THE COLOMBIAN BANKING CRISIS: Macroeconomic Consequences and What to Expect

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Abstract

While in the early nineties Colombia grew at rates exceeding 4% and was catalogued as one of the top emerging markets, in 1999 its economy fell 4%, its exchange rate regime (a target zone) collapsed and by June of 2000 its unemployment level peaked at 20.4%. This turn of events is clearly associated to an episode of financial distress and a troubled intermediary sector that has haunted the Colombian economy in the late 1990's. The purpose of this paper is to understand the macroeconomic consequences of the recent financial crisis in Colombia. I solve, calibrate and simulate a simple version of the optimal growth model where banks absorb real resources from the economy and are also vulnerable to crises. The results are useful because they replicate the recent behavior of several macroeconomic variables in Colombia. Moreover, they give some insight into what should be expected from these variables in the near future. There are two fundamental take aways. First, the negative wealth and welfare effects of the Colombian financial crisis are non-negligible and long lasting (five years approximately). Second, the data suggests that the crisis which permeated the Colombian financial system since the last months of 1997 or first months of 1998 has been deepened by another adverse financial shock that hit the Colombian intermediary sector in mid/late 1999.

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1. INTRODUCTION

Recent episodes of financial crises have painfully reminded us the importance of a sound financial system for successful economic performance[1]. The experience of Mexico in 1994 and the Asian crisis of 1997 illustrate the vulnerability of an economy to a fragile financial sector. Despite the fact that Thailand, Malaysia, Indonesia and South Korea all displayed strong macro fundamentals by that time, overinvestment, excessive risk-taking and poor regulation in their financial systems eventually spurred balance of payments crises in all these countries [see Krugman (1998), Corsetti et. al. (1998), Schneider and Tornell (1999)][2]. The economic consequences of these crises were unpleasant not only in the region but also in other countries because of contagion effects (e.g. Russia, Argentina and other Latin American countries).

More recent episodes of banking crises include Ecuador and Colombia. Systematic failures of banks in these two countries led their economies into deep recession and dramatic unemployment levels. This year Ecuador announced the abandonment of its currency and dollarization of its economy as a step towards economic and financial recovery. While in the early nineties Colombia grew at rates exceeding 4% and was catalogued as one of the top emerging markets, in 1999 its economy fell 4% and by June of 2000 its unemployment level peaked at 20.4%. The recent banking crisis in Colombia was also accompanied by a currency crisis. In 1999 its exchange rate regime (a target zone) collapsed and the exchange rate was allowed to float freely.

Sadly, the Colombian currency crisis seems to fit first generation models due to the fact that the country has been operating with serious macroeconomic misalignment in recent years. Indeed, Colombia abandoned its exchange rate regime in 1999 in the midst of a deep fiscal gap. In 1999 the fiscal deficit was 5.2% of GDP[3]. As a result, international financial markets lost confidence in the Colombian economy and its sovereign debt ranking was reduced. For example, Standard and Poors's reduced the sovereign debt ranking in two notches from BBB- to BB[4].

[1] The importance of the evolution of the financial system for successful economic performance has been widely documented in the literature [A good survey is found in Boyd and Smith (1995)].

[2] See also Kaminsky and Reinhart (1996) for a good empirical analysis of banking crises as a possible cause of balance of payments crises.

[3] Source: Banco de la Republica

[4] BBB: Adequate capacity to meet its financial commitments. However, adverse economic conditions or changing circumstances are more likely to lead to a weakened capacity of the obligor to meet its financial commitments.

Unfortunately, the financial crisis in Colombia enhanced its fiscal gap. In fact, the fiscal cost of the bail out is approximately 6%[5].

The Colombian case is the purpose of this paper. Specifically, I aim at understanding the macroeconomic consequences and possible duration of the recent banking crisis. I solve, calibrate and simulate a simple version of the optimal growth model where banks absorb real resources from the economy and are also vulnerable to crises. Specifically, the Colombian financial crisis is simulated. The results are useful because they replicate the recent behavior of several macroeconomic variables in Colombia. Moreover, they give some insight into what should be expected from these variables in the near future. It is important to highlight that explaining the cause of the crisis exceeds the ambition of this paper. My purpose is only to understand the macroeconomic consequences and possible duration of the recent banking crisis, independently of its cause.

The model has two sectors: i) a final good producing sector and ii) a banking sector. The banking sector operates as an intermediate good producer. Specifically, it uses deposits from the previous period and current labor to provide capital to the final good producing sector, which also demands labor. This approach is useful because it recognizes the fact that intermediation is a real activity that uses up real resources and not just an invisible entity or constraint on the economy. Moreover, this treatment allows me to avoid complicated bank motivating artifacts such as asymmetric information, moral hazard, CSV, Diamond's (1984) delegated monitoring or Diamond and Dyvbig's (1983) liquidity preference shocks. Intuitively, the approach means that all savings must be intermediated by a resource absorbing financial sector.

Additionally, the banking sector is subject to stochastic productivity shocks. Adverse stochastic productivity shocks to the intermediary sector are associated with episodes of banking crises or generalized financial distress in the economy. No doubt this is a very broad definition of what a banking or financial crisis is. Yet, it manages to capture the adverse effects of mismanagement, overinvestment, excessive risk taking, panics, poor regulation, unstable macroeconomic variables and a weak institutional structure in an economy's financial system. As we know, these illnesses are what usually trigger banking crisis phenomena. Consequently,

BB: Significant speculative characteristics but less vulnerable in the near term than other lower-rated obligors. However, it faces major ongoing uncertainties and exposure to adverse business, financial, or economic conditions which could lead to the obligor's inadequate capacity to meet its financial commitments.

[5] Source: Foresight Colombia, July 4, 2000.

it is reasonable to think that banking productivity falls during crisis episodes. An alternative interpretation follows Bernanke (1983). During banking crises there is a loss of intermediation capital which is simply bank-client private information that rises intermediation productivity. Thus, an adverse stochastic shock to the productivity of the financial system is a simple way to pin down the loss of intermediation capital during a banking crisis.

With and adverse stochastic productivity shock to the financial system I am not claiming that the only cause of the Colombian banking crisis is rooted in problems specific to the banking sector. I am not ruling out macroeconomic shocks as a possible trigger of the banking crisis. For instance, with an unstable macroeconomic environment bank managers probably are less productive in forecasting many of the relevant variables (interest rates, exchange rates, etc.) than in a stable economy. Productivity in the financial sector is not divorced from macroeconomic performance. For sure, both micro and macro elements had a role in the crisis. But this is not inconsistent with the way in which the crisis is engineered into the model. The only purpose of the shock to the financial sector is i) to recognize that a crisis occurred and ii) to pin that crisis down in a simple and tractable way. Recall that the goal of this paper is to analyze the macroeconomic consequences and duration of the recent banking crisis in Colombia, independently of its cause.

The paper proceeds as follows. In the next section some facts regarding the Colombian financial crisis are reviewed. Section three presents the theoretical model. In section four the model is solved after being calibrated for the Colombian economy. The business cycle properties of the economy are also discussed in that section. In section five the Colombian financial crisis is simulated. The last section concludes.

2. FACTS

2.1. Precedents

Troubled banking systems have always been around. From the long history of financial crises, those documented in the literature as generators of unemployment, reduction in growth and instability are numerous. The most notorious example is the Great Depression (1929-1933) in the US[6]. Other examples include[7]:

- Argentina: 71 of 470 financial institutions were liquidated between 1980 and 1982.
- Chile: Between 1981 and 1983 the government liquidated or intervened 45% of the financial system's assets. In September of 1988 the central bank held bad bank loans equivalent to 19% of GNP.
- Spain: Between 1978 and 1983 the government had to rescue intermediaries holding 20% of total deposits.
- US.: During the period 1981-1988, 1100 Savings and Loan institutions (S&L) were closed or merged. By 1989, 600 more were insolvent. These had total assets above $250 billion. Their insurer, the Federal Savings and Loan Insurance Corporation, had a capital deficit of $14 billion by the end of March 1987. In March 1990, 290 thrift institutions with assets totaling $130 billion were in conservatorship.
- US.: From 1985 to 1989, 803 banks insured by the Federal Insurance Deposit Corporation and with assets totaling $100 billion failed or were merged.

Demirguc-Kunt and Detragiache (1997) identify and date more than 30 episodes of banking sector distress during the period 1980-1995[8]. Their list is perplexing for it shows an immense variety of countries that have been exposed to periods of systematic bank failures. It seems that financial crises have infected all sort of countries no matter their size, geographic location, level of economic development

[6] Many authors argue that one of the main causes of the Great Depression was the systematic failure and suspension of banks. For instance, Bernanke (1983) claims that the severity of the loss of intermediation capital (bank-client private information that rises intermediation productivity) resulting from bank suspensions and failures was a fundamental factor behind the Depression. Other authors [Cole and Ohanian (2000)] find that banking shocks account only for a small fraction of the Depression.

[7] This information was obtained from Garber and Weisbrod (1992).

[8] Their list includes Colombia (1982-1985), Finland (1991-1994), Guyana (1993-1995), Indonesia (1992-1994), India (1991-1994), Israel (1983-1984), Italy (1990-1994), Jordan (1989-1990), Kenya (1993), Sri Lanka (1989-1993), Mexico (1982, 1994), Mali (1987-1989), Malaysia (1985-1988), Nigeria (1991-1994), Norway (1987-1993), Nepal (1988-1994), Philippines (1981-1987), Papua New Guinea (1989-1994), Portugal (1986-1989), Senegal (1983-1988), Sweden (1990-1993), Turkey (1991, 1994), Tanzania (1988-1994), U.S. (1981-1992), Uganda (1990-1994), Uruguay (1981-1985), Venezuela (1993-1994), South Africa (1985).

or per-capita GDP. Logically, some of these episodes of financial distress were more severe than others. Surely, their adverse macroeconomic effects were also diverse in magnitude and persistence.

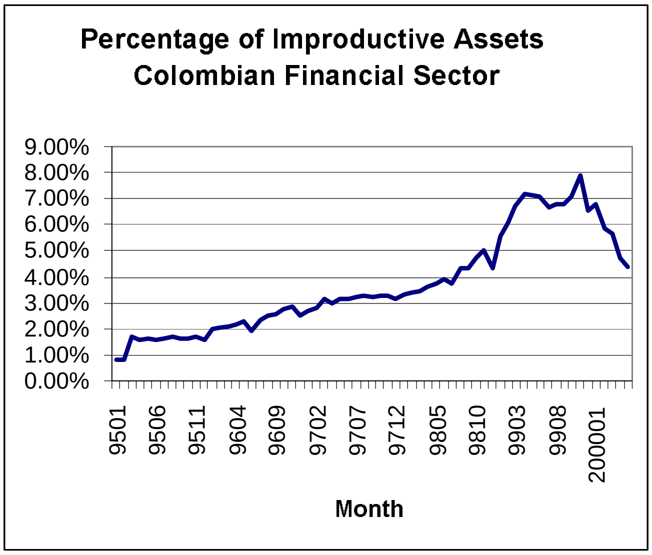
2.2. The Recent Colombian Case

Recently, Colombia has been experiencing big troubles in its intermediary sector. A considerable percentage of its financial system has presented vulnerability to failing or has actually failed. Those banks and financial institutions that have failed and several others that presented unhealthy balance sheets have been intervened by the government in bail-out or capitalization operations. The following table presents those institutions that were recently capitalized by the government. Capitalization began in July 1999. The stock of assets is the one presented in May 2000. These institutions received a credit line from FOGAFIN and continue to operate. Several other institutions were completely liquidated and ended their operations. Note that more than 30% of the financial system's stock of assets has been capitalized. Nine percentage points correspond to the private sector.

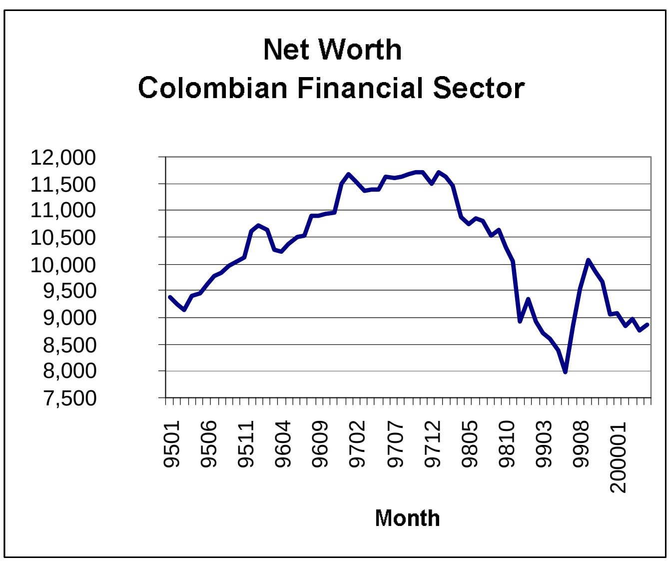
Capitalization of Financial Institutions since July 1999

PRIVATE	ASSETS (millions of pesos)	Percentage of Total Assets
Unión	305,074	0.39%
Superior	557,513	0.71%
Colpatria	2,683,415	3.43%
Interbanco	512,934	0.66%
Crédito	1,059,856	1.35%
Megabanco	1,374,298	1.76%
Coltefinanciera	229,456	0.29%
Multifinanciera	32,137	0.04%
Cofinorte	242,634	0.31%
Credinver	26,307	0.03%
Total Private	7,023,624	8.98%
PUBLIC		
Estado	1,422,447	1.82%
Agrario	3,076,000	3.93%
Bancafé	5,145,481	6.58%
Granahorrar	4,195,315	5.36%
IFI	2,698,720	3.45%
FES	314,285	0.40%
Total Public	16,852,249	21.54%
TOTAL	23,875,872	30.52%

In short, the last two years can be described as an episode of generalized financial distress in the Colombian economy. The following two graphs are illustrative of the Colombian financial crisis. The first graph presents the evolution of the percentage of unproductive assets in the Colombian financial sector during the period January/1995 - May/2000. This percentage has been rising steadily since 1995. Yet, in early 1998 it started to rise faster and peaked in November of 1999 at 7.9%. In the last months the percentage of unproductive assets has declined to a level close to 4.5%. This behavior is representative of troubled financial systems.



The second graph shows the evolution of the Colombian financial sector's net worth during the period, January /1995 - May/2000 (in thousands of millions of 1999 pesos). Starting in the first months of 1998 the Colombian financial sector has been experiencing a dramatic fall in its net worth. Note also that the data shows no signs of reversal in this downward trend. Again, this phenomenon reflects the episode of generalized finacial distress which the Colombian economy has been going through in the last two years.



Whether the Colombian financial crisis is over or not is a question that remains to be answered. A simple inspection of the previous graphs indicates that the crisis is not over yet. Indeed, the percentage of unproductive assets in the financial system has not fallen to pre-1995 levels. Additionally, the financial sector's net worth continues to fall in real terms. Also, at the time this paper is being written some financial institutions are still on the verge of failure. Hence, it seems safe to assume that the Colombian financial crisis is not over.

Any episode of generalized financial distress spreads to the rest of the economy through the main macroeconomic variables. While in the early nineties Colombia grew at rates exceeding 4% and was catalogued as one of the top emerging markets, in 1999 its economy fell 4%. Its exchange rate regime (a target zone) also collapsed during the same year and by june of 2000 its unemployment level peaked at 20.4%. Hence, the recent behavior of relevant macroeconomic variables in Colombia is key, especially if the crisis is not over yet. By comparing their behavior with the behavior expected under a theoretical model that replicates the crisis, we can predict the movement of these variables in the near future.

I focus on nine variables i) non financial output, ii) financial output, iii) GDP, iv) consumption, v) percentage of employment allocated to the non-financial sector, vi) wage, vii) deposit rate, viii) lending rate and ix) interest rate spread. Appendix 1 presents graphs with the quarterly evolution of the natural log of these variables for the period 1994:I - 2000:I[9]. The data was HP filtered to eliminate their trend so that it is possible to concentrate only on their respective cyclical fluctuations[10]. Positive and negative values indicate above and below trend percent deviations. The following facts are observed:

- Contraction of non-financial output starting in the second quarter of 1998. In the second quarter of 1999 it started to recover but by the first quarter of 2000 it was still halfway below the previous peak.
- Contraction of financial output starting in the last quarter of 1996. By the first quarter of 2000 it was still falling.
- Contraction of GDP starting in the last quarter of 1997. In the second quarter of 1999 it started to recover but by the first quarter of 2000 it was still more than halfway below the previous peak.

[9] All these variables (except vi) are in real terms (and the first four variables are in thousands of millions of 1994 pesos).

[10] As Hodrick and Prescott recommend, a value of $\lambda = 1600$ was used in order to eliminate cycles of frequency higher than 32 periods (i.e. 8 years).

- Contraction of consumption starting in the last quarter of 1997. In the second quarter of 1999 it started to recover but by the first quarter of 2000 it was still very close to the preceding trough.
- Fall of the real wage index starting in the third quarter of 1997. In the first quarter of 1999 it recovered significantly but did not achieve the level of the previous peak. In the fourth quarter of 1999 it started to fall again.
- Very small fluctuations of the percentage of employment allocated to the non-financial sector.
- Fall of the real deposit rate starting in the third/fourth quarter of 1996. Then, in the third/fourth quarter of 1997 it started to rise and reached, by the first quarter of 1999, a higher level than the previous peak level. Then it started to fall again.
- Hike of the real loan rate starting in the fourth quarter of 1997. By the first quarter of 1999 it reached a new and higher peak but started to fall again.
- High rise of the real interest rate spread when comparing the first quarter of 2000 with the fourth quarter of 1997.

These facts surely characterize the environment of financial distress under which the Colombian economy is operating. They depict an unhealthy intermediary system whose symptoms began to show up towards the end of 1996 but that definitely exploded in 1998/1999. Furthermore, the macroeconomic facts indicate that today the financial system is still under trouble. Ideally, any model that simulates the Colombian financial crisis should replicate these observed qualitative features in the main macroeconomic variables. One such model is to be developed in the next section.

3. MODEL

3.1. Literature

Two traditions can be distinguished in the literature that incorporates banks into growth models. The first tradition follows Diamond (1965) and uses an overlapping generation (OLG) structure. Two examples of such class of models are presented in Bhattacharya et. al. (1994) and Boyd and Smith (1995). Bhattacharya et. al. motivate banks by assuming spatial separation and stochastic relocation among agents. The possibility of stochastic relocation among agents plays the same role as Diamond and Dybvig's (1983) liquidity preference shocks. Thus, banks arise to insure against random liquidity needs coming from stochastic relocation. Competition among banks for depositors forces banks to chose return schedules and portfolio allocations so as to maximize the expected utility of a representative depositor. On the other hand, Boyd and Smith model banks by differentiating between an observable (low average) return investment technology and an unobservable (high average) return capital accumulation technology that is also subject to costly state verification (CSV). The authors associate the intensive use of the unobservable technology to financing investment with bank loans whereas the use of the observable technology corresponds to investment financed with equity issues.

The second tradition of growth models with banking falls into the class of real business cycle (RBC) models. Three of such models are those by Diaz-Gimenez et. al. (1992), Carlstrom and Fuerst (1995) and Chari et. al (1995). In the Diaz-Gimenez et. al. model banks pool household's savings and make two types of loans. First, they lend to other households that want to borrow. Second, they buy government issued interest-bearing debt. Specifically, the bank solves a static maximization problem where the objective function is its end of period stock of assets. Carlstrom and Fuerst motivate their banking sector by introducing a cash-in-advance constraint on the wage bill paid by firms. Hence, the intermediary accepts deposits from households, receives a monetary injection from the central bank and loans out all this cash to firms so that wage bills can be paid. Chari et. al. introduce banks by assuming two types of capital and that one of them must be intermediated by the banking system. In the last two cases the objective function of the bank is its instantaneous profit.

Yet, none of these models addresses the issue of banking or financial crises[11]. Furthermore, these models assume that the intermediary sector does not use resources from the economy. This boils down to assuming that the intermediary is simply a constraint on the economy [Chari et. al. (1995)][12]. In reality, a finan-

[11] The reason is that these papers study other issues: i) the role of equity (as opposed to bank loan) financed investment in the economic growth process [Boyd and Smith (1995)]; ii) budget deficits as the cause of indeterminacy of monetary equilibria and the use of reserve requirements to eliminate the undesirable steady states [Bhattacharya et. al. (1994)]; iii) welfare costs of alternative monetary and tax policies [Diaz-Gimenez et. al. (1992), Carlstrom and Fuerst (1995)]; iv) the real effects of following a procyclical interest rate policy rule [Diaz-Gimenez et. al. (1992)]; v) the negative correlation between inflation and growth [Chari et. al (1995)].

[12] Some dynamic models do assume that banks need resources from the economy in order

cial sector operates with real resources from the economy (labor and capital). In practice, banks carry out a variety of costly activities in order to maintain certain level of deposits and loans (e.g.: evaluating creditors, managing deposits, renting buildings, maintaining ATM's, etc.) [Edwards and Vegh (1997)]. For example, in the US. between January of 1990 and January of 2000 more people were employed in the finance, insurance and real estate (FIRE) sector than in the construction sector. Also, during the same period employment in the FIRE sector was approximately one third of total employment in the Manufacturing sector[13]. In Colombia, the financial sector absorbs approximately 8% of employment.

3.2. Theoretical Model

In this model the economy is populated by an infinite number of agents. Each atomistic agent is endowed with one unit of labor which he/she supplies inelastically. There is no population growth. Instantaneous utility of each agent is $U(C_t)$ where C_t is consumption. Agents discount the future with factor β. I assume that $U(C_t)$ is well-behaved and exhibits local non-satiation. There is a final good (say, corn). It is produced with capital and labor according to the neoclassical production function $F(K_t, N1_t)$ where K_t and $N1_t$ are the total stock of capital and labor used by the final good producing firm (firm hereafter). Now, the capital stock used by the firm is not the same good as the final good (i.e. it is not corn). Instead, it is an intermediate good produced by a banking sector. This sector uses savings of the final good (in the form of deposits from the previous period) and labor as inputs.

Simply put, the intermediary sector pools final good that agents decided to save in the previous period and (with some labor) produces an intermediate good (called capital) that serves as input for final good production. Banks operate with the neoclassical production function $G(D_t, N2_t)$ where D_t represents total deposits of final good and $N2_t$ is labor used in the banking sector. This framework implies that banks must intermediate all the savings. Note also that the stock of deposits in any given period t is determined in $t-1$. Clearly, the dynamics of the model come from deposits. I will first focus on the planning problem and then present the proper decentralization.

to operate. Two excellent examples are Cole and Ohanian (2000) for a closed economy and Edwards and Vegh (1997) for a small, open economy.

[13] Source: US Dept. of Labor, Bureau of Labor Statistics.

3.2.1. The Planning Problem

When the social planner wakes up every day she knows the stock of deposits. She also knows that she has one unit of labor to allocate between the two sectors of the economy. Once she observes the stochastic shock (the amount of rain over the bank) she decides how much labor to allocate to each sector. Since the stock of deposits is given, once labor allocations are determined the output of both sectors is also determined. The planner then decides how much final output will be allocated to consumption and how much will be carried over in the form of deposits to the next period. Mathematically, the planner faces the following sequential problem:

$$Max_{\{C_t, D_{t+1}, N1_t, N2_t\}} \quad E_0 \sum_{t=0}^{\infty} \beta^t U(C_t)$$

$s.t.$

$C_t + D_{t+1} \leqslant F(K_t, N1_t)$

$K_t \leqslant e^{z_t} G(D_t, N2_t)$

$N1_t + N2_t \leqslant 1$

$z_{t+1} = \rho z_t + \varepsilon_{t+1}$

$\varepsilon_{t+1} \backsim N(0, \sigma_\varepsilon^2)$

where z_t is the stochastic shock to which the banking sector is subject. The corresponding dynamic programming problem is given by:

$$\begin{aligned} V(D,z) &= Max_{D',N1} \left\{ U\left[F(K,N1) - D'\right] + \beta E V(D',z') \right\} \\ & \quad s.t. \\ K &= e^z G(D, 1-N1) \\ z' &= \rho z + \varepsilon', \quad \varepsilon' \backsim N(0, \sigma_\varepsilon^2) \end{aligned} \tag{P1}$$

First order conditions to this problem are:

$$D' : U'(C) = \beta E V_1(D', z') \tag{1}$$

$$N1 : U'(C)[F_2(K,N1) - F_1(K,N1)e^z G_2(D, 1-N1)] = 0 \tag{2}$$

The envelope condition is:

$$D : V_1(D,z) = U'(C) F_1(K,N1) e^z G_1(D, 1-N1) \tag{3}$$

Combining these three equations yields two optimality conditions:

$$F_2(K, N1) = F_1(K, N1)e^z G_2(D, 1 - N1) \tag{4}$$

$$U'(C) = \beta E \left[U'(C')F_1(K', N1')e^{z'} G_1(D', 1 - N1') \right] \tag{5}$$

Condition (4) shows that along an optimal path the planner will equate the marginal productivity of labor (in terms of final good) across both sectors in each period. Condition (5) is simply the Euler equation for this economy. If the planner allocates one unit of final output to consumption today she obtains $U'(C)$ additional units of happiness. If instead she carries that unit of final output to the next period in form of deposits, she obtains $F_1 e^z G_1$ units of additional output tomorrow, each producing $\beta U'(C')$ units of current additional happiness. Optimality implies that the planner must equate both such magnitudes in the margin.

Let $(K^*, D^*, N1^*)$ be the steady state of the non-stochastic version of the model. The steady state is defined by the following system of equations:

$$F_2(K^*, N1^*) = F_1(K^*, N1^*)G_2(D^*, 1 - N1^*) \tag{6}$$

$$1 = \beta F_1(K^*, N1^*)G_1(D^*, 1 - N1^*) \tag{7}$$

$$K^* = G(D^*, 1 - N1^*) \tag{8}$$

Note that equations (6)-(8) constitute a system of three equations in three unknowns $(K^*, D^*, N1^*)$ which correspond to the steady state. This system is derived by evaluating equations (4) and (5) and the definition of capital in $(K^*, D^*, N1^*)$. Steady state $(K^*, D^*, N1^*)$ is very important since it is a key ingredient for the methods employed in this paper when solving for the optimal decision rules $D'(D, z)$ and $N1(D, z)$ in the stochastic, non-stationary environment.

Now, computing the solution to the stochastic, non-stationary planning problem yields Pareto optimal allocations. Since the welfare theorems go through, Pareto optimal allocations can also be supported with relative prices in a properly decentralized, market environment. This is the purpose of the next section.

3.2.2. Recursive Competitive Equilibrium

A recursive competitive equilibrium will be used to decentralize the planner's problem. This is an easy way to support the Pareto optimum given the recursive nature of the planner's problem. In this setup there are three types of players: i) households, ii) final good producing firms and iii) banks. Additionally, there are four markets: i) deposits market (bank demands, households supply); ii) capital (or intermediate good) market (firm demands, bank supplies); iii) final good market (households demand, firm supplies); iv) labor market (firm and bank demand, agents supply).

Each household solves the following dynamic programming problem:

$$
\begin{aligned}
V(d, D, z) &= Max_{d'} \left\{ U\left[w(D, z) + R(D, z)d - d'\right] + \beta EV(d', D', z') \right\} \quad \text{(P2)} \\
& \quad s.t. \\
D' &= J(D, z) \\
z' &= \rho z + \varepsilon', \quad \varepsilon' \sim N(0, \sigma_\varepsilon^2)
\end{aligned}
$$

where d is the household's stock of deposits, D is the aggregate (per-capita) stock of deposits in the economy, $J(D, z)$ represents its law of motion, $w(D, z)$ is the wage and $R(D, z)$ is the gross rental rate of deposits. Note that D and z are aggregate state variables while d is an individual state variable. Intuitively, from the household's perspective d is something to be determined while D is simply an exogenous variable over which it does not have any influence. The distinction between d and D is fundamental to the notion of competitive equilibrium. Since individual agents cannot influence relative prices due to their atomistic nature, only aggregate state variables will determine the evolution of prices. Thus, w and R can only depend on D and z and not on d.

The final good producing firm solves the following static problem:

$$
Max_{k^f, h^f} \left\{ F(k^f, h^f) - w(D, z)h^f - p(D, z)k^f \right\} \quad \text{(P3)}
$$

where k^f and h^f represent the firm's demand of capital and labor. On the other hand, the bank solves the following static problem:

$$
Max_{d^b, h^b} \left\{ p(D, z)G(d^b, h^b) - w(D, z)h^b - R(D, z)d^b \right\} \quad \text{(P4)}
$$

where $P(D, z)$ is the relative price of banking output (i.e. capital) while d^b and h^b represent the intermediary's demand for deposits and labor. Again, note that the relative price of the bank's output depends only on aggregate state variables.

Definition 3.1. A recursive competitive equilibrium is:

1. A value function $V(d, D, z)$
2. An individual decision rule: $d'(d, D, z)$.
3. A set of demands for the final good producing firm: $k^f(D, z)$ and $h^f(D, z)$.
4. A set of demands for the bank: $d^b(D, z)$ and $h^b(D, z)$.
5. A set of pricing functions: $w(D, z)$, $R(D, z)$ and $P(D, z)$.
6. An aggregate decision rule: $J(D, z)$.

such that

- Given (5) and (6), (1) and (2) solve P2.
- Given (5), (3) solves P3.
- Given (5), (4) solves P4.
- Markets clear $\Longrightarrow$
  1. $h^f(D, z) + h^b(D, z) = 1$
  2. $k^f(D, z) = G[D, h^b(D, z)]$
  3. $d^b(D, z) = D$
- Perceptions are correct $\Longrightarrow d'(D, D, z) = J(D, z)$

Note that $P(D, z) - 1$ can be interpreted as the loan rate while $R(D, z) - 1$ corresponds to the deposit rate. In equilibrium both rates are tied through an optimality condition of the bank:

$$p(D, z)G_1[D, h^b(D, z)] = R(D, z)$$

It is interesting to note that the interest rate spread of the economy (P/R) is given by the inverse of the marginal productivity of deposits. The intuition underlying this result is simple. The higher the marginal productivity of deposits, the lower the interest rate that the bank can charge and the higher the deposit rate it will recognize in order to satisfy its zero-profit condition.

4. SOLUTION TO THE MODEL

4.1. Calibration

Consider the following functional forms:

- $U(C_t) = \frac{C_t^{1-\theta}}{1-\theta}$
- $F(K_t, N1_t) = K_t^{\alpha} N1_t^{1-\alpha}$
- $G(D_t, N2_t) = D_t^{\gamma} N2_t^{1-\gamma}$

In the previous section I showed that Pareto optimal allocations can be supported with relative prices in a properly decentralized, market environment. Hence, rather than solving the recursive competitive equilibrium I will compute the solution to the planning problem. Whenever relative prices are of interest, the recursive competitive equilibrium will be invoked.

Recall that the planner's optimum is described by equations (4) and (5). In this example, these equations are:

$$(1-\alpha)K^{\alpha}N1^{-\alpha} = [\alpha K^{\alpha-1}N1^{1-\alpha}][e^{z}(1-\gamma)D^{\gamma}(1-N1)^{-\gamma}] \tag{4'}$$

$$C^{-\theta} = \beta E\{C'^{-\theta}[\alpha K'^{\alpha-1}N1'^{1-\alpha}][e^{z'}\gamma D'^{\gamma-1}(1-N1')^{1-\gamma}]\} \tag{5'}$$

Condition (4') depicts labor allocation efficiency and condition (5') is just the Euler equation for this economy. The steady state of the non-stochastic version of the model is defined by equations (6)-(8). Under this scenario this system of equations is:

$$(1-\alpha)\overline{K}^{\alpha}\overline{N1}^{-\alpha} = \alpha(1-\gamma)\overline{K}^{\alpha-1}\overline{N1}^{1-\alpha}\overline{D}^{\gamma}(1-\overline{N1})^{-\gamma} \tag{6'}$$

$$1 = \beta\alpha\gamma\overline{K}^{\alpha-1}\overline{N1}^{1-\alpha}\overline{D}^{\gamma-1}(1-\overline{N1})^{1-\gamma} \qquad 7'$$

$$\overline{K} = \overline{D}^{\gamma}(1-\overline{N1})^{1-\gamma} \tag{8'}$$

Equations (6')-(8') constitute a system of three equations in $(\overline{K}, \overline{D}, \overline{N1})$ which is the steady state of the model. Steady state $(\overline{K}, \overline{D}, \overline{N1})$ is very important because it is a fundamental component of the tools employed in this paper to solve for the optimal decision rules $D'(D,z)$ and $N1(D,z)$ in the stochastic, non-stationary version of the model.

Appendix 2 presents the way in which the parameters of this model (α, β, γ) can be calibrated to fit some empirical features observed in the Colombian economy. Quarterly data from 1994 to 2000 was used. The following features were employed: i) In average, the fraction of total labor allocated to non-financial sectors is 91.9%, and ii) in average the ratio of deposits to non-financial output is 1.63. Due to lack of appropriate data, the following assumption was necessary : the elasticity of non-financial output to capital is 0.51. The following parameter values result[14]:

α	0.51
γ	0.91532
β	0.90821

To estimate the parameters of the stochastic process driving z $(\rho, \sigma_\varepsilon^2)$ I use as proxy the cyclical component of the (natural log of) financial output. Assuming that this variable is stationary, the following values result:

ρ	0.8772
σ_ε^2	0.0151

Certainty equivalence holds in the tools employed to solve the model. Thus, the values for $(\rho, \sigma_\varepsilon^2)$ do not affect the solution (i.e. decision rules) of the model. Hence, the assumption about the values of $(\rho, \sigma_\varepsilon^2)$ is sensible enough to simulate the financial crisis yet it does not change the equilibrium path of the model. It is important to highlight that the specific quantitative calibration of the model is not fundamentally important for this paper. Beyond quantitative results, it is qualitative insights what I am after. Besides very general quantitative conclusions, this paper will be limited to the qualitative understanding of the macroeconomic effects of the Colombian financial crisis.

4.2. Solving the Model

Recall the planning problem (P1):

[14] Since θ cannot be calibrated from the steady state equations, a value of $\theta = 2.0$ is assumed. Other values for θ were used but the qualitative results are not sensible to changes in this parameter value.

$$
\begin{aligned}
V(D,z) &= Max_{D',N1}\{U[F(K,N1)-D'] + \beta EV(D',z')\} \\
&\quad s.t \\
K &= e^z G(D,1-N1) \\
z' &= \rho z + \varepsilon', \quad \varepsilon' \vee N(0,\sigma_\varepsilon^2)
\end{aligned} \tag{4.1}
$$

As with any dynamic programming problem, we make an initial guess $V_0(D,z)$ and then iterate on the value function until a fixed point $V(D,z)$ is found. Blackwell's sufficient conditions for a contraction and the contraction mapping theorem guarantee the existence of a unique fixed point $V(D,z)$. Note that (P1) can be simplified to:

$$
\begin{aligned}
V(D,z) &= Max_{D',N1}\{U[F(e^z G(D,1-N1),N1)-D'] + \beta EV(D',z')\} \\
&\quad s.t. \\
z' &= \rho z + \varepsilon', \quad \varepsilon' \vee N(0,\sigma_\varepsilon^2)
\end{aligned}
$$

Given that the law of motion for z is linear, a quadratic approximation to the utility function around $(\overline{D},\overline{N1})$ facilitates the solution to Bellman's equation in (P1). In fact, this method of solution is called the linear-quadratic method and yields linear decision rules for the control variables $(D',N1)$ as functions of the state (D,z). Before proceeding with the linear quadratic method, an analytical solution for $(\overline{D},\overline{N1})$ must be obtained since it is around this point that the quadratic approximation to the return function in (P1) is implemented. From (8') in (7'):

$$1 = \beta\alpha\gamma[\overline{D}^{\gamma}(1-\overline{N1})^{1-\gamma}]^{\alpha-1}\overline{N1}^{1-\alpha}\overline{D}^{\gamma-1}(1-\overline{N1})^{1-\gamma}$$

After rearranging some terms this last equation becomes:

$$1 = \beta\alpha\gamma\overline{D}^{\alpha\gamma-1}(1-\overline{N1})^{\alpha(1-\gamma)}\overline{N1}^{1-\alpha}$$

Solving for $\overline{D}$ implies:

$$\overline{D} = \left[\frac{1}{\beta\alpha\gamma(1-\overline{N1})^{\alpha(1-\gamma)}\overline{N1}^{1-\alpha}}\right]^{\frac{1}{\alpha\gamma-1}} \tag{9}$$

From (8') in (6'):

$$\begin{aligned} & (1-\alpha)[\overline{D}^{\gamma}(1-\overline{N1})^{1-\gamma}]^{\alpha}\overline{N1}^{-\alpha} \\ = \; & \alpha(1-\gamma)[\overline{D}^{\gamma}(1-\overline{N1})^{1-\gamma}]^{\alpha-1}\overline{N1}^{1-\alpha}\overline{D}^{\gamma}(1-\overline{N1})^{-\gamma} \end{aligned}$$

Note that $\overline{D}$ drops out from the previous equation and the following equation results:

$$\overline{N1} = \frac{(1-\alpha)}{(1-\alpha\gamma)} \tag{10}$$

Using the calibrated parameters, the analytical steady state of the model, from (9) and (10) is:

$$\left[\overline{D}, \overline{N1}\right] = [0.1510, 0.9190] \tag{11}$$

With the analytical solution for $(\overline{D}, \overline{N1})$ and the corresponding quadratic approximation to the utility function around this point, the linear quadratic method solves (P1). 117 iterations on the value function were required to pin down the fixed point of Bellman's equation in (P1). The following linear decision rules for D' and $N1$ were obtained:

$$N1_t = 0.9190 \; \forall t \tag{12}$$

$$D_{t+1} = 0.0624 + 0.0658 z_t + 0.5868 D_t \tag{13}$$

Equation (12) shows that the fraction of total labor allocated to the final good producing sector (and, hence, to the financial sector) is constant over time. Stochastic productivity shocks to the bank do not induce a shift of labor across sectors. This feature is striking because it reveals that these shocks are completely absorbed by prices. The economics underlying this result is simple. A positive stochastic productivity shock to the banking sector increases the marginal productivity of its labor. However, this shock also increases the supply of banking output (i.e. capital). This brings down its relative price (p) and increases, ceteris paribus, the marginal productivity of labor in the final good producing sector. Thus, while the marginal productivity of labor has risen in both sectors, the movement in p

is such that the marginal productivity of labor in terms of final good (i.e. the wage) is equalized across both sectors without any change in labor allocations. Nevertheless note that the resulting wage level (or marginal productivity of labor in terms of final good) is higher.

Equation (13) simply depicts the path of deposit accumulation. Intuitively, deposits for next period increase with the current stochastic productivity parameter of the banking sector (z). Furthermore, this equation shows that in the absence of shocks deposits converge monotonically to their steady state level. Importantly, the steady state that is inferred from (12) and (13) coincides with the analytical steady state given in (11).

4.3. Business Cycle Properties of the Model

Before going on it is important to discuss the qualitative properties of the business cycle in this economy. I focus on nine variables i) non financial output, ii) financial output, iii) GDP, iv) consumption, v) percentage of employment allocated to final good production, vi) wage, vii) deposit rate, viii) lending rate and ix) interest rate spread. All these variables are in real terms and GDP, real wage and consumption are in terms of final good output. Given the realized value of z and the optimal values of $N1$, D and D', final good output, banking output, GDP and consumption can be computed in the following way:

- Banking output or capital stock $\Longrightarrow K = e^z D^\gamma (1 - N1)^{1-\gamma}$
- Final good output $\Longrightarrow Y = K^\alpha N1^{1-\alpha}$
- GDP $\Longrightarrow Y + pK$
- Consumption $\Longrightarrow C = Y - D'$

where p is the relative price of banking output or lending rate of the economy. Naturally, this lending rate as well as the wage (w) and deposit rate (R) do not come out of the planner's problem. However, given the optimal values for D and $N1$, wage, deposit rate and lending rate can be calculated invoking the recursive competitive equilibrium, in the following way :

- Lending rate (or relative price of banking output) $\Longrightarrow p = \alpha K^{\alpha-1} N1^{1-\alpha}$
- Deposit rate $\Longrightarrow R = pe^z \gamma D^{\gamma-1} (1 - N1)^{1-\gamma}$

- Wage $\Longrightarrow w = (1-\alpha)K^{\alpha}N1^{-\alpha} = pe^{z}(1-\gamma)D^{\gamma}(1-N1)^{-\gamma}$

With decision rules (12) and (13) and starting from steady state, the economy was simulated for 220 periods, 100 times. The first 100 observations of each simulation were discarded and the data was logged and filtered with the Hodrick and Prescott filter. Some statistics revealing the business cycle properties of the economy are reported in Appendix 3. Specifically, I report the sample mean across all simulations for the i) mean, ii) percent standard deviation, iii) contemporaneous correlations and iv) correlations with output (up to five lags and leads) of the deviations from the HP trend of the natural log of these nine variables in each simulation. The sample standard deviations of these statistics are also reported. These statistics are illustrative of business cycle properties if business cycles are defined as deviations of real economic activity from the Hodrick-Prescott trend. Simply put, regularities of the business cycle are the comovements of the deviations from trend of the different macroeconomic time series.

The business cycle properties of this economy are quite intuitive. First of all note that total GDP, final good output and banking sector output are perfectly correlated with each other. Nevertheless, production in the financial sector is two times more volatile than in the final good producing sector. This is not surprising given that the banking sector is directly exposed to a stochastic productivity shock while the final good producing sector is not. Consequently, this economy is one where the intermediary sector is much more unstable than the non-financial sector.

Turning to prices, note that the wage of this economy is procyclical and fluctuates as much as GDP. On the other hand, the lending rate is almost as volatile as GDP and more than one and a half times as volatile as the deposit rate. Additionally, the level of volatility of the spread between both interest rates is more than twice as high as that of the deposit rate and 30% higher than that of the lending rate. This is expected given that, in equilibrium, the spread is inversely related to the marginal productivity of deposits which, in turn, depends directly on the stochastic shock.

Note also that the deposit rate leads the cycle. This is a natural result given that the cycle of this economy is driven by shocks to the financial sector. In fact, a good shock to the banking sector increases the marginal productivity of deposits. Efficiency in the banking sector implies a contemporaneous rise in the deposit rate. This deposit rate hike induces agents to contemporaneously increase their stock of deposits. Nevertheless, deposit decisions in period t only become productive in period $t+1$. Thus, even though final good output will rise in the period of the shock due to the increase of banking output (i.e. capital), GDP will peak only in the following period when the higher stock of deposits becomes productive. As a result, it is natural for the deposit rate to lead the cycle. In contrast, note that the lending rate is completely anticyclical. When GDP is in the trough the lending rate is peaking and vice-versa. The underlying idea is very simple. Suppose that an adverse shock hits the banking sector in any period t. This implies a fall in banking output. The resulting reduction in capital supply generates two effects. First, it reduces final good output. Second, it creates a rise in the relative price of capital as this market adjusts to a fall in supply. While the former effect implies a fall in GDP, the latter is just a lending rate hike. This explains the anticyclical feature of the lending rate.

5. FINANCIAL CRISIS

A natural starting point is to define the concept of a banking or financial crisis. The focus is on episodes of generalized financial distress or systematic bank failures throughout the economy. This is the relevant analogy to Colombia in the late 1990's. I associate a financial crisis to an adverse stochastic productivity shock experienced by the intermediary sector. No doubt this is a very broad definition of what a banking or financial crisis really is. Yet, my definition manages to capture the perverse effects of mismanagement, overinvestment, excessive risk taking, panics, poor regulation, macroeconomic inestability and a weak institutional structure in an economy's financial system. As everybody knows, these illnesses reduce banking productivity and are what ultimately trigger banking crisis phenomena. Since banking productivity falls during episodes of financial distress, adverse productivity shocks to the intermediary sector are a sensible way to pin down financial crises. An alternative interpretation follows Bernanke (1983). During banking crises there is a loss of **intermediation capital** which is simply bank-client private information that rises intermediation productivity. Thus, an adverse stochastic shock to the productivity of the financial system is a simple way to pin down the loss of intermediation capital during a banking crisis.

With an adverse stochastic productivity shock to the financial system I am not claiming that the only cause of the Colombian banking crisis is rooted in problems specific to the banking sector. I am not ruling out macroeconomic shocks as a possible trigger of the banking crisis. For example, with an unstable macroeconomic environment bank managers probably are less productive in forecasting many of the relevant variables (interest rates, exchange rates, etc.) than in a stable economy. Productivity in the financial sector is not divorced from macroeconomic behavior. For sure, both micro and macro elements had a role in the crisis. But this is not inconsistent with the way in which the crisis is engineered into the model. The only purpose of the shock to the financial sector is i) to recognize that a crisis occurred and ii) to pin that crisis down in a simple and tractable way.

5.1. Results for the Model

In terms of the model, a banking crisis episode is engineered with an adverse shock to z. To simulate the financial crisis I set the economy at its steady state and then make the intermediary sector suffer a one standard deviation negative shock in ε. The impulse-response graphs of i) final good output, ii) banking output, iii) GDP, iv) consumption, v) labor allocated to the non-financial sector, vi) wage, vii) deposit rate, viii) lending rate and ix) interest rate spread are reported in Appendix 4. Recall that these variables are in real terms and, specifically, in terms of final good output. The financial crisis generates the following effects:

- Contraction of non-financial or final good output. This is a natural result given that the adverse shock to the financial sector reduces the availability of capital stock in the economy. This variable reaches its lowest level four quarters after the crisis is triggered and converges back to its steady state level approximately 22 quarters (or five and a half years) after that.

- Contraction of financial or banking output. This is a direct result of the adverse shock to the financial sector. This variable reaches its lowest level four quarters after the crisis starts and converges back to its steady state level approximately 18 quarters (or four and a half years) after that.

- Contraction of GDP. This is not surprising given the contraction of the financial and non-financial sectors of the economy. GDP reaches its lowest level four quarters after the crisis is triggered and converges back to its steady state level approximately 20 periods (or five years) after that.

- Consumption also falls on impact with the crisis. It reaches its lowest level four quarters after the shock and then takes 16/20 more periods to return back to its steady state level. In other words, a financial crisis reduces consumption below its steady state level during a period of five to six years.

- No reallocation of labor across sectors in the economy. This result is illustrative of a feature of the model that was highlighted in a previous section:

shocks are completely absorbed by prices so that the resulting wage (in terms of final good) is equalized across sectors without any change in the allocation of labor to the sectors.

- The real wage falls on impact with the financial crisis. The reason is that the adverse shock to the banking sector reduces the marginal productivity of its labor. The reduced capital supply also reduces the marginal productivity of labor in the final good producing sector. Again, the relative price of banking output adjusts so that the marginal productivity of labor in terms of final good remains identical, yet lower, in both sectors without any reallocation of labor. Now, the real wage reaches its lowest level five quarters after the crisis starts and converges back to its steady state level approximately 19 quarters after that.

- The deposit rate falls on impact with the crisis but then rises immediately above its steady state level before converging back to it. This rate peaks eight quarters after the crisis is triggered and converges back to its steady state level 18 quarters (four and a half years) after that. This pattern is a result of the model's dynamics. The adverse shock to the intermediary sector reduces the marginal productivity of deposits. Efficiency dictates that the deposit rate must fall contemporaneously with the crisis. But the shock also reduces the supply of capital and, consequently, of final good. This implies that there are less resources available for consumption and deposits. Thus, consumption smoothing implies that deposits taken into the following period are reduced. As a result, the marginal productivity of deposits rises in the next period meaning that, in equilibrium, the deposit rate must rise in the next period.

- The lending rate, on the other hand, rises immediately with the crisis, peaks four quarters after the shock and then converges back to its steady state level very slowly (44 quarters after the shock). This pattern has simple economics behind it. The adverse shock to the intermediary sector reduces the supply of banking output. This implies a reduction in the stock of capital available to the final good producing firm. Equilibrium requires that the relative price of capital or lending rate rises. After that, it evolves oppositely to how banking output or capital supply evolves.

- Finally, the interest rate spread follows a pattern similar to that of the lending rate. It peaks contemporaneously with the crisis and then converges very slowly (43 periods after the shock) back to its steady state level. This behavior is expected given that, in equilibrium, the interest rate spread is given by the inverse of the marginal productivity of deposits which falls during the crisis.

5.2. Comparison with Data

I argue that it is sensible to assume that an adverse financial shock hit the Colombian economy towards the end of 1997 or beginning of 1998. Recall from a previous section that it was in the first months of 1998 when the following phenomena began: i) fast rise in the percentage of unproductive assets in the Colombian financial sector and ii) dramatic fall in the sector's net worth. Consequently, the view taken in this paper is that the Colombian financial crisis began in the last months of 1997 or the first months of 1998. If this is true, the model's variables respond to the artificial financial crisis in a way that replicates **qualitatively** most of the features observed in the behavior of the same variables in Colombia during the period of financial distress (end of 1997/early 1998-):

- Four/five quarter contraction of non-financial output, GDP and consumption.
- Five/six quarter contraction of the real wage.
- Minimal fluctuations in the percentage of employment allocated to the non-financial sectors. The model replicates this behavior in extreme since the financial shock induces no reallocation of labor across sectors at all.
- Fall/rise pattern of the real deposit rate in a lapse of two years.
- Hike of the real loan rate during four/five quarters.
- Hike of the interest rate spread.

One caveat applies. According to the model, financial output should have started its recovery by now. Nonetheless, Colombian data shows that its cyclical component continues to fall. Besides, the model predicts that once a variable begins to converge back to its steady state level it does so monotonically. However, towards the end of 1999 the real wage started to fall again after three quarters of recovery. Also, by the third quarter of 1999 the real deposit rate began to fall again below its trend or steady state level (as if a new adverse financial shock had shown up). Moreover, by the first quarter of 2000 the interest rate spread still does not present a reversal of its cyclical rise.

In terms of the model, all this could be interpreted as another adverse financial shock hitting the Colombian economy towards the third quarter or end of 1999. In other words it could mean that the financial crisis has been deepened by another adverse financial shock that hit the Colombian economy in the second semester of 1999. But this is to be determined. If other variables like GDP, consumption and non-financial output enter into a new cyclical contraction and the real loan rate enters into a new cyclical hike, the continuation of the financial crisis is likely to be the case.

5.3. What to Expect

Even if the financial crisis comprises only an adverse shock in 1997/1998, the effects of that shock should last for several quarters. If this is the case, according to the model and ceteris paribus financial output, non-financial output, GDP and consumption will take around five years (after they stop falling) to return to their trend or steady state level. Since, non-financial output, GDP and consumption stopped falling in the second quarter of 1999, it should take around four more years from now before these aggregates return back to their trend or steady state level in the absence of other shocks. This result is consistent with stylized facts documented in the literature for Latin America: "...even where policymakers managed the crisis by following appropriate policies, resolving banking cries took four or five years and required major adjustments in the real economy." (Rojas-Suarez and Weisbrod, pp. 3)

It also takes around five years for the real wage to converge back to its steady state level after it stops falling. According to this result and recalling that the real wage first stopped falling in the first quarter of 1999, it should take around three and a half years from now for this variable to return to its trend level. However, recall that the real wage started to fall again in the fourth quarter of 1999 (as if a new adverse financial shock had hit the economy by then). Moreover, financial output has not stopped falling and the behavior of prices like the real deposit rate and the interest rate spread also suggest that a new adverse financial shock probably hit the Colombian economy towards mid/late 1999 (see the previous section).

If it is true that a new adverse financial shock hit the economy towards mid/late 1999, then the period of recovery and convergence of non-financial output, financial output, GDP, consumption and the real wage will be extended even further (to five years from now approximately) due to the cyclical contraction that these variables will exhibit with the new shock. Moreover, we should also expect soon a new hike of the real deposit and loan rate. As well, a continuation of the transitory rise in the interest rate spread should be expected. Once the deposit rate stops rising, it should take around four years for this rate to return back to its steady state level. It should take around ten years for the effects of the shock over the loan rate and the spread to vanish completely.

Of course, other shocks could speed up the return of the economy to its steady state by offsetting the adverse financial shock. For example, a positive terms of trade shock like the recent oil price rise could speed up the recovery of GDP and consumption. Nevertheless, the results of the model suggest that the sole effects of the adverse financial shock are significant and long-lasting.

6. CONCLUSIONS

This paper proposes a simple version of the optimal growth model where banks absorb real resources from the economy and are also vulnerable to crises. An artificial financial distress shock is engineered into the model in order to understand the macroeconomic consequences of a financial crisis. I find that a financial crisis generates a contraction of financial and non-financial output and, consequently, of GDP. Consumption also falls on impact with the crisis. Surprisingly, the financial crisis does not induce a reallocation of labor across sectors but the real wage falls on impact. The deposit rate also falls on impact with the crisis and then rises above its steady state level before converging back to it. This pattern is a result of the model's dynamics. The lending rate, on the other hand, rises immediately with the crisis and then converges back to its steady state level. Finally, the interest rate spread follows the same pattern as the lending rate.

The results are useful because they replicate the recent behavior of several macroeconomic variables in Colombia. Moreover, they give some insight into what should be expected from these variables in the near future. There are two fundamental take aways from this paper. First, the negative wealth and welfare effects of the Colombian financial crisis are non-negligible and long lasting (five years approximately). Second, the data suggests that the crisis which permeated the Colombian financial system since the last months of 1997 or first months of 1998 has been deepened by another adverse financial shock that hit the Colombian intermediary sector in mid/late 1999.

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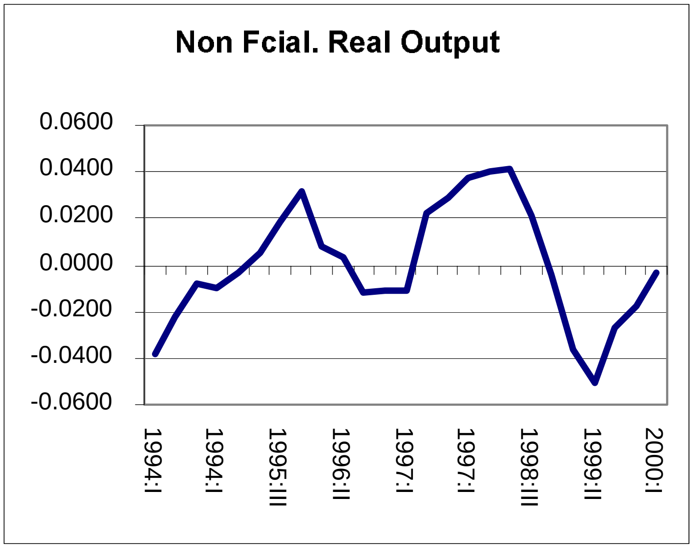
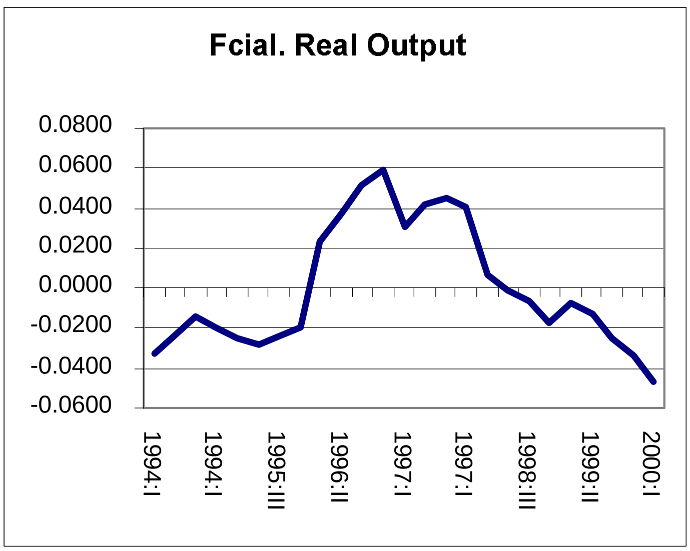
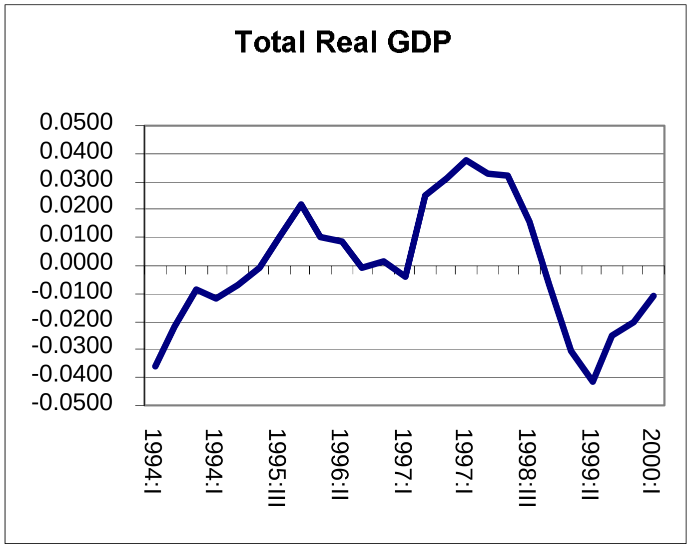
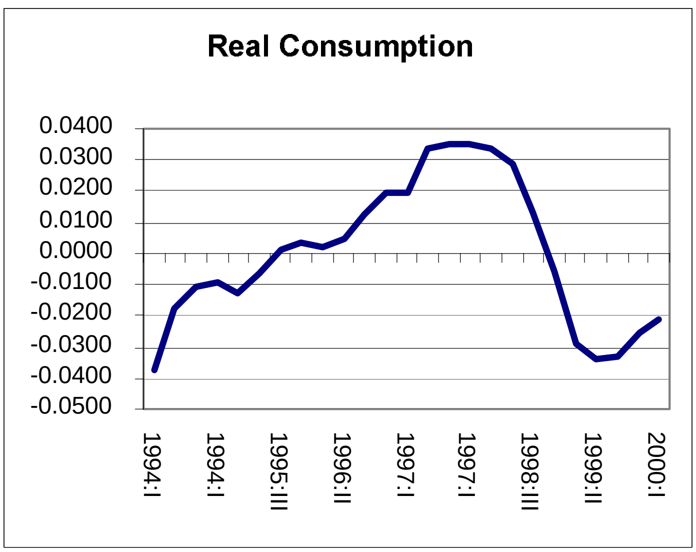
8. APPENDIX 1: Cyclical Behavior of Macroeconomic Variables for the Period 1994:I-2000:I



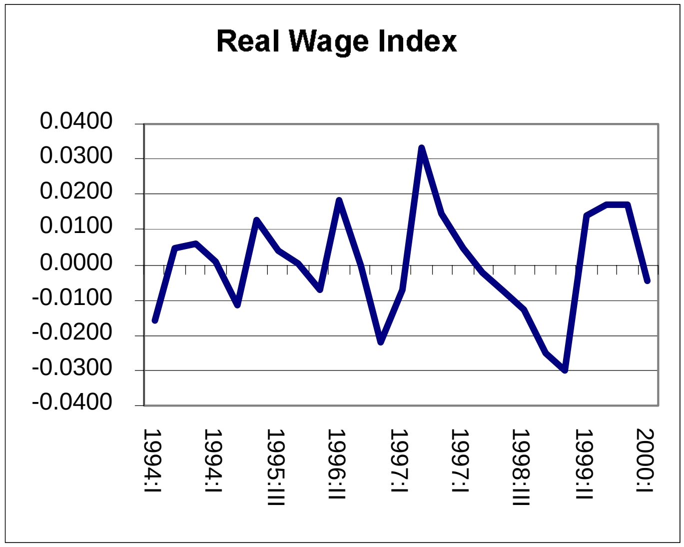


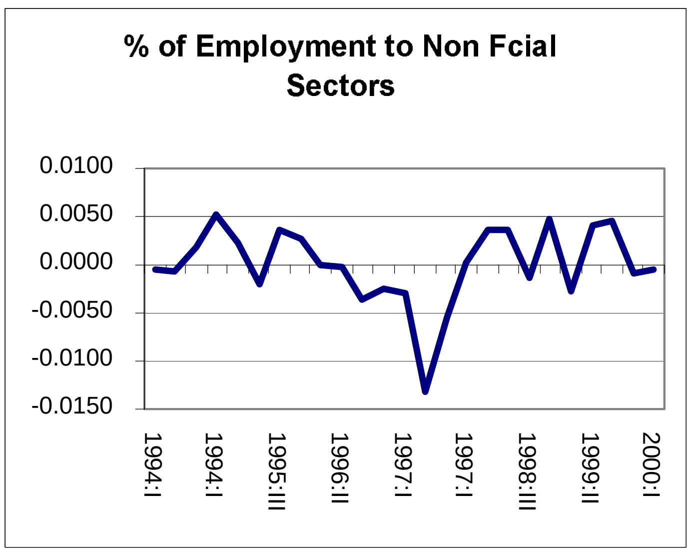


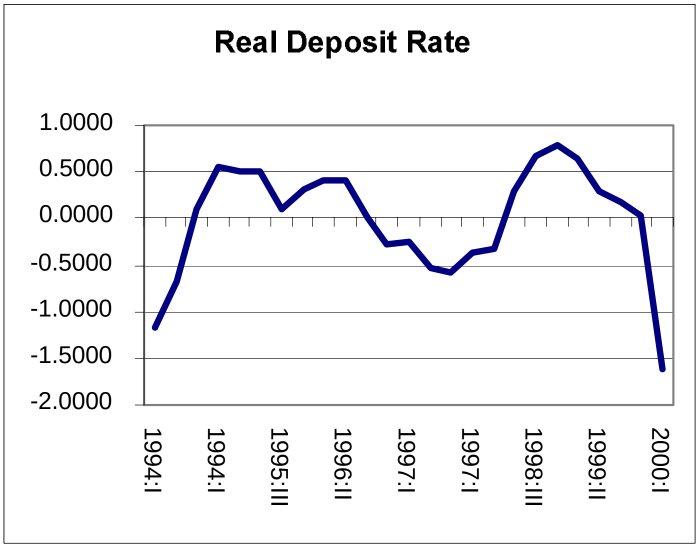
Total Real GDP
0.0500
0.0400
0.0300
0.0200
0.0100
0.0000
-0.0100
-0.0200
-0.0300
-0.0400
-0.0500
1994:I
1994:I
1995:III
1996:II
1997:I
1997:I
1998:III
1999:II
2000:I

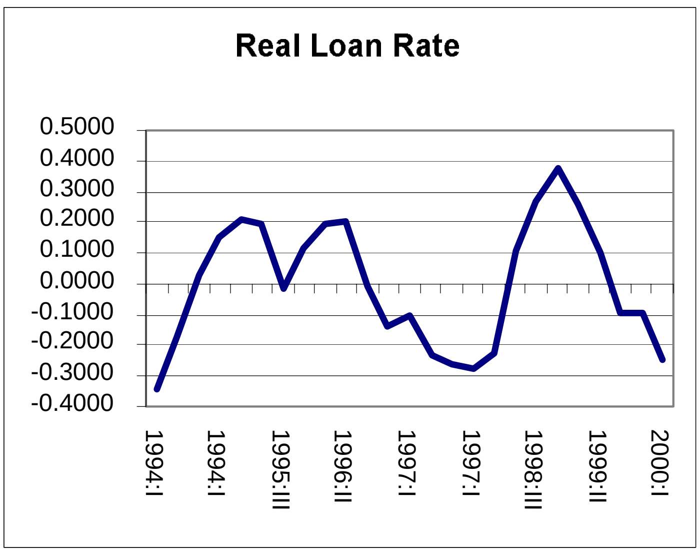


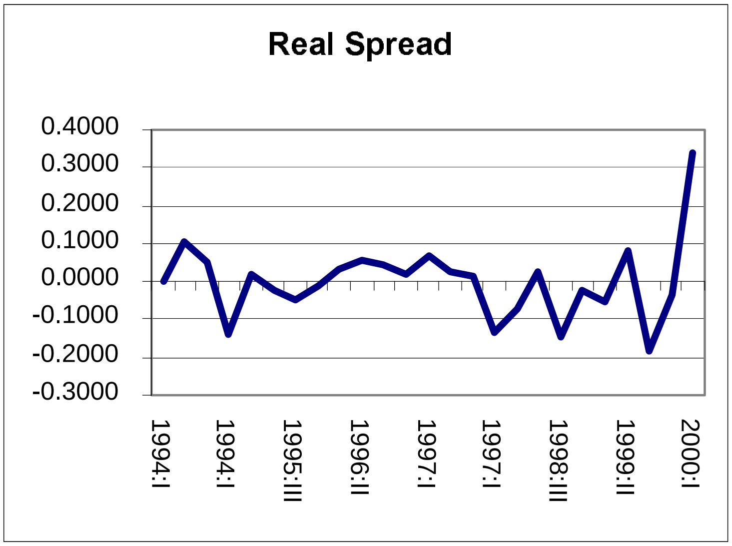
Real Consumption
0.0400
0.0300
0.0200
0.0100
0.0000
-0.0100
-0.0200
-0.0300
-0.0400
-0.0500
1994:I
1994:I
1995:III
1996:II
1997:I
1997:I
1998:III
1999:II
2000:I


Real Wage Index
0.0400
0.0300
0.0200
0.0100
0.0000
-0.0100
-0.0200
-0.0300
-0.0400
1994:I
1994:I
1995:III
1996:II
1997:I
1997:I
1998:III
1999:II
2000:I


% of Employment to Non Fcial Sectors
0.0100
0.0050
0.0000
-0.0050
-0.0100
-0.0150
1994:I
1994:I
1995:III
1996:II
1997:I
1997:I
1998:III
1999:II
2000:I


Real Deposit Rate
1.0000
0.5000
0.0000
-0.5000
-1.0000
-1.5000
-2.0000
1994:I
1994:I
1995:III
1996:II
1997:I
1997:I
1998:III
1999:II
2000:I


Real Loan Rate
0.5000
0.4000
0.3000
0.2000
0.1000
0.0000
-0.1000
-0.2000
-0.3000
-0.4000
1994:I
1994:I
1995:III
1996:II
1997:I
1997:I
1998:III
1999:II
2000:I


Real Spread
0.4000
0.3000
0.2000
0.1000
0.0000
-0.1000
-0.2000
-0.3000
1994:I
1994:I
1995:III
1996:II
1997:I
1997:I
1998:III
1999:II
2000:I

9. APPENDIX 2: Calibration

The calibration process departs from steady state equations (6')-(8').

$$(1-\alpha)\overline{K}^{\alpha}\overline{N1}^{-\alpha} = \alpha(1-\gamma)\overline{K}^{\alpha-1}\overline{N1}^{1-\alpha}\overline{D}^{\gamma}(1-\overline{N1})^{-\gamma} \tag{6'}$$

$$1 = \beta\alpha\gamma\overline{K}^{\alpha-1}\overline{N1}^{1-\alpha}\overline{D}^{\gamma-1}(1-\overline{N1})^{1-\gamma} \tag{7'}$$

$$\overline{K} = \overline{D}^{\gamma}(1-\overline{N1})^{1-\gamma} \tag{8'}$$

From (8') in (6'):

$$\begin{aligned} & (1-\alpha)[\overline{D}^{\gamma}(1-\overline{N1})^{1-\gamma}]^{\alpha}\overline{N1}^{-\alpha} \\ = \; & \alpha(1-\gamma)[\overline{D}^{\gamma}(1-\overline{N1})^{1-\gamma}]^{\alpha-1}\overline{N1}^{1-\alpha}\overline{D}^{\gamma}(1-\overline{N1})^{-\gamma} \end{aligned}$$

Note that $\overline{D}$ drops out from the previous equation and the following equation results:

$$\overline{N1} = \frac{(1-\alpha)}{(1-\alpha\gamma)} \tag{A1}$$

Equation (A1) is very intuitive because it is saying that (in a stationary environment) the higher the relative weight of labor in the firm's production function, $(1-\alpha)$, and the higher the weight of deposits in the bank's production function, γ, the higher the fraction of total labor allocated to the firm, $\overline{N1}$. As a result, the higher the relative weight of labor in the bank's production function, $(1-\gamma)$, and the higher the weight of capital in the firm's production function, α, the higher the fraction of total labor allocated to the bank, $1-\overline{N1}$ [15]. Note that (7') can be rewritten as:

$$1 = \beta\alpha\gamma\left[\frac{\overline{K}^{\alpha}\overline{N1}^{1-\alpha}}{\overline{K}}\right]\left[\frac{\overline{D}^{\gamma}(1-\overline{N1})^{1-\gamma}}{\overline{D}}\right] = \beta\alpha\gamma\left(\frac{\overline{Y}}{\overline{K}}\right)\left(\frac{\overline{B}}{\overline{D}}\right) \tag{A2}$$

where $\overline{Y}$ and $\overline{B}$ stand for final good output and banking output, respectively. According to the model, banking output is equal to the stock of capital. Thus, (A2) is:

[15] Note that it can be verified that : $\overline{N2} = 1-\overline{N1} = \frac{\alpha(1-\gamma)}{1-\alpha\gamma}$

$$1 = \beta\alpha\gamma \left(\frac{\overline{Y}}{\overline{D}}\right)$$

Equations (A1) and (A2) can be manipulated for calibration purposes. Indeed, we can solve for γ using equation (A1):

$$\gamma = \frac{1}{\alpha}\left(1 - \frac{(1-\alpha)}{\overline{N1}}\right) \tag{A3}$$

On the other hand, equation (A2) is useful to solve for β:

$$\beta = \frac{1}{\alpha\gamma}\left(\frac{\overline{D}}{\overline{Y}}\right) \tag{A4}$$

The following features in the data would allow for a proper calibration:

1. Fraction of total labor allocated to the final good producing sector. This pins down $\overline{N1}$.

2. Elasticity of non-financial output to capital. This determines α.

3. Ratio of deposits to non-financial output. This pins down $\overline{D}/\overline{Y}$.

With α and $\overline{N1}$ equation (A3) determines γ. With α, γ, and $\overline{D}/\overline{Y}$, equation (A4) pins down β. The only parameter that is still pending for calibration is θ, the coefficient of relative risk aversion. This parameter cannot be calibrated from the model's steady state equations. Therefore, the simplest way to treat this parameter is as exogenously given. In fact, the most appropriate thing to do is to solve the model using a sensible range of values for θ, say $\theta \in [1, 5]$.

APPENDIX 3: Business Cycle Properties of the Model

SAMPLE MEANS ACROSS SIMULATIONS

	MEANS*	ST. DEV. (%)
GDP	0,5373	1,4709
Final Good Output	0,3558	1,4709
Banking Output	0,1431	2,8841
Consumption	0,2050	1,4593
Labor to Final Good	0,9190	0,0000
Wage	0,1897	1,4709
Deposit. Rate	1,1016	0,8599
Lending Rate	1,2707	1,4132
Spread	1,1535	1,8369

* Of non-filtered data.

CONTEMPORANEOUS CORRELATIONS

	GDP	Final Good Output	Banking Output	Cons.	Labor to Final Good	Wage	Deposit Rate	Lending Rate	Spread
GDP	1,0000	1,0000	1,0000	0,9967	0,9870	1,0000	0,2638	-1,0000	-0,8915
Final Good Output	1,0000	1,0000	1,0000	0,9967	0,9870	1,0000	0,2638	-1,0000	-0,8915
Banking Output	1,0000	1,0000	1,0000	0,9967	0,9870	1,0000	0,2638	-1,0000	-0,8915
Consumption	0,9967	0,9967	0,9967	1,0000	0,9966	0,9967	0,3389	-0,9967	-0,9245
Labor to Final Good	0,9870	0,9870	0,9870	0,9966	1,0000	0,9870	0,4140	-0,9870	-0,9526
Wage	1,0000	1,0000	1,0000	0,9967	0,9870	1,0000	0,2638	-1,0000	-0,8915
Deposit. Rate	0,2638	0,2638	0,2638	0,3389	0,4140	0,2638	1,0000	-0,2638	-0,6698
Lending Rate	-1,0000	-1,0000	-1,0000	-0,9967	-0,9870	-1,0000	-0,2638	1,0000	0,8915
Spread	-0,8915	-0,8915	-0,8915	-0,9245	-0,9526	-0,8915	-0,6698	0,8915	1,0000

CORRELATION WITH GDPt

	(t-5)	(t-4)	(t-3)	(t-2)	(t-1)	t	(t+1)	(t+2)	(t+3)	(t+4)	(t+5)
GDP	-0,0296	0,1508	0,3682	0,6112	0,8463	1,0000	0,8463	0,6112	0,3682	0,1508	-0,0296
Final Good Output	-0,0296	0,1508	0,3682	0,6112	0,8463	1,0000	0,8463	0,6112	0,3682	0,1508	-0,0296
Banking Output	-0,0296	0,1508	0,3682	0,6112	0,8463	1,0000	0,8463	0,6112	0,3682	0,1508	-0,0296
Consumption	-0,0063	0,1764	0,3933	0,6328	0,8595	0,9967	0,8023	0,5555	0,3158	0,1084	-0,0604
Labor to Final Good	0,0180	0,2020	0,4170	0,6514	0,8679	0,9870	0,7520	0,4944	0,2598	0,0639	-0,0919
Wage	-0,0296	0,1508	0,3682	0,6112	0,8463	1,0000	0,8463	0,6112	0,3682	0,1508	-0,0296
Deposit. Rate	0,2728	0,3536	0,4124	0,4445	0,4163	0,2638	-0,2755	-0,4957	-0,5365	-0,4876	-0,4045
Lending Rate	0,0296	-0,1508	-0,3682	-0,6112	-0,8463	-1,0000	-0,8463	-0,6112	-0,3682	-0,1508	0,0296
Spread	-0,1083	-0,2857	-0,4803	-0,6812	-0,8466	-0,8915	-0,5195	-0,2374	-0,0344	0,1075	0,2061

SAMPLE STANDARD DEVIATIONS ACROSS SIMULATIONS

	MEANS*	ST. DEV. (%)
GDP	0,0081	0,2267
Final Good Output	0,0054	0,2267
Banking Output	0,0042	0,4444
Consumption	0,0030	0,2151
Labor to Final Good	0,0000	0,0000
Wage	0,0029	0,2267
Deposit. Rate	0,0011	0,0690
Lending Rate	0,0184	0,2178
Spread	0,0159	0,2028

* Of non-filtered data.

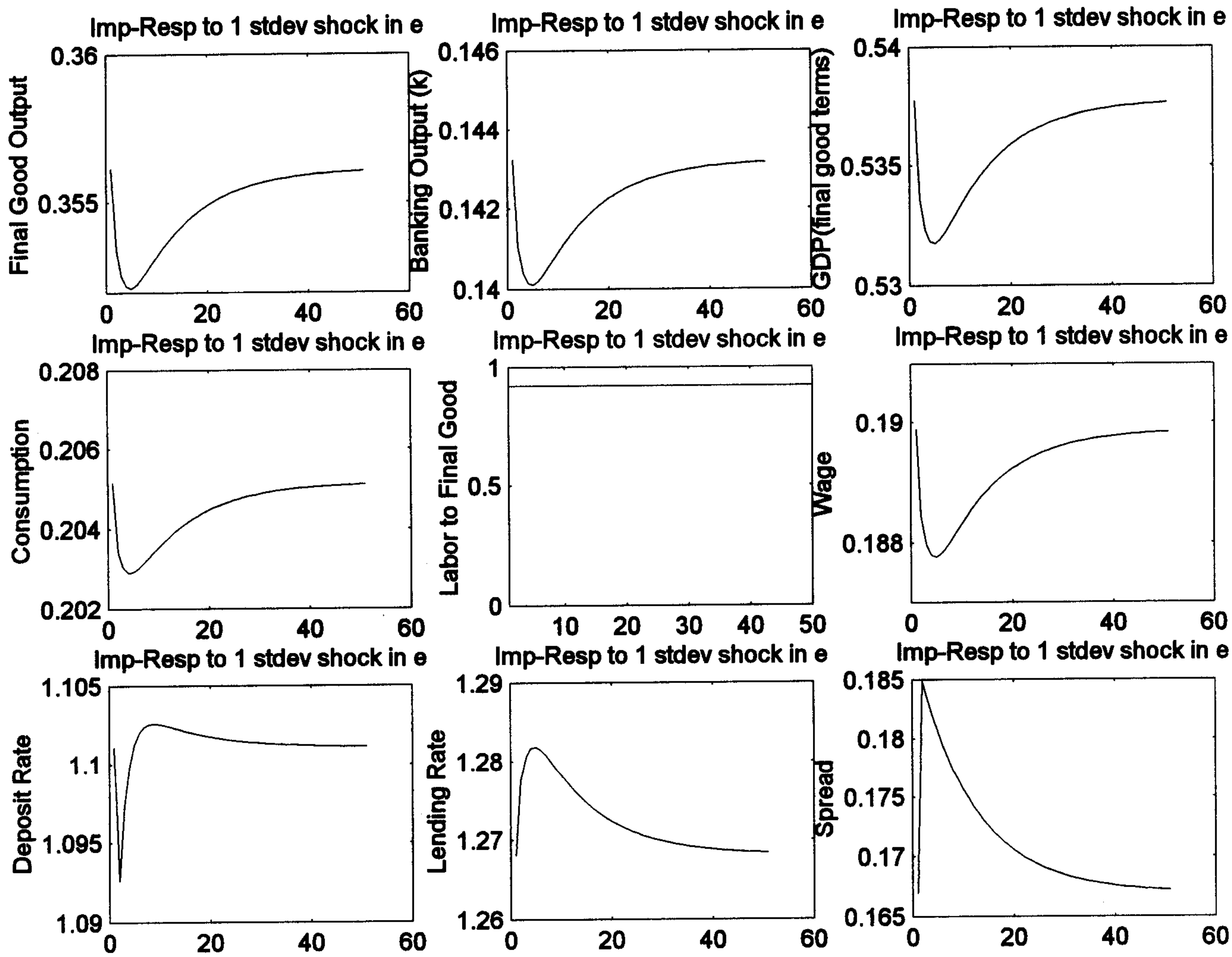
CONTEMPORANEOUS CORRELATIONS

	GDP	Final Good Output	Banking Output	Cons.	Labor to Final Good	Wage	Deposit Rate	Lending Rate	Spread
GDP	0,0000	0,0000	0,0000	0,0007	0,0024	0,0000	0,0618	0,0000	0,0112
Final Good Output	0,0000	0,0000	0,0000	0,0007	0,0024	0,0000	0,0618	0,0000	0,0112
Banking Output	0,0000	0,0000	0,0000	0,0007	0,0024	0,0000	0,0618	0,0000	0,0112
Consumption	0,0007	0,0007	0,0007	0,0000	0,0007	0,0007	0,0670	0,0007	0,0069
Labor to Final Good	0,0024	0,0024	0,0024	0,0007	0,0000	0,0024	0,0678	0,0024	0,0033
Wage	0,0000	0,0000	0,0000	0,0007	0,0024	0,0000	0,0618	0,0000	0,0112
Deposit. Rate	0,0618	0,0618	0,0618	0,0670	0,0678	0,0618	0,0000	0,0618	0,0606
Lending Rate	0,0000	0,0000	0,0000	0,0007	0,0024	0,0000	0,0618	0,0000	0,0112
Spread	0,0112	0,0112	0,0112	0,0069	0,0033	0,0112	0,0606	0,0112	0,0000

CORRELATION WITH GDPt

	(t-5)	(t-4)	(t-3)	(t-2)	(t-1)	t	(t+1)	(t+2)	(t+3)	(t+4)	(t+5)
GDP	0,1446	0,1359	0,1208	0,0891	0,0415	0,0000	0,0415	0,0891	0,1208	0,1359	0,1446
Final Good Output	0,1446	0,1359	0,1208	0,0891	0,0415	0,0000	0,0415	0,0891	0,1208	0,1359	0,1446
Banking Output	0,1446	0,1359	0,1208	0,0891	0,0415	0,0000	0,0415	0,0891	0,1208	0,1359	0,1446
Consumption	0,1418	0,1325	0,1177	0,0863	0,0396	0,0007	0,0510	0,0981	0,1253	0,1360	0,1425
Labor to Final Good	0,1394	0,1300	0,1156	0,0849	0,0390	0,0024	0,0598	0,1052	0,1278	0,1346	0,1393
Wage	0,1446	0,1359	0,1208	0,0891	0,0415	0,0000	0,0415	0,0891	0,1208	0,1359	0,1446
Deposit. Rate	0,1172	0,1007	0,0836	0,0674	0,0624	0,0618	0,0314	0,0388	0,0543	0,0800	0,1012
Lending Rate	0,1446	0,1359	0,1208	0,0891	0,0415	0,0000	0,0415	0,0891	0,1208	0,1359	0,1446
Spread	0,1293	0,1206	0,1090	0,0821	0,0405	0,0112	0,0837	0,1190	0,1244	0,1190	0,1205

APPENDIX 4


Imp-Resp to 1 stdev shock in e
Final Good Output
0.36
0.355
0 20 40 60
Imp-Resp to 1 stdev shock in e
Banking Output (k)
0.146
0.144
0.142
0.14
0 20 40 60
Imp-Resp to 1 stdev shock in e
GDP(final good terms)
0.54
0.535
0.53
0 20 40 60
Imp-Resp to 1 stdev shock in e
Consumption
0.208
0.206
0.204
0.202
0 20 40 60
Imp-Resp to 1 stdev shock in e
Labor to Final Good
1
0.5
0
10 20 30 40 50
Imp-Resp to 1 stdev shock in e
Wage
0.19
0.188
0 20 40 60
Imp-Resp to 1 stdev shock in e
Deposit Rate
1.105
1.1
1.095
1.09
0 20 40 60
Imp-Resp to 1 stdev shock in e
Lending Rate
1.29
1.28
1.27
1.26
0 20 40 60
Imp-Resp to 1 stdev shock in e
Spread
0.185
0.18
0.175
0.17
0.165
0 20 40 60