Exchange rate pass-through to Brazilian manufacturing prices: a GVAR approach

Abstract

This article produces estimates of exchange rate pass-through (ERPT) for import and wholesale prices for 21 sectors of Brazilian manufacturing. We adopt a global vector autoregression (GVAR) model to estimate a multisector model for import and wholesale prices of Brazilian manufacturing sectors to address the unobservable common factor and the presence of global variables. On average, we estimate an ERPT to import prices of 80% one quarter after and 73% twenty quarters after the shock, while wholesale prices have a shock transmission of 11% and 22% one and twenty quarters after the shock, respectively. We identify two different dynamics for the estimates of ERPT to import prices that are associated differently with the degree of the share of imports in different sectors. For approximately 50% of the manufacturing sectors considered, we obtain that foreign and domestic producers present a convergent dynamic of ERPT. This evidence corroborates the strategic interaction literature on ERPT.

Keywords: Exchange rate pass-through, Manufacturing sectors, GVAR model.

JEL Codes: C32, F12, F31, F41.

1 Introduction

The insensitivity of US trade deficits to dollar fluctuations in the 1980s cast questions about the validity of the law of one price and the result of full exchange rate pass-through (ERPT) on tradeable prices. Based on the assumptions of imperfect competition and segmented markets, the literature on ERPT develops theoretical arguments and obtains empirical evidence of incomplete ERPT on import and wholesale prices. This has implications for the effectiveness of the flexible exchange rate regime regarding the external adjustment of economies and the inflationary impact of currency devaluations.

Developing countries tend not to have strong currencies and are often concerned with currency restrictions. These countries use the exchange rate instrument to stimulate exports. On the domestic side, fiscal constraints make inflationary control strongly dependent on monetary policy. Exchange rate changes affect costs, inflation expectations and the behaviour of price makers. Incomplete ERPT increases the effectiveness of monetary policy in responding to real shocks to domestic prices.

This article produces estimates of ERPT for import and wholesale prices for 21 sectors of Brazilian manufacturing. Brazil has an inflationary history, and changes in the nominal exchange rate are cost shocks that tend to be absorbed, to different degrees, by price indexes in the economy. According to UNIDO (2009), Brazil was responsible for 19% of the value added in developing country manufacturing between 2005 and 2007, which denotes an integrated and consolidated industrial structure. Given the relevance of the ERPT topic within the industry, where imperfect competition prevails, the product differentiation is an integral part of the strategy. We regard these elements as factors for conducting a sector-level empirical analysis.

Auer and Schoenle (2016) argue that industry-level pricing is subject to unobservable cost shocks that drive price changes for the individual firm and its competitors. Unobservable cost shocks are intra-sectorally correlated, producing a feedback effect between firm and competitor pricing. Additionally, Burstein and Gopinath (2014) argue that shocks affecting the exchange rate can simultaneously induce movements in marginal cost components – such as foreign wages or global commodity prices – that impact price setting. If we do not adequately measure these costs, ERPT estimates will contain the effect of these omitted variables. Therefore, the presence of global shocks and unobservable correlated common effects may lead to biased estimates of ERPT.

We use the global vector autoregression (GVAR) model of Pesaran et al. (2004) that controls for global shocks and unobservable correlated common effects that affect ERPT estimation and address this potential problem. The present work seeks to contribute to the literature on the GVAR model to estimate the ERPT for import and wholesale prices at the sectoral level. This is the first work that uses the GVAR model to obtain multisectoral estimates of ERPT.[1] Other articles such as Ben Cheikh and Rault (2017) estimate sectoral ERPT but consider the global shock using time dummy variables and without interrelationships between sectors. This leads to loss when modelling the sector's dynamics by not adopting inter-sectoral feedback in the system and can lead to biased estimates. We suggest that the GVAR model leads to greater interpretability of the results than other models by allowing spillover effects from one sector to others. This spillover effect can even be a proxy for an input cost shock in our case with the GVAR model.

The GVAR model allows the estimation of the import and wholesale price determination systems of each of the manufacturing sectors from individual models while considering the joint determination of the sector variables. We estimate each sector model conditionally on all others since model errors for one sector are correlated with errors in all other sectors. In addition, we include global variables that simultaneously affect all manufacturing units. The GVAR model approximates the unobservable common factors of the sectors and incorporates them into the estimation via the links between the sectors and the global variables.

We obtain that ERPT to the import price decreases over time, reaching a value of 72.7% in the long run. Our estimated ERPT to import prices in the long run is similar to that calculated by Burstein and Gopinath (2014) for Organisation for Economic Co-operation and Development (OECD) countries. In the short term, our estimate of ERPT to import prices is higher than that obtained for OECD countries such as Campa and Goldberg (2005) and Burstein and Gopinath (2014). The estimated ERPT

[1] Razafindrabe (2016) uses the GVAR model to estimate long-term ERPT in the context of a multicountry model. Long-term model estimates are inputs to the dynamic stochastic general equilibrium model.

to wholesale prices increases over time, reaching 21.8% in the long run. This ERPT estimate in the long run is lower than that obtained by Belaisch (2003) for Brazil. The dispersion of ERPT between sectors is greater for the import price than for the wholesale price. We obtain heterogeneity of ERPT to import prices between sectors that is in line with Ben Cheikh and Rault (2017) for Euro Area countries using sectoral data. However, we identify two different dynamics in the estimates of ERPT to import prices that are associated differently with the degree of the share of imports in the sectors. Our results indicate that ERPT and its adjustment dynamics over time are dependent on the share of the foreign product in the domestic market to approximately 50% of the Brazilian manufacturing industry. This leads the foreign producer to reduce its markup over time to approximate the ERPT of the imported product to that made by the domestic producer. For the second group of sectors, ERPT to the import price is insensitive to the share of imports in the domestic market, with higher ERPT. The ERPT to wholesale price has no relation to trade indexes, as does the second group of ERPT for import prices. Our evidence also provides some contributions to the strategic interaction literature of ERPT.

We structure the article into six sections. After this introduction, we review the literature presenting the main models of ERPT that consider the strategic interaction between domestic and foreign producers in the domestic market. The third section presents an analytical framework for the empirical problem and the GVAR methodology. The fourth section provides information about the databases used in the study. In the fifth section, we introduce sectoral estimates of ERPT, and we discuss the evidence related to trade indexes (TIs). Finally, we present concluding remarks.

2 Literature Review: Strategic Interaction Models

Studies such as Goldberg and Knetter (1997) and Burstein and Gopinath (2014) define ERPT as the price elasticity of imported goods to the exchange rate measured in the importer's currency. The ERPT depends on the reaction of the foreign producer to the exchange rate movements of the importing country.

The empirical microeconomic and macroeconomic literature presents evidence for incomplete ERPT.[2] Burstein and Gopinath (2014) explain this empirical regularity as the result of price rigidity persisting for a certain period of time in the (local) importer's currency and/or indicating that when prices vary, these prices respond only partially to exchange rate variations. These authors cite the large dispersion in cross-country ERPT estimates, arguing that such dispersion may also be associated with the currency in which the price is set. The case of developing countries does not seem to fit this, as most of them use the US dollar as the reference currency for their exchange rate, reducing the interest in ERPT models that address currency invoicing.[3]

[2] Menon (1995) reviews the literature, including 43 studies on ERPT, finding that only six studies obtain complete pass-through. Goldberg and Knetter (1997) synthesize the ERPT and price literature and corroborate the evidence of incomplete ERPT. Campa and Goldberg (2005) report incomplete ERPT results for import prices from 23 OECD countries.

[3] Goldberg and Tille (2006) show that the dollar is the dominant currency among non-European countries and that a high percentage of goods traded in Asia, Latin America and Australia are denominated in dollars. Goldberg (2010) justifies this pattern because of factors such as inertia in the use of currency, the large size and relative stability of the US economy, and the pricing of oil and other commodities in dollars.

Our aim is the joint estimation of foreign ERPT for import prices and wholesale domestic prices. Therefore, the major theoretical focus is on models that consider the strategic interaction of domestic and foreign producers in the domestic market. These models contribute to explaining pricing for a segmented domestic market in an environment of imperfect competition. Dornbusch (1987) is a notable reference in this context. Based on the Dixit and Stiglitz (1977) model, Dornbusch (1987) uses utility and production functions of the constant elasticity of substitution (CES) type, with substitution between product variants on which foreign and domestic firms compete in the domestic market. Dornbusch (1987) represents the reaction of producers to cost shocks and, in particular, to exchange rate shocks and their impact on individual and aggregate price levels in the sector. We use the reduced-form representation of Burstein and Gopinath (2014) that synthesizes this class of models to interpret the evidence of incomplete ERPT. We summarize the main models of strategic interaction that rationalize the phenomenon of incomplete ERPT from a partial equilibrium model with flexible prices presented by Burstein and Gopinath (2014).

Denote the logarithm of the export price of a good produced in country f and sold in destination country d as p_{fd}. Assume a profit-maximizing firm; the sum of the logarithm of the gross profit margin (markup) μ_{fd} and the logarithm of the marginal cost mc_{fd} corresponds to the export prices in the foreign currency:

$$p_{fd} = \mu_{fd} + mc_{fd} \tag{1}$$

Assume that markup μ_{fd} is a function of the relative price $p_{fd} - p_d$; that is, $\mu_{fd} = \mu_{fd}(p_{fd} - p_d)$, where p_d is the logarithm of the aggregate industry price index in country d. The relative price elasticity is given by $\Gamma_{fd} = -\frac{\partial \mu}{\partial (p_{fd} - p_d)}$. The marginal cost function is given by $mc_{fd} = mc_{fd}(q_{fd}, w_f, e_{fd})$, where q_{fd} is the logarithm of demand, w_f summarizes the variables that impact the production cost incurred by foreign firms that are local to country f, and e_{fd} is the logarithm of the bilateral exchange rate between d and f. In addition, $\varphi_{fd} = \frac{\partial mc_{fd}}{\partial e_{fd}}$ is the partial elasticity of the marginal cost (expressed in the destination country's currency) to the exchange rate.

The logarithm of demand is given by the function $q_{fd} = q(p_{fd} - p_d) + q_d$, where q_d denotes the logarithm of aggregate industry demand in country d, with the price elasticity of demand given by $\eta_{fd} = -\frac{\partial q}{\partial p_{fd}} > 0$. From these assumptions, log-differentiating (1) yields:

$$\Delta p_{fd} = \frac{1}{1 + \Gamma_{fd} + \Phi_{fd}} [\Delta w_f + \varphi_{fd} \Delta e_{fd} + (\Gamma_{fd} + \Phi_{fd}) \Delta p_d + mc_q \Delta q_d] \tag{2}$$

where $\Phi_{fd} = mc_q \eta_{fd} \geq 0$ is the partial elasticity of the marginal cost with respect to the relative price with $mc_q \geq 0$.

Similarly, we can obtain prices for domestic producers p_{dd} but with $0 \leq \varphi_{dd} < \varphi_{fd} \leq 1$. That is, the marginal cost elasticity with respect to the exchange rate of domestic firms must be lower than that of foreign firms because the former have the smaller share of foreign inputs. This is one of the main factors that make the pass-through to domestic prices lower than to import prices.[4]

[4] Goldberg and Campa (2010) point out that differences in the size of the distribution sector and in the dependence on imported inputs help explain the differences in ERPT between industries and countries. Changes in distribution margins and the use of imported inputs explain changes in the ERPT to domestic prices over time.

Equation (2) shows that we should expect complete ERPT only under very strict conditions such that $\Delta p_{fd} = \Delta e_{fd}$. This would imply that the markup would be insensitive to relative price changes. That is, in this case, the price elasticity of the demand function would be constant ($\Gamma_{fd} = 0$), and the costs would be insensitive to quantity changes induced by exchange rate variations ($\Phi_{fd} = 0$), in addition to a cost composition derived only from inputs from country f ($\varphi_{fd} = 1$). In cases where the markups are variable ($\Gamma_{fd} > 0$), exporters would have diminishing returns to scale ($\Phi_{fd} > 0$), or if costs (in the currency of the destination country) did not fully respond to the exchange rate change ($\varphi_{fd} \leq 1$), ERPT would be incomplete.

There may also be indirect effects, represented by impacts on aggregate prices in country d, $\Delta p_d \neq 0$, and on aggregate demand, $\Delta q_d \neq 0$. Thus, the overall ERPT also depends on the details of how aggregate prices and quantities respond to exchange rate movements. These effects result from the assumptions made in the models.

In an extended model version of Dixit and Stiglitz (1977), Dornbusch (1987) assumes that individual firms can affect industry prices by interacting strategically with other firms in the country's market d. That is, variations in the price of the individual firm are expected to produce variation in the aggregate index, yielding $\Delta p_d \neq 0$. Yang (1997) makes the same kind of assumption, demonstrating that the elasticity of an industry's aggregate price relative to a firm's individual price, domestic or foreign, is equal to the firm's market share; that is, $\xi_{nd} = \frac{\Delta p_d}{\Delta p_{nd}} = s_{nd}$, where s_{nd} is the firm's market share in market d, with $n = d, f$. As a result, firms can charge different prices for their products within sectors, and firms' markup is increasing in market share.

Markup is negatively related to the substitution elasticity of the product. The lower the degree of product differentiation is, the lower the markup. Thus, the ERPT is negatively related to the degree of substitution between different variants of the product of the sector. When industry products are highly replaceable, a price increase drives consumers to switch to other variants. Thus, foreign companies are more likely to keep their prices in line with the domestic price and absorb exchange rate shocks rather than pass them through to prices, resulting in $\Gamma_{fd} > 0$.

Additionally, given the assumption of a small number of firms in the industry, if the cost of a single firm increases relative to that of other firms in the industry and passes on the price, that firm will lose market share. This will cause markup to decline in equilibrium, resulting in less-than-proportional price increases. Any change in the price of a product, $\Delta p_{fd} \neq 0$, must imply a change in the sector price, $\Delta p_d \neq 0$. Strategic interaction creates an indirect effect, causing the prices of imported products to rise given an appreciation of the foreign exchange rate, which also leads to an increase in the aggregate price of the industry. Thus, exchange rate variations also affect the prices of domestic producers.

A difference between the Yang (1997) model and the Dornbusch (1987) model is that the former allows marginal costs to be variable so that the marginal cost elasticity of the product is positive: $mc_q > 0$. Thus, marginal cost variation is a new indirect channel of influence on prices. The appreciation of the foreign exchange rate leads to an increase in the price of the imported product, which leads to a reduction in its sales and consequently its marginal cost. Thus, the term $\Phi_{fd} > 0$ affects pass-through, offsetting the effect of exchange rate movements and reducing the ERPT as

$mc_q \Delta q_d \leq 0$.

Atkeson and Burstein (2008) extend the Dornbusch (1987) model. Their model assumes a production aggregate composed of industrial sectors. These sectors contain domestic and foreign producers that compete with each other via product differentiation. Goods are imperfect substitutes within sectors, and the degree of substitutability is greater within a sector than between sectors. Therefore, a firm with a small market share within a sector is more concerned with its intra-sector competitors than with competitors from other sectors. On the other hand, a firm with a larger market share in a sector is more concerned with competition from other sectors. The authors demonstrate that markup is increasing in market share, while market share is decreasing in relative price.[5] Therefore, firms with lower relative prices and higher market share have higher markups. The effect of aggregate prices on the variation of the price itself is smaller the greater the market share.

If the cost of a single firm increases relative to that of other firms in the sector, that firm reduces its markup in equilibrium to avoid losing market share, so the price rises less than proportionally. Given the small number of firms in the sector, any change in the price of a product must imply a change in the price of the sector. Thus, a cost variation from an exchange rate is expected to have direct and indirect effects on prices, which according to these authors, makes ERPT nonmonotonic in market share.

Auer and Schoenle (2016) extend the model of Atkeson and Burstein (2008) to incorporate the cost response into market share and the price response of heterogeneous individual firms to competitor prices. The authors assume that consumers have Armington (1969) preferences and that foreign firms care only about their foreign competitors. They also assume that varieties are more substitutable than sectoral output, as in Atkeson and Burstein (2008).

The reason for this assumption lies in the effect of the price change of an individual firm on the aggregate price index. Thus, the reaction of the firm's own marginal costs to market share takes the form of a U-shaped curve. This is because a large firm – which has a large market share – or a small firm – which has very little market share – takes little account of its competitors' prices and tends to pass on cost changes entirely to prices. On the other hand, firms with intermediate market shares tend to only partially pass on cost variations. In contrast, the reaction of individual prices to competitors' price changes is hump-shaped in relation to market share, both of which are negatively correlated.

However, the authors admit that their derivation of firm-price reactions to competitors' costs and prices is made *ceteris paribus*. As such, they disregard a set of unobserved cost shocks that drive competitors' price changes. However, at the same time, these shocks are also correlated with individual firm shocks. That is, the authors argue that cost shocks are correlated intra-sectorally through common effects, producing a feedback effect between firm and competitor pricing. Auer and Schoenle (2016) demonstrate that this same mechanism governs ERPT to prices due to a change in costs induced by the exchange rate. Finally, the sectoral aggregate pass-through is a weighted average of the individual pass-throughs by their respective market shares.

[5] $\Gamma_{fd}(s_{fd})$ with $\dfrac{\Delta \Gamma_{fd}}{\Delta s_{fd}} > 0$ and $s_{fd} = s(p_{fd} - p_d)$ with $\dfrac{\Delta s_{fd}}{\Delta (p_{fd} - p_d)} < 0$.

3 Analytical Structure

Following the representation of markup equations presented in the previous section, we can express the price of foreign and domestic firms (both in local currency) as:

$$p_{fd}^{d} = \mu_{fd} + mc_{fd} + e_{fd} \tag{3}$$

$$p_{dd} = \mu_{dd} + mc_{dd} \tag{4}$$

where p_{fd}^{d} is the logarithm of the import price in the local currency, which is equal to the logarithm of the import price free on board added to the logarithm of the exchange rate $e_{fd} = \ln(d\$/f\$)$.

The formulation of Hooper and Mann (1989) is useful for representing the argument of strategic interaction between foreign and domestic firms. The foreign firm's markup term captures the competitive pressure in the domestic market represented by the difference between the prices of domestic competitors and the costs of foreign producers. We can apply an analogous argument to the domestic firm's markup. However, the competitive pressure of the domestic firm is measured by the difference between the prices of foreign competitors relative to the costs of domestic producers. These relationships are expressed in log-linear form as follows:

$$\mu_{fd} = \alpha_f + \delta_f(p_{dd} - (mc_{fd} + e_{fd})) \tag{5}$$

$$\mu_{dd} = \alpha_d + \delta_d(p_{fd} + e_{fd}) - mc_{dd}). \tag{6}$$

The parameter δ_f represents the sensitivity of foreign firms to competition from domestic firms, while δ_d captures the sensitivity of domestic firms to competition from foreign firms. Replacing the expressions (5) and (6) in (3) and (4), respectively, and adding their respective random terms leads to ERPT equations for the import and domestic product prices. That is,

$$p_{fd}^{d} = \alpha_f + \delta_f p_{dd} + (1 - \delta_f)e_{fd} + (1 - \delta_f)mc_{fd} + \xi_{fd} \tag{7}$$

$$p_{dd} = \alpha_d + \delta_d p_{fd} + (1 - \delta_d)e_{fd} + (1 - \delta_d)mc_{dd} + \xi_{dd}. \tag{8}$$

Equations (7) and (8) represent the simultaneity of the strategic interaction models discussed in section 2, in which $(1 - \delta_f)$ and $(1 - \delta_d)$ denote the respective ERPTs.

Then, consider an industry consisting of K sectors with $i = 1, 2, ..., K$, where equations (7) and (8) define the pricing of each sector i. Thus, at each time t, we have industry pricing behaviour given by estimating a system of $2K$ equations, where the price vector $p_{i,t} = (p_{fd,i,t}^{d}, p_{dd,i,t})'$ is a function of costs $mc_{i,t} = (mc_{fd,i,t}, mc_{dd,i,t})'$; the global component vector, ω_t, which includes the exchange rate; and the respective idiosyncratic errors, $\xi_{i,t} = (\xi_{fd,i,t}, \xi_{dd,i,t})'$, for every i. That is, $\forall i$

$$p_{i,t} = \alpha_i + \beta_{0,i}\omega_t + \beta_{1,i}mc_{i,t} + \xi_{i,t} \tag{9}$$

As various sectors compose the industry, the idiosyncratic components of each sector contain common disturbance factors because production relations are interdependent among the sectors, similar to the seemingly unrelated regression (SUR) problem of Zellner (1962). Assuming that mc_{it} and ω_t are exogenous variables, we can express the correlation between the idiosyncratic components of the equations of sectors i and h with $i \neq h$ as

$$E(\xi_{i,t}\xi'_{h,t}) = \begin{bmatrix} E(\xi_{fd,i,t}\xi_{fd,h,t}) & E(\xi_{fd,i,t}\xi_{dd,h,t}) \\ E(\xi_{dd,i,t}\xi_{fd,h,t}) & E(\xi_{dd,i,t}\xi_{dd,h,t}) \end{bmatrix}$$

However, costs are price functions of all sectors, considering goods produced internally or externally. They are also subject to the same common factors as $p_{i,t}$. Therefore, we cannot establish $mc_{i,t}$ as a vector of exogenous variables such as in the SUR method. Thus, we can solve the estimation problem with endogenous regressors and a multifactorial error structure as Pesaran (2006) proposes.

The multifactorial error decomposition proposed for $\xi_{fd,i,t}$ and $\xi_{dd,i,t}$, $i = 0, 1, 2, ..., N$, is similar to that of Pesaran (2006). The errors can be divided into three parts. The first is an idiosyncratic component related only to the specific price considered in the equation ($v_{fd,i,t}$ and $v_{dd,i,t}$), which is not correlated with the errors of the other cross-sectional units or with each other. The second is represented by the $\lambda_{i,t}$ vector with dimensions $q \times 1$. Here, $\lambda_{i,t}$ refers to those sectoral factors that affect both $p^d_{fd,i,t}$ and $p_{dd,i,t}$ for the competition already discussed between domestic and imported goods or for some intrinsic aspect of the sector. Finally, there is a component representing the common factors denoted by the f_t vector with dimension $r \times 1$ that affects the entire system, that is, all sectors – and so this part of the decomposition is not indexed to i. The multifactorial decomposition is represented by:

$$\xi_{fd,i,t} = \kappa^f_i \lambda_{i,t} + \gamma^f_i f_t + v_{fd,i,t} \tag{10}$$

$$\xi_{dd,i,t} = \kappa^f_i \lambda_{i,t} + \gamma^d_i f_t + v_{dd,i,t} \tag{11}$$

where κ^f_i, κ^d_i, γ^f_i and γ^d_i are factor loading matrices with fixed components such that factors contained in the errors affect each sector differently.

Additionally, we need a strategy to consider the effects of unobservable factors f_t on the endogenous variables $x_{i,t}$ when we estimate the vector autoregression with exogenous variables (VARX*) for each sector i. In this sense, Dées et al. (2007) and Chudik and Pesaran (2016) prove that the weighted averages of the variables in the other sectors $x^*_{i,t} = \sum_{j=1}^{N} w_j x_{j,t}$ for $j \neq i$ approximate the unobservable component f_t. Variables $x^*_{i,t}$ are called external specific variables (in this case, to the i sector) and must be weakly exogenous so that we can estimate the VARX* model for each sector of the manufacturing. The VARX* model can also consider the cointegration relationships of any variables inserted in the model. Finally, the global model is the combination of the VARX* models for each sector.

Chudik and Pesaran (2016) contend that we can insert the global variables as observable common factors to the cross-sectional units but also as dominant units defined by Chudik and Pesaran (2013). The authors note that the dominant unit directly and indirectly influences the rest of the model variables.[6] Following Chudik and Pesaran (2016), we extend the models of each sector by including the vector of global variables ω_t and their lagged values, in addition to specific external variables.

[6]In the GVAR model in the present work, the global variables make up the dominant unit.

The VARX*(p_i, q_i) model is given by

$$x_{i,t} = \sum_{\ell=1}^{p_i} \Phi_{i\ell} x_{i,t-\ell} + \Lambda_{i0} x^*_{it} + \sum_{\ell=1}^{q_i} \Lambda_{i\ell} x^*_{i,t-\ell} + D_{i0}\omega_t + \sum_{\ell=1}^{s_i} D_{i0}\omega_{t-\ell} + \varepsilon_{it} \tag{12}$$

where $\Phi_{i\ell}$ is a matrix $k_i \times k_i$ of lagged coefficients of $x_{i,t}$, Λ_{i0} and $\Lambda_{i\ell}$ are matrices $k_i \times k^*_i$ of coefficients associated with specific external variables $x^*_{i,t}$, and $\varepsilon_{i,t}$ is a matrix $k_i \times 1$ of idiosyncratic shocks in sector i.

We represent the internal specific variables to all $N+1$ sectors by a vector $k\times 1$, $x_t = (x'_{0t}, x'_{1t}, ..., x'_{Nt})'$, where $k = \sum_{i=0}^{N} k_i$ is the number of endogenous variables in the global model. x_t denote a vector of all endogenous variables in the panel. We can estimate the marginal model for the dominant variables with or without feedback from the variables x_t. The existence of feedback effects from the GVAR variables for the dominant unit is allowed through averages of the cross-sectional units[7]; that is, variation in x_t originating in ω_t now affects the model.

$$\omega_t = \sum_{\ell=1}^{p_\omega} \Phi_{\omega\ell}\omega_{t-\ell} + \sum_{\ell=1}^{q_\omega} \Lambda_{\omega\ell} x^*_{\omega,t-\ell} + \eta_{\omega t} \tag{13}$$

where $x^*_{\omega,t} = \tilde{W}_\omega x_t$ and $\tilde{W}_\omega$ is a weight matrix that defines the global cross-sectional averages.

We can establish the vector $z_{it} = (x'_{it}, x^{*\prime}_{it})'$ of each sector as a combination of the internal specific variables that make up the global vector x_t since $x^*_{i,t}$ is a linear combination of the internal specific variables to the system sectors that is based on x_t. In addition, z_{it} is given by

$$z_{it} = \begin{pmatrix} x_{it} \\ x^*_{it} \end{pmatrix} = W_i x_t \tag{14}$$

in which W_i is a matrix $(k_i + k^*_i) \times k$ of constants defined as a function of the sectoral weights of the model's endogenous variables. We obtain these weights by the matrix of technical coefficients from Brazilian input-output matrices.[8] Therefore, we can rewrite the VARX*(p_i, q_i) model as

$$A_{i0} W_i x_t = a_{i0} + a_{i1} t + \sum_{\ell=1}^{p} A_{i\ell} W_i x_{t-\ell} + D_{i0}\omega_t + \sum_{\ell=1}^{s_i} D_{i0}\omega_{t-\ell} + \varepsilon_{it}, \tag{15}$$

where both $A_{i0} W_i$ and $A_{i\ell} W_i$ have dimensions $k_i \times k$, $\forall \ell = 1, 2, ..., p$.

Stacking these equations, we obtain

$$G_0 x_t = a_0 + a_1 t + \sum_{\ell=1}^{p} G_\ell x_{t-\ell} + D_{i0}\omega_t + \sum_{\ell=1}^{s_i} D_{i0}\omega_{t-\ell} + \varepsilon_t \tag{16}$$

where $G_0 = \begin{pmatrix} A_{1,0} W_1 \\ A_{2,0} W_2 \\ \vdots \\ A_{N,0} W_N \end{pmatrix}$, $G_\ell = \begin{pmatrix} A_{1,\ell} W_1 \\ A_{2,\ell} W_2 \\ \vdots \\ A_{N,\ell} W_N \end{pmatrix}$, $\varepsilon_t = \begin{pmatrix} \varepsilon_{0t} \\ \varepsilon_{1t} \\ \vdots \\ \varepsilon_{Nt} \end{pmatrix}$ and $a_0 = \begin{pmatrix} a_{10} \\ a_{20} \\ \vdots \\ a_{N0} \end{pmatrix}$, $a_1 = \begin{pmatrix} a_{11} \\ a_{21} \\ \vdots \\ a_{N1} \end{pmatrix}$.

[7]Note that here, the weighted averages are not the specific external variables but the averages of all variables x^*_{it} of the N sectors in the global model.

[8]We discuss the construction of the weight matrix using the input-output matrices in the following section.

We combine the conditional (16) and marginal (13) models to solve the global model. For the systemic solution containing the dominant unit, Chudik and Pesaran (2016) define the vector $y_t = (\omega_t', x_t')'$ of order $(k + m_\omega) \times 1$, which contains all the observable variables in the model. Combining the sectoral models (12) with the model for the common variables given by (13), the GVAR model is then written as

$$G_{y,0} y_t = \sum_{\ell=1}^{p} G_{y,\ell} y_{t-\ell} + \varepsilon_{yt} \tag{17}$$

where the error term is decomposed as $\varepsilon_{yt} = (\varepsilon_t', \eta_{\omega t}')'$ and

$$G_{y,0} = \begin{pmatrix} I_{m_\omega} & 0_{m_\omega \times k} \\ D_0 & G_0 \end{pmatrix}, G_{y,\ell} = \begin{pmatrix} \Phi_{\omega\ell} & \Lambda_{\omega\ell} \tilde{W}_\omega \\ D_\ell & G_\ell \end{pmatrix}, \text{para } \ell = 1, 2, ..., p, \tag{18}$$

where $D_\ell = (D_{1\ell}', D_{2\ell}', ..., D_{N\ell}')'$ for $\ell = 0, 1, ..., p, p = \max_i\{p_i, q_i, s_i, p_\omega, q_\omega\}$. The authors define that $D_{i\ell} = 0$ for $\ell > s_i$, $\Phi_{\omega\ell} = 0$ for $\ell > p_\omega$, and $\Lambda_{\omega\ell} = 0$ for $\ell > q_\omega$.

Considering the causality of the dominant variables, the GVAR model is obtained for y_t:

$$y_t = \sum_{\ell=1}^{p} F_{y,\ell} y_{t-\ell} + G_{y,0}^{-1} \varepsilon_{y,t} \tag{19}$$

where $F_{y,\ell} = G_{y,0}^{-1} G_{y,\ell}$ with $\ell = 1, 2, ..., p$. In short, we first estimate the VARX* models and then solve the system according to (19).

In the presence of cointegration relationships between variables, we can write (12) in the form of an error correction model as

$$\Delta x_{it} = -\pi_i z_{i,t-1} + \sum_{\ell=1}^{p_i} \Phi_{i\ell} \Delta z_{i,t-\ell} + \Lambda_{i0} x_{it}^* + D_{i0} \Delta\omega_t + \varepsilon_{it} \tag{20}$$

where $z_{it} = (\omega_t', x_{it}', x_{it}^*)'$ represents global variables and specific and endogenous external variables. We can decompose the π_i matrix into loading matrices and cointegration vectors.

We include the nominal exchange rate and oil price as a global variable (ω_t) in the structure of GVAR as the dominant unit.[9] Thus, the exchange rate and oil price are simultaneously explanatory variables for wholesale and import prices and part of their own VARX*. In this structure, we have the feedback effect of the system variables as a whole for the global variables, and this effect comes from the lags of the averages of the sector variables x_{it}. Additionally, we do not consider these contemporary effects.

The literature treats exchange rate fluctuations as exogenous price variables in exchange rate regressions. Forbes et al. (2018) criticize this approach for assuming that the exchange rate is under pressure from the rest of the economy. For example, Faruqee (2006) and McCarthy (2007) find that exchange rate shocks have a contemporary effect on prices by Cholesky's decomposition in VAR models. However, they also find that price behaviour affects the exchange rate with at least a one-period lag. In this line, we use the Choudhri et al. (2005) hypothesis that exchange rate shocks

[9]This set of variables is usual in ERPT articles, as it represents the dynamics of the chain of shock transmission. Belaisch (2003) and McCarthy (2007) are some examples of this literature.

are not contemporaneously correlated with prices.[10]

Oil is a relevant input as a raw material for several productive activities, representing a supply shock. The commodity has a role in production processes across the globe. Several factors affect the price per barrel of oil in addition to the demand of firms and the prices of their products, such as geopolitical conflicts and uncertainties in the international economic scenario. Thus, the inclusion of the oil price as a global variable is necessary, as the proxy for common factors – obtained through specific external variables – may not capture its behaviour.

3.1 Exchange rate pass-through estimation

ERPT is the price elasticity of a country at the nominal exchange rate ($e_{P,E}$), that is, how much a change of one percentage point (pp) in the exchange rate affects the price. We estimate this elasticity from the impulse response functions of a GVAR model. The cumulative ERPT coefficient is given by Belaisch (2003) and Ito and Sato (2008) as

$$erpt_{l,i,t+j} = \frac{\sum_{j=1}^{T} \Delta p_{l,i,t+j}}{\sum_{j=1}^{T} \Delta e_{t+j}} \tag{21}$$

where $\Delta p_{l,i,t+j}$ is the response of the price variation after j periods to a shock in the nominal exchange rate at instant t with $l = fd, dd$, where fd refers to the import price and dd to the wholesale price. Δe_{t+j} denotes the response of the nominal exchange rate after j months to a shock to the same variable at time t. Thus, we consider the price responses to an exchange rate shock, and we normalize by the reaction of the exchange rate to a change in the exchange rate itself. As the import prices are in dollars, we obtain the pass-through of an exchange rate shock to the import prices, measured in Brazilian currency, adding one to the measure defined in (21). We use generalized impulse response function (GIRF) estimates of Koop et al. (1996) from the GVAR model.

4 Database

The variable vector $x_{i,t}$ is composed of the import price, wholesale and external cost variables; that is, $x_{it} = (p_{fd,i,t}, p_{dd,i,t}, mc_{fd,i,t})'$. The vector of global variables is composed of the nominal exchange rate and the oil price; that is, $\omega_t = (e_t, p_{o,t})$. We use the logarithm of the variables with quarterly data covering the period from 1999 to 2017, and we consider the end of period for the series that are not quarterly.[11]

The x_{it} vector does not contain the variable $mc_{dd,i,t}$ because the dynamics of domestic costs in sector i are captured by all the other cross-sectional units in the sample, being contained in the x^*_{it} vector. Domestic costs are weightings of wages and input prices, and x^*_{it} contains variables that are weighted output prices from other industry activities. We build weights from the inter-sectoral dependency structure. These price weights in other sectors are a proxy for the cost of domestic firms

[10] Although more reasonable for monthly data, this hypothesis may also be valid for quarterly data for most prices.

[11] The exception is the oil price variable, for which we adopt the average price in the quarter due to the high volatility of the variable, seeking to capture its behaviour during the period.

– from imported and domestic inputs. The advantage of this procedure is to reduce the number of estimated parameters, reducing the model's dimension.

We use the price index of Brazilian imports calculated by the Brazilian Center for Foreign Trade Studies Foundation; this index represents the import prices in foreign currency (measured in dollars) p_{fd}. Our wholesale price variable is the sectoral broad wholesale price index calculated by the Getulio Vargas Foundation. Our notation for wholesale prices is p_{dd}. The proxy variable for foreign firms' costs is the United States import price index, calculated by the Bureau of Labor Statistics. As imports from the United States come from several countries and because the market is competitive (which leads to a low markup), their prices are expected to reflect the global costs of such sectors.

We use the nominal exchange rate for the period in Brazilian reals per dollar (R$/US$) obtained from the Central Bank of Brazil. The Federal Reserve Economic Data database from the Federal Reserve Bank of St. Louis provides the series of Brent crude oil prices in dollars per barrel, since the Brazilian National Agency for Petroleum, Natural Gas and Biofuels considers this series as a reference.

We adopt the input-output matrix to build the weights of the external variables for each sector. The input-output matrix represents the intermediate exchanges between activities for the production of their respective final goods. Specifically, our analysis is based on the technical coefficients of the Brazilian input-output matrix of 68 sectors.[12] We build this weight matrix with data from the National Accounts System (NAS) using the methodology developed by Guilhoto and Sesso Filho (2005) and Guilhoto and Sesso Filho (2010).[13] We obtain the weights by selecting only the sectors that make up the manufacturing industry and then dividing the technical coefficient of intermediate consumption in sector i coming from sector j by the sum of all the coefficients of i.[14]

Finally, we emphasize that the use of global variables as the dominant unit also requires a weighting structure. We assume that the dominant unit suffers a feedback effect from the system variables coming from the lags of $x_{\omega_t} = W_\omega x_t$, so we need to insert a W_ω matrix in the estimation. To do so, we use the weights calculated by the Brazilian Institute of Geography and Statistics (IBGE) to build the production index of Brazilian manufacturing of the monthly industrial survey – physical output (PIM-PF).

[12]The technical coefficient represents the intermediate consumption value that a sector requires to produce one monetary unit of final product. That is, it is the ratio between the intermediate consumption of a given sector – coming from itself or from another sector – and its final product (Miller and Blair, 2009). Therefore, the sum of all of a sector's coefficients is the intermediate consumption value of any sector necessary for the production of a product unit.

[13]NAS data have not been available since 1999 with the new Brazilian National Classification of Economic Activities by the Brazilian Institute of Geography and Statistics. As a result, we adopt an average of the weights obtained from the input-output matrices.

[14]Since $w_{ii} = 0$, that is, since we do not include the sector information i in x^*_{it}, we replace the main diagonal of the weight matrix with zeros, and the columns are re-weighted so their entries sum one. Thus, the matrix of technical coefficients becomes a matrix where the columns represent the reference sector of the weights contained in it and where the lines report the weight that a sector has for that referenced in the column. Thus, we obtain the W_i matrices for each sector by the columns of the weight matrix.

5 Results

We divide the results section into three subsections. The first subsection presents the specifications used for the individual models. The second subsection reports ERPT estimates, and in the third, we seek to establish the relationship of ERPT estimates with TIs in an attempt to obtain further insight into the strategic interaction between foreign and domestic producers.

5.1 Model specification

We use the Akaike information criterion (AIC) to choose the lag orders for VARX* models, allowing us to have a maximum of two lags of x_{it} and one of x^*_{it}. Table 6 in the appendix shows the lag orders selected by the AIC and the number of cointegration relationships estimated from that specification.[15] We establish the number of cointegration ratios according to the Johansen cointegration test trace statistics following Pesaran et al. (2000) in the presence of exogenous variables with a unit root. All sectors have at least one cointegration relationship, with the exception of the food sector.

Table 1 presents the results of the F test for testing weak exogeneity for the external and global variables.[16] We reject the null hypothesis of weak exogeneity only for one specific external variable in the leather sector. Dées et al. (2007) report a similar problem for one of the UK-specific external variables. But they regard the evidence of rejection as problematic only if the cross-sectional unit with the rejection of exogeneity presents a high weight in the world economy for this exercise.[17] As the leather sector has only a 1.8% weight in the Brazilian manufacturing industry according to IBGE and given the number of units in the cross-section, we adopt a similar procedure, ignoring this specific case.

Insert table 1 here

According to Dées et al. (2007), we can interpret the contemporary effects of specific external variables, x^*_{it}, on the respective internal variables as impact elasticities. Table 7 in the appendix presents such coefficients and their t-statistics using the Newey-West variance estimator. The coefficients of these variables are not all statistically significant.

The import and wholesale price external specific variables result in statistically significant coefficients, and most have a positive sign. This helps justifying the use of such variables as a proxy for domestic sector costs (since x^*_{it} is positively correlated with the prices in which we are interested). After detailing the specification used and its validity, the next subsection addresses ERPT estimates.

5.2 Exchange rate pass-through estimates

Table 2 presents the sectoral estimates of ERPT to import prices. Table 3 shows the sectoral estimates of ERPT at wholesale prices. In general, the ERPT estimated in the long term (after 20

[15]Our choice is to obtain a more parsimonious model in terms of the number of parameters to be estimated considering our small sample, as described in Dées et al. (2007).

[16]We do not test this hypothesis for the food sector because there are no cointegration relationships.

[17]Hebous and Zimmermann (2013) observe that some external variables in different cross-sectional units reject the null hypothesis of weak exogeneity for the analysed GVAR model – with rejection of the null hypothesis being more widespread than in the present work. The authors consider variants of the model and obtain similar results that indicate the robustness of the global model.

quarters) to import prices, $erpt_{fd,t+20}$, is 0.727, and that to wholesale prices, $erpt_{dd,t+20}$, is 0.218.[18] According to Burstein and Gopinath (2014), the impact of exchange rate shocks is greater on import prices, while domestic prices have a lesser ERPT, so our estimates are in agreement with the available evidence. Our estimate of ERPT to import prices in the long term is close to that estimated by Burstein and Gopinath (2014) for OECD countries. In the short term (after 1 quarter), our estimate of ERPT to the import price is 0.80, higher than that obtained for other countries, which is 0.44 and 0.46 to OECD countries, respectively, by Campa and Goldberg (2005) and Burstein and Gopinath (2014), for example. However, in the short term, our estimate would be close to that calculated for Canada and the Netherlands by Campa and Goldberg (2005) and for Canada and Japan by Burstein and Gopinath (2014). We obtain an aggregated ERPT to import prices in the short term that is also higher than the range of estimates between 0.29% (for Austria) and 0.59% (for Italy) obtained by Ben Cheikh and Rault (2017) using sectoral data for each Euro Area country. We estimate a lower ERPT to wholesale prices in the long term than Belaisch (2003) for Brazil.

In the short term (1 quarter), the ERPT to import prices, $erpt_{fd,t+1}$, is complete in some cases or close to complete, with an average of 0.80, and a subsequent reduction in the magnitude of ERPT over time. On the other hand, we observe the opposite behaviour for wholesale prices, $erpt_{dd,t+1}$, with ERPT close to 0.11 on average after one quarter. This estimate of ERPT to wholesale price is similar to the one calculated by Belaisch (2003) for Brazil in the short term. On average, 99% of ERPT to import prices occurs through the eighth quarter after the shock, while for wholesale prices, this percentage is approximately 92%. In other words, almost all ERPT occurs within two years of the exchange rate shock. The standard deviation calculated from sectoral estimates indicates that the dispersion of ERPT estimates increases over time for import prices, peaking in the fourth quarter and for wholesale prices in the eighth quarter after the shock. We obtain heterogeneous estimates of ERPT to import and wholesale prices by sector in line with Ben Cheikh and Rault (2017) for Euro Area countries with sectoral data on import prices.

Insert Tables 2 and 3 here

We divide ERPT estimates for 4 and 20 quarters into two sets of sectors by cluster analysis.[19] The first group consists of 11 industrial sectors, while the second group consists of 10 industrial sectors and is described in table 8 in the appendix. In table 4, we observe that for sets of sectors belonging to group 1, average ERPT on import prices for 4 quarters is equal to 0.68 and for 20 quarters is equal to 0.64. In the first group, ERPT to wholesale prices for 4 quarters is 0.16 and is equal to 0.24 for 20 quarters. For the second group, ERPT to import prices is equal to 1.01 and 0.99 for 4 and 20 quarters, respectively, and ERPT to wholesale prices is equal to 0.13 and 0.17 for 4 and 20 quarters, respectively. In the first group, the difference between ERPT to import and wholesale prices is equal to 0.52 and 0.40 for 4 and 20 quarters, respectively, while in the second group, this difference between the ERPTs is equal to 0.88 for the two time intervals.

Insert table 4 here

We present the dynamics of the aggregate ERPT for manufacturing between 0 and 20 quarters

[18]We use the weights of PIM-PF to obtain the ERPT at aggregate prices.

[19]The cluster analysis was carried out for these estimates and their changes using the k-medians partition. Considering the small number of observations, we assume two groups (k=2).

for the wholesale and import prices in figure 1. We observe convergence between ERPT to import prices and wholesale prices. While in the initial period, ERPT to import prices is almost complete, ERPT to wholesale prices is 0.1. We observe a movement towards a reduced ERPT to import prices over time and, on the other hand, an increase in ERPT to wholesale prices.

Insert Figure 1 here

Figures 2 and 3 show the sectoral dynamics of ERPT to import and wholesale prices, respectively. We present the variations in ERPT between period zero and the fourth quarter ($\Delta erpt_{l,t+4}$) and between period zero and the twentieth quarter ($\Delta erpt_{l,t+20}$) grouped by sector as previously highlighted for ERPT levels, in which $l = fd, dd$. We observe that these variations are also related to the levels of ERPT according to table 4. In other words, the averages of variations in ERPT between quarters zero and four are -0.15 and 0.065 for import and wholesale prices, respectively, for the first group of sectors. In the second group of sectors, the averages of variations in ERPT between instant zero and the fourth quarter are equal to -0.009 and 0.064 for import and wholesale prices, respectively. We observe similar behaviour for the average variation in ERPT between instant zero and the twentieth quarter, which is equal to -0.019 for import prices and 0.138 for wholesale prices in the first group and -0.009 for import prices and 0.104 for wholesale prices in the second group.

Insert Figures 2 and 3 here

Information on the level of and variation in sectoral ERPT indicates that there is an association between the level of ERPT and its dynamics over time. The main difference in the dynamics of ERPT between groups of sectors is for ERPT to import prices. In the first group, import prices are more sensitive to exchange rate variation, while import prices have a low sensitivity to exchange rate shocks in the second group, with there being little difference between the short- and long-term impacts. In other words, we observe two distinct patterns of interaction between import prices and wholesale prices in Brazilian manufacturing in response to an exchange rate variation. In the first group of sectors, we obtain behaviour exhibiting a more interdependent adjustment of foreign and domestic producers, while foreign producers disregard the response of domestic producers to exchange rate variation in the second group of sectors, keeping their markup almost unchanged.

5.3 Exchange rate pass-through and trade indexes

According to the literature, the market share of imports matters when we consider the strategic interaction between domestic and foreign producers in the home market. Thus, as a next step, we analyse whether there is a relationship between the ERPT and the indicators that reflect international competition in domestic production. These indicators are the coefficients of imported manufacturing inputs (CII), penetration of imports (CPI) and exports (CE). Table 5 shows the average values of the CII, CPI and CE by sector between 2003 and 2017.[20] The CII measures the share of imported manufacturing inputs in all manufacturing inputs bought by the sector, denoting the dependence on domestic sectoral production from imported inputs. The CPI coefficient is the share of imported

[20]The National Confederation of Industry calculates these coefficients, which are available at http://www.portaldaindustria.com.br/cni/estatisticas/. We estimate CII for the food, beverage and tobacco sectors based on predictions from the CPI and CE.

products in apparent consumption (sum of imports and the value of production for the domestic market), representing the market share of imports in the sector. Finally, the CE shows the importance of the foreign market for manufacturing production.[21]

Insert table 5 here

We investigate the relationships between the estimated ERPT ($erpt_{l,t+j}$), their variation ($\Delta erpt_{l,t+j}$) and the difference between levels of pass-through to import prices and wholesale prices ($Diferpt_{t+j}$) with the TIs of Brazilian manufacturing. Our objective is to analyse whether there is an association between the ERPT and indicators that reflect international competition in domestic production.

To do so, we estimate simple linear regression models and regression models considering the addition of the interaction between the TI and the dummy variable for the sectors that belong to group 1 – we denominate the interaction as DCII, DCPI and DCE for each TI – as an explanatory variable. In general, we estimate the following equation for the three dependent variables:

$$ER_{l,i} = \gamma_0 + \gamma_1 TI_i + error_{l,i} \tag{22}$$

$$ER_{l,i} = \gamma_0 + \gamma_1 TI_i + \gamma_2 DTI + error_{l,i} \tag{23}$$

where $ER_{l,i} = erpt_{l,t+j}, \Delta erpt_{l,t+j}, Diferpt_{t+j}$ with $l = fd, dd$ and $j = 4, 20$.

The results are provided in the appendix. Tables 9, 10, 11, 12 and 13 present the results of linear regressions of the level and changes of $erpt_{fd,t+4}$, $erpt_{fd,t+20}$, $erpt_{dd,t+4}$, $erpt_{dd,t+20}$, and the difference $Diferpt_{t+j}$ against the TIs, respectively. Columns 1, 2, 3, 7, 8 and 9 of tables 9, 10, 11, 12 and 13 correspond to the estimates of equation (22) and indicate that the coefficients associated with trade indexes are not statistically significant in general. That is, the variables for trade indexes do not explain the level or variation in the ERPT – to import prices or wholesale prices – or even the difference between the ERPT to import prices and wholesale prices. The only exception is the coefficient associated with a CPI that is statistically significant at 10% in column 8 of table 11 for the change in ERPT to wholesale prices after 4 quarters. Concerning the estimates of equation (23), the results for models with a dependent variable representing the ERPT after 4 quarters do not differ significantly from those with a dependent variable representing the ERPT after 20 quarters. Then, we focus on the results considering the dependent variable of the ERPT after 4 quarters.

We observe a different response between the sectors in the two groups to foreign competition. For the ERPT ($erpt_{l,t+j}$) for sectors belonging to group 1, the results indicate that an increase of 1 pp in the CII reduces the ERPT to import prices by 0.016 pp relative to group 2, and this coefficient is statistically significant at 1% in column 4 of table 9. For an increase of 1 pp of the CPI, the ERPT for imports decreases by 0.006 pp, but for those sectors belonging to group 1, ERPT for imports decreases by 0.02 pp compared to group 2, as shown in column 5 of table 9. For the same group of sectors, a 1 pp increase in the CE reduces the ERPT by 0.014 pp compared to group 2, as shown in column 6 of table 9. The equations with the CII and CPI as explanatory variables have a better fit than the

[21] The CII and CPI are strongly correlated (0.83) because the input-output matrix has high technical coefficients in the sector itself. The correlation of these coefficients with CE is low, however. This is -0.33 between the CII and CE and -0.08 between the CPI and CE.

equation with the CE as an explanatory variable according to the R^2 statistics, indicating a stronger relationship with the content of imported inputs in domestic products or the presence of imports in those industrial sectors. We obtain a correlation that higher international trade shares in the sector are associated with lower ERPTs for import prices.

In a similar set of regressions, we analyse the variation in the ERPT to import prices between time 0 and the fourth quarter ($\Delta erpt_{fd,t+4}$) as a dependent variable. The results show that a 1 pp increase in the CII, CPI, and CE is associated with a decrease of 0.006, 0.007, and 0.006 in the ERPT for sectors belonging to group 1 compared to group 2 according to columns 10, 11, and 12 of table 9, respectively. However, only the coefficient associated with the CII is statistically significant at the 5% level, while the other two are statistically significant only at the 10 % level. Again, the dependent variables the CII and CPI have explanatory power superior to the model with the CE based on the R^2 of the regressions presented in columns 10 to 12 of this table.

However, when we consider the ERPT ($erpt_{dd,t+j}$) or the variation in the ERPT to wholesale prices ($\Delta erpt_{dd,t+j}$) as the dependent variable, our results are different from those above in terms of explaining the level of or variation in ERPT to import prices. The coefficients of the interactions between trade indexes and the dummy variable for group 1 are not statistically significant at the 10% level in columns 4 to 6 and 10 to 12 of table 11.

Finally, we consider the TIs to explain the difference between the ERPT to import prices and wholesale prices ($Diferpt_{t+j}$) in table 13. The results for the regressions for $Diferpt_{t+j}$ corroborate those obtained in regressions for ERPT to import prices. Even the estimated coefficients for the interaction between the dummy variable of belonging to group 1 and the TI, DTI, in table 13 are close to those estimated when explaining the ERPT to import prices in columns 4 to 6 of tables 9 and 10, respectively, after four and 20 periods. The next section presents our final comments.

6 Conclusion

In this paper, we solve the problem of estimating a system of simultaneous equations with endogenous regressors, considering the presence of common unobservable effects and global variables in the system to estimate ERPT to import and wholesale prices at a sectoral level. Our systemic estimation for the manufacturing sectors is based on the GVAR model of Pesaran et al. (2004). The GVAR model allows us to capture the spillover effects between the sectors, providing unprecedented evidence on ERPT to Brazilian manufacturing.

Unlike developed economies, our evidence indicates a high level of ERPT to import prices, especially in the short term, and differentiated adjustment dynamics across manufacturing sectors in an emerging and relatively closed economy, namely, Brazil. In general terms, we observe convergence between ERPT for imports and wholesale prices. This important result underscores the importance of accurately specifying common effects and sectoral interdependence in estimating ERPT at the sectoral level.

In a literature review, we present the theoretical models that offer predictions at the microeconomic level. These predictions relate the level of ERPT to market share and interaction with competitors. Our evidence indicates the possibility of interaction between foreign and domestic producers operating in the domestic market in response to exchange rate shocks. For a considerable number of manufacturing sectors, the pricing practices of imported producers and the consequent ERPT are associated with the market share of the imported product or with the dependence of these sectors on imported inputs. However, the aggregate level of the data does not allow further explanations about this evidence but encourages comparative research with other emerging or developed economies to verify the degree of specificity in our results.

The impacts of exchange rate shocks on domestic inflation and the demand for imports at the sectoral level are heterogeneous. In the group of sectors where there is convergence in ERPT, the level of ERPT to domestic prices is higher, which is expected to produce a greater inflationary impact at the domestic level but have a lesser effect on the demand for imports of these products. On the other hand, for sectors with greater independence between the degrees of ERPT, the reverse is likely to occur, since ERPT to domestic prices is lower, but the ERPT to import prices is higher. Depending on the price elasticity of demand in these sectors, the effect on demand for imports of these products may be relevant.

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A Appendix

Sectors	F test	Critic (5%)	$p^*_{fd,it}$	$p^*_{dd,it}$	$mc^*_{fd,it}$	e	p_o
Food	F(0,55)	-	-	-	-	-	-
Beverage	F(2,58)	3.156	2.729	1.752	0.854	1.623	0.131
Tobacco	F(1,63)	3.993	1.124	0.069	0.016	0.249	0.031
Textile	F(1,63)	3.993	0.278	0.888	0.013	1.231	0.000
Clothing	F(2,62)	3.145	1.598	0.362	1.537	1.355	1.104
Leather	F(3,61)	2.755	1.891	2.251	5.413†	1.018	1.258
Wood	F(2,62)	3.145	0.013	0.703	0.229	0.360	1.108
Paper and pulp	F(2,62)	3.145	0.353	1.914	1.089	0.682	0.346
Oil products	F(2,62)	3.145	0.815	0.027	0.199	0.763	0.006
Chemical	F(2,62)	3.145	2.901	1.915	2.121	1.821	2.060
Pharmochemical	F(2,62)	3.145	0.861	0.519	1.383	2.213	1.001
Rubber and plastic	F(1,63)	3.993	0.591	0.135	1.301	2.725	1.132
Non-metallic minerals	F(1,54)	4.020	0.035	0.197	0.210	0.112	0.004
Metallurgy	F(1,63)	3.993	1.194	1.784	0.192	0.754	0.154
Metal products	F(2,62)	3.145	0.330	1.804	1.466	1.241	0.943
Informatic	F(3,61)	2.755	0.351	0.122	1.333	1.210	1.092
Electrical machines	F(2,62)	3.145	1.625	2.958	1.537	0.107	1.176
Machinery and equipments	F(2,62)	3.145	0.031	0.617	0.297	0.596	0.995
Vehicles	F(2,62)	3.145	0.905	0.556	2.557	2.665	1.742
Other transport equipment	F(3,61)	2.755	0.321	1.698	2.401	1.313	1.788
Furniture and miscellaneous products	F(1,63)	3.993	0.080	0.042	1.664	0.189	2.647

† : Rejects null hypothesis of weak exogeneity at 5%.

Table 1: Weak exogeneity test

Sectors	Number of quarters after the shock				
	0	1	4	8	20
Food	0.719	0.685	0.637	0.629	0.625
Beverage	1.053	1.090	1.058	1.000	0.993
Tobacco	0.985	1.032	0.909	0.817	0.850
Textile	0.983	0.957	0.824	0.718	0.682
Clothing	1.009	1.012	0.873	0.754	0.695
Leather	0.906	0.981	0.897	0.793	0.744
Wood	0.875	0.870	0.838	0.836	0.868
Paper and pulp	0.871	0.816	0.595	0.624	0.624
Oil products	0.501	0.236	0.123	0.186	0.199
Chemical	0.876	0.778	0.662	0.671	0.683
Pharmochemical	0.617	0.765	0.596	0.564	0.568
Rubber and plastic	0.891	0.893	0.792	0.740	0.733
Non-metallic minerals	1.070	1.055	1.028	1.023	1.022
Metallurgy	0.775	0.660	0.668	0.686	0.706
Metal products	0.915	1.019	1.177	1.171	1.185
Informatic	1.085	1.080	1.002	0.977	0.955
Electrical machines	0.897	0.960	1.055	1.056	1.062
Machinery and equipments	0.923	0.933	0.968	0.961	0.964
Vehicles	0.987	0.922	0.821	0.795	0.786
Other transport equipment	1.333	1.199	1.202	1.188	1.185
Furniture and miscellaneous products	0.934	0.974	0.927	0.896	0.892
Mean	0.848	0.799	0.738	0.728	0.727
Standard deviation	0.180	0.248	0.281	0.257	0.254

Table 2: ERPT to import price for manufacturing sectors

Sectors	Number of quarters after the shock				
	0	**1**	**4**	**8**	**20**
Food	0.194	0.204	0.258	0.299	0.305
Beverage	0.032	0.069	0.090	0.100	0.105
Tobacco	0.081	0.084	0.097	0.105	0.107
Textile	0.045	0.068	0.160	0.228	0.241
Clothing	0.040	0.061	0.100	0.106	0.109
Leather	0.008	0.028	0.092	0.188	0.261
Wood	-0.015	0.006	0.069	0.148	0.193
Paper and pulp	0.243	0.246	0.300	0.408	0.405
Oil products	0.080	0.035	0.065	0.102	0.108
Chemical	0.272	0.271	0.358	0.428	0.448
Pharmochemical	-0.016	0.015	0.087	0.102	0.106
Rubber and plastic	0.079	0.118	0.217	0.288	0.308
Non-metallic minerals	0.071	0.083	0.122	0.158	0.166
Metallurgy	0.124	0.085	0.085	0.123	0.143
Metal products	0.091	0.119	0.157	0.178	0.192
Informatic	0.203	0.252	0.274	0.249	0.216
Electrical machines	0.091	0.078	0.125	0.153	0.168
Machinery and equipments	0.055	0.071	0.142	0.198	0.226
Vehicles	-0.002	0.008	0.063	0.123	0.156
Other transport equipment	0.063	0.102	0.193	0.236	0.253
Furniture and miscellaneous products	0.035	0.050	0.078	0.108	0.121
Mean	0.104	0.110	0.160	0.204	0.218
Standard deviation	0.085	0.086	0.096	0.105	0.104

Table 3: ERPT to wholesale price for manufacturing sectors

	Group 1				**Group 2**			
	Mean	sd	Min	Max	Mean	sd	Min	Max
$erpt_{fd,t+4}$	0.681	0.215	0.123	0.897	1.016	0.114	0.838	1.202
$erpt_{fd,t+20}$	0.640	0.159	0.199	0.786	0.998	0.119	0.850	1.185
$erpt_{dd,t+4}$	0.162	0.105	0.063	0.358	0.135	0.062	0.069	0.274
$erpt_{dd,t+20}$	0.235	0.122	0.106	0.448	0.175	0.051	0.105	0.253
$\Delta erpt_{fd,t+4}$	-0.150	0.109	-0.378	-0.009	0.009	0.119	-0.131	0.262
$\Delta erpt_{fd,t+20}$	-0.190	0.094	-0.314	-0.049	-0.009	0.136	-0.148	0.270
$\Delta erpt_{dd,t+4}$	0.065	0.052	-0.039	0.138	0.064	0.032	0.016	0.130
$\Delta erpt_{dd,t+20}$	0.138	0.077	0.019	0.253	0.104	0.066	0.013	0.208
$Diferpt_{t+4}$	0.518	0.237	0.058	0.805	0.882	0.101	0.728	1.020
$Diferpt_{t+20}$	0.405	0.170	0.091	0.630	0.823	0.104	0.675	0.993
N	11				10			

Table 4: Description of the variables: ERPT, ERPT variation, differential between the degrees of ERPT to import and wholesale prices

Sectors	Coefficients		
	CII	CPI	CE
Food	11.72	3.62	21.73
Beverage	16.04	3.47	1.29
Tobacco	5.60	1.28	42.22
Textile	25.01	14.14	11.52
Clothing	15.97	6.37	2.45
Leather	10.82	5.34	26.43
Wood	7.07	2.11	29.50
Paper and pulp	13.08	6.91	23.54
Oil products	32.22	16.88	7.85
Chemical	32.93	23.77	10.77
Pharmochemical	37.53	30.93	8.57
Rubber and plastic	21.47	11.95	7.61
Non-metallic minerals	13.87	5.19	8.43
Metallurgy	25.83	15.78	30.53
Metal products	11.29	10.50	6.53
Informatic	38.01	34.19	9.49
Electrical machines	22.65	21.05	11.10
Machinery and equipments	19.04	30.32	18.17
Vehicles	20.07	13.07	14.38
Other transport equipment	27.22	30.55	37.62
Furniture and miscellaneous products	17.72	3.47	8.75
Mean	20.25	13.85	16.12
Mean Group 1	22.42	13.52	15.05
Mean Group 2	17.85	14.21	14.17

Table 5: Trade indexes of Brazilian manufacturing sectors

Sectors	VARX*(p_i, q_i)		Number of cointegration relationships
	p_i	q_i	
Food	1	1	0
Beverage	1	1	2
Tobacco	1	1	1
Textile	1	1	1
Clothing	2	1	2
Leather	1	1	3
Wood	1	1	2
Paper and pulp	2	1	2
Oil products	1	1	2
Chemical	1	1	2
Pharmochemical	2	1	2
Rubber and plastic	2	1	1
Non-metallic minerals	2	1	1
Metallurgy	2	1	1
Metal products	1	1	2
Informatic	1	1	3
Electrical machines	1	1	2
Machinery and equipments	2	1	2
Vehicles	1	1	2
Other transport equipment	1	1	3
Furniture and miscellaneous products	2	1	1

Table 6: VARX* lags and the number of cointegration relationships in sectoral models

Sectors	Specific external variables		
	$p^*_{fd,it}$	$p^*_{dd,it}$	$mc^*_{fd,it}$
Food	0.30	$0.67^{\dagger\dagger}$	0.12
	[1.62]	[3.13]	[0.97]
Beverage	$0.63^{\dagger\dagger}$	-0.01	$0.20^{\dagger}$
	[2.81]	[-0.06]	[1.94]
Tobacco	$1.33^{\dagger\dagger}$	-0.12	0.27
	[2.12]	[-0.61]	[0.68]
Textile	0.10	$0.50^{\dagger\dagger}$	$0.19^{\dagger\dagger}$
	[0.57]	[3.77]	[2.52]
Clothing	0.12	$0.16^{\dagger\dagger}$	$0.38^{\dagger\dagger}$
	[0.39]	[2.10]	[3.22]
Leather	0.55	0.00	$0.12^{\dagger\dagger}$
	[1.44]	[0.04]	[1.99]
Wood	$1.15^{\dagger\dagger}$	$0.34^{\dagger\dagger}$	0.15
	[3.61]	[4.31]	[0.15]
Paper and pulp	$0.18^{\dagger}$	$0.45^{\dagger\dagger}$	-0.07
	[1.70]	[3.74]	[-0.49]
Oil products	0.19	$0.51^{\dagger\dagger}$	-0.16
	[1.48]	[3.27]	[-0.53]
Chemical	0.07	$0.21^{\dagger\dagger}$	-0.01
	[1.18]	[3.49]	[-0.32]
Pharmochemical	-0.23	-0.18	$0.36^{\dagger\dagger}$
	[-0.55]	[-1.28]	[2.53]
Rubber and plastic	0.17	$0.49^{\dagger\dagger}$	0.05
	[1.09]	[5.01]	[0.60]
Non-metallic minerals	$0.45^{\dagger\dagger}$	$0.38^{\dagger\dagger}$	-0.05
	[2.40]	[5.02]	[-1.25]
Metallurgy	$0.64^{\dagger\dagger}$	$0.72^{\dagger\dagger}$	$0.53^{\dagger\dagger}$
	[4.55]	[4.60]	[3.37]
Metal products	$0.94^{\dagger\dagger}$	$0.71^{\dagger\dagger}$	$0.05^{\dagger\dagger}$
	[6.22]	[9.53]	[2.59]
Informatic	0.26	$0.30^{\dagger}$	$-0.13^{\dagger\dagger}$
	[1.26]	[1.90]	[-2.41]
Electrical machines	0.26	$0.22^{\dagger}$	0.03
	[1.54]	[1.92]	[1.06]
Machinery and equipments	0.38	$0.29^{\dagger\dagger}$	-0.01
	[1.39]	[8.01]	[-0.13]
Vehicles	0.03	$0.42^{\dagger\dagger}$	-0.02
	[0.34]	[6.89]	[-0.65]
Other transport equipment	0.35	$0.32^{\dagger\dagger}$	$-0.18^{\dagger\dagger}$
	[1.19]	[5.37]	[-3.23]
Furniture and miscellaneous products	$0.38^{\dagger\dagger}$	$0.67^{\dagger\dagger}$	$0.13^{\dagger}$
	[1.98]	[5.84]	[1.89]

Note: † e †† respectively indicate the rejection of the null hypothesis at 10% and 5%.
t-statistics is shown in brackets.

Table 7: Contemporary effects of specific external variables on their internal counterparts

Group 1	Group 2
Food	Beverage
Pharmochemical	Tobacco
Leather	Informatic
Oil products	Wood
Rubber and plastic	Machinery and equipments
Metallurgy	Non-metallic minerals
Paper and pulp	Electrical machines
Chemical	Furniture and miscellaneous products
Textile	Other transport equipment
Clothing	Metal products
Vehicles	

Table 8: Sectors in each group

Table 9: Relationship between the trade indexes of the Brazilian manufacturing and the ERPT to the import price after four periods

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Variables	$erpt_{fd,t+4}$	$erpt_{fd,t+4}$	$erpt_{fd,t+4}$	$erpt_{fd,t+4}$	$erpt_{fd,t+4}$	$erpt_{fd,t+4}$	$\Delta erpt_{fd,t+4}$	$\Delta erpt_{fd,t+4}$	$\Delta erpt_{fd,t+4}$	$\Delta erpt_{fd,t+4}$	$\Delta erpt_{fd,t+4}$	$\Delta erpt_{fd,t+4}$
CII	-0.00776			0.00438			-0.00460			-8.27e-06		
	(0.00635)			(0.00381)			(0.00314)			(0.00322)		
CPI		0.000409			0.00606**			-0.000352			0.00178	
		(0.00448)			(0.00267)			(0.00186)			(0.00242)	
CE			0.00115			0.00445			-0.00137			-0.000137
			(0.00457)			(0.00411)			(0.00199)			(0.00201)
DCII				-0.0158***						-0.00599**		
				(0.00321)						(0.00241)		
DCPI					-0.0204***						-0.00770*	
					(0.00473)						(0.00405)	
DCE						-0.0136***						-0.00509*
						(0.00371)						(0.00263)
Constant	0.998***	0.835***	0.822***	0.938***	0.901***	0.876***	0.0192	-0.0691*	-0.0518	-0.00340	-0.0441	-0.0317
	(0.112)	(0.0654)	(0.104)	(0.0761)	(0.0486)	(0.0901)	(0.0696)	(0.0372)	(0.0568)	(0.0658)	(0.0406)	(0.0577)
Observations	21	21	21	21	21	21	21	21	21	21	21	21
R-squared	0.092	0.000	0.003	0.610	0.520	0.294	0.100	0.001	0.013	0.330	0.230	0.140

Note: Standard error is shown in parenthesis

*, **, *** denote statistical significance at 10%, 5% and 1% levels respectively.

Table 10: Relationship between the trade indexes of the Brazilian manufacturing and the ERPT to the import price after 20 periods

Variables	(1) $erpt_{fd,t+20}$	(2) $erpt_{fd,t+20}$	(3) $erpt_{fd,t+20}$	(4) $erpt_{fd,t+20}$	(5) $erpt_{fd,t+20}$	(6) $erpt_{fd,t+20}$	(7) $\Delta erpt_{fd,t+20}$	(8) $\Delta erpt_{fd,t+20}$	(9) $\Delta erpt_{fd,t+20}$	(10) $\Delta erpt_{fd,t+20}$	(11) $\Delta erpt_{fd,t+20}$	(12) $\Delta erpt_{fd,t+20}$
CII	-0.00657			0.00585			-0.00342			0.00147		
	(0.00575)			(0.00395)			(0.00287)			(0.00378)		
CPI		0.00166			0.00727**			0.000901			0.00299	
		(0.00434)			(0.00275)			(0.00202)			(0.00283)	
CE			0.00197			0.00533			-0.000548			0.000749
			(0.00432)			(0.00418)			(0.00226)			(0.00252)
DCII				-0.0162***						-0.00638**		
				(0.00304)						(0.00273)		
DCPI					-0.0202***						-0.00755*	
					(0.00433)						(0.00399)	
DCE						-0.0138***						-0.00534*
						(0.00338)						(0.00272)
Constant	0.944***	0.787***	0.779***	0.883***	0.853***	0.833***	-0.0349	-0.116**	-0.0952	-0.0589	-0.0920*	-0.0740
	(0.106)	(0.0638)	(0.0982)	(0.0685)	(0.0446)	(0.0860)	(0.0731)	(0.0436)	(0.0636)	(0.0716)	(0.0454)	(0.0670)
Observations	21	21	21	21	21	21	21	21	21	21	21	21
R-squared	0.074	0.006	0.010	0.681	0.579	0.348	0.049	0.004	0.002	0.280	0.201	0.126

Note: Standard error is shown in parenthesis

*, **, *** denote statistical significance at 10%, 5% and 1% levels respectively.

Table 11: Relationship between the trade indexes of the Brazilian manufacturing and the ERPT to the wholesale price after four periods

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Variables	$erpt_{dd,t+4}$	$erpt_{dd,t+4}$	$erpt_{dd,t+4}$	$erpt_{dd,t+4}$	$erpt_{dd,t+4}$	$erpt_{dd,t+4}$	$\Delta erpt_{dd,t+4}$	$\Delta erpt_{dd,t+4}$	$\Delta erpt_{dd,t+4}$	$\Delta erpt_{dd,t+4}$	$\Delta erpt_{dd,t+4}$	$\Delta erpt_{dd,t+4}$
CII	0.00219			0.00250			0.000397			0.000644		
	(0.00234)			(0.00240)			(0.000931)			(0.000882)		
CPI		0.00235			0.00239			0.00104*			0.00110	
		(0.00170)			(0.00154)			(0.000559)			(0.000654)	
CE			-8.27e-05			-0.000455			-0.000373			-0.000170
			(0.00132)			(0.00131)			(0.00103)			(0.00107)
DCII				-0.000407						-0.000323		
				(0.00177)						(0.000912)		
DCPI					-0.000159						-0.000232	
					(0.00269)						(0.00112)	
DCE						0.00153						-0.000834
						(0.00209)						(0.00122)
Constant	0.105**	0.117***	0.150***	0.103**	0.117***	0.144***	0.0566***	0.0503***	0.0707***	0.0554***	0.0510***	0.0740***
	(0.0450)	(0.0273)	(0.0297)	(0.0463)	(0.0295)	(0.0307)	(0.0155)	(0.0104)	(0.0160)	(0.0157)	(0.00957)	(0.0168)
Observations	21	21	21	21	21	21	21	21	21	21	21	21
R-squared	0.058	0.086	0.000	0.061	0.086	0.030	0.008	0.068	0.010	0.015	0.070	0.045

Note: Standard error is shown in parenthesis
*, **, *** denote statistical significance at 10%, 5% and 1% levels respectively.

Table 12: Relationship between the trade indexes of the Brazilian manufacturing and the ERPT to the wholesale price after 20 periods

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Variables	$erpt_{dd,t+20}$	$erpt_{dd,t+20}$	$erpt_{dd,t+20}$	$erpt_{dd,t+20}$	$erpt_{dd,t+20}$	$erpt_{dd,t+20}$	$\Delta erpt_{dd,t+20}$	$\Delta erpt_{dd,t+20}$	$\Delta erpt_{dd,t+20}$	$\Delta erpt_{dd,t+20}$	$\Delta erpt_{dd,t+20}$	$\Delta erpt_{dd,t+20}$
CII	0.000430			-0.000704			-0.00136			-0.00256		
	(0.00260)			(0.00240)			(0.00187)			(0.00208)		
CPI		0.00120			0.000889			-0.000111			-0.000400	
		(0.00187)			(0.00146)			(0.00157)			(0.00182)	
CE			0.00125			0.000377			0.000961			0.000661
			(0.00189)			(0.00171)			(0.00174)			(0.00179)
DCII				0.00148						0.00156		
				(0.00193)						(0.00141)		
DCPI					0.00112						0.00104	
					(0.00320)						(0.00180)	
DCE						0.00360						0.00124
						(0.00236)						(0.00225)
Constant	0.198***	0.190***	0.186***	0.203***	0.186***	0.172***	0.150***	0.124***	0.107***	0.155***	0.120***	0.102***
	(0.0522)	(0.0331)	(0.0367)	(0.0518)	(0.0368)	(0.0345)	(0.0415)	(0.0271)	(0.0267)	(0.0408)	(0.0263)	(0.0269)
Observations	21	21	21	21	21	21	21	21	21	21	21	21
R-squared	0.002	0.017	0.022	0.029	0.027	0.147	0.032	0.000	0.023	0.088	0.015	0.050

Note: Standard error is shown in parenthesis
*, **, *** denote statistical significance at 10%, 5% and 1% levels respectively.

Table 13: Relationship between the trade indexes of the Brazilian manufacturing and the difference between the degrees of ERPT to import and wholesale prices

Variables	(1) $Diferpt_{t+4}$	(2) $Diferpt_{t+4}$	(3) $Diferpt_{t+4}$	(4) $Diferpt_{t+4}$	(5) $Diferpt_{t+4}$	(6) $Diferpt_{t+4}$	(7) $Diferpt_{t+20}$	(8) $Diferpt_{t+20}$	(9) $Diferpt_{t+20}$	(10) $Diferpt_{t+20}$	(11) $Diferpt_{t+20}$	(12) $Diferpt_{t+20}$
CII	-0.00994			0.00188			-0.00700			0.00656		
	(0.00589)			(0.00542)			(0.00591)			(0.00504)		
CPI		-0.00194			0.00367			0.000464			0.00638*	
		(0.00472)			(0.00365)			(0.00470)			(0.00337)	
CE			0.00123			0.00490			0.000722			0.00495
			(0.00456)			(0.00362)			(0.00462)			(0.00343)
DCII				-0.0154***						-0.0177***		
				(0.00363)						(0.00331)		
DCPI					-0.0202***						-0.0213***	
					(0.00526)						(0.00506)	
DCE						-0.0151***						-0.0174***
						(0.00474)						(0.00439)
Constant	0.893***	0.718***	0.672***	0.835***	0.784***	0.731***	0.746***	0.598***	0.592***	0.679***	0.667***	0.661***
	(0.121)	(0.0802)	(0.105)	(0.101)	(0.0704)	(0.0908)	(0.125)	(0.0832)	(0.104)	(0.0920)	(0.0706)	(0.0859)
Observations	21	21	21	21	21	21	21	21	21	21	21	21
R-squared	0.132	0.006	0.003	0.561	0.453	0.318	0.068	0.000	0.001	0.650	0.514	0.434

Note: Standard error is shown in parenthesis
*, **, *** denote statistical significance at 10%, 5% and 1% levels respectively.

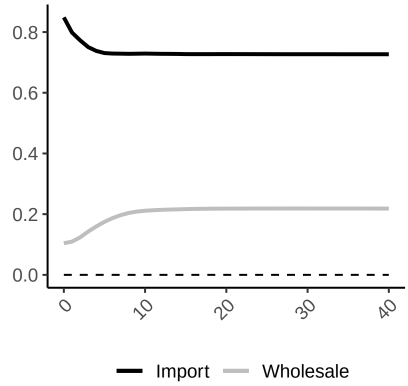

Figure 1: Aggregated ERPT to import and wholesale prices

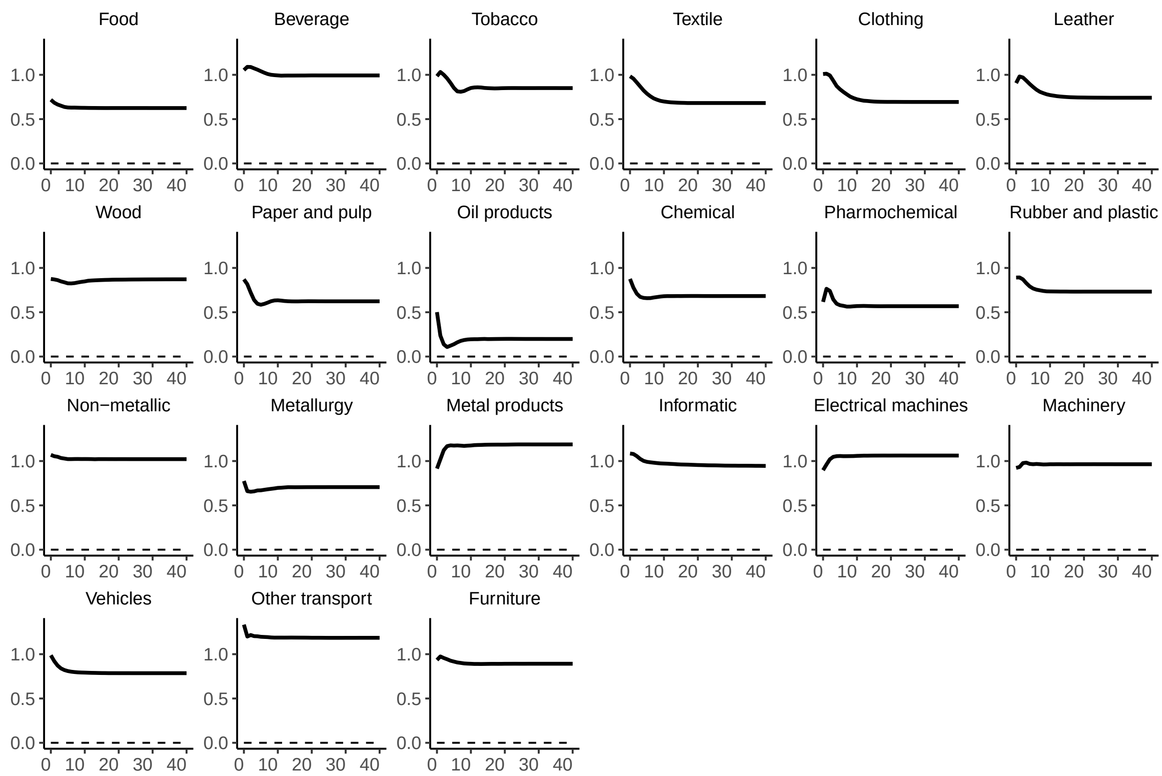

Figure 2: Dynamics of ERPT to import prices

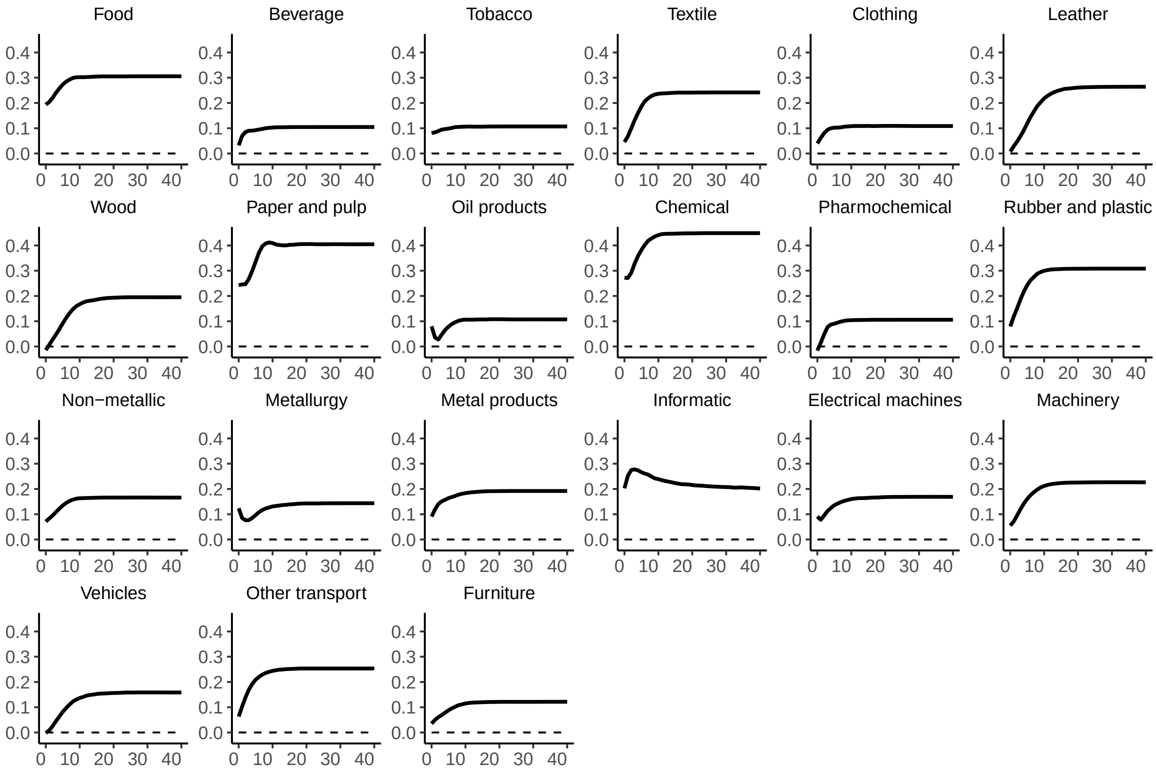

Figure 3: Dynamics of ERPT to wholesale prices