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Article

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Asymmetric cost pass-through: An analysis of 21 industrial activities in Brazil from 1996 to 2014

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Abstract

This paper investigates the existence of asymmetric transmission from industrial costs to prices (IPA/FGV) in Brazil from 1996 to 2014. We construct cost indices based on intermediate consumption of industrial activities from the National Accounts (SCN/IBGE). The paper estimates symmetric and asymmetric SVAR models for 21 industrial activities using a decomposition of industrial costs into positive and negative changes. The results of the pass-through estimates indicate that the magnitude of the cost pass-through is heterogeneous among industrial activities. The estimates and Wald tests on the asymmetrical model coefficients show that most industrial activities exhibit positive asymmetric price transmission, i.e., cost increases have a larger pass-through rate than cost decreases.

JEL classification: E31; D43

Keywords: Asymmetric price transmission; Cost pass-through; SVAR; Brazil

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1. Introduction

Asymmetric cost pass-through, or asymmetric price transmission, refers to how the transmission of cost variations differs in the case of positive cost shocks compared to negative cost shocks. According to the classification proposed by Meyer and Von Cramon-Taubadel (2004), asymmetric price transmission can occur taking into consideration its speed of transmission, magnitude and direction (positive if the pass-through following a positive cost shock is greater than the pass-through following a negative change, or negative in the opposite case). The heterogeneity among sectors according to the magnitude, speed and direction of the asymmetry that they present must also be considered.

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Theoretically speaking, the existence of asymmetric price transmission and price rigidity can be justified by factors which are defined by sectors or according to each market, its structures and its characteristics. The theoretical discussions on the possible reasons for the existence of asymmetry between sectors in the pass-through of cost changes attempt to understand how the process of price formation takes place, in different types of structures. Thus, the size of the increase in the price as a result of the increase in marginal cost would depend on the magnitude of the cost variation and on the inclinations and formats of the market's supply and demand curves, in the case of markets in perfect competition. In a monopoly market, the same will take place, except that in this case there is no supply curve. In oligopolistic markets however, the analysis of the decision process on price considers, in particular, the interdependence of the companies' activities. Thus, the companies evaluate their competitors' reactions and the pricing schemes are more difficult to predict and more uncertain. Issues arise such as leadership, maximum price and barriers to entry; even cooperative actions, that enable some type of price coordination (tacit or explicit). The recent literature¹ on cost pass-through in oligopolies is largely based on Bertrand or Cournot models, with non-cooperative Nash equilibriums, that do not necessarily consider coordination, or even the possibility of diversity of arrangements and asymmetry among companies.

As previously mentioned, part of the literature focuses on explaining the existence of price rigidity in diverse markets. Empirical evidence shows that to some extent prices are rigid in certain oligopolistic markets². Regarding cost variations, one can assume a certain level of price rigidity for small variations, given that a price war is avoided at all costs (Carlton and Perloff, 1999, p. 545). Regarding price rigidity, we can highlight the classic contributions made by Sweezy (1939) and Hall and Hitch (1939). The common thread in these contributions is how they attribute rationality to rigidity as a way of avoiding price changes as a generating factor of instability in coordination.

When evaluating possible price rigidity, or positive asymmetry in cost pass-through, the theory points out - though no common consensus has been reached - several explanatory factors. Meyer and Von Cramon-Taubatel (2004) give that the majority of the literature associates market power to positive asymmetric price transmission. Toolsema and Jacobs (2007) highlight the high concentration as an explanation for positive asymmetry via coordination. Borenstein et al. (1997) found that the price rigidity of cost reductions would lead to positive asymmetry given that the companies are working around a reference price (past). Ward (1982) affirms that the existence of market power can result in negative asymmetry if the oligopolies are reluctant to risk losing market-share in the event of a price increase. Bailey and Brorsen (1989) conclude that it is not possible to determine if the resultant asymmetry would be negative or positive, due to a function of kinked demand (concave or convex). Radchenko (2005) on the other hand presents an explanation that is close to the interpretation of kinked demand but affirms that it is a possible cause of positive asymmetry.

Menu cost and stock management (such as variance adjustment) are also possible reasons for asymmetry and rigidity. Reagan and Weitzman (1982) argue that, when demand is low, companies will prefer to reduce the quantity and adjust stocks rather than lower prices. On the contrary, when demand is high, they tend to increase prices. This tendency, together with an aversion to stockouts, would generate positive asymmetry (Meyer and Von Cramon-Taubatel, 2004). Another source of asymmetry is the existence of countercyclical markups. A positively inclined marginal cost curve suggests pro-cyclical marginal costs: costs increase at the same time as production increases. When markups are countercyclical, prices become acyclical. Price rigidity would be the result of compensating an increase in costs with a fall in the markup during a phase of increased production. Markups can be countercyclical due to the procyclicality of elasticity of demand (Blinder et al., 1998) or if price wars are more frequent during periods of increased production when greater gains can be had from avoiding price fixing (Rotemberg and Saloner, 1986).

There are a number of econometric studies that provide evidence for the existence of asymmetric price transmission in products in the agricultural and fuel industries in various countries around the world, including Brazil. Works that provide a broad analysis of diverse industrial activities are in general less common and, in Brazil, are non-existent. Peltzman (2000) and Gwin (2009) indicated asymmetric price transmission in diverse industries in the United States.

The specific objective of this study is to investigate the presence of asymmetric cost pass-through in Brazil from January 1996 to July 2014. The magnitude, direction and existence of heterogeneity between the industrial activities will be analyzed. The construction of a cost index for 21 industrial activities and its decomposition into positive cost variations and negative cost variations makes it possible to estimate symmetric and asymmetric structural vector autoregression (SVAR) models.

¹ For more information see RBB Economics (2014) and Tirole (1988).

² See Carlton and Perloff (2005); Koutsoyiannis (1979) for a review on the subject.

The study aims to contribute to the knowledge on Brazilian inflationary dynamics following the implementation of the “Plano Real”, considering that structural factors (market structures, price formation rules, competition patterns and/or market power) play a crucial role in the formation of prices in the various economic activities, that, as a result, present a heterogenous inflationary dynamic. Specific characteristics of price trajectories provide relevant information when considering the dynamic of aggregate inflation.

Thus, the monetary authority must take into consideration the heterogeneity in the transmission of cost shocks to final prices, due to some sectors potentially being less sensitive to the effects of monetary policy, given that they do not necessarily compete via price, as well as having more control over their pricing policy, and thus are more able to pass on cost increases to prices while cost decreases are passed on to a smaller degree.

The existence of asymmetries in price transmission could also have implications on competition policy given that well-thought-out policies should prevent coordinated market power from taking place, when in the form of tacit collusion, and punish, when exercised explicitly.

This article is structured into two sections, in addition to the introduction and conclusion. The first deals with the theoretical literature on cost pass-through and possible theoretical explanations for the existence of asymmetry, as well as the empirical literature, focusing on international studies that analyze diverse industries and Brazilian studies that focus on specific industries in the country. The second section describes the SVAR model together with the decomposition of positive and negative cost changes, in addition to presenting the data utilized, how the series were constructed, and the results obtained.

2. Theory

Based on the above information, it can be concluded that different market structures, considering, for example, demand structures, stock management and propensity to adjust prices and their real or perceived costs, and the ability to coordinate and exercise market power can influence cost pass-through. It may therefore be useful to characterize the sectors according to the presence of factors such as concentration, number of companies and entry conditions. A large amount of information on possible coordination in a given market can also be found in the literature. Considering this backdrop, [Stigler \(1964\)](#), in his article “A Theory of Oligopoly”, highlighted, based on Consensus-Detection-Punishment, which, associated to the development behind game theory, listed the factors necessary to establish market collusion, such as: concentration/small number of firms, barriers to entry, repeated interaction, frequent and small orders, contacts in various markets, symmetric companies, product homogeneity, excess capacity, stable demand conditions, elasticity of demand and, finally, a buyer with market power³.

2.1. Empirical studies on the analysis of asymmetric price transmission

The existence of asymmetric price transmission is largely discussed and analyzed in the international literature considering specific product markets, notably gas and products derived from oil and agricultural products. [Meyer and Von Cramon-Taubadel \(2004\)](#) provide a review of this literature while [Frey and Manera \(2007\)](#) provide a review of the econometric methods used. There are far fewer analyses that cover diverse sectors, most notably [Peltzman \(2000\)](#) and [Gwin \(2009\)](#).

[Peltzman \(2000\)](#) carried out an analysis using BLS (The US Bureau of Labor Statistics) producer and consumer price index data for 165 products and with wholesale and retail data on products sold by the second largest supermarket chain from Chicago from 1978 to 1996. The estimation results on how final producer prices react to input price shocks indicate that more than two thirds of markets presented asymmetry, with the response being almost twice as big when the prices rise than when they fall. The estimation results using the second sample with data on both the producer price index and consumer price index are notably similar to the first sample. The data on the supermarket chain however do not present significant asymmetry.

Finally, [Peltzman \(2000\)](#) carries out an exploratory analysis to identify regularities in the asymmetries found, using regression analysis on the degree of market asymmetry versus a list of the market characteristics. The variables used

³ These characteristics usually make up what is known in Antitrust Law as a Checklist, used to analyze the possibility of coordination in a given market, which defines a series of factors that must be considered, cited both in the literature and in official antitrust guidelines.

as market characteristics fall into the following categories: i) the behavior of input prices (share of the input cost, price volatility and two variables relative to the menu cost ii) the structure of the industries (number of companies, the HHI, and stock related variables) and iii) geographic concentration of the industries.

Regarding producer prices, two results emerged: lower volatility associated with higher asymmetry and the importance of the market structure in the sense that fewer companies are associated with higher asymmetry, but a lower degree of asymmetry is produced by markets that are more concentrated. None of the other variables were considered relevant. Regarding consumer prices, the negative effect of volatility on asymmetry is also present.

Gwin (2009) investigated the existence of asymmetric price adjustment in the USA from 1966 to 2006. As with Peltzman (2000), the Bureau of Labor Statistics (BLS) producer price index was used. However, to build a proxy for the industrial costs, Gwin (2009) used a series of disaggregated public company data taken from Standard and Poor's (S&P) known as "the cost of goods sold". The disaggregation of data into 6 digits according to the North American Industry Classification System (NAICS) enabled an analysis of 269 industries (6 digits) in 42 subsectors (3 digits) and 24 sectors (2 digits) with quarterly data.

Of the 42 subsectors analyzed by Gwin (2009), 7 showed positive asymmetric price transmission (oil and gas, beverages and tobacco, wood, primary metals, railways, aquatic transport and telecommunications). The author concluded, however, that it is not possible to confirm that there is a high presence of price asymmetry in the American economy and that the evidence only confirms that such asymmetry exists in certain industries.

A possible explanation presented by the author for the lack of evidence for the presence of asymmetry would be the lack of cost variation in these industries. The industries that presented positive asymmetry in general, use few inputs in their production (in some cases only one) while the other industries use a large number of inputs. However, an analysis carried out by ANOVA on cost variation did not support this hypothesis, with the results indicating a similar variability among the sectors that presented positive asymmetry and those that did not present asymmetry.

Finally, the author analyzed his findings based on five explanatory theories on the existence of asymmetry present in the literature. Gwin (2009) found evidence contradicting the explanation that asymmetry would originate from menu costs, given that asymmetric price transmission was more evident in natural resource manufacturing that usually present price variations with minimum menu costs.

In relation to supply costs, markups relating to the economic cycle and market power, the author estimated an equation where the price asymmetry of the industries is explained by the Herfindahl-Hirschman index (HHI), with one dummy for durable goods (which, in theory, would be more sensitive to economic cycles) and another for goods associated to high supply costs. The results indicated that the price asymmetry was lower for durable goods than for nondurable goods, contrary to what the theory indicated; the negative coefficient of the HHI found also contradicted the theory. The result indicating that asymmetry is lower in industries with low supply costs compared to those in which these costs are high is the only one that would be in line with the expected result.

The author concluded that the explanation in relation to the stock management was closest to the results obtained. Stock can be easily accumulated in the industries that presented more evidence for asymmetric price transmission: manufacturers of nondurable goods and of natural resources. However, there is no evidence of asymmetries in the industries where it is more difficult to manage stock as in the case of durable goods and mining, in addition to cases where there is no stock such as the service sector.

As with the majority of studies in the international literature, the works on asymmetric price transmission in Brazil focus on oil products and agricultural product markets.

Regarding oil product markets in Brazil, Canêdo-Pinheiro (2012) investigated the asymmetric price transmission of wholesale diesel (from refineries and distributors) for final consumers from 1999 to 2010. Uchôa (2008) analyzed the resale price of gas in relation to price variations of oil on the international market and the exchange rate during the period 2001–2006. Both studies uncovered asymmetric price transmission. Santos et al. (2015) carried out a study based on data from 18 municipalities in the state of São Paulo on ethanol distributors and retailers from 2005 to 2011. The results indicate asymmetric price transmission from distributors to retailers in the majority of the municipalities, with the pass-through being higher after an increase in prices than a reduction. In addition, in the majority of municipalities, the price increases are transmitted entirely in the same month, while reductions are distributed over two months in all of the municipalities. Silva et al. (2014) used data from 134 Brazilian municipalities on wholesale and retail gas prices from 2004 to 2011. The results indicated that asymmetry does not occur at a national level, but only in a small number of the municipalities analyzed (approximately 30%).

Studies on the transmission of prices of agricultural products in Brazil also utilized regional data. [Aguiar and Figueiredo \(2011\)](#) analyzed the presence of asymmetry in the transmission of eight agricultural products (rice, beans, beef, chicken, eggs, soybean oil, cheese and pork meat) in the state of São Paulo, using producer price data - wholesale and retail - from the Institute of Agricultural Economics from 1989 to 2008. The results highlighted the presence of asymmetric price transmission from wholesale to retail in all products (with the exception of two products that only presented short-term asymmetry) analyzed, both in the short and long term. [Figueiredo et al. \(2013\)](#) analyzed the asymmetric price transmission in the agro-industrial citrus system in Brazil from 2001 to 2011. Analyzing the monthly prices of oranges and orange juice, the authors found evidence that when the prices of the juice (gained by the industry) are in decline, there are significant variations in the prices of the oranges paid to producers. There are, however, no statistically significant variations when the prices are increasing. [Alves et al. \(2013\)](#) investigated the presence of asymmetric price transmission between the producer, wholesale and retail levels of table grapes in the state of Paraná between 1997 and 2011. The authors found evidence that the agents involved in the commercialization pass on price increases faster than price decreases.

3. Asymmetric SVAR model

Structurally, a VAR(*p*) model of the variables $Y_t = (y_1, y_2, y_3)'$ can be described as follows:

$$AY_t = v_0 + B_1Y_{t-1} + \dots + B_pY_{t-p} + Bu_t \tag{1}$$

The matrix *A* establishes the coefficients of contemporary relations between variables Y_t , u_t is the vector of structural errors, white noise with variance-covariance matrix $E(u_t, u_t') = \Sigma_u$. The structural errors are, by definition, not correlated in such a way that the matrix Σ_u is diagonal. If we pre-multiply the structural form (8) by A^{-1} , we obtain the VAR in its reduced form:

$$Y_t = c_0 + \Phi_1Y_{t-1} + \Phi_2Y_{t-2} + \dots + \Phi_pY_{t-p} + e_t \tag{2}$$

where: $c_0 = A^{-1}v_0$; $\Phi_i = A^{-1}B_i$; $Ae_t = Bu_t$

The reduced form of VAR makes it possible to consistently estimate the parameters c_0, Φ_i, e_t using ordinary least squares (OLS). However, the objective of the present study is to analyze how vector Y_t reacts to structural shocks u_t . We pose the question: how can the elements of matrix *A* be recuperated, structurally speaking, using the estimated parameters in the reduced form so that the matrix Bu_t can be reconstructed using $Ae_t = Bu_t$ and the matrices B_i using $\Phi_i = A^{-1}B_i$?

Written as: $Ae_t = Bu_t$, therefore the variance of e_t is:

$$E(e_t e_t') = A^{-1}E(u_t u_t') A^{-1} \tag{3}$$

$$\Sigma_e = A^{-1}B \Sigma_u B' A^{-1'}$$

Σ_e can be consistently estimated by OLS via the reduced form. The system of linear equations can therefore be resolved as long as the number of unknown parameters does not exceed the number of equations. To do so it is necessary to impose restrictions on determined elements of *A*.

A way to recuperate the structural innovations using the reduced form innovations is to estimate a structural model (SVAR) imposing restrictions such as $a_{ij} = 0$ on the matrix *A*.⁴

$$\begin{bmatrix} 1 & a_{12} & a_{13} \\ a_{21} & 1 & a_{23} \\ a_{31} & a_{32} & 1 \end{bmatrix} \begin{bmatrix} e_{Y1} \\ e_{Y2} \\ e_{Y3} \end{bmatrix} = \begin{bmatrix} b_{11} & 0 & 0 \\ 0 & b_{22} & 0 \\ 0 & 0 & b_{33} \end{bmatrix} \begin{bmatrix} u_{Y1} \\ u_{Y2} \\ u_{Y3} \end{bmatrix} \tag{4}$$

⁴ It is necessary to jointly impose $K(K + 1)/2$ restrictions on matrices ($K \times K$) *A* and *B* to meet the order condition to make an exact identification. The order condition is necessary but may not be sufficient if the postconditions are not satisfactory. [Rubio-Ramirez et al. \(2010\)](#) discuss these conditions.

The imposition of different restrictions will result in different impulse response functions depending on the degree of correlation between the reduced form errors e . Only if all of the correlations between the errors are zero, will the impulse response functions be the same, independent of the restrictions imposed.

The criteria used to impose restrictions began with an analysis of the correlation matrix of the residuals and identification of the pairs of variables with residual correlations above $|0,2|$ according to the rule of thumb, as later suggested by [Enders \(2008\)](#). For these pairs only, restrictions were imposed considering theoretically that the costs simultaneously affect the prices (a_{21}), and that costs and prices simultaneously affect the production (a_{31} and a_{32}); the other coefficients were considered $a_{ij} = 0$.

One can investigate the presence of asymmetry on the effects of an explanatory variable x_t on the independent variable y_t by breaking down the variable x_t into two new series: x_t^+ , of their positive variations and x_t^- , of the negative variations and checking if the impacts on y_t differ.

Based on the [Schorderet \(2004\)](#) methodology and [Granger and Yoon \(2002\)](#), a temporal series can be broken down in the following way: $x_t = x_0 + x_t^+ + x_t^-$, where

$$x_t^+ = \sum_{i=1}^t \theta_i (\Delta x_i); \begin{cases} \theta_i = 1 \text{ se } \Delta x_i > 0, \\ 0, \text{ in the opposite case.} \end{cases} \quad (5)$$

$$x_t^- = \sum_{i=1}^t \theta_i^* (\Delta x_i); \begin{cases} \theta_i^* = 1 \text{ se } \Delta x_i < 0, \\ 0, \text{ in the opposite case.} \end{cases} \quad (6)$$

In such a way that its value at any time t is equal to its initial value plus the sum of all positive and negative variations up to t .

Thus, we have the first difference of the series:

$$dx_t^+ = \theta_i (\Delta x_i); \begin{cases} \theta_i = 1 \text{ se } \Delta x_i > 0, \\ 0, \text{ in the opposite case.} \end{cases} \quad (7)$$

$$dx_t^- = \theta_i^* (\Delta x_i); \begin{cases} \theta_i^* = 1 \text{ se } \Delta x_i < 0, \\ 0, \text{ in the opposite case.} \end{cases} \quad (8)$$

Two models were estimated for each activity in format (1). The symmetric where the vector Y_t is made up of three variables at first difference $Y_t = (\Delta C_t, \Delta P_t, \Delta Y_t)'$ where C_t is the time series of the cost of the activity, P_t prices and Y_t production. The asymmetric model where Y_t is a vector with four variables $Y_t = (\Delta C_t^+, \Delta C_t^-, \Delta P_t, \Delta Y_t)'$ where ΔC_t^+ and ΔC_t^- correspond to the decomposition of the series of costs in their positive and negative variations as in (7) and (8).

In the asymmetric model, the matrices A and B of the SVAR are 4×4 matrices and the same identification criteria was employed: we identified the pairs of variables whose residuals had a correlation above $|0,2|$. For these pairs only, we then established theoretically that the costs (negative and positive) simultaneously affect the prices (a_{31} and a_{32}) and that costs (positive and negative) and prices simultaneously affect production (a_{41} , a_{42} and a_{43}).

3.1. Data and calculation

The analysis period is from January 2006 to July 2014 and the sample was selected according to the availability of data. The data used were: i) the IPA-OG (*Global Offer Wholesale Price Index*) from the Getúlio Vargas Foundation (FGV), renamed in 2010 as the *Broad Producer Price Index*; ii) Intermediate Consumption by industry provided in the resource and use tables from the National Accounts System/Brazilian Institute of Geography and Statistics (SCN/IBGE) and; iii) the PIM-PF/IBGE (*Monthly Industrial Research on Physical Production*): Industrial production per deseasonalized industrial activity.

Based on these data, the following series were constructed and employed in the estimations:

i) *Price index*

The price index, P_{jt} , of the activity j in the period t , corresponds to the IPA-OG/FGV of the activity.

ii) *Production Index*

The production index, Y_{jt} , of the activity j in the period t , corresponds to the industrial production per deseasonalized industrial activity of the PIM-PF/IBGE.

iii) *Cost Index (Intermediate Consumption)*

There are no industrial cost indexes available for a number of industries in Brazil⁵. The construction of this series is one of the contributions of this article. The estimation methodology is based on Muendler (2003). The cost index, C_{jt} , of activity j in period t , corresponds to the average of the prices P_{it} in the period t of the goods i used in the activity's production process j , weighted by w_{ji} , the weight of the activity i in the production of the activity j according to the intermediate consumption tables of the 2005 National Accounts.

$$C_{jt} = \sum w_{ji} \cdot P_{it} \quad (9)$$

where $\sum w_{ji} = 1$. The year 2005 was chosen as an intermediate point in the data series. The use of fixed weights in the period emulates the Laspeyeres index, employed by the IBGE to calculate its Producer Price Index. Since the classifications of the economic activities of the IPA-OG/FGV and of the National Accounts/IBGE do not correspond, it was necessary to make the two classifications compatible. It is possible to add up the economic activities of the National Accounts that correspond to an individual activity of the IPA-OF/FGV since the intermediate consumption values are provided.⁶

iv) *Consumer Price Index - IPCA*

To estimate the pass-through models of prices from the producer to the consumer, it was necessary to create a classification “translator” between the IPA/FGV and the IPCA. The IPA uses a classification that is very similar to the *National Classification of Economic Activities* (CNAE) - two-digit level. Thus, based on the translator created between the IPCA and the NCM (*Mercosur Common Nomenclature*), we were able to use the translator made available by the IBGE for the NCM and the CNAE in order to construct the translator for the IPCA and the CNAE.⁷

It can be highlighted that there was no correspondence among the IPCA subitems of the activities (10) Wood products; (15) Basic metallurgy and (3) Extraction - metallic minerals. Activity (2) Extraction - non-metallic minerals corresponds to two of the IPCA subitems, sand and tile, both series start in January 2012, which is why no estimations were made for these activities. Finally, the activity (19) Machines and equipment corresponds to just one IPCA item, air conditioning, and it was concluded that the use of this correspondence was inadequate.

Table A1 in the attachment shows the correlation among the IPA activities and IPCA subitems.

4. Results and discussion

The choice of lags in the symmetric and asymmetric SVAR models was carried out by looking for the most parsimonious model with “well-behaved” residuals, i.e. ones that did not present serial autocorrelation nor heteroscedasticity and that were normally distributed. To enable a better comparison, the symmetric and asymmetric models for the same activity were estimated with the same number of lags. From the 42 estimated models, not all residuals presented

⁵ The CNI (Brazilian National Industrial Federation) produces the Industrial Cost Indicator, however it refers to the industry as a whole.

⁶ A cost index was also calculated that incorporates expenditure on salaries given as $C_{it}^{CI+W} = r^W W_{it} + r^{CI} C_{it}$. The cost index C_{it}^{CI+W} of activity i in period t corresponds to the mean intermediate consumption index, C_{it} with the index W_{it} , payroll per worker (PIMES/IBGE), weighted by the proportions of expenditure on intermediate consumption, r^{CI} , and on remuneration, r^W , according to the table of resources and uses (TRU) of the National Accounts (SCN/IBGE) from 2005. This index tends to be very similar to the index that only considers the intermediate consumption. Since the PIMES/IBGE series only begins in December 2002, we chose to use a longer series which only considers the intermediate consumption.

⁷ The IPCA and NCM translator was used in the estimations given in part III. Its construction is described in section 2 and available in the attachment.

Table 1
Cost pass-through by activity, symmetric, asymmetric and measure of the degree of asymmetry.

Activity	Pass-through after 12 months			1-(Pos./Neg.)
	Symmetric	Asymmetric		
		Positive	Negative	
2 - Extractive industry - metallic minerals	1.79	1.78	1.72	0.03
3 - Extractive industry - non-metallic minerals	1.55	1.56	1.55	0.00
4 - Oil and alcohol products	1.24	1.25	1.20	0.04
5 - Food and beverage products	0.83	0.87	0.44	0.50
6 - Tobacco products	0.27	0.21	0.22	-0.02
7 - Textile products	1.00	1.01	0.98	0.02
8 - Clothing	0.32	0.31	0.08	0.76
9 - Leather and footwear	0.82	0.83	0.38	0.55
10 - Wood products	0.90	0.94	0.25	0.73
11 - Cellulose, paper, etc.	1.19	1.22	1.01	0.17
12 - Chemical products	1.02	0.91	0.87	0.05
12 - Rubber and plastic products	0.87	1.06	0.37	0.66
14 - Nonmetallic mineral products	0.62	0.63	0.56	0.11
15 - Basic metallurgy	0.83	0.87	0.71	0.18
16 - Metal products	0.75	0.80	0.40	0.50
17 - Electronic materials and communication equip.	1.06	1.09	0.96	0.12
18 - Electrical machines and materials	0.78	0.83	0.53	0.36
19 - Machines and equipment	0.66	0.68	0.35	0.49
20 - Automotive vehicles etc.	0.79	0.83	0.71	0.15
21 - Other transport equipment	0.92	0.96	0.57	0.41
22 - Furniture and furnishings	0.69	0.77	0.22	0.72

Source: Own elaboration.

heteroscedasticity and were normally distributed, however, models that did not present serial autocorrelation were always selected, according to the Lagrange Multiplier and Portmanteau tests.

To calculate the impulse response functions, it was necessary to impose restrictions on the matrix of contemporary relations A of the SVAR according to the criteria discussed in sections 2.1 and 2.2.

The pass-through calculation of costs to prices can be carried out using the impulse response functions estimated using the SVAR model. This calculation was used by McCarthy (2007) to measure the exchange-rate-pass-through for inflation in various industrialized countries and by Belaisch (2003) for Brazil:

$$R_{t,t+j} = \left(\frac{\sum \Delta P_{t,t+j}}{\sum \Delta C_{t,t+j}} \right) \cdot 100 \quad (10)$$

Table 1 below shows the results of the estimations of the symmetric and asymmetric models and the calculation to measure the degree of asymmetry found: the ratio between the positive cost pass-through and the negative cost pass-through subtracted from the unit. The greater this value, the greater the degree of estimated asymmetry.

The graphs relating to the impulse response functions of the prices to cost and production shocks are found in the attachment.

Wald tests (coefficient restriction) were also carried out on the asymmetric models to test the hypothesis that the coefficients relative to the positive cost variations are statistically different from negative cost variations.

The test was carried out under two different specifications from the null hypothesis. In specification A the null hypothesis was considered as the sum of all coefficients of the lags of ΔC^+ (positive cost variations) equal to the sum of all coefficients of the lags of ΔC^- (negative cost variations). Specification B considered the coefficient of lag i of ΔC^+ to be equal to the coefficient of lag i of ΔC^- for all of the lags.

Table 2
 Statistics and Probabilities of the two specifications of the Wald test.

Activity	Lags	Wald Test			
		Specification A		Specification B	
		Statistics	Probability	Statistics	Probability
2 - Extractive industry - metallic minerals	2	30.71	0.00	62.61	0.00
3 - Extractive industry - non-metallic minerals	2	26.40	0.00	34.14	0.00
4 - Oil and alcohol products	1	–	–	20.04	0.00
5 - Food and beverage products	2	13.63	0.01	19.25	0.01
6 - Tobacco products	2	4.90	0.30	10.37	0.24
7 - Textile products	1	–	–	58.73	0.00
8 - Clothing	2	39.96	0.00	52.71	0.00
9 - Leather and footwear	2	39.23	0.00	80.17	0.00
10 - Wood products	2	9.63	0.05	13.98	0.08
11 - Cellulose, paper etc.	4	53.82	0.00	88.72	0.00
12 - Chemical products	3	60.88	0.00	85.98	0.00
13 - Rubber and plastic products	2	55.60	0.00	127.54	0.00
14 - Non-metallic mineral products	2	33.15	0.00	37.89	0.00
15 - Basic metallurgy	3	2.09	0.72	20.02	0.01
16 - Metal products	1	–	–	166.30	0.00
17 - Electronic materials and communication equip.	1	–	–	11.49	0.02
18 - Electrical machines and materials	2	84.82	0.00	107.10	0.00
19 - Machines and equipment	3	50.27	0.00	60.02	0.00
20 - Automotive vehicles etc.	4	83.35	0.00	120.41	0.00
21 - Other transport equipment	1	–	–	2.18	0.70
22 - Furniture and furnishings	2	148.37	0.00	163.26	0.00

Source: Own elaboration.

For example, the asymmetric SVAR (2), in the reduced form, is as follows:

$$\begin{cases} \Delta C_t^+ = c_1 \Delta C_{t-1}^+ + c_2 \Delta C_{t-2}^+ + c_3 \Delta C_{t-1}^- + c_4 \Delta C_{t-2}^- + c_5 \Delta P_{t-1} + c_6 \Delta P_{t-2} + c_7 \Delta Y_{t-1} + c_8 \Delta Y_{t-2} + c_9 \\ \Delta C_t^- = c_{10} \Delta C_{t-1}^+ + c_{11} \Delta C_{t-2}^+ + c_{12} \Delta C_{t-1}^- + c_{13} \Delta C_{t-2}^- + c_{14} \Delta P_{t-1} + c_{15} \Delta P_{t-2} + c_{16} \Delta Y_{t-1} + c_{17} \Delta Y_{t-2} + c_{18} \\ \Delta P_t = c_{19} \Delta C_{t-1}^+ + c_{20} \Delta C_{t-2}^+ + c_{21} \Delta C_{t-1}^- + c_{22} \Delta C_{t-2}^- + c_{23} \Delta P_{t-1} + c_{24} \Delta P_{t-2} + c_{25} \Delta Y_{t-1} + c_{26} \Delta Y_{t-2} + c_{27} \\ \Delta Y_t = c_{28} \Delta C_{t-1}^+ + c_{29} \Delta C_{t-2}^+ + c_{30} \Delta C_{t-1}^- + c_{31} \Delta C_{t-2}^- + c_{32} \Delta P_{t-1} + c_{33} \Delta P_{t-2} + c_{34} \Delta Y_{t-1} + c_{35} \Delta Y_{t-2} + c_{36} \end{cases}$$

Specification A:

$$H_0 : c_1 + c_2 = c_3 + c_4 \quad e \quad c_{10} + c_{11} = c_{12} + c_{13} \quad e \quad c_{19} + c_{20} = c_{21} + c_{22} \quad e \quad c_{28} + c_{29} = c_{30} + c_{31}$$

Specification B:

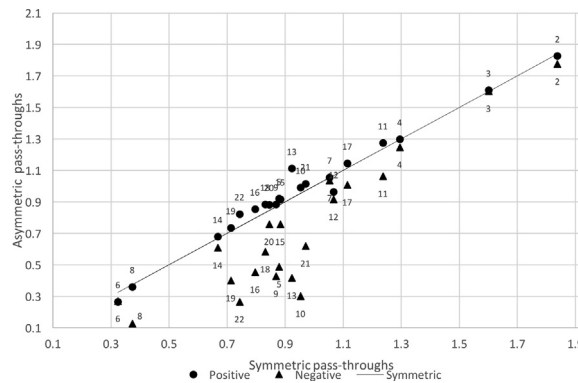
$$H_0 : c_1 = c_3 \quad e \quad c_2 = c_4 \quad e \quad c_{10} = c_{12} \quad e \quad c_{11} = c_{13} \quad e \quad c_{19} = c_{21} \quad e \quad c_{20} = c_{22} \quad e \quad c_{28} = c_{30} \quad e \quad c_{31} = c_{32}$$

Table 2 below shows the results of both specifications using the Wald test. It can be highlighted that specification A does not apply to estimated models with just one lag.

The results indicate the presence of asymmetric cost pass-through in the majority of activities. The Wald test results indicate that in the case of just three activities we cannot reject the null hypothesis, at a 10% significance level, of which the coefficients of positive cost variations are equal to the coefficients of the negative cost variations: (6) Tobacco products, (15) Basic metallurgy and (21) Other transport equipment. Considering these activities, the calculation of asymmetric pass-through had already indicated that no asymmetry was present in the Tobacco product industry.

Graph 1 below shows the asymmetric cost pass-through in horizontal order according to the symmetric pass-through calculated. A 45° straight line was drawn to facilitate visualization. For example, the indicators referring to activity 3 (Extractive industry - non-metallic minerals) are found over the 45° line since the symmetric and asymmetric positive and negative pass-throughs are the same (1.55).

The indicators referring to positive (●) and negative (▲) asymmetric pass-through are vertically aligned since they refer to the same industry. The vertical distance between them measures the difference between the positive and negative



Graph 1. Symmetric and asymmetric cost pass-throughs.

Source: Own elaboration.

pass-through. For example, the indicators for activity 19 (Machines and equipment), are found vertically aligned at 0.66 on the horizontal axis, with this being the symmetric pass-through calculated. The positive indicator (●) is found close to the 45° line since the positive asymmetric pass-through is very close to symmetric: 0.68. The negative indicator, however, (▲) is found far below the positive, at 0.35, with this being the negative asymmetric pass-through.

The analysis of the results presented in Table 1 and Graph 1 show that in the asymmetric model, the pass-through based on positive cost variance is extremely close to the pass-through calculated using the symmetric model, while the pass-through based on negative cost variance is the same or less than the symmetric model and the positive pass-through for all activities.

The results show that the activities related to the extractive industry 2 (minerals and metallics) and 3 (non-metallic minerals) present a significantly higher cost pass-through than for the manufacturing industry, as well as showing no significant asymmetry between the positive and negative pass-throughs calculated. In addition, the two activities from the manufacturing industry with the highest pass-throughs are also commodity-based activities: 4) Oil and alcohol products and 11) Cellulose and paper. Oil and alcohol also do not present a significant difference between the positive and negative pass-throughs; the cellulose and paper industry presents a relatively low pass-through.

Also presenting high symmetric pass-throughs are activities 17 (electronic material and communication equipment), 12 (Chemical products) and 7 (Textile products); these three activities do not show a very large difference between the positive and negative cost pass-throughs. We can also include in this group the activities that the Wald tests indicated as not presenting a significant statistical difference between the positive and negative coefficients: 15 (Basic metallurgy) and 21 (Other transport equipment).

Activities 20 (Automotive vehicles) and 4 (Non-metallic minerals) also do not present a high degree of asymmetry between the positive and negative cost pass-throughs, however, they showed lower pass-throughs than those previously mentioned.

One group with a high number of activities presents a pass-through (symmetric and positive) of between 0.7 and 1 and a considerable degree of asymmetry, as follows: (5) food and beverage products, (9) leather and footwear, (10) wood products, (13) rubber and plastic products, (16) metal products, (18) electrical machines and materials, (19) Machines and equipment and (22) Furniture and furnishings.

Activity 8 (Clothing) stands out with an extremely low pass-through and high asymmetry. Activity 6 (Tobacco products), however, is an atypical case given the fact that its prices are fixed.

Another result of the SVAR models can be seen in the impulse response graphs of the asymmetric models presented in the Attachment. In the majority of activities, the impact of a production shock does not cause a high rise in prices. For industries 19 (Machines and equipment) and 20 (Automotive vehicles) alone, the response of the prices to a shock in production appears to be significant, albeit small and lower than the impact of a positive shock in costs.

Table 3 below shows the results of the Wald tests in the coefficients of the asymmetric pass-through model from producer prices to consumer prices.

The results of specification B indicate the existence of asymmetric price transmission from the producer to the consumer in all of the industries analyzed. Specification A does not reject the null hypothesis at a significance level of

Table 3
Wald Tests – IPA to IPCA.

Activity	Lags	Specification A		Specification B	
		Statistics	Prob.	Statistics	Prob.
4 - Oil and alcohol products	4	11.05	0.05	45.33	0.00
5 - Food and beverages	4	56.68	0.00	195.90	0.00
6 - Tobacco products	4	8.97	0.11	107.41	0.00
7 - Textile products	2	43.04	0.00	84.81	0.00
8 – Clothing	4	2.40	0.79	61.35	0.00
9 - Leather and footwear	4	26.16	0.00	94.07	0.00
11 - Cellulose, paper, etc.	2	17.16	0.00	70.97	0.00
12 - Chemical products	4	50.12	0.00	129.56	0.00
13 - Rubber and plastic products	2	17.60	0.00	72.05	0.00
14 - Non-metallic mineral products	4	4.45	0.49	78.23	0.00
16 - Metal products	4	13.61	0.02	26.94	0.04
17 - Electronic materials and communication equip.	4	8.60	0.13	48.81	0.00
18 - Electrical machines and materials	4	9.31	0.10	40.64	0.00
20 - Automotive vehicles etc.	4	20.05	0.00	85.05	0.00
21 - Other transport equipment	4	2.59	0.76	83.56	0.00
22 - Furniture and furnishings	4	0.90	0.97	52.69	0.00

Source: Own elaboration.

Note: Sectors that were not compatible were omitted.

Table 4
Pass-throughs from IPA to IPCA per activities, symmetric, asymmetric and asymmetry.

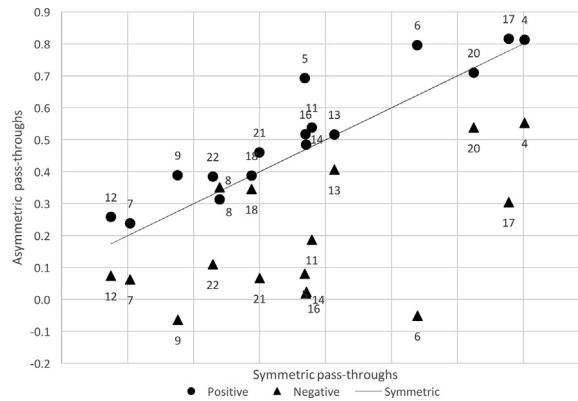
Activity	Symmetric	Asymmetric		1-(Pos./Neg.)
		Positive	Negative	
4 - Oil and alcohol products	0.80	0.81	0.55	0.32
5 - Food and beverages	0.47	0.69	0.08	0.88
6 - Tobacco products	0.64	0.80	-0.05	1.06
7 - Textile products	0.20	0.24	0.06	0.74
8 – Clothing	0.34	0.31	0.35	-0.13
9 - Leather and footwear	0.28	0.39	-0.06	1.16
11 - Cellulose, paper etc.	0.48	0.54	0.19	0.65
12 - Chemical products	0.17	0.26	0.07	0.71
13 - Rubber and plastic products	0.51	0.52	0.41	0.21
14 - Non-metallic mineral products	0.47	0.48	0.02	0.95
16 - Metal products	0.47	0.52	0.02	0.96
17 - Electronic material and communication equipment	0.78	0.82	0.31	0.63
18 - Electrical machines and materials	0.39	0.39	0.35	0.11
20 - Automotive vehicles etc.	0.72	0.71	0.54	0.24
21 - Other transport equipment	0.40	0.46	0.07	0.86
22 - Furniture and furnishings	0.33	0.38	0.11	0.71

Source: Own elaboration

10% for the following activities: (6) Tobacco products, (8) Clothing, (14) Non-metallic mineral products, (17) Electronic material and communication equipment, (21) Other transport equipment and (22) Furniture and furnishings.

We can highlight that for activities (6) Tobacco products and (21) Other transport equipment, the same result was obtained - no asymmetry - when analyzing the cost pass-through to the IPA from the previous sector.

What can also be observed in [Table 3](#) is that the number of lags necessary for the pass-through model to the IPCA to satisfy the selection criteria is higher in the pass-through model to the IPCA than to the IPA. Only in activity (11) Cellulose and paper, the number of lags used was higher than the previous model. [Table 4](#) below shows the estimation results of the pass-throughs from the IPA to the IPCA.



Graph 2. Pass-throughs from IPA to IPCA.

Source: Own elaboration.

In some activities in which specification A of the Wald test indicated symmetry, the estimation results pointed out a high degree of asymmetry. This was the case for (14) Non-metallic mineral products, (17) Electronic material and communication equipment, (21) Other transport equipment and (22) Furniture and furnishings. However, in specification B of the test, the results highlighted the presence of asymmetry in all activities. It was therefore concluded that the evidence suggests the presence of asymmetry in these activities.

Therefore, the results indicate positive asymmetry in the cost pass-through from the producer to the consumer in a number of industries. In general, the estimated magnitude of pass-through from producer to consumer was lower than that found in the pass-through model from costs to producer prices; the degree of asymmetry was higher. This result is compatible with that obtained by Peltzman (2002) for the United States, which presented higher asymmetry in the transmission from producer to consumer than from inputs to the producer.

Activity (4) Oil/alcohol products presented the highest pass-through from IPA to IPCA (0.8) in addition to the highest cost pass-through to IPA. The pass-through to IPCA, however, presented asymmetry, which was not found in the IPA.

The activities with the highest pass-throughs are as follows: (17) Electronic material and communication equipment (0.78) and (20) Automotive vehicles (0.72). While both activities presented asymmetry, the automotive vehicles industry presented relatively low asymmetry when compared to the other industries.

The following industries presented very low asymmetry: (8) Clothing (-0.13, the only one to present negative asymmetry); and (18) Machines and electronic materials (0.11), both of which also presented a low magnitude of pass-through (0.34 and 0.39).

Of the 15 activities analyzed, nine presented a positive pass-through from the IPA to the IPCA of between 0.3 and 0.55. This level is lower than the degree of cost pass-through to the IPA, nine of the 21 positive pass-throughs were between 0.6 and 0.9.

Graph 2 below shows the asymmetric pass-throughs calculated in horizontal order according to the symmetric pass-through calculated.

The graph shows how the activities largely fall into three groups: i) (7) Textile products and (12) Chemical products presented very low IPA to IPCA pass-through at around 0.2; ii) the majority of activities presented pass-throughs of between 0.3 and 0.55 and iii) (4) Oil and alcohol products and (20) Automotive vehicles presented higher pass-throughs of between 0.7 and 0.8.

5. Conclusion

The aim of this study was to identify if the pass-through of cost variations to industrial prices in Brazil presented asymmetric behavior in the period from January 1996 to July 2014. In other words, if the price variation of a determined industrial activity was higher after a positive cost variation than after a negative cost variation of the same magnitude. Another objective of the study was to detect heterogeneity in the magnitude of asymmetry among the industrial activities.

From a theoretical point of view, the existence of pass-through among industries or positive asymmetry in the same industry, originates from a discussion on rigidity, in particular from the ability to maintain collusive equilibrium and market power.

Empirically speaking, there are a number of econometric studies that highlight the existence of asymmetric price transmission in certain sectors or specific products, such as fuels and agricultural products, for various countries including Brazil. In general, [Peltzman \(2000\)](#) and [Gwin \(2009\)](#) show that this phenomenon can be observed in diverse industries in the United States.

The first stage of the study was to construct cost indexes for each industrial activity in the research, based on weights of the IPA/FGV series according to the intermediate consumption of the activity as provided by the National Accounts System of the IBGE. This cost variance was then broken down into positive and negative variations.

For each industrial activity, two SVAR estimates were carried out: one symmetric model with cost, price and production variables, and an asymmetric model with the cost variable broken down into positive and negative costs, prices and production. Based on impulse response functions, symmetric, positive asymmetric and negative asymmetric cost pass-throughs were calculated for each activity. To test the hypothesis that the asymmetric model is not statistically different from the symmetric model, Wald tests were carried out on the asymmetric model coefficients with two different specifications.

The results indicated the existence of asymmetry in the majority of activities, with the pass-through of the positive variations being higher than for the negative variations in all cases. The extractive industries presented no asymmetry while a much higher pass-through was identified when compared to the manufacturing industries. Two other manufacturing industries based on commodities, oil and alcohol products and cellulose and paper also presented high cost pass-throughs. This result is consistent with the result obtained by [Gwin \(2009\)](#) for the United States, who also found no asymmetry for the NAICS sector 21: Mining, quarrying, and oil and gas extraction.

Explanations for the heterogeneity in asymmetry found in the industries based on the theoretical literature are subsequent areas of study to be investigated in future works.

Funding

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Appendix A

See [Fig. A1](#), [Table A1](#), [Table A2](#).

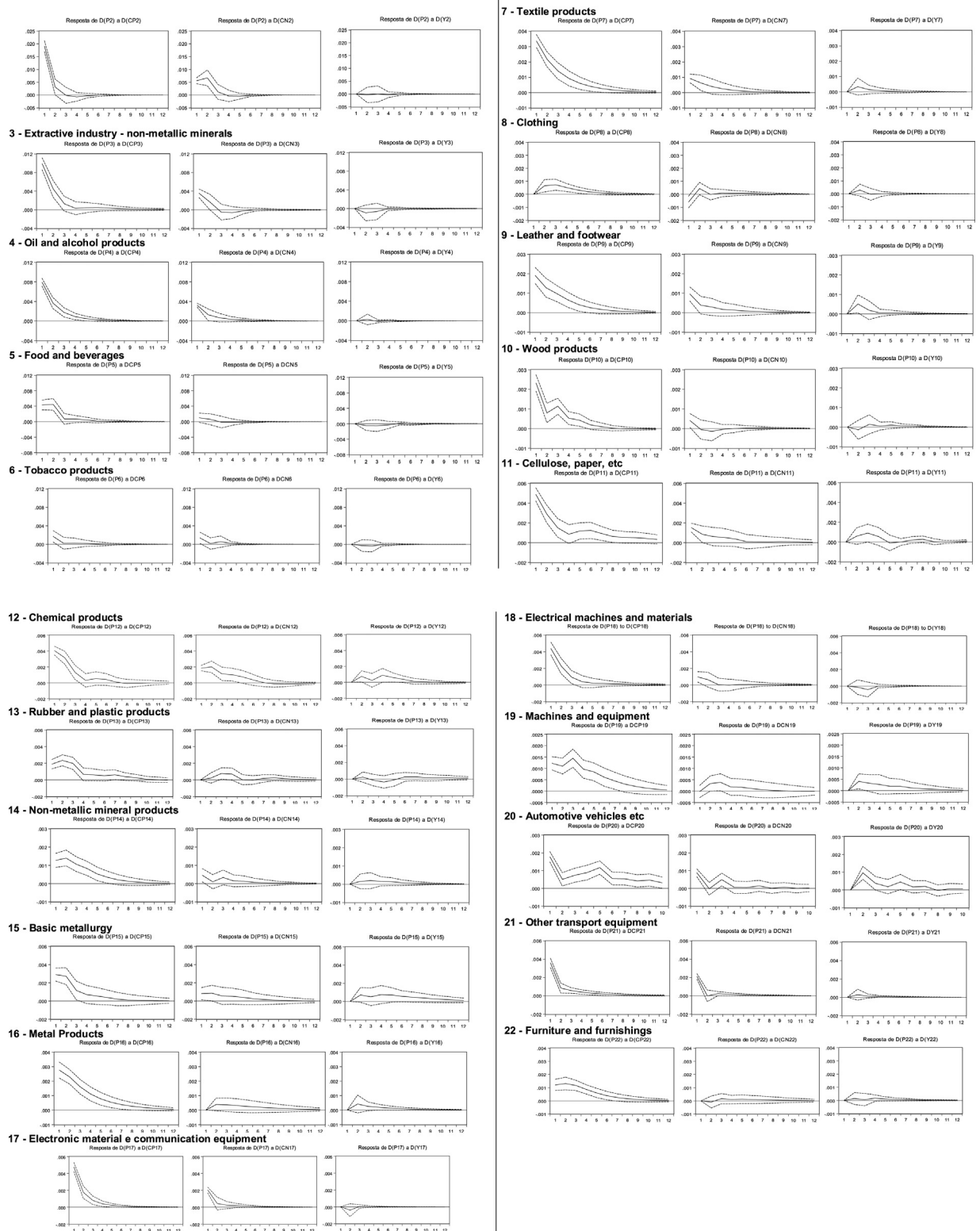


Fig. A1. Impulse Response Functions – Structural Decomposition. Response to a 1 standard-deviation shock (confidence interval ± 2 s.d.).

Table A1
PPI-CPI correlation and CPI weights in feb/2014.

PPI activity	CPI	CPI weights in feb/2014
2	Extractive industry - metallic minerals	NA
3	Extractive industry - non-metallic minerals	Sand; Tile
4	Oil and alcohol products	LP gas; engine oil; Gasoline; Ethanol; Diesel oil; natural vehicle gas
5	Food and beverages	Household foods
6	Tobacco products	Cigarettes
7	Textile products	Carpet; Curtain; Bed linen; Towels; Fabric; Curtained (mosquito net)
8	Clothing	Men's pants; Suits; Men's sweater; Men's shorts; Men's briefs; Men's shirt/t-shirt; Women's pants; Women's sweater; Skirt; Top; Dress; Underwear; Women's shorts; School uniform; Children's trousers; Children's sweater; Children's dress; Children's shorts; Children's shirt/t-shirt; Children's clothing sets
9	Leather and footwear	Men's shoes; Women's shoes; Children's shoes; Men's sandals/flip-flops; Women's sandals/flip-flops; Children's sandals/flip-flops; Bag; sneakers
10	Wood products	NA
11	Cellulose, paper, etc.	Disposable diaper; Sanitary pad; Toilet paper; Notebook;
12	Chemical products	Paint; Bleach; Detergent; Soap powder; Disinfectant; Insecticide; Soap bar; Cleaning sponge; Softener; Pharmaceutical products; Hair products; Men's shaving products; Skin products; Dental hygiene products; Nail products; Perfume; Deodorant; Soap; Make-up products
13	Rubber and plastic products	Hydraulic material; plastic utensils; Tires
14	Non-metallic mineral products	Painting material; Glass; Cement; Bricks; Glass and chinaware
15	Basic metallurgy	NA
16	Metal Products	Hardware; Metalware
17	Electronic material e communication equipment	Telephone; TV set; Stereo system; DVD player; Antenna; Microcomputer; Watch; Camera; Smartphone
18	Electrical machines and materials	Electrical appliances; Refrigerator; Washing machine; Liquidizer; Fan; Oven; Electric shower; Microwave
19	Machines and equipment	NA
20	Automotive vehicles etc.	New automotive; Accessories and parts
21	Other transport equipment	Motorcycle
22	Furniture and furnishings	Living room furniture; Bedroom furniture; Kitchen/Dining room furniture; Children's furniture; Mattress

Source: Based on IBGE and FGV data.

Table A2
Intermediate Consumption (industrial activities in columns, inputs in rows).

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
2	0.36												0.02	0.13				0.01				
3	0.08	0.21								0.01	0.07		0.15	0.17	0.01		0.01					
4	0.25	0.20	0.86	0.04	0.02	0.04	0.01	0.01	0.08	0.04	0.21	0.06	0.15	0.05	0.01	0.04	0.09	0.03	0.01	0.05	0.02	
5			0.01	0.71				0.22		0.01	0.02										0.01	
6					0.30																	
7		0.08			0.25	0.65	0.92	0.04		0.03		0.02	0.02								0.06	
8							0.02															
9							0.01	0.45														
10									0.68	0.02			0.04		0.01	0.01					0.22	
11	0.02	0.03		0.03	0.28	0.01		0.03	0.03	0.49	0.02	0.03	0.04		0.02	0.02	0.01	0.01			0.07	
12	0.03	0.10	0.03	0.05	0.05	0.24	0.01	0.16	0.09	0.23	0.57	0.69	0.15	0.11	0.14	0.05	0.15	0.05	0.02	0.02	0.19	
13	0.02	0.12	0.01	0.06	0.02	0.02	0.01	0.03	0.03	0.05	0.03	0.10	0.01	0.02	0.06	0.04	0.04	0.05	0.13	0.08	0.09	
14				0.01				0.01			0.01		0.27	0.02	0.01	0.01	0.02	0.01	0.02	0.02	0.05	
15		0.03							0.01	0.01		0.02	0.04	0.32	0.55	0.06	0.25	0.31	0.16	0.17	0.11	
16	0.07	0.07	0.02	0.05	0.05			0.02	0.04	0.05	0.03	0.02	0.02	0.10	0.15	0.07	0.11	0.14	0.05	0.04	0.07	
17		0.02														0.49	0.02	0.15	0.01			
18	0.01	0.02	0.02	0.01	0.01			0.01				0.01	0.02			0.19	0.23	0.08	0.05	0.02	0.03	
19	0.15	0.12	0.03	0.03	0.03	0.04	0.01	0.01	0.03	0.05	0.02	0.02	0.06	0.05	0.04	0.01	0.02	0.11	0.05	0.02	0.02	
20	0.01	0.01															0.03	0.04	0.49			
21																				0.59		
22							0.02			0.01				0.02							0.06	

Fonte: Own elaboration based on SCN/IBGE data. Nota: For industrial activities numbers see [Table 1](#). For the index calculation see Eq. (9). Row sums add up to 1.

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