraints related to limited contract enforcement affect the credit contracts of savers, producers and financial intermediaries, and those constraints capture the mark-to-market rules that have been at play in the current crisis.

In this setup, cross-country differences in enforcement lead financial integration to produce a surge in debt in the most financially developed country. Thus, the model matches the fact observed in the data indicating that an initial ingredient of the current crisis was a surge in debt and leverage in the United States largely financed with foreign lending. Moreover, the model predicts that relatively small shocks to the marked-to-market value of equity of one country's financial intermediaries produce large responses in equilibrium asset prices world wide. Thus, the model can explain large asset price declines and global contagion of these asset price effects.

We also find that replacing contemporaneous mark-to-market regulations for the valuation of collateral in financial contracts with historical book valuations reduces significantly the magnitude of the asset price declines induced by credit shocks. Hence, our model lends support to the view that mark-to-market valuation practices should be abandoned, or replaced with a more flexible rule, or at least discontinued in times of financial turbulence. Of course, the same outcome can also be reached by keeping the mark-to-market principle but relaxing the constraint on capital requirement.

A Appendix: Set of feasible contingent claims

Suppose that agents have the ability to divert part of their income. Diversion is observable but not verifiable in a legal sense. If an agent diverts x, he or she retains $(1-\phi)x$ while the remaining part, ϕx, is lost. We allow ϕ to be greater than 1. This can be interpreted as a fine or additional punishment. A similar assumption is made in Castro, Clementi, & MacDonald (2004) but in an environment with information asymmetry.

Contracts are signed with financial intermediaries in a competitive environment. Financial contracts are not exclusive, meaning that agents can always switch to another intermediary from one period to the other. The set of state-contingent claims that an intermediary is willing to offer must be incentive-compatible.

Let $V_t(w,b)$ be the value function for an agent with current realization of endowment w and non-endowment wealth b. After choosing the contingent claims $b(w_j)$, the next period value is $V_t(w_j, b(w_j))$. In case of diversion, the agent would claim that the realizations of the endowment was the lowest level w_1 and divert the difference $w_j - w_1$. In this process the agent retains $(1-\phi)(w_j - w_1)$ and receives $b(s_1)$. The non-endowment wealth would be $\tilde{b}(w_j) = b(w_1) - \phi(w_j - w_1)$ and the value of diversion is:

$$V_t\Big(w_j\,,\, b(s_1) - \phi\cdot(w_j - w_1)\Big)$$

Incentive-compatibility requires:

$$V_t\Big(w_j\,,\, b(w_j)\Big) \geq V_t\Big(w_j\,,\, b(w_1) - \phi\cdot(w_j - w_1)\Big)$$

which must hold for all $j = 1, .., N$.

It is important to emphasize that the financial intermediary can tell whether the agent is diverting but there is no court that can verify this and force the repayment of the diverted funds. Compared to the standard model with information asymmetries, this assumption is convenient because it simplifies the contracting problem when shocks are persistent. Also convenient is the assumption that financial contracts are not exclusive and agents can switch to other intermediaries without a cost. This further limits the punishments available to the current intermediary. Also notice that, although the new level of wealth after diversion is verifiable when a new contract is signed, this does not allow the verification of diversion because the additional resources could derive from lower consumption in previous periods, which is not observable and verifiable. Again, the intermediary knows that the additional resources come from diversion but it cannot legally prove it.

The last assumption is limited liability for which agents renegotiate negative values of net worth, and therefore, $w_j + b(w_j) \geq 0$. The agent's problem can be written as:

$$V_t(w, b) = \max_{c, b(w')} \left\{ U(c) + \beta \sum_{w'} V_{t+1}\Big(w', b(s')\Big) g(w, w') \right\}$$

subject to

$$\begin{aligned} a &= c + \sum_{w'} b(w') q(w, w') \\ V_t\Big(w_j \, , \, b(w_j)\Big) &\geq V_t\Big(w_j \, , \, b(w_1) - \phi \cdot (w_j - w_1)\Big) \\ w_j + b(w_j) &\geq 0 \end{aligned}$$

Using standard arguments for recursive problems, we can prove that there is a unique solution and the function $V_t(w, b)$ is strictly increasing and concave in b. The strict monotonicity of the value function implies that the incentive-compatibility constraint can be written as:

$$b(w_j) \geq b(w_1) - \phi \cdot (w_j - w_1)$$

for all $j = 1, .., N$. This is the constraint we imposed on the original problem.

B Appendix: Equivalent economy

Let $\bar{b}_t$ be the expected next period value of contingent claims, that is, $\bar{b}_t = \sum_{w_{t+1}} b(w_{t+1}) g(w_t, w_{t+1})$. Then a contingent claim can be rewritten as $b(w_{t+1}) = \bar{b}_t + x(w_{t+1})$ where, by definition, $\sum_{w_{t+1}} x(w_{t+1}) g(w_t, w_{t+1}) = 0$. The variable $\bar{b}_t$ can be interpreted as a non-contingent bond and the variable $x(w_{t+1})$ is the pure insurance component of contingent claims.

Because agents choose as much insurance as possible, the constraint for incentive-compatibility will be satisfied with equality, that is,

$$b(w_1) - b(w_j) = \phi \cdot (w_j - w_1)$$

Using $b(w_{t+1}) = \bar{b}_t + x(w_{t+1})$, the constraint can be rewritten as:

$$x(w_1) - x(w_j) = \phi \cdot (w_j - w_1)$$

which must hold for all $j > 1$. The variables $x(s_j)$ must also satisfy the zero-profit condition, that is,

$$\sum_j x(s_j) g(w_t, w_j) = 0$$

Therefore, we have N conditions and N unknowns. We can then solve for all the N values of x. The solution can be written as:

$$x(w_j) = -\phi \cdot W_j(w_t)$$

where $W_j(w_t)$ is an exogenous variable defined as $W_j(w_t) = w_j - \sum_i g(w_t, w_i) w_i$. Notice that this variable depends on the current shock which affects the probability distribution of next period shock.

Define the following variable:

$$\tilde{w}_j(w_t) \quad = \quad w_j - \phi \cdot W_j(w_t)$$

This is a transformation of the shock. Using this new shock, the budget constraint can be written as:

$$\tilde{w}_j(w_{t-1}) + \bar{b}_t = c_t + \frac{\bar{b}_{t+1}}{1 + r_t}$$

By redefining the endowment to be $\tilde{w}_j(w_t)$, it is as if agents choose non contingent claims $\bar{b}_t$. Differences in financial deepness are captured by difference in the stochastic properties of the transformed shock. So, for example, if $\phi = 0$, we go back to the original shock because contingent claims are not feasible. If $\phi = 1$ and shocks are iid, the transformed shock becomes a constant. We are in the case of full insurance. Any intermediate values allow only for partial insurance.

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