Consumption, Credit Restrictions and Financial Stability: A DSGE Approach *

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Abstract

In this document we develop a dynamic stochastic general equilibrium model (DSGE) to analyze the effect that different exogenous shocks have on financial stability. The results suggest that negative productivity shocks and consumption booms driven by a change in households intertemporal preferences decrease financial stability. Additionally, we studied the effect of a regulatory policy which restricts the portion of past utilities that banks can use to issue new credits. We found that if this regulation is tied up to the level of default in the economy, there would be a positive short run effect on financial stability that later reverts due to additional credit restriction this regulation imposes.

JEL Classification: D58,E32, E44.

Key words: financial stability, colombian financial system , consumption booms, arrears indicator, DSGE model with banking sector.

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1 Introduction

The financial and economic crisis that the world experienced since mid 2008, has incentive the development of a growing literature focus on the study of the causes and consequences of financial instability. Recent facts show that crisis periods are associated with macroeconomic downturns, indicating to supervisory authorities that the promotion of a healthy financial system should be prioritize in their agendas (Blanchard(2009), Guichard(2009) y Mishkin(2000)). It is important to analyze how different exogenous shocks might lead to instability problems in the financial system, and suggest countermeasures to ameliorate the potential negative effects over the economy. Recent literature has addressed some of this questions and is evolving towards the construction of dynamic stochastic general equilibrium models (henceforth DSGE) that explicitly include an intermediary banking system (deWalque(2008), Gerali(2008) y Perez(2009)).

A first obstacle in the analysis of financial stability using these type of models, is the lack of consensus about its definition. In general terms, financial stability is regarded as a "situation where the financial system is able to broker financial flows efficiently. Financial stability contributes to better resource allocation, which is important to preserve macroeconomic stability"[1]. Within the context of a DSGE, this definition has to be modified in order to identify financial instability episodes. Following Goodhart et al(2006), in this article a financial instability situation is one where there is simultaneously a decrease in banks' benefits and an increase in agents' default rate[2].

As mention above, the incorporation of financial markets to a DSGE model has focused in the inclusion of a banking system that intermediates between agents. Gerali et al (2008) developed one of these models and studied the macroeconomic impact of a decrease in the loan supply and in the value of the collateral of mortgages. Although they do not explicitly consider financial instability situations, the article is useful to understand the mechanisms through which the changes in the price of the collateral in housing loans, may cause a crisis[3]. Additionally the authors model a deposit market which is replicated in the model developed in this article.

Similarly, deWalque(2008) analyze the effect of financial regulation and monetary policy over financial stability. In their model, they consider the interaction of firms, households, a central bank and an heterogenous banking system composed by lending banks and borrowing

[1] *Financial Stability Report*, March de 2010.

[2] There are some articles that have address more profoundly the problem of finding an appropriate measurement of financial stability and the construction of reliable indicators, see for example Aspachs(2006) or Morales(2010).

[3] In comparison to the countries where the financial crisis originated, Colombia's recent concerns regarding the financial system have centered in the evolution of consumer loans. For this reason, the model constructed here includes only consumer and commercial loans, this latter one being the most representative in the banks' loans portfolio.

banks. It includes endogenous default probabilities so it allows the identification of financial instability situations in concordance with Goodhart et al(2006) definition. Although the article allows for commercial loans, consumer loans are not considered. In Colombia these loans account for over 30 % of the total[4] highlighting the importance of considering them in the construction of an adequate DSGE model.

In the same direction, Perez(2009) develops a DSGE model that includes endogenous default probabilities and a bank provision requirement. The article shows the effect of varying the central bank's intervention rate or reserve requirements, over the financial stability of the banking system. Changes in regulatory penalties towards the households, are also analyzed. The main differences between the model presented here and the one developed by Perez(2009), is the former includes the existence of a commercial loans and a deposit market[5].

Following some of the ideas proposed by the articles mention above, in this paper we develop a DSGE model that contributes to the recent literature as it includes simultaneously a deposit market, endogenous default probabilities, and a commercial and consumer loan market where the credit is provided by a representative bank taking into account the different risk profiles of the debtors. Results show, that financial stability worsens when there are negative productivity shock and consumption booms driven by changes in consumer intertemporal preferences. Additionally, we studied the effect of a regulatory policy which restricts the portion of past utilities that banks can use to issue new credits. We found that if this regulation is tied up to the level of default in the economy, there would be a positive short run effect on financial stability that later reverts due to additional credit restriction this regulation imposes. Finally, the model is calibrated with Colombian financial system data to replicate some stylized facts presented below.

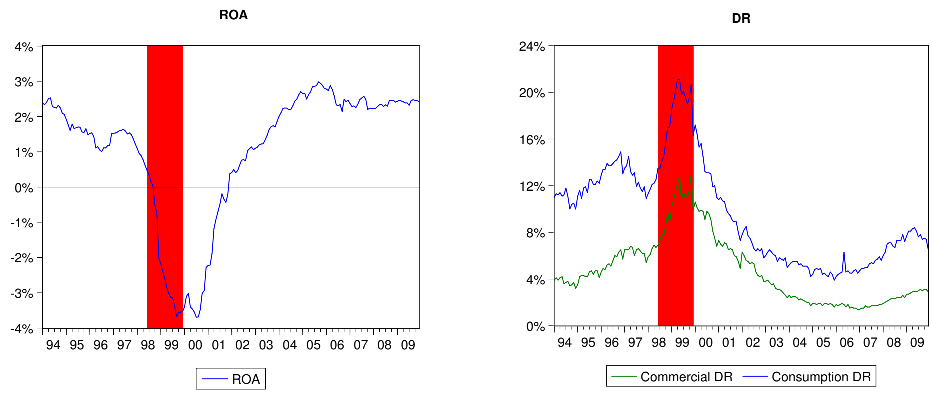
When the data is studied with the Goodhart et al(2006) definition, one can easily identify that in recent year Colombian economy has only experienced a financial instability episode during the late 90's (Figure 1). Between 1998 and 2000, the banks' rentability indicator (ROA)-defined as total profits over assets- plunged while, simultaneously, the delinquency ratio (DR) -defined as the ratio between non preforming loans and total loans- rallied both for consumption and commercial loans.

After this crisis Colombia's financial system has experienced peaceful times, stability wise. The DR for both commercial and consumption loans exhibit a declining tendency until mid 2007, where this financial indicator deteriorate to revert only until the last semester of 2009. Although current levels are considerably below the maxima recorded during 1999, it is crucial to examine the determinants of financial instability , in particular during times of economic downturn and growing uncertainty in the foreign markets.

[4]Source:*Superintendencia Financiera de Colombia*

[5]As to March of 2010 commercial loans accounted for 59% of the total bank loans, according to the information provided by the *Superintendencia Financiera de Colombia*.

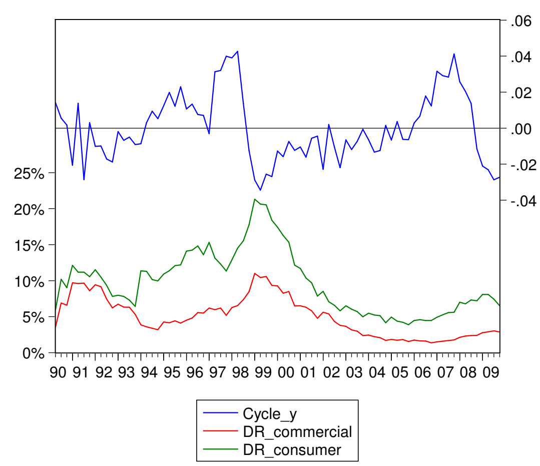
Figure 1: Banks' DR and ROA



Source: *Superintendencia Financiera de Colombia*. Authors calculations.

Historically, the DR of both commercial and consumer loans appear to be countercyclical[6] (Figura 2). Recent studies reaffirm this fact, showing that the cycles of the DR and economic activity move in different directions (Gutiérrez and Saade(2009)) and in particular for the commercial loans, a decrease in the product increases the firms' probability of default (Gonzalez(2010)).

Figure 2: GDP Gap and DR



Source: *Superintendencia Financiera de Colombia*. Authors calculations.

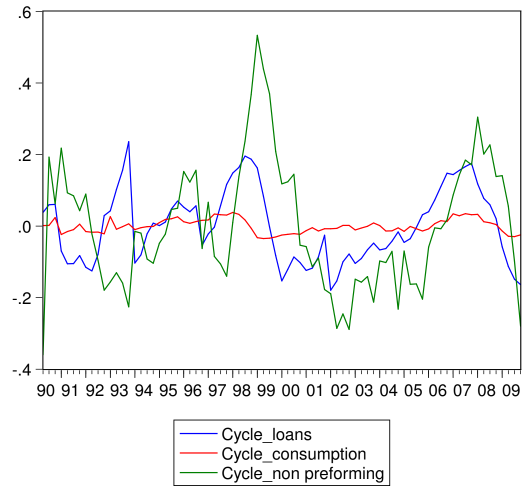
Similarly during the period after the crisis, the consumption growth was partly leveraged by consumer credits. The rapid increase in the consumer loans was accompanied by an equally dynamic lagged behavior in the non preforming loans of this type of credit (Figure 3)[7]. This

[6]If one considers the annual series for the data the correlation between the DR's and the GDP are roughly -0.36 and -0.15 respectively. This suggest opposite comovements between this variables.

[7]The study of the correlations between these variables show that there is a positive contemporaneous correlation between consumption and consumer loans (0.59), and also between the consumer loans and the

paper intends to shed some light to the mechanisms through which this might happen. In particular, we study the behavior of financial stability variables in response to a shock in consumer intertemporal preference to replicate a potential problematic credit boom.

Figure 3: Consumption variables cycles



Source: *Superintendencia Financiera de Colombia*. Authors calculations.

The remaining of the document is organized as follows: section 2 describes the general characteristics of the DSGE model, in section 3 we explain the solution methodology and the calibration strategies used for the Colombian case. In section 4 both macroeconomic and consumption shocks are simulated and the results are analyzed. Finally in section 5 we sketch some final comments.

2 Model

Suppose a closed economy with no government. Firms produce a unique consumption good under perfect competition, using a standard production technology whose inputs are capital, property of the firms, and labor, property of the households. There are two types of households: depositors and debtors. A representative bank raises resources from depositors and issue credit to firms and debtor households. Both type of debtors have the possibility of defaulting a portion of their debt. In contrast, we suppose that deposits are free from repayment risk from banks [8].

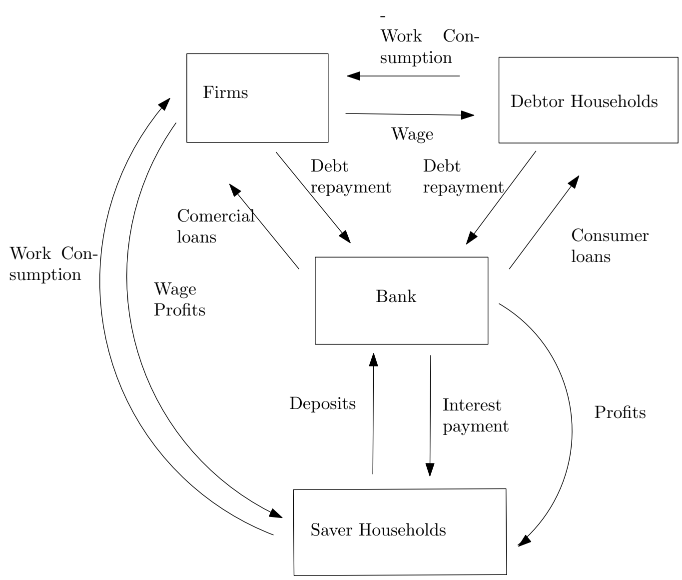
Four type of agents interact in the model; depositor households, debtor households, firms and a representative bank. We suppose a discrete infinite period framework. Households

two period lagged non preforming loans,0.34.

[8] In Colombia deposits under 20 million Colombian pesos (approximately $10,000$ US dollars) are ensured by the Fondo de Garantías de Instituciones Financieras (FOGAFIN).

decide the optimal amount of work they provide to firms. Firms use this labor and their capital to produce the consumption good each period. The replacement of capital partially depends upon the commercial loan that each period the firms acquire from the bank. Once the consumption good is produce, the firms pay the workers' salaries and a punishment for defaulting part of their debt. At the end of the period the debtor households receive their salary and choose the amount of debt they are going to pay to the banks. At the begging of each period the depositor households receive their past labor income, the dividends from banks and firms, and use the resources for consumption and new deposits. Figure 4 summarize the agents interactions within the model.

Figure 4: Agent interactions



Source: authors

2.1 Firms

Each period firms maximize the discounted value of their profits π_t^f, by choosing the level of capital k_t, of labor n_t, of commercial loans l_t and the proportion of repayment $\alpha_t^f \in (0, 1]$ of the loans acquire with the banks [9]. If the firms do not pay their credits completely, they incur in the costs of obtaining new credits for next period. This translates into quadratic defaulting costs, with parameter $\widetilde{\gamma_f}$. We suppose this parameter is a random variable with mean $\overline{\gamma_f}$ and variance σ_f^2 [10]. All firms are homogenous in all other ways and know their

[9]The case $\alpha_t = 0$ might be problematic in terms of assuring the stability of the model

[10]We suppose that the cost of defaulting has a random component since later in the model the representative bank does not know for certain how costly is defaulting , but do know the distribution of the defaulting costs. In order to find a steady state we will additionally assume that the bank optimize facing the average debtor agent.

cost typology in each period. The price of the consumption good is normalized to 1. These agents solve the following maximization problem [11]:

$$\max_{k_t,n_t,l_t^f,\alpha_t^f} \sum_{t=0}^{\infty} \beta_f^t \pi_t^f \tag{1}$$

subject to[12]

$$k_t = (1-\delta)k_{t-1} + l_t^f + \xi\pi_{t-1}^f \tag{2}$$

$$\pi_t^f = F(k_t, n_t, Z_t) - w_t n_t - \alpha_t^f(1+r_{t-1}^f)L_{t-1}^f - \frac{\widetilde{\gamma_f}}{2}((1-\alpha_{t-1}^f)L_{t-2}^f)^2 \tag{3}$$

$$L_t^f = (1-\alpha_t^f)L_{t-1}^f + l_t^f. \tag{4}$$

Equation (2) describes the dynamic of the firm's capital. Capital depreciates at a constant rate δ and the firm´s investment is the sum of a fraction ξ of past utilities π_{t-1}^f and the new loan they obtain from the bank l_t at the beginning of period t. Debt L_t^f accumulates with the portion of the previous period loan that the firm defaulted $(1-\alpha_t)L_t^f$ and the new loan l_t acquire in period t. The firm decides the portion of the previous period debt α_t^f that it is going to pay $(1+r_{t-1}^f)L_{t-1}^f$, where r_t^f denotes the interest rate the representative bank charges each firm every period. Equation 3 describes the firm's profits. The firm derives income from producing the consumption good with capital and the labor supplied by households, Z_t denotes the total productivity factor in the production technology. Firms pay a wage w to workers and know that if they default a portion of their previous period debt, they incur in quadratic defualting cost[13].

2.2 Households

We suppose there exist two type of households: debtors h and savers s. The maximization problem of the saver households is the following:

[11]In the model we assume there is a large number of firm and hence the maximization problem should be indexed to represent an arbitrary one. Nonetheless we omit this indexation to avoid unnecessary complications.

[12]Additionally the following transversality conditions are needed $\underset{t\to\infty}{lim}\beta_f^t\lambda_t^{f1}k_t = 0$ and $\underset{t\to\infty}{lim}\beta_f^t\lambda_t^{f2}L_t^f = 0$, where λ_t^{f1} y λ_t^{f2} denote the lagrange multipliers for (2) and (4), respectively.

[13]The costs are supposed to be quadratic in so that the punishment grows more than proportional in comparison to the amount defaulted.

$$\max_{C_t^s, n_t^s, D_t} \sum_{t=0}^{\infty} \beta_s^t \left[ln(C_t^s) + \phi_s ln(1 - n_t^s) \right] \tag{5}$$

subject to the budget restriction [14]

$$C_t^s + D_t = w_{t-1} n_{t-1}^s + (1 + r_{t-1}^s) D_{t-1} + (1 - \xi) \pi_{t-1}^f + (1 - \nu) \mu_{t-1}, \tag{6}$$

where C_t^s denotes saver household's consumption, ϕ_s is the parameter of relative substitution between consumption and leisure, n_t^s is the labor supplied by this type of household, D_t are the household's deposits and $(1 + r_{t-1}^a) D_{t-1}$ are the returns and principal of the previous period deposits[15]. Saver households are owners of both banks and firms and consequently receive part of their profits as dividends, $(1 - \xi)\pi_{t-1}^f$ and $(1 - \nu)\mu_{t-1}$.

Similarly, the debtor households maximize their every period utility which depend positively on their consumption C_t^h and leisure $1 - n_t^h$. As firms, this type of households may pay only a proportion $\alpha_t^h \in (0, 1]$ of their debt with the bank. Once again, the default cost parameter is suppose to be a random variable with mean $\overline{\gamma}_h$ and variance ${\sigma_h}$[16]. The maximization problem of this type of households is:

$$\max_{C_t^h, n_t^h, l_t^h, \alpha_t^h} \sum_{t=0}^{\infty} \beta_h^t \left[ln(C_t^h) + \phi_h ln(1 - n_t^h) \right] \tag{7}$$

subject to[17]

$$C_t^h + \frac{\widetilde{\gamma}_h}{2} [(1 - \alpha_{t-1}^h) L_{t-2}^h]^2 = l_t^h \tag{8}$$

$$\alpha_t^h (1 + r_{t-1}^h) L_{t-1}^h = w_t n_t^h \tag{9}$$

$$L_t^h = (1 - \alpha_t^h) L_{t-1}^h + l_t^h. \tag{10}$$

The debtor households maximize the discounted sum of their utility and optimally choose their consumption C_t^h, work supply n_t^h, demand for new loans l_t^h and debt repayment fraction α_t^h. Equation 8 shows that debtor household's consumption and the punishment for defaulting previous period debt, has to be equal to the new loans they get from the bank. This could be interpret as if these households perceive income only after they took their

[14] The transversality condition of this agent is $\lim_{t \to \infty} \beta_a^t \frac{D_t}{C_t^a} = 0$.

[15] Note that deposits are only for one period.

[16] The steady state of the model is found assuming that the random variables are at their mean, this is $\widetilde{\gamma_i} = \overline{\gamma_i}$, para $i \in \{f, h\}$.

[17] The transversality conditions of the debtor households are $\lim_{t \to \infty} \beta_f^t \lambda_t^h L_t^h = 0$.

consumption decision. Once they have consumed, they decide the amount of debt they want to pay according to their work income and the interest rate for that period. Finally, the debt's dynamic depends both on the level of previous period default and the amount of new loans obtained on that period(equation 10).

2.3 Banks

The representative bank receives deposits D_t from saver households and issue credits to firms L_t^{bf} and debtor households L_t^{bh}. Additionally, we suppose that the bank's previous period profits that are not transferred to households as dividends, are split into funds F_t which can be utilized to issue new credit, or reserves R_t which by regulation cannot[18]. Table 1 summarize the bank's balance sheet:

Table 1: Banks' Balance Sheet

Assets	**Liabilities**
Commercial loans L_t^f	Deposits D_t
Household loans L_t^h	**Equity**
Unloanable Reserves R_t	Bank's funds F_t
	Reserves R_t

Source:author

We suppose the representative bank can't distinguish the debtor household or firm they face, but know their default cost distribution. Hence, banks assume they are facing the average household and solve the maximization problem:

$$\max_{D_t, L_t^{bf}, L_t^{bh}} \sum_{t=0}^{\infty} \beta_b^t \left(\mu_t - \frac{\rho_t}{2} \sigma_t^2 \right) \tag{11}$$

subject to a

[18]These reserves can be associated with a preventive cushion that the regulator imposes in order to counter act against an unexpected increase in debtor agents' credit risk.

$$\begin{aligned}
\mu_t &= \pi_t^{bf} + \pi_t^{bh} - (1+r_t^s)D_t + \frac{\widetilde{\gamma_h}}{2}((1-\alpha_{t-1}^h)L_{t-2}^{bh})^2 \\
&+ \frac{\widetilde{\gamma_f}}{2}((1-\alpha_{t-1}^f)L_{t-2}^f)^2 & (12)\\
\pi_t^{bh} &= \alpha_{t+1}^h(1+r_t^h)L_t^{bh} & (13)\\
\pi_t^{bf} &= \alpha_{t+1}^f(1+r_t^f)L_t^{bf} & (14)\\
\sigma_t^2 &= (L_t^{bf})^2\sigma_{bf}^2 + 2L_t^{bf}L_t^{bh}\sigma_{bf,bh} + (L_t^{bh})^2\sigma_{bh}^2, & (15)
\end{aligned}$$

where σ_{bf}^2 and σ_{bh}^2 denote the implicit variance of π_t^{bf} and π_t^{bh} respectively, and $\sigma_{bf,bh}$ its covariance. Banks total profit is denoted by μ_t. As mentioned above, in order to find a steady state we impose the condition that $\widetilde{\gamma_f} = \overline{\gamma_f}$ and $\widetilde{\gamma_h} = \overline{\gamma_h}$. When we solve the model this way we are finding the average behavior of the economy, this is, the mean trace around which it would fluctuate in the long run.

We suppose the bank's risk aversion parameter rises when the default level in the economy increases. In particular we assume $\rho_t = \hat{\rho}\left(\frac{(1-\alpha_t^f)+(1-\alpha_t^f)}{2}\right)$, where $\hat{\rho}$ is a fixed parameter [19].

The bank's budget restriction for each period is:

$$D_t + F_t = L_t^{bf} + L_t^{bh}, \tag{16}$$

where funds F_t are a fraction of the previous period profits that are not distributed to saver households as dividends. In this paper there are two regulatory scenarios: first, we suppose that this fraction ζ of the profits is held fixed; and second, that the available funds to issue new credits are linked to the proportion of debt defaulted such that, $F_t = g(\alpha_t^h, \alpha_t^f)\nu\mu_{t-1}$, where $g(\alpha_t^h, \alpha_t^f)$ is an increasing function on the agent's repayment fraction. In order to compare both cases, we impose the restriction that on steady state $\zeta = g(\alpha_t^{h*}, \alpha_t^{f*})$. The remaining resources $R_t = (1-g(\alpha_t^h, \alpha_t^f))\nu\mu_{t-1}$, are the reserves that the bank has to maintain in both sides of the balance sheet and cannot be used to issue new credits.

The profits associated with each type of credit are stochastic, since the bank does not know for certainty the costs which a firm or a debtor household has to incur for defaulting a part of their debt. Each period the bank receives the expected value of borrowing to firms and debtor households, and pays back the savers' deposits. Additionally we suppose that the quadratic costs are transferred to the banks(equation 12)[20]. The budget constraint states that every period the bank deposits D_t and funds F_t, must equal the sum of commercial L_t^{bf}

[19] Note that the dynamic risk adjustment of banks is done without complicating their maximization problem since α_t^f and α_t^h are given when he optimizes.

[20] If we assume that this costs aren't transferred to the banks the results of this paper also hold.

and consumer L_t^{bh} loans [21].

3 Methodology and Calibration

The model is solved around the steady state in which all random variables assume their mean value. In particular we suppose that the default cost parameters for both firms and household debtors are $\overline{\gamma_f}$ and $\overline{\gamma_h}$ respectively. Likewise, the variance and covariance of the bank's assets, σ_{bf}, σ_{bh} and $\sigma_{bh,bf}$ are supposed to be known an constant throughout time. This way, the basic model turns out to be deterministic and therefore, allows to find a solution using dynamic optimization traditional methods.

The stochastic part of the model consists of a series of random shocks that temporarily deviate the variables from their steady state values. In this way, we study the optimal trajectories that drive variables back to equilibrium levels. This paper analyzes two type of shocks, productivity and consumer intertemporal preference, and infers their effect on financial stability variables. We follow a methodology common to most DSGE models, by calculating a linear approximation of the variables around their steady state values, when they are exposed to the different shocks (Canova(2007) or Heer(2005)). This analysis is useful since it indicates the local effect that different shocks might have over the financial stability variables; default levels and the banks profits. However one has to be careful in the conclusions drawn since they are only valid for " small" shocks around the steady state. This implies that the following results might not be appropriate to study extreme cases in which variables are significantly deviated from their equilibrium values[22].

3.1 Calibration

The model is calibrated to the Colombian case, using average data from January 2002 until December 2009. The calibration is focus in key financial and macroeconomic variables that are, to some extent, the ones we are interested in. Table 2 shows the calibration used.

Similarly, table 3 presents the theoretical and empirical value of some relevant macroeconomic ratios. One can observe that although it is not possible to replicate all ratios, their level is quite similar. The details concerning parameter values used in this model to get such

[21] Note that a sufficient condition to solve the bank's optimization problem is that the objective function is concave. In this case in a neighborhood around the steady state values it is true that the following conditions hold, $\frac{\rho_t}{2}\sigma_{bh}^2 > \frac{\widetilde{\gamma_h}}{2}(1-\alpha_{t-1}^h)^2$, $\frac{\rho_t}{2}\sigma_{bf}^2 > \frac{\widetilde{\gamma_f}}{2}(1-\alpha_{t-1}^f)^2$ y $\rho_t\sigma_{bh}^2\sigma_{bh}^2 - \rho_t\widetilde{\gamma_h}(1-\alpha_{t-1}^h)^2 - \rho_t\widetilde{\gamma_f}(1-\alpha_{t-1}^f)^2 + \widetilde{\gamma_h}\widetilde{\gamma_f}(1-\alpha_{t-1}^h)^2(1-\alpha_{t-1}^f)^2 > \sigma_{bf,bh}^2$ which guarantee that the objective function is concave.

[22] There exist some two period general equilibrium models that are constructed in such a way that they can cope with this extreme situations (Tsomocos(2003) o Saade(2007)). Nonetheless, this type of analysis is costly since it doesn't allow appropriate dynamic inference.

a calibration are outlined in Appendix B [23].

Table 2: Variable calibration

Variable	Value	Description
r_h	0.248	Monthly average of the consumer credit annual real rate
r_f	0.133	Monthly average of the commercial credit annual real rate
α_h	0.942	Monthly average of $(1 - DR)$ for consumer loans
α_f	0.974	Monthly average of $(1 - DR)$ for commercial loans
r_c	0.019	Monthly average of the annual real deposit rate
$\frac{L_f}{L_h}$	2.73	Average commercial loans over consumer loans[24]

Superintendencia Financiera de Colombia. Authors calculations.

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Table 3: Macroeconomic Ratios

Ratio	Model	Empirical	Description
$\frac{C^D+C^A}{y}$	0.61	0.61	Ratio between total consumption and GDP
$\frac{\mu}{y}$	0.0298	0.0326	Ratio between bank profits and GDP
$\frac{\zeta\pi^f+l^f}{y}$	0.351	0.224	Ratio between total investment and GDP
$\frac{n}{2}$	0.208	0.208	Average working hours
$\frac{L_f}{y}$	0.194	0.143	Ratio between total commercial loans and GDP

Superintendencia Financiera de Colombia. Authors calculations.

4 Results

In this section we present the effects that macroeconomic and consumption preference shocks have on financial stability indicators. Particularly we evaluate two regulation scenarios; one in which banks can use a fixed portion of their previous period profits to issue new credit, and other in which this proportion is linked to the default levels within the economy. Equilibrium is computed using the first order conditions as well as market equilibrium conditions

[23]The calibration was made supposing and annual periodicity.

[24]For this relationship to hold one has to sacrifice the calibration of σ^2_{bh},that is calculated as the variance of the marginal income of borrowing households. While empirically this parameter is around $\sigma^2_{bh} = 0.000355$, the models calibration implies a value close to $\sigma^2_{bh} = 0.00124$. This result suggest that the model might be missing an implicit collateral consideration that plays an important roll in the determination in the commercial loan amount within a bank's portfolio.

presented in Appendix A. From the linearized system of equations obtained, the impulse response functions are calculated[25]. Following Uhlig(1997), the impulse response functions represent percentage deviations of variables with respect to their steady state value since the equilibrium equations are log linearized.

4.1 Total Productivity Shock

As mentioned above, understanding the relation between real shocks and financial stability variables is fundamental for policy makers. In this first simulation we model a negative productivity shock to understand its effects over financial stability. The results reported in this section of the paper suppose a Cobb-Douglas production function $F(k_t, n_t, Z_t) = Z_t k_t^{\eta} n_t^{1-\eta}$, with $\eta \in (0, 1)$. We suppose that the external shock is driven by the following autoregressive process,

$$z_t = \psi_z z_{t-1} + (1 - \psi_z) z_{ee} + \epsilon_z, \tag{17}$$

where $z_t^f = ln(Z_t)$, z_{ee} is the logarithm of the steady state value of total factor productivity and ϵ_z denotes the productivity shock. We assume that the variance of the shock is 0.01 and that its persistence is around $\psi_a = 0.9$[26].

Figure 5 shows the consequences of a negative productivity shock over financial instability variables. The solid line represent the impulse response function when the banks profit reinvestment policy is tied up to the portion of debt that agents pay in that period, $F_t = g(\alpha_t^h, \alpha_t^f)\nu\mu_{t-1}$[27]. On the other hand the dotted line represent a situation in which banks can use a constant fraction ζ of their previous period profits that where not transferred to saver households[28].

Results show that negative productivity shocks have a negative effect over financial stability. We observe that a there is an initial collapse in household and firms repayment levels and a simultaneous drop in bank profits(Figure 5).

The behavior of the repayment rates in the economy can be explained by the evolution of both commercial and consumer interest rates. Initially the negative productivity shock leads to a contemporaneous drop in the demand for both types of credit inducing to a decline in their interest rates (Figure 6). While both interest and debt are below steady state levels, the

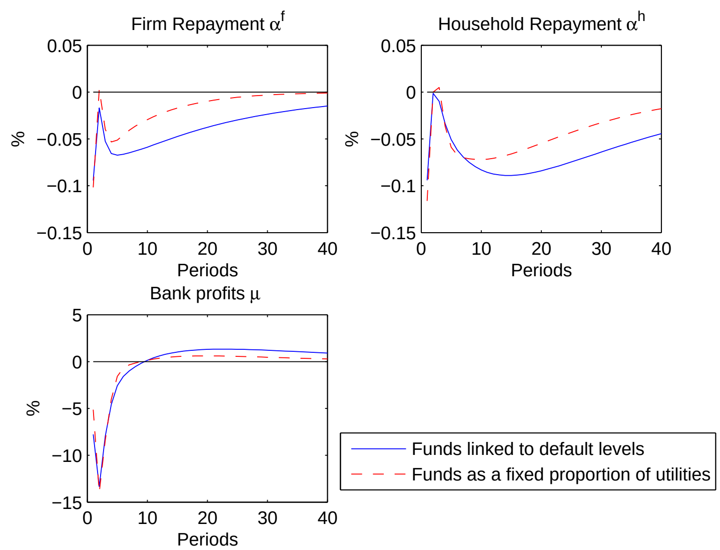
[25] DYNARE software is use to find the solutions presented here.

[26] Following most of DSGE literature we suppose a high persistence and a small variance (?).

[27] We assume the following functional form of $g(\alpha_t^h, \alpha_t^f) = \zeta \frac{10^{8(\alpha_t^h + \alpha_t^f)}}{10^{8(\alpha^{h*} + \alpha^{f*})}}$ in order to emphasis the results. Nonetheless any monotonically increasing function $g(\alpha_t^h, \alpha_t^f)$ will lead to the same results.

[28] As mentioned earlier it is easy to observe that the steady state values of both cases is equivalent.

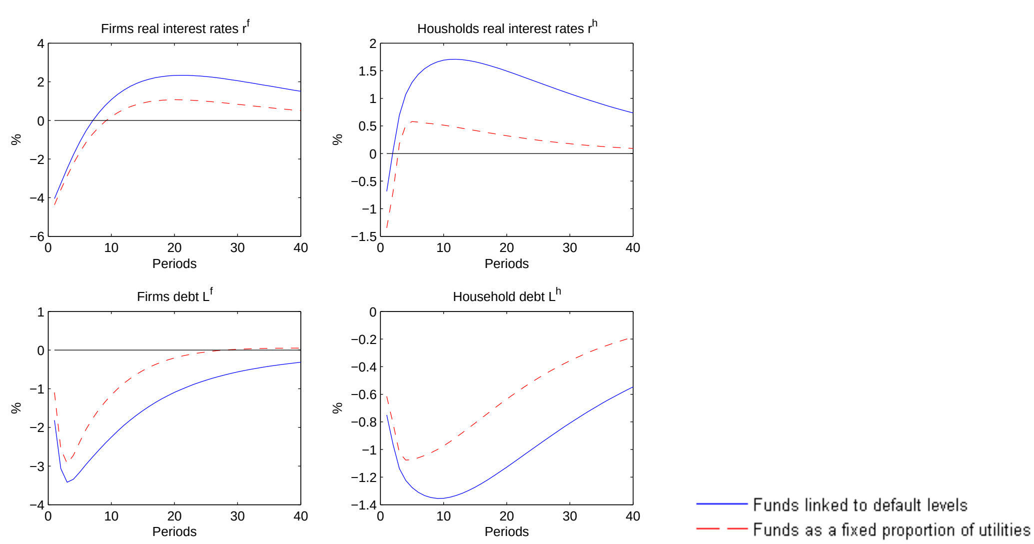
Figure 5: Financial Stability Variables with a Negative Productivity Shock z_t



Source: author calculations.

financial burden to firm and debtor households is mollified and hence, their repayment rates increase in comparison to their initial fall(Figure 5). However this tends to revert as interest rates surge over their equilibrium values[29]. From the above discussion, one infers that there is a negative net effect over financial stability variables after an inimical macroeconomic episode.

Figure 6: Other Financial Variables



Source:author calculations.

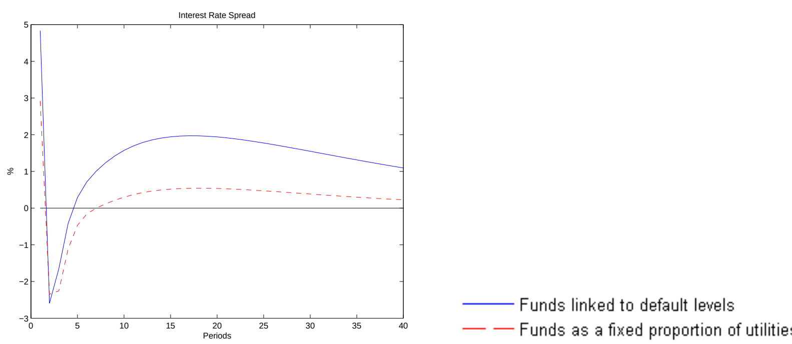
Comparing both regulatory scenarios, we found that at the beginning of the simulation the dotted line lies beneath the solid one, indicating that during these periods, the regulation

[29]This dynamic is robust to changes in parameter specifications

tied up to risk considerations partially appeases the negative effects of the macroeconomic shocks (Figure 5). Nevertheless, this reverts after a few periods, showing that in the long run this kind of regulation may act as a restriction to the credit supply. Figure 6 shows that the interest rates associated with the risk driven regulation policy are higher than the ones from a fixed utility reinvestment regulation. This occludes the rapid convergence of financial variables towards their steady state levels. A possible implication of this result is that although one might want to foment bank to be cautions when issuing credits in adverse risk scenarios, an obdurate regulation policy can perpetuate the negative effects of the macroeconomic shocks.

Figure 7 shows the banks credit and deposits interest rate spread[30]. This profit margin increases during the first periods as a consequence of the negative productivity shocks, which seems to be in line with the negative empirical correlation between GDP cycle and the bank's interest rate spread[31].

Figure 7: Interest Rate Spread



Source:author calculations.

Finally , in Figure 8 we show that the usual dynamic of other macroeconomic variables holds, after experiencing a negative productivity shock. As expected, the shock has a negative effect over the GDP y, household consumption and wages. We stress the fact that macroeconomic variables also tend to return slower to their steady state when the regulation is linked to repayment levels in the economy. This argues in favor of our credit supply restriction hypothesis.

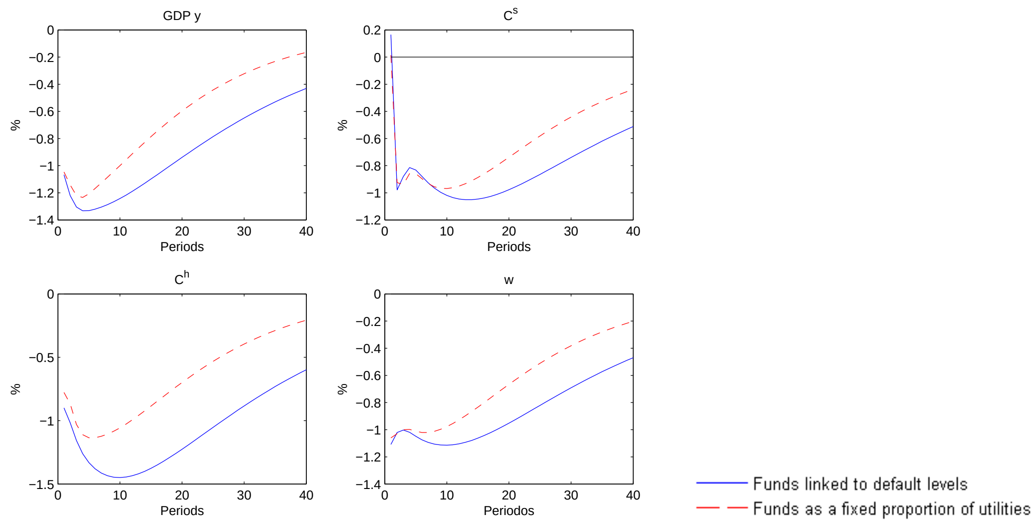
4.2 Shock to Consumer Preferences

This shock replicates a consumption boom that might generate financial stability problems. We suppose that the debtor households experience a negative shock to their intertemporal preferences parameter. We assume a 1%, one period decrease in these households' discount

[30]The interest rate spread is defined as $margin = \frac{r_t^f l_t^f + r_t^h l_t^h - r_t^c D_t}{D_t}$.

[31]The correlation between this variables is around -0.22 if you take quarterly data from March 1994 until December 2009.

Figure 8: Macroeconomic Variables with a Negative Productivity Shock z_t



Source:author calculations.

factor[32]

$$\beta_{h,t} = \beta_h + \epsilon_{\beta_h,t}, \quad (18)$$

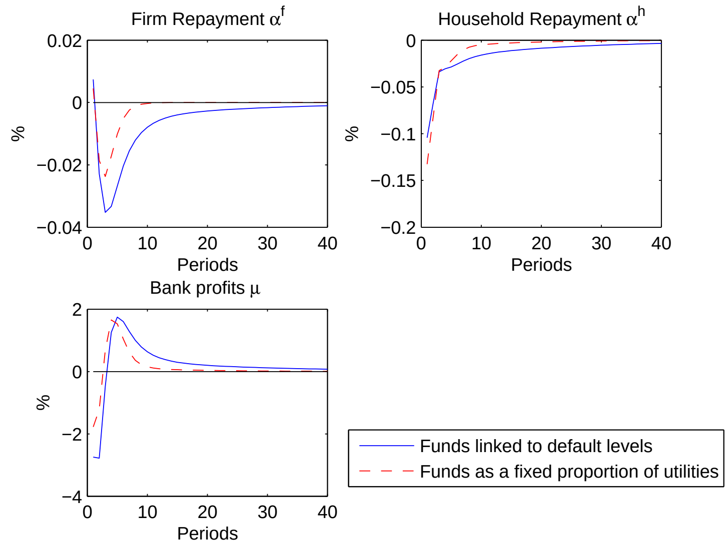
This shock provokes an increase in household consumption during the period of the shock. The impulse response function shows a net increase in default levels for both debtor households and firms. Although firm's repayment rate increases during the first period, after the shock, repayment falls beneath steady state levels. On the other hand, households default levels increase sharply after the consumption boom and stay over the steady state values throughout it convergence towards the long run equilibrium (Figure 9).

Meanwhile, bank's profits fall during the shock although they rise afterwards. It is worth noting that the effect on the consumer and commercial loans repayment is qualitatively different. This shows that there are shocks that have different results on the bank's credit portfolio, and hence to analyze financial stability as a whole, one has to include at least the most representative types loans of the economy.

Examining both types of regulation, we find that if the bank's funds are a fixed proportion of past profits, there is sharper fall in debtor households repayment rate, which may indicate financial stability problems related with this type of credit. The subsequent Figures confirm this by showing that the slower convergence dynamic discussed in the previous shock, still applies after this consumer preference shock.

[32] We suppose only a one period shock to facilitate the interpretation of the shock.

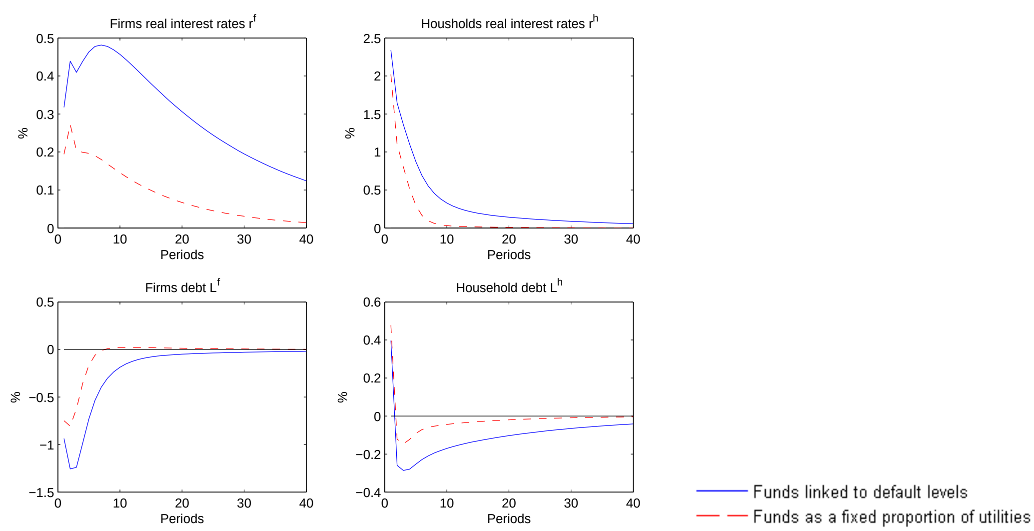
Figure 9: Financial Stability Variables with a Negative Shock to $\beta_{h,t}$



Source:author calculations.

Figure 10 shows the evolution of some financial variables after the consumption shock. The household debt increases during the period of the shock due to the increase in consumption during that period. This occur simultaneously to a raise in the interest rate of this type of credit and the worsening in its delinquency ratio. In the following periods the debt falls below the steady state levels. Consumption exhibits a similar pattern as consumer loans; during the shock it rises sharply and after the shock it contracts under the long run equilibrium levels (Figure 11).

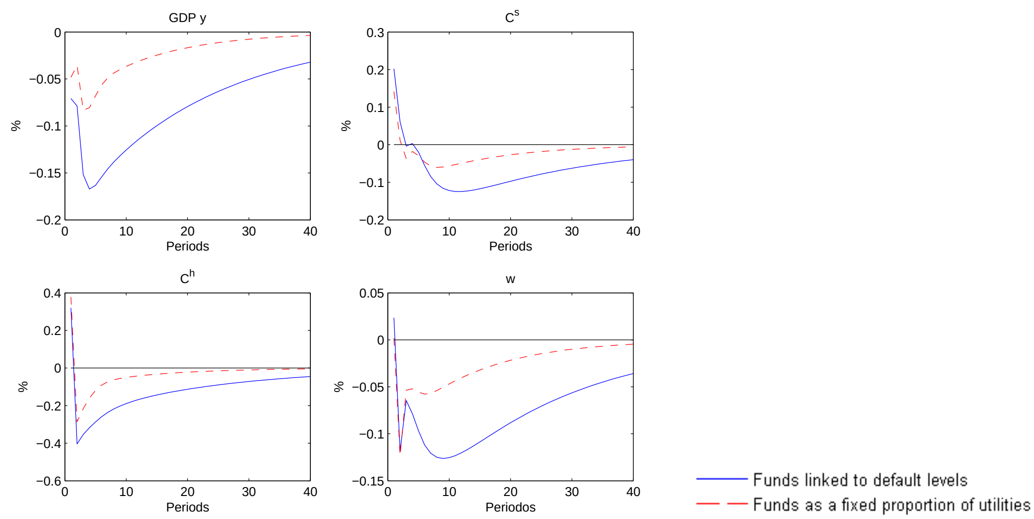
Figure 10: Other Financial Variables



Source:author calculations.

Macroeconomic variables show that the consumption boom is induced during the first period for both debtor and saver households. Substitution between commercial and consumer loans, leads to a decrease in the former and therefore the firm's capital decreases, implying a decline in the product even though consumption increased (Figure 11).

Figure 11: Macroeconomic Variables



Source:author calculations.

5 Final Comments

In this paper we developed a DSGE model to analyze the effect of macroeconomic and consumption preference shocks over the financial stability of the Colombian banking system. The model contributes to the existing and growing literature on the field, since it simultaneously considers a consumer and commercial loan market, and debtor agents that endogenously choose the amount of debt they default. Additionally in the model banks internalize risk considerations to find the solution to their optimization problem. In line with previous investigations and empirical facts, the results suggest that financial instability exacerbates when a negative productivity shock happens. The consumption shock also causes financial stability problems, specially in the debtor household side.

The regulation exercise done in this paper showed that if the fraction of previous period profits that a bank can utilize to issue new credit depends on the repayment levels in the economy, there tends to be a positive short run effect over the financial stability variables; whereas in the long run this reverts due to a restriction in the credit supply . This alerts policy makers of the importance of elucidating all possible consequences of applying such regulatory policies.

Finally, this paper pretends to be the building block of other models that may help explore the convoluted world of financial stability. In this sense, there are numerous extension to the model that are of vital interest in the field. For example, the banking system also provides a fundamental credit term transformation roll that is not consider in the model presented here. Also there are liquidity risk questions that are still under discussion and introducing them in this type of models might shed some light about some possible answers. Lastly, there are other regulatory measures that could be studied by modifying a few characteristics of the model developed for this paper.

6 References

Aspachs, O., Goodhart, C.A.E., Segoviano, M., Tsomocos, D.P., Zicchino, L.(2006)"Searching for a metric for financial stability ". *LSE Financial Markets Group Special Paper Series.* Special paper No. 167

Banco de la Republica (2009). Reporte de Estabilidad Financiera. Marzo".

Banco de la Republica (2009). Reporte de Estabilidad Financiera. Septiembre".

Banco de la Republica (2010). Reporte de Estabilidad Financiera. Marzo".

Blanchard, O.(2009)."The Crisis: Basic Mechanisms and Appropriate Policies". *IMF Work-*

ing Papers, pp. 1-22. Available at SSRN: http://ssrn.com/abstract=1394780

Bonaldi, P.; Gonzáles, A.; Prada, J.D;Rodríguez,D.A (2009). "Método númerico para la calibracion de un modelo DSGE". *Borradores de Economía del Banco de la República*, 548.

Canova, F. " Methods for Applied Macroeconomic Research" , Princeton University Press, 2007.

de Walque,G; O. Pierrard y A. Rouabah (2008). "Financial (in)stability, supervision, and liquidity injections: a dynamic general equilibrium approach". *Working Paper Reasearch 148, National Bank of Belgium*, Octubre de 2008.

Dib,A.(2009). "Banks, Credit Market Frictions and Business Cycles". *International Economic Analysis Department, Bank of Canada*, Agosto 19 de 2009.

Gerali, A.; S. Neri; L. Sessa y F. M. Signoretti (2008). "Credit and Banking in a DSGE Model". *Banca d' Italia*, Junio , 2008.

González, A. (2010) "Determinantes del riesgo de crédito comercial en Colombia". *Temas de Estabilidad Financiera*, Departamento de Estabilidad Financiera del Banco de la República, 45.

Goodhart,C.; p. Sunirand y D. Tsomocos (2006). "A model to analyse financial fragility". *Economic Theory.*27, pp 107-142.

Guichard, S., D. Haugh and D. Turner (2009), "Quantifying the Effect of Financial Conditions in the Euro Area, Japan, United Kingdom and United States", OECD Economics Department Working Papers, No. 677, OECD Publishing.

Gutierrez, J.; A. Saade (2009) "Cíclos del Riesgo de Crédito". *Temas de Estabilidad Financiera*, Departamento de Estabilidad Financiera del Banco de la República, 43.

Heer, B.; Maussner A. (2005) " Dynamic General Equilibrium Modelling: Computational Methods and Applications". Springer. (2005)

Lorenzoni, G. (2008). "Inefficient Credit Booms". *Review of Economic Studies*, Blackwell Publishing, vol. 75(3),pages 809-833, 07.

McCallum, B. (1994). "A reconsideracion of uncovered interest rate parity relationship.". *Journal of Monetary Economics.* 33, pp 105-132.

Mishkin, F.(2000) "Financial Stability and the Macroeconomy." *Working Paper 9, Central Bank of Iceland*Mayo de 2000.

Morales, M.A., D. Estrada (2010), "A Financial Stability Index for Colombia", Annals of Finance, Springer Berlin / Heidelberg Department, 1614-2446.

Parra Alvarez, J.C. (2008). “Hechos estilizados de la economía colombiana:fundamentos empíricos para la construccion y evaluacion de un modelo DSGE”. *Borradores de Economía del Banco de la República*, 509.

Pérez Reyna, D. (2009). ” Una aproximación para analizar la estabilidad financiera por medio de un DSGE”. *Temas de Estabilidad Financiera*, Departamento de Estabilidad Financiera del Banco de la República, 40.

Smets, F. y R. Wouters (2007). “An estimated dynamic stochastic general equilibrium model of the euro area”. *Journal of the European Economic Association.* (5), pp 1123-1175.

Saade, A. ;Osorio, D; Estrada, D. (2007) “ An equilibrium approach to financial stability analysis: the Colombian case,” Annals of Finance, Springer, vol. 3(1), pages 75-105, January.

Tsomocos, D. (2003). ”Equilibrium Analysis,Banking, and Financial Instability”, en Journal of Mathematical Economics, No. 39,pp. 619-655.

Uhlig, H. (1997) “A toolkit for analyzing nonlinear economic dynamic models easily”. *CentEr, Tilburg University and CEPR.* Working paper.