The relationship between productivity and inflation: an empirical analysis of the Brazilian economy from 2009 to 2017

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Abstract: The article offers an empirical test of the hypothesis that productivity expansions are the answer to the inflation problems experienced by the Brazilian economy. The evidence obtained by the study, from estimation of a SVAR model for the period after December 2009, confirmed the existence of an inverse relationship between inflation and productivity in Brazil's manufacturing industry. However, this relationship is inelastic, that is: Brazilian entrepreneurs tend to convert productivity gains largely into mark-up, instead of passing them on primarily to prices. Thus, productivity increases yield smaller inflation control effects than expected.

Key words: Inflation targeting regime, non-monetary controls, productivity, economic development

JEL Classification: E31 040 M21

1. Introduction

In June 1999, Brazil's monetary authorities introduced an inflation targeting regime (ITR) for a monetary anchor as the price-control methodology in place of the exchange-rate anchor that had underpinned the Real Plan. From then on, the Selic base interest rate became officially the main instrument for combating inflation in Brazil's economy.

However, a number of economists have come to question the relation between the Selic rate and inflation, problematising how successful interest rate increases are in fostering price stability in Brazil. A simple examination of mean annual Selic and inflation rates from 1999 to 2017 warrants these questions: in that period, although the Selic rate was kept high, at a mean 14.4% p.a., inflation in Brazil also remained high for an ITR: the Extended Consumer Price Index (*Índice de Preços ao Consumidor Amplo*, IPCA) averaged 6.6% p.a. Also, in the 19 years the ITR has been in place in Brazil, the upper limit set for inflation was breached in five, and in only three did inflation remain below the pre-established limit.

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There is no lack of explanations for the peculiarities of inflation in Brazil under the ITR. It is argued in this article that inflation there is not primarily a demand phenomenon, as the ITR presupposes, but rather is determined mainly by: (i) inflation inertia; (ii) administered price adjustment policies; (iii) international dollar price and exchange rate dynamics; and (iv) rising wage trends. In recent years, in the wake of that idea, studies have come to prominence suggesting that one concrete, definitive solution to the problems of inflation facing Brazil's economy would be to stimulate productivity in the widest possible range of productive sectors.

In the meantime, Braga (2011: 121, 129) remarked that "policies that promote economic development can have significant beneficial impacts on the process of maintaining prices stable, even in a context of rapid growth", and that, in the conjuncture of Brazil's cost-push inflation, "aggregate productivity gains have sought to offset growth in average wages". Gentil & Araujo (2015) argued that the inflation observed recently in the Brazilian economy has shown itself to be a phenomenon influenced primarily by the existence of distributive conflicts, which means that accommodating it depends on obtaining productivity gains by focusing on the productive structure, innovation and investment. In their words:

> Low growth in productivity in a context of rising real wages has led to discomfort in accommodating the distributive conflict latent in Brazilian society, resulting in inflationary pressures that, as a rule, have been combated by means of restrictive macroeconomic policies, subjecting Brazil's economy to a stop-go type growth trajectory (GENTIL & ARAUJO, 2015: 55).

Nonetheless, however much this idea may have been introduced and discussed in analyses of inflation in Brazil in the post-ITR period, the economic literature lacks empirical evidence of its validity. Accordingly, seeking to fill that gap, this article tests the nature of the relationship between inflation and productivity in Brazil empirically. The article comprises four sections in addition to this Introduction. The next section explains briefly the reasons behind the choice of model to be estimated and describes the difficulties involved in that estimation – which resulted basically from the difficulty of obtaining official statistics. Section 3 presents the methodology guiding the empirical part of the study. Section 4 considers the results obtained from the estimation processes employed. The final section sets out the authors' conclusions.

2. Theoretical definition of the model and information constraints

Generally the studies that suggest increasing productivity as a means to ensuring price stability base their propositions ultimately on the impacts that productivity yields on production costs. For the purposes of this article, it was decided to base the empirical analysis on a model whose functional specification is inspired by Câmara & Feijó (2017), whose model used the variation in Producer Price Index (*Índice de Preços ao Produtor*, IPP) as a measure of inflation, in place of the more commonly used IPCA. This is because the IPP reflects the dynamics of production costs more precisely, given that it is limited to the realm of production, while the IPCA is liable to contamination by elements connected with the circulation of goods.

However, as the core purpose of Câmara & Feijó (2017) differs from the basic question guiding this study, important alterations have been made here to the model proposed previously by those authors. In that regard, while the model in Câmara & Feijó (2017) uses nominal wage per unit of output as its measure of wage cost, here the concept of nominal wage paid per worker is used. This enables the model to separate out the effect of productivity, a variable those authors did not consider explicitly.

The decision to use the IPP in the econometric analysis does, however, entail certain operational difficulties, which culminate in constraints on the study time period and sectors included. It is only recently that Brazil's official statistics bureau – *Instituto Brasileiro de Geografia e Estatística* (IBGE) – has published historical series for the IPP (IBGE, 2018a), so that, in order to maximise the sample size, it was necessary to employ the IPP series for the manufacturing industry, which began in December 2009. The other variants of the IPP – for the extractive industry and for industry overall – did not begin until December 2013. In addition to which, there is no aggregate measure for the indicator in question to cover all sectors of domestic economic activity.

Another technical difficulty posed by estimation of the model was that in 2002 the IBGE interrupted its calculation of the series for productivity in the manufacturing industry.[1] Since then, empirical studies on the subject have been estimating the variable by dividing the series for physical production and hours paid in industry overall;[2] the latter, however, has also entered the list of historical series that the IBGE has ceased publishing. It is now once again proving possible to measure productivity in the manufacturing industry, but this requires

[1] As a result of the limitations underlying the IPP, the model as a whole had to be focused on the manufacturing industry.
[2] Changes in IBGE surveys eventually made it impossible to calculate productivity by industrial sector.

using, as the denominator in the ratio described above, the series of hours worked in production in the manufacturing industry, according to the data of the National Confederation of Industry (*Confederação Nacional da Indústria*, CNI).

Although the lack of statistics ultimately restricted the scope of the sample – which initially was intended to comprise all sectors of economic activity and the complete period for which the ITR was in place in Brazil –, the results presented here are significant. In addition, it is the manufacturing industry, the most dynamic sector of economic activity, that is studied at a time when the ITR was fully established in Brazil, meaning that the results are important and thought provoking.

3. Methodological considerations

3.1. Estimation method

The estimates presented here derive from application of the Autoregressive Vector (VAR) and Structural Autoregressive Vector (SVAR) methodologies, which, as explained by Enders (2015), draw on multiple-equation time series, in the context of which all the variables are treated symmetrically as endogenous.

The system of equations below illustrates the structure of the VAR model in its most simplistic version, i.e., the first-order bivariate case:[3]

(1) $y_t = b_{10} - b_{12}x_t + \gamma_{11}y_{t-1} + \gamma_{12}x_{t-1} + \varepsilon_{yt}$

e

(2) $x_t = b_{20} - b_{21}y_t + \gamma_{21}y_{t-1} + \gamma_{22}x_{t-1} + \varepsilon_{xt}$.

In equations (1) and (2), the assumption is that the variables y and x are both stationary and that ε_{yt} and ε_{xt} consist in white noise-type error terms.

These equations constitute a first-order VAR model, as the longest time lag included on the right-hand side of the equations is only one period. The VAR model, in accordance with the equations, cannot be estimated directly by the Ordinary Least Squares technique, because there is a problem of endogeneity – given that x has a contemporary effect on y and vice-versa. Accordingly, the estimation process must transform this primitive system into what is termed a standard-form VAR model, which is performed by the algebraic procedures described below.

Rewriting equations (1) and (2) gives:

[3] Multivariate and higher-order models are merely extensions of this simpler representation.

(3) $y_t + b_{12}x_t = b_{10} + \gamma_{11}y_{t-1} + \gamma_{12}x_{t-1} + \varepsilon_{yt}$

e

(4) $b_{21}y_t + x_t = b_{20} + \gamma_{21}y_{t-1} + \gamma_{22}x_{t-1} + \varepsilon_{xt}$.

These can be restructured into the matrix system:

(5) $\begin{bmatrix} 1 & b_{12} \\ b_{21} & 1 \end{bmatrix} \begin{bmatrix} y_t \\ x_t \end{bmatrix} = \begin{bmatrix} b_{10} \\ b_{20} \end{bmatrix} + \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{bmatrix} \begin{bmatrix} y_{t-1} \\ x_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{yt} \\ \varepsilon_{xt} \end{bmatrix}$,

The matrix system can be rewritten as:

(6) $\boldsymbol{B}\boldsymbol{z}_t = \boldsymbol{\Gamma}_0 + \boldsymbol{\Gamma}_1\boldsymbol{z}_{t-1} + \boldsymbol{\varepsilon}_t$,

where: $\boldsymbol{B} = \begin{bmatrix} 1 & b_{12} \\ b_{21} & 1 \end{bmatrix}$, $\boldsymbol{z}_t = \begin{bmatrix} y_t \\ x_t \end{bmatrix}$, $\boldsymbol{\Gamma}_0 = \begin{bmatrix} b_{10} \\ b_{20} \end{bmatrix}$, $\boldsymbol{\Gamma}_1 = \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{bmatrix}$ e $\boldsymbol{\varepsilon}_t = \begin{bmatrix} \varepsilon_{yt} \\ \varepsilon_{xt} \end{bmatrix}$.

Premultiplying (6) by $\boldsymbol{B}^{-1}$ gives:

(7) $\boldsymbol{B}^{-1}\boldsymbol{B}\boldsymbol{z}_t = \boldsymbol{B}^{-1}\boldsymbol{\Gamma}_0 + \boldsymbol{B}^{-1}\boldsymbol{\Gamma}_1\boldsymbol{z}_{t-1} + \boldsymbol{B}^{-1}\boldsymbol{\varepsilon}_t$

e

(8) $\boldsymbol{z}_t = \mathbf{A}_0 + \mathbf{A}_1\boldsymbol{z}_{t-1} + \boldsymbol{e}_t$.

In the previous equation (8), which relates to the standard-form VAR model, the values of $\mathbf{A}_0$, $\mathbf{A}_1$, and $\boldsymbol{e}_t$ are the following: $\mathbf{A}_0 = \boldsymbol{B}^{-1}\boldsymbol{\Gamma}_0$, $\mathbf{A}_1 = \boldsymbol{B}^{-1}\boldsymbol{\Gamma}_1$ e $\boldsymbol{e}_t = \boldsymbol{B}^{-1}\boldsymbol{\varepsilon}_t$.

Lastly, (8) can be rewritten as:

(9) $y_t = \alpha_{10} + \alpha_{11}y_{t-1} + \alpha_{12}x_{t-1} + e_{1t}$

e

(10) $x_t = \alpha_{20} + \alpha_{21}y_{t-1} + \alpha_{22}x_{t-1} + e_{2t}$.

The coefficients for the primitive model are identified from the standard-form model by way of a resource known as the Cholesky decomposition, following Sims (1980), which is processed by decomposing the residuals into a triangular matrix, thus giving rise to a recursive system. In terms of the matrix system (5), the Cholesky decomposition can be illustrated on the basis that $b_{21} = 0$, which means assuming that y_t exerts no contemporary influence on x_t – thus conferring on y_t a greater degree of endogeneity in the system in relation to x_t. In other words, the restriction that $b_{21} = 0$ entails the hypothesis that ε_{yt} and ε_{xt} have contemporary impact on y_t, but only ε_{xt} has contemporary impact on x_t. Enders (2015: 294) argues that:

> In an *n*-variable VAR, **B** is an *n* x *n* matrix since there are *n* regression residuals and *n* structural shocks. […] exact identification requires that $(n^2\text{-}n)/2$ restrictions be placed on the relationship between the regression residuals and the structural innovations. Since the Cholesky decomposition is triangular, it forces exactly $(n^2\text{-}n)/2$ values of the **B** matrix to equal zero.

Important diagnostic instruments derived from the VAR methodology include impulse-response functions and variance decomposition analysis. With impulse-response functions, it is possible to assess, qualitatively and quantitatively, how the variables included in the model behave in response to shocks – in the system described here, how y_t and x_t react to the dynamics of ε_{yt} and ε_{xt}. Variance decomposition analysis, meanwhile, clarifies what proportion of the movements of a given variable are due to the shocks on that particular variable and what proportion are due to shocks on the other variables.

VAR models have come in for strong criticism over time because of their essentially theory-free nature, which will not admit knowledge to be incorporated from economic theory. This has resulted in the development of SVAR models, with which economic theory can be used as a basis for imposing restrictions on the model and thus producing results that are not ad hoc. Accordingly, in parallel with the Cholesky decomposition, other decompositions are performed, as in Sims (1980), and, in that context, it is possible to impose error constraints so as to allow structural shocks to be identified in a manner consistent with the theoretical underpinning of the model in question. Bueno (2015: 226) wrote:

> In such forms, economic arguments are followed more strictly, to the point that constraints are applied that go as far as to over-identify the model if the number of constraints is greater than the number of coefficients estimated in the reduced form. That is, while the methodology of Sims (1980) used the economy to specify an order of variables, it is possible to seek economic constraints more comprehensively. That is, economic theory is used to specify constraints on the **A** matrix completely.[4]

[4] In the example given in this section, understood as B matrix.

The Blanchard & Quah (1989) decomposition is also performed, which allows even the variables' long-term dynamics to be analysed. Lütkepohl (2005) explained that this decomposition starts on the principle that it is unnecessary to impose constraints directly on the matrices in order to identify structural shocks. In order to exemplify the Blanchard-Quah decomposition with regard to our bivariate model, let us suppose that the sequence to be decomposed is of variable y_t, assuming I(1), as regards its transitory and permanent components, and that x_t is stationary. Disregarding the intercepts, in the Blanchard-Quah (1989) decomposition, the sequences $\{y_t\}$ and $\{x_t\}$ can be represented as:

(11) $$\Delta y_t = \sum_{k=0}^{\infty} c_{11}(k)\varepsilon_{1t-k} + \sum_{k=0}^{\infty} c_{12}(k)\varepsilon_{2t-k}$$

e

(12) $$x_t = \sum_{k=0}^{\infty} c_{21}(k)\varepsilon_{1t-k} + \sum_{k=0}^{\infty} c_{22}(k)\varepsilon_{2t-k}.$$

In matrix notation:

(13) $$\begin{bmatrix} \Delta y_t \\ x_t \end{bmatrix} = \begin{bmatrix} C_{11}(L) & C_{12}(L) \\ C_{21}(L) & C_{22}(L) \end{bmatrix} \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix},$$

where ε_{1t} and ε_{2t} are independent white noise shocks, and the components $C_{ij}(L)$ of the C matrix are L-degree polynomials whose individual coefficients are denoted as $c_{ij}(k)$.

Use of the Blanchard-Quah decomposition requires that at least one of the variables involved in the estimation process not be stationary, given that stationary variables have no permanent component – which is essential to conduct the long-term analysis. However, the technique is employed by introducing the variables into the model in their stationary forms. Note that the Blanchard-Quah procedure does not associate shocks on $\{\varepsilon_{1t}\}$ and $\{\varepsilon_{2t}\}$ directly with the sequences $\{y_t\}$ and $\{x_t\}$; on the contrary, the sequences $\{y_t\}$ and $\{x_t\}$ are taken to be endogenous variables, and the sequences $\{\varepsilon_{1t}\}$ and $\{\varepsilon_{2t}\}$ what could be termed exogenous variables.

3.2. Specification of the model

The vector of variables, $\boldsymbol{z}$, for the VAR and SVAR systems estimated, is composed as follows:

$$z = \begin{bmatrix} A \\ \epsilon \\ i \\ u \\ w \\ P_p \end{bmatrix}, \quad (14)$$

Where: A is the productivity of labour in the manufacturing industry; ϵ is the nominal exchange rate; i is the basic market interest rate; u = utilisation of installed capacity in the manufacturing industry; w is the average nominal wage paid in the manufacturing industry; and P_p is the producer price index for the manufacturing industry.

3.2.1. Description of the variables

In order to perform the estimates, monthly data were used for the period from December 2009 to July 2017, totalling 92 observations. As mentioned above, the time range and industrial sector of reference for the analysis were chosen in view of data availability. The variables involved in the estimation process were specified as follows:

(i) ptd = index for labour productivity in the manufacturing industry. Calculated as the ratio of the portion of the monthly industrial index (*Produção Industrial Mensal*, PIM) relating to the manufacturing industry (Source: IBGE/PIM-PF, 2019) to the index for hours worked in production in the manufacturing industry (Source: CNI/Indicadores Industriais, 2019);

(ii) cmb = index for nominal exchange rate. Commercial exchange, end of period, mean of buy and sell (Source: Brazilian Central Bank (BCB), 2019);

(iii) jur = index for nominal market interest rate. Selic (*Overnight*) rate, % p.m. (Source: BCB, 2019);

(iv) uci = index for utilisation of installed capacity in the manufacturing industry. Mean percentage (Source: CNI/Indicadores Industriais, 2019);

(v) slr = index for mean nominal wage paid in the manufacturing industry. Calculated as the ratio of the index for the manufacturing industry wage bill (Source: CNI/Indicadores Industriais, 2018) to the index for employees in the manufacturing industry (Source: CNI/Indicadores Industriais, 2019);

(vi) ipp = IPP for the manufacturing industry (Source: IBGE, 2019).

All the indices used are to the same base, that is, 2012 average = 100. The variables were de-seasonalised by the Census X-13 method. In the estimation process, they were used in logarithm form.

4. Analysis of the results

Tables 1 and 2 show the results of the unit root tests performed on the variables included in the model to be estimated. In view of the divergences found among the tests performed, it was concluded that all the variables could be considered to be I(1). That assertion includes the interest rates, although the Augmented Dickey-Fuller test and Zivot-Andrews test do leave room for ambiguities, because the other tests confirmed the stationarity hypothesis when that variable was considered in first difference. As it was found that all the variables had to be included in the model in their first-difference versions, it can be seen that, given that the variables were expressed in logarithmic form, the coefficients for the estimates executed will refer to elasticities.

Table 1. Unit Roots Test, variables in levels

TEST		Ptd	cmb	jur	uci	slr	ipp
ADF	**t-statistic**	-2.711528*	-0.666589	-2.321665	-2.803488*	-3.631234*	-2.650261*
	p-value	0.2347	0.8490	0.1676	0.2000	0.0326	0.2597
KPSS	**LM statistic**	0.174206*	0.114257*	0.148539*	0.271630*	0.218900*	0.086862*
	Critical Value 1%	0.216000	0.216000	0.216000	0.216000	0.216000	0.216000
	Critical Value 5%	0.146000	0.146000	0.146000	0.146000	0.146000	0.146000
	Critical Value 10%	0.119000	0.119000	0.119000	0.119000	0.119000	0.119000
ADF (Break)	**t-statistic**	-2.586509	-2.553750	-3.709575	-2.894235	-1.884412	-2.591340
	p-value	0.8737	0.8860	0.2781	0.7417	0.9881	0.8719
ZA	**t-statistic**	-3.895	-3.069	-2.496	-5.055	-3.527	-2.614
	Critical Value 1%	-5.34	-5.34	-5.34	-5.34	-5.34	-5.34
	Critical Value 5%	-4.80	-4.80	-4.80	-4.80	-4.80	-4.80
	Critical Value 10%	-4.58	-4.58	-4.58	-4.58	-4.58	-4.58

Note: ADF = Augmented Dickey-Fuller; KPSS = Kwiatkowski-Phillips-Schmidt-Shin; ADF Break = Augmented Dickey-Fuller with structural break; ZA = Zivot-Andrews; and * Test equation with time trend term.
Source: Results of the estimation process. Produced by the authors.

Table 2. Unit Roots Test, variables in first difference

TEST		Dptd	Dcmb	djur	duci	dslr	dipp
ADF	t-statistic	-13.96488*	-9.760973	-1.991412	-13.32437	-12.76937	-6.542762
	p-value	0.0000	0.0000	0.2901	0.0001	0.0001	0.0000
KPSS	LM statistic	0.223430	0.115096	0.139291	0.058259	0.124130	0.173177
	Critical Value 1%	0.739000	0.739000	0.739000	0.739000	0.739000	0.739000
	Critical Value 5%	0.463000	0.463000	0.463000	0.463000	0.463000	0.463000
	Critical Value 10%	0.347000	0.347000	0.347000	0.347000	0.347000	0.347000
ADF (Break)	t-statistic	-14.61660	-10.84901	-14.32303	-13.66376	-13.45417	-7.425025
	p-value	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
ZA	t-statistic	-14.309	-10.884	-4.225	-13.687	-7.582	-7.382
	Crit. Val. 1%	-5.34	-5.34	-5.34	-5.34	-5.34	-5.34
	Crit. Val. 5%	-4.80	-4.80	-4.80	-4.80	-4.80	-4.80
	Crit. Val. 10%	-4.58	-4.58	-4.58	-4.58	-4.58	-4.58

Note: ADF = Augmented Dickey-Fuller; KPSS = Kwiatkowski-Phillips-Schmidt-Shin; ADF Break = Augmented Dickey-Fuller with structural break; ZA = Zivot-Andrews; and *Test equation with time trend term.
Source: Results of the estimation process. Produced by the authors.

To select the order of SVAR model, an examination of the statistics condensed in Table 3 reveals that, while the Akaike information criterion suggests using 3 lags, the Schwartz information criterion indicates a second-order model. However, it is possible to obtain a model that is homoscedastic and non-auto-correlated only by including at least 4 lags in the model. Specification of a second-order SVAR model would entail the existence of autocorrelation, as well as of heteroscedasticity in the equation underlying the variable *duci*. Thus, a third-order SVAR model would be subject to the presence of heteroscedasticity in the equation for the variable *dcmb*.

Accordingly, it was decided to estimate a fourth-order SVAR model, which, in addition to the good results mentioned above as regards tests of heteroscedasticity and auto-correlation, also offered excellent normality statistics, as shown in Table 4. Only one equation (for the variable *dcmb*) pointed to problems of normality, a result that can be considered quite satisfactory (in comparison with what is commonly found when working with estimation procedures) and the model as a whole proved normal. Also, with the inclusion of four lags, the model proved stable (as seen in Figure 1).

Table 3. Test of the Model: Selection Criteria, Heteroscedasticity Test and Autocorrelation Test

Level	**2**		**3**		**4**		**5**	
Selection criteria	**AIC**	**SBC**	**AIC**	**SBC**	**AIC**	**SBC**	**AIC**	**SBC**
	-32.9676	-30.7415	-33.0741	-29.8207	-32.8624	-28.5815	-32.7524	-27.4441
Heteroscedasticity Tests								
Equation	**χ^2**	**p-value**	**χ^2**	**p-value**	**χ^2**	**p-value**	**χ^2**	**p-value**
dptd	0.0011	0.9994	1.0672	0.7850	1.8453	0.7642	4.1369	0.5299
dcmb	2.9668	0.2269	6.7209	0.0813	5.8060	0.2141	6.5518	0.2562
djur	1.7245	0.4222	1.9106	0.5912	3.3320	0.5039	3.2123	0.6673
duci	7.0145	0.0300	3.2696	0.3519	2.0199	0.7321	7.3107	0.1985
dslr	0.9826	0.6118	2.7508	0.4317	1.2766	0.8653	2.2182	0.8182
dipp	2.4462	0.2943	3.7394	0.2910	1.7999	0.7725	6.2594	0.2818
Autocorrelation Tests								
Lags	**χ^2**	**p-value**	**χ^2**	**p-value**	**χ^2**	**p-value**	**χ^2**	**p-value**
1	68.1568	0.00096	39.7114	0.30811	40.9333	0.26285	29.3592	0.77540
2	48.8143	0.07529	42.0495	0.22538	35.8764	0.47444	30.3347	0.73452

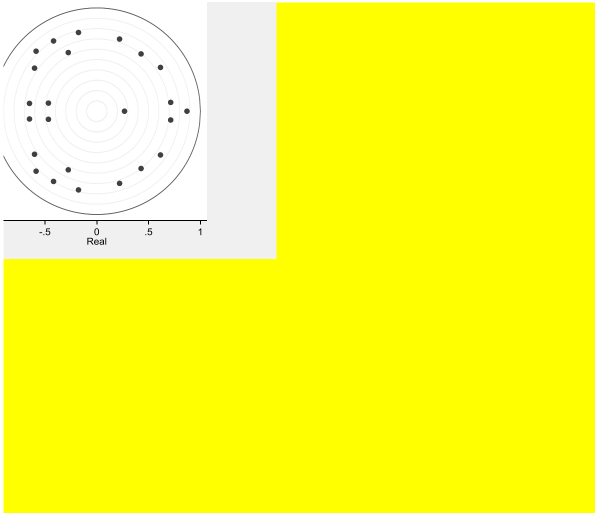
Note: AIC = Akaike Criterion; SBC = Schwartz Criterion; Heteroscedasticity Test = Portmanteau teste for white noise; and Auto-correlation test = Lagrange Multiplier (LM).
Source: Results from the estimation process. Produced by the authors.

Table 4. Jarque-Bera Test for Normality

Equation	Dptd	dcmb	djur	duci	dslr	dipp	Set
χ^2	0.224	8.689	0.637	0.714	0.206	0.073	10.542
G.L.	2	2	2	2	2	2	12
p-value	0.89388	0.01298	0.72713	0.69994	0.90213	0.96430	0.56848

Note: Test with the fourth-order SVAR model.
Source: Results from the estimation process. Produced by the authors.

Figure 1. Test of the Model: Stability Testing



Source: Results from the estimation process.

As a first exercise, with a view to identifying the short-term behaviour of the variables involved in the estimation process, the Cholesky decomposition was performed for the proposed model. The results are summarised in Table 5. When the Cholesky decomposition was analysed with the assistance of the tables for the equivalent impulse-response functions, only the variables relating to exchange rate and the IPP itself were found to have a statistically significant influence on inflation. Those results were quite consistent with the existing literature (AIZENMAN, HUTCHISON & NOY, 2011; FONSECA, PERES & ARAÚJO, 2016), which in fact shows exchange to be the main variable affecting inflation in the short run and highlights the importance of inflation inertia in recent times. The estimates obtained confirmed the validity of those findings also for “factory gate” inflation in the sector and periods studied.

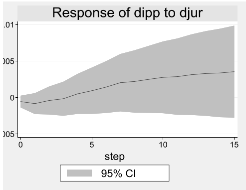
Table 5. Cholesky Decomposition

Equation	dptd	dcmb	djur	duci	dslr	dipp
dptd	0.0098257	0	0	0	0	0
dcmb	0.00004992	0.03788503	0	0	0	0
djur	0.01397239	-0.00420024	0.04657547	0	0	0
duci	0.00143742	-0.00087231	0.00153026	0.00420819	0	0
dslr	-0.00066297	0.00224166	0.00028373	0.00126037	0.00956542	0
dipp	0.00031779	0.00283911	-0.00055389	0.00036671	-0.00031057	0.00380011

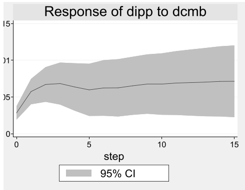
Source: Results do estimation process. Produced by the authors.

However, the effects of exchange variation and inflation feedback are rather inelastic, and a 1% rise in the exchange rate results in an increase of only 0.2% in the IPP, while the analogous coefficient for inflation inertia was 0.3%. The short-term effects on the IPP from exchange rate, and feedback by the IPP on itself, can be even better understood by examining the graphs for the impulse-response functions associated with the Cholesky decomposition that was performed (Figure 2). Graph (b) reveals that a shock on $dcmb$ is reflected, over time, in cumulative increases in $dipp$. In Graph (f) it can be seen that a shock on $dipp$ produces a rapid response in that variable, which lasts about three periods and then begins to dissipate.

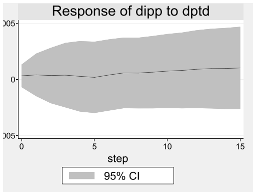
Figure 2. Impulse-Response Functions (IRFs)



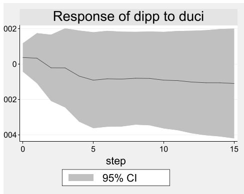
(a)



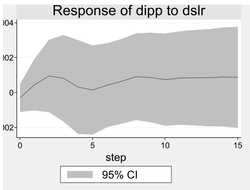
(b)



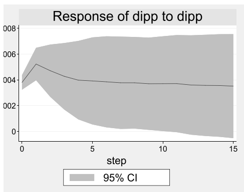
(c)



(d)



(e)



(f)

Source: Results from the estimation process.

Lastly, Table 6 groups the results from the Blanchard-Quah decompositions with a view to ascertaining what long-term relations are established between the variables involved in the estimation process. Note that exchange variations and the inertial component also stand out, in this method of estimation, as the fundamental determinants of the recent behaviour of inflation in the manufacturing industry (because they display the highest elasticity coefficients). The evidence obtained shows that a 1% increase in *dcmb* led to a 0.5% expansion in *dipp*, a coefficient analogous to that for the elasticity of *dipp* to itself.

Table 6. Blanchard-Quah Decomposition

Equation	Dptd	dcmb	djur	duci	dslr	dipp
	0.0106284					
dptd	(0.0008057)	0	0	0	0	0
	[0.000]					
	-0.0203615	0.0529174				
dcmb	(0.0058796)	(0.0040117)	0	0	0	0
	[0.001]	[0.000]				
	-0.0757563	0.0046718	0.0727121			
djur	(0.0096956)	(0.0078036)	(0.0055123)	0	0	0
	[0.000]	[0.549]	[0.000]			
	0.003604	-0.0027417	-0.0029581	0.0033499		
duci	(0.000625)	(0.0005223)	(0.0004234)	(0.000254)	0	0
	[0.000]	[0.000]	[0.000]	[0.000]		
	-0.0038287	0.0031609	-0.0005669	-0.0007815	0.0041907	
dslr	(0.0006416)	(0.0005196)	(0.0004591)	(0.0004532)	(0.0003177)	0
	[0.000]	[0.000]	[0.217]	[0.085]	[0.000]	
	-0.003942	0.00579	0.0033468	0.000094	0.0009092	0.0054324
dipp	(0.0009758)	(0.0008187)	(0.0006428)	(0.0005906)	(0.0005865)	(0.0004118)
	[0.000]	[0.000]	[0.000]	[0.874]	[0.121]	[0.000]

Note: Standard deviation in round brackets; p-value in square brackets.
Source: Results from the estimation process. Produced by the authors.

Meanwhile, the coefficients estimated for the impacts exerted by wages and utilisation of installed capacity proved not to be statistically significant. In other words, the variable *dslr* exerts no significant influence on *dipp*. This result it is really intriguing, given that it constitutes an important component of firms’ costs. Contrariwise, the lack of any substantial correlation between *dipp* and *duci* causes no surprise; rather, it tallies with the idea that inflation in Brazil is not determined primarily by the level of aggregate demand.

The findings regarding the relation between $dipp$ and interest rate proved very interesting and telling. It was found that, in the context of the ITR, increases in the base interest rate, introduced into the Brazilian economy for the stated purpose of containing inflationary processes, ultimately and contradictorily led $dipp$ to expand to a long-term horizon. That effect may be explained by the fact that interest rates influenced firms' financial costs (which were passed on to final product prices), and it may also be regarded as an indication that using the interest rate as an anti-inflationary instrument, in view of its contractionary impacts on economic activity, proved not only inefficient, but also ineffective.

Lastly, the findings deriving from measurement of the nature of the link between productivity and inflation in Brazil's manufacturing industry are as follows: the result obtained from the estimates supports the idea presented in the Introduction, that is, it points to the existence of a statistically significant, inverse relationship between $dptd$ and $dipp$. However, the coefficient estimated to reflect the quantity and quality of that relationship shows that it is inelastic, as a 1% rise in $dptd$ is reflected in a decrease of only 0.3% in $dipp$. Accordingly, the proposition that expansions in productivity in the manufacturing industry assist in controlling prices is confirmed, although to a lesser extent than expected.

This empirical evidence provides food for thought as to Brazilian entrepreneurs' behaviour. If productivity increments in the manufacturing industry are not passed on substantially in the form of price reductions, it is to be concluded that ultimately they result in expansions in firms' mark-up. That conjecture may assist in understanding why, in the model estimated, wage increases did not figure prominently as a significant component in determining the dynamics of inflation as measured by $dipp$. In that connection, as firms operate with a tendency to accumulate profit margins, they can absorb increases in wage costs more easily.

5. Conclusion

For reasons of availability of official statistics, the empirical analysis which was the core objective of this study had to be restricted to an assessment of the manufacturing industry and the period after December 2009. These restrictions underlying the functional specification of the model as first intended did not prevent significant original findings being made by means of the econometric procedures adopted. As shown by heterodox theoretical approaches in general,[5] the manufacturing industry is the most dynamic sector in the economic system and, accordingly, measurements taken from it will give quite an accurate idea of the functioning of the productive sector as a whole. Also, examining the period after 2009 entailed an analysis based on a time frame when the ITR was already established in Brazil, thus eliminating the initial period of adaptation to the new monetary arrangements, which could have introduced distortions into the results if taken into consideration.

This study found clear indications that, in the recent period, the IPP for the manufacturing industry showed sensitivity to exchange rate variations and that its dynamic behaviour displayed a significant inertial component. On the other hand, the IPP was not significantly affected by the degree of utilisation of installed capacity, indicating that the behaviour of aggregate demand did not constitute a significantly important determinant in the index's behaviour. In addition, the basic interest rate, the key anti-inflation instrument in the context of the ITR, tended to exert an opposite effect on the IPP to that desired by the monetary authorities, confirming the finding that is widely documented in the literature, that Brazil's inflation did not respond as expected to monetary contractions. As interest is a component of firms' financial expenditures, that finding stands as yet another indicator of the validity of the post-Keynesian propositions regarding cost inflation.

Moreover, when a long-term timeframe is considered, rising interest rate policies under the ITR, by subjecting the Brazilian economy to an incessant *stop-go* trajectory, ultimately undermined the very price stability they were officially designed to preserve. In an emerging economy with an inflationary dynamics impregnated with a series of particularities and not determined primarily by aggregate demand conditions – as it has been endeavoured to show here is the case with Brazil –, the phenomenon of inflation should not be regarded as a variable uncorrelated with the national development process. Leaving aside the blind, single-minded belief in demand inflation ideology so widely propagated by mainstream economics and considering a broader perspective that contemplates cost inflation, it is clear that supply-side elements are important to explaining inflation in Brazil.

In that light, in structuring the econometric model estimated here, the point of departure was given by arguments as to the existence of a relation between productivity and inflation in the Brazilian economy. The evidence observed confirmed the hypothesis that increments in productivity over time do help to control inflation in the manufacturing industry; however, the magnitude of the effect of expanding productivity proved smaller than

[5] Such as Kaldorian Neo-Keynesianism, Latin American Structuralism and Neo-Schumpeterianism.

expected. That given, it must be said that productivity gains in Brazil's manufacturing industry are not substantially reflected in price reductions, but as a result are significantly absorbed in the form of increases in firms' profit margins. These expansions in mark-up can assist in explaining why the model estimated indicated that increases in wages paid to workers do not produce significant impacts on the IPP, as already mentioned.

In conclusion, by obtaining empirical evidence on observable realities, barriers were found to exist that prevent productivity from exerting theoretically expected effects on inflation in Brazil, these barriers being intrinsic to aspects of the behaviour of Brazilian entrepreneurs. Accordingly, it is envisaged that achieving definitive price stability in the Brazilian economy poses a complex set of problems (contrary to the simplistic view embodied in the ITR) on which how public policies are conducted has significant impact. Other aspects of that complex of problems, however, cannot be directly manipulated, because they depend on the directions to be taken by the process of Brazil's socioeconomic development and on the evolution of the country's deep-rooted institutions and the habits and customs ingrained in its society, considered as an organic, and thus dynamic, whole.

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