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Banking Productivity and Economic Fluctuations: Colombia 1998-2000

Andres F. Arias*

Abstract

This paper builds 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. This further modifies the present and future volume of collateral, thereby amplifying and propagating the initial shock. The paper argues that changes in banking regulation in Colombia in the late 1990's increased intermediation costs, reduced banking productivity and induced a credit multiplier 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 support this argument.

Key words: financial accelerator, banking productivity, intermediation costs, borrowing limit, credit crunch, amplification, propagation.

JEL Classification: E32, E42, E44, G21.

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Introduction

The average growth rate in Colombia for the years 1998,1999 and 2000 was negative. This economic downturn was accompanied by a severe asset price plunge and crisis in the financial sector that began in late 1997 or early 1998 and that has been attributed to a sudden stop of international capital flows. Since then, real credit suffered a severe crunch. Between January of 1998 and January of 2001 the stock of real credit fell 30%. Between July of 1999 and May of 2000 more than 30% of the financial system's stock of assets was capitalized by the government[1]. Many other financial intermediary institutions failed and were liquidated or bailed-out. The fiscal cost of the bail out has been estimated at 6% of GDP[2, 3]. This situation contrasts with the early nineties when Colombia grew at rates exceeding 4%.

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 that received the home was given the right to a loan from the government equivalent to the value of the corresponding loss. The loan is to 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

1 *Source*: Banco de la Republica, Subgerencia 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 i.freelylt.

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

5 Article 14 of Decree 2331.

6 Article 15 of Decree 2331.

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]. This rate was later risen to 3 per 1000.

The purpose of all this new regulation was to aid a troubled financial system. Whether this was accomplished has not yet been determined. What is clear is that the spread between the loan and deposit interest rates in Colombia systematically rose to higher levels in 1999, just after the new banking regulation and financial transaction tax was introduced. It is argued in this paper that this hike in the loan-deposit interest rate spread reflects a rise in intermediation costs and financial inefficiency attributable to the new banking regulation. In other words, the new regulation tightened banking operational constraints and introduced additional costs into financial intermediation activity. Consequently, financial intermediaries suffered a productivity meltdown as they lost operational versatility and additional real resources were required to operate with and implement the new regulations and tax[9]. 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 actually reduced the productivity of financial intermediaries and increased intermediation costs.

This negative productivity shock to financial institutions exacerbated the credit crunch and corresponding economic contraction that was already underway. But this did not occur in a linear fashion. Interestingly, it seems that the Nov./1998 shock was significantly amplified and propagated into the future. Indeed, the data show that after 1998

7 Article 16 of Decree 2331.

8 Articles 29 and 30 of Decree 2331.

9 In addition to the new banking regulation of Nov. 1998, between 1996 and 1999 new regulation was also passed in Colombia ordering bankers to verify that deposits beyond a certain volume did not come from illicit activities [Articles 102-107 from the Organic Statute of the Financial System; Law 365 of 1997, articles 9,24 and 25; Law 526 of 1999, article11]. In carrying out this police work, Colombian bankers have to spend additional time and resources before they can accept and intermediate a deposit. This can be interpreted as an additional negative productivity shock to the Colombian financial system.

the economic contraction has been longer lived and more persistent than other previous economic slumps in Colombia. This paper pursues the hypothesis that *due to the new banking regulation of Nov./1998 and to borrowing constraints attributable to the credit crunch that was already underway, what otherwise would have been a regular and short-lived economic contraction became the biggest economic downfall of recent Colombian history.*

To prove the hypothesis of the paper I suggest a general equilibrium model capable of replicating recent macroeconomic regularities in Colombia. The model shows how a negative productivity shock to financial intermediaries, interpreted as a perverse regulatory change for the financial system, is amplified and propagated in macro aggregates due to credit constraints. On an empirical level the contribution of the paper is a qualitative and quantitative approximation to the recent macroeconomic behavior of Colombia, in the light of its new banking regulation. In fact, *the punchline of the paper is that the qualitative and quantitative 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 Nov/1998 was a negative productivity shock to its financial system*. Nonetheless, the model applies to any other episode or country where the banking sector experiences a productivity shock. Thus, on a theoretical level the contribution of the paper is important for evaluating the welfare impact of regulatory changes and policies that modify the productivity of banks in environments with financial frictions (like credit constraints attributable to a shortage of international capital).

The paper is organized as follows. The next section briefly relates the paper to the existing literature. Section two presents the stylized facts regarding the macroeconomic behavior of Colombia before and after the new banking regulation of Nov/1998. In section three I argue that this new regulation induced a rise in intermediation costs and a corresponding slump of banking productivity in Colombia. Section four suggests a theoretical model that rationalizes how a negative productivity shock to the financial system can account for the observed macroeconomic behavior in Colombia during the period 1998-2000. In section five I use the model to implement two numerical experiments that simulate the response of the artificial economy to an adverse productivity shock in the financial system. The idea there is to replicate qualitatively, and to some extent quantitatively, the macroeconomic behavior of Colombia after the Nov/1998 regulation and the associated negative productivity shock to financial intermediation. The last section concludes.

I. Links to the Literature

Links between banking productivity and regulation in the financial arena have been abundantly established in the literature. The basic intuition is that with the tightening of regulatory constraints, banks tend to loose versatility in their operations and, consequently, experience a fall in productivity. On the other hand, a deregulatory process increases competitive forces in the financial system so that “banks not allocating their resources efficiently would perish unless they could become more like their efficient competitors by producing more output with existing inputs” [Alam (2001), pp. 122].

Berg, Forsund and Jansen (1992) find a productivity fall in Norwegian banks prior to the deregulation of the Norwegian financial system in the 1980’s. They also document a fast productivity increase in the post-deregulation years up to 1989. Their results indicate that the observed productivity gains were mainly due to the convergence of inefficient banks towards the production possibilities frontier rather than a shift of the frontier itself. Berg et. al. (1993) expanded the study to Finland and Sweden. Zaim (1995) documents similar results for Turkish banks. Bhattacharya, Lovell and Sahay (1997) find that the impact of liberalization on the productivity of Indian banks depends on the type of ownership. Gilbert and Wilson (1998) argue that privatization of Korean financial institutions, rather than deregulation of deposit interest rates, induced an increase in banking productivity. Leightner and Lovell (1998) find that the average bank in Thailand experienced rapid total factor productivity (TFP) growth between 1989 and 1994, as the financial and foreign exchange systems of this country were liberalized. Khumbakar et. al. (2001) study Spanish savings banks between 1986 and 1995, a period during which the Spanish banking industry went through major regulatory reforms. They find high levels of technical inefficiency but high rates of productivity growth due to frontier shifts attributable to the deregulatory process. Rebelo and Mendes (2001) report results of productivity increases in Portuguese banks during the 1990-1997 deregulation period.

In a recent paper Alam (2001) computes the Malmquist index of U.S. commercial banks with more than US$ 500 million in assets for the period 1980-1989[10]. His results indicate that banks facing tighter branching constraints exhibited productivity regress while those facing looser branching regulatory requirements experienced an increase in productivity during this period. Humphrey (1991) studies the relationship between deregulation and banking productivity in the US during the 1980's. He finds that between 1977 and 1987 productivity growth of U.S. banks ranges between -0.07% and 0.6% per year. He attributes this variation to the deregulation of the 1980's. Other studies that find positive productivity growth in U.S. banks during the 1980's (the decade of financial deregulation) are Hunter and Timme (1991), Bauer, Berger and Humphrey (1993) and Berger and Mester (1999).

In contrast, some studies have found negative or zero productivity growth rates in U.S. banks during the 1980's, the era of deregulation [Elyasiani and Mehdian (1995), Humphrey and Pulley (1997), Berger and Humphrey (1992), Humphrey (1993), Bauer, Berger and Humphrey (1993) and Wheelock and Wilson (1999)]. The results in these papers apparently contradict the expected mapping between deregulation and productivity growth. Yet, these findings could be simply indicating that banks face difficulties and take some time in their adjustment towards the increased competition and freedom created by deregulation [Khumbakar et. al. (2001)]. Moreover, many of these studies consider only far apart years [e.g.: Elyasiani and Mehdian (1995)] or average out several years of data [e.g.: Humphrey and Pulley (1997)]. By doing so the authors could have overlooked major productivity fluctuations in U.S. banks during the years in between [see Alam (2001)]. Tirtiroglu, Daniels and Tirtiroglu (1998) find that

[10] The Malmquist index is computed with data envelopment analysis. The latter "is a linear programming methodology that constructs a non-parametric, piecewise-linear, best practice frontier from observable input and output data" [Semenick (2001), pp. 122]. The index decomposes productivity fluctuations into two elements: i) expansion of the frontier (technological change) and ii) convergence towards the frontier (efficiency change or catching up).

any regulatory change, no matter if it tightens or loosens restrictions, reduces banking TFP growth. These authors identify a negative overall impact of both regulation and deregulation over U.S. commercial banking TFP growth.

All the substantial empirical evidence documenting some link between productivity of financial intermediaries and regulatory changes in the banking arena supports the idea behind this paper. Indeed, the model suggested in this paper blends the financial regulation - banking productivity empirical link and the financial accelerator literature in an attempt to replicate the recent macroeconomic behavior in Colombia. It builds upon the borrowing limit-financial accelerator idea by using 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.

II. Stylized Facts: 1998-2000

Figures 1-5 present the evolution of the following macroeconomic variables in Colombia[11]: i) real GDP per capita cycle (1977:I-2000:IV), ii) stock prices in real terms (1991:01-2001:01), iii) gross and net of non-performing loans stock of real credit (1992:01-2001:06), iv) ex-post real loan rate (1990:01-2000:02) and v) loan/deposit interest rate spread (1986:01-2000:12). When financial distress erupted in Colombia (end of 1997, beginning of 1998) its GDP entered into a cyclical contraction, asset prices plunged, real credit was crunched and the real loan rate increased significantly. 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 of credit crunch/financial distress episodes and fits the "sudden stop of international capital" hypothesis.

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11 A detailed description of the data is available in the Data Appendix.

Note also that during the initial phase (or year) 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, just after the new banking regulation of Nov/1998 was introduced, the loan/deposit interest rate spread systematically rose to higher levels. For instance, the average spread between the nominal annual loan rate and the nominal annual 3-month certificate of deposit rate between Jan/1986 and Dec/1998 was 997 basis points. The corresponding average spread for the period Jan/1999-Dec/2000 was 1166 basis points, a 17% increase with respect to the pre-1999 average. The average spread for the period Jan/2000-Dec/2000 was 1423 basis points, a 43% increase with respect to the pre-1999 average.

After the regulation was issued, the economic contraction became wider and longer lived than most other previous downward economic fluctuations in Colombia. Indeed, when the new financial transaction tax and banking regulation were implemented in the fourth quarter of 1998, GDP per capita was already 3.5% below its 1977:I-1998:II linear trend[12]. But by the first and second quarters of 1999, it slumped further to 7.6% and 9.1% below trend, respectively. Moreover, in the following quarters (and until 2000:IV) GDP per capita remained between 7.8% and 8.9% below the trend value.

In a similar fashion, after the implementation of the banking regulatory changes, asset prices maintained their downward momentum. In fact, by January of 2001 real stock prices had fallen to their 1991 level. 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 (the date of the new regulation).

Additionally, once the new banking regulation was in place, real credit was further crunched in Colombia after a slight recovery in the third quarter of 1998. For instance, comparing the total stock of real credit in January of 2001 with its corresponding value in December of 1997

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[12] Fitting the linear trend between 1977:I and 1997:IV, 1998:II or 1998:IV yields very similar results in terms of percent deviations from trend in 1999 and 2000. Here 1998:II was chosen because it is the second quarter into the first year of distress.

reveals a 30% fall, with 24 of these percentage points being lost after December of 1998 (the date of the new regulation). These numbers are higher if non-performing loans are not considered. The realized real loan interest rate also displayed another peak around the time of the new regulation. While the average for this rate between Jan/1990 and Dec/1997 was 14.68%, by the fourth quarter of 1998 this rate had more than doubled to an average of 33.32%[13].

In sum, the macroeconomic effects of the initial credit crunch and the associated economic contraction were enhanced dramatically after the new banking regulation and financial transaction tax were implemented. Were the regulatory changes responsible for the observed macroeconomic behavior? The next section tries to answer this question.

III. The Nov/98 Regulation: Negative Shock to Banking Productivity?

To pursue the argument that the regulatory changes of Nov/1998 turned out to be an adverse productivity shock to the financial system, first consider a bank that uses a constant returns to scale (crs) technology to intermediate resources. Suppose that the bank accepts deposits at given rate R, uses the intermediation technology to provide loans at rate ρ and, for every unit of deposits, loses $z \in [0, 1)$ units in the corresponding intermediation process. Under this environment, banks behave competitively and are price takers so that in every period they solve the following static problem:

$$\text{Max}_{\{d_t\}} \quad (1 + \rho_t)(1 - z_t)d_t - (1 + R)d_t$$

Free entry and exit drives profits to zero and in equilibrium banks produce where the relative price of their output $(1 + \rho)$ equals their marginal cost:

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

[13] The corresponding monthly values are 34.62%, 33.08% and 32.26% in October, November and December of 1998, respectively.

or:

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

Not surprisingly, intermediation cost z creates a spread between the lending and deposit rates. In fact, the spread or ratio between the gross lending rate and the gross deposit rate is a metric of the inverse of the average (and marginal) productivity of deposits [$1/(1 - z)$]. The higher the productivity of the financial system, the lower the ratio between the gross lending rate and the gross deposit rate and vice-versa. Assuming the financial structure of the economy is as simple as the one suggested here, it is possible to back up any corresponding percentage change in the productivity of the banking sector [$\Delta\%(1 - z)$] with the observed percentage change in the ratio between the gross loan and deposit interest rates [$\Delta\%(1 + \rho)/(1 + R)$]. Let $s = (1+ \rho)/(1 + R)$. Hence:

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

where · symbolizes a derivative with respect to time. As expected, any change in the ratio between the gross loan and deposit interest rates maps back into an equiproportional opposite sign change in financial intermediation productivity. This result is important because it provides a simple way to measure productivity changes in the financial sector using observed data of the gross lending rate to gross deposit rate ratio or spread.

Figure 6 shows the behavior of the *ratio* between the gross annual nominal loan rate and the gross annual nominal 3-month certificate of deposit rate in Colombia during the period Jan/1986-Dec/2000[14]. Note that this ratio, which is a metric of the *inverse of productivity* in the financial system, displays a fairly steady pattern until December of

[14] 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.

1999. Beginning in January of 1999, less than two months after the new banking regulation and financial transaction tax were introduced, this ratio began to rise. The following table summarizes the average behavior of this ratio before and after the new banking regulation was introduced:

Table 1. Average Loan-Deposit Interest Rates Ratio in Colombia Before and After the New Regulation (Nov/98).

	Jan/86-Oct/98	Jan/99-Dec/00	Jan/00-Dec/00
s	1.33	1.81	2.17
Δ%[15]	0%	36.1%	63.2%

Source: Superintendencia Bancaria and Banco de la Republica; see Data Appendix.

Suppose that the financial system of Colombia is as simple as the one suggested above. Suppose also that, besides the new regulation of Nov/1998, no other major event in the banking arena occurred during the Nov/1998-Dec/2000 period. Under these assumptions the numbers in table 1 seem to suggest that the regulatory changes of Nov/1998 generated a highly persistent or long-lived banking productivity meltdown in Colombia that ranges between 36% and 60%.

A closer look at the data might reveal an alternative identification of the negative banking productivity shock attributable to the new regulation. Table 2 presents the month to month behavior of the ratio between the gross annual nominal loan rate and the gross annual nominal 3-month certificate of deposit rate in Colombia around the time of the new regulation. Note that this ratio starts to rise in Jan/1999, peaks for the first time in May/1999, starts to fall during the third quarter of 1999 and then starts to climb back up again during the fourth quarter of the same year. Thus, it could be argued that instead of a long-lived or highly persistent shock, the new regulation only induced a short-lived (two-quarter) negative productivity shock to financial intermediaries. If so, the big hike of the gross loan-deposit rates ratio starting in the fourth quarter of 1999 is due to some other shock(s).

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[15] With respect to the pre-1999 average.

Table 2. Monthly Loan-Deposit Interest Rates Ratio in Colombia Before and After the New Regulation (Nov/98).

Month	Nov/98	Dec/98	Jan/99	Feb/99	Mar/99	Apr/99	May/99	Jun/99
s	1.26	1.26	1.27	1.27	1.42	1.48	1.54	1.53
$\Delta\%$	0%	0%	0.8%	0%	11.8%	4.2%	4.1%	-0.6%
Month	**Jul/99**	**Aug/99**	**Sep/99**	**Oct/99**	**Nov/99**	**Dec/99**	**Jan/00**	**Feb/00**
s	1.43	1.39	1.45	1.45	1.50	1.64	2.11	2.31
$\Delta\%$	-6.5%	-2.8%	4.3%	0%	3.4%	9.3%	28.7%	9.5%

Source: Superintendencia Bancaria and Banco de la Republica; see Data Appendix.

The short-lived/highly transitory shock story assumes that after the new banking regulation of Nov/1998 no other major event occurred in Colombia's banking arena at least until the third quarter of 1999. This might be more plausible than assuming, as with the long-lived shock story, that the Colombian financial system was shock-free during Jan/1999-Dec/2000 given that this two-year period covers some events that could also be interpreted as shocks to financial intermediation (e.g.: collapse of the target zone, a new banking law towards the end of 1999, further shortage of international capital, etc.). However, this short-lived shock hypothesis still assumes that the financial system of Colombia is as simple as the one suggested above.

Which is the correct identification of the shock structure? Was the shock long-lived/highly persistent? Was it a short lived/highly transitory shock? This is a difficult question to be answered at this point. Hopefully, the model and numerical experiments suggested below will shed some light on this issue. In fact, two numerical experiments will be carried out with the theoretical model, each replicating one of the two possible shock structures. The reader can then choose which shock structure is more reasonable and decide whether the new banking regulation of Nov/1998 can be understood as a highly persistent, negative productivity shock to financial intermediation in Colombia, or simply as a highly transitory, short-lived adverse productivity shock to financial institutions in that country.

It is important to recognize that there might be some flaws in all this evidence in favor of the idea that the new banking regulation of Nov/1998 represents a negative productivity shock to financial intermediation in Colombia. First, the Colombian financial system is far more complex than the one depicted above and the rise in the loan-deposit interest rate spread after Jan/1999 might be capturing other phenomena like i) the sudden deterioration of loan quality, ii) an increase of banking risk due to the increase in macroeconomic instability (i.e. frequent and high swings in the real interest rate) and the maturity mismatch between deposits and loans and/or iii) an increase in non-competitive practices as several banks failed and were removed from the market[16]. Second, it can be argued that the fact that the jump in the spread coincides with the implementation of the new banking regulation is simply a coincidence. In fact, the three phenomena mentioned above also occurred around the time the new regulation was being implemented. Hence, a very skeptical reader might argue that the behavior of the domestic loan-deposit interest rate spread after Nov/1998 does not necessarily imply, for a more realistic financial sector, that the productivity of financial intermediaries went down due to the banking regulation that was issued in that date.

However, three important facts support the claim that there is an element of response in the Colombian loan-deposit interest rate spread to the regulatory changes of Nov/1998. First, the new banking regulation of Nov/1998 was a *major* change in the rules of the banking arena game in Colombia. Second, the spread jump occurs some days *after* and not days before or at the same time the new regulation was issued. Third, no other major event in the banking arena occurred between the last quarter of 1998 and the first quarter of 1999. The closest major relevant event for the financial system is the collapse of the target zone towards the end of the second quarter of 1999. Hence, at least a transitory fall of financial intermediation productivity seems a reasonable explanation for the first peak of the gross loan-deposit rates ratio.

For those that are still skeptic, figure 7 provides additional evidence that the Jan/1999 loan-deposit interest rate spread jump is associated to a productivity regress of the Colombian financial sector attributable

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[16] Using panel data techniques and monthly data available for 22 commercial banks for the period 1992-1996, Steiner, Barajas and Salazar (2000) find that non-financial expenses are a statistically significant component of the loan-deposit interest rate spread in Colombia and that, on average, non-financial expenses explain 27.6% of such spread. However, they also find that the rest of the spread is explained by non-performing loans (34.4%), reserve requirements (22.1%) and market power (15.9%).

to the Nov/1998 banking regulation. This picture shows the quarterly evolution of a proxy for labor productivity in the financial sector of the Colombian economy during the period 1994:I-2000:IV. The proxy is constructed as the ratio between the seasonally adjusted real output of financial intermediation services (in millions of 1994 pesos) and the number of financial sector employees in the seven main metropolitan areas[17]. Tables 3 and 4 present the average and the quarter to quarter behavior of this labor productivity indicator before and after the new regulation and financial transaction tax were introduced:

Table 3. Average Labor Productivity in Colombian Financial Sector Before and After the New Regulation (98:IV) (Millions of 1994 pesos).

	94:I-98:IV	**99:I-00:IV**	**00:I-00:IV**
Productivity	2.40	1.88	1.90
Δ%[18]	0%	-21.7%	-20.1%

Source: DANE; see Data Appendix.

Table 4. Quarterly Labor Productivity in Colombian Financial Sector Before and After the New Regulation (98:IV) (Millions of 1994 pesos).

Quarter	**98:I**	**98:II**	**98:III**	**98:IV**
Productivity	2.41	2.36	2.27	2.25
Δ%	0%	-2.1%	-3.8%	-0.9%
Quarter	**99:I**	**99:II**	**99:III**	**99:IV**
Productivity	1.93	2.00	1.84	1.69
Δ%	-14.2%	3.6%	-8.0%	-8.2%
Quarter	**00:I**	**00:II**	**00:III**	**00:IV**
Productivity	1.92	1.95	1.88	1.85
Δ%	13.6%	1.6%	-3.6%	-1.6%

Source: DANE; see Data Appendix.

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17 The reason for using financial sector employees in the seven most important cities is the lack of a quarterly series of financial sector employees in the whole country. Since the change in financial sector productivity is the object of interest at this point, using financial sector employees in the seven most important cities should not be a problem assuming that it accurately reflects the change in financial sector employees over the whole country.

18 With respect to the pre-1999 average.

During the first year of financial distress (i.e. 1998) the labor productivity indicator for the Colombian financial system fell 6.6%. This should not be surprising given the level of distress that the system was going through due to the shortage of international capital. However, table 3 shows that in the two years following the new banking regulation of Nov/1998 (i.e. 1999 and 2000) the average for the labor productivity indicator of the Colombian financial sector lies approximately 20% below the corresponding pre-1999 average. This could indicate that the new regulation came through as a long-lived/highly persistent negative productivity shock to financial intermediation.

As with the gross loan-deposit rates ratio, a closer look at the data might reveal an alternative identification of the shock structure. Table 4 shows that the labor productivity indicator of the Colombian financial sector declined slowly during 1998 but slumped drastically in the first quarter of 1999. Afterwards, the indicator recovered a little and then started to fall again in the third and fourth quarters of the same year. It recovered again in the first two quarters of 2000 but never reached pre-1999 levels. It could be reasonable to identify the Nov/1998 banking regulation as a very short-lived (one quarter) negative productivity shock to financial intermediation. If so, the shock hit in the first quarter of 1999 with the additional fall of labor productivity in the last two quarters of 1999 being attributed to something else. Again, for skeptics regarding the magnitude of the shock, this alternative structure might be more plausible than the one where the Nov/1998 banking regulation is interpreted as a long-lived/highly persistent negative productivity shock to financial intermediation. As stated previously, this issue will be delayed until the numerical experiments are presented and the reader can choose which structure is more credible.

Figure 8 presents the quarterly evolution of still another proxy for labor productivity in the financial sector of the Colombian economy during the period Mar/1992-Dec/2000. This proxy is constructed as the ratio between the stock of real credit (including non-performing loans) from the whole financial system and the number of financial sector employees in the seven main metropolitan areas[19]. In order to

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[19] Using the stock of loans to measure banking output is common in the literature. Tirtiroglu, Daniels and Tirtiroglu (1998), for example, use the stock of loans to measure the output and TFP of U.S. commercial banks. These authors refer to the study by Humphrey (1992) and claim that “there is not much difference in the predictive accuracy of aggregate (banking) productivity based on stock or flow measurements”.

obtain labor productivity proxies for the different types of financial institutions that exist in Colombia, the stock of real credit from the whole system is also disaggregated into credit from commercial banks, credit from savings and mortgage loan institutions (CAV), credit from financial corporations (CF) and credit from companies of commercial finance (CFC).

The labor productivity indicator fell 4.6% for the whole system between Dec/1997 and Dec/1998, the first year of financial distress. As suggested in a previous paragraph this should not be surprising. In particular, the labor productivity indicator increased 9.1% for banks and fell 29.2%, 11.9% and 14.4% for CAV, CF and CFC, respectively, during that first year of crisis. Thus, it seems that the sudden shortage of international capital and financial distress erupted more severely in the three latter types of financial institutions than in commercial banks. Between Dec/1998 and Dec/2000, the period comprising the first two years in which the new regulation was in effect, the labor productivity proxy fell 18.8% for the whole system. This represents, for each of these two years, a fall in financial intermediation productivity twice as large as the one observed during the first year of the crisis. At a disaggregated level and during the same period, the labor productivity proxy fell 3.8%, 54.8%, 9.3% and 33.0% in commercial banks, CAV, CF and CFC, respectively. In sum, this evidence also suggests that the new banking regulation of Nov/1998 constitutes a visible and significant negative productivity shock to financial intermediation in Colombia that can be interpreted either as highly persistent or highly transitory. Moreover, it seems that the biggest contribution to the observed productivity fall came from savings and mortgage loans institutions.

In the next section a model capable of rationalizing the empirical facts of sections one and two is suggested. The ultimate objective is to construct an artificial economy in which to study the effects of a negative banking productivity shock similar to the one observed in Colombia towards the end of 1998, and to compare the response of this artificial economy to that observed in Colombia during the years 1999 and 2000, the post shock/post-regulation years.

IV. Model

This section suggests a theoretical model that predicts a macroeconomic behavior similar to the one observed in Colombia between the end of 1997 and the end of 2000. Again, the idea is to use this model in order to replicate qualitatively and quantitatively the response of the main macro aggregates in Colombia to the negative productivity shock to financial intermediaries in late 1998.

A. Basic Assumptions

The economy is inhabited by an infinite number of identical, infinitely-lived, riskaverse entrepreneurial households. The mass of households has measure 1. In every period households have access to a riskless technology that needs land, and internal and external funds as inputs to produce a final good as output. The three inputs are complementary in production. Internal funds and land are accumulated by the household from one period to the other. External funds are supplied by a banking sector in the form of intraperiod loans at rate ρ. Total land supply is fixed at 1. Internal funds are a final good that has been previously accumulated and represent installed physical capital belonging to the household. External funds should be interpreted as working capital provided by financial intermediaries. One possible motivation for this loan-in-the-production function assumption is that firms usually need to pay for some intermediate inputs (or labor services) in advance of production and must rely on the liquidity provided by banks to do so. Without these liquid external funds firms could not operate their technologies. In this sense, external funds can be understood as a different input of production.

Banks operate with a costly, 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 technology is riskless (i.e. free of shocks), funding the household is risky for the bank. In every period the household has the option of running away with the proceeds from the project (i.e. the technology's output) without paying back the loan to the bank. But in doing so the household must leave its total assets (i.e. land plus undepreciated internal funds) behind. Moreover, default is not penalized with market exclusion. Banks know of this possibility and so they take care not to let the household borrow more than the value of its 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 (·)]: 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 $(1 + \rho)$ is known at this point, the household now determines its optimal demand for external funds or loans (b^*). However, because of the credit constraint, the volume of loans that the household finally receives (b) need not be equal to the optimal volume (b^*). If the outstanding value of debt associated to the optimal loan volume $(1 + \rho)b^*$ is *less than or equal* to the household's total volume of collateralizable resources [$ql + (1 - \delta)x$ where δ is the depreciation rate of internal funds], then the household is not credit constrained and its demand for loans is satiated completely:

$$b = b^* \leq \frac{ql + (1-\delta)x}{(1+\rho)}$$

Otherwise, the household's credit constraint binds and the volume of external funds received is equivalent to:

$$b = \frac{ql + (1+\delta)x}{(1+\rho)} < b^*$$

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 (ql') and iv) repayment of the outstanding debt $[(1 + \rho)b]$.

Note that it is optimal for the household to repay the loan because the credit constraint imposed by financial intermediaries is simply an incentive compatibility constraint aimed at repayment. Keeping in mind that default is not penalized with market exclusion, whenever the household flees at the end of a period without paying back its debt it receives a payoff equivalent to:

$$F(x, b, l)$$

However, if it stays and pays back the loan, it will obtain a payoff equivalent to:

$$F(x, b, l) + ql + (1 - \delta)x - (1 + \rho)b$$

Incentive compatibility with repayment requires:

$$F(x, b, l) \leq F(x, b, l) + ql + (1 - \delta)x - (1 + \rho)b$$

or:

$$b \leq \frac{ql + (1-\delta)x}{(1+\rho)}$$

which is simply the credit constraint imposed by banks on households. Thus, it is always optimal for households to repay any loan extended to them. As in other credit limit models, borrowing is so tightly constrained by the level of collateral that default never occurs in equilibrium.

B. Household's Problem

Formally, the household solves the following sequential problem:

$$Max_{\{c_t, b_t, x_{t+1}, l_{t+1}\}} \quad E_0 \sum_{t=0}^{\infty} \beta^t U(c_t)$$

s.t.

$$c_t + x_{t+1} + q_t l_{t+1} + (1 + \rho_t) b_t = F(x_t, b_t, l_t) + (1 - \delta) x_t + q_t l_t$$

$$b_t (1 + \rho_t) \leq q_t l_t + (1 - \delta) x_t$$

$$c_t, x_t, l_t \geq 0$$

$$q_t, \rho_t \ given$$

$$x_0, l_0 = 1 \ given$$

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 complementarity assumption ahead. Note also that if the constraint is binding, any fall in asset (i.e. land) prices, in landholdings or in internal fund volume and any lending rate hike will tighten 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 establishes 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. Simply put, 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 optimal 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 and the borrowing constraint will bind. Moreover, the marginal productivity of external funds will exceed its marginal cost (or gross loan rate) and an inefficiency will result in the economy. As a result, the demand for external funds will be determined in the following way:

$$\text{If} \quad F_2\left[x_t, \frac{q_t l_t + (1-\delta)x_t}{(1+\rho_t)}, l_t\right] > 1 + \rho_t \quad \text{then}$$

$$b_t = \frac{q_t l_t + (1-\delta)x_t}{(1+\rho_t)} \quad \text{and} \quad \lambda_t > 0 \tag{4}$$

$$\text{If} \quad F_2\left[x_t, \frac{q_t l_t + (1-\delta)x_t}{(1+\rho_t)}, l_t\right] \leq 1 + \rho_t \quad \text{then}$$

$$b_t \ni F_2(x_t, b_t, l_t) = (1+\rho_t) \text{ and } \lambda_t = 0$$

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

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

$$+ [F_2(x_{t+1}, b_{t+1}, l_{t+1}) - (1 + \rho_{t+1})] \frac{(1-\delta)}{(1+\rho_{t+1})}] \}$$

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 present 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 $F_2(x_{t+1}, b_{t+1}, l_{t+1}) > (1 + \rho_{t+1})$ and $\lambda_t > 0$]. 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 also 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):

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

$$+ [F_2(x_{t+1}, b_{t+1}, l_{t+1}) - (1 + \rho_{t+1})] \frac{q_{t+1}}{(1+\rho_{t+1})}]\}$$

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 $F_2(x_{t+1}, b_{t+1}, l_{t+1}) > (1 + \rho_{t+1})$ and $\lambda_t > 0$]. 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 a no-bubble condition 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:

$$\Omega_t = \frac{F_2(x_t, b_t, l_t)}{(1+\rho_t)}$$

As usual, the price of land is given by the expected present discounted value of its forever flow of future rental payments. Discounting is done with the stochastic discount factor as with any other asset. As expected, future rental payments to land include not only its future direct contribution to output as an input of production $[F_3(x_{t+j}, b_{t+j}, l_{t+j})]$, but also its future cumulated indirect contribution to output as collateral $\left(\prod_{i=1}^{j-1}\Omega_{t+i}\right)$. Of course, land's indirect contribution to future output as collateral is only relevant if the borrowing constraint binds at least for some future period [i.e. if $F_2(x_{t+j}, b_{t+j}, l_{t+j}) > (1 + \rho_{t+j})$ and $\Omega_{t+j} > 1$ for some $j \geq 1$].

Equation (7) is an interesting result because it shows that credit constrained agents value assets not only for their future direct rental payments but also for their future role as collateral. But 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 future rental payments to land and, consequently, a fall in its current price (*q*), thus triggering the credit multipliers (more on the credit multipliers ahead). 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 generate a bigger impact out of the credit multiplier.

C. Financial Structure and Bank's Problem

Banks are modelled in the same way as in section three, where it was argued that the new banking regulation of Nov/1998 in Colombia induced a negative productivity shock to financial intermediaries. 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 have to carry out a variety of costly activities like evaluating creditors, managing deposits, renting buildings, maintaining ATMs, etc. [Edwards and Vegh (1997)][20]. In equilibrium banks produce where the relative price of their output $(1 + \rho)$ equals marginal cost:

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

20 The banking technological specification employed here 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 $D - G(D, Z) \geq 0$ captures resources used in the intermediation process. Under the tech-

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). Finally, it is assumed that $z \in [0, 1)$ moves according to a stochastic process Γ .

D. Market Clearing Conditions

In this economy markets clear if:

$b_t = (1 - z_t)d_t \Rightarrow$ loans market (9)

$l_t = 1 \Rightarrow$ land market (10)

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

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

E. 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*:

$$b_{ss} = \frac{q_{ss} l_{ss} + (1-\delta) x_{ss}}{1+\rho_{ss}} \text{ if } F_2\left[x_{ss}, \frac{q_{ss} l_{ss} + (1-\delta) x_{ss}}{1+\rho_{ss}}, 1\right] > 1 + \rho_{ss} \qquad (1_{ss})$$

$b_{ss} \ni F_3(x_{ss}, l_{ss}, b_{ss}) = 1 + \rho_{ss}$ otherwise

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nology 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 fulfill the same purpose. Finally, under this specification resources lost in the intermediation process are given by $d - (1 - z)d = zd < d$.

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

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

$$1+\rho_{ss}=\frac{1+R}{1-z_{ss}} \tag{4$_{ss}$}$$

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

$$l_{ss}=1 \tag{6$_{ss}$}$$

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

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

F. 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 experiments that follow, 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.

$$b\le\frac{q(S)l+(1-\delta)x}{1+\rho(S)}$$

$$S'=[\Gamma,H(S)]$$

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: $x'(z, X, X,1) = H(z, X)$.

G. Financial Acceleration

In this economy there is a financial acceleration mechanism which is articulated by static and dynamic multipliers a-la-Kiyotaki and Moore (1997). The multipliers propagate and amplify any change in banking productivity. Consider an adverse productivity shock to banks meaning that their intermediation cost goes up. This would induce 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 instantaneously reduce 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 future rental payments. As shown previously, these rental payments have two components. The first one comes from the direct contribution of land to future output as an input of production. The second one comes from land's indirect contribution to future output as collateral (recall that accumulating more land today increases external fund availability tomorrow and, thereby, tomorrow's output, as long as the borrowing constraint binds). Not surprisingly, these rental payments are an increasing function of the future 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. This 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 to converge back to the steady state than in a financially frictionless setup.

Whenever there is a shock to z, the propagation and amplification mechanisms of the multipliers induce hump-shaped responses in the different variables of the model. The size and amplitude of the humps depends on the magnitude and degree of persistence of the shock. But even with one-period (zero-persistence) shocks, a hump in consumption is always observed. For high values of α a hump in output is also observed with these one-period shocks. This result is robust to different functional forms in production.

V. Numerical Experiments

In this section the credit channel of the theoretical model is studied within numerical experiments that aim at understanding the effects of the negative productivity shock endured by financial intermediaries in Colombia after the new banking regulation was issued towards the end of 1998. Recall that given the post-Nov/1998 response of the gross loan-deposit rates ratio and of labor productivity in the financial sector in Colombia, two alternative shock structures are reasonable interpretations of the new banking regulation issued in Nov/1998. Under the first structure the regulatory changes of Nov/1998 are viewed as a long-lived, highly persistent, negative productivity shock to financial intermediation in Colombia. Under the second structure, the new regulation is only a short-lived, highly transitory, adverse productivity shock to financial intermediaries; if so, the big peaks in the gross loan-deposit rates ratio and the big slump exhibited by financial sector labor productivity after the third quarter of 1999 must be attributed to something else. Two numerical experiments will be carried out, each attempting to replicate one of the two possible shock structures.

Before going into the details of the experiments, some criteria to evaluate the quantitative accuracy of the experiments must be chosen. The natural criteria is to compare the fluctuations in income (y), consumption (c), credit (b) and asset prices (q) predicted by the experiment with those observed in the data. In both experiments it will be assumed that the shock first hits in the first quarter of 1999. Even though the new banking regulation was issued during the fourth quarter of 1998, the date in which it was implemented (November 16, 1998) lies closer to the end of that quarter and the beginning of the first quarter of 1999. Hence, the relevant sample to evaluate the fit of the model starts in the first quarter of 1999.

The following table displays the observed percent change in i) GDP, ii) total consumption, iii) outstanding stock of credit (including non-performing loans), and iv) asset prices in Colombia between the first quarter of 1999 and the last quarter of 2000. Asset prices were proxied with the closing value of the IBB index. Before computing their changes, all variables were measured in real terms. Nominal asset prices (i.e. the closing values of the IBB index) and the nominal stock of outstanding credit were obtained from Banco de la Republica and were deflated with the CPI (1998:12 =100), also available at Banco de la Republica[21]. GDP and consumption were taken from the national accounts that are reported by DANE with seasonal adjustment in millions of 1994 pesos, according to the new methodology. GDP, consumption, and the outstanding stock of credit were also measured in per capita terms[22]:

Table 5. Percent Changes in Macro Variables.

	GDP (*y*)	**Consumption (*c*)**	**Credit (*b*)**	**Asset Prices (*q*)**
99:I	-0.7%	-1.4%	-5.4%	-21.8%
99:II	-1.5%	+0.1%	-1.8%	+6.3%
99:III	+0.1%	-0.1%	-2.9%	-6.5%
99:IV	+0.7%	+0.7%	-4.0%	+5.9%
00:I	+0.0%	-1.3%	-10.3%	-8.9%
00:II	-0.2%	-0.6%	-3.3%	-21.6%
00:III	+0.8%	+0.1%	-1.5%	-2.4%
00:IV	-0.1%	-0.2%	-2.8%	-5.8%

Note that there is some movement in GDP and consumption in the first two or three quarters of the sample but not thereafter. Contrarily, investment, credit and asset prices exhibit high swings throughout the period. Of course, the model will not account for all the swings in the variables. Nevertheless, unexplained fluctuations can be attributed to other economic shocks during this period that did not operate through the channel that the model suggests.

To measure the magnitude of the shock in each experiment the observed fluctuations in the indicator of labor productivity in the finan-

21 The nominal stock of credit is gross of non-performing loans and corresponds to the stock outstanding in the first day of the last month of each quarter.

22 To construct per capita values population in the seven most important cities was used as a proxy for total population (source: DANE). The reason for doing so is the lack of an official series of total population at a quarterly frequency during 1998-2000. Since the first difference of per capita variables is the object of interest at this point, using population in the seven most important cities should not be a problem as long as it reflects accurately population changes in the whole country.

cial sector of Colombia will be used as a proxy of z. An alternative metric of the z is the inverse of the gross loan-deposit rates ratio. As mentioned earlier, this ratio might be capturing other phenomena alien to the theoretical model suggested here. Hence, measured labor productivity in the financial sector of Colombia is a cleaner proxy of overall productivity and intermediation costs in the Colombian financial system. In table 4 it can be seen that labor productivity of financial intermediaries fell 14.2% during the first quarter of 1999. This was a significant slump in comparison to the observed labor productivity reduction during the four quarters of 1998, the first year of financial distress (-6.6% for the whole year), and also in comparison to the observed subsequent fluctuations of this variable. In consequence each experiment will be constructed as a 14.2% increase in intermediation costs (z) on the impact period. However, the rate of decay of the shock will vary across the two experiments.

For both experiments the following functional forms and distribution for the intermediation costs are used:

- $U(c) = \log(c)$
- $F(x, l, b) = x^{\alpha} l^{1-\alpha} + Ab$
- $z_{t+1} = \mu(1 - \gamma) + \gamma z_t + \zeta_{t+1}$ where $\gamma \in [0, 1)$, $\zeta_t \sim N(0, \sigma^2)$ and $0 \leq z_t \leq 2\mu < 1$.

Note that external funds yield output through a linear technology while internal funds and land are combined in a Cobb-Douglas technology. As the reader will see, this is just a simplifying assumption to facilitate the choice of parameter values. If $A = 1$ the example reduces to the one suggested by Kocherlakota (2000).Under this setup external funds are a perfect substitute to internal funds and land. As said earlier, the lack of complementarity between internal and external funds will reduce the impact obtained from the credit multipliers. Yet, the multipliers are still present due to the complementarity between internal funds and land. Recall that this complementarity assumption is enough to activate the financial acceleration mechanism.

The distribution of z is not central to the argument. In fact, the AR(1) distribution was chosen to impose some structure on the rate of decay of the shocks. Alternatively, z could have been *iid* uniform between 0 and 2µ and the results still go through. Note also that z is bounded from above at twice its unconditional mean (2µ). This upper bound simply facilitates the illustration of the choice of parameter values that make the credit constraint bind in every period. Given that none of the experiments will take z to this upper bound, such bound is irrelevant for practical purposes. It only serves illustrative purposes and does not alter in any way the results of the experiments.

Note that the loan demand decision is taken according to the following rule:

If $A = (1+ \rho_t) \Rightarrow b_t \in [0, \infty]$

If $A > (1 + \rho_t) \Rightarrow b_t \rightarrow \infty$

If $A < (1 + \rho_t) \Rightarrow b_t = 0$

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

$$A = \frac{(1+R)}{1-2\mu} + \varepsilon \tag{12}$$

where ε is an arbitrarily small number. In other words, A is constructed so that it always exceeds the highest possible gross loan rate of the economy. The important point to note is that, under these circumstances, in every period the household will want the highest loan volume it can get. Consequently, its borrowing constraint will be binding in every period:

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

In the technical appendix it is shown that a sufficient (and rather strong) condition to satisfy the no-bubble condition is $\beta F_2(x_t, b_t, l_t) < (1 + \rho_t)$ $\veebar t$. Under the present setup this is equivalent to $\beta A < (1 + \rho_t) \veebar t$. To guarantee that this condition is satisfied at all times β is defined as:

$$\beta = \frac{(1+\rho_{ss})}{A} - \varepsilon \tag{13}$$

where ρ_{ss} is the steady state loan interest rate.

In the experiments each period should be thought of as a quarter. Parameter R is given a value of 1.9% which is equivalent to the average quarterly ex-post deposit real interest rate in Colombia for the period January/1990-February/2000[23]. This rate should be associated to the safe quarterly rate that any depositor obtains in international financial markets. The value for μ was chosen so that the steady state quarterly loan real interest rate is 3.9%, which coincides with the average quarterly ex-post loan real interest rate in Colombia for the period January/1990-February/2000[24]. The value for ε is set arbitrarily at 0.001 and together with the value of R and μ and equation (12) imply a return to loans (i.e. A - 1) of 6.1% in every period. The values for A, ε and μ and equation (13) imply a value for β of 0.978. The quarterly depreciation rate (i.e. δ) is given the ad-hoc (yet reasonable) value of 2.5%.

The elasticity of final output to internal funds (α) is manipulated in each experiment so that the results match as closely as possible the empirical features of table 5. Parameter γ (which has to be lower than one so that z is stationary) is treated in the same way but its value also depends on the type of experiment. It will be close to 1 if the experiment tries to capture a long-lived shock and close to 0 otherwise. In a sense, α and γ operate as free parameter values. As long as one of them remains free, the experiments are flexible enough to yield results not far away from the targeted empirical features. This treatment of parameter values can be found elsewhere in the literature [see for example Correia, Neves and Rebelo (1994)].

The value of σ is not relevant for the purpose of the two experiments because the shocks given to z will not be based on its empirical variance. Given that the experiments try to replicate an unexpected and irregular event (the Nov/1998 regulation), the value of the shocks to z will

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23 The corresponding annual rate is 8%.

24 The corresponding annual rate is 16.5%.

depend on the observed value of its proxy (the labor productivity indicator of Colombian financial intermediaries) in the first quarter of 1999. Table 6 summarizes the parameter values.

Table 6.

Primitive Parameter	Value
δ	0.025
α	*free*
R	0.019
μ	0.01925
γ	< 1
ε	0.001

$\Rightarrow$

Parameter	Resulting Value
β	0.9784
ρ_{ss}	0.039
A	1.0608

Initially the economy is set at its non-stochastic stationary state:

$$\zeta_{ss} = (c_{ss}, x_{ss}, l_{ss}, b_{ss}, d_{ss}, z_{ss}, q_{ss}, \rho_{ss})$$

which is the solution to:

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

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

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

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

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

$$l_{ss} = 1$$

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

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

Once in steady state, the economy is ready to be shocked and the numerical experiments can be carried out. Again, each experiment will be defined by a different shock structure.

A. Experiment 1: A highly transitory, short-lived shock; $\gamma = 0.05$

This first experiment is defined as a shock that increases intermediation costs (*z*) in 14.2% on the impact period (which is analogous to the first quarter of 1999). In the subsequent periods the shock decays according to $\gamma = 0.05$ and rapidly returns to its normal stationary level (i.e. its unconditional mean). The shock induces a 7.5% rise in the quarterly real loan rate (equivalent approximately to a 30 basis point increase) on impact. The value given to α was 0.837.

The diamond-shaped line of figure 9 presents the response of *y*, *c*, *b*, and *q* to the shock during 100 periods. Two features are worth highlighting. The first one is that despite the short life of the shock, its effects are not trivial due to the propagation mechanism in the credit multipliers of the model. In fact, consumption (*c*) falls 1.4% below its stationary value on the period of the shock and 100 quarters later it is still 1% below its stationary level. Very similar responses are observed in output (*y*), credit (*b*), and asset prices (*q*). Taken literally, this means that, ceteris paribus, the perverse effects of the Nov/1998 banking regulation will still be felt 25 years from now. In other words, the cumulated loss of welfare attributable to this shock is not trivial according to this experiment. The second feature is the two period hump-shaped response in income (*y*) and consumption (*c*). In the data (see table 6) there seems to be a hump in output and credit. As mentioned earlier, this type of response in the model economy is attributable to the propagation and amplification mechanisms of the credit multipliers.

The following table presents the changes in the variables of the model economy during the 8 periods (or quarters) following the shock. This table is useful to evaluate the quantitative accuracy of the model.

Table 7. Percent Changes in Model's Variables.

Period	GDP (*y*)	Consumption (*c*)	Credit (*b*)	Asset Prices (*q*)
1	-1.58%	-1.42%	-1.59%	-1.55%
2	-0.01%	-0.17%	0.00%	0.01%
3	0.01%	0.00%	0.01%	0.01%
4	0.01%	0.01%	0.01%	0.01%
5	0.01%	0.01%	0.01%	0.01%
6	0.01%	0.01%	0.01%	0.01%
7	0.01%	0.01%	0.01%	0.01%
8	0.01%	0.01%	0.01%	0.01%

A comparison of tables 5 and 7 shows that regarding income (y) and consumption (c), the model seems to do a decent job. Even though the experiment captures the big fall in output one period ahead of time, the big fall in consumption is replicated with the right timing. Regarding credit (*b*) and asset prices (*q*) the model comes short of explaining a considerable percentage of the observed fluctuations. Consider for example asset prices. According to the data, asset prices fell 21.8% on the period of the shock (i.e. first quarter of 1999) and then rebounded 6.3% on the following period. The model only captures 7.1% of the first period's movement and 0.16% of the second period's movement. Now consider credit. According to the data, credit fell 5.4% on the period of the shock and continued to fall in the following periods. The model only captures 30% of the first period's movement, none of the second period's fluctuation and misses the sign of the subsequent periods' movements. But again, in the real economy other shocks are always at work. Thus, some of the unexplained fluctuations might be due to shocks other than the regulatory changes of Nov/1998. Moreover, if these shocks did not operate through the channel that the model suggests, they could have induced the observed movements in credit and asset prices not captured by the experiment.

It is important to note that the magnitude of the shock (14.2%) is not driving the results alone. Hence, the quantitative accuracy of the model should not be judged on the basis of the specific change in z used to construct the experiment. The choice of (α, γ) plays a key role. Recall that the values of (α, γ) are chosen arbitrarily to match the empirical targets (i.e. the numbers in table 6) as closely as possible. Using a lower value for α and a higher value for γ would increase the magnitude of the impact responses. This would improve the accuracy of the model's predictions in terms of asset prices and credit but would reduce the accuracy in terms of income and consumption. In trying to match the empirical targets, income and consumption were given a higher priority since they are more direct welfare indicators.

B. Experiment 2: A highly persistent, long-lived shock; $\gamma = 0.85$

As with the first experiment, this second exercise is defined as a shock that increases intermediation costs (z) in 14.2% on the impact period. But in contrast to the first experiment, in the subsequent periods of this experiment the shock decays according to $\gamma = 0.85$. This implies that the shock will vanish completely in 50 periods (12.5 years). As before, the shock induces a 7.5% rise in the quarterly real loan rate (equivalent approximately to a 30 basis point increase) on impact. The value given to α was 0.972. Given the strong propagation and amplification mechanisms of the model and the high persistence of the shock, a smaller weight of land on output is required in order to get results not far away from the empirical targets of table 5.

The solid line of figure 9 presents the response of y, c, b, and q to the shock during 100 periods. Note the hump-shaped responses of income (y), consumption (c) and credit (b). In the data there is a small hump in income and a large hump in credit. Again, the hump-shaped responses of the artificial economy are due to the strong propagation and amplification mechanisms of the static and dynamic credit multipliers. There is no hump in asset prices (q) because this variable is the present discounted value of the forever flow of rental payments to land (l). As such, q tends to absorb on impact all the future adverse effects of the humpshaped fall in internal funds (x), which due to their complementarity with land, are responsible for the fall in these rental payments[25].

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[25] Under this example rental payments to land are simply the marginal productivity of land $[(1 - \alpha)\ (x/l)\ \alpha]$ -the direct contribution of land to output- times the discounted marginal productivity of credit $[A/(1 + \rho)]$ -the indirect contribution of land to output-. Thus, any fall in x_{t+i} for $i > 0$ reduces future rental payments to land and its current price, q_t. In this case all the hump-shaped reductions in x_{t+i} are absorbed by q_t on impact.

Given these hump-shaped responses, the long-run effects of the shock exceed in magnitude those of the first experiment. For instance, consumption (*c*) falls 1.4% below its stationary value on the impact period but 100 quarters later it lies further below (3% below its stationary level). Very similar responses are observed in output (*y*), credit (*b*), and asset prices (*q*). In consequence, the cumulated loss of welfare attributable to this shock is very high and is underestimated by looking only at the short-run responses of the variables. This contrasts with the first experiment where the big cuts are taken on the impact period. Taking the results of this experiment literally means that if nothing else had happened in Colombia, the observed fall in output, consumption, credit and asset prices during the first quarter of 1999 was only the beginning of a deeper and very long-lived economic contraction. If so, the welfare loss would be enormous given that consumption in Colombia would still be 3% below its stationary or potential value 25 years from now.

The following table presents the changes in the variables of the artificial economy during the 8 periods (or quarters) following the shock

Table 8. Percent Changes in Model's Variables.

Period	GDP (*y*)	Consumption (*c*)	Credit (*b*)	Asset Prices (*q*)
1	-1.59%	-1.42%	-1.61%	-3.12%
2	-0.23%	-0.23%	-0.23%	0.00%
3	-0.20%	-0.20%	-0.20%	0.00%
4	-0.17%	-0.18%	-0.17%	0.00%
5	-0.14%	-0.16%	-0.14%	0.00%
6	-0.12%	-0.14%	-0.12%	0.00%
7	-0.10%	-0.12%	-0.10%	0.00%
8	-0.09%	-0.10%	-0.09%	0.00%

A comparison of tables 5 and 8 shows that regarding income (*y*) and consumption (*c*), the model seems to do a decent job at least in the initial periods. Of course, the artificial economy displays wide humps in income (*y*), consumption (*c*) and credit (*b*) whereas the data only reveals a small hump in income and a wide hump in credit. As in the first experiment, this second exercise captures the big fall in output one period ahead of time and the big fall in consumption with the right timing. Regarding credit (*b*) and asset prices (*q*), the still model comes short of explaining a considerable percentage of the observed fluctuations. Consider first asset prices. According to the data, asset prices fell 21.8% on the period of the shock (i.e. first quarter of 1999) and then rebounded 6.3% on the following period. The model only captures 14.3% of the first period's movement and none of the subsequent periods' movements. Now look at credit. According to the data, credit fell 5.4% on the period of the shock and continued to fall in the following periods. The model only captures 30% of the first period's movement and an average of 5.6% of the subsequent periods' movements. But in the real economy other shocks are always present. Some of the unexplained fluctuations might be due to these other shocks and not to the productivity shock attributable to the new regulation of Nov/1998. Indeed, if these other shocks did not operate through the credit multipliers of the model, they could have induced the observed movements in credit and asset prices not captured by the experiment's results.

Conclusion

Economic performance in Colombia during the last three years has been disappointing. The unemployment rate is currently above 15%. The average economic growth rate for the years 1998,1999 and 2000 was negative. Asset prices have been falling since the end 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 began 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. Whether financial distress in Colombia was alleviated or not is a question that has not yet been answered. What is true though is that the spread between the loan and deposit interest rates in Colombia systematically rose to higher levels in 1999, just after the new banking regulation and financial transaction tax was introduced.

This paper argues that this hike in the loan-deposit interest rate spread reflects a rise in intermediation costs attributable to the new banking regulation. The new regulation and the 2/1000 financial transaction tax tightened banking operational constraints and added costs to financial intermediation activity. Consequently, financial intermediaries suffered a productivity meltdown as they lost operational versatility and additional real resources were required to implement and continue to operate under 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.

Not surprisingly, this negative productivity shock enhanced the credit crunch and corresponding economic contraction that was already underway. The enhancement, however, did not proceed in a linear way. The data show that the effects of the shock were amplified and propagated into the future. Specifically, the contraction of per capita GDP became wider and longer lived than other previous economic contractions. Asset prices maintained a downward trend. 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 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.

If one interprets the new banking regulation of Nov/1998 in Colombia as an adverse productivity shock to financial intermediation, the predictions of the model fit decently the recent macroeconomic behavior of that country. This was shown with two numerical experiments that were carried out to capture alternative interpretations of the shock. The reader is to choose which experiment is more reasonable and decide whether the new banking regulation of Nov/1998 can be understood as a long-lived/highly persistent negative productivity shock to financial intermediation in Colombia, or simply as a short-lived/highly transitory but still adverse productivity shock to financial institutions in that country. *In short, the main point being pushed 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.*

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 negligible or really small and did not generate 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 and credit crunch when credit limits are more likely to be binding. These are just tentative answers to be explored in further research.

Bibliography

Aghion, P., Bacchetta, P. and A. Banerjee, 2000, "A Simple Model of Monetary Policy and Currency Crises", EER, vol. 44, pp. 728-738.

Aghion, P., Bacchetta, P. and A. Banerjee, 2000, "Capital Markets and the Instability of Open Economies", manuscript, CEPR.

Aiyagari, R., 1993, "Explaining Financial Market Facts: The Importance of Incomplete Markets and Transaction Costs", Federal Reserve Bank of Minneapolis Quarterly Review, vol. 17, no. 1, pp. 17-31.

Alam, I. M. S., 2001, "A Nonparametric Approach for Assessing Productivity Dynamics of Large U.S. Banks", JMCB, vol. 33, no. 1, pp. 121-139.

Arias, A. 2000, "The Colombian Banking Crisis: Macroeconomic Consequences and What to Expect", Borradores Semanales de Economia, No 158, Banco de la Republica, Colombia.

Bauer, P., Berger, A. and D. Humphrey, 1993, "Efficiency and Productivity Growth in U.S. Banking", in *The Measurement of Productive Efficiency: Techniques and Applications*, ed. Harold O. Fried, C.A. Knox Lovell and Shelton S. Schmidt, Oxford, Oxford University Press, pp. 386-413.

Berg, S., Forsund, F. and E. Jansen, 1992, "Malmquist Indices of Productivity Growth during the Deregulation of Norwegian Banking, 1980- 1989", Scandinavian Journal of Economics, vol. 94, pp. 211-228.

Berg, S., Forsund, F., Hjalmarsson, E. and M. Suominen,1993, "Banking Efficiency in Nordic Countries", Journal of Banking and Finance, vol. 17, pp. 371-388.

Berger, A. and D. Humphrey, 1992, "Measurement and Efficiency Issues in Commercial Banking", in *Measurement Issues in the Services Sectors*, ed. Zvi Griliches, Chicago: NBER, University of Chicago Press, pp. 245-279.

Berger, A. and L. Mester, 1999, "What Explains the Dramatic Changes in Cost and Profit Performance of the U.S. Banking Industry?" Working Paper no. 99-1, Federal Reserve Bank of Philadelphia.

Bernanke, B., 1983, "Non-monetary Effects of the Financial Crisis in Propagation of the Great Depression", AER, 73, pp. 257-276.

Bernanke, B. and M. Gertler, 1989, "Agency Costs, Net Worth and Business Fluctuations". AER, vol. 79, no.1, pp. 14-31.

Bernanke, B. and M. Gertler, 1990, "Financial Fragility and Economic Performance", QJE, vol. 105, no.1, pp. 87-114.

Bernanke, B., Gertler, M. and S. Gilchrist, 1999, "The Financial Accelerator in a Quantitative Business Cycle Framework", in *Handbook of Macroeconomics*, vol. 1, ed. J. B. Taylor and M. Woodford, Elsevier Science B.V.

Bhattacharya, J., M. Guzman, E. Huybens and B. Smith, 1994, "Monetary, Fiscal and Bank Regulatory Policy in a Simple Monetary Growth Model". Center for Analytic Economics, Working Paper no. 94-14.

Bhattacharya, A., Lovell, C.A. and P. Sahay, 1997, "The Impact of Liberalization on the Productive Efficiency of Indian Commercial Banks", European Journal of Operational Research, vol. 98, pp. 332-345.

Boyd, J. and B. Smith, 1995, "The Evolution of Debt and Equity Markets in Economic Development", Federal Reserve Bank of Minneapolis Research Department, Working Paper no. 542.

Caballero, R. and A. Krishnamurthy, 2000, "Emerging Market Crises: An Asset Markets Perspective", manuscript, MIT.

Caprio, G. and D. Klingebiel, 1996, "Bank Insolvency: Bad Luck, Bad Policy or Bad Banking?" in *Annual World Bank Conference on Development Economics*, Washington D.C., The World Bank, pp. 79-104.

Carlstrom, C. and T. Fuerst, 1997, "Agency Costs, Net Worth and Business Fluctuations: A Computable General Equilibrium Analysis" AER, vol. 87, no. 5, pp. 893-910.

Chari, V., Jones, L. and R. Manuelli, 1995, "The Growth Effects of Monetary Policy", Federal Reserve Bank of Minneapolis Quarterly Review, vol. 19, no. 4, pp. 18-32.

Cole, H. and L. Ohanian, 2000, "Re-Examining the Contribution of Money and Banking Shocks to the U.S. Great Depression", forthcoming in NBER Macro Annual.

Cooley, T. and V. Quadrini, 1999, "Monetary Policy and the Financial Decisions of Firms", manuscript, NYU.

Cooley, T. and V. Quadrini, 2000, "Financial Markets and Firm Dynamics", manuscript, NYU.

Corsetti, G., Pesenti, P. and N. Roubini, 1998, "Paper Tigers? A Model of the Asian Crisis", manuscript, NBER, December.

Correia, I. Neves, J. and S. Rebelo, 1994, "Business Cycles in a Small Open Economy", CEPR Discussion Paper 996.

Demirguc-Kunt, A. and E. Detragiache, 1997, "The Determinants of Banking Crises: Evidence from Developed and Developing Countries", World Bank Working Paper no. 1828, September.

Demirguc-kunt, A., Detragiache, E. and P. Gupta, 2000, "Inside the Crisis: An Empirical Analysis of Banking Systems in Distress", World Bank Working Paper no. 2431, August.

Diamond, P. A., 1965, "National Debt in a Neoclassical Growth Model", AER, 32, pp. 233-240.

Diamond, D., 1984, "Financial Intermediation and Delegated Monitoring", Review of Economic Studies, 51, pp. 393-414.

Diamond, D. and P. H. Dybvig, 1983, "Bank Runs, Deposit Insurance, and Liquidity", JPE, Vol. 91, no. 3.

Diaz-Jimenez, J., Prescott, E., Fitzgerald, T. and F. Alvarez, 1992, "Banking in Computable General Equilibrium Economies", JEDC, vol. 16, pp. 533-559.

Edwards, S. and C. Vegh, 1997, "Banks and Macroeconomic Disturbances Under Predetermined Exchange Rates", JME, vol. 40, pp. 239-278.

Elyasiani, E.and S. Mehdian, 1995, "The Comparative Efficiency Performance of Small and Large U.S. Commercial Banks in the Pre- and Post- deregulation Eras", Applied Economics, vol. 27, pp. 1069-1079.

Galor, O., 1992, "A Two-Sector Overlapping-Generations Model: A Global Characterization of the Dynamical System", Econometrica, Vol. 60, no. 6, pp. 1351-1386.

Garber, P. andS.Weisbrod, 1992, *The Economics of Banking*, Liquidity and Money, D.C. Heath and Company, Lexington, Massachusetts.

Gilbert, R. A. and P. W. Wilson, 1998, "Effects of Deregulation on the Productivity of Korean Banks", Journal of Economics and Business, vol. 50, no. 2, pp. 133-156.

Hayashi, F. and E. Prescott, 2000, "The 1990's in Japan: A Lost Decade", Paper presented at the *Great Depressions of the 20th Century Conference*, October 2000, Federal Reserve Bank of Minneapolis.

Humphrey, D., 1991, "Productivity in Banking and Effects from Deregulation", Economic Review, vol. 77, pp. 16-28.

Humphrey, D., 1992, "Flow versus Stock Indicators of Banking Output: Effects on Productivity and Scale Economy Measurement", Journal of Financial Services Research, vol. 6, pp. 115-135.

Humphrey, D., 1993, "Cost and Technical Change: Effects from Bank Deregulation", Journal of Productivity Analysis, vol. 4, pp. 5-34.

Humphrey, D. and L. Pulley, 1997, "Banks' Responses to Deregulation: Profits, Technology and Efficiency", JMCB, vol. 29, pp. 73-93.

Hunter, W. and S. Timme, 1991, "Technological Change and Production Economies in Large U.S. Commercial Banking", Journal of Business, vol. 64, pp. 339-362.

Kaminsky, G., 1999, “Currency and Banking Crises: The Early Warnings of Distress”, IMF Working Paper no. 178, December.

Kaminsky, G. and C. Reinhart, 1999, “The Twin Crises: The Causes of Banking and Balance of Payments Problems”, AER, vol. 89, no. 3, pp. 473-500.

Kaminsky, G. and C. Reinhart, 1998, “Financial Crises in Asia and Latin America: Then and Now”, AER: Papers and Proceedings, May, vol. 88, pp. 444-448.

Khumbakar, S., Lozano-Vivas, A., Lovell, C.A. and I. Hasan, 2001, “The Effects of Deregulation on the Performance of Financial Institutions: The Case of Spanish Savings Banks”, JMCB, vol. 33, no. 1, pp. 101-120.

King, R. and C. I. Plosser, 1984, “Money, Credit and Prices in a Real Business Cycle”, AER, vol. 74, no. 3, pp. 363-380.

Kiyotaki, N. and J. Moore, 1997, “Credit Cycles”, JPE, vol. 105, no. 2, pp. 211-248.

Kocherlakota, N., 2000, “Creating Business Cycles Through Credit Constraints”, Federal Reserve Bank of Minneapolis Quarterly Review, vol 24, No. 3, pp. 2-10.

Krugman, P., 1998, “What Happened to Asia?” manuscript, MIT, January.

Leightner, J. and C. A. Lovell, 1998, “The Impact of Financial Liberalization on the Performance of Thai Banks”, Journal of Economics and Business, vol. 50, pp. 115-131.

Mendoza, E., 2001, “Credit, Prices, and Crashes: business Cycles with a Sudden Stop”, manuscript, Duke University.

Rebelo, J. and V. Mendes, 2001, “Malmquist Indices of Productivity Change in Portuguese Banking: The Deregulation Period” International Advances in Economic Research, vol. 6, no. 3, pp. 531-543.

Rojas-Suarez, L. and S. Weisbrod, 1996, "Banking Crises in Latin America: Experiences and Issues", in *Banking Crises in Latin America*, Inter-American Development Bank, John Hopkins University Press, Baltimore, Maryland.

Scheinkman, J. and L. Weiss, 1986, "Borrowing Constraints and Aggregate Economic Activity", Econometrica, vol. 54, no. 1, pp. 23-46.

Schneider, M. and A. Tornell, 2000, "Balance Sheet Effects, Bailout Guarantees and Financial Crises" manuscript, UCLA.

Steiner, R., Barajas, A. and N. Salazar, 2000, "Structural Reforms and Bank Spreads in the Colombian Banking System", in *Why So High? Understanding Interest Rate Spreads in Latin America*, ed. Philip Brock and Liliana Rojas-Suarez, Inter-American Development Bank, Washington D.C.

Tirtiroglu, D., Daniels, K. and E. Tirtiroglu, 1998, "Total Factor Productivity Growth and Regulation in U.S. Commercial Banking During 1946-1995: An Empirical Investigation", Journal of Economics and Business, vol. 50, pp. 171-189.

Townsend, 1979, "Optimal Contracts and Competitive Markets with Costly State Verification", JET, vol. 21, pp.265-293.

Wheelock, D. and P. Wilson, 1999, "Technical Progress, Inefficiency, and Productivity Change in U.S. Banking, 1984-1993", JMCB, vol. 31, pp. 212-234.

Zaim, O., 1995, "The Effect of Financial Liberalization on the Efficiency of Turkish Commercial Banks", Applied Financial Economics, vol. 5, pp. 257-264.

Technical Appendix

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

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

This is:

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

Let $\Omega_t = F_2(x_t, b_t, l_t)/(1+\rho)$.

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:

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

$$+ \beta E_t \left\{ \frac{U'(c_{t+1})}{U'(c_t)} \Omega_{t+1} \left[\beta E_{t+1} \left[\frac{U'(c_{t+2})}{U'(c_{t+1})} F_3(x_{t+2}, b_{t+2}, l_{t+2}) \right] + \right. \right.$$

$$\left. \left. \beta E_{t+1} \left[\frac{U'(c_{t+2})}{U'(c_{t+1})} \Omega_{t+2} q_{t+2} \right] \right] \right\} \tag{6.4}$$

Using the law of iterated expectations (6.4) becomes:

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

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

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

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:

$$Lím_{j\to\infty} E_t\left[\frac{U'(c_{t+j})}{U'(c_t)} q_{t+j-1}\beta^j \prod_{i=1}^{j} \Omega_{t+i}\right] = 0 \qquad (6.8)$$

equation (7) is obtained:

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

Note that a sufficient condition for (6.8) to hold is:

$$\beta\Omega_t \leq 1, \quad \forall t$$

This is:

$$\beta \frac{F_2(x_t, b_t, l_t)}{(1+\rho_t)} \leq 1, \quad \forall t$$

Data Appendix

- **Real GDP per capita cycle:** Quarterly flow of GDP per capita in 1994 pesos (i.e quarterly values are not annualized). The original real GDP series covers the period 1977:I-2000:III and is not seasonally adjusted. Its source is DANE in Colombia. Seasonal adjustment to this original real GDP series was done with the X-11 ARIMA method. The last observation of the final seasonally adjusted real GDP series (00:IV) was constructed by applying to the last observation of the original seasonally adjusted real GDP series (00:III) the quarterly growth rate of real GDP according to the post-1994 DANE methodology (which is already seasonally adjusted and also in 1994 pesos). The total population series at a quarterly frequency was constructed from the annual series under the assumption of no population growth during the year. The cycle of the resulting real GDP per capita series was obtained by fitting an OLS trend between 1977:I and 1998:II.
- **Asset prices in real terms (Dec./97=100):** Monthly closing value 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 opening value in millions of pesos of the total stock of credit (gross and net of non-performing loans) from the financial system [Banks, Savings and Mortgage Loan Institutions (CAV), Financial Corporations (CF), Companies of Commercial Finance (CFC), Leasing Companies, Cooperative Organisms and Special Institutions]. 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 1992:01-2001:06.
- **Real loan rate:** Monthly values of the ex-post real annual loan interest rate. This rate is calculated as $(1 + i^l)/(1 + \pi) -1$, where i^l is the observed nominal annual loan interest rate and π is the realized annual inflation rate. The nominal annual 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 nominal annual loan interest rate and the nominal annual 3-month COD interest rate: i^l -i^d . The nominal annual loan rate is “tasa activa total sistema” (monthly average) calculated by Superintendencia Bancaria in Colombia. The nominal annual 3-month COD rate is “tasa de interes de los CDT a 90 dias, total sistema” (monthly average). Source is Banco de la Republica. Period is 1990:01-2000:12.
- **Inverse productivity of financial system:** Monthly ratio between the gross nominal annual loan interest rate and the gross nominal annual 3- month COD interest rate: $(1 + i^l)/(1 + i^d)$. The nominal annual loan rate is “tasa activa total sistema” (monthly average) calculated by Superintendencia Bancaria in Colombia. The nominal annual 3-month COD rate is “tasa de interes de los CDT a 90 dias, total sistema” (monthly average). Source is Banco de la Republica. Period is 1986:01-2000:12.
- **Labor productivity of financial system I:** Quarterly ratio between the seasonally adjusted real output of financial intermediation services (in millions of 1994 pesos) and the number of financial sector employees in the seven main metropolitan areas. Source for employment is DANE - Encuesta Nacional de Hogares. Source for output of financial intermediation services is DANE. Period is 1994:I-2000:IV.
- **Labor productivity of financial system II:** Quarterly ratio between the real stock of credit (in millions of pesos, gross of non-performing loans and outstanding in the first day of the last month of the quarter) and the number of financial sector employees in the seven main metropolitan areas. To deflate and obtain real credit values the CPI (1998:12 =100) was used. Source for employment is DANE - Encuesta Nacional de Hogares. Source for credit volume is Banco de la Republica. Period is 3/1/1992-12/1/2000.

Figures

Figure 1a

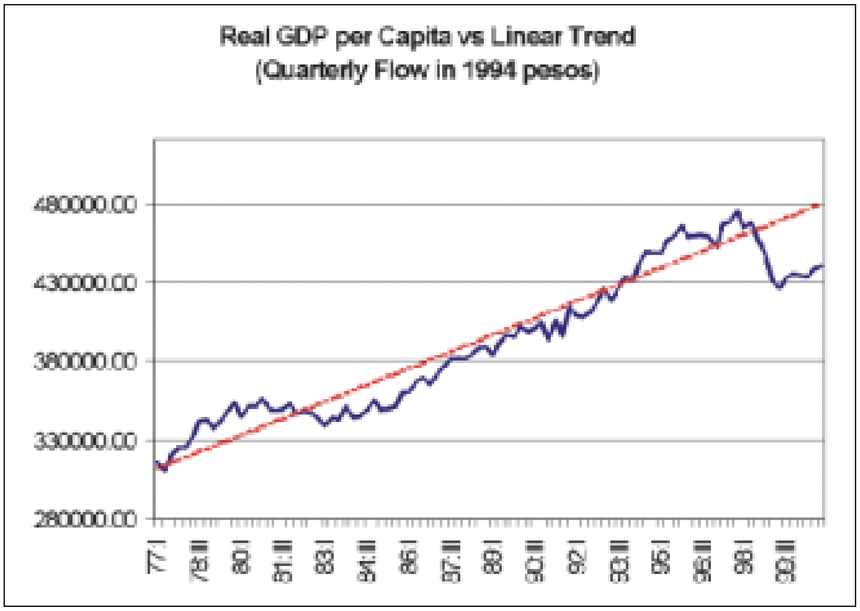


Figure 1b

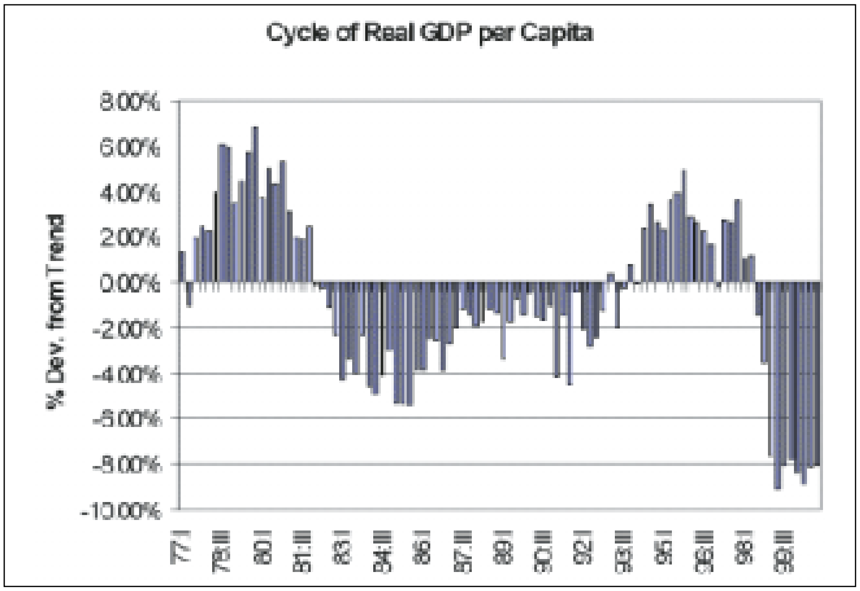


Figure 2

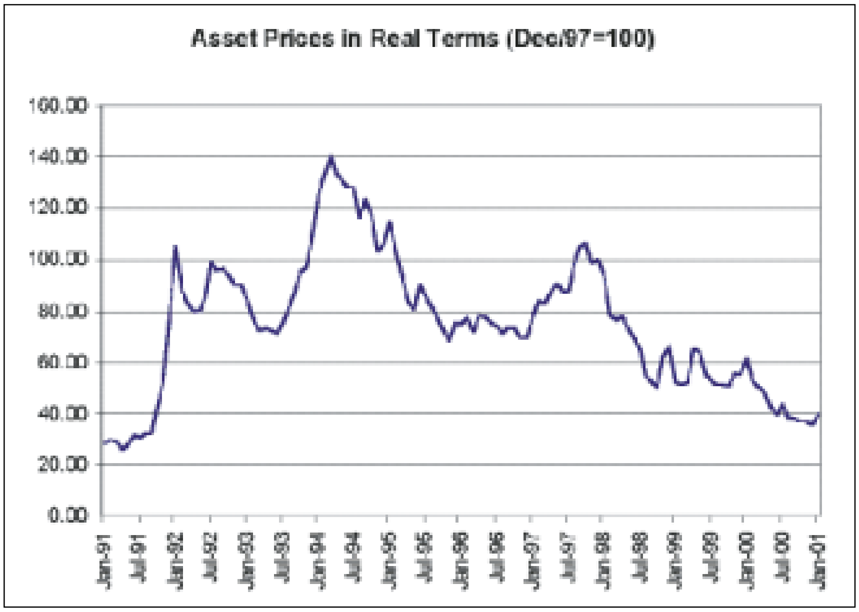


Figure 3

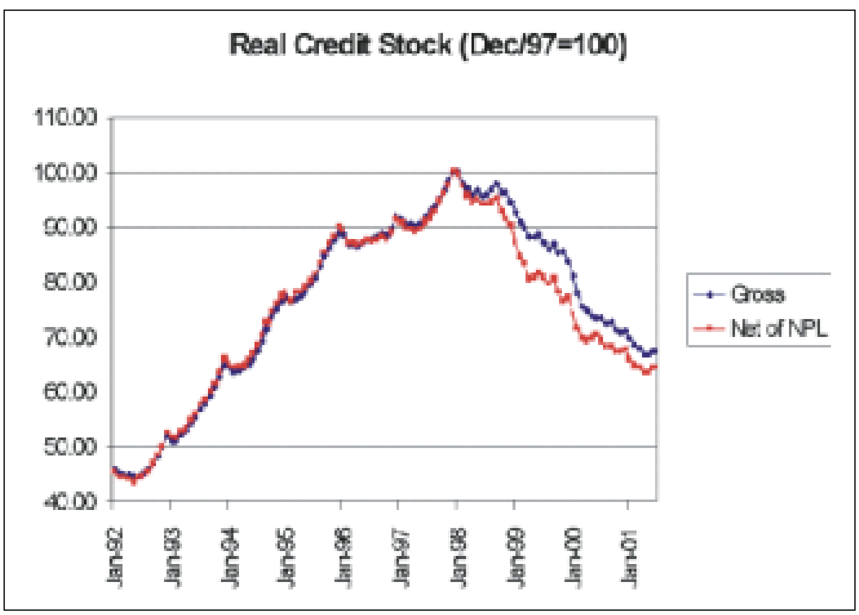


Figure 4

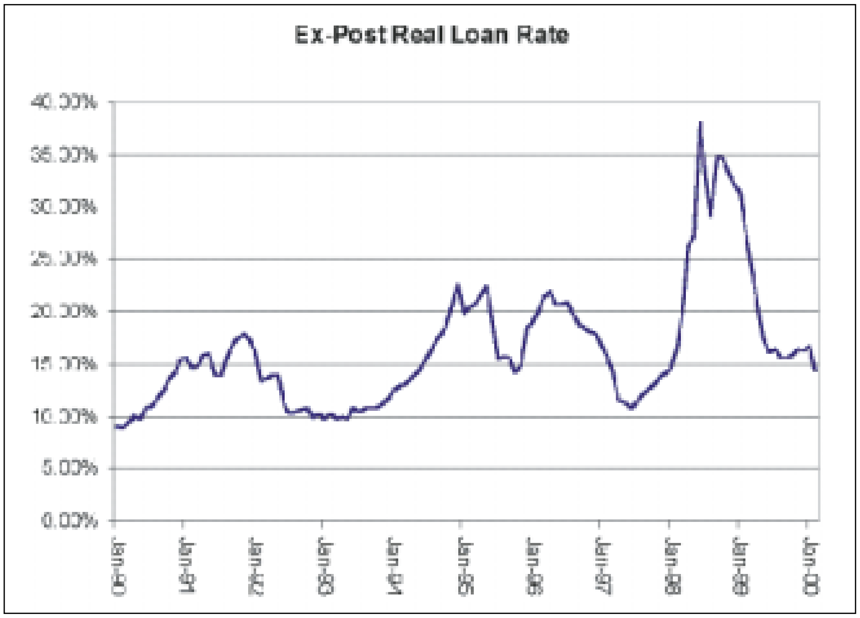


Figure 5

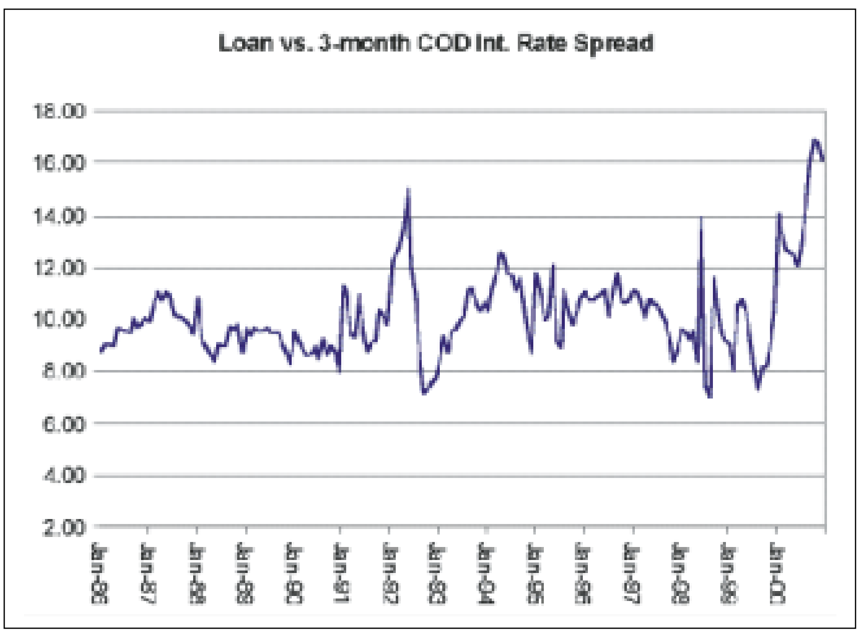


Figure 6

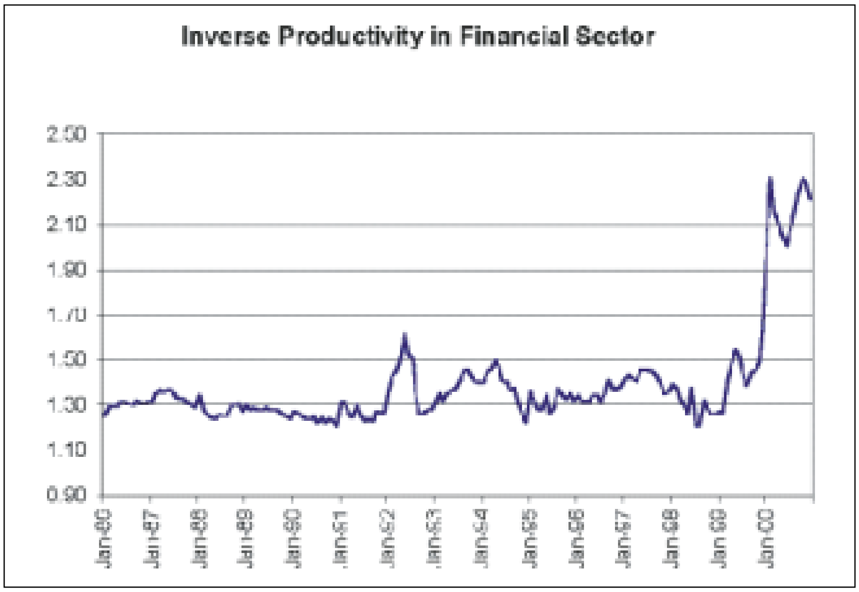


Figure 7

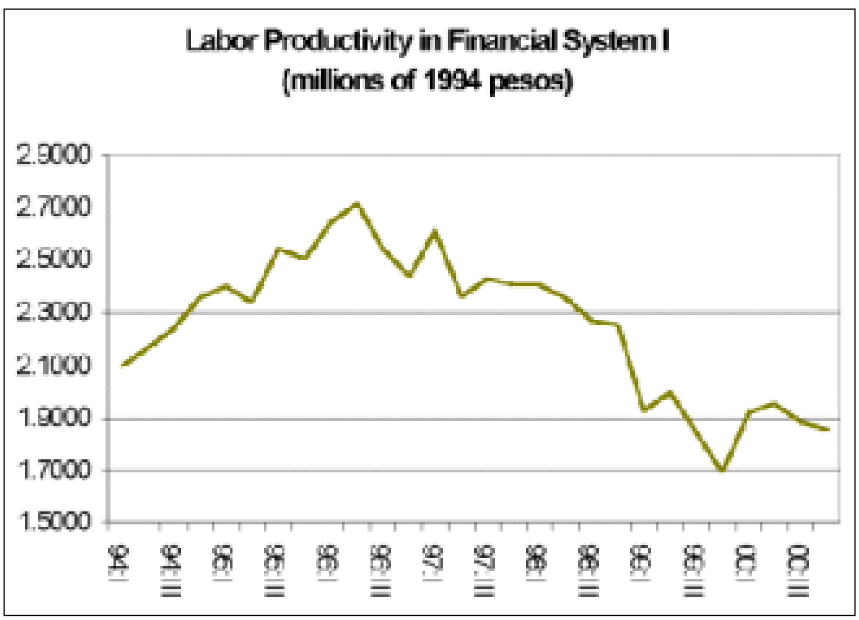


Figure 8

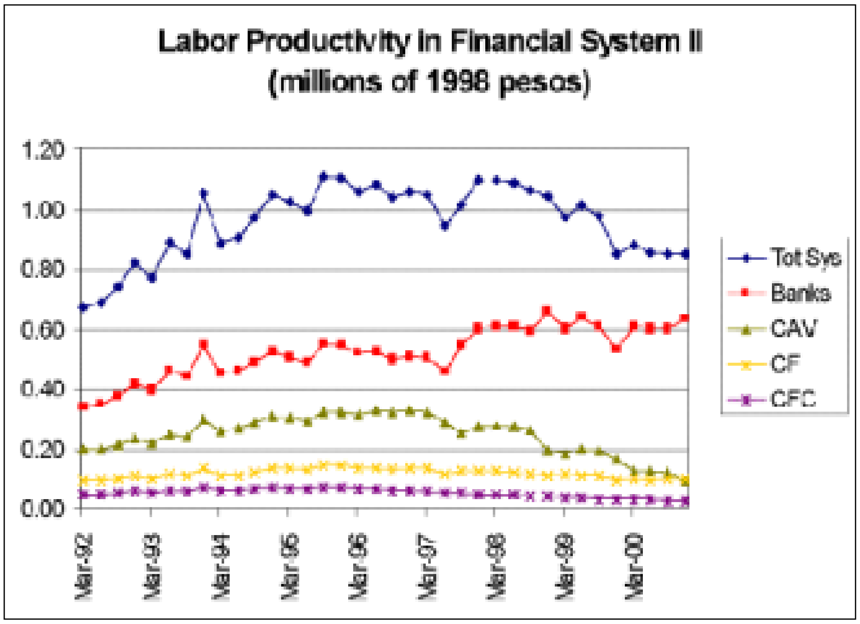


Figure 9a

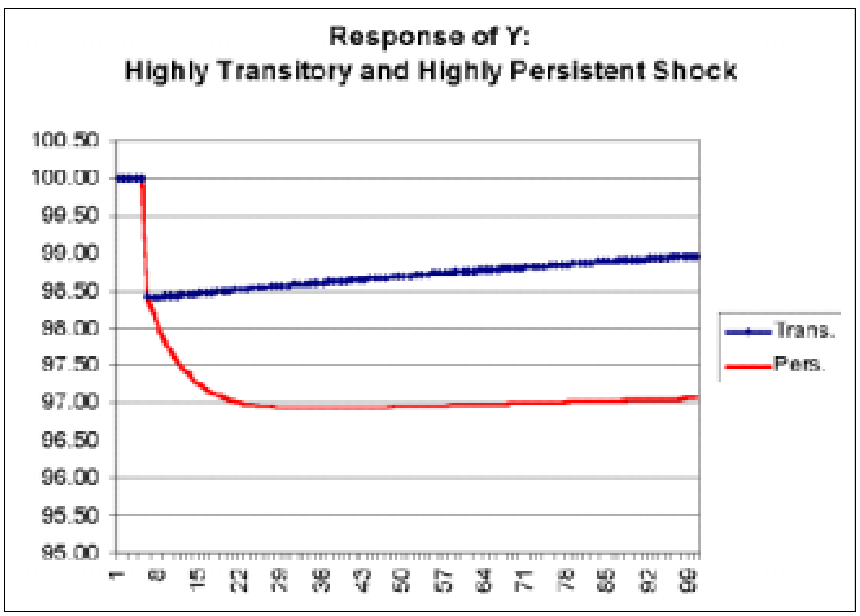


Figure 9b

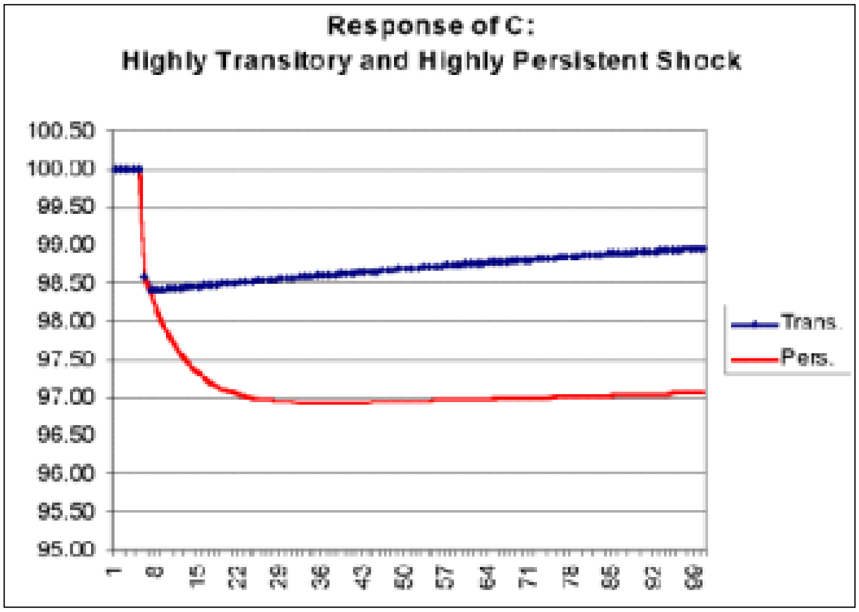


Figure 9c

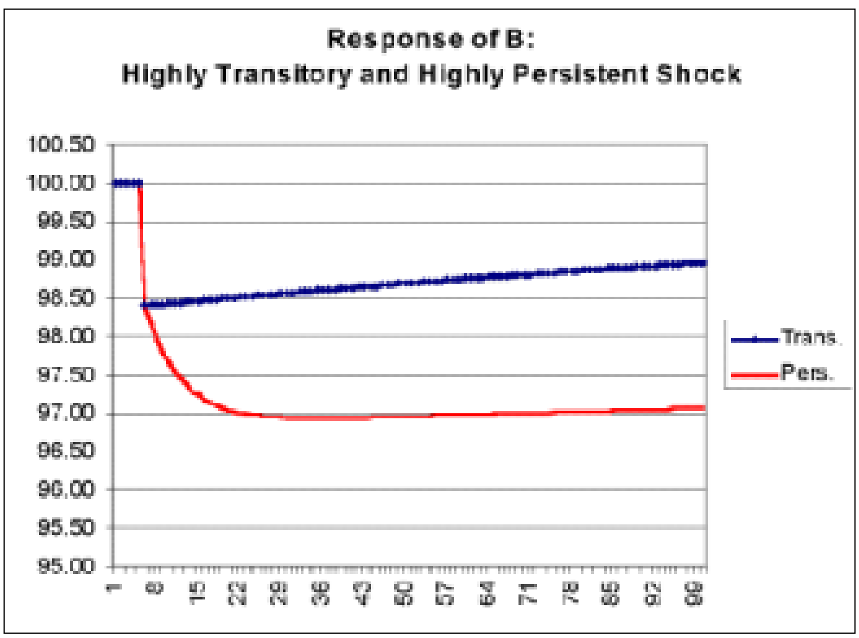
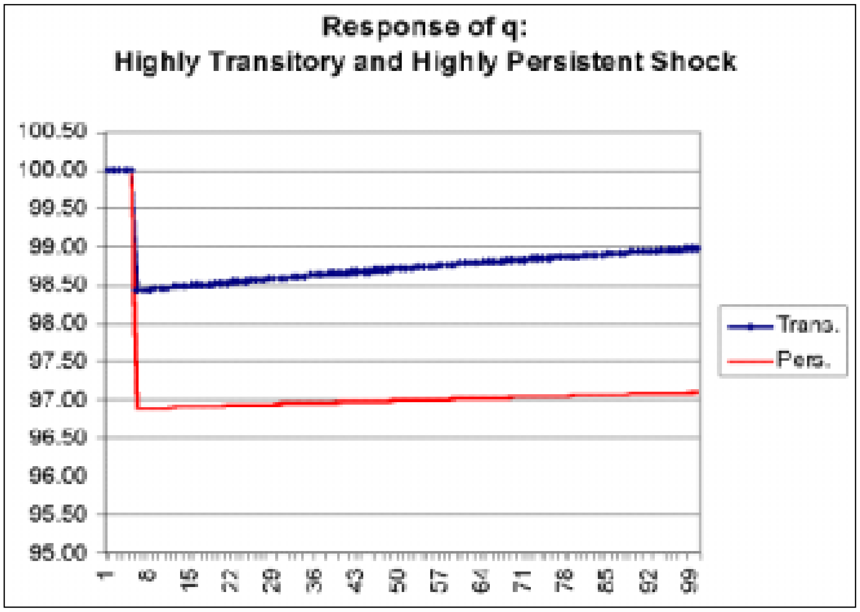


Figure 9d


Response of q:
Highly Transitory and Highly Persistent Shock
100.50
100.00
99.50
99.00
98.50
98.00
97.50
97.00
96.50
96.00
95.50
95.00
1
8
15
22
29
36
43
50
57
64
71
78
85
92
99
Trans.
Pers.