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BANKING PRODUCTIVITY AND ECONOMIC FLUCTUATIONS: The Story of Colombia and its New Banking Regulation in the Late 1990's.

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Abstract

I build a general equilibrium, financial accelerator model that incorporates an explicit technology for the intermediary sector. A credit multiplier emerges because of a borrowing constraint that is a function of asset prices, internal funds and lending rates. With this financial friction I show that small changes in the productivity and intermediation costs of banks generate large and persistent fluctuations in economic activity. The transmission channel relies on the role that assets and internal funds play as collateral. After a negative shock hits financial intermediation productivity, the resulting credit crunch and economic slowdown induce a fall in asset prices and internal fund accumulation that further modifies the present and future volume of collateral, thus amplifying and propagating the initial shock. I argue that changes in banking regulation in Colombia in the late 1990's increased intermediation costs, reduced banking productivity and induced

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a credit channel story that fits the theoretical model presented here. This new regulation enhanced the credit crunch and economic slowdown that was already underway. Colombian data on loan/deposit interest rate spreads, credit volume, asset prices and economic activity supports this argument.

Keywords: Financial accelerator, banking productivity, intermediation costs, borrowing limit, credit crunch, amplification, propagation.

JEL: E32, E42, E44, G21.

1. INTRODUCTION

According to the media and to most analysts the economic performance of Colombia in the last three years has been disastrous. The evidence used to support this claim is an unemployment rate currently above 20%, a negative average economic growth rate for the years 1998,1999 and 2000 and an asset price plunge starting in the last months of 1997. This situation contrasts with the early nineties when Colombia grew at rates exceeding 4% and was catalogued as one of the top emerging markets in the world. This economic downturn has been accompanied by a severe crisis in the financial sector that begun in the end of 1997 or early 1998 [See Arias (2000)]. Real credit has suffered a severe crunch. Between January of 1998 and January of 2001 real credit fell 30%. Between July 1999 and May 2000 more than 30% of the financial system's stock of assets was capitalized by the government[1]. Many other intermediary institutions failed and were liquidated and bailed-out by the government. The fiscal cost of the bail out has been estimated at 6% of GDP[2,3].

In order to alleviate the financial distress and to finance the bail-out, the Colombian government issued new banking regulation towards the end of 1998[4]. For instance, whenever the outstanding value of a home mortgage debt exceeded the market value of the home, debtors were given the right to repay completely the debt by giving back their home to the financial institution that issued the credit. The financial institution receiving the home was given the right to a loan from

[1] *Source*: Banco de la Republica, Subegerencia de Estudios Economicos. See Arias (2000).

[2] *Source*: Foresight Colombia, July 4, 2000.

[3] The banking crisis in Colombia was parallel to a currency crisis. In 1999 the exchange rate regime (a target zone) collapsed and the exchange rate was allowed to float freely.

[4] Decree 2331, of November 16,1998. The new regulation can be consulted in: http://juriscol.banrep.gov.co:8080/cgi/normas_buscar.pl

the government equivalent to the value of the corresponding loss. The loan is be repaid at six month intervals during a ten year period at an interest rate equal to forecasted inflation by the central bank plus five percentage points [5]. Additionally, an upper bound of 1.5 times the current bank interest rate was imposed on unpaid home mortgage credits[6]. The new regulation also prohibited banks from translating home mortgage repayment request expenditures to individual debtors[7]. One of the most controversial regulatory changes was a new tax on financial transactions aimed at financing the bail-out and capitalization of troubled institutions. Indeed, as of November 17, 1998 most financial transactions were to be taxed at a 2 per 1000 rate[8].

Of course, the purpose of all this new regulation was to aid a troubled financial system. But things did not turn out as expected. The reason is that rather than improving the financial system's situation, many of the new regulatory changes introduced additional distortions and costs into financial intermediation activities. Not surprisingly, the spread between the loan and deposit interest rates in Colombia systematically rose to higher levels in 1999, after the new banking regulation and financial transaction tax was introduced. For example, the average spread between the nominal loan and deposit interest rates for three month contracts between Jan/1986 and Dec./1998 was 997 basis points. The corresponding average spread for the period Jan/1999-December/2000 was 1166 basis points. This represents a 169 basis points or 17% increase in the spread. The average spread for the period Jan/2000-Dec/2000 is 1423 basis points. This represents a 430 basis points or 43% increase with respect to the pre-1999 average. It is shown in this paper that this hike in the loan-deposit real interest rate spread reflects a rise in intermediation costs due to the new banking regulation. The new regulation, and specially the 2/1000 financial transaction tax, introduced strong distortions into intermediation activity. Consequently, financial intermediaries suffered a productivity meltdown as additional real resources were required to operate with and implement the new regulations and tax. As a result, financial intermediaries had to charge a higher loan-deposit interest rate spread in equilibrium, as observed in the data. While aimed at alleviating financial distress, the new regulation ended up reducing the productivity of financial intermediaries and increasing intermediation costs.

[5] Article 14 of Decree 2331.
[6] Article 15 of Decree 2331.
[7] Article 16 of Decree 2331.
[8] Articles 29 and 30 of Decree 2331.

This negative productivity shock enhanced the credit crunch and corresponding economic contraction that was already underway. Interestingly, the data also shows that this shock enhanced the economic recession not in a linear fashion. In other words, the shock was significantly amplified and propagated into the future. Indeed, the numbers show that the economic contraction has been longer lived and more persistent than any other previous downward economic fluctuation in Colombia.

The hypothesis of this paper is that due to the new regulation and to financial imperfections (specifically credit constraints), what otherwise would have been a regular and short-lived economic contraction became the biggest economic downfall of recent Colombian history. To support this argument the paper suggests a general equilibrium, financial accelerator model that incorporates an explicit technology for the intermediary sector and that explains how a negative productivity shock to financial intermediaries is amplified and propagated due to credit constraints. In fact, this financial imperfection reveals a transmission channel that amplifies and propagates productivity shocks to financial intermediaries. On a theoretical level addressing this issue is important for evaluating the welfare impact of regulatory changes and policies that modify the productivity of banks. On an empirical level the idea of the paper is to formalize the recent macroeconomic behavior of Colombia in the light of its new banking regulation. Nonetheless, the model applies to any other episode where the banking sector experiences a productivity shock.

Financial accelerator models [Bernanke and Gertler (1989), Bernanke and Gertler (1990), Kiyotaki and Moore (1997), Carlstrom and Fuerst (1997), Bernanke, Gertler and Gilchrist (1999), Cooley and Quadrini (1999), Schneider and Tornell (2000), Kocherlakota (2000)] have shown that conditions in financial markets play a significant role in explaining an economy's reaction to exogenous shocks. Yet, existing models of this type lack an appropriate representation of the banking technologies through which resources are intermediated. Indeed, most of these models treat financial intermediation as a costless, invisible and intangible activity. This basically boils down to assuming that the intermediary is simply an additional constraint in the economy [Chari et. al. (1995)]. Even though models with costly intermediation technologies have been widely used in the literature "for banks to play a non-trivial macroeconomic role" [Edwards and Vegh (1997) pp. 246; see also King and Plosser (1984), Diaz-Gimenez et. al. (1993) and Cole and Ohanian (2000)], they have not been extended to the financial accelerator literature. Incorporating costly intermediation technologies in financial accelerator models opens the space to study the macroeconomic consequences of productivity shocks to banks in environments where financial conditions are key in amplifying and propagating exogenous shocks.

As stated previously, many studies have shown that conditions in financial markets play a critical role in propagating and amplifying macroeconomic shocks (both real -i.e. technological and fiscal- or monetary). Most of these papers use models that rely on a self-feeding, internal finance mechanism called *financial accelerator* to propagate and amplify shocks. Usually, in this literature the firm's ability to finance its production plan is an increasing function of the value of its assets. When the value of these assets increases (either because the price of assets increases or because the firm reinvests more profits), the firm is able to expand its production plan (either because some external finance premium falls or because borrowing limits become less stringent). A higher level of production and investment increases asset demand (and asset prices) and/or earnings (and reinvestment of profits), thus increasing even further the value of the firm's assets and its ability to expand its production plan. And so on. The financial accelerator mechanism is at work. It is the basic source of propagation and amplification of shocks. These types of models can be classified in two categories: i) agency cost models and ii) borrowing limit models.

In agency cost models [e.g. Bernanke and Gertler (1989), Bernanke and Gertler (1990), Carlstrom and Fuerst (1997), Bernanke, Gertler and Gilchrist (1999)] the net worth or financial position of entrepreneurs/borrowers is critical for macroeconomic dynamics due to a contracting problem with agency costs that must be compensated by an external finance premium. The higher the net worth to capital ratio of a firm, the lower its leverage level, the lower the expected default or agency costs and so the lower the required external finance premium. This implies a higher investment demand that feeds back into a higher net worth and triggers the self-feeding propagation and amplification mechanism called financial accelerator. Agency costs are typically adopted from the CSV model of Townsend (1979). In these models lending exceeds net worth and so default is an equilibrium phenomenon.

In borrowing limit models [e.g. Kiyotaki and Moore (1997), Cooley and Quadrini (1999), Schneider and Tornell (2000), Kocherlakota (2000)] enforceability problems imply that credit constraints are imposed on the productive sector of the economy (entrepreneurs or firms). These borrowing limits play a key role in the business cycle dynamics of the economy. The higher the net worth or value of a firm, the less tight its borrowing limits and the higher its ability to expand production. This generates a higher investment demand that feeds back into a higher net worth and articulates the self-feeding propagation and amplification channel called financial accelerator. In these models borrowing is so tightly constrained by the level of net worth that default never occurs in equilibrium.

The model presented in this paper builds upon the borrowing limit-financial accelerator idea and uses an environment similar to the one suggested by Kocherlakota (2000). A different feature is that banks operate with a costly intermediation technology. For every unit of deposits they accept, a fraction is lost in the intermediation process. This intermediation cost creates a spread between the deposit and lending rates. It also determines the productivity of intermediation. Naturally, a lower cost implies a higher productivity. Many households populate the economy. Each has access to a riskless technology that needs land, internal funds and external funds (from banks) to operate. Even though the household's project is riskless, funding the household is risky for the bank. In fact, in every period the household can run away with the proceeds from the project without paying back the loan to the bank. But in doing so the household must leave its assets (or land) and internal funds behind. Banks know of this possibility and so they take care not to let the household borrow more than the value of its assets or landholdings plus internal funds. In other words, to avoid the risk of default banks impose a natural credit constraint on the household: it cannot borrow beyond the value of its collateralizable resources (value of landholdings plus internal funds). This credit constraint pushes up the value of land. Indeed, as long as the borrowing constraint is binding land will be valued not only because of its direct contribution to output, but also because of its role as collateral. Simply put, accumulating an additional unit of land is valuable not only because it increases future output directly, but also because it rises the household's future volume of collateral, loosens its future borrowing constraint and increases the future availability of external funds, thus expanding future output indirectly. This feature of the asset is not present in the Kocherlakota (2000) model either.

The punchline of the model is a credit channel that amplifies and propagates small, transitory shocks to banking productivity. In fact, small changes in the productivity of the intermediation technology generate large and persistent fluctuations in economic activity. The credit channel arises because borrowing constraints that depend on asset prices, internal funds and lending rates induce static and dynamic credit multipliers a-la Kiyotaki and Moore (1997). The transmission mechanism is triggered by a rise in lending rates that tightens borrowing constraints on impact. The credit crunch is magnified and propagated by a fall in *asset prices and internal fund accumulation that accompanies the lower level of economic activity and that further tightens the credit limit on impact and in the future. The qualitative predictions of the model are in line with the recent behavior of macroeconomic variables in Colombia if it is accepted that the new banking regulation of November 1998 was a negative productivity shock to its financial system.*

The paper is organized as follows. The next section presents the empirical facts regarding the macroeconomic behavior of Colombia before and after the new banking regulation. Section three displays a theoretical model to account for these facts. Section four shows how the new regulation induced a rise in intermediation costs and a corresponding slump of banking productivity in Colombia. In section five a numerical experiment is presented to simulate the results of a similar shock in the artificial economy. The last section concludes.

2. COLOMBIA: 1998-2000

Figures 1-5 present the evolution of the following macroeconomic variables in Colombia[9]: i) real GDP cycle (1977:I-2000:III), ii) stock prices in real terms (1991:01-2001:01), iii) real credit volume (1996:01-2001:01), iv) ex-post real loan rate (1990:01-2000:02), v) loan/deposit interest rate spread (1986:01-2000:12). When financial distress erupted in Colombia (end of 1997, beginning of 1998) its GNP entered into a cyclical contraction, asset prices plunged, real credit was crunched and the real loan rate took a big hike. As is well documented by the empirical literature [see Caprio and Klingebiel (1996), Demirguc-Kunt and Detragiache (1997), Kaminsky and Reinhart (1998, 1999), Kaminsky (1999) and Demirguc-Kunt, Detragiache and Gupta (2000)], this macroeconomic behavior is typical around credit crunch and financial distress episodes. Note also that during the initial phase of the crisis the loan/deposit interest rate spread did not display any drastic fluctuation. There is only an isolated hike in June of 1998.

But in 1999, after the new banking regulation and financial transaction tax was introduced, the loan/deposit interest rate spread systematically rose to higher levels. For instance, the average spread between the nominal loan and deposit interest rates for three month contracts between Jan/1986 and Dec./1998 was 997 basis points. The corresponding average spread for the period Jan/1999-December/2000 was 1166 basis points. This represents a 169 basis points or 17%

[9] A detailed description of the data is available in the Data Appendix.

increase in the spread. The average spread for the period Jan/2000-Dec/2000 is 1423 basis points. This represents a 430 basis points or 43% increase with respect to the pre-1999 average. Ahead it will be shown that the hike in the loan-deposit interest rate spread reflects a rise in intermediation costs due to the new banking regulation. The new regulation, and specially the 2/1000 financial transaction tax, introduced strong distortions into intermediation activity. Consequently, financial intermediaries suffered a productivity meltdown as additional real resources were required to operate with and implement the new regulations and tax. As a result, financial intermediaries had to charge a higher loan-deposit interest rate spread in equilibrium, as observed in the data. While aimed at alleviating financial distress, the new regulation ended up reducing the productivity of financial intermediaries and increasing intermediation costs.

At the same time the contraction of GNP became wider and longer lived than all other previous downward economic fluctuations. Asset prices maintained their downward trend after what seemed a slight stabilization of their initial plummeting. By January of 2001 the stock price levels of 1992 were being reached. This means that between December of 1997 and January of 2001 a 60% fall in real stock prices was observed, with 26 of these percentage points being lost after December of 1998. To give an idea about the severity of this crash, note that in the U.S. between 1929 and 1932 (the Great Depression) the S&P Index fell about 68% in real terms [Cole and Ohanian (2000)]. Another familiar stock market crash episode is that of Japan in the early nineties when the Nikkei Index fell about 55% in real terms between 1989 and 1992 [Cole and Ohanian (2000)]. The Colombian asset price plunge exceeds that of Japan and is close to the one experienced during the Great Depression in the U.S. Additionally, real credit was further crunched in Colombia after a slight recovery in the third quarter of 1998. Comparing real credit volume in January of 2001 with its corresponding value in December of 1997 reveals a 30% fall, with 24 of these percentage points being lost after December of 1998. The real loan also rate displayed another peak around the time of the new regulation. In sum, the macroeconomic effects of the initial credit crunch and financial distress were enhanced dramatically after the new banking regulation and financial transaction tax were implemented.

In the light of these events it seems that the regulatory changes not only reduced banking productivity on impact but also had effects that were magnified and propagated into the future. In other words, the new banking regulation and financial transaction tax of November of 1998 constitute a visible negative productivity shock to financial intermediation that was amplified and propagated, turning what otherwise would have been a regular short lived economic contraction into the deepest downward swing of recent history in Colombia. Why was this shock amplified and propagated? The next section suggests a theoretical model with a financial imperfection that might have the answer to this question.

3. MODEL

This economy is inhabited by an infinite number of identical, infinitely-lived, risk-averse entrepreneurial households. The mass of households has measure 1. In every period households have access to a riskless project. The project is simply a technology that needs internal and external funds as inputs to produce final good as output. The household also needs some land to operate the technology. Internal funds and land are complementary and are accumulated by the household from one period to the other. External funds are provided by a banking sector in the form of intraperiod loans at rate ρ and are also complementary to the other two inputs. The idea is that external funds represent working capital for the household and so they enhance the marginal productivity of land and internal funds. Total land supply is fixed at 1.

Banks operate with a costly, constant returns to scale (crs), intermediation technology. For every unit of deposits they accept, a fraction z is lost in the intermediation process. Note that this cost determines the productivity of intermediation. Of course, a lower cost implies a higher productivity. It is assumed that banks take intraperiod deposits from international financial markets at rate R. This rate is exogenously determined by supply and demand conditions in foreign credit markets.

Even though the household's project is riskless, funding the household is risky for the bank. In fact, in every period the household can run away with the proceeds from the project without paying back the loan to the bank. But in doing so the household must leave its assets (i.e. land) and undepreciated internal funds behind. Banks know of this possibility and so they take care not to let the household borrow more than the value of its assets or landholdings plus undepreciated internal funds. In other words, to avoid the risk of default banks impose a natural credit constraint on the household. *The household cannot borrow beyond the value of its collateralizable resources (value of landholdings plus undepreciated internal funds).*

Note that agents can trade in three markets [relative price of each market in $(\cdot)$]: i) final good (1), ii) land (q) and iii) loans (ρ). The order of events in every period is very simple. When the household wakes up in any given period it has some internal funds x and some landholdings l. At the same time the productivity of the banking sector (i.e. its intermediation cost z) is revealed. The levels of z and R determine the equilibrium lending rate ρ that will be charged by banks for any intraperiod loan. Additionally, the price of land q has been simultaneously determined in the land market.

Since the marginal cost of a loan ρ is known at this point, the household then determines its optimal demand for external funds (i.e. loans) from the bank b. If the corresponding outstanding debt at the end of the period $(1+\rho)b$ is below the household's total volume of collateralizable resources (i.e. value of landholdings plus undepreciated internal funds), then the household's demand for loans is satisfied completely. Otherwise, the household only obtains a loan volume equivalent to $b = [ql + (1-\delta)x]/(1+\rho)$, where δ is the depreciation rate of internal funds The volume of loans extended to the households determines the volume of deposits d taken by domestic banks from international financial markets. With x, l and b the household operates its technology $F(x, b, l)$. After production takes place, resources available to the household in terms of final good are given by $F(x, b, l) + (1-\delta)x + ql$. The household allocates these resources to four uses: i) consumption (c), ii) accumulation of internal funds (x'), iii) purchasing of land for next period (l') and iv) repayment of received loans $[(1+\rho)b]$. It is optimal for the household to repay its loans because if it runs away it must leave behind all its landholdings and undepreciated internal funds which are worth more than or the same as the value of the outstanding debt $[ql + (1-\delta)x \geqslant (1+\rho)b]$.

3.1. Household's Problem

Formally, the household solves the following sequential problem:

$$
\begin{gathered}
Max_{\{c_t, b_t, x_{t+1}, l_{t+1}\}} \quad E_0 \sum_{t=0}^{\infty} \beta^t U(c_t) \\
s.t. \\
c_t + x_{t+1} + q_t l_{t+1} + (1+\rho_t) b_t = F(x_t, b_t, l_t) + (1-\delta) x_t + q_t l_t \\
b_t (1+\rho_t) \leqslant q_t l_t + (1-\delta) x_t \\
c_t, x_t, l_t \geqslant 0 \\
q_t, \rho_t \ given \\
x_0, l_0 = 1 \ given
\end{gathered}
$$

It is assumed that $F_{ij}(x, b, l) = F_{ji}(x, l, b) > 0 \veebar i, j = 1, 2, 3$. In other words, land, internal funds and external funds are complementary inputs in the production technology. The complementarity assumption between land and internal funds is also used by Kocherlakota (2000). More on this assumption ahead. Note also that if the constraint is binding, any fall in asset prices, internal fund volume or lending rate hike tightens the constraint.

Let λ_t represent the Kuhn-Tucker multiplier associated to the borrowing constraint. λ_t can be interpreted as the shadow price of collateral. Optimality conditions for the household are:

$$\lambda_t = \frac{U'(c_t)[F_2(x_t, b_t, l_t) - (1+\rho_t)]}{(1+\rho_t)} \tag{1}$$

$$U'(c_t) = \beta E_t\{U'(c_{t+1})[F_1(x_{t+1}, b_{t+1}, l_{t+1}) + (1-\delta)] + \lambda_{t+1}(1-\delta)\} \tag{2}$$

$$q_t U'(c_t) = \beta E_t\{U'(c_{t+1})[F_3(x_{t+1}, b_{t+1}, l_{t+1}) + q_{t+1}] + \lambda_{t+1} q_{t+1}\} \tag{3}$$

Equation (1) is a key result of the model. It says that if $F_2(x_t, b_t, l_t) > (1+\rho_t)$ then $\lambda_t > 0$ and the borrowing constraint binds. Contrarily, if $F_2(x_t, b_t, l_t) = (1+\rho_t)$ then $\lambda_t = 0$ and the borrowing constraint does not bind. In other words, the entrepreneurial household always wants a level of external funds that equates the marginal productivity of this input to the gross loan rate. The latter is simply the marginal cost of external funds. Of course, optimality dictates that marginal productivity and cost of external funds always be equated. However, if the desired level of external funds exceeds the borrowing limit, this optimality condition is not possible. In this case the household will take as higher a loan volume as it can, the borrowing constraint will bind and the marginal productivity of external funds will exceed its marginal cost or gross loan rate. As a result, the demand for external funds will be determined in the following way:

$$\begin{aligned} &If \quad F_2\left[x_t, \frac{q_t l_t + (1-\delta)x_t}{(1+\rho_t)}, l_t\right] \; > \; 1+\rho_t \;\; then \;\; b_t = \frac{q_t l_t + (1-\delta)x_t}{(1+\rho_t)} \;\; and \;\; \lambda_t > 0 \qquad (4) \\ &If \quad F_2\left[x_t, \frac{q_t l_t + (1-\delta)x_t}{(1+\rho_t)}, l_t\right] \; \leq \; 1+\rho_t \;\; then \;\; b_t \ni F_2(x_t, b_t, l_t) = (1+\rho_t) \;\; and \;\; \lambda_t = 0 \end{aligned}$$

The Euler Equation governing the consumption-internal fund accumulation decision of the household follows from equations (1) and (2):

$$U'(c_t) = \beta E_t\{U'(c_{t+1})[F_1(x_{t+1}, b_{t+1}, l_{t+1}) + (1-\delta) + [F_2(x_{t+1}, b_{t+1}, l_{t+1}) - (1+\rho_{t+1})]\frac{(1-\delta)}{(1+\rho_{t+1})}]\} \tag{5}$$

The left hand side (lhs) of (5) captures the marginal loss of utility from accumulating an additional unit of internal funds for next period. The right hand side (rhs) captures the expected presented discounted value of the corresponding marginal utility gain. As (5) states, along the optimal consumption-internal fund accumulation path the marginal loss and gain of accumulating an additional unit of internal funds must always be equated. Note, however, that the marginal benefit of accumulating an additional unit of x has two components. The first one is standard and is presented in the first line of (5). Since x is an input of production, accumulating an additional unit of x rises next period's output in $F_1(x_{t+1}, b_{t+1}, l_{t+1})$ and its undepreciated part can be sold for $(1-\delta)$. The second component reveals the value of internal funds as collateral and is presented in the second line of (5). Accumulating an additional unit of x loosens next period's credit constraint in $(1-\delta)/(1+\rho_{t+1})$. Each of these additional units of available external funds generate a net gain of $[F_2(x_{t+1}, b_{t+1}, l_{t+1}) - (1+\rho_{t+1})]$ units of output to the entrepreneurial household. Note that this gain is only relevant if the borrowing constraint is binding [i.e. only if $F_2(x_{t+1}, b_{t+1}, l_{t+1}) > (1+\rho_{t+1})$]. In consequence, as long as the borrowing constraint binds the collateral properties of internal funds enhance their marginal contribution to output. Equation (5) is very important to the story of the paper. It dictates consumption smoothing to the household. Hence, it captures the household's incentive to cut internal fund accumulation whenever there is a reduction in revenues such as the one that results after a credit crunch is triggered by a lending rate hike due to a fall in banking productivity.

The pricing equation for land follows from (1) and (3):

$$q_t U'(c_t) = \beta E_t\{U'(c_{t+1})[F_3(x_{t+1}, b_{t+1}, l_{t+1}) + q_{t+1} + [F_2(x_{t+1}, b_{t+1}, l_{t+1}) - (1+\rho_{t+1})]\frac{q_{t+1}}{(1+\rho_{t+1})}]\} \tag{6}$$

The lhs of (6) captures the marginal utility loss from buying an additional unit of land for next period. The rhs portrays the expected present discounted value of the corresponding marginal utility gain. As shown by (6), along the optimal consumption-land accumulation path the marginal loss and gain of buying an additional unit of land must always be equated. As with internal funds, the marginal benefit of purchasing an additional unit of land comes from two sources. The first source is typical and is presented in the first line of (6). Since land is an input of production, purchasing an additional unit of land increases next period's output in $F_3(x_{t+1}, b_{t+1}, l_{t+1})$ and, afterwards, that unit of land can be sold for q_{t+1}. The second source comes from the value of land as collateral and is presented in the second line of (6). Buying an additional unit of l loosens next period's credit constraint in $q_{t+1}/(1+\rho_{t+1})$. Each of these additional units of available external funds generate a net gain of $[F_2(x_{t+1}, b_{t+1}, l_{t+1}) - (1+\rho_{t+1})]$ units of output to the entrepreneurial household. Again, note that this gain is only relevant if the borrowing constraint is binding [i.e. only if $F_2(x_{t+1}, b_{t+1}, l_{t+1}) > (1+\rho_{t+1})$]. In sum, as long as the credit constraint binds the collateral properties of land enhance its marginal contribution to output.

Iterating forward on (6) and imposing the no-bubble condition $\beta F_2(x_t, b_t, l_t) < (1+\rho) \veebar t$, reveals an expression for the price of land (see technical appendix):

$$q_t = E_t \left\{ \sum_{j=1}^{\infty} \beta^j \frac{U'(c_{t+j})}{U'(c_t)} \left[F_3(x_{t+j}, b_{t+j}, l_{t+j}) \prod_{i=1}^{j-1} \Omega_{t+i} \right] \right\} \tag{7}$$

where $\Omega_t = F_2(x_{t+1}, b_{t+1}, l_{t+1})/(1+\rho_{t+1})$. As usual, the price of land is given by the expected present discounting value of its forever flow of rental payments. Discounting is done with the stochastic discount factor as with any other asset. Note that rental payments to land include not only its direct contribution to output $[F_3(x_{t+j}, b_{t+j}, l_{t+j})]$, but also its accumulated indirect contribution as credit constraint loosener or collateral $\left(\prod_{i=1}^{j-1} \Omega_{t+i}\right)$. Of course, the indirect contribution is only relevant if the borrowing constraint binds [*i.e. if* $F_2(x_t, b_t, l_t) > (1+\rho_t)$ *and* $\Omega_t > 1$]. Equation (7) is a nice result because it shows that credit constrained agents value assets not only for their direct rental payments but also for their role as collateral. On the other hand, equation (7) also reveals the reason for assuming complementarity in the three inputs of production x,b and l. As evidenced in (7), rental payments to land are an increasing function of the marginal productivity of land (l) and external funds (b). Complementarity between x and (b, l) implies that a reduction in internal fund accumulation (i.e. a fall in x') reduces $F_3(x', b', l')$ and $F_2(x', b', l')$ or Ω. Hence, a credit crunch that induces a cut in x'

also induces a fall in rental payments to land and, consequently, a fall in its price q, thus triggering the credit multipliers. Complementarity is what articulates the transmission channel from the credit crunch to asset prices and back to the credit constraint. Of course, either complementarity between x and l or between x and b is enough to do the trick. But assuming both generates a bigger kick out of the credit multipliers.

3.2. Financial Structure and Bank's Problem

Banks own a crs technology to intermediate resources from international financial markets to domestic entrepreneurial household projects. Specifically, banks accept deposits from foreign credit markets at rate R. This rate is exogenously determined by demand and supply conditions in those markets. Banks use the intermediation technology to provide intraperiod safe loans to domestic households at rate ρ. Note that $(1+\rho)$ is the relative price of banking output.

The intermediation technology is costly in the sense that for every unit of deposits, $z \in [0,1)$ units are lost in the intermediation process. This captures the idea that in order to intermediate deposits into loans, banks must carry out a variety of costly activities like evaluating creditors, managing deposits, renting buildings, maintaining ATMs, etc. [Edwards and Vegh (1997)]. Thus, in every period the volume of intermediated resources is given by:

$$I = (1-z)d$$

This technological specification is similar to the one used by Cole and Ohanian (2000). In their paper the intermediation technology is $G(D,Z)$ where D is uninstalled physical capital, Z is intermediation capital (in fixed supply), $G(\cdot)$ exhibits crs and $D - G(D,Z) \geqslant 0$ captures resources used in the intermediation process. Under the technology specified here there is no intermediation capital but there is a productivity parameter $(1-z)$ playing an analogous role. There is no uninstalled physical capital either but deposits d play the same role. Finally, under this specification resources lost in the intermediation process are given by $d - I = d - (1-z)d = zd < d$.

With crs in the intermediation technology it is possible to assume an atomistic structure in the banking industry. This assumption is also consistent with the fact that firms of many sizes coexist in the financial industry. In other words, under this environment banks behave competitively and are price takers. Formally, in every period banks solve the following static problem:

$$Max_{\{d_t\}} \quad (1+\rho_t)(1-z_t)d_t - (1+R)d_t$$

Free entry and exit will drive profits to zero so that in equilibrium banks produce where the relative price of their output $(1+\rho)$ equals their marginal cost. This is:

$$1+\rho_t = \frac{1+R}{1-z_t} \tag{8}$$

Equation (8) is crucial to the results of the paper because it shows that any shock to banking productivity is transmitted to the borrowing constraint through the lending rate ρ. Note that the intermediation cost z also creates a spread between the lending and the deposit rates:

$$\frac{1+\rho_t}{1+R} = \frac{1}{1-z_t}$$

This last equation shows that the ratio between the gross lending rate and the gross deposit rate is a metric of the average (and marginal) productivity of deposits $(1-z)$. The higher the productivity of the financial system, the lower the ratio between the gross lending rate and the gross deposit rate. This result is important because it provides a way to measure productivity changes in the financial sector using observed data.

Finally, it is assumed that $z \in [0,1)$ moves according to a stochastic process Γ. In other words, the intermediation cost fluctuates randomly through time.

3.3. Market Clearing Conditions

Markets clear if:

$$b_t = (1-z_t)d_t \quad \Longrightarrow \quad loans\ market \tag{9}$$

$$l_t = 1 \quad \Longrightarrow \quad land\ market \tag{10}$$

$$c_t + x_{t+1} = F[x_t, (1-z_t)d_t, 1] + (1-\delta)x_t - (1+R)d_t \quad \Longrightarrow \quad final\ good\ market \tag{11}$$

At this point equilibrium concepts must be defined. First a stationary equilibrium for the non-stochastic version of the model is introduced. Then, a recursive competitive equilibrium for the stochastic version of the model is defined. The latter facilitates the solution for the numerical experiment below.

3.4. Stationary Equilibrium

Under the non-stochastic version of the model z must be set at its unconditional mean $E(z)$.

Definition 1. *A stationary equilibrium is the vector* $\zeta_{ss} = (c_{ss}, x_{ss}, l_{ss}, b_{ss}, d_{ss}, z_{ss}, q_{ss}, \rho_{ss})$ *that solves:*

$$b_{ss} = \frac{q_{ss}l_{ss} + (1-\delta)x_{ss}}{1+\rho_{ss}} \quad if \;\; F_2\left[x_{ss}, \frac{q_{ss}l_{ss} + (1-\delta)x_{ss}}{1+\rho_{ss}}, 1\right] > 1+\rho_{ss} \quad (1_{ss})$$
$$b_{ss} \ni F_3(x_{ss}, l_{ss}, b_{ss}) = 1+\rho_{ss} \quad otherwise$$

$$1 = \beta\left[F_1(x_{ss}, b_{ss}, 1) + \frac{F_2(x_{ss}, b_{ss}, 1)}{1+\rho_{ss}}(1-\delta)\right] \quad (2_{ss})$$

$$q_{ss} = \frac{\beta F_3(x_{ss}, b_{ss}, 1)}{1 - \beta\frac{F_2(x_{ss}, b_{ss}, 1)}{1+\rho_{ss}}} \quad (3_{ss})$$

$$1+\rho_{ss} = \frac{1+R}{1-z_{ss}} \quad (4_{ss})$$

$$d_{ss} = \frac{b_{ss}}{(1-z_{ss})} \quad (5_{ss})$$

$$l_{ss} = 1 \quad (6_{ss})$$

$$c_{ss} = F[x_{ss}, b_{ss}, 1] - \delta x_{ss} - (1+R)d_{ss} \quad (7_{ss})$$

$$z_{ss} = E(z) \quad (8_{ss})$$

3.5. Recursive Competitive Equilibrium

Whenever the economy is shocked out of steady state a different equilibrium concept must be used. Due to its usefulness in the experiment that follows, the concept of recursive competitive equilibrium is now introduced. Let $S = (z, X)$ be the aggregate state vector and $s = (x, l)$ be the household's individual state vector.

Definition 2. *P1 is the following dynamic programming problem for the household*

$V(S,s) = Max_{s',b}\{U[F(x,b,l) + (1-\delta)x + q(S)l - x' - q(S)l' - (1+\rho(S))b] + \beta EV(S', s')\}$

s.t.
$b \leqslant \frac{q(S)l+(1-\delta)x}{1+\rho(S)}$
$S' = [\Gamma, H(S)]$

Definition 3. *P2 is the following static problem for the bank*
$Max_d \; [1+\rho(S)](1-z)d - (1+R)d$

Definition 4. *A recursive competitive equilibrium is*

1. *A value function:* $V(S,s)$.
2. *A set of individual decision rules:* $s'(S,s)$ *and* $b(S,s)$.
3. *A demand for deposits:* $d(S)$.
4. *A set of pricing functions:* $q(S)$ *and* $\rho(S)$.
5. *A stochastic process and an aggregate law of motion:* $[\Gamma, H(S)]$.

   such that:

- *Given (4) and (5), (1) and (2) solve (P1).*
- *Given (4), (3) solves (P2).*
- *Markets clear:*
  1. $l'(z,X,X,1) = 1$
  2. $b(z,X,X,1) = (1-z)d(z,X)$
- *Aggregate Consistency:* $x'(z,X,X,1) = H(z,X)$.

3.6. Credit Channel

In this economy there is a credit channel which is articulated by a static and dynamic multiplier a-la-Kiyotaki and Moore (1997). It propagates and amplifies any change in banking productivity. Suppose that banks experience an adverse productivity shock as their intermediation cost goes up. This induces a contemporaneous hike in the loan rate charged by banks in equilibrium. The jump in the loan rate immediately tightens the borrowing limit of the household. As a result, households suffer a crunch in the volume of external funds or working capital available to them. Their ability to finance production is reduced with this credit crunch. As their revenue falls, they reduce on impact their accumulation of internal funds in an attempt to smooth out consumption. Recall that land is an asset and, as such, its price is given by the present discounted value of its forever flow of rental payments. As shown previously, these rental payments include not only the direct contribution of land to output but also its indirect contribution as collateral (recall that more land increases external fund availability and, hence, output, as long as the borrowing constraint binds). Not surprisingly, these rental payments are an increasing function of the marginal productivity of land and external funds. Since internal funds are complementary to both land and external funds, the instantaneous reduction in internal fund accumulation implies a fall in the future marginal productivity of land and external funds. Consequently, the future flows of direct and indirect (or collateral-based) rental payments to land fall. As a result, in the period of the shock the price of land falls. This reduces the value of land on impact and, hence, tightens even further the borrowing constraint. The credit crunch is enhanced and revenue and internal fund accumulation fall even more. And so on. The same story is repeated again and again. This is the static multiplier. It basically magnifies the initial impact of the shock.

But this is not the end of the story. The reduction in internal fund accumulation reduces the volume of collateral available for next period. Thus, the borrowing constraint of next period is also tightened even if the shock has vanished and the lending rate has returned to its normal level. This propagates the credit crunch or reduced availability of external funds into the next period. Hence, household revenue and internal fund accumulation fall in the period following the shock. And so on. The story told above is repeated in the periods after the shock. This is the dynamic multiplier. It propagates into future periods the effect of the shock. The economy takes longer in converging back to the steady state than in a financially frictionless setup.

4. NUMERICAL EXPERIMENT

In this section the credit channel of the theoretical model is studied within a numerical experiment that aims at replicating the negative productivity shock endured by financial intermediaries in Colombia after the new banking regulation was issued. First it is shown that the claim that financial intermediaries in Colombia experienced a productivity meltdown after the new banking regulation was issued is not only a hypothesis. Observed data confirms it. Then, the assumptions (i.e. functional forms and parameter values) for the numerical experiment are presented. Finally the results are discussed.

4.1. Banking Productivity in Colombia after the November/1998 Regulation

It was hypothesized in previous paragraphs that the November/1998 banking regulation, and specially the 2/1000 financial transaction tax, introduced strong distortions into intermediation activity in Colombia. Apparently, financial intermediaries suffered a productivity meltdown as additional real resources were required to operate with and implement the new regulations and tax. As a result, financial intermediaries had to charge a higher loan-deposit interest rate spread in equilibrium, as observed in the data. While aimed at alleviating financial distress, it seems that the new regulation ended up reducing the productivity of financial intermediaries and increasing intermediation costs. Can this hypothesis be verified? Yes, if productivity shocks to financial intermediaries can be measured from observed data.

But how can such productivity shocks be measured? Recall that the metric suggested by the model to measure productivity in the financial system is the ratio of the gross loan interest rate to the gross deposit interest rate: $(1+\rho)/(1+R)$ [see equation (8)]. The higher this ratio, the higher the intermediation costs and the lower the average (and marginal) productivity of the financial system $(1-z)$. Figure 6 presents the behavior of such ratio in Colombia during the period Jan/1986-Dec/2000[10]. It displays a fairly steady pattern until January of 1999. Yet, by January of 1999, less than two months after the new banking regulation and financial transaction tax was introduced, this ratio took a dramatic hike. For instance, between Jan/1986 and Dec./1998 the average ratio between the gross three month contract annual loan and deposit interest rates was1.33. The corresponding average ratio for the period Jan/1999-Dec/2000 was 1.81. This represents a 33.14% increase. The average ratio for the period Jan/2000-Dec./2000 was 2.17. This represents a 63.36% increase with respect to the pre-1999 average.

[10] The annual nominal loan rate is "tasa activa total sistema" (monthly average) calculated by Superintendencia Bancaria in Colombia. Two different annual nominal deposit rates are used: "tasa de interes de los CDT a 90 dias, total sistema" (monthly average) and "tasa de interes de los CDT a 90 dias, bancos y CF" (monthly average). Source is Banco de la Republica. Period is 1986:01-2000:12. See Data Appendix.

With the percentage change in the ratio between the gross loan and deposit interest rates $(1+\rho)/(1+R)$ it is possible to back up the corresponding percentage change in the productivity of the banking sector $(1-z)$. Recall:

$$\frac{1+\rho}{1+R}=\frac{1}{1-z}$$

Now let $y=(1+\rho)/(1+R)$. Hence:

$$\frac{\dot{y}}{y}=-\frac{\dot{(1-z)}}{(1-z)}$$

where $\cdot$ symbolizes a derivative with respect to time. Thus, any change in the ratio between the gross loan and deposit interest rates maps into an equiproportional opposite sign change in financial intermediation productivity. Note then that the data is revealing a drastic negative productivity shock to financial intermediaries in Colombia right after the new banking regulation was issued. According to the data, the productivity meltdown ranges from 30% to 60%! Of course, other distortions might play a role in this productivity collapse. In fact, the 30%-60% range is quite high and must be taken cautiously. These numbers are only indicative of the presence of a negative productivity shock in the financial system of the Colombian economy right after the new banking regulation was implemented. Filtering out those components of the shock attributable to distortions other than the new regulation or to measurement error is complicated. Thus no stance is taken here with regards to the magnitude of the shock.

To give another idea of the productivity meltdown in the Colombian financial sector after the November/1998 banking regulation was implemented, figure 7 presents the evolution of real credit stock per financial sector employee in Colombia for the period 1996-1999[11]. While this indicator fell 5% between December of 1997 and December of 1998, it then fell an additional 18% during the period December/1998 - December/1999. The story is very simple. When financial distress erupted towards the end of 1997, productivity in the Colombian financial sector began to erode (5%). However, once the new banking regulation was in place in December of 1998, productivity in this sector plunged. According to these

[11] During credit crunch episodes the level of financial activity is better proxied by the outstanding stock of real credit than by the corresponding flow of new real credit. The reason is that possible disintermedation amid financial distress might yield negative new credit flows for some years. Additionally, monitoring clients or dealing with non-performing loans also represents activity for the banking sector and this is not captured by the flow of new loans.

numbers, the sector lost almost an additional one fifth of its productivity after the new regulation was implemented. In sum, these numbers also suggest that the new banking regulation of November/1998 constitutes a visible and significant negative productivity shock to financial intermediation in Colombia.

The purpose of the following exercise is to use the artificial economy to study the effects of a negative banking productivity shock similar to the one observed in Colombia towards the end of 1998, right after the new banking regulation was implemented. Afterwards, the effects in the theoretical model can be compared to those observed in Colombia during the years 1999 and 2000, the post-regulation years.

4.2. Functional Forms and Parameter Values

For this experiment the following functional forms and assumptions are used:

- $U(c) = \log(c)$
- $F(x, l, b) = x^{\alpha} l^{1-\alpha} + Ab$
- $z'^{\sim}\ iid\ \ uniform\ [0, \overline{z}]$

Note that external funds yield output through a linear technology while internal funds and land must be combined in a Cobb-Douglas technology in order to produce output. As the reader will see, this is just a simplifying assumption to facilitate the choice of parameter values so that the borrowing constraint binds in every period. If $A = 1$ the example reduces to the one suggested by Kocherlakota (2000).

Under this setup external funds are neither a complement nor a substitute to internal funds and land. As said earlier, the lack of complementarity between internal and external funds will reduce the kick obtained from the credit multipliers. Yet, these multipliers are still there due to the complementarity between internal funds and land. Recall that this complementarity assumption is enough to do the trick. On the other hand, loan demand decision is taken according to the following rule:

$$\begin{aligned} If\ A &= (1+\rho_t) \implies b_t \in [0, \infty] \\ If\ A &> (1+\rho_t) \implies b_t \longrightarrow \infty \\ If\ A &< (1+\rho_t) \implies b_t = 0 \end{aligned}$$

Parameter values are set so that $A > (1+\rho_t) \veebar t$. This is guaranteed with the following condition:

$$A = \frac{(1+R)}{1-\overline{z}} + \varepsilon$$

where ε is an arbitrarily small number. The important point is that in every period the household wants as many loans as it can get. Consequently, its borrowing constraint will be binding in every period:

$$b_t = \frac{q_t l_t + (1-\delta)x_t}{1+\rho_t} \veebar t$$

Recall also that the no-bubble condition $\beta F_2(x_t, b_t, l_t) < (1+\rho) \veebar t$ must be met. Under the present setup this condition is equivalent to $\beta A < (1+\rho) \veebar t$. To guarantee that this condition is satisfied at all times β is defined as:

$$\beta = \frac{(1+\overline{\rho})}{A} - \varepsilon$$

where $\overline{\rho}$ is the steady state loan interest rate[12].

The following parameter values were used for the experiment:

TABLE 1

Primitive Parameter	**Value**
δ	0.025
α	0.5
R	0.019
$\overline{z}$	0.0385
ε	0.001

$\Longrightarrow$

Parameter	**Resulting Value**
β	0.978
$\overline{\rho}$	0.039
A	0.0608

Each period should be thought of as a quarter. The value for R implies a quarterly deposit interest rate of 1.9% which is equivalent to the average ex-post quarterly real deposit interest rate in Colombia for the period January/1990-Febreuary/2000[13]. This rate should be associated to the safe quarterly rate that any depositor obtains in international financial markets. The value for $\overline{z}$ was chosen so that the steady state quarterly loan interest rate is 3.9% which coincides

[12] In the experiment ρ will rise only during one period above $\overline{\rho}$. Hence, the no-bubble condition wil not be violated given that the rhs of the equation will rise.

[13] The corresponding annual rate is 8%.

with the average ex-post quarterly real loan interest rate in Colombia for the period January/1990-Febreuary/2000[14]. The value for ε implies a gross return to loans (i.e. A) of 6.1% and a value for β of 0.978. The quarterly depreciation rate is set at 2.5% and the elasticity of final output to both internal funds and land is 0.5. This last value was chosen as a benchmark so that output is neither land nor internal fund intensive. One caveat regarding parameter values. They are just reasonable numbers used to implement a quantitative exercise. There is no calibration whatsoever to long-run empirical regularities. This is future work and so specific quantitative responses should be taken with caution.

4.3. Results

Initially the economy is set at its steady state $\zeta_{ss} = (c_{ss}, x_{ss}, l_{ss}, b_{ss}, d_{ss}, z_{ss}, q_{ss}, \rho_{ss})$, which is the solution to:

$$b_{ss} = \frac{q_{ss} + (1-\delta)x_{ss}}{1+\rho_{ss}}$$

$$1 = \left[\beta\alpha x_{ss}^{\alpha-1} + \frac{A(1-\delta)}{1+\rho_{ss}}\right]$$

$$q_{ss} = \frac{\beta(1-\alpha)x_{ss}^{\alpha}}{1-\frac{\beta A}{1+\rho_{ss}}}$$

$$1+\rho_{ss} = \frac{1+R}{1-z_{ss}}$$

$$d_{ss} = \frac{b_{ss}}{(1-z_{ss})}$$

$$l_{ss} = 1$$

$$c_{ss} = x_{ss}^{\alpha} + Ab_{ss} - \delta x_{ss} - (1+R)d_{ss}$$

$$z_{ss} = \frac{\overline{z}}{2}$$

Once in steady state, z is given a one-time positive shock that induces a one-time 50 basis point increase in the lending rate ρ. The magnitude of the corresponding fall in banking productivity $(1-z)$ is 0.48%. In any case, the shock drives the lending rate from 3.9% (its steady state value) to 4.4%. Recall that these are quarterly rates. In annual terms the shock is equivalent to a rise in

[14] The corresponding annual rate is 16.5%.

the loan rate from 16.65% to 18.80%. Even though no definitive stance is taken here with regards to the magnitude of the shock observed in Colombia, looking at this country's ex-post annual real loan rates shows that the average between January/1999 and February/2000 (the period right after the new regulation was issued) was 18.85%. In contrast, the average for the period January/1990-February/2000 was 16.65%. Hence, the magnitude of the shock used in this experiment mimics crudely the negative productivity shock suffered by financial intermediaries in Colombia after the new banking regulation of November/1998 was implemented[15].

In the period following the shock z goes back to its unconditional mean and the loan rate falls back to its stationary 3.9% level. The use of a one time shock instead of a persistent or longer lived one is necessary to isolate the propagation features of the credit channel. The response of the artificial economy is obtained by solving this economy's (P1) and (P2) in the context of a recursive competitive equilibrium. The solution to (P1) was obtained with the linear-quadratic method. Figure 8 shows the response to the shock of i) internal funds (x), ii) asset prices (q), iii) the loan rate ρ, iv) the loan volume (b), v) output (Y) and vi) consumption (c).

Table 2 presents the percent deviation from steady state of variables ρ, x, q, b, Y and c for the ten periods following the shock. On impact, asset prices (q), credit (b) and output (Y) fall almost 9% while consumption (c) falls only 7% as a consequence of the household's desire to smooth consumption. Yet, the real loan rate ρ only rose 50 basis points (a 12.82% increase[16]). Note also that the shock vanishes immediately and the loan rate returns to its stationary level in the period following the shock. Yet, internal funds (x), asset prices (q), loan volume (b), output (Y) and consumption (c) remain considerably depressed and below their stationary levels for more several periods after the shock. For instance, in the period following the shock internal funds (x) fall more than 12%. This is expected given that in order to smooth consumption in the event of a negative shock the household cuts internal fund accumulation. A very interesting response indeed is that of consumption. As evidenced from table 2 the response of consumption displays a hump. Consumption falls contemporaneously with the shock but falls

[15] Why not use a shock to z so that $(1+\rho)/(1+R)$ rises 30%, as observed in the data? Again, bacause other distortions might have played a role in this 30% figure and filtering out those components attributable to distortions other than the new regulation or to measurement error is complicated. In fact, with a shock of such magnitude the model blows away.

[16] This is equivalent to a 0.48% rise in the *gross* loan rate $(1+\rho)$ and also to a 0.48% fall in banking productivity $(1-z)$.

even more in the period after the shock. Furthermore, in the following periods it remains below its impact level.

TABLE 2: Percent Deviations from Steady State

period ↓ / variable ⟶	ρ	x	q	b	Y	c
t	*+12.82%*	*0*	*-8.79%*	*-8.91%*	*-8.89%*	*-7.06%*
$\mathbf{t+1}$	*0*	*-12.42%*	*-8.63%*	*-8.77%*	*-8.77%*	*-8.79%*
$\mathbf{t+2}$	*0*	*-12.20%*	*-8.48%*	*-8.61%*	*-8.61%*	*-8.63%*
$\mathbf{t+3}$	*0*	*-11.97%*	*-8.32%*	*-8.46%*	*-8.45%*	*-8.47%*
$\mathbf{t+4}$	*0*	*-11.76%*	*-8.17%*	*-8.31%*	*-8.30%*	*-8.32%*
$\mathbf{t+5}$	*0*	*-11.55%*	*-8.03%*	*-8.16%*	*-8.15%*	*-8.17%*
$\mathbf{t+6}$	*0*	*-11.34%*	*-7.88%*	*-8.01%*	*-8.00%*	*-8.02%*
$\mathbf{t+7}$	*0*	*-11.13%*	*-7.74%*	*-7.86%*	*-7.86%*	*-7.87%*
$\mathbf{t+8}$	*0*	*-10.93%*	*-7.60%*	*-7.72%*	*-7.72%*	*-7.73%*
$\mathbf{t+9}$	*0*	*-10.73%*	*-7.46%*	*-7.58%*	*-7.58%*	*-7.59%*

Are these responses of the artificial economy similar to those observed in Colombia after the new banking regulation was implemented? In the first, second and third quarters of 1999, GDP in Colombia was 3.6%, 4.5% and 3.04% below trend, respectively. This is less than what the artificial economy displays. Between December of 1998 and January of 2001 stock prices in the Colombian economy have fallen a little more than 40%. This is a considerable plunge but still below what the artificial economy predicts (66%). Between December of 1998 and January of 2001 total real credit in Colombia was crunched an additional 30%. This number is quite high but is also overshot by the prediction of the artificial economy (67%). But, again, specific quantitative results from the artificial economy should be taken cautiously given that the model was not calibrated to long-run empirical regularities. Moreover, available macroeconomic data for the period following the new banking regulation (the shock) is limited given that it was only implemented two and a half years ago.

In any case, the results are illustrative of the propagation and amplification features of the model because this specific setup allows the borrowing constraint to articulate an extreme case of amplification and propagation. Indeed, if there were no financial friction and the borrowing constraint were slack, the level of external funds (b) would not affect the level of household revenue and consumption[17]. The reason is that for the credit constraint to be slack, it must be the

[17] Also, the level of external funds demanded and supplied is indeterminate.

case that $A = 1 + \rho$. Thus, the net gain from receiving an additional unit of x is zero. This is different to the binding constraint case where the net gain from an additional unit of x is $A - (1 + \rho) > 0$. In consequence, in the absence of a binding borrowing constraint the one-time shock to intermediation costs z and the corresponding gross loan rate hike drive to zero the volume of loans on impact. However, household revenue, internal fund accumulation and consumption remain unchanged as net resources for the household do not change. Asset prices also remain unchanged because the future flow of direct rental payments to land (i.e. of marginal productivity of land) has not changed. Moreover, since the constraint is slack the collateral value of land is zero. In the period following the shock the gross loan rate returns to its stationary level and the loan volume may jump to any level because its value is indeterminate. Yet, household revenue, internal fund accumulation, asset prices and consumption remain unchanged. Contrarily, if the borrowing constraint binds, the shock gives birth to a long-lived and more than proportional response in every macroeconomic variable. Hence, the financial friction arising from a binding borrowing constraint introduces an extreme case of amplification and propagation in this economy.

But why does a binding borrowing limit create these propagation and amplification effects? The jump in the loan rate immediately tightens the borrowing limit of the household. As a result, households suffer a crunch in the volume of external funds or working capital available to them. Their ability to finance production is reduced with this credit crunch. As their revenue falls, they reduce on impact their accumulation of internal funds in an attempt to smooth out consumption. Recall that land is an asset and, as such, its price is given by the present discounted value of its forever flow of rental payments. These rental payments include not only the direct contribution of land to output but also its indirect contribution as collateral (recall that more land increases external fund availability and, hence, output, as long as the borrowing constraint binds). Not surprisingly, these rental payments are an increasing function of the marginal productivity of land and external funds. Since internal funds are complementary to land, the instantaneous reduction in internal fund accumulation implies a fall in the future marginal productivity of land. Consequently, the future flows of direct rental payments to land fall. As a result, in the period of the shock the price of land falls. This reduces the value of land on impact and, hence, tightens even further the borrowing constraint. The credit crunch is enhanced and revenue and internal fund accumulation fall even more. And so on. The same story is repeated again and again. The static multiplier is at work. It basically magnifies the initial impact of the shock. But this is not the end of the story. The reduction in internal fund accumulation reduces the volume of collateral available for next period. Thus, the borrowing constraint of next period is also tightened even if the shock has vanished and the lending rate has returned to its normal level. This propagates the credit crunch or reduced availability of external funds into the next period. Hence, household revenue and internal fund accumulation fall in the period following the shock. And so on. The credit crunch story told above applies again in the periods after the shock. The dynamic multiplier is at work. It propagates into future periods the effect of the shock. The economy takes longer in converging back to the steady state than in a financially frictionless setup.

5. CONCLUSION

Economic performance in Colombia during the last three years has been disappointing. The unemployment rate is currently above 20%. The average economic growth rate for the years 1998,1999 and 2000 was negative. Asset prices have been falling since the last months of 1997. This situation contrasts with the early nineties when Colombia grew at rates exceeding 4% and was catalogued as one of the top emerging markets in the world. This economic downturn has been accompanied by a severe crisis in the financial sector that begun in the end of 1997 or early 1998. Indeed, real credit suffered a severe crunch starting in January of 1998 and the real loan rate took a big hike around the same time. In order to alleviate financial distress and to finance the bail-out, the Colombian government issued new banking regulation towards the end of 1998. Among other distortions and costs stemming from the regulatory changes, a new 2/1000 financial transaction tax was introduced. In January of 1999, less than two months after the new regulation was issued, the spread between the loan and the deposit interest rates in Colombia took a big hike.

The view of this paper is that this hike in the loan-deposit interest rate spread reflects a rise in intermediation costs due to the new banking regulation. The new regulation, and specially the 2/1000 financial transaction tax, introduced strong distortions and new costs into intermediation activity. Consequently, financial intermediaries suffered a productivity reduction as additional real resources were required to operate with and implement the new regulations and tax. As a result, financial intermediaries had to charge a higher loan-deposit interest rate spread in equilibrium, as observed in the data. While aimed at alleviating financial distress, the new regulation ended up reducing the productivity of financial intermediaries and boosting intermediation costs.

Not surprisingly, this negative productivity shock enhanced the credit crunch and corresponding economic contraction that was already underway. The enhancement was not linear though. The data shows that the effects of the shock were amplified and propagated into the future. Specifically, the contraction of GNP became wider and longer lived than all other previous downward economic fluctuations. Asset prices maintained a downward trend after what seemed a slight reversal of their initial plummeting. Real credit was further crunched after a slight recovery in the third quarter of 1998. Additionally, the real loan rate displayed another peak around the time of the new regulation. In sum, the macroeconomic effects of the initial credit crunch and financial distress were significantly amplified and propagated after the new banking regulation and financial transaction tax were implemented.

This paper suggests a general equilibrium, financial accelerator model that incorporates an explicit technology for the intermediary sector and that explains how a negative productivity shock to financial intermediaries is amplified and propagated due to credit constraints. This financial imperfection articulates static and dynamic credit multipliers that amplify and propagate productivity shocks to financial intermediaries. The credit channel arises because of borrowing constraints that depend on asset prices, internal funds and lending rates. The transmission mechanism is triggered by a rise in lending rates that tightens borrowing constraints on impact. The credit crunch is magnified and propagated by a fall in asset prices and internal fund accumulation that accompanies the lower level of economic activity and that further tightens the credit limit on impact and in the future. The qualitative predictions of the model are in line with the recent behavior of macroeconomic variables in Colombia if it is accepted that the new banking regulation of 1998 was a negative productivity shock to its financial system. *In short, due to the new regulation and to financial imperfections (specifically credit constraints), what otherwise would have been a regular and short-lived economic contraction became the biggest economic downfall of recent Colombian history.*

Some questions and issues remain open for further research. It seems reasonable to think that the financial sector is constantly exposed to productivity shocks. If so, why did credit limits or financial imperfections kick in only with this last productivity shock? In other words, why did previous productivity shocks to financial intermediaries not generate large and persistent fluctuations as the one recently observed in Colombia? Maybe previous shocks were all negligible or really small and not generated significant real effects. After all, the last shock stems from major regulatory changes in the banking arena. Another possibility is that borrowing constraints did not bind when previous shocks arrived. In contrast, the last shock arrived in the middle of an economic contraction when credit limits are more prone to be binding. These are just tentative answers to be explored in further research.

Another issue that arises has to do with the life-span of the productivity shock coming from the new banking regulation. Is this shock transitory or permanent? If it is transitory, is it also very persistent? If the shock is permanent or transitory but very persistent then the enhanced macroeconomic effects that are observed in Colombia need not be the result of a financial friction but simply a direct consequence of the life-span of the shock. It would be difficult to argue that the shock was perceived as permanent since the new regulation was issued as an emergency mechanism to transitorily alleviate ongoing financial distress and to finance the bail-out of troubled institutions. The regulation is still operating but some of its components (especially the financial transaction tax) are expected to end at some point in the future. On the other hand, evaluating the persistence of the shock is difficult because new elements have been added to the original regulation after it was implemented in November 17 of 1998. For instance, the government recently decreed an increase of the financial transaction tax rate from 2 per 1000 to 3 per 1000. In any case, it is reasonable to assume that financial intermediaries eventually find a fast way to adapt to the new regulation until the associated productivity effects vanish completely. If so, the shock should not be very persistent and the credit multipliers articulated by the borrowing constraint are relevant in explaining the amplification and propagation of the shock, as observed in the data. Again, this is just a tentative answer. A rigorous evaluation of the life-span of the shock is left for future research.

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7. TECHNICAL APPENDIX

In this appendix I show the derivation of equation (7). Equation (6), which dictates optimality in land accumulation, is:

$$\begin{aligned} q_t U'(c_t) &= \beta E_t\{U'(c_{t+1})[F_3(x_{t+1}, b_{t+1}, l_{t+1}) + q_{t+1} \\ &\quad +[F_2(x_{t+1}, b_{t+1}, l_{t+1}) - (1+\rho_{t+1})]\frac{q_{t+1}}{(1+\rho_{t+1})}]\} \end{aligned} \tag{6}$$

This is:

$$\begin{aligned} q_t U'(c_t) &= \beta E_t\{U'(c_{t+1})[F_3(x_{t+1}, b_{t+1}, l_{t+1}) + q_{t+1} \\ &\quad +\frac{F_2(x_{t+1}, b_{t+1}, l_{t+1})}{(1+\rho_{t+1})} q_{t+1} - q_{t+1}]\} \end{aligned} \tag{6.1}$$

Let $\Omega_t = F_2(x_{t+1}, b_{t+1}, l_{t+1})/(1+\rho_{t+1})$. With this notation equation (6.1) is:

$$q_t U'(c_t) = \beta E_t\{U'(c_{t+1})[F_3(x_{t+1}, b_{t+1}, l_{t+1}) + \Omega_{t+1} q_{t+1}]\} \tag{6.2}$$

or:

$$q_t = \beta E_t\left\{\frac{U'(c_{t+1})}{U'(c_t)} F_3(x_{t+1}, b_{t+1}, l_{t+1})\right\} + \beta E_t\left\{\frac{U'(c_{t+1})}{U'(c_t)} \Omega_{t+1} q_{t+1}\right\} \tag{6.3}$$

Using (6.3) to substitute for q_{t+1} in (6.3) implies:

$$\begin{aligned} q_t &= \beta E_t\left\{\frac{U'(c_{t+1})}{U'(c_t)} F_3(x_{t+1}, b_{t+1}, l_{t+1})\right\} \\ &\quad +\beta E_t\left\{\frac{U'(c_{t+1})}{U'(c_t)} \Omega_{t+1}\left[\beta E_{t+1}\left[\frac{U'(c_{t+2})}{U'(c_{t+1})} F_3(x_{t+2}, b_{t+2}, l_{t+2})\right] + \beta E_{t+1}\left[\frac{U'(c_{t+2})}{U'(c_{t+1})} \Omega_{t+2} q_{t+2}\right]\right]\right\} \end{aligned} \tag{6.4}$$

Using the law of iterated expectations (6.4) becomes:

$$\begin{aligned} q_t &= \beta E_t\left\{\frac{U'(c_{t+1})}{U'(c_t)} F_3(x_{t+1}, b_{t+1}, l_{t+1})\right\} \\ &\quad +\beta^2 E_t\left\{\frac{U'(c_{t+2})}{U'(c_t)} \Omega_{t+1} F_3(x_{t+2}, b_{t+2}, l_{t+2})\right\} \\ &\quad +\beta^2 E_t\left[\frac{U'(c_{t+2})}{U'(c_t)} \Omega_{t+1}\Omega_{t+2} q_{t+2}\right] \end{aligned} \tag{6.5}$$

Using (6.3) to substitute for q_{t+2} in (6.5) implies:

$$\begin{aligned} q_t &= \beta E_t\left\{\frac{U'(c_{t+1})}{U'(c_t)}F_3(x_{t+1},b_{t+1},l_{t+1})\right\} \\ &+\beta^2 E_t\left\{\frac{U'(c_{t+2})}{U'(c_t)}\Omega_{t+1}F_3(x_{t+2},b_{t+2},l_{t+2})\right\} \\ &+\beta^2 E_t\left\{\frac{U'(c_{t+2})}{U'(c_t)}\Omega_{t+1}\Omega_{t+2}\left[\begin{array}{c}\beta E_{t+2}\left[\frac{U'(c_{t+3})}{U'(c_{t+2})}F_3(x_{t+3},b_{t+3},l_{t+3})\right] \\ +\beta E_{t+2}\left[\frac{U'(c_{t+3})}{U'(c_{t+2})}\Omega_{t+3}q_{t+3}\right]\end{array}\right]\right\} \end{aligned} \tag{6.6}$$

Using the law of iterated expectations (6.6) becomes:

$$\begin{aligned} q_t &= \beta E_t\left\{\frac{U'(c_{t+1})}{U'(c_t)}F_3(x_{t+1},b_{t+1},l_{t+1})\right\} \\ &+\beta^2 E_t\left\{\frac{U'(c_{t+2})}{U'(c_t)}\Omega_{t+1}F_3(x_{t+2},b_{t+2},l_{t+2})\right\} \\ &+\beta^3 E_t\left\{\frac{U'(c_{t+3})}{U'(c_t)}\Omega_{t+1}\Omega_{t+2}F_3(x_{t+3},b_{t+3},l_{t+3})\right\} \\ &+\beta^3 E_t\left[\frac{U'(c_{t+3})}{U'(c_t)}\Omega_{t+1}\Omega_{t+2}\Omega_{t+3}q_{t+2}\right] \end{aligned} \tag{6.7}$$

After additional iterations and imposing the no-bubble condition $\beta\Omega < 1$ or $\beta F_2 < (1+\rho)$ reveals equation (7):

$$q_t = E_t\left\{\sum_{j=1}^{\infty}\beta^j\frac{U'(c_{t+j})}{U'(c_t)}\left[F_3(x_{t+j},b_{t+j},l_{t+j})\prod_{i=1}^{j-1}\Omega_{t+i}\right]\right\} \tag{7}$$

8. DATA APPENDIX

- **GDP cycle:** Seasonally adjusted quarterly gross domestic product in millions of 1975 pesos. To construct this series two original series were used: i) seasonally unadjusted quarterly GDP in millions of 1975 pesos and ii) seasonally adjusted quarterly GDP in millions of 1994 pesos. The first series was adjusted with seasonal dummies. The chained and final series was constructed by applying to the first (or 1975 pesos) series the computed growth of the second (or 1994 pesos) series. The cycle component was calculated as the percent deviation of the observed series from the Hodrick-Prescott trend (with $\lambda = 1600$). Source is DNP in Colombia. Period is 1977:I-2000:III.

- **Asset prices in real terms (Dec./97=100):** Monthly closing and average values of the Bogota Stock Market Index (IBB). To deflate and obtain the real values the CPI (1998:12 =100) was used. Resulting values were normalized by the December/1997 value. Source is Banco de la Republica in Colombia. Period is 1991:01-2001:01.

- **Real credit volume (Dec./97=100):** Monthly closing values in pesos of the stock of outstanding total credit from the financial system [Banks, Financial Corporations (CF), Savings and Mortgage Loan Institutions (CAVS) and Companies of Commercial Financing (CFC)]. Total outstanding credit includes commercial, consumption and mortgage loans. To deflate and obtain the real values the CPI (1998:12 =100) was used. Each observation was normalized by the December/1997 value. Source is Banco de la Republica in Colombia. Period is 1996:01-2001:01.

- **Real loan rate:** Monthly values of the ex-post annual real loan interest rate. This rate is calculated as $(1 + i^l)/(1 + \pi) - 1$, where i^l is the observed annual nominal loan interest rate and π is the realized annual inflation rate. The annual nominal loan rate used is "tasa activa total sistema" (monthly average) calculated by Superintendencia Bancaria in Colombia. Inflation rates were calculated with the CPI (1998:12 =100). Source is Banco de la Republica. Period is 1990:01-2000:02.

- **Loan/deposit interest rate spreads:** Monthly basis point difference between the annual loan nominal interest rate and the annual deposit nominal interest rate for three-month contracts. The spread is calculated as $i^l - i^d$, where i^l is the observed annual loan nominal interest rate and i^d is the observed annual deposit nominal interest rate. The annual nominal loan rate is "tasa activa total sistema" (monthly average) calculated by Superintendencia Bancaria in Colombia. Two different annual nominal deposit rates are used: "tasa de interes de los CDT a 90 dias, total sistema" (monthly average) and "tasa de interes de los CDT a 90 dias, bancos y CF" (monthly average). Source is Banco de la Republica. Period is 1990:01-2000:02.

- **Inverse productivity of financial system:** Monthly values of the ratio of the gross nominal annual loan interest rate to the gross nominal annual deposit rate for three month contracts. The spread is calculated as $(1 + i^l)/(1 + i^d)$, where i^l is the observed annual nominal loan interest rate and i^d is the observed annual nominal deposit interest rate. The annual nominal loan rate is "tasa activa total sistema" (monthly average) calculated by Superintendencia Bancaria in Colombia. Two different annual nominal deposit rates are used: "tasa de interes de los CDT a 90 dias, total sistema" (monthly average) and "tasa de interes de los CDT a 90 dias, bancos y CF" (monthly average). Source is Banco de la Republica. Period is 1986:01-2000:12.

- **Real credit stock per financial sector employee:** Yearly December value of the ratio of real credit volume to the number of financial sector employees in the seven main metropolitan areas. Source is DANE - Encuesta Nacional de Hogares. Period is Dec./1996-Dec./1999.

9. FIGURES

Figure 1

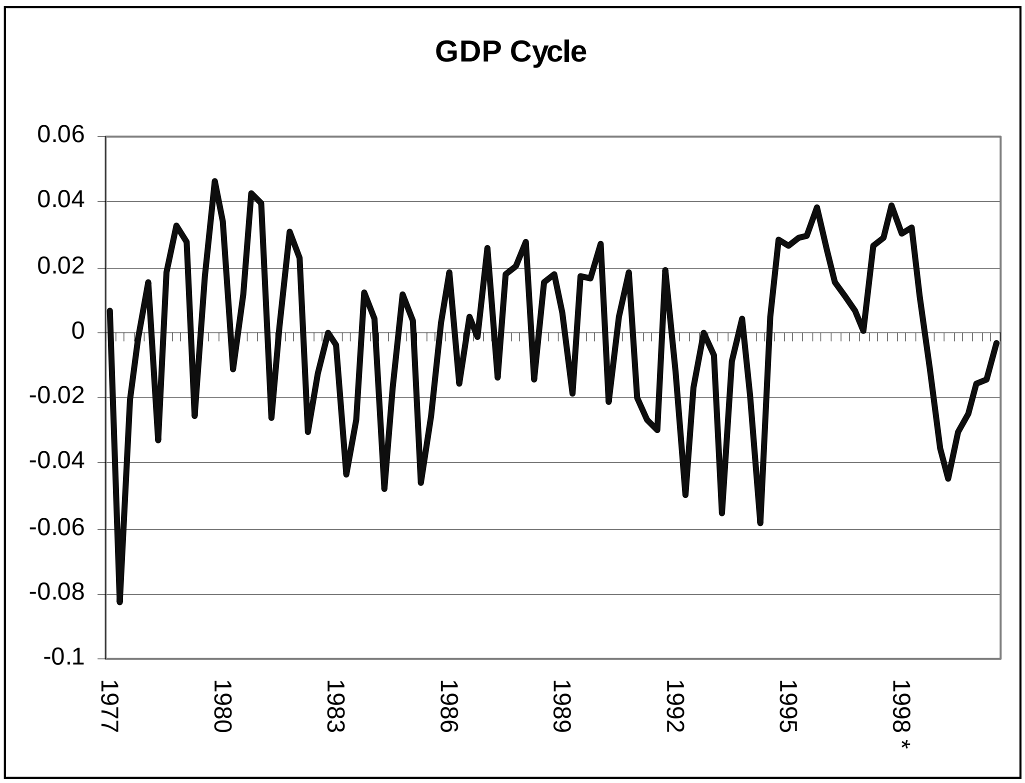


Figure 2

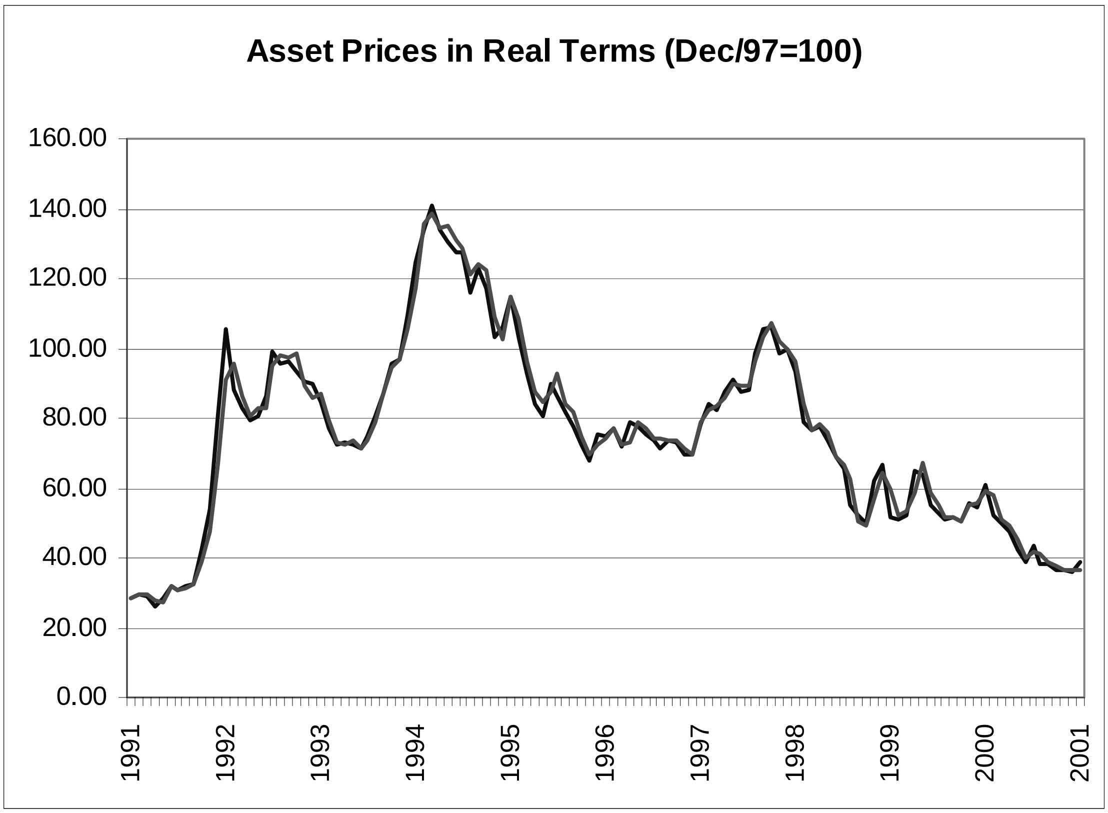

Asset Prices in Real Terms (Dec/97=100)
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001

Figure 3

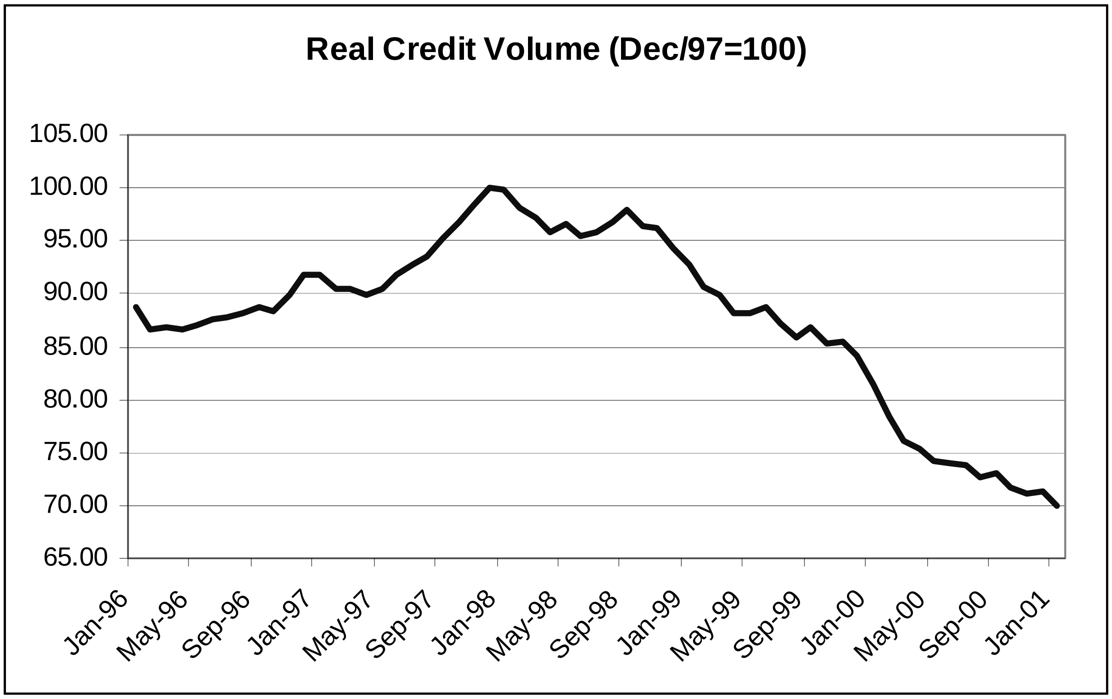

Real Credit Volume (Dec/97=100)
105.00
100.00
95.00
90.00
85.00
80.00
75.00
70.00
65.00
Jan-96
May-96
Sep-96
Jan-97
May-97
Sep-97
Jan-98
May-98
Sep-98
Jan-99
May-99
Sep-99
Jan-00
May-00
Sep-00
Jan-01

Figure 4

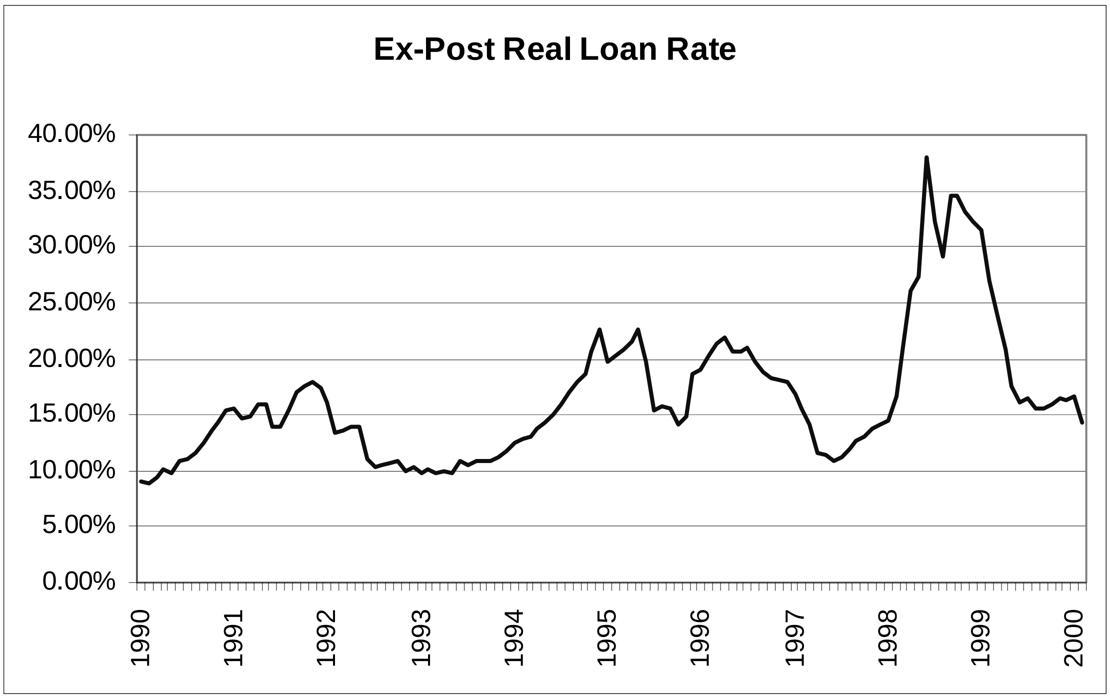

Ex-Post Real Loan Rate
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000

Figure 5

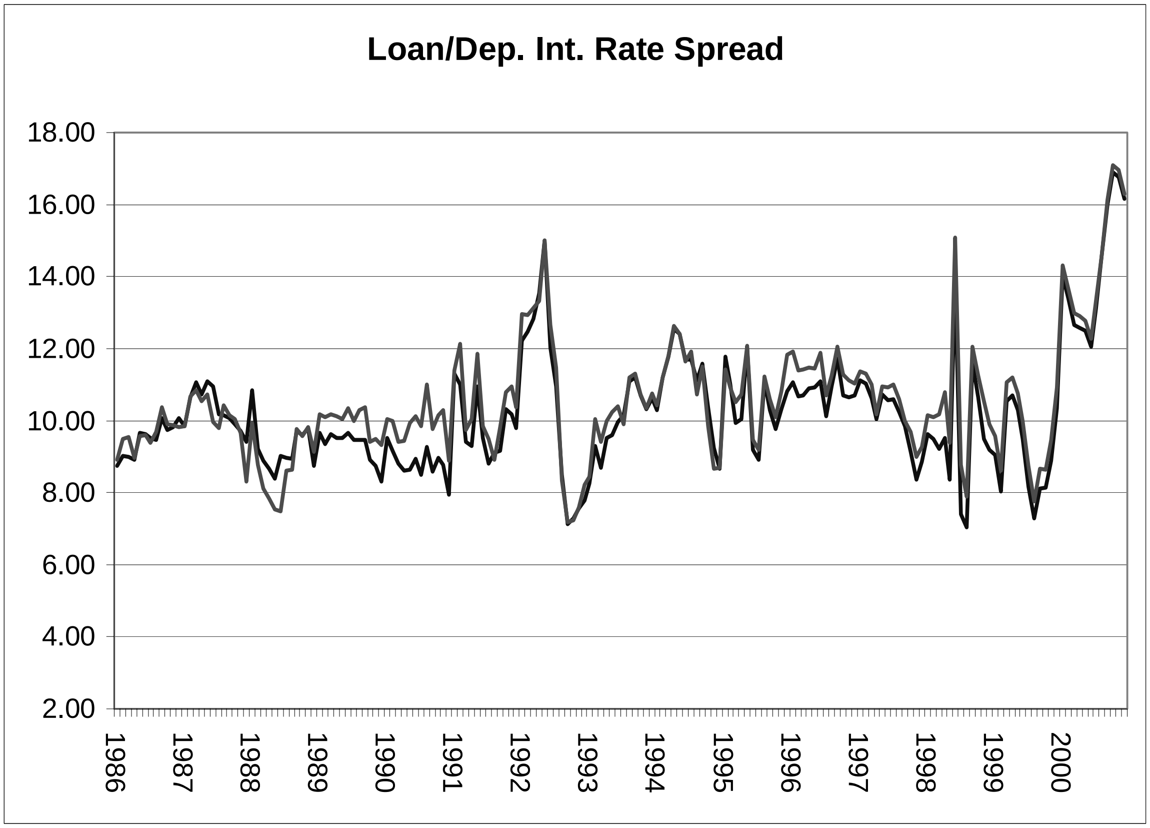

Loan/Dep. Int. Rate Spread
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000

Figure 6

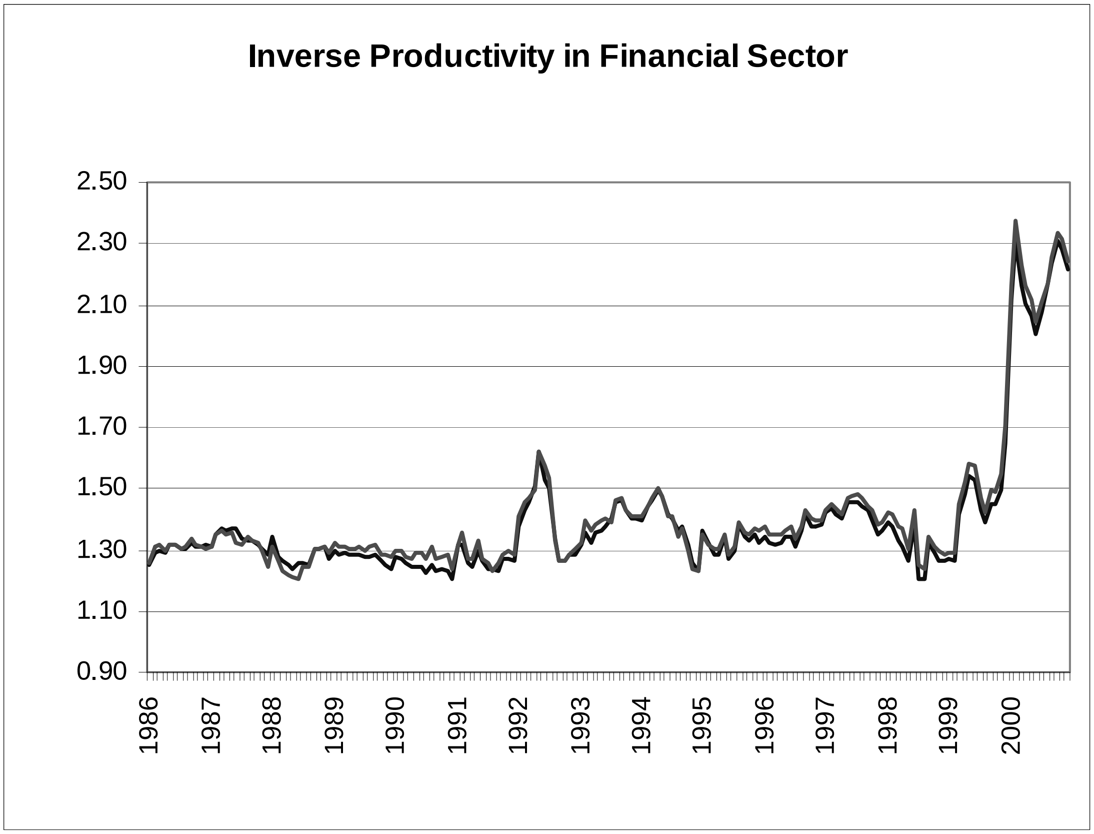
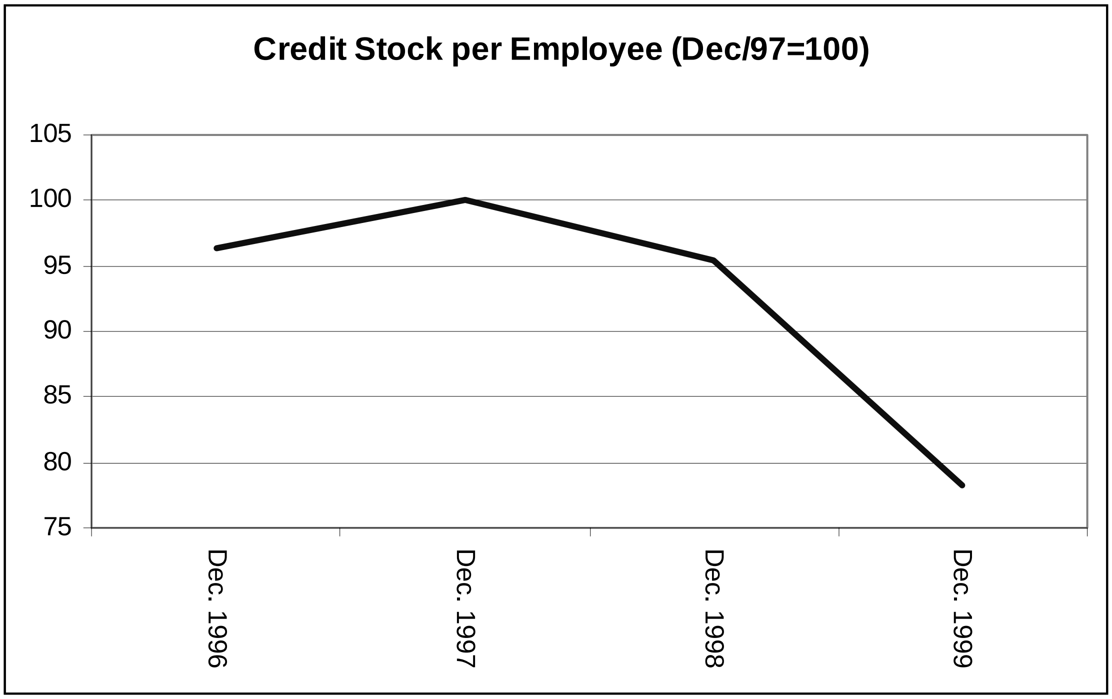
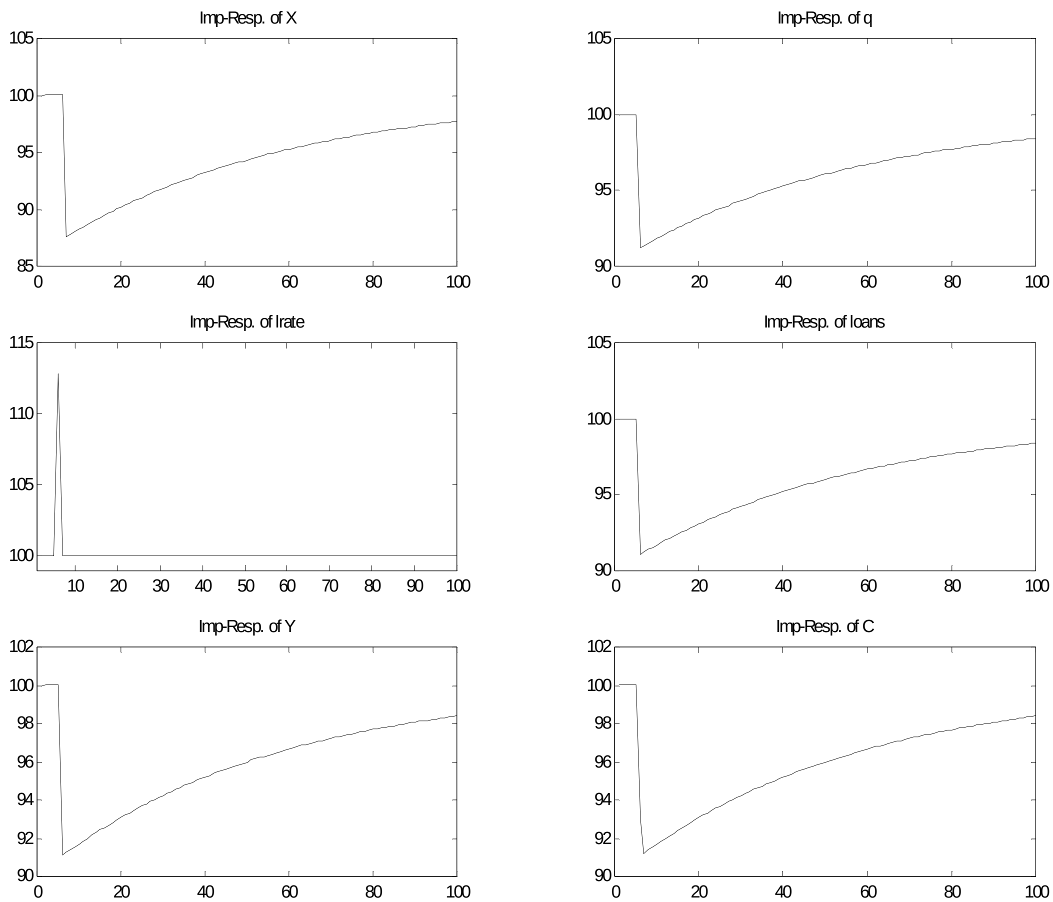

Inverse Productivity in Financial Sector
2.50
2.30
2.10
1.90
1.70
1.50
1.30
1.10
0.90
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000

Figure 7



Credit Stock per Employee (Dec/97=100)
105
100
95
90
85
80
75
Dec. 1996
Dec. 1997
Dec. 1998
Dec. 1999

Figure 8



Imp-Resp. of X
105
100
95
90
85
0
20
40
60
80
100
Imp-Resp. of q
105
100
95
90
0
20
40
60
80
100
Imp-Resp. of Irate
115
110
105
100
10
20
30
40
50
60
70
80
90
100
Imp-Resp. of loans
105
100
95
90
0
20
40
60
80
100
Imp-Resp. of Y
102
100
98
96
94
92
90
0
20
40
60
80
100
Imp-Resp. of C
102
100
98
96
94
92
90
0
20
40
60
80
100