Reporte de
Estabilidad
Financiera

Countercyclical Banking Capital Buffers in
a DSGE Model

Santiago Caicedo Soler
Dairo Estrada
Mariana Laverde Quintero

Countercyclical banking capital buffers in a DSGE model[*]

SANTIAGO CAICEDO SOLER[*]

DAIRO ESTRADA[†]

MARIANA LAVERDE QUINTERO[‡]

Abstract

In this document we develop a DSGE model to analyze the effect that a consumption boom and a productivity shock have over financial stability and macroeconomic variables, in both, an economy with and without Basel III capital requirements and earnings reinvestment rule. The results suggest that Basel III requirements have a positive impact over financial stability variables and that additional capital requirements do not restrict banking activity.

JEL classification: *D58, E32, E44.*

***Keywords*:** financial stability, colombian financial system , consumption booms, DSGE model with banking sector.

---

[*]Specialized Analyst, Financial Stability Department. E-mail: scaicedosoler@uchicago.edu

[†]Director, Financial Stability Department. E-mail: destrada@banrep.gov.co

[‡]Analyst, Financial Stability Department. E-mail: mlaverqu@banrep.gov.co

1. Introduction

As pointed out by the Bank for International Settlements (BIS), some of the main reasons that amplified the financial crisis that began in 2007 were the graduate erosion in the level and quality of capital of financial institutions, and the excessive on and off-balance sheet leverage (Basel Committee on Bank Supervision (2010)). Bank's capital quality fell as the asset market deteriorated and the banks found it difficult to roll over short-term loans against asset-backed securities. This drove banks to fire sales that reduced asset value even below their fundamentals which in turn just made it more difficult for the banks to get funding. Finally, this liquidity constraints spilled over to bank borrowers and other economic agents resulting in a contraction of liquidity and credit availability (Kashyap et al. (2008)).

To asses the regulatory failures revealed by the crisis, the Basel Committee on Banking Supervision (BCBS) proposed a series of reforms with the aim of enhancing the banking system's resilience against adverse shocks. The BCBS proposals include increasing the quality and quantity of capital base reducing procyclicality, addressing systemic risk and introducing liquidity standards, among others.

Before discussing the proposals made by the Basel Committee its important to address the importance of capital regulation. According to Kashyap et al. (2008), in the traditional view there are some main premises about capital regulation. The first, capital serves as a protection to the deposit insurer and the society from losses due to bank failure. As deposit insurance exists and bail-outs appear as a choice for governments, bank's risk taking decisions may be in detriment of the sovereign or deposit insurance. A way of assessing this is to make sure that banks have a large enough capital buffer such that expected losses to government or insurer are minimized. On the other hand, capital requirements don't just serve the purpose of ex-post protection, these increase the economic exposure of bank shareholders which will give them the incentives to monitor carefully manager decisions in order to avoid excessive risk taking. As discussed by (Admati et al. (2011)), capital requirements not only reduce the inefficiencies of high leverage and the deadweight cost of distress, but attenuates the probabilities of facing stress periods by reducing systemic risk exposures and TBTF distortions. Additionally, more strict capital requirements do not limit banking activity; then adding up, as Admati et al. (2011) proposes, high capital requirements are not costly and would not affect credit markets adversely.

In line with what is mentioned above, the main contributions made by Basel III in terms of capital regulation are the implementation of minimum capital quality standards, a countercyclical capital buffer in order to protect the banking sector from periods of excessive credit growth and a rule for earnings reinvestment that guarantees a minimum level of solvency that is progressively achieved. In Europe and the USA, some of Basel III suggestions have been implemented. In Colombia, the reforms have addressed the problem of enhancing the quality of capital.

Parallel to the reforms that have been proposed, there is a growing literature that studies the effects that these capital related policies will be likely to have after implementation on financial systems. This article aims to study the effect of implementing a Basel III capital regulation in the Colombian economy.

Following a DSGE approach, in this paper we model an economy with a financial system and evaluate the effect of different shocks with and without Basel III restrictions. The financial system we have modeled includes a deposit market, endogenous default probabilities, and a commercial and consumer loans market. Credit is provided by a representative bank, taking into account the mean debtors' risk profiles. In order to address the Basel III resilience approach, we incorporate counter-cyclical capital requirements and earnings reinvestment necessary to achieve the former, and study the effects these policies have over

financial stability and macroeconomic variables once a shock hits the economy. 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[1].

It should be noted that the Basel III calibration has been taken from the one proposed by the BCBS, which was computed using data from UE countries. Although this is an approximation is probably the second best approach in this case.

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

2. Technical discussion: Model

Motivated by recent financial downturns, recent DSGE literature has attempted to incorporate financial frictions (de Walque et al. (2008), Gerali et al. (2008) and Pérez Reyna (2009) among others). In our aim to analyze the effect of capital regulation over financial stability and macro variables, we modeled an economy with a banking system that faces endogenous credit risk, which in turn means that in every period the representative bank lacks information regarding the repayment rate associated with its loans portfolio.

The model describes a closed economy with no government. Firms produce a unique consumption good under perfect competition using a standard production technology whose inputs are capital and labor, property of the firms and the households, in each case. There are two types of households: savers and debtors. A representative bank obtains 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 risk free[2].

We suppose a discrete infinite period framework. Households 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 and each period firms decide the amount of debt and the portion of repayment of past debt. Once the consumption good is produced, the firms pay the workers' wages and a punishment for defaulting part of their debt. At the end of the period the debtor households choose an indebtedness level and the amount of past debt they are going to pay to the banks. At the beginning of each period the saver households receive their past labor income, the dividends from banks and firms, and use the resources for consumption and new deposits. Figure 1 summarize the agents interactions within the model.
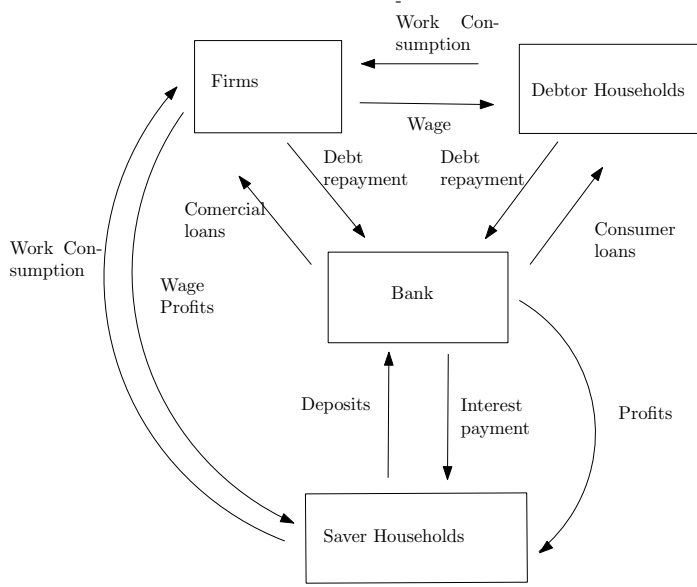
2.1. Firms

Each period firms maximize the discounted value of their profits π_t^f, by choosing the level of capital k_t, labor n_t, commercial loans l_t and the proportion α_t^f of repayment of the loans acquired with the banks

---

Figure 1: **Agent interactions**

the previous period. If the firms do not pay their credits completely, they incur in quadratic defaulting costs, proportional to the amount of debt defaulted. The price of the consumption good is normalized to 1. These agents solve the following maximization problem:

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

subject to

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

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

$$\mathfrak{F}(k_t, n_t, Z_t) = Z_t k_t^\eta n_t^{1-\eta} \tag{4}$$

Equation (2) describes the dynamic of the firm's future capital. Current capital depreciates at a constant rate δ, and the firm's investment is the sum of a fraction ξ of the firm's profits (π_t^f) and the loans they obtain from the bank (l_t) at the beginning of period t. The firm decides the repayment portion (α_t^f) of the previous period debt $((1+r_{t-1}^f)l_{t-1}^f)$, where r_t^f denotes the lending interest rate. The firm knows that defaulting a portion of their debt, implies he will be assuming quadratic defaulting costs[3]. Equation 11 describes the firm's profits. Finally, firms produce under a Cobb-Douglas technology that takes capital and labor as production factors, where Z_t denotes the factor productivity.

---

[3]The costs are quadratic to assure that the punishment grows more than proportional in comparison to the amount defaulted.

2.2. Saver and Debtor Households

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

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

subject to the budget restriction

$$c_t^s + D_t = w_t n_t^s + (1 + r_{t-1}^s) D_{t-1} + (1 - \xi) \pi_t^f + (1 - \nu) \mu_t, \tag{6}$$

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 $(1 + r_{t-1}^s) D_{t-1}$ are the returns of the previous period deposits[4]. Saver households are owners of both banks and firms and consequently receive part of their profits as dividends, $(1 - \xi) \pi_t^f$ and $(1 - \nu) \mu_t$.

Similarly, the debtor households maximize the discounted sum of their utility which depends positively on their consumption c_t^d and leisure $1 - n_t^d$. Similar to firms, this type of households may pay only a portion α_t^d of their debt with the bank. Once again, the default cost parameter is γ_d, in this case, defaulting costs are proportional to the debt repayment fraction, α_t^d, taking this as a measure of the quality of debtors.

The maximization problem of this type of households is:

$$\max_{c_t^d, n_t^d, l_t^d, \alpha_t^d} \sum_{t=0}^{\infty} \beta_d^t \left[ln(c_t^d) + \phi_d ln(1 - n_t^d) \right] \tag{7}$$

subject to

$$c_t^d + \alpha_t^d (1 + r_{t-1}^d) l_{t-1}^d + \frac{\widetilde{\gamma_h}}{2} [(1 - \alpha_{t-1}^d)]^2 = w_t n_t^d + l_t^d \tag{8}$$

The debtor households maximize the discounted sum of their utility and optimally choose their consumption c_t^d, work supply n_t^d, demand for new loans l_t^d and debt repayment fraction α_t^d. Equation 8 is the agent's budget constraint.

2.3. Banks

The representative bank receives deposits D_t from saver households and issues l_t^f and l_t^d credits, to firms and debtor households respectively. Additionally, we suppose that bank's have capital $\tilde{F}$ which is augmented each period with utility reinvestment. Table 1 summarize the bank's balance sheet:

---

[4]Note that deposits, as debt, have a maturity of one period, then there is no maturity mismatch.

TABLE 1: Banks' Balance Sheet

Assets	Liabilities
Commercial loans l_t^f	Deposits D_t
Household loans l_t^d	**Equity**
	Bank's funds F_t

We suppose the representative bank can't distinguish between good and bad debtors but know their default cost distribution. Hence, banks assume they are facing the average debtor and solve the maximization problem:

$$\max_{D_t, l_t^f, l_t^d} \sum_{t=0}^{\infty} \beta_b^t \left(\mu_t - \frac{\rho_t}{2}\sigma_t^2 - \gamma_s \left(\frac{s_t - s^*}{s_t - \underline{s}} \right)^2 \right) \tag{9}$$

subject to

$$\mu_t = \pi_t^f + \pi_t^d - (1 + r_{t-1}^s)D_{t-1} \tag{10}$$

$$\pi_t^f = \alpha_t^f(1 + r_{t-1}^f)l_{t-1}^f \tag{11}$$

$$\pi_t^d = \alpha_t^d(1 + r_{t-1}^d)l_{t-1}^d \tag{12}$$

$$\sigma_t^2 = ((1 + r_{t-1}^f)l_{t-1}^f)^2\sigma_f^2 + 2(1 + r_{t-1}^f)l_{t-1}^f(1 + r_{t-1}^h)l_{t-1}^h\sigma_{f,h} + ((1 + r_{t-1}^h)l_{t-1}^h)^2\sigma_h^2 \tag{13}$$

$$s_t = F_t/(l_t^f + l_t^d) \tag{14}$$

where σ_f^2 and σ_h^2 denote the variance of α_t^f and α_t^d respectively, and $\sigma_{f,h}$ their covariance. Bank's face a cost of choosing a capital adequacy ratio (CAR) level, s_t, different from the optimal level, s^*. If s_t is less than s^* then the bank is signaling less strength to depositors. In this region, the cost increases rapidly and tends to infinity as s_t approaches the minimum regulatory level $\underline{s}$. If the bank chooses a capital ratio greater than the optimal, then is inefficient.

The bank's budget restriction for each period is:

$$D_t + F_t = l_t^f + l_t^d, \tag{15}$$

and the bank's capital dynamic,

$$F_t = \tilde{F} + \nu_t\mu_t. \tag{16}$$

Each period, the bank receives the expected value of lending to firms and debtor households, and pays back the savers' deposits. Equation (15) states that every period the bank's deposits D_t and capital F_t, must equal the sum of commercial l_t^f and consumer l_t^d loans. The capital at the beginning of each period is equal to a constant initial capital $\tilde{F}$ and a portion ν of the bank's past profits, ν_t is initially assumed to be fixed. Once the shock is introduced in the economy, the profits associated with each type of credit

are uncertain since the bank does not know the portion of loans $1 - \alpha$ that the firm and debtor household will default.

So far we have described the base model. In addition, we are going to build a parallel economy in which the banking sector faces Basel III restrictions regarding the utilities reinvestment and counter-cyclical capital requirements.

2.4. Basel III

Counter-cyclical capital buffers are designed to increase capital defense against future potential losses when excess aggregate credit growth is associated with a build up of system wide risk.

Basel III states that the ratio between Common Equity Tier 1 and risk weighted assets (RWA) must be higher than $4,5\%$ plus a conservation buffer of $2,5\%$ and a counter-cyclical buffer that varies between 0% and $2,5\%$ according to credit growth. In our model Common Equity Tier 1 is summarized in the bank's funds F_t [5] and the loans correspond to the RWA. In the model,

$$\frac{\text{Common equity Tier 1}}{RWA} := \frac{F_t}{l_t^d + l_t^f} \geq 4,5\% + \underbrace{2,5\%}_{\text{Conservation Buffer}} + \underbrace{(0\% - 2,5\%)}_{\text{Countercyclical Buffer}} . \tag{17}$$

Following Basel III recommendations, the credit-to-GDP gap is chosen as the target variable in order to determine the counter-cyclical buffer. In our model this gap is defined as follows,

$$G_t = \frac{l_t^d + l_t^f}{y_t} - \frac{l^d + l^f}{y} \tag{18}$$

where G_t denotes the gap, and the variables without time subindex are assumed to be at their steady state value.

The counter-cyclical buffer proposed by the Basel Committee is an increasing function of the gap, which is zero when the gap is least than or equal to 2%, and takes the value of $2,5\%$ when the gap is greater than or equal to 10%. Since the model uses optimization procedures that demand functions to be at least twice differentiable, we approximate the Basel III counter-cyclical buffer rule with the following increasing logistic function:[6],

$$CC_t = \frac{0.025}{1 + \kappa_1 e^{-\varpi_1 G_t}}, \tag{19}$$

---

[5] According to Basel III, the Tier 1 is composed by Core Tier 1 (common equity, retained earnings and portions of minority interests) and additional Tier 1 (some preference shares). In our model we suppose that the bank's capital F_t is composed only by equity that is aggregated with a portion of past earnings.

[6] Basel explicit recommendation for policy implementation is to define a piece-wise function $CC = \begin{cases} 0 & \text{if } G_t < 0.02 \\ 0.025/0.08(G_t - 0.02) & \text{if } 0.02 < G_t < 0.1 \\ 0.25 & \text{if } G_t > 0.1 \end{cases}$, as the counter-cyclical capital requirements rules. Nonetheless, this function is clearly not differentiable and therefore has to be approximated by a smoother twice differentiable function.

where κ_1 and ϖ_1 are parameters that determine the concavity/convexity of the function and its symmetry[7].

The counter-cyclical capital buffer (CC_t) and the capital adequacy ratio determine the portion of past earnings that need to be reinvested by the bank. If we define the adjusted capital ratio as $\tilde{s}_t$, where

$$\tilde{s}_t = s_t - CC_{t-1}, \tag{20}$$

Basel III suggestion are summarized in the next table.

TABLE 2: Bank minimum capital conservation standards

Adjusted Solvency $(\tilde{s}_t)$	Percentage of reinvested earnings (ν_t)
$2,0\% - 3,25\%$	100%
$3,25\% - 5,0\%$	80%
$5,0\% - 5,75\%$	60%
$5,75\% - 7\%$	40%
$> 7\%$	0%

Source:FSI

In the model, the bank'ts reinvestment proportion of past earning is denoted by ν. We want to make this variable a twice differentiable function that approximates the reinvestment proportion presented on table (2). Following the above discussion, we define ν_t to be a function of the capital ratio and the counter-cyclical buffer as follows,

$$\nu_t = \frac{1}{1 + \kappa_2 e^{\varpi_2(\tilde{s}_{t-1} - s)}}, \tag{21}$$

where the parameters κ_2, ϖ_2 and s determine the shape of the reinvestment proportion function[8].

Then, in the scenario where the banking system follows Basel III suggestions the maximization problem of the representative bank would be as follows:

$$\max_{D_t, l_t^f, l_t^d} \sum_{t=0}^{\infty} \beta_b^t \left(\mu_t - \frac{\rho_t}{2}\sigma_t^2 - \gamma_s \left(\frac{\tilde{s}_t - s^*}{\tilde{s}_t - \underline{s}} \right)^2 \right) \tag{22}$$

subject to 10, 11, 12 and 13. Where $\tilde{s}_t$ is the adjusted capital ratio defined in 20, the bank's budget restriction remains unchanged as defined in 15 and the bank's capital dynamic is modified according to the definition of ν_t.

---

[7]We chose these parameters as $\varpi_1 = \frac{ln\left(\frac{(2.5-\delta_1)^2}{\delta_1^2}\right)}{8}$ and $\kappa_1 = \left(\frac{\delta_1}{2.5-\delta_1}\right)e^{10\varpi_1}$, where δ_1 denotes an arbitrary variable that determines the distance of the function to its theoretical value at the extreme of the counter-cyclical buffer function, this is, when the gap equals 2% or 10%.

[8]Analogous to the case of the CC_t function, we determine the values of these parameters in order to replicate the function's desired convergence and symmetry properties. This yields $\varpi_2 = \frac{ln\left(\frac{(1-\delta_2)^2}{\delta_2^2}\right)}{5}$ and $\kappa_2 = \left(\frac{\delta_2}{1-\delta_2}\right)e^{\varpi_2(s-7)}$, where δ_2 is a variable used to calibrate the distance of the function to its theoretical value at the extremes of its domain. $s = 10,75\%$ is the value of $\frac{F_t}{l_t^h + l_t^f} - CC_t$ where $\nu(s) = 0.5$ and was calibrated consistently with table (2).

3. Methodology and Calibration

The model is solved around the steady state in which all variables assume their mean value. We suppose that the default cost parameters for both firms and household debtors ($\overline{\gamma_f}$ and $\overline{\gamma_h}$) are supposed to be known an constant through time, likewise the variance and covariance of the repayment rates, σ_{bf}, σ_{bh} and $\sigma_{bh,bf}$. In 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 two random shocks of productivity and consumer intertemporal preference that temporarily deviate the variables from their steady state values. In particular this shocks have an effect over the repayment rate that is unknown to the bank in the moment he decides the optimal level of loans, nevertheless the banks do know the historic variance of this variables. We study the optimal trajectories that drive variables back to equilibrium levels with each shock.

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 shocks (Canova (2007) or Heer & Maussner (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.

3.1. Calibration

The base model was calibrated using average quarterly data of the colombian economy from 2002 to 2012. The calibration focus in key financial variables and macroeconomic ratios that are, to some extent, the ones we are interested in.

The lending and borrowing rates were computed as the average of these quarterly rates from june 2002 to june 2012, the value of the repayment rate, α, was calibrated as the ratio between $(1 + r_p)$ and $(1 + r_a)$, where r_p and r_a represent the ex-post and ex-ante quarterly borrowing rates, in its order. This enables us to introduce some timming to this variable which is consistent with that of the model. The parameters σ_f^2 and $\sigma_{f,h}$ where calibrated as the variance of the historic (2002 to 2012) values of α^h and the covariance of α^h and α^f. The average working hours $n/2$ is calibrated as in Caicedo & Estrada (n.d.) and finally the parameters η, γ_s and ϕ_d where chosen as reasonable values.

Table 3 shows the calibration used for the base model, the parameters whose values were determined by solving the model are denoted by $*$.

When we introduce Basel III restrictions some additional calibration is needed. In order to guarantee a reasonable level of comparability we kept unchanged the values of some fundamental variables such as discount rates, capital's participation in the production function, variances and covariance of the repayment rates, relative preferences between leisure and consumption for saver and debtor households, optimal and limit capital ratios, capital depreciation rate and the marginal defaulting costs for firms and households, and solvency costs for banks. Finally we assume that the level of capital that the bank owners have plugged in these ($\tilde{F}$) remains constant (i.e) there is the same amount of "moneyťť in the economy.

Table 4 summarize the steady state values of some variables and macroeconomic ratios in both the Benchmark and Basel III models.

After introducing Basel III restrictions, the banks reinvest of past earnings increases which in turn implies that the banks have more capital and that saver households perceive less transfers from bank prof-

TABLE 3: Variable calibration

Variable	Value	Variable	Value
r^d	0.052	β_b	0.99
r^f	0.027	β_f	0.99
r^s	0.058	β_h	0.95*
α^d	0.992	σ_f^2	$1.86 \cdot 10^{-5}$
α^f	0.997	$\sigma_{f,h}$	$2.23 \cdot 10^{-5}$
n	0.416	σ_h^2	$1.53 \cdot 10^{-4}$*
η	0.4	s^*	0.12
ϕ_d	2	$\underline{s}$	0.07
$\tilde{F}$	0.071*	γ_h	139.7*
ρ	740.2*	γ_f	601.8*
δ	0.006*	γ_s	0.01
ϕ_s	3.425*	l^f/l^h	2.467
$(l^f + l^h)/y$	0.215		

Superintendencia Financiera de Colombia. Authors calculations.

TABLE 4: Variable calibration

Variable	Benchmark	Basel III	Variable	Benchmark	Basel III
α^f	0.997	0.997	y	3.446	3.468
α^h	0.992	0.992	c	2.986	3.000
μ	0.102	0.101	k	82.15	83.32
s_t	0.121	0.119	w	4.970	4.996
l^f	0.526	0.534	n	0.416	0.416
l^h	0.213	0.240	ν	0.178	0.206
F	0.089	0.092	c/y	0.867	0.865
d	0.650	0.681	k/y	23.84	24.03
r^f	0.027	0.019	l^f/l^h	2.467	2.224
r^h	0.052	0.052	$(l^f + l^h)/y$	0.215	0.223
r	0.014	0.014			

Superintendencia Financiera de Colombia. Authors calculations.

its. Banks can lend more money and demand more deposits, which implies that capital and consumption rises. Although saver households perceive less income from bank profits the rise in wages makes this household's income increase. Finally, solvency marginally decreases.

4. Results

In this section we present the effects that macroeconomic and consumption preference shocks have on financial stability indicators. Equilibrium is computed using the first order conditions as well as market equilibrium conditions presented in Appendix A. From the linearized system of equations obtained, the impulse response functions are calculated[9]. The impulse response functions represent deviations of variables within their steady state values, we don't present the results as percentage deviations as usual

---

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

because doing this will bias the results if we want to compare the impulse response functions of the Benchmark Model and the Basel III Model which have different steady states. In the following impulse response functions we'll present the deviations from steady state values for both economies and our aim is to compare the effects of the shocks in both.
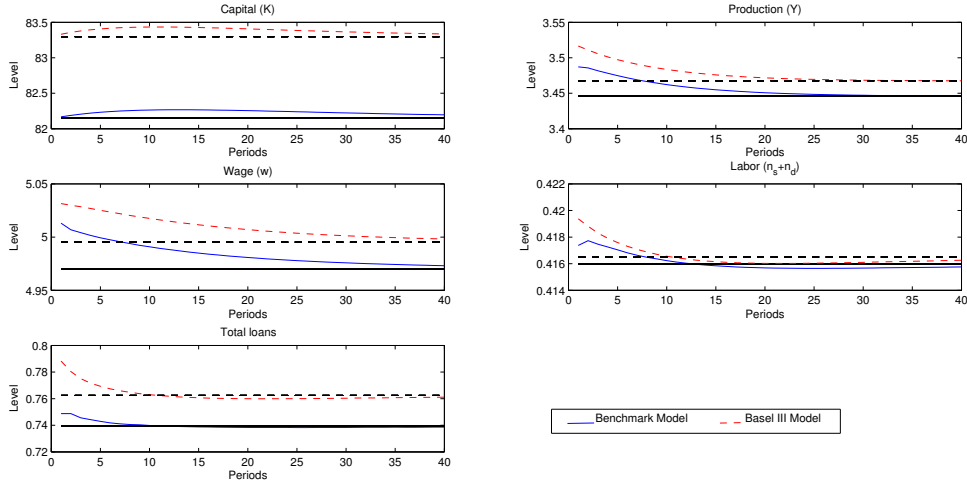
4.1. Total Productivity Shock

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 positive productivity shock to understand its effects over financial stability. We suppose that the external shock is driven by the following autoregressive process,

$$z_t = \psi_z z_{t-1} + (1 - \psi_z)z_{ee} + \epsilon_z, \tag{23}$$

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 $\psi_a = 0.9$[10].

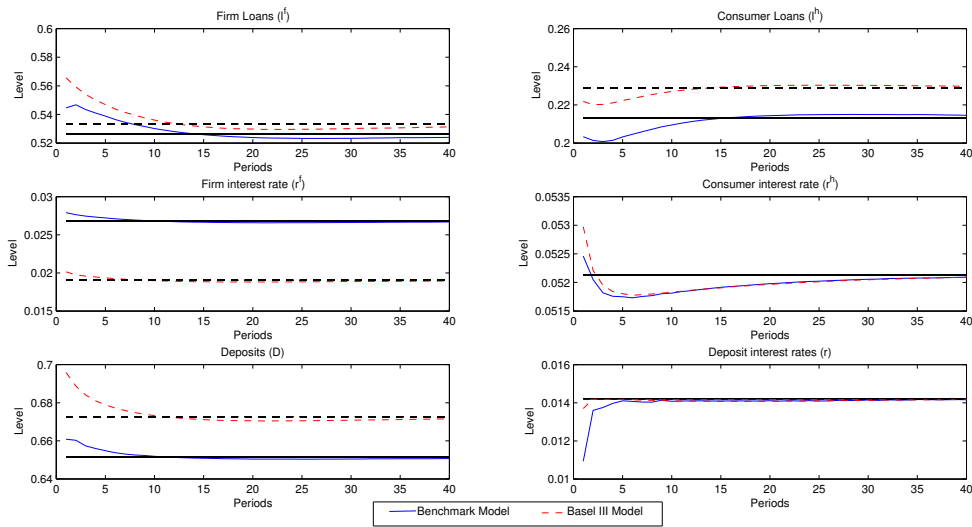FIGURE 2: **Macroeconomic Variables with a Positive Shock to z_t**

Source: Authors calculations.

A positive productivity shock will increase the demand for firm loans and reduce the offer of consumption loans (interest rates raise). The increase in capital increases the demand for labor and induces a rise in wages. Then saver and non saver households perceive more labor income (Figures 9 and 8).

As a result of both the rise in production and in commercial debt value, which increases default costs, firms repayment rate increases. On the other hand, debtor households income increases and consumption increases. As bank's offer for consumption credit decreases the interest rate rises and debtor households decide to repay a smaller portion of their debt and pay a greater punishment for the first periods of the model. Bank's profits increase as a result of the rise in commercial loans rate of return.
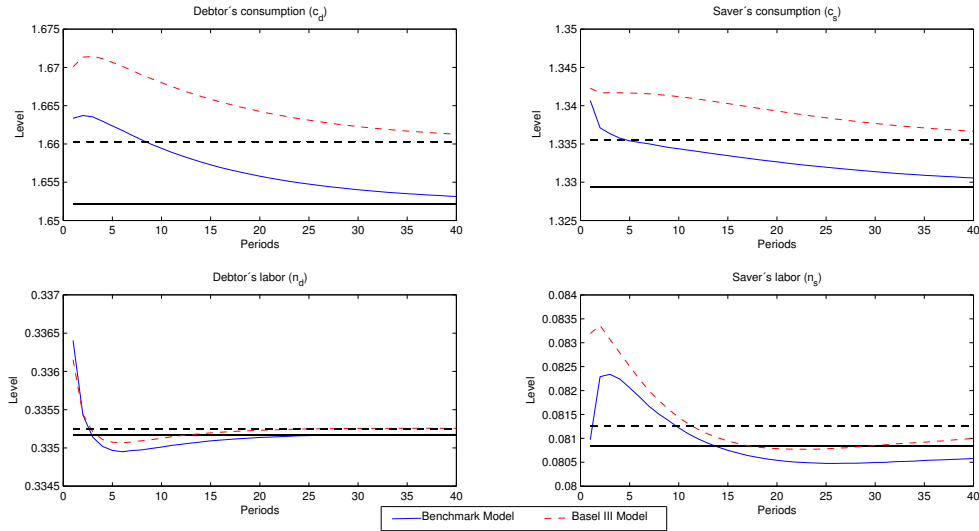
---

[10]Following most of DSGE literature we suppose a high persistence and a small variance (Heer & Maussner (2005)).

FIGURE 3: **Financial Variables with a Positive Shock to** z_t

Source: Authors calculations.

FIGURE 4: **Macroeconomic Variables with a Positive Shock to** z_t

Source: Authors calculations.

As loans to GDP gap increased and the capital ratio decreased as a consequence of the rise in loans portfolio, Basel III restrictions start to work and the portion of utilities reinvested increases in the Basel III model which contains capital ratio to fall lower. Then banks have more space for lending without incurring in greater solvency costs and banks utilities increase for subsequent periods. For debtor houses the increase in earnings reinvestment implies less income for the first periods, but once the banks utilities increase this households perceive more income even when the portion the get is smaller.
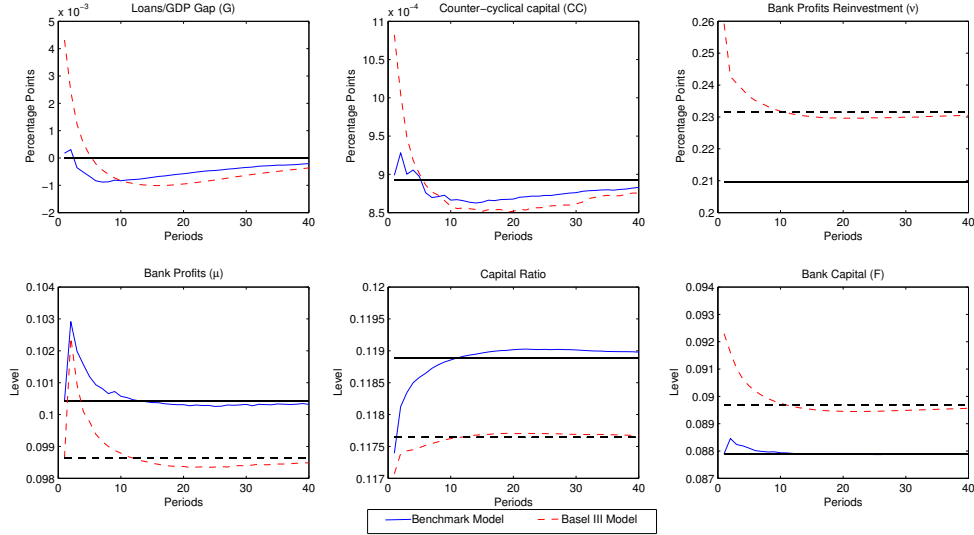
Finally the intermediation margin increased as a result of both the rise in lending rates and the decrease in deposit rates.

Figure 5: **Financial Stability Variables with a Positive Shock to z_t**
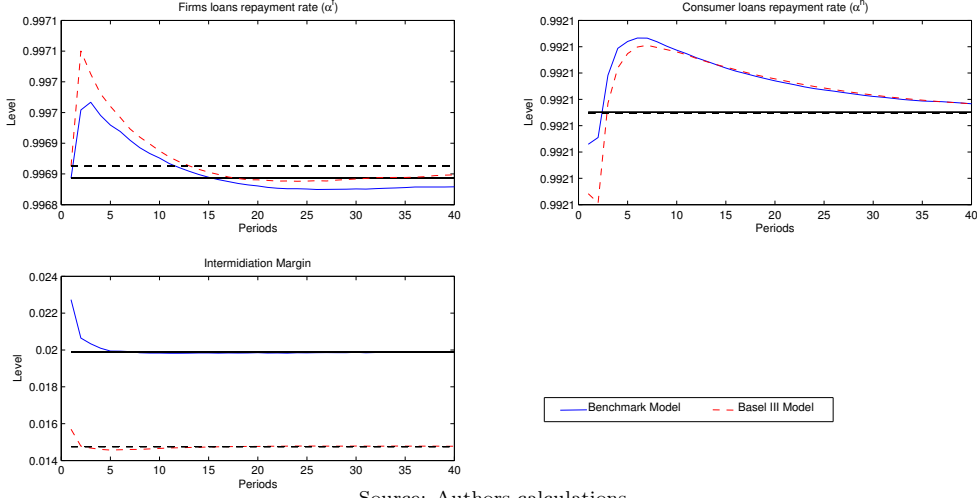
Source: Authors calculations.

Figure 6: **Basel III Variables with a Positive Shock to z_t**
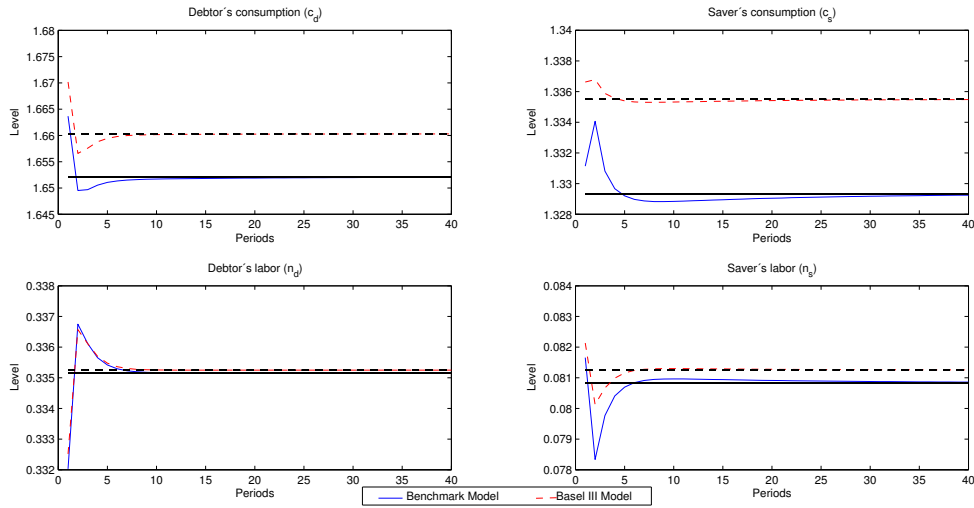

Source: Authors calculations.

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 the factor with which they discount consumption over time. We suppose that the shock is driven by the following autoregressive process,

$$\beta_t = \psi_\beta \beta_{t-1} + (1 - \psi_\beta)\beta_{ee} + \epsilon_\beta, \tag{24}$$

where β_{ee} is the steady state value of the discount rate and ϵ_β denotes the shock. We assume that the variance of the shock is 0.01 and that its persistence is $\psi_\beta = 0.1$, which is smaller than that of the productivity shock.
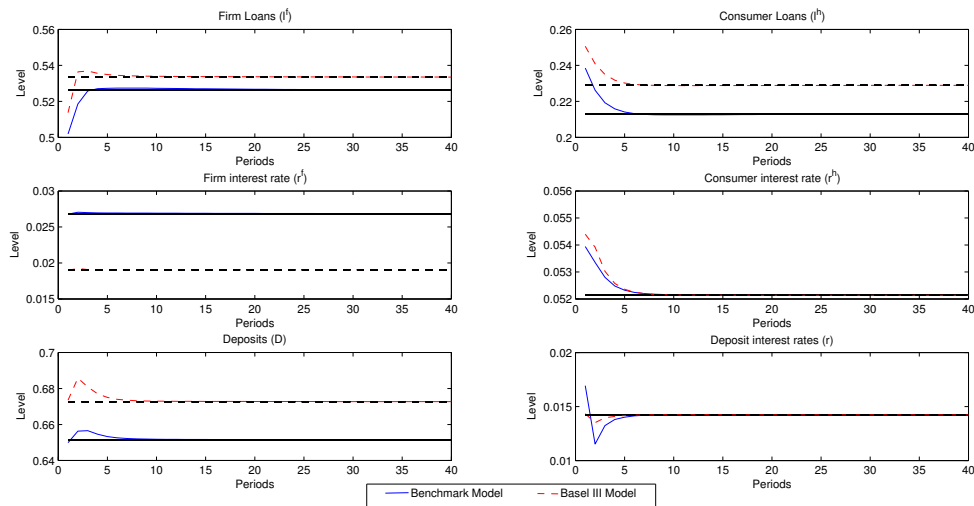
13

FIGURE 7: **Macroeconomic Variables with a Negative Shock to** $\beta_{h,t}$

Source: Authors calculations.

In the initial periods after the shock, debtor household's consumption increased while labor offer reduced for both models. Given that the debtor households represent the majority of the labor force, this initial reduction drove a contraction in total labor offer which in turn increased the wages in the initial periods of the model and as a result saver households decide to work more. Then labor income for debtor households reduced while labor income for saver households increased. Finally, this caused an initial increase in saver household's consumption (Figures 7 and 9).

FIGURE 8: **Financial Variables with a Negative Shock to** $\beta_{h,t}$

Source: Authors calculations.

As expected, the demand for consumer loans increased as a result of the consumption boom (consumption interest rate increased). The initial reduction in labor came along with a reduction in capital demand, which implied a contraction in the demand for firm loans in the first periods of the model and,

as a result, production decreased. In spite of the decrease in firm loans, total loan portfolio increased for the Basel III model and for the Benchmark model with a lag (Figures 8 and 9).

FIGURE 9: **Macroeconomic Variables with a Negative Shock to $\beta_{h,t}$**
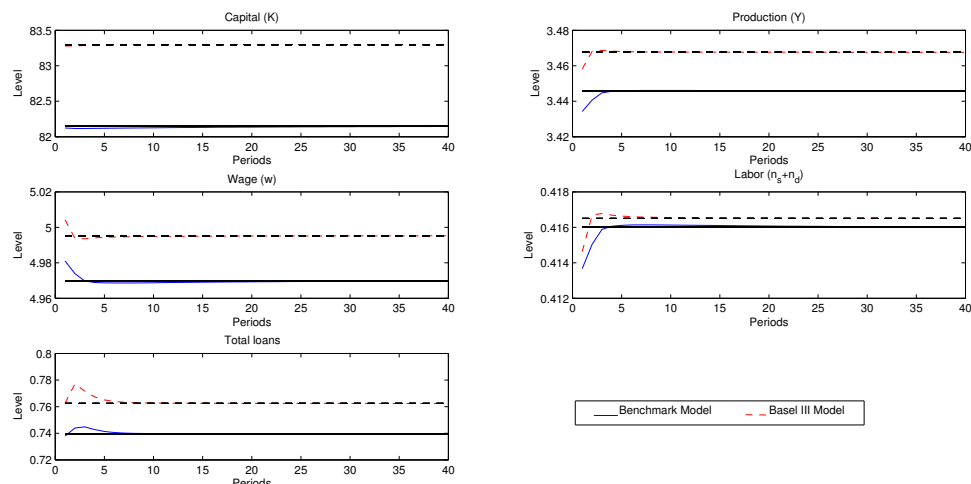
Source: Authors calculations.

In terms of financial stability, households repayment rate reduces marginally as a response to the increase in the value of debt and decrease in the labor income. On the other hand, the repayment rate of the firms decreases slightly (with a one period lag) and afterwards increases as a response of the firms debt value and its interaction with the firm's default cost (Figure 8).

FIGURE 10: **Financial Stability Variables with a Negative Shock to $\beta_{h,t}$**
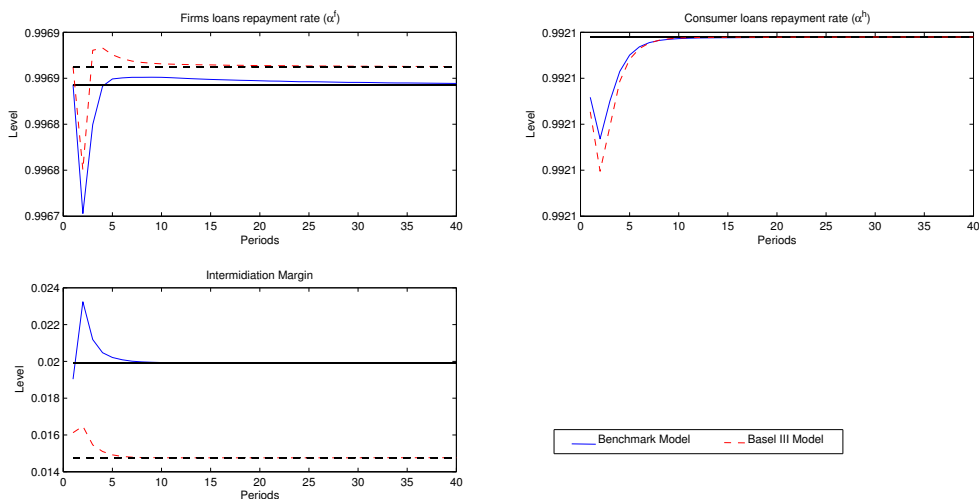
Source: Authors calculations.

The boom increased consumption but after some periods this effect was reverted and consumption fell below the steady state value, this happens because the debtor household's default cost increases rapidly and this households need to give up some of its consumption. When the default cost reaches its maximum the consumption reaches its minimum level. This effect combined with the rise in wages incentivates debtor households to supply more work. Firms demand for capital implies and increase in

15

firm loans which in turn rose firms default cost and its repayment rate in subsequent periods (Figures 8 and 11).

Main differences between Benchmark and Basel III Model arise from the reinvestment parameter (ν). The rise in loans due to the shock and its subsequent effects implied an increase in the loans to GDP gap and an initial decrease in capital ratio. Then, for the Basel III model, the portion of utilities reinvested increased making capital ratio converge to its steady state faster and allowing banks to to lend more without incurring in extra solvency costs. This in turn increased bank profits.

FIGURE 11: **Basel III Variables with a Negative Shock to** $\beta_{h,t}$
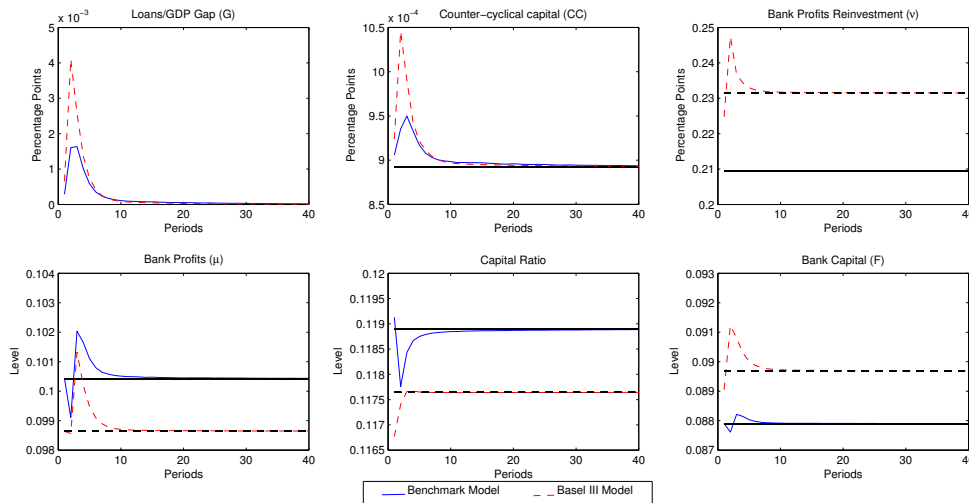
Source: Authors calculations.

In both shocks, Basel III restriction on profits reinvestment and capital ratio requirements acted as buffers for the periods in which credit growth reached levels above its steady state value. What could be seen is that this extra requirement of capital and mandatory profit reinvestment increased banks solvency faster than in the Benchmark model, this reduced the credit rationing that could have taken place if the solvency costs increased. Then banks with a solid capital could keep on lending which ended in an increase of banks utilities. When the portion of earnings reinvested increases, saver households, who own banks, perceive less income but the model shows that after some periods the increase in banks utilities increases their income even when the portion they get is smaller.

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.

Basel III restrictions on capital requirements and profits reinvestment, showed to be handy in terms of financial stability in periods where credit growth is accelerated. It is important to consider that the Basel III parameters are calibrated in this model as is suggested by the Basel Committee, but that this

calibration does not necessarily respond to the reality of Colombian economy. Finally, as a next step, it is important to quantify the effects of Basel III proposals not just over financial stability variables but over the welfare of the society.

References

Admati, A., De Marzo, P., Hellwig, M. & Pfleiderer, P. (2011), 'Fallacies, irrelevat facts, and myths in the discussion of capital regulation: Why bank equity is not expensive', *Rock Center for Corporate Governance at Stanford University* (86).

Aspachs, O., Segoviano, M., Tsomocos, D. & Zicchino, L. (2006), 'Searching for a metric for financial stability', *LSE Financial Markets Group Special Paper Series* (167).

Basel Committee on Bank Supervision, B. (2010), 'Basel iii: A global regulatory framework for more resilient banks and banking systems'.

Caicedo, S. & Estrada, D. (n.d.), 'Consumption, credit restrictions and financial stability: A dsge approach', *Working Paper* .

Canova, F. (2007), 'Methods for applied macroeconomic research', *Princeton University Press* .

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

Gerali, A., Neri, S., Sessa, L. & Signoretti, F. (2008), 'Credit and banking in a dsge model', *Banca d' Italia* .

Goodhart, C., Sunirand, P. & Tsomocos, D. (2006), 'A model to analyse financial fragility', *Economic Theory* (pp 107-142).

Heer, B. & Maussner, A. (2005), 'Dynamic general equilibrium modelling: Computational methods and applications', *Springer* .

Kashyap, A., Rajan, R. & Stein, J. (2008), 'Rethinking capital regulation', *National Bureau of Economic Research* .

Morales, M. & Estrada, D. (2010), 'A financial stability index for colombia', *Annals of Finance, Springer Berlin* .

Pérez Reyna, D. (2009), 'Una aproximación para analizar la estabilidad financiera por medio de un dsge', *Temas de Estabilidad Financiera, Banco de la República* .