Exchange rate pass-through from the perspective of a semi-structural model

The magnitude of the exchange rate pass-through to the consumer's price level depends on several factors and may vary over time.[1] Mapping these factors contributes to a better understanding of the dynamics of inflation.

This box presents a study on the determinants of the magnitude of the exchange rate pass-through in Brazil from the perspective of a small-scale semi-structural model. We investigate how factors such as magnitude of depreciation, economic cycle, anchoring of expectations and operating margin of firms affect the intensity of the exchange rate pass-through.

Semi-structural modelling and the exchange rate pass-through

The BCB uses several models to project macroeconomic variables, to construct scenarios and to simulate the effects of economic policies, aiming to assisting the decision-making process of the Monetary Policy Committee (Copom). In the case of the semi-structural models, the exchange rate pass-through to domestic price inflation is captured by a term on the Phillips curve that represents the external inflation expressed in Brazilian *reais*.[2] In this box, we present estimates of a set of models that seeks to capture, in the Phillips curve of market prices, the role of possible factors that affect the degree of exchange rate pass-through in the Brazilian economy. It is worth noting that the exchange rate pass-through also operates in BCB models through administered prices, for which there are specific models. In these models, the exchange rate pass-through to administered prices depends primarily on the rules for adjusting certain items.[3] For this reason, the analysis in this box focuses on the exchange rate pass-through to market price inflation.

The effect of the exchange rate variation on inflation is usually estimated through a parameter that reflects, in the sample considered, the average exchange rate variation pass-through to inflation, as usually occurs with any variable of a standard regression model. However, at each moment, the exchange rate pass-through may detach from the average historical pass-through due to several factors, such as the economic cycle and possible asymmetries in the level of pass-through between appreciation and exchange depreciation.

In order to evaluate possible determinants of the level of exchange rate pass-through to market price inflation in the Brazilian economy, a small-scale aggregate semi-structural model was used. The model is formed by the following equations: a Phillips curve for market price inflation; an IS curve, which describes the trajectory of the output gap; a curve for the 360-day pre-DI swap premium; and a Taylor rule.

1/ See, e.g., Goldfajn and Werlang (2000), Correa and Minella (2010), Frankel et al. (2012), IMF (2016), and de Mendonça and Tiberto (2017).

2/ In the semi-structural models, the external inflation is represented by the variation of a commodity price index in US dollars converted into national currency by the corresponding exchange rate. For more details see box "Small-scale aggregate model – 2017" in the June 2017 Inflation Report, and "Small-scale model of disaggregated price – 2018" in the June 2018 Inflation Report.

3/ See box "Revision of the medium-term projection models for administered prices", in the September 2017 Inflation Report.

The Phillips curve for market prices inflation is represented by:[4]

$$(1)\ \pi_t^L = \sum_{i>0} \alpha_{1i} E_t\pi_{t+i} + \sum_{j>0} \alpha_{2j}\, \pi_{t-j} + \sum_{k\geq 0} \alpha_{3k}\, \pi_{t-k}^* + \sum_{l>0} \alpha_{4l}\, h_{t-l} + \sum_{n\geq 0}\sum_{p} \alpha_{5n}^p Z_{t-n}^p + \varepsilon_t,$$

where π_t^L is the market prices inflation of the IPCA; $E_t\pi_{t+i}$ is the expectation in time *t* regarding the IPCA inflation *i* quarters ahead; π_t is the IPCA inflation; π_t^* is an imported inflation measure; h_t is an output gap measure; Z_t^p is the control variable *p*; and ε_t is the error term. The parameters are estimated by imposing the verticality constraint of the Phillips curve in the long run, $\sum_i \alpha_{1i} + \sum_j \alpha_{2j} + \sum_k \alpha_{3k} = 1$.

Different specifications of the Phillips curve were tested in order to analyze how the exchange pass-through is affected by different non-linearities. The following possible determinants of exchange rate pass-through were examined: (i) the stage of the economic cycle; (ii) the level of anchoring of inflation expectations; (iii) the magnitude of the exchange rate depreciation; and (iv) the ability of firms to absorb cost shocks, represented by their operating margin.

The coefficient of the exchange rate pass-through α_{3k} is modeled as a function of the variables of interest to analyze how the level of exchange rate pass-through varies with these determinants. Thus, this parameter becomes variant over time:

$$(2)\ \alpha_{3k,t} = \beta_{1k} + \beta_2 h_{t-1}^{neg} + \beta_3 \sum_{r=0}^{1} \hat{\pi}_{t-r}^e/2 + \beta_4 \sum_{s=0}^{1} \Delta e_{t-s}^{depr}/2 + \beta_5 \bar{m}_{t-1},$$

where

$h_t^{neg} = \begin{cases} h_t;\ se\ h_t < 0 \\ 0;\ otherwise \end{cases}$, that is, it is the value of the output gap when it is in the negative field and zero, otherwise;

$\hat{\pi}_t^e = \begin{cases} \pi_{t,24m}^{e,12m} - \bar{\pi}_{t,24m};\ if\ \pi_{t,24m}^{e,12m} - \bar{\pi}_{t,24m} > 0 \\ 0;\ otherwise \end{cases}$, being $\pi_{t,24m}^{e,12m}$ the analysts' expectation in quarter *t* for inflation 24 months ahead, 12-month accumulated, based on the Focus survey,[5] and $\bar{\pi}_{t,24m}$ the interpolated measure for the inflation target 24 months ahead[6, 7];

$\Delta e_t^{depr} = \begin{cases} \Delta e_t - (\pi - \pi^{ext})\ if\ \Delta e_t > \pi - \pi^{ext} \\ 0; otherwise \end{cases}$, being Δe_t the variation of the nominal exchange rate (R$/US$) and $\pi - \pi^{ext}$ is a term that seeks to capture the differential between domestic and external inflation consistent with the long-term conditions in the modeling of the Phillips curve for market prices; and $\bar{m}_t$ is the moving average of the last period(s) of the cyclical component of the operating margin of the companies in the Brasil 100 index (IBrX 100).

In some specifications, instead of using continuous values to measure the output gap, a dummy variable was used to indicate the periods when the output gap was negative. On the other hand, the term Δe_t^{depr}

4/ The specification of the IS curves and the curve for the 360 day pre-DI swap premium is set out in the "Small-scale aggregate model – 2017" box of the June 2017 Inflation Report. In its turn, Taylor's rule relates the Selic rate to expected inflation deviations from its target, to the output gap, to the Selic equilibrium level, and to the Selic self-regulatory terms.

5/ The series was built by means of interpolations. When monthly inflation expectations beyond a calendar year ahead were available, the interpolation between inflation expectation for two calendar years ahead and the last monthly expectation of available inflation, accumulated in twelve months, was made. Otherwise, the interpolation between the expectation of inflation for two calendar years ahead and the expectation of inflation for a calendar year ahead was made.

6/ In cases where the expectation was below the target, the variable assumed a zero value.

7/ Since inflation targets are defined only for calendar years, the series was built by interpolating the target for two calendar years ahead and one calendar year ahead by using the target values that had been announced at the time. When necessary, the target was extrapolated by using the hypothesis that the value for the longest horizon announced would remain until the second calendar year ahead.

assumes non-zero values only when the depreciation of the nominal exchange rate exceeds the term of the domestic and external inflation differential.

Replacing equation (2) by equation (1), we have:[8]

$$(3)\ \pi_t^L = \sum_{i>0} \alpha_{1i}\, E_t\pi_{t+i} + \sum_{j>0} \alpha_{2j}\, \pi_{t-j}$$

$$+ \sum_{k\geq 0}\left(\beta_{1k}\pi_{t-k}^{*} + \beta_2 \pi_{t-k}^{*} h_{t-1}^{neg} + \beta_3\, \pi_{t-k}^{*} \sum_{r=0}^{1} \hat{\pi}_{t-r}^{e}/2 + \beta_4 \pi_{t-k}^{*} \sum_{s=0}^{1} \Delta e_{t-s}^{depr}\,/2 + \beta_5 \pi_{t-k}^{*} \bar{m}_{t-1} \right)$$

$$+ \sum_{l>0} \alpha_{4l}\, h_{t-l} + \sum_{n\geq 0} \sum_{p} \alpha_{5n}^{p}\, Z_{t-n}^{p} + \varepsilon_t.$$

The estimation of the system of equations was performed using Generalized Methods of Moments (MMG), with quarterly data and considering in the sample at least the period between 2003Q1 and 2018Q1[9]. We considered 23 specifications, which are differentiated by the set of variables determinant of the exchange rate pass-through used. In some estimates, all variables of interest were included, while in others, only a subset of possible determinants of the pass-through was considered. The variety of specifications is intended to counterbalance the uncertainty inherent to any model estimation method, and especially in the case of this study, it helps mitigating the level of uncertainty arising from the relatively small sample size used. For the purpose of presenting the results, the specifications were grouped into nine subgroups, corresponding to the different possible combinations of sets of variables of interest.

Results

Table 1 presents the effects of the variables of interest on the exchange rate pass-through. For each of the subgroups of estimated models, the minimum and maximum values of each coefficient within the subgroup are presented.[10] The coefficients presented in the table correspond to the values estimated for the parameters $\beta_2, \beta_3, \beta_4$ and β_5 of equation (3). Thus, they indicate in how many percentage points (p.p.) the pass-through coefficient is affected by a variation of 1 p.p. in each variable of interest.[11] Therefore, comparisons between the impacts of the variables of interest on the exchange rate pass-through depend on the estimated coefficients as well as on the magnitude and unity of the variables of interest.

In all specifications, the coefficients of the variables of interest were statistically significant and presented the expected signal. Thus, the estimates show that the negative output gap and the anchoring of the inflation expectations contribute to reduce the exchange rate pass-through, while the reduction of the operating margin of the firms and the magnitude of the exchange rate depreciation are factors that increase the exchange rate pass-through.

The results suggest that the magnitude of the exchange rate depreciation affects the level of the pass-through: the higher the depreciation, the higher the exchange rate pass-through. The subgroups that also include the measure of inflation expectations (5, 7 and 9) indicate that, for every 1.0 p.p. of increase in depreciation, the exchange rate pass-through increases in the range of 0.11 p.p. to 0.19 p.p.

8/ Note that when the term Δe_t^{depr} is positive, it multiplies another variable (imported inflation) that already includes the exchange rate variation, resulting in a quadratic term in the magnitude of the exchange rate depreciation. For the purposes of comparability, the lag structure used for the product gap and the exchange rate variation did not vary between specifications.

9/ The start of the sample varies according to the availability of the variables of interest used in each specification.

10/ The range of values of each coefficient took into account the point value of the parameter in each estimation instead of its confidence interval.

11/ In cases where the variable h_t^{neg} is replaced by a dummy, the parameter β_2 indicates the impact, in percentage points, of the presence of a negative gap on the exchange rate pass-through coefficient.

Table 1 – Estimates of the effects of exchange rate pass-through determinants*

Lower and upper limits of the range of point estimates of factors influencing the exchange rate pass-through**

Specification subgroups***	Negative output gap β_2	Unanchoring of inflation expectations β_3	Magnitude of exchange rate depreciation β_4	Companies' operating margin β_5
1	(-3.2 -2.1)			
2		5.0		
3			(0.32 0.33)	
4	(-5.9 -4.7)	(6.5 6.7)		
5		4.8	0.12	
6		2.8		-0.7
7	(-7.0 -4.0)	(6.4 6.6)	(0.11 0.12)	
8	(-9.1 -3.2)	(3.6 6.6)		(-1.1 -0.4)
9	(-8.4 -7.9)	(1.5 5.0)	(0.18 0.19)	(-1.5 -0.7)

* 23 specifications were estimated. All variables of interest were significant at the 10% significance level or less in all specifications.

** The values refer to the estimated values for the β_2, β_3, β_4 and β_5 parameters in equation (3), expressed in percentage points. Subgroups 2, 5 and 6 have only one specification each.

*** The specification subgroups comprise the following factors: Subgroup 1: Negative output gap; Subgroup 2: Unanchoring of inflation expectations; Subgroup 3: Magnitude of exchange rate depreciation; Subgroup 4: Negative output gap and unanchoring of inflation expectations; Subgroup 5: Unanchoring of inflation expectations and magnitude of exchange rate depreciation; Subgroup 6: Unanchoring of inflation expectations and companies' operating margin; Subgroup 7: Negative output gap, unanchoring of inflation expectations and magnitude of exchange rate depreciation; Subgroup 8: Negative output gap, unanchoring of inflation expectations and companies operating margin; Subgroup 9: Negative output gap, unanchoring of inflation expectations, magnitude of exchange rate depreciation and companies' operating margin.

Estimates indicate that the degree of anchoring of expectations plays a central role in determining the exchange rate pass-through. For each increase of 1.0 p.p. in the degree of disanchoring, the pass-through coefficient is between 1.5 p.p. and 6.7 p.p. These results highlight the importance of anchoring expectations for inflation control. When expectations are anchored, the impact of exchange rate depreciations on inflation expectations is mitigated, reducing the exchange rate pass-through to prices. A key element to the anchoring of expectations is the central bank credibility and the economic policy regime.

Regarding the business operating margin cycle, estimates suggest that for every 1.0 p.p. increase in this indicator, the exchange rate transfer coefficient decreases between 0.4 p.p and 1.5 p.p. This evidence is compatible with the hypothesis that, when their operating margin is higher, firms are more able to absorb cost pressures, moderating the transfer of exchange rate depreciation to prices. On the other hand, when the operating margin is lower, firms have less space to absorb exchange rate variations, which tends to increase the degree of pass-through.

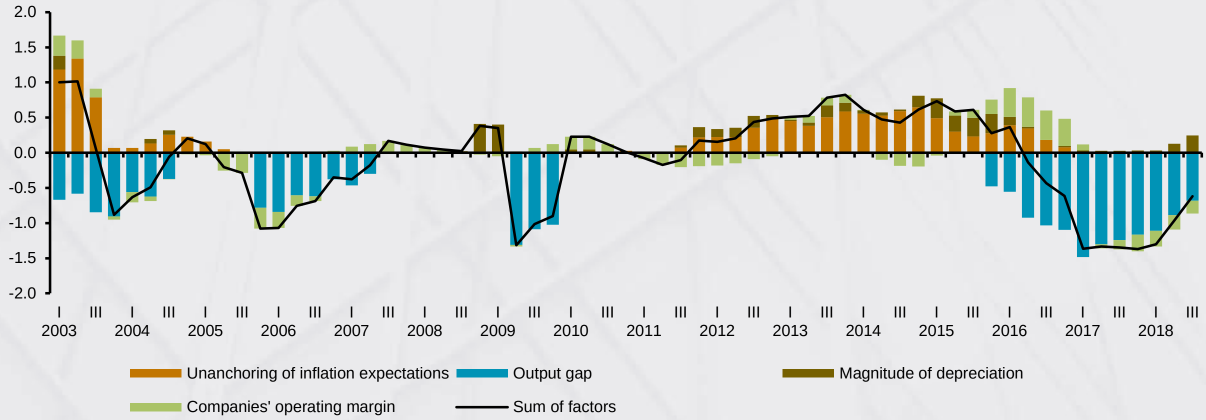
Another important factor in determining the magnitude of the exchange rate pass-through is the stage of the economic cycle. The estimates show that, as the output gap becomes more negative, the pass-through coefficient decreases. Specifications that include this variable suggest that in the case of a negative output gap of 1.0%, the exchange rate pass-through is 2.1 p.p. to 9.1 p.p. lower than when the economy is operating above or at its potential. These estimates involve both specifications that use a dummy variable for the negative gap, and those that consider the magnitude of the negative gap. This result is consistent with the hypothesis that, in times of low economic activity, firms find it more difficult to pass on exchange rate depreciation to the consumer.

Based on the results presented in Table 1, it is possible to identify how, in each period of time, the analyzed factors contributed to the evolution of the exchange rate pass-through. Figure 2 shows the relative contribution of each of the determinants of the variable part of the exchange rate pass-through coefficient ($\boldsymbol{\alpha}^{v}_{3,t} = \boldsymbol{\alpha}_{3,t} - \boldsymbol{\beta}_1$) to the exchange rate pass-through in each time period. The contribution of each determinant was calculated by multiplying each coefficient by the value of its respective determinant and then normalizing the result so the sum of the contributions is equal to 1 in the 2003Q1. Positive (negative) values indicate factors that, at that time, contributed to a larger (smaller) transfer.

Applying the model to the recent period – which refers to the second and third quarters of 2018 – one can observe that, although the magnitude of the exchange rate depreciation acts for a higher exchange rate pass-through, the anchoring of expectations, the position in the economic cycle and the operating margin of companies contribute to reduce the level of the exchange rate pass-through when compared to other periods.[12] Considering the magnitude of the contributions of each factor, it is the effect of factors that reduce the exchange rate pass-through that preponderates.

Figure 1 – Contribution of factors that impact the magnitude of the exchange rate pass-through

Values normalized so that factor contributions sum to 1 in the first quarter of 2003



Conclusion

This box explores how the exchange rate coefficient can be affected by different conjunctures. In particular, the results reinforce the importance of anchoring inflation expectations for the conduct of monetary policy, since they show that the exchange rate pass-through is more contained in the anchored expectations environment.

As has been emphasized in other Inflation Reports, models are tools to support the decision-making process and the economic analysis and should be combined with the use of a broad set of information and the exercise of judgment.

References

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12/ In this exercise, it was assumed that the exchange rate of September 2018 would be equal to the average rate observed in the five business days ended on the Friday prior to the September 2018 Copom meeting (R$4.15/US$).

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