



# REPORTE DE ESTABILIDAD FINANCIERA

---

Septiembre de 2010

Implications on Households of Bank's Asset  
Substitution

Santiago Caicedo  
David Pérez-Reyna

# Implications on Households of Bank's Asset Substitution\*

Santiago Caicedo  
David Pérez-Reyna<sup>†</sup>

December 2010

## Abstract

In this paper we develop a DSGE model to analyze the welfare implications over households that bank's asset recomposition might have. We model a representative bank that potentially faces liquidity difficulties due to a mismatch between credits issued to firms and deposits supplied by households. This bank has a portfolio consisting of loans and bonds. The results show that positive liquidity shocks, driven by changes in the household preferences, affect the bank's asset allocation decisions and are beneficial to households. Similarly, when the bond's return rate increases, there is a substitution effect that lowers the loan to bond ratio, but despite this, the bank's intermediation activity increases inducing a positive effect over the household's welfare.

**JEL classification numbers:** D58, E32, E44.

**Keywords:** bank asset recomposition, DSGE model with banking sector, loans deposit mismatch, liquidity shock.

---

\*The authors would like to thank Dairo Estrada and Franz Hamman for very valuable comments. We are also very grateful for the discussions made among the staff of the Financial Stability Department at the Banco de la República (Central Bank of Colombia). The views expressed in this paper are those of the authors and do not necessarily reflect those of the Banco de la República, nor of its Board of Directors. The authors are solely responsible for any errors or omissions.

<sup>†</sup>The authors are, respectively, Professional of the Financial Stability Department and Graduate student at the University of Minnesota. This paper was written while David Pérez-Reyna worked at the Financial Stability Department of the Banco de la República. Corresponding email: scaiceso@banrep.gov.co.

# 1 Introduction

Recently the function banks used to have as intermediaries of resources has lost relative importance against investment fund functions. Financial innovation has promoted the incursion of traditional banks into investment activities that in the past were managed by other financial institutions <sup>1</sup>. Although this integration resulted in important profits for a considerable time span, it also caused problems since the exposure to market risk increased. The recent international financial crisis clearly revealed the potential dangers of allowing banks perform activities outside their main social financial intermediation function (Izquierdo and Talvi (2010)). In spite of this, there is general consensus that fomenting the adequate usage of financial instruments to underpin different types of risks, increases social welfare. In this line, recent literature shows that financial innovation can be beneficial for agent's welfare and concludes that exogenous shocks might be better tackled in an economy in which there is diversity in the financial instruments used (Mullineux (2010), Palmerio (2009) and Arias (2008)).

Although in Colombia banks are not allowed to invest directly in equities or in risky bonds, they are able to have a portfolio based on government debt (TES). Theoretically since this government bonds are more liquid <sup>2</sup>, banks invest in them to ameliorate possible liquidity issues derived from the loan-deposit mismatch. In practice, bond investments have become an important source of revenue for banks. In the period between 2003 to 2006 their participation in total revenue peaked, representing more than 20% of the bank's total income (Banco de la República (2010)). Colombian data shows that there is an evident substitution effect between TES holdings and credit issuing (Figure 1). Monetary policy plays a fundamental role in this substitution dynamic. In fact, the decrease in the Colombia's Central Bank intervention rate that began on December 2008, has motivated banks to increase their TES holdings, while loan's relative importance in the banks' portfolio has diminished. Although during this period banks' profits grew due to the increase in value of government bonds, their exposure to market risk has risen accordingly. A compulsory question surges; is it beneficial to allow banks invest in bonds at the expense of reducing the credit supply in the economy? The main purpose of this paper is to analyze how the tradeoff faced by banks between investing in liquid bonds and less liquid commercial loans can affect households' welfare.

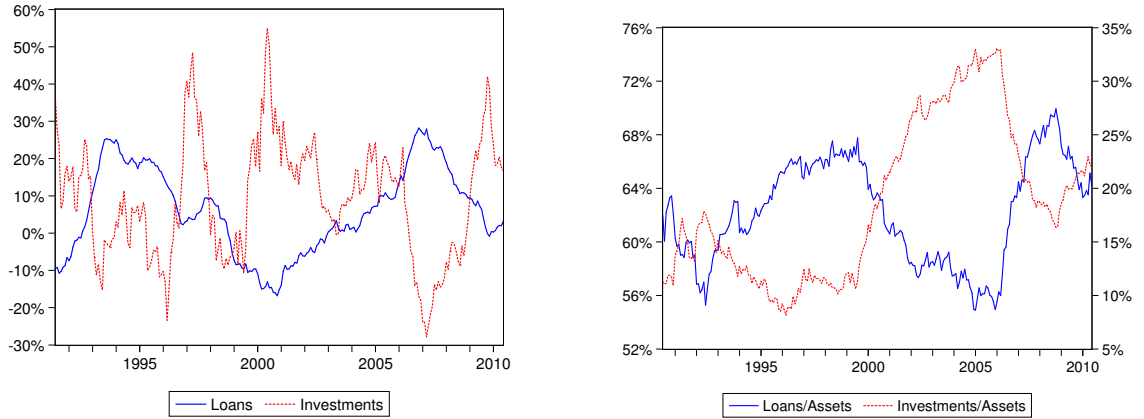
We develop a dynamic stochastic general equilibrium (DSGE) model in which a representative bank potentially faces liquidity difficulties due to a mismatch between credits issued to firms and deposits supplied by households. In this model, firms demand loans to invest in

---

<sup>1</sup>In developed economies it is common to have banks expand their businesses into investment bank markets, having portfolios that include equities and risky bonds.

<sup>2</sup>A bank's portfolio in this kind of bonds is divided between the negotiable ones (which are the ones considered in this paper) and the bond kept until maturity.

**Figure 1: Loans and Investments Real Annual Growth and Bank's Portfolio Composition**



Source: Superintendencia Financiera de Colombia. Calculation by Banco de la República.

capital. The bank faces a portfolio decision problem and maximizes a mean-variance utility function. Following McCandless (2010) we measure the change in household's welfare by computing its value function. Results show that positive liquidity shocks driven by changes in the household preferences, affect bank's allocation decisions as well as its profits, and are beneficial to households. Additionally, we find that an exogenous increase in the government bond's return rate lowers the loan to bonds ratio but has a positive effect over household's welfare since the amount of loans issued also grows.

The rest of the article proceeds as follows: section 2 describes the model used, section 3 shows the calibrated parameters that reflect key steady state values and ratios of relevant variables, section 4 explains the main results, and section 5 concludes.

## 2 Model

We suppose a closed economy without government. There are three types of homogenous agents: households, banks, and firms. Households own both banks and firms. They supply deposits to the former and labor to the latter. They also demand consumer goods, which are produced by the firm. On the other hand, banks demand deposits from households and choose optimal levels of bonds and loans according to a mean-variance objective function. Finally, firms demand loans from the bank, to invest in physical capital. We suppose all agents have rational expectations.

## 2.1 Household

The household seeks to maximize its expected discounted utility stream derived from consumption  $c_t$  and leisure  $\bar{n} - n_t$ , where  $n_t$  represent work hours. To accomplish this, the household chooses its optimal consumption level, deposits and leisure, taking into account its budget constraint. The household perceives income from the bank's profits  $\pi_t^b$ , firm's profits  $\pi_t^f$ , the return on deposits ( $d_t$ ) from the previous period  $(1 + r_{t-1}^d)d_{t-1}$ , and wage income  $w_t n_t$ .  $\beta_h$  denotes the household's intertemporal discount factor and  $\phi$  the substitution parameter associated with the tradeoff between leisure and consumption. The household solves the following optimization problem:

$$\begin{aligned} \max_{\{c_t, d_t, n_t\}} V_t = E_t \left[ \sum_{j=0}^{\infty} \beta_h^j [\ln c_{t+j} + \phi \ln (\bar{n} - n_{t+j})] \right] \\ \text{s. t. } c_t + d_t = \pi_t^b + \pi_t^f + (1 + r_{t-1}^d)d_{t-1} + w_t n_t. \end{aligned} \quad (1)$$

First order conditions for (1) with respect to  $d_t$  and  $n_t$  are, respectively:

$$\frac{1}{c_t} = E_t \left[ \frac{\beta_h}{c_{t+1}} (1 + r_t^d) \right] \quad (2)$$

$$\frac{w_t}{c_t} = \frac{\phi}{\bar{n} - n_t}. \quad (3)$$

Note that equation (2) represents the usual Euler equation and (3) equates the marginal opportunity cost of leisure to its marginal benefit.

## 2.2 Bank

We suppose the bank is risk-averse and maximizes an expected discounted mean-variance objective function. The bank knows the variance of the income derived from lending to firms and of the government bonds rate. We suppose that the bond return rate is at its expected value, which is exogenously fixed at  $r_t^{m3}$ . The bank must satisfy the balance sheet equation  $d_t = l_t + b_t$  on every period, where  $d_t$  denotes the deposits demanded,  $b_t$  the amount of government bonds and  $l_t$  is loans supplied. We assume that the bank offers two-period loans to the firm at the beginning of each period, which are paid back at the end of the next period. Since the bank must honor deposits, but receives loan payment with a one-period

---

<sup>3</sup>Assuming an exogenous bond return is equivalent to incorporating a government who finances public expenditure by issuing bonds and then transfers its expenditure to households through a lump-sum transfer.

lag, it faces a liquidity issue when optimizing. The expected bank income is given by

$$\pi_t^b = (1 + r_{t-1})^2 l_{t-1} + r_t^m b_t - r_t^d d_t - l_t.$$

The income variance is given by

$$\sigma_t^2 = \sigma_l^2 l_t^2 + 2\sigma_{l,b} l_t b_t + \sigma_b^2 b_t^2,$$

where  $\sigma_l^2$  denotes the variance of the income derived from loans,  $\sigma_b^2$  the variance of the return on the bonds and  $\sigma_{l,b}$  is the covariance between this variables<sup>4</sup> The bank solves the following optimization problem:

$$\begin{aligned} \max_{\{l_t, b_t, d_t\}} \Pi_t^b = E_t \left[ \sum_{j=0}^{\infty} \beta_b^j \left[ \pi_{t+j}^b - \frac{\rho}{2} \sigma_{t+j}^2 \right] \right] \\ \text{s. t. } d_t = l_t + b_t. \end{aligned} \quad (4)$$

First order conditions for problem (4) with respect to  $l_t$  and  $b_t$  are given by

$$\beta_b (1 + r_t)^2 - (1 + r_t^d) = \rho (\sigma_l^2 l_t + \sigma_{l,b} b_t) \quad (5)$$

$$r_t^m - r_t^d = \rho (\sigma_{l,b} l_t + \sigma_b^2 b_t). \quad (6)$$

Equation (5) shows that the marginal discounted profits of issuing commercial credits, should be equal to the marginal risk of lending to firms. Similarly, equation (6) tells the same story, but for government bonds.

## 2.3 Firm

The firm produces the good available for consumption using physical capital and labor. We suppose that the production technology is a Cobb-Douglas function:  $F(n, K) = An^\alpha K^{1-\alpha}$  where  $K$  denotes physical capital stock,  $\alpha \in (0, 1)$  and  $A$  is a technological parameter. To accumulate capital, which depreciates at a rate equal to  $\delta$ , the firm demands loans from the bank at the beginning of each period and repays at the end of the following period. In this way the firm's profits are given by the following expression:

---

<sup>4</sup>This parameters are calibrated according to colombian financial data, details of the calibration are given in section 3.

$$\pi_t^f = An_t^\alpha K_t^{1-\alpha} - w_t n_t - (1 + r_{t-1})^2 l_{t-1},$$

where  $r_t$  denotes the one period rate over the commercial loan. The firm seeks to maximize its expected discounted benefits choosing optimal loan  $l_t$  and labor demand  $n_t$  and solving the following optimization problem:

$$\begin{aligned} \max_{\{n_t, l_t\}} \Pi_t^f = E_t \left[ \sum_{j=0}^{\infty} \beta_f^j \pi_{t+j}^f \right] \\ \text{s. t. } K_{t+1} = (1 - \delta)K_t + l_t. \end{aligned} \quad (7)$$

First order conditions for problem (7) with respect to  $n_t$  and  $l_t$  are given by:

$$\alpha A \left( \frac{K_t}{n_t} \right)^{1-\alpha} = w_t \quad (8)$$

$$E_t \left[ (1 - \alpha) A \left( \frac{n_{t+1}}{K_{t+1}} \right)^\alpha \right] = (1 + r_t)^2. \quad (9)$$

Equation (8) shows that in equilibrium the marginal product of labor is equal to its marginal cost  $w_t$ . Equation (9) show that the benefit for an additional unit of capital in the next period should be the same as the investment cost  $(1 + r_t)^2$ .

### 3 Calibration

A period of the model corresponds to one year. The model is calibrated to match key steady-state levels and ratios for Colombia, taking into account data from 2002 to 2009 (see Table 1). The calibrated parameters are summarized in Table 2.

To calibrate the average commercial loan return ( $r$ ), we used the average real rate at which banks supplied commercial loans ( $r^c$ ) as well as the non-performing loan ratio for this loan portfolio ( $NPL$ ).<sup>6</sup> This data was supplied by the Superintendencia Financiera de Colombia.

For  $r^d$ , we used the monthly real average term deposit rate, supplied by the Banco de la República. Given the average of this rate from January 2002 to December 2009, 1.92%, we

<sup>5</sup>Note that  $r_t$  represent the one period compound interest rate.

<sup>6</sup>Non-performing loans are defined as those that are overdue more then 30 days.  $NPL$  is defined as the ratio between non-performing loans and the total loan portfolio.

**Table 1: Steady State Level and Ratios of Variables**

Variable or Ratio	Value	Interpretation
$r$	6.98%	Average commercial loan return
$r^d$	1.92%	Average deposit rate
$n/\bar{n}$	20.79%	Share of available time that household decides to work
$l/b$	3.38	Ratio between commercial loan portfolio and Colombian public debt portfolio

Sources: Caicedo (2010), Banco de la República, Pérez-Reyna (2009), and Superintendencia Financiera de Colombia. Authors' calculations.

**Table 2: Parameter Values**

Parameter	Value	Interpretation
$A$	33.43*	Firm technology parameter
$\alpha$	0.4753	Share of labor in firm production function
$\beta_b$	0.9812*	Bank discount factor, assumed to be equal to $\beta_h$
$\beta_f$	0.9812*	Firm discount factor, assumed to be equal to $\beta_h$
$\beta_h$	0.9812	Household discount factor, equal to $\frac{1}{1+r^d}$ by equation (2)
$\delta$	11.98%	Capital depreciation
$\bar{n}$	1*	Household available time
$\phi$	1.91	Share of leisure in household utility function, calculated from equation (3)
$r^m$	8.12%	Average Colombian public debt return
$\rho$	8	Bank risk aversion coefficient
$\sigma_l$	4.30%	Variance of commercial loan return, calculated from equation (5)
$\sigma_b$	7.40%	Variance of Colombian public debt return
$\sigma_{l,b}$	-0.06%	Covariance between commercial loan return and Colombian public debt return

Free parameters are denoted by \*.

Sources: Caicedo and Estrada (2010), Pérez-Reyna (2009), Reveiz and Leon (2008), and Superintendencia Financiera de Colombia. Authors' calculations.

had an estimate of the household discount factor (0.9812). We supposed this same value for  $\beta_b$  and  $\beta_f$ .

To calibrate  $n/\bar{n}$ , we followed the process used in Pérez-Reyna (2009) and, as a result, the average share of available time the household decides to work was set at 20.79%. We normalized  $\bar{n}$  to one. Finally we calibrates the ratio between commercial loan portfolio and Colombian public debt portfolio to the observed monthly average ratio of these holdings for banks since 2003. Its steady state value  $l/b$  was set to 3.38.

We established  $A = 33.43$  so that  $\rho$  reflect's an aversion coefficient of 4. With respect to  $\alpha$ , we used the same value as in Pérez-Reyna (2009). The value of  $\phi$  used is close to the



share of leisure in the utility function of households in Pérez-Reyna (2009) and of saver households in Caicedo and Estrada (2010).

For  $r^m$  we calculated the average monthly real return of the Colombian public debt index constructed in Reveiz and Leon (2008)<sup>7</sup>. Using this series we calibrated  $\sigma_b$  and  $\sigma_{l,b}$  to reflect observed variance of the index return and covariance between the return of this index and commercial loan return.

## 4 Results

To analyze the implications on households of asset substitution by banks, we decided to perform two exercises. First we shocked parameters that affect household's decision for supplying deposits. In this way we could analyze the behavior of the modeled economy when it faces changes in liquidity. Then, we considered a shock on the bond's return  $r^m$  to study policy changes that could affect the public debt market. For example one can associate an increase in the return in bonds with a decrease in the central bank's intervention rate. Likewise a shock on  $r^m$  can also be mapped with changes in public debt supply.

Additionally we compared the value function of the household under the shocks, with their value function in the absence of shocks. In this way we could analyze the impact of the different shocks, and how optimal decisions made by the bank affects the representative household<sup>8</sup>.

We supposed that agents' expectations of  $\phi$ ,  $\beta_h$  and  $r_t^m$  behave according to the following first order autoregressive processes:

$$\begin{aligned}\tilde{\phi}_t &= \lambda^\phi \tilde{\phi}_{t-1} + \varepsilon_t^\phi \\ \tilde{\beta}_{ht} &= \lambda^{\beta_h} \tilde{\beta}_{ht-1} + \varepsilon_t^{\beta_h}, \\ \tilde{r}_t^m &= \lambda^{r^m} \tilde{r}_{t-1}^m + \varepsilon_t^{r^m},\end{aligned}\tag{10}$$

where  $\{\varepsilon_t^\phi\}_t$ ,  $\{\varepsilon_t^{\beta_h}\}_t$  and  $\{\varepsilon_t^{r^m}\}_t$  are sequences of independent and identically normally distributed errors with variance equal to 1 and mean equal to 0. In (10)  $\tilde{\phi}_t$ ,  $\tilde{\beta}_{ht}$  and  $\tilde{r}_t^m$  denote the percentage deviation of  $\phi_t$ ,  $(\beta_h)_t$  and  $r_t^m$ , with respect to their steady state values. Using (10) we shocked  $\varepsilon_t^\phi$  and  $\varepsilon_t^{\beta_h}$  by 1% and  $\varepsilon_t^{r^m}$  by 10%<sup>9</sup>.

<sup>7</sup>We would like to thank these authors for supplying the series of this index.

<sup>8</sup>Concretely, using Matlab<sup>®</sup> based toolbox *Dynare*<sup>®</sup> we estimated a second order approximation of the equations of the model.

<sup>9</sup>We considered shocks that lasted for 20 periods. That is, that after 20 periods variables are sufficiently close to their steady state values. Because equations were approximated using a second order Taylor ap-

## 4.1 Liquidity Shock

Although changes in  $\phi$  or  $\beta_h$  do not affect liquidity available in the economy in a direct way, they do indirectly through the household's consumption and labor supply decisions. Intuitively these shocks could be related to periods of time where consumption decreases its importance for households due to a higher share of leisure in the household's utility function, or to lower urge to consume<sup>10</sup>.

An increase in  $\phi$  causes leisure to have a higher share in the household's utility function. Therefore the price of leisure,  $w$ , increases. This causes both a reduction in consumption and in labor supply (Figure 2). Also, deposit supply decreases, which results in a higher deposit rate.

On the other hand, lower labor supply implies a reduction in production. As a consequence loan demand decreases as well, causing a lower equilibrium credit interest rate. Nonetheless, since the fourth period after the shock loan demand increases, as well as its equilibrium rate. Finally, lower production, with higher prevailing rates causes a decrease in profits.

Since loan demand decreases, banks lower its ratio of loans to bonds in the shock's period. However, since deposits decreased, so does bonds demand, only in lesser degree than loans. Nevertheless, increasing loan's demand in the following periods results in increasing bank's exposure to the firm. Finally, an increment in the rate differential between credit and deposit rate is the main reason why bank's profits decrease from the second period after the shock, even though profits increased in the first period due to the past debt paid by the firm.

A shock causing an increase in  $\beta_h$  affects intertemporal decisions for the household. Since future consumption and leisure weights more in its expected discounted utility stream, the household reduces its consumption and increases its labor supply. A lesser consumption level and higher labor income allows an increase in deposit supply, along with a reduction in the equilibrium deposit rate (Figure 3).

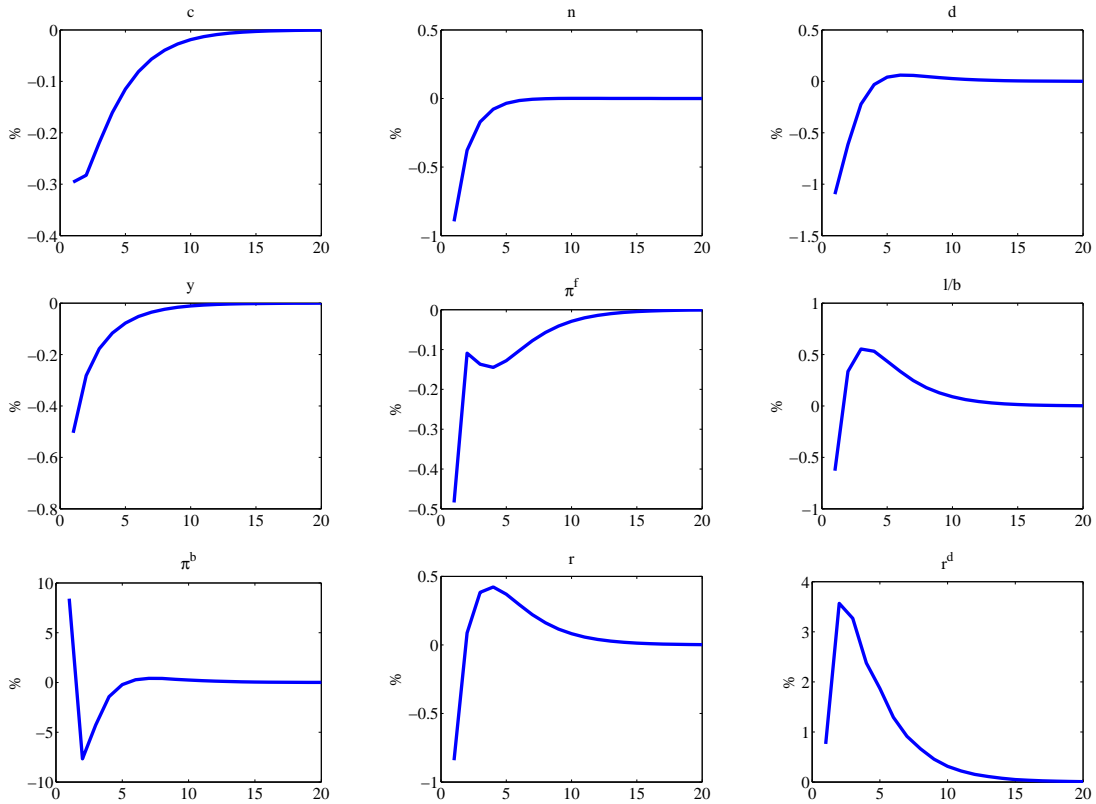
The increase in resources causes the bank to augment both its loan supply and bond demand. However, a higher increase in loan supply than in demand has as a consequence a lower equilibrium interest rate. Due to this, banks change their asset composition to be more exposed to bonds than to firms. Nonetheless the increase in assets, liquidity issues regarding the lag between supplying loans and receiving its interest payments cause that bank benefits

---

proximation, the error of a 1% shock in  $\varepsilon_t^\phi$  and  $\varepsilon_t^{\beta_h}$  deviation would be smaller than  $\epsilon = (0.01)^3$ . In this way, we calibrated  $\lambda^\phi$  and  $\lambda^{\beta_h}$  so that after 20 periods variables would be have a deviation with respect to their steady state variables of less than  $\epsilon$ . Therefore we assumed  $\lambda^\phi = \lambda^{\beta_h} = 0.01^{3/20}$ . Similarly, we supposed  $\lambda^{r^m} = 0.1^{3/20}$ .

<sup>10</sup>Note that the results might depend on the fact that we are only considering commercial loans due to the fact that they represent the most significant portion of total loans for the colombian case. Future work should focus in including other types of loans in order to check the robustness of the results found in this article.

**Figure 2: Percentage Change of Variables with Respect to Their Steady State Values after a Shock on  $\varepsilon^\phi$**



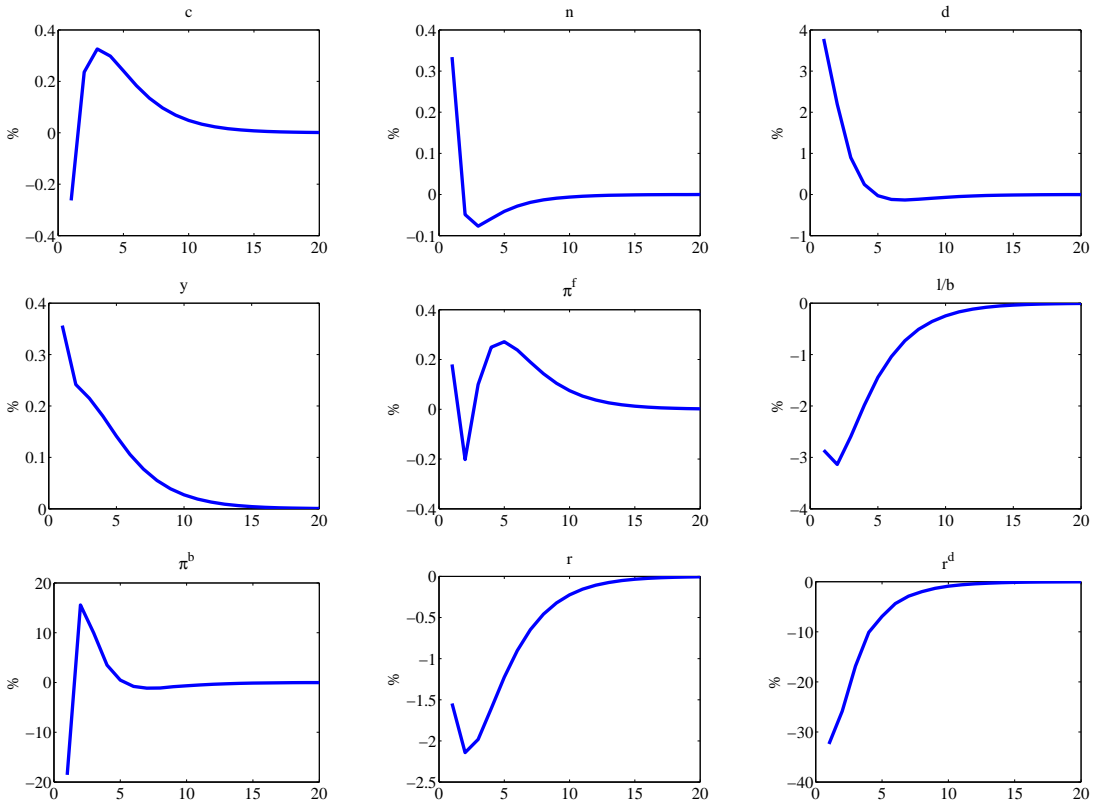
Source: Authors' calculations.

decrease in the first period after the shock. From the second period on, benefits are higher than their steady state value.

Finally firms increase their production due to higher investment in capital and more available labor resources. However increasing labor costs cause benefits to decrease during the second period after the shock, only to increase afterwards.

As a conclusion, both shocks have an impact on liquidity and hence, on the bank's decision to allocate resources between loans and bonds. An increase in  $\phi$  is associated to lesser available liquidity, while an increase in  $\beta_h$  causes the contrary. The fact that loans are less liquid than bonds is reflected on the lagged behavior in some of the analyzed variables. In particular, the impact of both shocks over the bank's benefits is opposite between the first and the second period after each shock. This suggests that banks buffer the liquidity shock mainly with its profits.

**Figure 3: Percentage Change of Variables with Respect to Their Steady State Values after a Shock on  $\varepsilon^{\beta_h}$**



Source: Authors' calculations.

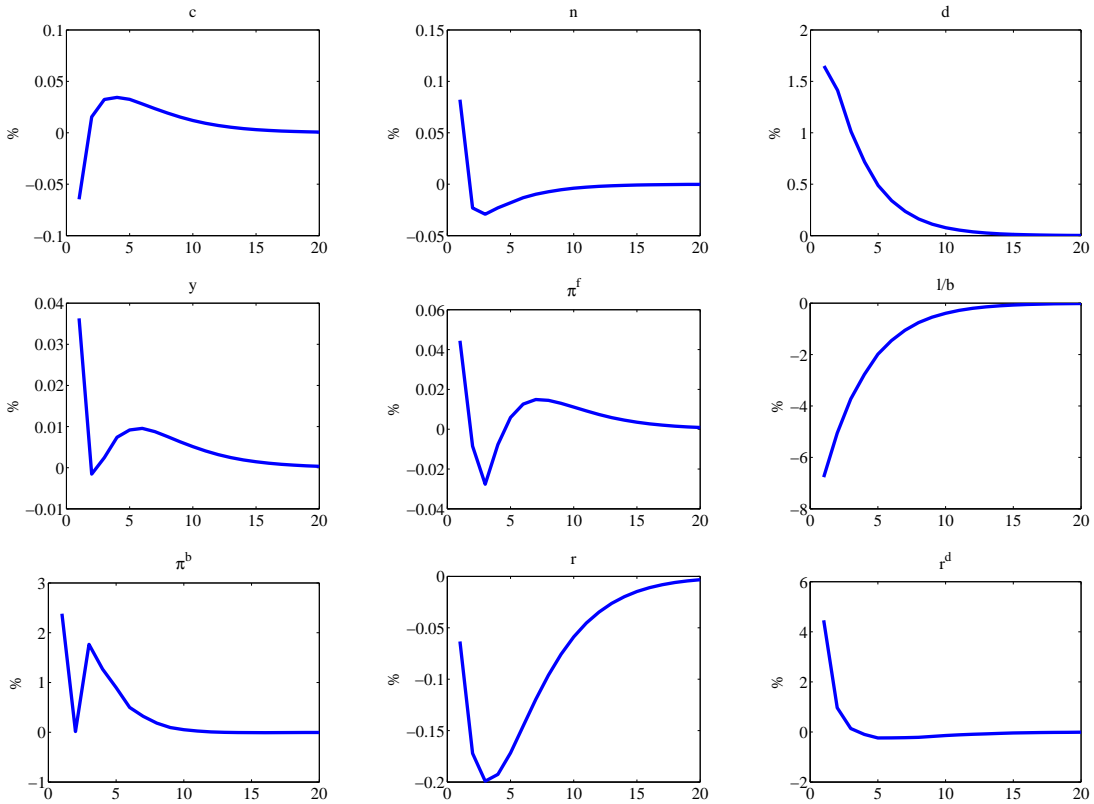
## 4.2 Bond Return Shock

To analyze the asset recomposition of the bank in case a market event occurred, we modeled an exogenous increase in  $r^m$ . In a real life economy, an increase in bond return could be a consequence of, for example, a decrease in the central bank's intervention rate. Additionally, an increase in bond supply caused by higher liquidity needs by the government could cause the opposite effect: a lower bond return. Consequences of this last event would be somewhat opposite to the ones shown in Figure 4.

Since bonds have higher return, the bank substitutes loans for bonds in its balance sheet. To seize the higher profitability, the bank's demand for deposits and  $r^d$  increase. Since loans are less liquid, their supply increases with a lag causing a lower equilibrium rate in the credit market. Thus the intermediation margin, defined as the gap between credit and deposit rate, tightens.

The increase in loan's supply from the second period after the shock translates into a higher production and capital stock level. However, since decreasing loan rates benefit the firm

**Figure 4: Percentage Change of Variables with Respect to Their Steady State Values after a Shock on  $\varepsilon^{r,m}$**



Source: Authors' calculations.

with a lag, it is only after the fifth period that the firms benefits are higher than their steady state value.

Since deposits increase, the household's consumption decreases right after the shock. Nonetheless, the higher return of deposits in subsequent periods allows the household to consume more afterwards simultaneously with an increase in leisure.

In conclusion, an increase in bond's return induce substitution between the bank's assets. However, there is also an increase in loan supply due to higher resources available from deposits, although with a lag. In this model this suggests that the fact that banks perform functions other than intermediation of resources may not necessarily have a negative effect on households, since it increases bank's demand for deposits.<sup>11</sup>

<sup>11</sup>Although with a different modeling scheme, in Saade and Pérez (2009) regulatory changes leading to greater liquidity in the economy also cause the intermediation margin to shorten.

### 4.3 Implications on Household

The impulse-response functions shown in sections 4.1 and 4.2 reflect the consequence of the analyzed shocks on the relevant variables of the model. However, to study the effect of these shocks on households, we considered their discounted utility stream in a situation with and without the shocks.

More formally, let  $\widehat{C}(\varepsilon) = \{\widehat{c}_t(\varepsilon)\}_{t=0}^{\infty}$  and  $\widehat{N}(\varepsilon) = \{\widehat{n}_t(\varepsilon)\}_{t=0}^{\infty}$  be optimal consumption and labor streams for the 20 periods that lasts the shock on  $\varepsilon$ , where  $\varepsilon \in \{\varepsilon^\phi, \varepsilon^{\beta_h}, \varepsilon^{r^m}\}$ . On the other hand, let  $\bar{c}$  and  $\bar{n}$  be the steady state values. Similarly, let  $\widehat{\mathcal{B}}(\varepsilon) = \{\widehat{\beta}_{ht}(\varepsilon)\}_{t=0}^{\infty}$  and  $\widehat{\Phi}(\varepsilon) = \{\widehat{\phi}_t(\varepsilon)\}_{t=0}^{\infty}$  be the streams of  $\beta_f$  and  $\phi$  under a shock on  $\varepsilon$ , where  $\varepsilon \in \{\varepsilon^\phi, \varepsilon^{\beta_h}, \varepsilon^{r^m}\}$ .

Now for  $\varepsilon \in \{\varepsilon^\phi, \varepsilon^{\beta_h}, \varepsilon^{r^m}\}$  we define

$$\begin{aligned}\widehat{V}(\varepsilon) &:= \sum_{t=0}^{\infty} \left(\widehat{\beta}_{ht}(\varepsilon)\right)^t \left[ \ln \widehat{c}_t(\varepsilon) + \widehat{\phi}_t(\varepsilon) \ln (\bar{n} - \widehat{n}_t(\varepsilon)) \right] \\ V &:= \sum_{t=0}^{\infty} \beta_f^t [\ln \bar{c} + \phi \ln (\bar{n} - \bar{n})] = \frac{1}{1 - \beta_h} [\ln \bar{c} + \phi \ln (\bar{n} - \bar{n})],\end{aligned}\tag{11}$$

where  $\widehat{\beta}_{ht}(\varepsilon) \in \widehat{\mathcal{B}}(\varepsilon)$ ,  $\widehat{\phi}_t \in \widehat{\Phi}(\varepsilon)$ ,  $\widehat{c}_t(\varepsilon) \in \widehat{C}(\varepsilon)$ , and  $\widehat{n}_t(\varepsilon) \in \widehat{N}(\varepsilon)$  for all  $t \geq 1$ . In (11)  $\widehat{V}(\varepsilon)$  is the household's discounted utility stream under the shocks, while  $V$  is its objective function in the absence of shocks.

Since the shocks were calibrated so that the deviation of the variables after 20 periods are sufficiently close to their steady state values, the first equation in (11) can be approximated by

$$\widehat{V}(\varepsilon) \approx \sum_{t=0}^{19} \left(\widehat{\beta}_{ht}(\varepsilon)\right)^t \left[ \ln \widehat{c}_t(\varepsilon) + \widehat{\phi}_t(\varepsilon) \ln (\bar{n} - \widehat{n}_t(\varepsilon)) \right] + \beta^{20} V.\tag{12}$$

Then we compare  $\widehat{V}(\varepsilon)$  for  $\varepsilon \in \{\varepsilon^\phi, \varepsilon^{\beta_h}, \varepsilon^{r^m}\}$  with  $V$ . Main results are shown in Table 3. Results suggest that available liquidity in the economy may have positive consequences on households. In this way, an increase in  $\phi$ , which causes lower deposit supply, results in a lower values for the household's Value function. On the other hand, both an increase in  $\beta_h$  and a higher bond return augmented the discounted stream of utility for the household.

Even though an increase in  $r^m$  causes asset substitution in the bank's balance sheet, which resulted in a lower loans to bonds ratio than in steady state, the increment in deposit's demand ultimately translates into higher loan supply. This way households are better off with higher deposit returns, and the firm and the bank benefits transfer to them. This result

suggests that although banks may have other options to allocate their resources does not necessarily imply the reduction in their credit supply.

**Table 3: Change in Value Function after a Shock on  $\varepsilon^\phi$ ,  $\varepsilon^{\beta_h}$  and  $\varepsilon^{r^m}$**

Shock	$\widehat{V}(\varepsilon)$	$V$
$\varepsilon^\phi$	236.339	236.352
$\varepsilon^{\beta_h}$	236.450	236.352
$\varepsilon^{r^m}$	236.354	236.352

Source: Authors' calculations.

Nonetheless, the previous results need to be analyzed more thoroughly. The fact the value function under all three shocks has a very similar value to the one under steady state, this reflects that ultimately the shocks' impact on the household's are somehow marginal<sup>12</sup>. In all three cases only the bank's benefits and its asset composition suffered significant deviations from their steady state values. In this way shocks would be needed to be sufficiently big for the value function to have significant changes.

It is worth noting that the fact that neither consumption nor labor supply decisions had important variations after the shocks, may be of modeling representative households. In the real economy, not every household would own banks and firms. Hence, if the model is extended an heterogenous households considered, the impact of the shocks on their discounted streams could be significant. Nonetheless, aggregated results should not be very different.

## 5 Concluding Remarks

The model developed in this paper is a simple first step to analyze the welfare implications of banks asset allocation decisions. The model is a contribution to current literature since it considers possible liquidity difficulties due to the loans deposit maturity mismatch, and therefore justifies the natural role that liquid bonds have in a bank's balance sheet. Two specific characteristics of the banking assets are considered: liquidity and volatility of returns. Bonds represent liquid assets, with high average return but also imply more volatility; whereas commercial credits are modeled as two period assets that have a lower return rate and volatility.

The results show that positive liquidity shocks change the bank's loans bonds ratio decision and have an aggregate positive effect over household's welfare. Similarly, when the return rate of bond is increased, both loans and credits increase, resulting beneficial to households.

<sup>12</sup>This is closely related to near steady state approximation approach adopted in this paper. If one wants to study out of steady state dynamics a different methodology we highly recommend reading Aiyagari (1994) and Diaz-Giménez *et al.* (2010).

Although these results shed some light to the questions presented above, the effect of liquidity and market shocks over household's decision is mild. This is partly due to the local around the steady state analysis carried out in this paper. Future works should focus in this issue and determine out of steady state dynamics, in order to analyze the effect of large shocks over the model's parameters. Additionally, the impulse response functions showed that there is an amplification effect of the parameters' shocks over the bank's decision variables and especially over its profits. Extensions of the current model should emphasis the role of liquidity concerns and its relation with regulatory policies, such as solvency ratios and capital requirements. Also one could focus on explicit monetary policy objectives and its influence over bank's asset recomposition.

## References

- Aiyagari, R. (1994). "Uninsured Idiosyncratic Risk and Aggregate Saving." *The Quarterly Journal of Economics*, Vol. 109, No. 3
- Arias, M. (2008). "Welfare Implications of Financial Innovation in Emerging Markets." Master's thesis, University of Oxford, Oxford, UK.
- Banco de la República (2010). "Reporte de Estabilidad Financiera. Septiembre".
- Caicedo, S. (2010). "Consumo, racionamiento de crédito y estabilidad financiera." Master's thesis, Universidad de los Andes, Bogotá, Colombia.
- Corredor-Waldrón, A. & Pérez-Reyna, D. (2009). "El mercado de crédito comercial y las restricciones de endeudamiento en Colombia." *Temas de Estabilidad Financiera*, Financial Stability Department of the Banco de la República (Central Bank of Colombia), 42.
- Diaz-Giménez, J.; Prescott, E. ; Fitzgerald, T. and Alvarez, F. (1992). "Banking in Computable General Equilibrium Economies." Research Department Staff Report 153, Federal Reserve Bank of Minneapolis.
- Izquierdo, A. and Talbi E. (2010) "The Aftermath of the Global Crisis Policy Lessons and Challenges Ahead for Latin America and the Caribbean ". *IDB*. March
- McCandless, G. (2010). "On the Social Value of Banks." Forthcoming in *Ensayos Sobre Política Económica*.
- Mullineux, A. W. (2010). "Financial innovation and social welfare." *Journal of Financial Regulation and Compliance*; 2010, Vol. 18 Issue 3, p243-256, 14p
- Palmerio, G. (2009). "Some Thoughts on Financial Innovation and Financial Crises." *Amfiteatru Economic*, v. 11, iss. 26, pp. 522-32.



- Pérez-Reyna, D. (2009). “Análisis de estabilidad financiera por medio del canal de crédito de consumo.” Master’s thesis, Universidad de los Andes, Bogotá, Colombia.
- Reveiz, A. & León Rincón, C. E. (2008). “Índice representativo del mercado de deuda pública interna: IDXTES.” *Borradores de Economía*, Banco de la República (Central Bank of Colombia), 488.
- Saade Ospina, A. & Pérez-Reyna, D. (2009). “Cambios en los incentivos de los bancos como consecuencia de modificaciones en los esquemas de encaje.” *Temas de Estabilidad Financiera*, Financial Stability Department of the Banco de la República (Central Bank of Colombia), 41.