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POLICY RATE PASS-THROUGH: EVIDENCE FROM THE COSTA RICAN ECONOMY

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ABSTRACT

This paper examines the pass-through of the policy interest rate for the Costa Rican economy in the period 1996-2007. By estimating a non-linear asymmetric vector error correction model we found evidence supporting the hypothesis of a complete pass-through in the long run. Results also show that since the introduction of the administrated band exchange rate system (October 2006) banks react faster in the short run to movements of policy rate. Evidence does not favor the hypothesis that in the short run banks react differently to policy rate movements depending on whether such changes are positive or negative, in other words, there is no evidence of an asymmetric reaction of retail interest rates to movements of policy rate. On average, loan and deposit rates take 9.4 and 5 months respectively to fully pass a shock of policy rate. These average times are reduced to 3.5 and 2 towards the end of the sample. Private Banks pass a larger portion of any given movement of policy rate than State owned ones, but take more time to fully do so. Such results, by signaling a smother transmission mechanism of the monetary policies, denote an encouraging environment to the process of migrating to an inflation targeting monetary regime.

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1. Introduction

Monetary policy is a fundamental tool in macroeconomic management. Its appropriate implementation requires a detailed knowledge of the instruments that are available and an accurate understanding of the channels through which they operate.

One of the mechanisms more frequently studied in literature is the interest rate channel. By this means, it is possible to explain how movements in the short run interest rate, which are indirectly influenced by the monetary authority, have an effect on aggregate demand and then over inflation levels.

Mishkin, F. (1996) provides a very appropriate illustration of this mechanism into a context of an economy with significant rigidities in which the long run interest rate is conceived as a weighted average of the expected short run interest rates[2]. Under those assumptions, the author shows how an increase of the policy interest rate leads nominal short run interest rates to raise and, given the assumed price rigidities, such increment will rise short run real rates and long term real rates according to the term structure expectation hypothesis. Finally, higher long run real rates dampen aggregate demand and so loosen up inflationary pressures.

It should be clear then, that it is fundamental that the monetary authority has real capacity to influences short run market nominal interest rates. The successfulness of monetary policy actions is a direct function of the magnitude and velocity with which the financial system passes to agents any change of policy interest rate.

Many of the theoretical models found in literature assume a complete an immediate pass-through of the policy rate[3], yet there are also several empirical works that do not support such assumption[4] by showing the existence of a lagged and incomplete pass-through that also differs across countries.

Those are reasons why it is important to know the particular pass-through interest rate mechanism in the Costa Rican economy. The subject is chiefly relevant into the current stage of a transition from an monetary aggregates control regime towards an inflation targeting monetary regime in which the main instrument to regulate inflationary pressures is the policy interest rate.

A first approach to the subject in Costa Rica is found in Madrigal, J., Torres, C. and Villalobos, L. (1999) where, by using graphic analysis, forward indicators and vector autoregressive techniques, authors study whether the Central Bank reference rate is a guide to the rest of the financial system. Their study concludes that both, loan and deposit rates, respond relatively fast to shocks of the 6-months yield of Monetary Stabilization Central Bank Bonds (BEMS6), yet the sensibility declined after the joint auction of the Central Bank and Finance Ministry started to work in 1996.

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[2] This assumption is known as *term structure expectation hypothesis*.
[3] See for instance Barnanke, B. and Gertler, M. (1995)
[4] For example Cottarelli, C. and Kourelis, A. (1994).

Literature mentions several reasons why the pass-through of the policy interest rate might not be complete. Among them, it is included the absence of a fully competitive banking market and the existence of costs due to asymmetric information. In Laverde, B. and Madrigal, J. (2005) the degree of competitiveness of the Costa Rican Banking system is studied by applying Bresnahan, T. (1982) model. In a nutshell, authors conclude that the Costa Rican banking market exhibit a not very high level of monopoly power which is clustered basically on State owned banks.

Such characterization might signal an incomplete pass-through of the policy interest rate. This document aims, among other things, to test such incompleteness hypothesis. The paper also tries to find out which is the velocity of the policy interest rate pass-through and whether loan and deposit rates react differently when facing a shock of policy rate. It is also tested if State owned banks react differently from private banks in both, the long and the short run, in adjusting their retail rates after a movement of policy rate.

Additionally, two key issues are addressed, the possible asymmetry and non-linearity of the pass-through. We try to determine if retail rates react in a different way depending on whether the shocks of the policy rate are positive or negative. On the other hand, the hypothesis of non-linearity is tested by analyzing if the pass-through effect significantly accelerated after October 2006 when the Central Bank of Costa Rica switched from a crawling peg exchange rate regime to one of administrated bands.

The study will try to add up to the analysis of the subject in several aspects in relation to what Madrigal, J., Torres, C. and Villalobos, L. (1999) exposed. Firstly, according to the advice of using a very short run policy interest rate[5], we used, as a proxy of policy interest rate, a shorter run reference rate (30-days instead of 6-months BEMS rate). Secondly, the methodological approach is previously chosen based on stationary properties of the series. Last but not least, microfundations of the equations subject to econometrical analysis are provided.

The organization of the paper is as follows, after this introduction, section 2 offers a short literature review on the field. Section 3 exposes a model that provides microfundations to the econometric estimations. After that, in section 4 all methodological aspects regarding econometric approach, data collection and interpretation of parameters are fully explained. Following, main results are shown and explained in section 5. Finally, section 6 summarizes key conclusions.

[5] See Edwards, S. (2000).

2. What Influences the Pass-Through of the Policy Rate in the Short and the Long Run? A Short Literature Review.

What is shown below in section 3, that is, retail interest rates may adjust sluggishly and not fully to movements of the policy rate, is a phenomenon that literature associates with banking markets where the information is not complete and, in general, with markets that are not completely competitive.

Many empirical works have found evidence of an incomplete pass-through of the policy rate even in the long run[6]. Such an output may arise, as Lahura, E. (2005) points out, as the consequence of significant market power of some agents and/or the existence of costs due to asymmetric information.

Large barriers to entrance, hidden costs or regulations that do not permit an easy entrance of new banks are commonly mentioned as reasons for the existence of a non competitive banking industry. If this is the case, those banks already into the system may well delay, not completely adjust, or even keep their retail rates unchanged when there is an increase in their marginal cost (interbank rate). This will erase profit opportunities that candidates to enter the industry might have had otherwise.

On the other hand, costs for asymmetric information create adverse selection and moral hazard problems when the market determines retail interest rates. As it will be explained forward, Stiglitz, J. and Weiss, A. (1981) signals that banks may not fully react to an increase of the policy rate because this can increase the risk of default of some of their current clients and persuade new ones to choose higher risk projects.

The literature mentioned until now is dedicated to analyze the case of an incomplete pass-through of the policy rate. Yet there are empirical works that have found evidence of an over-reaction of the retail rates to movements of the policy rate. A model that generates such a reaction can be found in De Bondt, G. (2002). The author assumes two kinds of borrowers, one with no risk of default, and the other one with a probability of default that increases with the interest rate. This last assumption eventually makes the derivative of the equilibrium interest rate charged to the second group of clients with respect to the interbank rate, bigger than one. A hint of intuition about this result is that banks should increase their rates more than what the interbank rate increases in order to compensate a higher probability of default.

If we move to the short run pass-through analysis, reasons for an incomplete adjustment are found in the work of Heffernan, S. (1997) for instance. The author argues that banks can take advantage of consumer´s inertia by dynamically discriminating prices. There are many reasons for clients to behave *inertially*, many of them usually get out-of-time information and are reluctant to switch between banks due to perceived, or real, high costs associated.

[6] See for example Brendin, D.; Fitzpatrick , T. and O Reilly, G. (2001); Kwapil, C. and Scharler, J. (2006); Balázs, É.; Crespo-Cuaresma, J. and Reininger, T. (2004); Lahura, E. (2005).

Lahura, E. (2005) points out that the cost to switch between banks when there is a change in interest rates are linked to the costs of analyze options, look for candidates banks, etc. This may explain, for example, why clients do not change their banks accounts or deposits when their banks reduce deposit rates. Klemperer, P. (1987) shows an interesting approach where the existence of costs of adjustment generates market segmentation and reduces demand elasticities.

Last but not least, the argument about the way a change in policy rate is perceived (transitory or permanent) is well exposed in Brendin, et al. (2001). According to the authors, if a change in policy rate is perceived as too small or transitory, then banks will not have enough incentive to change their retail rates.

Regarding the analysis about non linearities of the pass-through that is developed next in the paper, Lahura, E. (2005) develops an imperfect information and signal extraction short model to show how commercial banks may fix their retail rates. The conclusion suggested on this model is that the pass-through effect depends inversely on a noise/signal ratio in a way such that, the clearer the policy signal sent along with a policy rate change (this is a small noise/signal ratio) , the bigger will be the transmission to the specter of retail rates of the market.

In the case of Costa Rica, a kind of model like this would suggest that the pass-through of the policy rate may have increased after 2005 when Central Bank announced its intention to migrate to an Inflation Targeting (IT) monetary regime. The reason is that before 2005 financial intermediaries probably perceived a higher portion of noise when there was a change in the reference rate of the Central Bank. This used to be the case because the monetary authority was not intensively using such instrument to implement their monetary policy.

The pass-through may have not reacted immediately right after the IT announcement, financial intermediaries more likely waited until a first concrete step was taken. One of the hypotheses of this paper is that the event that might have accelerated the pass-through was the switch in the exchange rate regime (October 2006)[7], which can have been taken as a real compromise to migrate to a system in which the interest rate is much more intensively used as an instrument to regulate aggregate expenditures and so short run inflation pressures.

[7] The Central Bank of Costa Rica changed the crawling peg exchange rate system to one of administrated bands as a first step looking for a more flexible system, which is needed to adopt an IT monetary regime.

3. A Model of Interest Rate Adjustment, Why Commercial Banks React to Movements of Policy Rate?

Other things being equal, the interbank interest rate is commonly treated as the marginal cost to commercial banks. In this sense, literature refers to it as a fundamental of the rates that those banks finally fix in dealing with the public. The following model gives micro-foundations to such behavior by showing its implicit rationality in a partial equilibrium context and under the alternatives assumptions of perfect and monopolistic competition[8].

3.1 Behavior of Commercial Banks.

Assumptions:

i) The banking sector is integrated by N identical banks, each one receiving a particular level of deposits D_i. Each bank carries out loans of an amount L_i and owns a neat position in the interbank market M_i. $i=1,2,\ldots N$
ii) Each bank is a price taker, meaning that the loan rate r_L, the deposit rate r_D and the interbank rate r are all given.
iii) Each bank faces an identical function of administrative cost $C_i=C(D_i, L_i)$
iv) There is a compulsory share α of deposit that must be kept as reserves. $0 < \alpha < 1$

According to these assumptions, the profit function of each bank can be described as follows (for simplicity the subscript i has been omitted):

$$\pi = r_L L + rM - r_D D - C(D, L) \qquad (3.1)$$

Notice also that the neat position in the interbank market can be written as:

$$M = (1-\alpha)D - L \qquad (3.2)$$

Using (3.2), expression (3.1) can be reformulated as:

$$\pi(D, L) = (r_L - r)L + [r(1-\alpha) - r_D]D - C(D, L) \qquad (3.3)$$

Expression (3.3) describes the profit of each bank as the summation of the intermediation margins on loans and deposits excluding administrative cost. If we further assume that $\pi(.)$ is concave and by differentiating (3.3) with respect to L and D, first order conditions for the maximum profit are obtained:

$$\frac{\partial \pi}{\partial L} = (r_L - r) = \frac{\partial C}{\partial L}(D, L) \qquad (3.4)$$

$$\frac{\partial \pi}{\partial D} = [r(1-\alpha) - r_D] = \frac{\partial C}{\partial D}(D, L) \qquad (3.5)$$

[8] The model here exposed closely follows Freixas, X. y Rochet, JC. (1998)

The intuition behind conditions (3.4) and (3.5) is standard; each financial intermediary will select the amount of deposits and loans that equal the intermediation margins to the respective administrative marginal cost.

3.2 Competitive Equilibrium in the Banking Market.

In a context of perfect competition, conditions (3.4) and (3.5) determine, for each one of the *N* banks, a supply of loans $L^n(r_L, r_D, r)$ and a demand for deposits $D^n(r_L, r_D, r)$.

If demand for funds for investing is named $I(r_L)$; the supply of saves from households is $S(r_D)$ and the amount in bonds placed by the government[9] is B; then the equilibrium in the banking market can be described as follows:

$$I(r_L) = \sum_{n=1}^{N} L^n(r_L, r_D, r) \qquad (3.6)$$

$$S(r_D) = B + \sum_{n=1}^{N} D^n(r_L, r_D, r) \qquad (3.7)$$

$$\sum_{n=1}^{N} L^n(r_L, r_D, r) = (1-\alpha)\sum_{n=1}^{N} D^n(r_L, r_D, r) \qquad (3.8)$$

Equations (3.6), (3.7) and (3.8) describe, respectively, equilibrium in three markets: new loans, saves and interbank market. Notice that equation (3.8) came up after imposing the condition that the aggregate position of the *N* banks in the interbank market is zero.

Now if it is assumed that the Central Bank can control *r* (by increasing or decreasing cash in the interbank market), equation (3.8) simply disappears from the system.

Additionally, with constant marginal administrative cost, that is if we assume $C_L' \equiv \Phi_L \; and \; C_D' \equiv \Phi_D$ it is possible, from expression (3.4) and (3.5), to characterize in a very simple way the equilibrium:

$$r_L = r + \Phi_L \qquad (3.9)$$

$$r_D = r(1-\alpha) - \Phi_{DL} \qquad (3.10)$$

From (3.9) and (3.10) it is clear that $\frac{dr_L}{dr} = 1 > 0$ and $\frac{dr_D}{dr} = 1 - \alpha > 0$

3.3 Equilibrium Under Monopolistic Competition

In an industry such as baking, where there exist important barriers to entrance, the assumption of perfect competition is probably not quite appropriate. This section is devoted to briefly draw a model of monopolistic competition from which it can be derived similar conclusions to those recently obtained in section 3.3. The exposition is worth because it more closely approaches the reality of the banking industries, particularly the Costa Rican one.

[9] For simplicity, it will be assumed that Government's bonds and bank deposits are perfect substitutes from the household's point of view. Then in equilibrium, their interest rates must be the same.

It is assumed that a monopolistic bank faces the following inverse demand functions for loans and supply of deposits: $r_L(L)$and $r_D(D)$. By using the same notations as in the two previous sections, the profit of the representative bank will be:

$$\pi = \pi(L, D) = [r_L(L) - r]L + [r(1-\alpha) - r_D(D)]D - C(D, L) \qquad (3.11)$$

Differently from(3.3), in (3.11) the bank considers the influence that the loaned amount L(or deposited D) has under $r_L(r_D)$. First order conditions derived from (3.11) and from assuming that π is concave goes as follows:

$$\frac{\partial\pi}{\partial L} = r_L'(L)L + r_L - r - C_L'(D, L) = 0 \qquad (3.12)$$

$$\frac{\partial\pi}{\partial D} = -r_D'(D)D + r(1-\alpha) - r_D - C_D'(D, L) = 0 \qquad (3.13)$$

Before continuing, it is useful to define elasticities of loan demand (ξ_L)and deposit supply (ξ_D)that a monopolistic bank faces:

$$\xi_L = -\frac{r_L L'(r_L)}{L(r_L)} > 0 \qquad (3.14)$$

$$\xi_D = -\frac{r_D D'(r_D)}{L(r_D)} > 0 \qquad (3.15)$$

Now by using equations (3.12) to (3.15), the optimal choice (r_L^*, r_D^*) of the bank can be draw as follows:

$$\frac{r_L^* - (r + C_L')}{r_L^*} = \frac{1}{\xi_L(r_L^*)} \qquad (3.16)$$

$$\frac{r(1-\alpha) - C_D' - r_D^*}{r_D^*} = \frac{1}{\xi_D(r_D^*)} \qquad (3.17)$$

It is worth to study the intuition of those last two expressions; they say that as the market power of a bank increases (which is reflected in a lower elasticity), the correspondent intermediation margins will be greater. The particular extreme case of a perfectly competitive market will be the one in which $\xi_L \to \infty \; and \; \xi_D \to \infty$.

Finally, in order to determine $\frac{dr_L^*}{dr} \; and \; \frac{dr_D^*}{dr}$, notice that both, (3.16) and (3.17), implicitly define L^* and D^* as functions of *r*:

$$\frac{\partial\pi}{\partial L} = [L^*(r), r] = \frac{\partial\pi}{\partial D}(D^*(r), r) = 0 \qquad (3.18)$$

Then, differentiating (3.18) yields the following:

$$\frac{\partial^2\pi}{\partial L^2}\frac{dL}{d_r} + \frac{\partial^2\pi}{\partial L \partial r} = 0 \qquad (3.19)$$

$$\frac{\partial^2\pi}{\partial L^2}\frac{dD}{d_r} + \frac{\partial^2\pi}{\partial D \partial r} = 0 \qquad (3.20)$$

Given that $\pi(.)$ is concave, then both, $\frac{\partial^2\pi}{\partial L^2}(r_L^*, r)$ and $\frac{\partial^2\pi}{\partial D^2}(r_D^*, r)$, are negative. So, in order to keep (3.19), it must be the case that $\frac{dL}{dr}$ has the same sign as $\frac{\partial^2\pi}{\partial L\partial r}$; and in order to keep (3.20), then $\frac{dD}{dr}$ ought to have the same sign as $\frac{\partial^2\pi}{\partial D\partial r}$. But note that from (3.12) and (3.13) it is possible to derive:

$$\frac{\partial^2\pi}{\partial L\partial r} = -1 < 0; \quad \frac{\partial^2\pi}{\partial D\partial r} = 1 - \alpha > 0$$

Then, as a result $\frac{dL^*(r)}{dr} < 0$ and $\frac{dD^*(r)}{dr} > 0$. Given that $L(r_L)$ y $D(r_D)$ are decreasing and increasing functions respectively, then it is the case that $\frac{dr_L^*}{dr} > 0$ y $\frac{dr_D^*}{dr} > 0$. In words, the model derives a direct relation between the interbank rate and the optimal rates charged by banks for loans and paid for deposits.

The model of perfect competition exposed in section 3.3 and modified in section 3.4 in order to consider monopolistic competition gives robust microfundations for arguing that commercial banks will fix their rates for loans and deposits as a direct functions of the interbank rate. This last rate can be directly influenced by the Central Bank and for purposes of this paper will be called “monetary policy rate” or just “policy rate”.

3.4 Disequilibrium in the Banking Market, Generating Sluggish Adjustment to Movements of the Interbank Rate

Being the main objective of this paper quantifying the pass-through of the policy rate to the specter of interest rates of the market, as well its velocity, it is important to micro found not only the direct relation among those variables, but also the incomplete and lagged adjustment that is implicit in the vector error correction model (VECM) parameterization that will be exposed next in the paper.

As many empirical work shows, the direct relation between the interbank rate and retail market rates fixed by banks tends to hold mainly in the long run. Several arguments have been exposed to explain the stylized fact that in the short run, adjustments of the interest rate in response to changes in the interbank rate may be incomplete and the dynamic response may be slow.

Stiglitz, J. and Weiss, A. (1981) point out the role that asymmetric information and credit rationing may have in this non monotonic relation between the interbank and retail market rates. In their model, those asymmetries in information generate problems of adverse selection and moral hazard that impose restrictions to a complete and instant reaction of the retail rates.

In a nutshell, the authors argue that when there is a positive shock to the interbank rate, a bank will be reluctant to immediately adjust in the same direction their loan rate because this will reduce the probability of success of some of their client´s projects reducing the expected return of the bank, a classical adverse selection story. On the other hand, the moral hazard issue arises when there is a negative shock to the interbank rate; banks will react sluggishly adjusting their rates because that may attract clients with high risk projects that suddenly found a higher probability of success.

It is clear that the kind of models of sections 3.3 - 3.4, also called Marginal Cost Pricing models (MCP) and those inspired in Stiglitz, J. and Weiss, A. (1981) have important deficiencies. The former ignores the fact that the reaction of retail banking rates may not be complete while the last one implicitly suggest that the variance of the retail rates tends to zero. Neither of this has found empirical support in real world. In addition, neither explains the dynamic adjustment of retail rates. Scholnick, B. (1991) proposes an intertemporal model that mixes those two kinds of models and seems to solve their deficiencies. By doing so, the author generates appropriate microfundations for a VECM approach to quantify the pass through of the policy rate.

To fully understand the intuition of what Scholnick proposes, let us go forward in two steps, first by analyzing the behavior of banks when setting the lending rate and after that, the focus will switch to deposit rates.

3.4.1 Sluggish Adjustment of the Loan Rate.

It has to be clear that banks face costs when setting their loan rates. MCP models state that those costs arise if banks do not shift their loan rates after a movement of the interbank rate. At the same time, banks also face adverse selection costs if they do change their loan rate away from r_L^*. As in section 3.4, if the banking system is not competitive, banks which first adjust their rates will bear those adverse selection costs because they will attract higher risk borrowers. It follows then, that banks will find optimal delaying adjusting their loan rates and, as a consequence, the interbank rate will be more volatile than the loan retail market rate, ai. $Var(r) > Var(r_L)$. These opposite incentives are captured in a quadratic loss function like the following:

$$\min_{r_{Lt}} L = \lambda_L[r_{Lt} - (r_t + \Phi_L)]^2 + \psi_L[r_{Lt} - r_{Lt-1}]^2 - \delta_L[r_{Lt} - r_{Lt-1}][r_t - r_{t-1}] \qquad (3.21)$$

Where Φ_L is a constant mark up as in (3.9).

Differently from (3.9) and (3.11), which are static problems, expression (3.21) formalizes a dynamic optimization, and as such, it specifies a long run desired variable (r_t) and a choice variable (r_{Lt}) for which the agent must choose a path in time that minimizes the lost function.

The lost function (3.21) has three components. The first one $\lambda_L(.)$, tells us that banks will have loss as long a as r_{Lt} differs from the desired level r_t plus a fixed mark up. This ensures that the optimal path of the choice variable will, some way or another, follow the evolution of the target variable. Notice that this is the long run implicit implication of MCP models. The second component $\psi_L(.)$, punishes any fast movements of the choice variable. It must be clear that this reflects the adverse selection problem raised by Stiglitz, J. and Weiss, A. (1981). Finally, the third component $\delta_L(.)$ states that banks will lower their lost if they move their rates in the same direction as the interbank rate. This is where the error correction term of a VECM approach is implicit. Notice that this third component ensures that the disequilibrium *error* from a shock to the target variable will be corrected in the same direction as the long run relation indicates.

For the purpose of this paper, what is probably more important from equation (3.21) is that it clearly ensures that in the long run the choice variable will always approach the target variable, at least asymptotically. Notice also in (3.21) that, while r_{Lt} will adjust slowly to movements of r_t, this last variable is a market clearing rate, so it can be as volatile as needed. Furthermore, there will always be some dynamic response of r_{Lt} , thus (3.21) fits the observed fact that $Var(r) > Var(r_L) > 0$.

3.4.2 Sluggish Adjustment of the Deposit Rate.

What about rates set for deposits? Stiglitz, J. and Weiss, A. (1981) completely omit dealing with it because since banks act as price setters, it is depositors who face the risk of default, so the problem of adverse selection is absent in the market of deposits.

In MCP models, deposit rates are treated equally as loan rates (see equations (3.19) and (3.20)). In this sense it is expected that in the long run both rates follow the movements of the interbank rate.

Scholnick, B. (1991) proposes that the dynamics of short run response of both rates are similar but of a different nature. He argues that even though there is no reason for the deposit rate to adjust slowly to movements of the interbank rate due to adverse selection issues, banks face menu cost that might induce them to limit and/or delay their response. According to this author, banks face a similar minimization problem when deciding how to modify the deposit rates after a shock on interbank rate:

$$\min_{r_{Dt}} L = \lambda_D[r_{Dt} - (r_t + \Phi_D)]^2 + \psi_D[r_{Dt} - r_{Dt-1}]^2 - \delta_D[r_{Dt} - r_{Dt-1}][r_t - r_{t-1}] \quad (3.22)$$

Where Φ_D is a constant mark up.

The problem(3.22), like the one in(3.21), has 3 components. The fist one $\lambda_D(.)$ tells us that there is a constant mark up that establish the long rung relationship between the deposit rate and the interbank rate. The second one $\psi_D(.)$ incorporates the menu costs that make banks try to less-adjust their deposit rates. The last component $\delta_D(.)$ tells us that banks would want to move their rates in a way that *correct* any deviations of the deposit rate from its long run relation with the interbank rate, this is a typical error correction scheme.

Up to this point in the paper it has been shown several arguments on which the methodological an empirical section will be based. Those arguments can be summarized as follows:

i. There exist a long run relation between both, loan and deposit rates and the interbank rate. This last one can be directly influenced by the Central Bank.
ii. This long run relationship keeps in a context of perfect competition and monopolistic competition
iii. Deviations from the long run relation can be modeled in a way that fits a Vector Error Corrections approach to carry out empirical test of what is proposed by the theory.

4. Methodological Aspects

In order to analyze the pass-through of the policy rate, a wide range of different retail interest rates were considered, yet the evidence presented in this paper fully covers only 6 of them[10]:

- Average loan rate of the whole banking system
- Average deposit rates of the whole banking system
- Average loan rate on "other activities" charged by State owned banks
- Average loan rate on "other activities" charged by private banks
- Average 6-months deposit rate paid by State owned banks
- Average 6-months deposit rate paid by private banks

As a proxy for monetary policy rate, the 30-days interest rate paid for Central Bank Instruments[11] was used. The sample covers monthly observations for the period 1996 m1 – 2007 m12[12].

In what follows in this section, different empirical approaches that has been used to explain the pass-through of the policy rate are briefly exposed. Special focus is offered on the VECM procedure that is the one used in the empirical tests whose results are the subject of the coming section.

Widely speaking, literature has approached the analysis of the interest rate pass-through by using three groups of methodologies: VECM, VAR in levels and First Difference Estimation. The order of integration and whether the series cointegrate or not, is the criteria for selecting among them. The following chart summarizes such criteria and offers some references for each case:

Chart 1

Empirical Approaches to the Interest Rate Pass-Through.

Stationary Properties of the Series.	Appropriate Empirical Approach	Reference
Series I(0)	VAR in levels	• Bernstein, S. y Fuentes,R. (2003).
Series I(1) that cointegrate	VECM	• Hefferman, S. (1997) • De Bont, G. (2002) • Toolsema, L.A. et al (2002) • Espinoza-Vega, M. and Rebucci, A. (2003). • Brendin, D. et al (2001). • Sarno, L. and Thornton, D. (2003) • Crespo-Cuaresma et al. (2004)
Series I(1) that do not cointegrate	First Difference estimation	• Disyatat, P. y Vongsinsirikul, P. (2003)

[10] Details of how these series are build can be accessed in: http://indicadoreseconomicos.bccr.fi.cr/indicadoreseconomicos/

[11] In February 2004 the official monetary policy rate was defined as the 30-days rate paid in the *Short Run Investment System* of the Central Bank of Costa Rica (BCCR). In March 2006 the 1-day rate paid in the BCCR deposit facility became the official monetary policy rate. Even though it does not belongs to our sample, in June 2008 the policy rate was redefined as an active rate; it is currently the rate at which the BCCR loan money to the commercial banks in the Money Interbank Market (MID by its Spanish abbreviation).

[12] Average rates are only available from January 1999 up to the present date.

In order to determine the more suitable empirical approach for the Costa Rican interest rates series, unit roots tests were applied. In addition to the standard augmented Dickey-Fuller test, the procedures proposed by Zivot, E. and Adrews, D. (1992) and Perron, P. (1997) that considers possible break points in the series, were also carried out. These last procedures were run by using a RATS software. All remaining econometric calculations on this paper were obtained by using Econometric Views 6.0.

As it will be shown in section 5, we find statistical evidence supporting the hypothesis that the interest rates series are all integrated of order one and cointegrate with the policy rate series, which it is worth to mention, is also I(1). Given this evidence, the right empirical approach for the Costa Rican case would be a VECM one, were the policy rate is assumed to be exogenous[13].

4.1 Measuring Long and Short Run Reaction of Retail Interest Rates, an Asymmetric Non-linear VECM Approach.

As in Lahura, E. (2005), this paper uses an asymmetric non-linear VECM instead of a standard VECM. By doing so, it is possible to test for the presence of asymmetries (different impact on retail interest rates of positive or negative shocks of the policy rate) and non-linearities (significant changes across time) of the pass-through effect.

In section 3.4 (see equations (3.16) and (3.17)) it was established a long run implicit direct relationship between r and both r_D and r_L. If we generically call r_R (retail loan or deposit interest rate), the long run relation can be expressed as the following stochastic and econometrically tractable equation:

$$r_{Rt} = \beta_1 + \beta_2 r_t + \mu_t \qquad (4.1)$$

Where the series μ_t is independently and identically distributed with $E(\mu_t) = 0$ and $Var(\mu_t) = \sigma^2$

Now, if the series actually cointegrate, there must be a unique cointegration vector $[1 \quad -\beta_1 \quad -\beta_2]$ which represents the long run relation. If there is a shock on any of the variables, a deviation from this long run relation will appear and can be written down as:

$$\mu_{t-1} \equiv r_{R(t-1)} - \beta_1 - \beta_2 r_{t-1} \qquad (4.2)$$

Notice that a positive deviation will take place if either r_{Rt} goes up or if r_t goes down (or both of them), and a negative deviation will came up if either r_{Rt} decreases or if r_t increases (or both of them).

Additionally, *Granger representation theorem* allows us to represent the short run dynamics of these two cointegrated variables as follows:

$$\Delta r_{Rt} = \gamma_0 + \alpha\left(r_{R(t-1)} - \beta_1 - \beta_2 r_{t-1}\right) + \sum_{i=0}^{p} \sigma_i \Delta r_{t-i} + \sum_{i=1}^{q} \theta_i \Delta r_{R(t-i)} + \epsilon_t \qquad (4.3)$$

[13] Joint Granger causality test are also provided in order to support this assumption. By such test it is shown that the policy rate is not granger caused by the group of interest rate series considered.

A standard interpretation of (4.3) tells us that the long run pass-through is measured by β_2 while the speed at which the adjustment happen will be given by the parameter α. β_2 is the total portion of a given 1-point change in the policy rate that is passed to the retail interest rate after all adjustments have took place. On the other hand, α indicates how much of this total pass-through happens every period.

The completeness of the pass-through effect can then be evaluated by testing the null hypothesis $H_0: \beta_2 = 1$.

A very useful measure that can be obtained from the VECM specification is the average number of periods that a retail interest rate takes to fully accommodate a given change in policy rate. Such measure is given by $\frac{\beta_2 - \sum \sigma_i}{\beta_2 \alpha}$.

4.1.1 Measuring Non-Linearities

Furthermore, by analyzing the evolution across time of this parameters, conclusion about whether some economic events might have affected the magnitude of the pass-through effect may be reached.

For instance, as mentioned above, in 2005 the Central Bank of Costa Rica announced its intention to switch their monetary-aggregates-control economic policy regime towards an inflation targeting scheme. This requires a much more intensive use of the interest rate as an instrument of aggregate expenditure control which might have produced an increment of the pass-through of the policy interest rate. To test such hypothesis the following non-linear VECM model can be used:

$$\Delta r_{Rt} = \gamma_0 + \alpha_1 \mu_{t-1} + \alpha_2 (d_t \mu_{t-1}) + \sum_{i=0}^{p} \sigma_i \Delta r_{t-i} + \sum_{i=1}^{q} \theta_i \Delta r_{R(t-i)} + \epsilon_t \qquad (4.4)$$

Where d_t is a dummy variable taking a value equal to zero if it belongs to the period before the announcement, and one after it. In this case we test $H_0: \alpha_2 = 0$. If H_0 is rejected then there is statistical evidence that the pass-through effect is not constant across both periods. It is worth to mention that if this is the case and additionally $\alpha_2 > 0$, the evidence will support a significant increment of the pass-through.

4.1.2 Measuring asymmetries

On the other hand, in order to test for asymmetries in the velocity of adjustment of the retail rates (that is testing whether those rates equally respond to positive or negative deviations from the long run relation established in (4.1)) a general asymmetric VECM specification as the following is used:

$$\Delta r_{Rt} = \gamma_0 + \alpha_0 \mu_{t-1} + \alpha_1 \mu_{t-1}^{+} + \alpha_2 \mu_{t-1}^{-} + \sum_{i=0}^{p} \sigma_i \Delta r_{t-i} + \sum_{i=1}^{q} \theta_i \Delta r_{R(t-i)} + \epsilon_t \qquad (4.5)$$

Where $\mu_t^{+} = \begin{cases} \mu_t \ if \ \mu_t > 0 \\ 0 \ if \ \mu_t < 0 \end{cases}$

and $\mu_t^{-} = \begin{cases} \mu_t \ if \ \mu_t < 0 \\ 0 \ if \ \mu_t > 0 \end{cases}$

Notice that in any case $\mu_t = \mu_t^+ + \mu_t^-$. Also keep in mind that a positive deviation μ_t^+ is associated with an increase in r_{Rt}, a decrease in r_t or both of them. A negative deviation μ_t^- occurs when r_{Rt} decreases, r_t increases or both of them.

Now, from the general case (4.5) it is possible to test the hypothesis of asymmetry if α_1 and α_2 are both statistically different from zero and if the null $H_o: \alpha_1 = \alpha_2$ is rejected in the following equation:

$$\Delta r_{Rt} = \gamma_0 + \alpha_1 \mu_{t-1}^+ + \alpha_2 \mu_{t-1}^- + \sum_{i=0}^{p} \sigma_i \Delta r_{t-i} + \sum_{i=1}^{q} \theta_i \Delta r_{R(t-i)} + \epsilon_t \quad (4.6)$$

If it is not possible to reject $\alpha_1 = \alpha_2$, then the data will be telling a story of non asymmetric response of retail rates. In this case the relevant model will be one similar to (4.3) . Notice though, that it is not possible to conclude something about the presence of asymmetries if any of the $\alpha' s$ is not different from zero.

The idea is that in the short run, commercial banks might try to increase their margins between loan and deposit rates by reacting asymmetrically when there is a shock on the policy rate. For instance, if the policy rate increases, both loan and deposit rates will increase in the long run, but in the short run the margin can be increased through a faster reaction of the loan rates.

Then, if it is expected a faster reaction of loan rates when there is an increase of the policy rate (that is a negative deviation from the long run relation) than when there is a decrease, from the relevant asymmetric VECM either of the following joint test hypotheses has to be non rejected:

I. $\alpha_2 \neq 0$ and $|\alpha_2| > |\alpha_1|$
II. $\alpha_2 \neq 0$ and $\alpha_1 = 0$

The same way, if it is suspected that the deposit rate will respond faster when there is positive deviation from the long run relation (here this takes the form of a decrease in the policy rate) than when there is a negative deviation, in the correspondent asymmetric VECM either of the following joint null hypothesis needs to hold:

I. $\alpha_1 \neq 0$ and $|\alpha_1| > |\alpha_2|$
II. $\alpha_1 \neq 0$ and $\alpha_2 = 0$

Finally, both kind of hypothesis, non-linearity and asymmetry, can be jointly tested by using the following general model:

$$\Delta r_{Rt} = \gamma_0 + \alpha_0 \mu_{t-1} + \alpha_1 (d_t \mu_{t-1}) + \alpha_2 \mu_{t-1}^+ + \alpha_3 \mu_{t-1}^- + \alpha_4 (d_t \mu_{t-1}^+) + \alpha_5 (d_t \mu_{t-1}^-) \sum_{i=0}^{p} \sigma_i \Delta r_{t-i} + \sum_{i=1}^{q} \theta_i \Delta r_{R(t-i)} + \epsilon_t \quad (4.7)$$

All VECMs for testing non-linearities and asymmetries of alternatives retail interest rates were carried out by using Engle and Granger (1987) two steps methodology, yet general conclusions about the cointegration relation and the long and short run adjustment between policy interest rate and retail interest rates where reached by using Johansen, S. and Juselius, K. (1990) VECM approach.

5. Results.

5.1 Unit root test. Which is the right methodological approach for the Costa Rican interest rate series?

In order to follow what Chart 1 specifies as the more appropriate methodological approach, unit root tests were applied to the interest rate series. Looking for robustness and since the Augmented Dickey-Fuller (ADF) test is not suitable when the series are stationary with some kind of brake, Perron, P. (1997) and Zivot, E. and Andrews, D. (1992) tests were carried out as well.

Before showing some of the unit root test outputs, it is worth to mention that individual and joint Granger causality test were previously applied to the series. This was in order to verify that retail interest rates are effectively granger-caused by the policy interest rate and not the other way around. Results are shown in appendix A. According to the individual tests, it is not possible to reject the null hypothesis that, individually, each retail interest rate is granger caused by the policy rate series. On the other hand, the joint test examines the null hypothesis that the block of interest rate series granger-causes the policy rate. The evidence strongly rejects such a null.

Unit root test shown below includes only those that allow for brakes in the series, standard augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) test under alternatives assumptions about a constant and trend are exposed in appendix B. Outputs show tests for the seven interest rate series considered forward in the VECM analysis, a decryption of those seven series goes as follows:

PR: Policy interest rate.
ALR: Average loan rate of the whole banking system
ADR: Average deposit rates of the whole banking system
OR_S: Average loan rate on “other activities” charged by State owned banks
OR_P: Average loan rate on “other activities” charged by private banks
DR6_S: Average 6-months deposit rate paid by State owned banks
DR6_P: Average 6-months deposit rate paid by private banks

Chart 2 contains Perron, P. (1997) tests for 3 alternative kinds of brake (intercept, intercept and slope and a transitory slope switch). For all 7 variables the null hypothesis of a unit root cannot be rejected against an alternative of stationarity with a brake at 5% and 1% significance levels. Critical values reported are for infinite samples.

Chart 2
Perron, P. (1997) Unit Root Test

Varaible		Intercept t(alpha=1)	Intercept Break date	Intercept and Slope t(alpha=1)	Intercept and Slope Break date	Transitory Slope t(alpha=1)	Transitory Slope Break date
PR		-5.13	2006:01:00	-5.15	2004:05:00	-4.94	2006:01:00
ADR		-3.78	2006:11:00	-3.67	2006:12:00	-3.50	2007:05:00
ALR		-4.91	2006:09:00	-4.42	2005:03:00	-4.27	2007:09:00
OR_S		-4.30	2006:08:00	-3.93	2004:01:00	-4.13	2004:06:00
OR_P		-4.16	2006:12:00	-3.96	2005:03:00	-4.01	2007:07:00
DR6_S		-4.50	2006:11:00	-4.78	2005:03:00	-4.00	2006:06:00
DR6_P		-4.39	2006:08:00	-4.12	2005:07:00	-4.25	2007:06:00
Critical Values at:	1%	-5.71		-6.21		-5.45	
	5%	-5.09		-5.55		-4.83	

Ho: The Variable is I(1), Ha: The variable is stationary with a brake
* Ho is rejected at a 5%, ** Ho is rejected at 1%

In general, the I(1) hypothesis made over the interest rate series is robust to the application of Zivot, E. and Andrews, D. (1992) unit root test which also allows for brakes in the series. Chart 3 shows such tests assuming 2 kinds of brakes in the alternative (intercept and intercept and slope). Again, critical values reported are those used for infinite samples.

Chart 3
Zivot, E. and Andrews, D. Unit Root Test

Variable		Intercept Minimum T_Statistic	Intercept Brake date	Intecept and Slope Minimum T_Statistic	Intecept and Slope Brake date
PR		-4.91 *	2006:02:00	-5.15 *	2004:07:00
ADR		-3.36	2006:09:00	-3.80	2005:10:00
ALR		-3.87	2006:08:00	-4.42	2005:05:00
OR_S		-3.43	2006:03:00	-3.82	2002:01:00
OR_P		-3.66	1998:10:00	-3.95	2005:05:00
DR6_S		-4.19	2006:06:00	-4.78	2005:05:00
DR6_P		-3.29	2001:12:00	-4.19	2005:09:00
Critical Values at:	1%	-5.34		-5.57	
	5%	-4.81		-5.08	

Ho: The Variable is I(1), Ha: The variable is stationary with a brake
* Ho is rejected at a 5%, ** Ho is rejected at 1%

The policy rate was found stationary with a brake by the Zivot-Andrews test at 5% level, but given that at 1% the variable is I(1) and so it is at all levels according to Perron, P. (1997) and the ADF test, the variable was taken to be I(1) in any case.

Given the above evidence, all 7 series can then be treated as integrated of order one. The next step is then investigating whether each of the retail interest rate series cointegrates with the policy rate. Standard ADF unit root test were applied to the residuals of regressions in which the retail rates are explained by the policy rate and a zero-mean equal-variance stochastic error term, that is to the residuals of an equation like (4.1). Chart 4 exposes those tests. Notice that residuals series are named by adding a U_ term before the corresponding name of the interest rate series.

Chart 4
Augmented Dickey-Fuller Test Statistic of Residuals

	U_ALR	U_ADR	U_DR6_P	U_DR6_S	U_OR_P	U_OR_S
t-Statistic	**-3.268**	**-3.063**	**-3.920**	**-3.414**	**-2.742**	**-2.461**
1% level	-2.587	-2.587	-2.581	-2.581	-2.581	-2.581
5% level	-1.944	-1.944	-1.943	-1.943	-1.943	-1.943
10% level	-1.615	-1.615	-1.615	-1.615	-1.615	-1.615
Prob.*	0.0013	0.0025	0.0001	0.0008	0.0063	0.0139

*MacKinnon (1996) one-sided p-values.
Ho: Residuals are non stationary.

For all 6 series, and at all levels of significance, the data rejects the null hypothesis of non stationarity of the residuals, giving us strong evidence that there exists at least one linear combination of the policy rate and each retail rate series that is stationary, in other words, that there is a cointegration relation among those variables.

According to the evidence, and following what Chart 1 indicates, the most appropriate methodological approach for analyzing the pass-through of the policy rate for the Costa Rican data is a VECM one. In what follows, results of such analysis will be exposed.

5.2 VECM Results.

In order to quantify long and short run pass-through effects, the one step Johansen, S. and Juselius, K. (1990) methodology was used. Summarized outputs for the 6 retail rates analyzed are shown in Chart 5 which contains, in a nutshell, most of the key results of this paper. Notice that with this methodology, an equation like (4.3) is the one which is being estimated.

First of all, notice the information in the first two columns. The long run pass-through on the average loan rate (ALR) is 1.19. It is important to mention that it was not possible to reject a null hypothesis of this coefficient being statistically equal to one. This leads us to consider an almost one to one stable long run relation among the policy interest rate and the ALR. In other words, given enough time, changes in the policy rate will be fully reflected in the ALR of the Costa Rican banking system. On the other hand, the long run coefficient of the average deposit rate (ADR) is 0.73. Even though it is lower than the one associated to the ALR, it was not statistically different from one as well.

By taking a look at the error correction coefficients associated with the lagged series of error terms (U(-1)), it is possible to note that ADR reacts faster than ALR. Each period the ADR adjusts 0.2 of a given 1 point deviation from the long run relation with the policy rate, while ALR adjust only 0.11 of the same kind of deviation.

Chart 5
Short and Long Run Pass-Through Effect of Policy Rate and Average Velocity of Adjustment of Retail Rates

	Costa Rican Banking System		State Owned Banks Vs. Private Banks			
			Loan Rates		Deposit Rates	
	ALR	ADR	OR_S	OR_P	DR6_S	DR6_P
Lonf Run Model:						
Total Pass-Through	1.19	0.73	1.35	1.65	0.92	1.27
t-statistic	*[8.70]*	*[10.04]*	*[8.00]*	*[7.29]*	*[8.92]*	*[19.66]*
Error Correction Model (Short Run):						
U(-1)	-0.11	-0.20	-0.06	-0.05	-0.11	-0.11
t-statistic	*[-4.87]*	*[-6.04]*	*[-2.99]*	*[-3.44]*	*[-3.89]*	*[-5.58]*
Lagged Diferenced Policy Rate	0.0001	0.01	0.20	0.28	0.34	0.02
t-statistic	*[0.001]*	*[0.25]*	*[4.55]*	*[4.56]*	*[4.14]*	*[2.34]*
Lagged Differenced Retail Rate	0.1400	0.12	0.38	0.12	0.11	0.36
t-statistic	*[1.54]*	*[1.50]*	*[2.24]*	*[2.03]*	*[1.04]*	*[2.67]*
Constant	-0.1200	-0.10	-0.03	-0.06	-0.02	-0.06
t-statistic	*[-3.45]*	*[-4.07]*	*[-0.67]*	*[-1.61]*	*[-0.52]*	*[-1.98]*
Adjusted R^2	0.26	0.59	0.25	0.24	0.54	0.58
Velocity of Adjust (Average Number of Months):						
Total sample	9.4	4.9	14.8	17.4	5.8	8.6
Before October 2006	10.5	4.6	11.1	25.9	7.6	8.5
After October 2006	3.5	1.9	8.3	2.9	3.1	2.6

Then it is possible to say that, talking about total banking system, even though in the long run loan rates more fully pass changes in policy rates, deposit rates reacts faster when going back to their own long run equilibrium relation with the policy rate. On average, deposit rates takes almost 5 months to fully pass a shock of policy rate, whereas loan rates took roughly 9 months. This is shown below in the chart.

Columns from the 3rd to the 6th of Chart 5 are exposed in order to contrast the long and short run pass-through of State owned banks vs. Private banks, both in loan rates[14] (3rd and 4th columns) and in deposit rates[15] (5th and 6th columns).

Private Banks show a higher total pass-through than State owned banks both in loan and deposit rates. Notice though that State owned banks react faster when facing a policy rate shock in the case of loan rates. Every period, State owned banks correct 0.06 of any 1-point deviation from the long run relation of loan rates with the policy rate, while private banks adjust barely slower at a rate of 0.05 each period. The velocity of reaction of both kinds of banks is equally as fast in the case of deposit rates (0.11 each period).

[14] Since an average loan rate for State owned banks and private banks are not separately available, it was decided to take rates charged on the category of "other activities" as the most representative loan rate of both kinds of banks. This category includes loans made to industries such as retail, services and personal consumption. Historically the category accounts from 65% to 70% of the total loans made by the banking system.

[15] As a representative deposit rate, the 6-month deposit rate was taken both for State owned and private banks.

From combining long run model and error correction coefficients, average number of moths that each kind of bank takes to fully pass a shock of policy rate is obtained. It is possible to see that due to a higher total pass-through, private banks take a higher number of months for returning to the equilibrium relation with the policy rate. This is so in the case of loan rates (14.8 vs. 17.4 months) and deposit rates as well (5.8 vs. 8.6 months) for the total sample considered.

Notice also that, the number of months that retail rates need to fully adjust to a shock of policy rate decreases after October 2006. This reduction seems more sever in the case of private banks, especially in loan rates. More about this will be said below when dealing with non-linearities of the pass-through.

Now we move to analyze some hypothesis dealing with asymmetries. In order to do that, we follow the methodological approach exposed in section 4.2.2.

According to theoretic literature review and from some evidence of lack of competitiveness of Costa Rican banking system[16], it is plausible that banks may try to increase their margins by reacting differently when facing an increase or a decrease of the policy rate. The hypothesis is that when there is an increase in policy rate, banks will adjust more easily loan rates than deposit rates and, on the other hand, when facing a decrease in policy rate, they will react faster lowering deposit rates.

In charts 6 and 7 the main outputs from applying equation (4.6) to average loan and deposit rates are shown[17].

Chart 6
Asymetric VECM. Average Loan Rate

	Coefficient	t-Statistic	Prob.
C	-0.04	-0.681	0.498
U-(-1)	-0.15	-2.188	0.031
U+(-1)	-0.04	-0.934	0.353
Diff. Policy Rate	0.02	1.022	0.309
Diff. ALR(-1)	0.157	2.450	0.016
Adjusted R-squared	*0.52*		
Durbin-Watson stat	*1.72*		

As it is possible to see in chart 6, which tests asymmetries of loan rates, the coefficient associated to negative shocks is not statistically different from zero. Following the exposition of section 4.2.2, that is enough for not being able to conclude something about the existence of asymmetries when talking about the reaction of average loan rates.

[16] Laverde, B. and Madrigal, J. (2005).

[17] Due to lack of flexibility of Johansen, S. and Juselius, K. (1990) methodology, the analysis dealing with asymmetries and non-linearities where carried out by using Engle, R. and Granger, C. (1987) two steps VECM approach.

On the other hand, there exists statistic evidence to reject a hypothesis of asymmetric response of deposit rates to movements of policy rates. From what it is possible to infer from chart 7, both coefficients, the one associated with positive and to negative shocks, are statistically different from zero. Additionally, a Wald test applied to those coefficients fails to reject a null hypothesis of both coefficients being equal. This evidence combination tells that, in the short run, deposit rates equally react to positive and negative shocks of the policy interest rate.

Chart 7

Asymetric VECM. Average Deposti Rate

	Coefficient	t-Statistic	Prob.
C	-0.10	-3.440	0.001
U+(-1)	-0.12	-2.528	0.013
U-(-1)	-0.10	-4.599	0.000
Diff. Policy Rate	0.07	3.294	0.001
Diff. ALR(-12)	-0.121	-1.804	0.075
Adjusted R-squared	*0.66*		
Durbin-Watson stat	*1.61*		

Wald Test. Ho: α1 = α2

Test Statistic	Value	df	Probability
F-statistic	0.095151	(1, 88)	0.7585
Chi-square	0.095151	1	0.7577

Another hypothesis that is tested by using a non-linear VECM is whether the pass through of the policy rate has accelerated from some point forward in the sample. The methodology to test such a hypothesis was exposed in section 4.2.1.

In what follows, it can be found the main outputs from estimating equation (4.4) with the dummy variable build with a brake in October 2006. The hypothesis behind this brake point is that by taking a first concrete step toward an *Inflation Targeting* regime[18], the Central Bank gave a clear and credible signal that it was ready to start more intensively using their reference policy rate as a tool to regulate inflationary pressure. As a credible measure, commercial banks will then start to more rapidly react to movements in such reference Central Bank rate.

Results for average loan rates and average deposit rates are shown in chart 8 and 9 respectively. In either case the variable resulting from multiplying the dummy by the error of the long run equation (Dummy*U_ALR and Dummy*U_ADR) was statistically different from zero. According to what was explained above, this constitutes strong evidence supporting the hypothesis that retail rates react differently since October 2006 compared with the previous period. Additionally, both coefficients are, as expected, negatively signed, which indicates that from the selected brake point up to the end of the sample, the policy rate pass-through has accelerated.

[18] In this month the Central Bank of Costa Rica switched to an administrated band exchange rate regime

It is also possible to calculate the average number of months that those retail rates take to fully adjust a deviation from the long run equilibrium relation with the policy interest rate. This is shown in the lasts two rows on chart 5.

Chart 8
Non-Linear VECM. Average Loan Rate

	Coefficient	t-Statistic	Prob.
C	-0.06	-2.045	0.044
U_ALR	-0.07	-2.578	0.012
Dummy*U_ALR	-0.20	-3.423	0.001
Diff. Policy Rate	0.06	1.505	0.136
Diff. ALR(-1)	0.12	1.659	0.101
Adjusted R-squared	*0.60*		
Durbin-Watson stat	*1.72*		

By combining long and short run parameters the conclusion is that the pass-through of the policy rate to average loan rate accelerated from an average of 10.5 months before October 2006 to 3.5 after that. On the other hand, average deposit rate also pass shocks of policy rate faster after the switch of the exchange rate regime. Before October 2006, average deposit rate took about 4.6 months to fully adjust to a change in policy rate, after that, the reaction takes approximately 2 months.

This acceleration of the pass-through is also revealed by comparing the number of months that loan rates charged on "other activities" takes to fully adjust a policy interest rate shock. Notice though that the reduction is more significant in the case of private banks which use to take more than 20 months before the break point and after that they take barely 3 months. The acceleration of the pass-through is more or less equally considerable for State owned and private banks in the case of deposit rates, the former kind of banks reduces from 7.6 to 3.1 months while the last kind of banks reduces the number of months from 8.5 to 2.6.

Chart 9
Non-Linear VECM. Average Deposit Rate

	Coefficient	t-Statistic	Prob.
C	-0.09	-4.506	0.000
U_ADR	-0.09	-5.986	0.000
Dummy*U_ADR	-0.13	-3.398	0.001
Diff. Policy Rate	0.06	2.394	0.019
Diff. ALR(-12)	-0.11	-1.825	0.071
Adjusted R-squared	*0.70*		
Durbin-Watson stat	*1.85*		

The evidence implied by outputs in chart 8 – 9 and last rows of chart 5 is not trivial. It not only implies that commercial banks now respond faster to movements in policy rate and so that the mechanism of transmission of the monetary policy might have accelerated, but also that banks take the information sent along with those movements as credible. Such implication should be well received by authorities who are looking forward to continue developing the necessary mechanisms to fully implement an inflation targeting monetary scheme.

We can sum up what data tells about asymmetries and non-linearities as follows: There is no enough evidence to keep the hypothesis of an asymmetric response of either loan or deposit rates and the reaction of those rates to policy rate shocks have increased towards the end of the sample period.

6. Conclusions.

So long the aim of this paper was to investigate the pass-through effect of the policy interest rate to retail rates of the banking system in the Costa Rican economy in the last 9 years. We were interested in finding out whether in the long run retail interest rates fully reflect changes of the policy rate or not. Additionally there was a hypothesis postulating that the first concrete step of the Central Banks towards and IT regime accelerated the pass-through. Another hypothesis was claiming that commercial banks might try to increase their spreads of interest rates by asymmetrically reacting to shocks of policy rate.

After determining the right methodological approach given the stationary characteristics of Costa Rican interest rates series, the application of a non-linear asymmetric VECM lead us to the following conclusions:

- In the long run, average loan rate passes almost 1.2 of any 1-point change of policy rate while deposit rate passes almost 0.75. Yet neither of those coefficients is statistically different from one. Then it is possible to say that there has been a complete pass-through of the policy interest rate if a sample starting in January 1999 that goes up to December 2007 is considered.

- Considering the full sample, average loan rate takes almost 9.5 months to fully accommodate a policy rate shock. Average deposit is faster, it takes 5 months. After the introduction of the administrated band exchange rate system, those velocities accelerated to 3.5 and 2 respectively. This validates the hypothesis on a non-linear pass-through.

- There is no evidence of asymmetries in the reaction of the average retail interest rates to movements of policy rate. In the case of loan rates the tests did not allow us to extract any specific conclusion while in the case of deposit rate the evidence rejects the hypothesis of an asymmetric reaction. That is, deposit rate equally react when facing an increase or a decrease of the policy interest rate.

- Generally speaking, the reaction of State Owned banks differs from the reaction of private banks mostly in the long run. The last kind of banks passes to its retail rates a bigger portion of any given shock of policy interest rate than the former kind. This is the case on both, loan and deposit rates. The short run reaction differs between those two groups of banks just in loan rates, State owned banks correct slightly faster than private ones. In what it refers to deposit rates, both kind of banks correct equally faster any given deviation from the long run relation with the policy rate. Due to differences in magnitude of total pass-through, State owned banks takes less time to fully adjust a shock of policy rate both in loan and deposit rate.

- Such a combination of results might suggest that private banks are behaving as followers in dealing with decisions about whether and when adjust retail rates when facing a policy rate change. This behavior is supported by literature mostly in the case of loan rates. As it was mentioned early in this paper, banks who adjust their loan rates early to a policy rate shock will more likely face adverse selection problems than those who manage to delay the adjustment.

- The findings of this paper tend to signal an encouraging environment to the process of migrating to an inflation targeting monetary regime. The proved acceleration of the pass-through coefficient after October 2006 favors a smother transmission mechanism of the monetary policies that are implemented by movements of the policy rate.

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Appendix A.

Abbreviations of the Interest rates	
ALR	Average loan rate
ADP	Average deposit rate
OR_S	Average loan rate charged on "other activities" by State owned banks
OR_P	Average loan rate charged on "other activities" by private banks
DR6_S	**Average 6-months deposit rate paid by State owned banks**
DR6_P	Average 6-months deposit rate paid by private banks
agro_S	Average loan rate charged on "agro industry" by State owned banks
agro_P	Average loan rate charged on "agro industry" by Private banks
const_S	Average loan rate charged on "construction industry" by State owned banks
const_p	Average loan rate charged on "construction industry" by Private banks
ganad_S	Average loan rate charged on "livestock industry" by State owned banks
ganad_p	Average loan rate charged on "livestock industry" by private banks
ind_S	Average loan rate charged on "manufacture industry" by State owned banks
ind_p	Average loan rate charged on "manufacture industry" by private banks
DR12_S	**Average 12-months deposit rate paid by State owned banks**
DR12_P	Average 12-months deposit rate paid by private banks
DR1_S	**Average 1-month deposit rate paid by State owned banks**
DR1_P	Average 1-month deposit rate paid by private banks
DR3_S	**Average 3-months deposit rate paid by State owned banks**
DR3_P	Average 3-months deposit rate paid by private banks

Individual Granger Causality Test

	Probability of not rejecting Ho	
Interes rate	Independent*	Dependent**
ALR	0.0027	0.8825
ADP	0.0000	0.1748
OR_S	0.0001	0.5472
OR_P	0.0010	0.9819
DR_S	0.0000	0.2403
DR_P	0.0000	0.0419
agro_S	0.0000	0.5441
agro_P	0.3516	0.4693
const_S	0.0005	0.2866
const_p	0.0092	0.2079
ganad_S	0.0000	0.4166
ganad_p	0.0616	0.0435
ind_S	0.0026	0.1467
ind_p	0.0220	0.8904
DR12_S	0.0006	0.9052
DR12_P	0.0005	0.6881
DR1_S	0.0000	0.2712
DR1_P	0.0039	0.7935
DR3_S	0.0000	0.2564
DR3_P	0.0001	0.0106

* Ho: The policy rate does not Granger cause the respective interest rate series

**Ho: The respective interest rate does not Granger cause the policy rate

Joint Granger Causality Test

Dependent variable: PR

Excluded	Chi-sq	df	Prob.
agro_S	20.85315	2	0.0000
agro_P	8.200567	2	0.0166
const_S	4.017769	2	0.1341
const_p	5.851542	2	0.0536
ganad_S	7.288496	2	0.0261
ganad_p	14.99933	2	0.0006
ind_S	1.200548	2	0.5487
ind_p	30.42756	2	0.0000
OR_S	4.187530	2	0.1232
OR_P	4.183722	2	0.1235
DR12_S	0.950568	2	0.6217
DR12_P	0.293165	2	0.8637
DR1_S	4.929511	2	0.0850
DR1_P	14.58407	2	0.0007
DR3_S	4.541882	2	0.1032
DR3_P	4.798731	2	0.0908
DR6_S	0.418245	2	0.8113
DR6_P	0.361881	2	0.8345
All*	**464.9555**	**40**	**0.0000**

* Ho: All interest rate series Granger cause PR

Appendix B.

Unit Root Test Under Alternative Specification of Constant and Trend for a Wide Range of Interest Rates Series 1/

		Probability of Not Rejecting Ho*	
Interest Rate	Especification**	ADF	PP
PR	NCNT	0.0523	0.0545
	CNT	0.7808	0.7684
	CT	0.7409	0.6714
ALR	NCNT	0.0112	0.047
	CNT	0.986	0.9929
	CT	0.9367	0.8571
ADP	NCNT	0.0068	0.0108
	CNT	0.8214	0.9011
	CT	0.6551	0.734
DR6_S	NCNT	0.0258	0.0577
	CNT	0.8199	0.7111
	CT	0.8739	0.7085
DR6_P	NCNT	0.0495	0.0271
	CNT	0.8296	0.9408
	CT	0.5624	0.8684
agro_S	NCNT	0.2064	0.2052
	CNT	0.9778	0.9847
	CT	0.818	0.8243
agro_P	NCNT	0.0111	0.0392
	CNT	0.9883	0.9765
	CT	0.8834	0.7515
const_S	NCNT	0.2351	0.1875
	CNT	0.9397	0.9837
	CT	0.7106	0.8608
const_P	NCNT	0.0915	0.0553
	CNT	0.9612	0.9872
	CT	0.7065	0.7888
ind_S	NCNT	0.0904	0.1555
	CNT	0.9958	0.9833
	CT	0.9604	0.8877
ind_P	NCNT	0.0002	0.0015
	CNT	0.9946	0.9905
	CT	0.9672	0.9256
OR_S	NCNT	0.1801	0.1801
	CNT	0.9636	0.9685
	CT	0.7799	0.7787
OR_P	NCNT	0.0034	0.0074
	CNT	0.9978	0.9979
	CT	0.9668	0.9447
DR12_S	NCNT	0.1762	0.2456
	CNT	0.9804	0.9555
	CT	0.8868	0.8723
DR12_P	NCNT	0.1982	0.1386
	CNT	0.9525	0.9914
	CT	0.7127	0.8666
DR1_S	NCNT	0.0095	0.0188
	CNT	0.9855	0.9796
	CT	0.9002	0.8163
DR1_P	NCNT	0.0154	0.0065
	CNT	0.7387	0.8772
	CT	0.5269	0.8032
DR3_S	NCNT	0.006	0.0144
	CNT	0.9366	0.9165
	CT	0.8585	0.7288

*Ho: The series has a unit root

** NCNT: No constant no trend; CNT: Constant and no trend; CT: Constant and trend