Box 3
Interest Rate Model for the SYSMO Stress Test Exercise

Wilmar Cabrera
Diego Cuesta
Santiago Gamba
Camilo Gómez*

This box introduces the structure of the interest rate models to be used in the sensitivity exercise presented in the third chapter of this Report, starting with the current edition. According to the findings in local and international literature,[1] the interest rates on each type of loan, CDT and savings account are modeled separately. Additionally, the commercial portfolio is divided between ordinary and preferential loan segments to capture the differences in their dynamics and the heterogeneous response to changes in the policy rate set by *Banco de la República* (Banrep). Preferential and ordinary commercial loans are divided, in turn, between the rates of disbursements granted by the largest banks in terms of assets and the rest of the credit institutions (CIs), given the differences observed in the way these variables react to changes in the monetary policy rate. On the other hand, the estimation does not include micro-credit or the interest rate on deposits by individuals, given the low relationship observed between these rates and the policy rate.[2]

The proposed models combine two elements. First, they consider the cointegration that has been documented between consumer, commercial and CDT rates with the interbank rate (TIB), as well as the relationship between the mortgage loan rate and the yield on government bonds (TES) with ten-year maturity. Secondly, the models distinguish the response of the different interest rates according to the monetary policy cycle (periods of increases or reductions in the Banrep rate) and consider the different response speeds that rates may exhibit at specific contexts by estimating these coefficients by quantiles.

Considering the forgoing, the models estimated have the following structure:

$$Y_t = \alpha_0 + \alpha_1 X_t + \epsilon_t \quad (1)$$

$$\Delta Y_t^{\tau} = \beta_{2,1}^{\tau} \epsilon_{t-1} + I_{CBR}\, \beta_{2,2}^{\tau}\, \epsilon_{t-1} + \psi(p)^{\tau}\, \Delta Y_{t-p} + \Psi(q)^{\tau}\, \Delta X_{t-q} + \Phi(r)^{\tau}\, \Delta Z_{t+1-r} + \mu_t^{\tau} \quad (2)$$

Where *Y* represents the interest rate, X is the variable for which evidence of cointegration with *Y* has been found, and *Z* is a set of macroeconomic variables (inflation, unemployment, the economic monitoring index (EMI) and NHPI are considered). Equation (1) can be understood as the long-term average relationship found among the variables analyzed, and equation (2) is the one that establishes the relationship between the monthly variation in interest rates and the adjustment to their long-term relationship, as well as the relationship with own lags and lags of the other variables included in the model. In addition, this equation captures the differential effect in the response of rates according to the monetary policy cycle through the interaction between the error term and a dichotomous variable, I_{CBR}, which takes the value of 1 in periods of increases in the policy interest rate. Lastly, p, q and r are the maximum lag that can be taken by the lag operators $\psi(\cdot)$, $\Psi(\cdot)$ y $\Phi(\cdot)$, respectively.

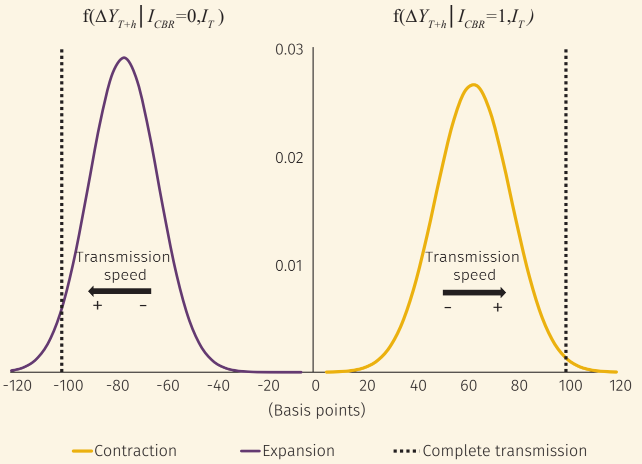
Equation (2) is estimated with the quantile regression method, where the superscripts indicate the quantile of the conditional distribution of the change in interest rates. The combined use of quantile estimation and the distinction in the response of rates according to the monetary policy cycle makes it possible to find the conditional distribution of the change in interest rates in each phase of the cycle. Graph B3.1 illustrates, in a general way, the results that can be extracted from the model when there is a policy rate change of 100 basis points (bp) in the direction of the policy phase under study for analysis period $T+h$. The resulting conditional distribution in the expansion phase is shown in purple, while the distribution associated with the contraction phase is shown in yellow. The dotted lines show a complete transmission of the change in the policy rate, while the arrows indicate the direction of the quantiles in which a greater transmission of the shock is observed.

1 For the Colombian case, see Chavarro-Sánchez *et al.* (2015), Cristiano-Botia *et al.* (2017), Galindo and Steiner (2020), Huertas *et al.* (2005), July (2001) and Vargas *et al.* (2010). For the international case, see Apergis and Christou (2015).

* The authors are part of the Financial Stability Department at *Banco de la República*. The opinions expressed herein are solely the responsibility of the authors and imply no commitment on the part of *Banco de la República* or its Board of Directors.

2 In the sensitivity exercises usually presented in chapter 3 of the *Financial Stability Report*, it is assumed the microcredit rate spread reaches historical highs and the deposit rate for individuals remains constant.

Graph B3.1
Schematic of Conditional Distributions Generated by a Quantile Regression of Changes in Interest Rates



Note: The distribution of the variation in Y, $f(\Delta Y_{T+h} | I_{CBR}=0, I_T)$ conditional on being in the expansion phase and the set of information available for the estimate in period T, I_T, is shown in violet. The distribution of the variation in Y, $f(\Delta Y_{T+h} | I_{CBR}=1, I_T)$ conditional on being in the contraction phase and with the same set of information, in turn, is shown in yellow. The vertical dotted line on each side of the graph reflects the full transmission of a change in the policy rate (100 bp in the contraction phase and -100 bp in the expansion phase).
Source: calculations by *Banco de la República*.

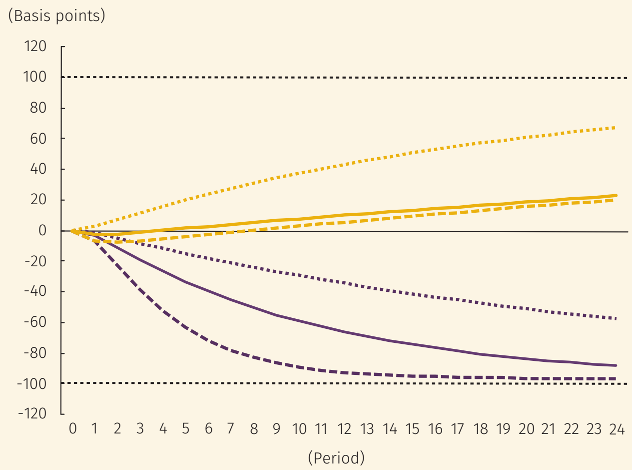
With respect to the transmission of monetary policy shocks, Graph B3.1 shows the high quantiles in the contraction phase are those that are closer to the dotted line, which represents full transmission, while the low quantiles show low transmission. In contrast, the low quantiles in the conditional distribution of interest rate changes in the expansion phase are those that show the highest transmission of the shock, and the high quantiles are those that reflect a low variation in the interest rate.

The selected models match the most parsimonious specifications with a low out-of-sample forecast error for two-year horizons. The results are synthesized in the impulse-response functions shown in Graph B3.2, which contain the reaction of interest rates to a 100 bp drop (purple lines) and an increase of the same size (yellow lines) in the monetary policy rate. Three quantiles of the conditional distributions drawn from equation 2 are presented for analysis horizons that range from one to 24 months. The results show these specifications capture the different responses to monetary policy changes, with preferential commercial lending rates reacting faster and to a larger extent, while the rate on corporate deposits shows a lower reaction to policy decisions.

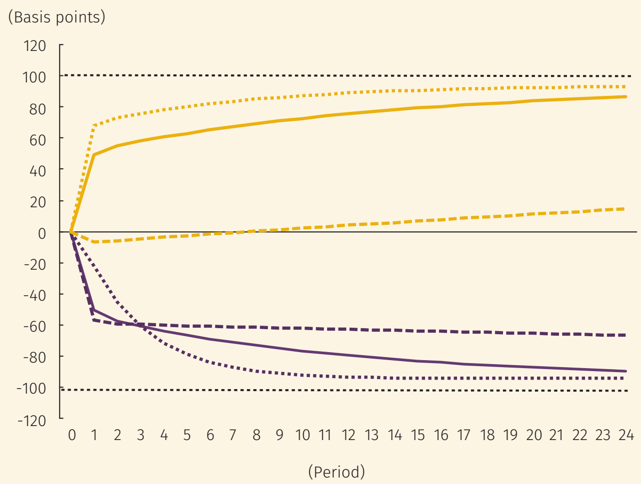
As mentioned, the quantile estimation captures different monetary policy transmission speeds, depending on the policy cycle. For example, panel D in Graph B3.2 shows a reduction in the policy rate is transmitted almost fully after 24 months in the median, while such transmission in quantile 75 would not occur in this time horizon. On the other hand, when faced with an increase in the policy rate, quantile 25 is the one that shows an incomplete transmission of the policy shock.

Graph B3.2
Impulse-Response Functions of the Interest Rates

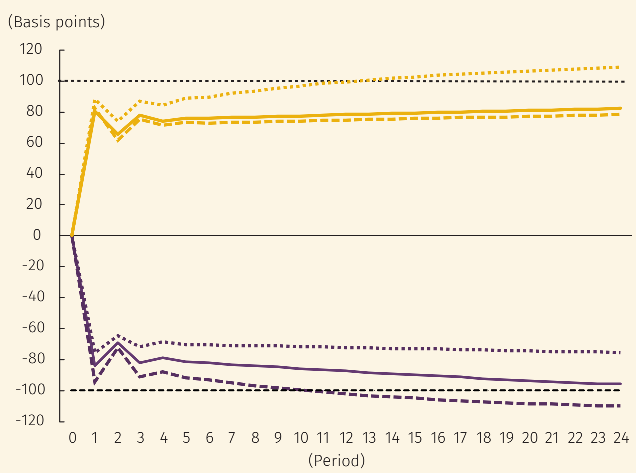
A. Mortgages



B. Consumer Credit

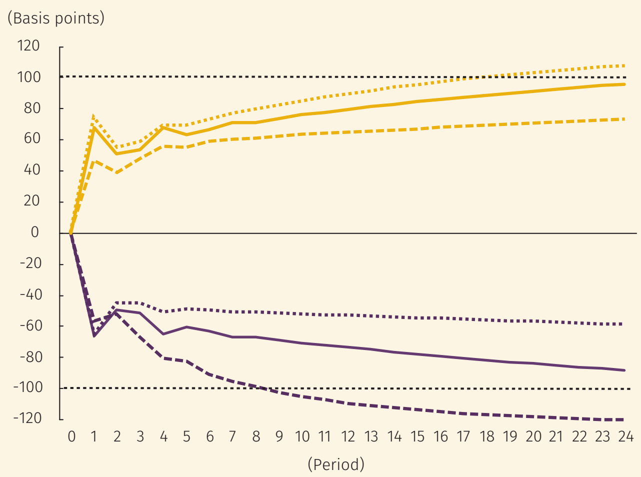


C. Ordinary Commercial Credit of Large CIs

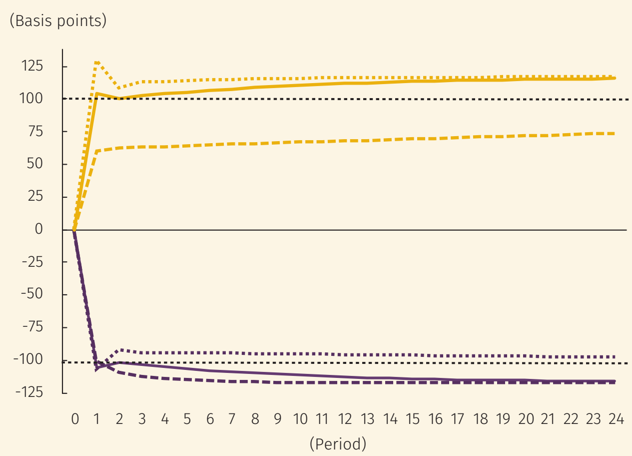


Graph B3.2 (Continuation)
Impulse-Response Functions of the Interest Rates

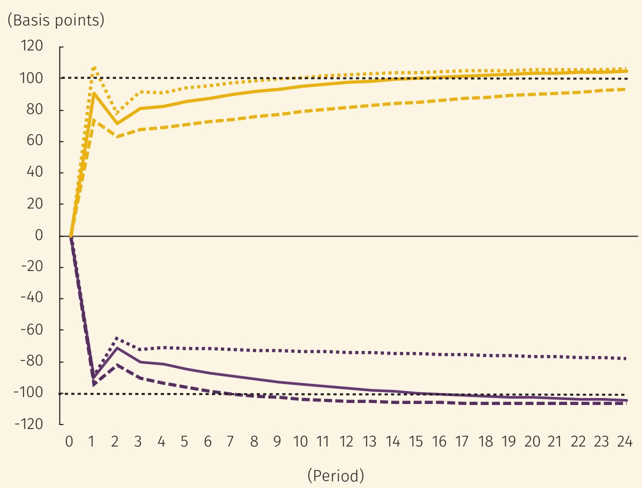
D. Ordinary Commercial Credit of the Remaining CIs



E. Preferential Commercial Credit of Large CIs

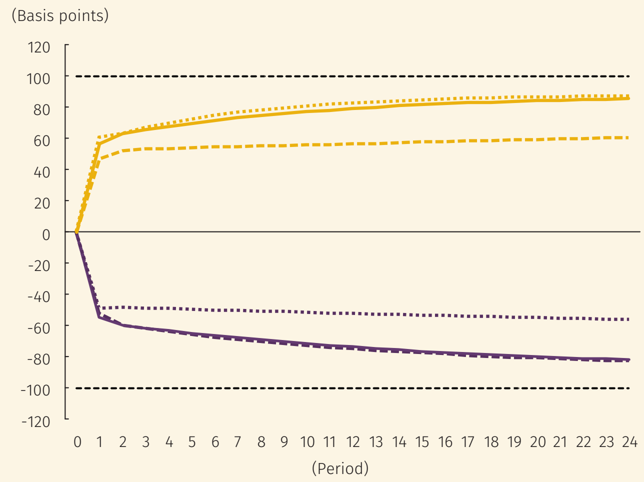


F. Preferential Commercial Credit of the Remaining CIs

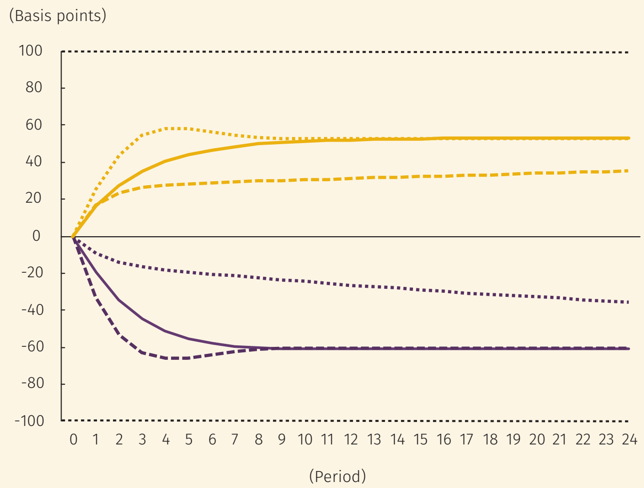


Note: the impact of the rates in the event of positive and negative variations of 100 bp in the IBR (10-year TES rate for the Panel A. Mortgages) is shown.
Source: Office of the Financial Superintendent, calculations by *Banco de la República*.

G. CD



H. Judicial Entity's Savings Accounts



Finally, there are some asymmetric reactions to monetary policy cycles. For example, the model suggests the mortgage rate reacts faster to reductions than to increases. Moreover, this asymmetric behavior varies depending on the quantile considered in the simulation of the model.

References

Apergis, N.; Christou, C. (2015). "The Behavior of the Bank Lending Channel when Interest Rates Approach the Zero Lower Bound: Evidence from Quantile Regressions," *Economic Modelling*, vol. 49, pp. 296-307.

Chavarro-Sánchez, X.; Cristiano-Botia, D.; Gómez-González, J. E.; González-Molano, E.; Huertas-Campos, C. (2015). "Evaluación de la transmisión de la tasa de interés de referencia a las tasas de interés del sistema financiero," *Borradores de Economía*, no. 874, *Banco de la República* de Colombia.

Cristiano-Botia, D.; González-Molano, E.; Huertas-Campos, C. (2017). "Evaluación de la transmisión de la tasa de interés de referencia a las tasas de interés del sistema financiero considerando las expectativas de los agentes," *Borradores de Economía*, no. 988, *Banco de la República* de Colombia.

Galindo, A.; Steiner, R. (2020). "Asymmetric Interest Rate Transmission in an Inflation Targeting Framework: The Case of Colombia," *Borradores de Economía*, no. 1138, *Banco de la República de Colombia*.

Huertas, C.; Munir, J.; Olarte, S.; Romero, J. (2005). "Algunas consideraciones sobre el canal del crédito y la transmisión de tasas de interés en Colombia," *Borradores de Economía*, no. 351, *Banco de la República de Colombia*.

Julio, J. (2001). "Relación entre la tasa de intervención del *Banco de la República* y las tasas del mercado: una exploración empírica," *Borradores de Economía*, no. 188, *Banco de la República de Colombia*.

Vargas Hernando, Hamann Franz y González Andrés, 2010. "Efectos de la política monetaria sobre las tasas de interés de los créditos hipotecarios en Colombia," *Borradores de Economía*, no. 592, *Banco de la República de Colombia*.