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 based on historical asset values.

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1 Introduction

The global financial crisis that started with the meltdown of the U.S. sub-prime 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 crises has focused mainly on emerging economies in a small open economy setup. 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 finan-

¹Data 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.

**U.S. Net Credit Market Assets as a Share of GDP**

- **Domestic nonfinancial sector**
- **Financial sector**
- **Rest of the world**

**Foreign credit market borrowing and lending (fraction of GDP)**

- **Foreign borrowing**
- **Foreign lending**


- **Net credit market debt**
- **Net total financial assets**
- **U.S. Treasuries**
cial 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 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 vis-a-vis the United States 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

\(^2\)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.
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 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, and 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 are not explicitly modeled. The second difference with 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 takes 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 commentators conjecture mark-to-market accounting rules are playing an important role in the current financial crisis.\footnote{The claim is that marking to market worsened 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.}

In our setup, the financial constraint faced by financial intermediaries implies that a “small” shock that reduces the value of their equity (by about 0.5 percent of the value of world wide loans) induces a large reduction in equilibrium asset prices (almost 13 percent on impact). Moreover, it takes a long period of time for asset prices to fully recover (about 12 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 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.

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 of 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 \( \mu_i \). 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 \( \beta \) 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 \( P^i_t \). 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 \( g(w_t, w_{t+1}) \). We also assume that the savers are the shareholders of the financial intermediaries from which they receive non-negative dividends \( d_t \).

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 \( q^i_t(w_t, w_{t+1}) = g(w_t, w_{t+1})/(1 + r^i_t) \), where \( r^i_t \) is the equilibrium interest
The budget constraint for an individual saver is:

\[ d_t + w_t + b(w_t) = c_t + \sum_{w_{t+1}} b(w_{t+1}) q_t(w_t, w_{t+1}). \] (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 \( \phi^i \) of the diverted income. The parameter \( \phi^i \) characterizes the degree of enforcement of financial contracts in country \( i \). 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:

\[ b(w_1) - b(w_j) \leq \phi^i \cdot (w_j - w_1) \] (2)

\[ w_j + b(w_j) \geq 0 \] (3)

for all \( j \in \{1, \ldots, J\} \). Here \( J \) denotes the number of all possible realizations of the endowment and \( w_1 \) is the lowest (worst) 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 \( \phi^i \). When \( \phi^i \) is sufficiently large, savers are able to get full insurance of idiosyncratic risk, which guarantees constant consumption. When \( \phi^i = 0 \), only non-state-contingent claims are feasible. A key assumption is that \( \phi^i \) pertains to the country of residency of the savers. Cross-country differences in financial development are captured by differences in \( \phi^i \). 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 \( \{q_t^i(w_\tau, w_{\tau+1})\}_{\tau=t}^\infty \) be a (deterministic) sequence of prices in country \( i \). The optimization problem of an individual saver can be written as:

\[ V_t^i(w, b) = \max_{c, b(w')} \left\{ U(c) + \beta \sum_{w'} V_{t+1}^i(w', b(w')) g(w, w') \right\} \] (4)

subject to

(1), (2) and (3)

The contingent claims are sold by competitive intermediaries as described below.
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,

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

subject to

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

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

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

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 receive a constant flow of endowment $w^p$ and generate income $y_{t+1} = F(k_{t+1}) = Ak_{t+1}^{\nu}$, where $k_{t+1}$ is the quantity of the productive asset purchased at time $t$. The parameter $\nu$ 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 neither in the endowment $w^p$ nor in production, 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 \(l_{t+1}/(1+r_t)\) the loan borrowed from a financial intermediary (or the amount lent to an intermediary if \(l_{t+1} < 0\)). Limited enforcement constrains the amount that the intermediary is willing to lend as follows:

\[
l_{t+1} \leq \psi^i \cdot \left[ k_{t+1}P_{t+1} + F(k_{t+1}) \right]
\]  

(7)

This constraint derives from the assumption that the producer can always default on a contract at the beginning of next period. At this point the intermediary can only recover a fraction \(\psi^i\) of the productive asset plus production. Notice that this parameter could differ across countries.

Producers can also get additional loans without the intermediation of banks. However, these additional loans are costly. In particular, if the producer borrows \(x_{t+1}\) units without the intermediation of banks, it incurs the cost:

\[
\phi(x_{t+1}) = \kappa x_{t+1}^2
\]

This is a cost on top of the interest rate, so that trivially producers will only access these funds when their demand for loans exceeds what banks are willing to lend at the market interest rate.

In the steady state producers will borrow only from the financial intermediary. However, this is not necessarily the case outside the steady state if banks are constrained in the amount of loans they can make.

The problem solved by the producer reads:

\[
V^i_t(k, \tilde{l}) = \max_{c, k', \tilde{l}', x'} \left\{ U(c) + \beta V^i_{t+1}(k', \tilde{l}) \right\}
\]

subject to

\[
w^p + kP_t + F(k') + \frac{\tilde{l}' + x' - \varphi(x')}{1+r_t} = c + l + k'P_t
\]

\[
\tilde{l}' \leq \psi[k'P_{t+1} + F(k')]
\]

(8)

where the term \(\varphi(x')\) denotes the financial cost for loans received without the intermediation of banks. The variable \(\tilde{l} = l + x\) represents the total liabilities of firms.
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:

\[
U'(c_t) = \left[ \beta U'(c_{t+1}) + \mu_t \right] \left( \frac{1 + r_t}{1 - \varphi'(x')} \right) \tag{9}
\]

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

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

Assuming that all producers in each country start with the same initial states, \( k \) and \( \tilde{l} \), 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 there is an equity premium in our model. Because the term \( \varphi'(x') \) is usually zero, the parameter restriction \( \psi < 1 \) implies that the return from the productive asset is bigger than the interest rate. This implies that equilibrium asset prices will be lower than in the absence of the constraint.\(^5\)

### 2.3 Financial intermediaries

Financial intermediaries are profit maximizing firms owned by savers. They sign financial contracts with savers and producers, and they own a fixed quantity \( \bar{k}^f \) of the economy’s 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 our analysis is that the balance sheet of financial intermediaries depends on the market price of the asset. The consolidated budget constraint for the

\(^5\)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.
financial intermediation sector is:

\[ \bar{k}f P_t + \frac{L_{t+1}}{1+r_t} + d_t = \frac{B_{t+1}}{1+r_t} + e_t \]  \hspace{1cm} (11)

The left-hand-side of this expression represents the financial intermediaries' uses of funds. These are given by the value of the productive assets, \( \bar{k}f P_t \), the loans made to the producers, \( \frac{L_{t+1}}{1+r_t} \), and the payment of dividends to savers. The right-hand-side includes the source of funds given by deposits from savers, \( \frac{B_{t+1}}{1+r_t} \), and the equities before the payment of dividends, \( e_t \). The deposits from savers are the value of all contingent claims determined as

\[ B_{t+1} = \int \omega, b, \omega' \sum \omega' \beta_t(w, b, \omega') g(w, \omega') M_t(w, b). \]

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 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 the loans \( L_{t+1} \) cannot be bigger than a multiple of the bank's equity after the payment of dividends, that is, \( \alpha(e_t - d_t) \). 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:

\[ V_t(B, L) = \max_{d \geq 0, B', L'} \left\{ d + \frac{1}{1+r_t} V_{t+1}(B', L') \right\} \]  \hspace{1cm} (12)

subject to

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

\[ L' \leq \alpha \left( \bar{k}f P_t + \frac{L'}{1+r_t} - \frac{B'}{1+r_t} \right) \]  \hspace{1cm} (13)

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

At this point we can provide an intuitive interpretation of the role that
asset prices play in the optimal decisions of intermediaries. A fall in asset
prices $P_t$ reduces the equity of the financial intermediaries. Because of the
capital requirement, lower equity forces the intermediaries to cut loans. This
reduces the demand for 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 some of the loans made to producers (because, for
instance, some producers default on their debt). Alternatively we can think
of this shock as an unexpected physical depreciation in $\bar{k}^f$. This is a one
time unanticipated shock. The shock leads to transition dynamics that are
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 $X_t^i$, and the stock of productive capital owned by producers, $K_t^i$. Once
we know the distribution of savers and the loans made without the interme-
diation of banks, 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 param-
eter, $\phi^i$ and $\psi^i$, initial distributions of savers, $M_t^i(w, b)$, banks’ loans, $L_t^i$,
non-intermediated loans, $X_t^i$, productive capital owned by producers, $K_t^i$, for
problems (4), (8) and (12); (ii) prices satisfy $q^r(v)$ distributions $\{\tau\}$, $(i)$ savers’ policies, $\{l^i(k, l)\}_{\tau=t}^\infty$, $\{w^i(k, l)\}_{\tau=t}^\infty$ and $\{k^i_x(k, l)\}_{\tau=t}^\infty$ (iii) intermediaries’ policies, $\{d^i_r(B, L)\}_{\tau=t}^\infty$, $\{l^i_r(B, L)\}_{\tau=t}^\infty$ and $\{B^i_r(B, L)\}_{\tau=t}^\infty$; (iv) prices $\{P^i, r^i, q^c_i(w, w')\}_{\tau=t}^\infty$; (v) distributions $\{M^i_r(w, k, b)\}_{\tau=t+1}^\infty$. Such that: (i) the policy rules solve problems (4), (8) and (12); (ii) prices satisfy $q^i_r = g(w, w')/(1 + r^i_1)$; (iii) asset markets clear, $\int_{w,b,w'} b^i_r(w, b, w') M^i_r(w, b) g(w, w') = B^i_r(B, L) + x^i_r(K, L)/2$ and $k^i_r(K, L)/2 = \tilde{k} - \tilde{k}^f$ for each $i \in \{1, 2\}$ and $t \geq t$; (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 $q^1_r = g(w, w')/(1 + r^1_1) = g(w, w')/(1 + r^2_1) = q^2_r$ and $P^1_r = P^2_r$. Furthermore, asset markets clear globally instead of country by country. Therefore, the market clearing condition for the productive assets becomes $\sum_{i=1}^2 k^i_r \mu^i = \tilde{k} - \tilde{k}^f$ and the market clearing condition for contingent claims becomes $\sum_{i=1}^2 \int_{w,b,w'} b^i_r(w, b, w') M^i_r \mu^i(w, b) g(w, w') = \sum_{i=1}^2 B^i_r(B, L) \mu^i$.

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 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 endowments as labor income and the income generated by productive assets as capital income. Based on this interpretation we set average per-capita endowment, $\bar{w} + w^p$, to 0.8 and the income generated
with productive assets to \( y = Ak^\nu = 0.2 \). Given the normalization \( k = 1 \) this is obtained by setting \( A = 0.2 \). Notice that the capital income is only 20 percent (and correspondingly the labor income is 80 percent) because this is net of depreciation. Finally, we split equally the endowment between producers and savers, that is, \( \bar{w} = w^p = 0.4 \).

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. These are the parameters \( \phi^1, \phi^2, \psi^1 \) and \( \psi^2 \), where the superscript denotes the country. For the parameters \( \phi^1 \) and \( \phi^2 \), what matters is the difference not the absolute values. Therefore, we set \( \phi^2 = 0 \). We are then left with three parameters. Their values are chosen to replicate the following targets in the steady state equilibrium with capital mobility:

1. Domestic credit in country 1 (the US) is 195% the value of domestic output.

2. Domestic credit in country 2 (the Rest of the World) is 119% the value of domestic output.

3. The net foreign asset position of country 1 (the US) is 30% the value of domestic output.

These numbers come from the 2005 World Development Indicators. The Rest of the World includes OECD countries (except the US) and emerging economies. The parameters that generate these targets are: \( \phi_1 = 0.21 \), \( \psi_1 = 0.62 \) and \( \psi_2 = 0.45 \).

At this point we are left with the parameters characterizing the intermediation sector and the financing cost for non-banking loans, \( \kappa \). This last parameter is important for the equilibrium outside the steady state and its value will be specified in the quantitative exercise. The per-capita endowment of the productive asset is set to \( \bar{k} = 1.05 \) and the one held by financial intermediaries is set to \( k^f = 0.05 \). Therefore, the productive asset 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 \( \alpha = 10 \). This implies that loans must be backed by 10 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. Given the parameter values assigned above, which are based on the steady state with perfect capital mobility, we solve the model for the autarky equilibrium. In this case the domestic credit of country 1 is 169 percent (v. 195 percent in the calibrated equilibrium with financial integration). Therefore, the model predicts that capital markets liberalization has contributed to an increase in domestic credit of 26 percentage points of the value of domestic income. In country 2, instead, capital liberalization has generated a decline in domestic credit of 7 percentage points.

Capital liberalization has also induced an increase in the net foreign position of country 1 in the productive asset. The net position in productive assets of country 1 is 34% the value of income. This has been associated with an increase in foreign borrowing of 64% the value of income. Therefore, the net foreign asset position of country 1 is -30%. Hence, the model captures the fact that capital liberalization has generated a significant amount of foreign borrowing for country 1, in the order of 64% the value of domestic income.

3.2 Shock to bank equity

We start by studying the impulse response of asset prices to a shock that decreases bank equity in country 1 by a certain percentage of outstanding loans. As explained, this can be interpreted as unexpected loss due to unrecoverable loans made to producers. We consider a loss of 0.5 percent of the value of worldwide loans. This is equivalent to about 1.5% of the value of
loans made to country 1.

In considering the transition dynamics produced by this shock, the cost of non-banking loans plays an important role. This is captured by the parameter $\kappa$. As banks become constrained and unable to fulfil the demand for loans, producers start borrowing without the intermediation of banks. The bigger is the value of $\kappa$ the lower is the substitution of bank loans for non-bank loans. This will induce a larger drop in asset prices.

In the simulation we set $\kappa = 0.1$. As we decrease $\kappa$ the magnitude of the responses decreases but they display similar patterns. As we increase $\kappa$ the responses become larger. However, when $\kappa$ becomes too big we are unable to solve for the transition dynamics.

Figure 2 plots the response of the asset price to the shock (equity loss of banks) in the regimes with and without international mobility of capital. Let’s look first at the regime with capital mobility. As shown by the continuous line, in the regime with capital mobility the shock generates an initial drop in the price of assets of about 13 percent.

Figure 2: Impulse response of asset prices to credit shocks in the regime with and without mobility of capital
Figure 3 plots the impulse responses for other variables (in levels) but only in the case with capital mobility. The interest rate drops as banks demand less deposits and the demand for non-bank loans is contained by the increasing cost of this type of financing. The marginal cost of loans increases. This is the ratio \((1 + r_t)/(1 - \varphi_d(x_{t+1}))\) which in the figure is called ‘effective interest rate’. Because producers cannot get enough loans from banks, they borrow outside the banks. But this becomes very costly in the margin. The loans made by banks contract significantly, while the total loans (inclusive of the non-bank loans) contract at a much lower rate. As a result of the credit contraction, producers cut their consumption initially.

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 shown in Figure 2.

The dashed line in Figure 2 is for the case in which country 1 faces the same shock but in a regime without capital mobility. As can be seen, the response of asset prices is much bigger.

Why is the asset price drop bigger in the autarky regime? The key to the answer is the fact 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
Figure 3: Impulse responses to credit shocks in the regime with capital mobility
a financial instrument based on its current market price. Because of this principle, the current asset price drop has caused a large drop in the equity value of banks, impairing their ability to make loans. This has led many academics and practitioners to propose the suspension or adjustment of this principle given the widespread financial difficulties (see, for example, the interviews with Robert Shiller and James Chanos in the March 30, 2009 Wall Street Journal). In this section we explore how the change in this accounting principle modifies the response of the economy to the initial financial shock.

In the previous simulations we assumed that the ‘equity’ of financial intermediaries relevant for the capital requirement was 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.

We now consider an alternative scenario in which the banks’ asset are valued at historical value. In our context this means that the value of the bank asset, \( \bar{k}_f \) continues to be valued at the steady state price even if the market price changes. The capital requirement becomes:

\[
L' \leq \alpha \left( \bar{k}_f \bar{P} + \frac{L'}{1 + r_t} - \frac{B'}{1 + r_t} \right)
\]

The impulse responses of asset prices under marking-to-market and marking-to-historical-value are shown in Figure 4. The initial drop in the market value of assets is now about 7 percent, which is significantly smaller than the 13 drop generated in the previous case. The changes in all the remaining variables plotted in Figure 3 are also smaller when the capital requirement is based on historical values.

The intuition for this result is simple. Even if there is a drop in the market price of assets, the ‘book value’ of equities does not fall and this allows financial intermediaries to maintain higher levels of loans. On the other hand, when the bank equities are valued at market prices, a drop in \( P_t \) generates a drop in \( e_t \) which reduces the banks’ ability to make loans. If the drop in \( P_t \) is small, banks may not be forced to cut lending because they can reduce dividends. If the drop is large, however, the non-negativity of dividends binds and banks are forced to cut lending.

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, \( \phi x \), is lost. We allow \( \phi \) 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:

\[
V_t\left(w_j, b(s_1) - \phi \cdot (w_j - w_1)\right)
\]

Incentive-compatibility requires:

\[
V_t\left(w_j, b(w_j)\right) \geq V_t\left(w_j, b(w_1) - \phi \cdot (w_j - w_1)\right)
\]

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:

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

subject to

\[
a = c + \sum_{w'} b(w') q(w, w')
\]

\[
V_t(w_j, b(w_j)) \geq V_t(w_j, b(w_1) - \phi \cdot (w_j - w_1))
\]

\[
w_j + b(w_j) \geq 0
\]

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 \( j = 1, \ldots, N \). 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:

\[
\tilde{w}_j(w_t) = w_j - \phi \cdot W_j(w_t)
\]

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

\[
\tilde{w}_j(w_t) + \bar{b}_t = c_t + \frac{\bar{b}_{t+1}}{1 + r_t}
\]

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.
References


