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TRADE OPENNESS AND INFLATION DYNAMICS IN BRAZIL

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1. INTRODUCTION

Inflation is a relevant indicator of welfare in a society. This phenomenon erodes the purchasing power of consumers, alters the relative prices of products and inputs for production, and also clouds the forecasting horizon of economic agents (Kydland and Prescott, 1977). Therefore, it is important for formulators of economic policy to understand the various factors that affect the inflation dynamics, especially those that contribute to its reduction/stabilization.

An economic relation that is widely used in this sense is the Phillips curve, which since its inception in 1958 has undergone important modifications. One of the most recent alterations is called the hybrid New Keynesian Phillips curve (HNKPC), used by Blanchard and Gali (2007). In this formulation, inflation is explained by a forward-looking expectations component, an inertial component, a measure of economic cycles that incorporates the tradeoff between inflation and unemployment, and the so-called exchange rate pass-through.

Recent studies have indicated that this relation can have asymmetries, or nonlinearities, depending on some conjunctural aspects. For example, Ferreira, Gois and Arruda (2018) estimate nonlinear HNKPC models with a threshold effect, with regimes determined by the monetary authority's level of credibility. The results indicate that in the high-credibility regime, there is no tradeoff between inflation and unemployment and the inflation expectation coefficient is significant. On the other hand, in the low-credibility regime, the statistically significant coefficients are those of past inflation and unemployment.

Besides the credibility of monetary policy, another factor that can provoke asymmetries in the inflation dynamics is the degree of trade openness. According to Watson (2016), more commercial openness increases the number of products available to consumers in the domestic economy, triggering sharper competition. In this scenario, the price elasticity of demand and the mark-ups desired by the firms are adjusted, increasing the real rigidity of the economy, which in turn attenuates the tradeoff between inflation and unemployment. Çiçek (2012) found that trade openness reduces the effects of the inertial components of inflation because of the greater inflow of products from countries with lower production costs.

In this work, we estimate a nonlinear HNKPC model of the Brazilian economy with the degree of trade openness serving as the threshold variable. The hypothesis tested is the absence of a tradeoff between inflation and unemployment and the absence of inflation inertia under the most open regime, i.e., a more forward-looking HNKPC and a tendency for a traditional HNKPC to be significant in a scenario of a more closed economy. For this purpose, we rely on monthly data from January 2002 to December 2017 and the method proposed by Caner and Hansen (2004).

This study contributes to the investigation of possible asymmetries in Brazil's inflation dynamics based on nonlinear models of the HNKPC in which changes in regime are explained by the degree of trade openness, an exercise not previously undertaken in studies of this nature.

The paper is divided into five sections including this introduction. The second section presents a review of the literature that associates trade openness and inflation dynamics. The third section presents the database, empirical model and econometric strategy. Then the results are presented and discussed in the fourth section and our final considerations are expressed in the fifth section.

2. THEORETICAL FRAMEWORK

Kydland and Prescott (1977) showed that in the absence of a commitment by the monetary authority to a determined price level, inflation can converge to a high level, i.e., monetary policy will have a certain inflationary bias. Romer (1993) argued that the benefits of

a monetary expansion not expected by economic agents are decreasing in relation to the level of openness, given that in these cases the inflationary bias of discretionary actions of the monetary authority will tend to be aggravated. To test this hypothesis, he analyzed a cross-section of 114 countries during the period from 1973 to 1988. The results indicated a negative and statistically significant relationship between trade openness and inflation.

Lane (1997) used a general equilibrium model with a small economy having two sectors, the tradables and non-tradable goods sectors, and concluded that the more open the economy is, the lower will be the participation of non-tradables in consumption and the lesser will be the distortions caused by this sector. Assuming that the government is concerned with social welfare, this generates an inverse relation between trade openness and the incentive to generate an inflation surprise in exchange for higher employment. Hence, greater openness tends to attenuate the tradeoff between inflation and unemployment.

In turn, Çiçek (2012) analyzed the impact of globalization on the Phillips curve for the Turkish economy in the period from 1987 to 2007. He used a model of the Phillips curve with time-varying parameters and the results indicated that globalization reduces inflation inertial and the economy's sensitivity to cyclical fluctuations of economic activity.

Employing panel data techniques for developed and emerging countries over the preceding two decades, Samimi et al. (2012) tested whether globalization was disinflationary. The evidence confirmed the hypothesis of Romer (1993) that greater activity of the external sector in the domestic economy has a negative impact on inflation, based on globalization indices as indicators of openness.

Ghosh (2014) investigated the interplay of trade openness, financial openness and exchange rate regimes for 137 countries between 1999 and 2012. His results showed that a more open capital account and a fixed foreign exchange regime reduce inflation. Furthermore, he found no clear evidence of the impact of trade openness on this indicator, except for the countries less open to commerce. In these cases, openness was disinflationary. Through a panel data model for the countries of Sub-Saharan Africa, Lin *et al.* (2017) also found evidence that trade openness is disinflationary.

A widely used hypothesis in this area is that the parameters estimated among the countries are homogeneous. However, Eijffinger and Qian (2016) questioned this assumption using a panel data with time series approach, and found that it is not valid for highly industrialized countries. By permitting the parameters to be heterogeneous among countries, the authors observed that economic openness has a negative influence on inflation, even in highly industrialized countries like the United States, Italy, France, Canada and Sweden.

Watson (2016) proposed a DSGE model with non-constant price elasticity of demand and with firms that set prices as proposed by Calvo (1983). However, while the likelihood of firms changing their prices in a given period is not exogenous, it is subject to optimal decisions of other firms. The author showed that the trade openness produces two opposing effects on the optimal level of prices of each firm and on inflation. On one hand, greater commercial integration with the rest of the world, and a higher level of competition, generate an increase of the strategic complementarity between decisions to set prices of each form, and also raise the real rigidity of prices, making inflation less sensitive to cyclical oscillations of economic activity. On the other hand, the greater competition increases the opportunity cost of not adjusting the price when rivals do so, leading to more frequent alterations of prices, and reducing their nominal rigidity, which makes inflation more vulnerable to economic activity shocks. According to the author, the net effect of these changes in the short-term tradeoff between inflation and output, or inflation and unemployment, depends on the initial level of competition in the economy in question and the degree of openness.

It can be seen from the above that the majority of works that have examined whether trade openness is disinflationary have not investigated how this indicator can produce

asymmetries in the HNKPC. Our intention here is to contribute in this direction, by estimating a HNKPC with a regime change, with trade openness as the threshold variable.

3. METHODOLOGY

3.1. Database

The data used are monthly from January 2002 to December 2017. Various measures have been used to represent the degree of trade openness in the literature[1]. Romer (1993) employed the average share of imports in the gross domestic product (GDP) [2], which has also been used by other authors, such as Pickering and Valle (2008) and Watson (2016). This metric appears to be the most suitable to analyze inflation dynamics. It more accurately represents the contribution of the external sector in the domestic supply of goods and services, and, thus, on the setting of prices in the economy. Therefore, the trade openness indicator used here as a threshold variable is the share of total value of imports in GDP. These data were obtained from Brazil's Ministry of Industry, Foreign Trade and Services (*Ministério da Indústria, Comércio Exterior e Serviços* - MDIC) and the Central Bank of Brazil (*Banco Central do Brasil* - BCB), respectively.

We calculate inflation based on the Broad Consumer Price Index (*Índice de Preço Consumidor Amplo* - IPCA), available in the National Consumer Price System (*Sistema Nacional de Índices de Preços ao Consumidor* - SNIPC) of the Brazilian Institute of Geography and Statistics (*Insituto Brasileiro de Geografia e Estatística* - IBGE).

The measure of the economic cycle used here is the unemployment gap. For this we use unemployment data for the São Paulo metropolitan region as a proxy for the national unemployment supplied by the BCB. The choice for this proxy is motivated by the fact that the national indicator was discontinued at the start of 2016, precluding analyzing a more recent sample. This measure has been used in other works, such as Mendonça, Sachsida and Medrano (2012) and Sachsida (2013). We apply the Hodrick-Prescott (HP) filter to calculate the gap of this variable.

The inflation expectation variable was obtained from the Focus survey conducted periodically by the BCB, which measures the inflation expectation on the first day of each month for the following month. In turn, for the backward-looking expectation, or inflation inertia, we use the lagged IPCA. The indicator of the exchange rate pass-through is the variation of the real exchange rate, which is calculated by the trade-weighted geometric mean of the main trading partners of a given economy, and is used as a measure of the competitiveness of exports of a determined country. We use this rate corrected by the Wholesale Price Index (*Índice de Preços por* Atacado - IPA), available from the Time Series Generation System of the BCB (BCB-SGS).

3.2. Hybrid New Keynesian Phillips Curve with Threshold

The Phillips curve has evolved substantially since the seminal work of Phillips (1958), who established an inverse relationship between wage inflation and unemployment. Figure 1 show the scatter of Brazilian inflation and unemployment and a quadratic regression fit.

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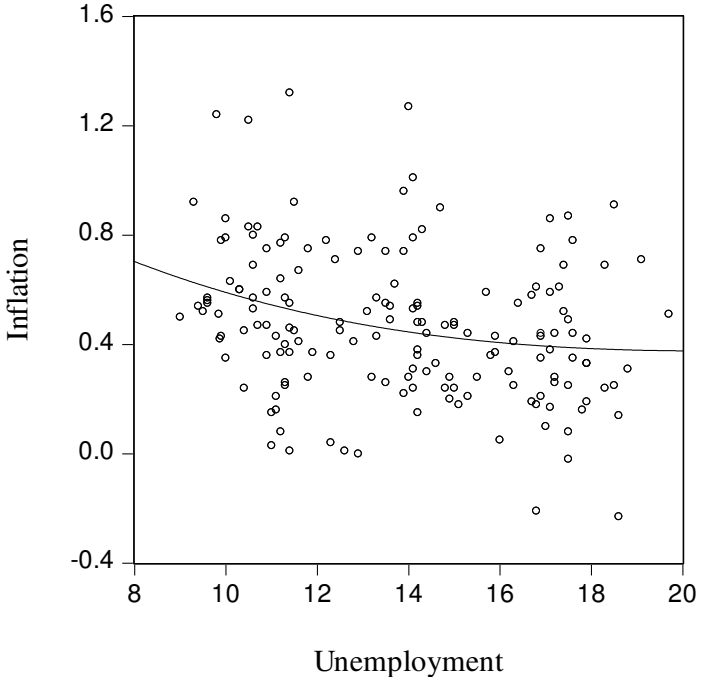
[1] In 1990, the Brazilian economy implemented an economic opening process. Despite the policies adopted for this purpose, data from the World Bank show that Brazil's opening rate in 2017 (24%) is much lower than that of the euro zone (84%) and Latin America & the Caribbean itself (45%).

[2] Another widely used indicator is the proportion of current trade (exports + imports) in relation to GDP. However, this metric has been used more often in works with applications in the area of economic growth.

Figure 1: Brazilian Phillips Curve: Inflation x Unemployment



Note: regression line obtained with quadratic unemployment.

Friedman (1968) and Phelps (1967) introduce a component in the Phillips model to capture inflation expectations. After many revisions, such as the insertion of adaptive expectations, suggested by Friedman (1968) and Phelps (1967); the introduction of rational expectations, formulated by Lucas (1972) and Sargent (1971); and the addition of a measure of economic cycles or the marginal cost of firms, used by Gali and Getler (1999), the most recent version is called the hybrid New Keynesian Phillips curve (HNKPC) with the exchange rate pass-through, as posited by Blanchard and Gali (2007).

In this version, besides the three factors already mentioned that influence current inflation, an indicator is also used for supply shocks on inflation. Traditionally, the most often used supply shock indicator is the exchange rate pass-through. The HNKPC in the form suggested by Blanchard and Gali (2007) can be represented as:

$$\pi_t = \lambda x_t + \gamma_f E_t\{\pi_{t+1}\} + \gamma_b \pi_{t-1} + \theta v_t + \varepsilon_t \quad (1)$$

where π_t is current inflation, x_t is a measure of the tradeoff between inflation and unemployment, $E_t\{\pi_{t+1}\}$ is the forward-looking inflation expectation, π_{t-1} is the past inflation (or inflation inertia), and v_t is the exchange rate pass-through to inflation.

Nevertheless, as discussed in the previous sections, different levels of trade openness can have asymmetric effects on inflation dynamics, thus modifying the behavior of the HNKPC. To incorporate this possibility, we use a nonlinear version of the HNKPC, with the openness measure presented previously as a threshold variable. This version can be represented as:

$$\pi_t = \left(\lambda^1 x_t + \beta_f^1 E_t\{\pi_{t+1}\} + \beta_b^1 \pi_{t-1} + \theta^1 v_t\right) I(Openness_{t-d} \leq \gamma) + \left(\lambda^2 x_t + \beta_f^2 E_t\{\pi_{t+1}\} + \beta_b^2 \pi_{t-1} + \theta^2 v_t\right) I(Openness_{t-d} > \gamma) + \varepsilon_t \quad (2)$$

where I(·) is an indicator function, *Openness* is an indicator that incorporates the share of the external sector in the domestic economy (the participation of the total value of imports in the gross domestic product), and γ is its threshold value, which is determined endogenously. According to Samimi et al. (2012), Çiçek (2012) and Watson (2016), if the participation of the external sector in the domestic economy is less than a threshold value, then the greater the coefficient of inertial inflation. Or, if the share of the total value of imports in the gross domestic product is greater than a threshold value, then the forward-looking inflation coefficient will be higher.

Agents can rely on current inflation to form their inflation expectations. Thus, the error in equation (2) can be correlated with the expected inflation component. To avoid this problem of endogeneity, we use the method proposed by Caner and Hansen (2004) to estimate eq(2). The procedure consists of three steps. First, we use a reduced-form regression to obtain a forecast series for the endogenous variables, as:

$$E_t\{\pi_{t+1}\} = \delta_1' w_t I(Openness_{t-d} \leq \rho) + \delta_2' w_t I(Openness_{t-d} > \rho) + u_t \quad (3)$$

Where w_t is a vector of exogenous (instrumental) variables. Following Galí and Gertler (1999), w_t contains the unemployment gap and the SELIC rate (the Brazilian Central Bank benchmark rate), both lagged by one period. Equation (3) is estimated as in Hansen (1999).

In the second step, $E_t\{\widehat{\pi_{t+1}}\}$ obtained in the first step is used in eq(2) instead of $E_t\{\pi_{t+1}\}$. Again the procedure in Hansen (1999) is applied to obtain $\hat{\gamma}$. Let Y, Z+ and Z- be the matrices of stacked vectors π_t, $[x_t\ E_t\{\widehat{\pi_{t+1}}\}\ \pi_{t-1}\ v_t]I(Openness_{t-d} > \gamma)$ and $[x_t\ E_t\{\widehat{\pi_{t+1}}\}\ \pi_{t-1}\ v_t]I(Openness_{t-d} \leq \gamma)$. Let $S_n(\gamma)$ be the sum of squared errors from a regression of Y on Z+ and Z-. Then $\hat{\gamma} = arg\min_{\gamma \epsilon \Gamma} S_n(\gamma)$, where Γ is a subset of the support of $Openness$. Lastly, we use $\hat{\gamma}$ to split the sample and we apply the generalized method of moments (GMM) for each subsample to obtain the estimated coefficients of the main model in each regime, following Caner and Hansen (2004).

4. RESULTS

We first test the null hypothesis of a unit root by the augmented Dickey-Fuller test (ADF) and the null hypotheses of stationarity through the Kwiatkowoski, Phillips, Schmidt and Shin (KPSS) (1992) test. Both tests indicate that all the series used are stationary at the 5% level, as reported in Table 1.

Table 1: Unit Root Tests

VARIABLE	ADF	KPSS
Inflation IPCA	-5.54 [-2.87]	0.21 [0.46]
Trade Openness	-4.58 [-2.87]	0.12 [0.46]
Inflation Expectations	-5.22 [-2.87]	0.22 [0.46]
Unemployment Gap	-4.31 [-2.87]	0.03 [0.46]
Exchange Rate Pass-through	-11.27 [-2.87]	0.15 [0.46]

Source: Prepared by the Authors.
Note 1. Critical value of the test at significance level 5% expressed in brackets.

Next, we test the null hypothesis of linearity against the alternative of a model with threshold effect via the Hansen (1999) test. The results of this procedure are summarized in Table 2. The null hypothesis of linearity is rejected at 5%. We then test the null hypothesis of a model with two regimes against the alterative of three regimes, in which case the null hypothesis is not rejected. Therefore, we use the nonlinear version of eq(2) with only one threshold (two regimes).

Table 2: Nonlinearity Tests

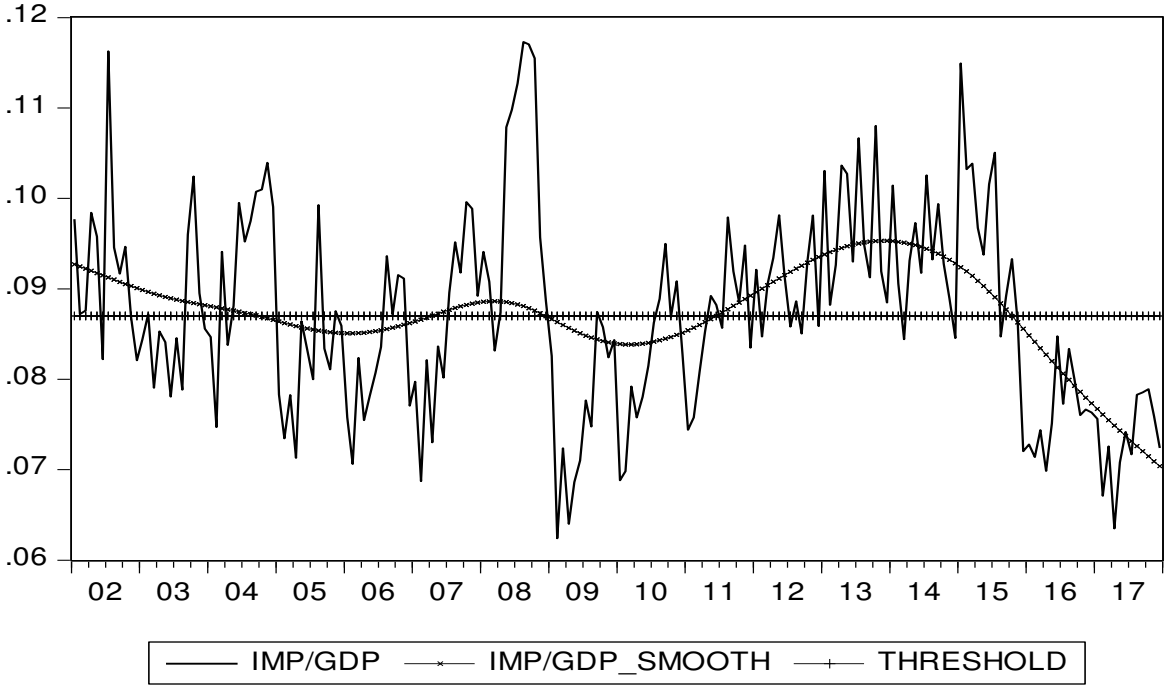
Nonlinearity Tests	F - Test	Critical Value
Linear Model vs Nonlinear Model (Two Regimes)	22.29*	18.23
Nonlinear Model (Two Regimes) vs. Nonlinear Model (Three Regimes)	7.01	19.91

Source: Prepared by the Authors. * Significant at the 5% level.

The results of estimating the model chosen by the method proposed by Caner and Hansen (2004) are presented in Table 3. The estimated threshold value for the share of the external sector in domestic supply is 0.087 (8.7%). The subsamples of the low and high openness regimes have 99 and 89 observations, respectively.

Figure 2 depicts the trajectory of the openness measure around the estimated threshold value. The period from 2002 until mid-2008 was, to a large extent, one of good macroeconomic performance, institutional stability and a favorable external scenario to the Brazilian economy. In this period, the level of imports in relation to the GDP was greater than the threshold at several moments. There was a perceptible reduction of this variable shortly after the 2008 financial crisis. The values of the openness variable were below the threshold between January 2009 and July 2010. After a recovery in the period from mid-2011 to the end of 2015, this variable returned to having values below the threshold. This period coincided with a Brazilian economic crisis that started in 2014 and worsened in 2016 and 2017 due to a strong decline in fiscal results and the deepening of the political crisis, which culminated in an impeachment process in 2016.

Figure 2: Trade Openness and Estimated Threshold



Note: IMP/GDP = % of imports in the gross domestic product; IMP/GDP_SMOOTH = trend of IMP/GDP estimated by Hodrick-Prescott filter. THRESHOLD = $\hat{\gamma}$

We now estimate the HNKPC with a threshold effect. Here the exchange rate pass-through variable is included in the model with four lags, and it is not possible to reject the null hypothesis that the instruments are valid by the J test.

Table 3: Results of the Nonlinear HNKPC

Variables	Low Openness Regime $Openness_t < 0.087$ (99 Obs.)		High Openness Regime $Openness_t \geq 0.087$ (89 Obs.)	
	Coefficients	Standard Error	Coefficients	Standard Error
$E_t\{\pi_{t+1}\}$	0.53*	0.12	0.97*	0.16
π_{t-1}	0.52*	0.10	0.12	0.11
x_t	-0.05*	0.02	-0.008	0.02
v_{t-4}	0.02*	0.01	0.02*	0.008
J Test	Test Statistic	Critical Value	Test Statistic	Critical Value
	0.03	3.84	0.03	3.84

Source: Prepared by the Authors. * Significant at the 5% level.

In general, it can be inferred that the hypothesis tested is confirmed, *i.e.*, the inexistence of a tradeoff between inflation and unemployment, a more forward-looking Phillips curve in the high openness regime, and statistical significance of a traditional HNKPC in a scenario of a less open economy. These results are in the same direction as Çiçek (2012) for Turkey, another emerging country[3].

According to the theoretical model of Watson (2016), these factors indicate the prevalence of a strategic complementarity in the setting of prices among firms in the high

[3] We estimate two additional models. In the first, we use unemployment data from Brazil that are only available for a smaller sample in the period 2002.01 to 2015.08. In this model, $\hat{\gamma} = 0.09$ and the exchange rate pass-through parameter is only significant in the first regime. In the other model, we use the IMP/GDP_SMOOTH (see figure 2) as the openness *proxy*. This is the trend estimate (smoothed values) from the HP filter and the results are very similar to those reported in table 3 with $\hat{\gamma} = 0.087$.

openness regime, which raises the real rigidity of prices and makes inflation less sensitive to cyclical variations of economic activity. Similar results were found by Romer (1993), Eijffinger and Qian (2016) and Lin *et al.* (2017).

The exchange rate pass-through with four lags has a statistically significant coefficient and the same value in both regimes. Its positive value indicates that a depreciation of Brazil's currency against the dollar can put pressure on inflation four months later.

Specifically, in the model estimated in the high openness regime, an increase of 1 percentage point (p.p.) in expectations raises inflation by 0.97 p.p., and also a real depreciation in the exchange rate of 1 p.p. four periods beforehand tends to increase current inflation by 0.02 p.p.

In the low openness regime, the impacts of the forward-looking expectations and inflation inertia are statistically robust and on the order of 0.53 p.p. and 0.52 p.p., respectively. In increment of 1 p.p. in the deviation of unemployment from its natural level reduces inflation by 0.05 p.p. Lastly, the exchange rate pass-through has a similar impact as in the high openness regime. This evidence confirms the robustness of the HNKPC to explain Brazilian inflation dynamics, especially in scenarios of low openness.

5. FINAL CONSIDERATIONS

This paper investigated whether distinct levels of trade openness have asymmetric effects on Brazil's inflation dynamics. For this purpose, we estimate a nonlinear hybrid New Keynesian Phillips curve model (HNKPC) with exchange rate pass-through, and trade openness as threshold variable, through the method proposed by Caner and Hansen (2004).

The results indicate that under the regime of greater trade openness, the coefficients of the tradeoff between inflation and unemployment and the inertial component of inflation (past inflation) are statistically nil, with a fully forward-looking HNKPC. In turn, under the regime of lesser openness, the impact of inflationary expectations is lower and the coefficients of inertia inflation and of the unemployment gap become statistically significant, with the expected signs.

According to the theoretical model of Watson (2016), greater trade openness and more intense competition tend to align the price-setting strategies of firms and increase their rigidity. Under these conditions, the inflationary dynamic tends to be more forward-looking and less vulnerable to cyclical movements of economic activity. Furthermore, Çiçek (2012) found evidence of reductions of inflation inertia and the tradeoff between inflation and unemployment in a more globalized setting. Eijffinger and Qian (2016) and Lin *et al.* (2017) also observed results in this direction.

The Brazilian economy is still relatively closed to foreign trade, both in relation to developed countries and many emerging ones. The results presented here suggest that efforts should be undertaken to increase Brazil's insertion in global trade, since in this scenario the inflationary dynamic is less influenced by cyclical changes in economic activity, is less inertial, and, thus, forward-looking.

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