Evaluating the effect of exchange rate and labor productivity on imports penetration of Brazilian manufacturing sectors

João Paulo Martin Faleiros (Brazilian Development Bank)
José Carlos Domingos da Silva (PUC-SP e FECAP)
Marcos Yamada Nakaguma (FEA-USP)

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Abstract

Recently some economists have pointed out a dangerous process consisting of a loss of competitiveness in the Brazilian industry caused by the strong exchange rate appreciation. However, others economists have linked this dangerous process to the weakness performance of the Brazilian industrial productivity. In this context our paper evaluates the differences in the impact of exchange rate and labor productivity on the Brazilian market share of imports measured here by the coefficient of import penetration of total demand for manufacturing goods. Furthermore, we develop a simple micro model for understanding under what conditions do these impacts differs. Empirically, we made use of a GMM panel data analysis for 17 manufacturing sectors in the period among 1996 and 2011. Our results suggest that both variables matter to explain the annual difference of coefficient of imports. Nevertheless, labor productivity has the highest negative impact on import's market share even when the assessment is made in terms of groups of sectors.

Resumo

Recentemente, alguns economistas têm apontado um perigoso processo que consiste na perda de competitividade da indústria brasileira causada pela forte apreciação cambial. No entanto, outros economistas têm relacionado esse processo à fraqueza da produtividade industrial brasileira. Neste contexto, o nosso trabalho avalia as diferenças do impacto da taxa de câmbio e da produtividade do trabalho sobre a participação das importações medida aqui pelo coeficiente de penetração da demanda total por bens importados decomposta em setores industriais. Além disso, desenvolvemos um modelo teórico para o entendimento e diferenciação dos de tais impactos. Empiricamente, fizemos uso de uma análise de dados em painel (GMM) considerando 17 setores da indústria transformadora no período entre 1996 e 2011. Nossos resultados sugerem que ambas as variáveis são importantes para explicar a diferença anual do coeficiente de importações. No entanto, a produtividade do trabalho tem o maior impacto sobre a participação das importações, mesmo quando a avaliação é feita em termos de grupos setoriais.

Key-Words: Industrial Sector; imports; exchange rate; labor productivity.
Classificação JEL: O14. L6. L16. C23

1 Introduction

In the recent years, the competitiveness of the Brazilian manufacturing sector has become a prominent issue in the national economic debate as a result of a rapid increase of the imports' participation on the domestic market since the 90´s. In 1996, imports represented only 6.5% of the domestic consumption of manufactured goods. This participation soared during the 2000s, reaching 23.0% in 2008, with a small decline in 2011 to 19.5%. According to several economists, policymakers and manufacturing associations, this large increase in the imports penetration is to be blamed on the appreciation of the Real.

Indeed, after the 1999 crisis, the Brazilian currency (Real) appreciated in real terms (relative to U.S dollar) by 60 percent between 2003 and 2011. According to Armando Monteiro Neto, president of National Confederation of Industries (CNI), appreciated exchange rate affects the competitiveness of the Brazilian manufacturing sector not only abroad, but also inside the domestic market. Furthermore, more than 50% of all industrial segments in 2009 faced import competition (Monteiro, 2010).

Cano (2012) and Bresser-Pereira as well as Marconi (2010) also emphasize this aspect, suggesting that the level of the exchange rate is the main factor behind the loss of competitiveness of the manufacturing sector observed during the last decade, and warn that it could lead eventually to a process of deindustrialization.

There is no doubt that exchange rate has an important impact on the level of competitiveness in Brazilian manufactured goods. According to Broz and Frieden (2006) a real appreciation of exchange rate increases the purchasing power of local residents by lowering the relative price of foreign tradable goods. These authors also emphasize that there is a trade-off between competitiveness and purchasing power and the exchange rate has a crucial role in it.

However, it is important to point out that despite his importance exchange rate is not the only factor that explain the loss of competitiveness of Brazilian manufactured goods. Productivity is also a key variable for understand it. Bonelli and Pinheiro (2012) listed direct and indirect factors related to productivity that have constrained the Brazilian competitiveness of the manufacturing industry. For instance, the quality of infrastructure, the investments in R&D, absorption of foreign technology, labor cost and the educational level. As consequence, in terms of domestic factors, not only is exchange rate the key for explaining the increase of import penetration but productivity is also a crucial element. It is convenient to clarify, therefore, what is the factor that has a major role in import penetration of the demand for manufactured goods.

This article evaluates the broad effect of exchange rate and productivity on the recent dynamic of import penetration in the Brazilian demand for goods in the manufacturing sectors. Moreover, this paper elucidates which factor has the greatest impact.

At first time it is not clear why the impact of exchange rate and productivity on import penetration may differ. Considering this aspect we propose a simply micro-funded model demonstrating that under some specific conditions productivity measured by the ratio between industrial production and number of workers could be more important for explaining the increase of import participation on domestic market when compared to exchange rate. The necessary condition that creates this superior impact of labor productivity is a higher participation of foreign inputs on the total production. This theoretical result reinforces the argument of Lisboa and Pessoa (2013) that devaluations may protect national industry, but, at the same time, raises the costs of foreign inputs.

To corroborate empirically the difference of impacts we made use of panel data regressions for 17 manufacturing Brazilian sector covering a period between 1996 and 2011. By the fact that there is an eventual simultaneity between labor productivity, exchange rate and import penetration yielding biased estimators, we apply GMM panel data estimation based on Arellano and Bond (1991).

In particular this method takes the first differences of the variables to eliminate unobserved sector-specific effects and use lagged instruments to correct for simultaneity. However, as pointed by literature, the lagged instruments in the first-difference equation may be weak and may cause large finite-sample biases. To circumvent this problem we also apply the system GMM panel estimation based on Arellano and Bover (1995) as well as Blundell and Bond (1998).

In this context, our empirical findings confirm that the impact of labor productivity on import penetration is superior to exchange rate. These result contest the broad argument that exchange rate is the key factor that explain the massive increase of imports on domestic market between 1996 and 2011. It is also possible to evaluate empirically whether this result may be sustained by two distinct groups of sectors that constitute our data: consumption goods sectors as well as intermediate and capital goods sectors. Findings also attest the superior importance of productivity considering both groups of sectors.

In the case of consumption goods sectors group the impact of exchange rate on import penetration is slightly superior when compared to the results for the whole sectors. On the other hand, the impact of exchange rate of the group of intermediate and capital goods sectors is lower but not statistically significant.

As a consequence these results support that fact that exchange rate is not crucial for explaining the increase of imports participation on the domestic demand for intermediate and capital goods. This last result is important in terms of policy given that devaluation of Brazilian currency may not be effective for increase the market share of local intermediate and capital goods on the domestic market.

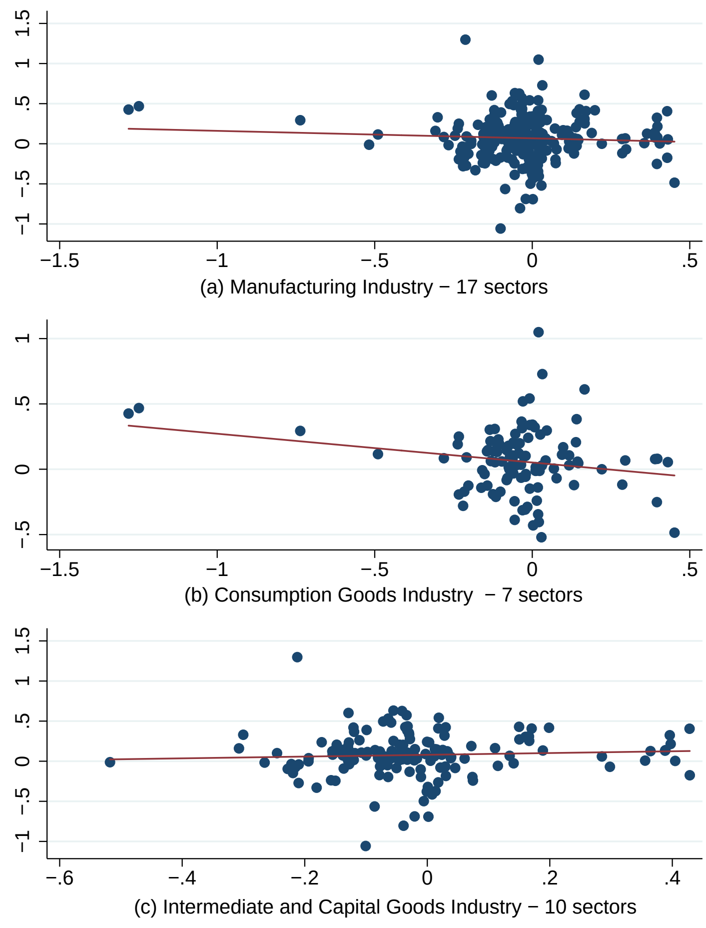
The rest of the paper is organized as follow. Section 2 presents some stylized facts about the relationship between import penetration and labor productivity and real exchange rate. Section 3 presents the micro-funded model that supports the theoretical view about the importance of productivity over exchange rate. Section 4 and 5 present, respectively, the empirical model and results. Finally section 6 concludes this article.

2 Stylized facts: exchange rate, productivity and import penetration

The recent process of rapid increase of manufacturing imports in the Brazilian domestic consumption became a relevant issue in the economic debate and exchange rate has turned out to be the key factor for understand it. There are two mainly reasons for that. At first place, economic theory expects that the relationship between import penetration, measured by the share of imports over the manufacturing apparent consumption, and exchange rate is negative. In general, there is evidence that Brazilian imports react positively when home currency appreciates against major foreign currencies. Secondly, over the last 20 years, real exchange rate appreciation reached its lowest level. However, despite of the fact that these arguments gained importance on the national debate, there is some aspects related to this process that remains unclear, i.e., the degree of import penetration sensitiveness to exchange rate evaluated at sector level.

A preliminary and basic view of these relationship reveals that the correlation is negative as expected, but with a small degree. Figure 1(a) presents the dispersion between the log difference of the share of imports in the domestic market (measured by import penetration coefficient calculated at constant prices) and the log difference of sectoral exchange rate[1] for 17 manufacturing sectors, during the period between 1997 and 2011. As we observe, the linear relationship is weak and the correlation coefficient is only -0.06. This characteristic is consequence of the low correlation in the group of intermediate and capital goods sectors. Figure 1(c) reveals that those sectors relationship between these two variables is slightly positive and near zero. Whereas the sectors of consumption good industries, as shown in Figure 1(b), has a pronounced relationship and presents a higher degree correlation with a coefficient of -0.21.

Figure 1: Dispersion between the annual difference of the import coefficient (vertical axis) and the annual growth rate of sectoral exchange rate (horizontal axis) for 17 manufacturing sectors between 1997-2011.



Furthermore, these stylized fact puts in check the effectiveness of devaluation policies for protecting the national manufacturing industry. The exchange rate appears to be important for reducing import penetration in the consumer goods sector. However, this is not true in the case of intermediate and capital goods import penetration. Whether import penetration coefficient of intermediate and capital goods sectors is indeed inelastic to the exchange rate, currency devaluations elevate input costs and make new investments more expensive.

According to Lisboa and Pessoa (2013) the effect of the exchange rate is ambiguous. Devaluations may protect national industry, but, at the same time, raises the costs of imported inputs. Because of these ambiguity, Broz

[1] The sectoral exchange rate is calculated here from the real exchange rate of the Brazilian currency relative to the trading partners for 17 industry sectors. measured in terms of consumer prices. weighted by the share of imports of the trading partner in the total value of imports. More information about the construction of sectoral exchange and other variables. see section 5.

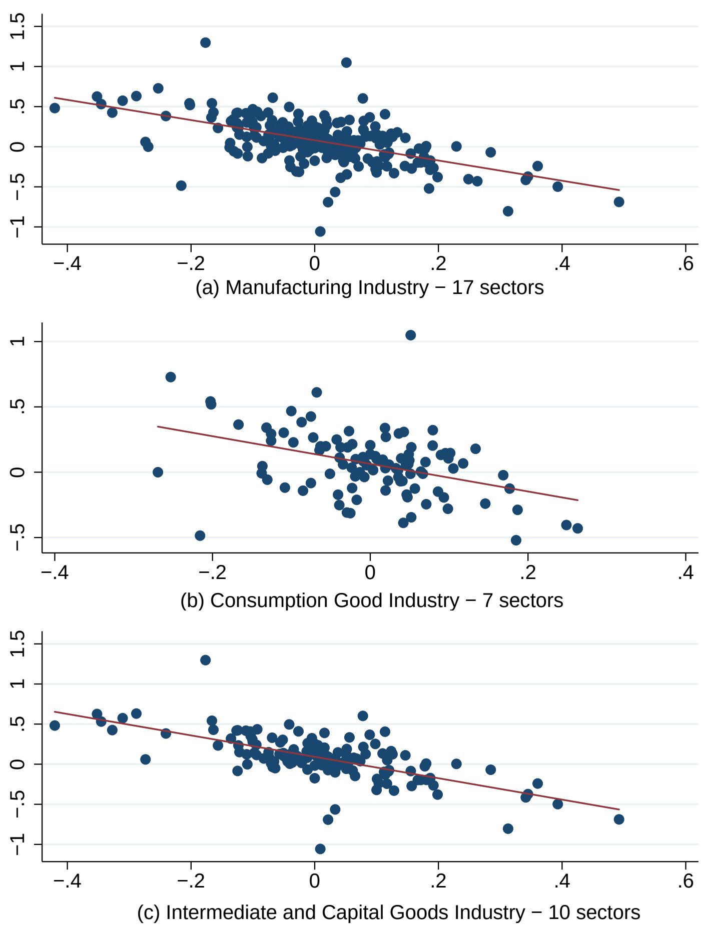
and Frieden (2006) pointed out that there is no clear economic policy that could determine one appropriate level of exchange rate.

In this sense, it is possible that the existence of manufacturing imported goods that are used as input in the national industry decreases the sensitiveness of import penetration for all industry to the exchange rate. In fact, intermediate and capital goods sectors, in general, has a level of imported input participation on total inputs superior than consumption goods sectors. According to the databases of input-output matrix estimated by different authors for the period between 2000-2009 (Freitas et all 2012; Guilhoto and Sesso Filho, 2010; Martinez, 2015) the sectors present in these group has, on average, a participation of around 16% imported inputs in total inputs demanded in final production against a percentage of 8.0% in the consumption goods sectors.

On the other hand, some economists have explained the recent raise of import penetration by emphasizing the role of productivity performance (Bonelli and Pessoa, 2010; Ferreira and Fragelli, 2011). According to Lisboa and Pessoa (2013), while certain sectors in the decade of 2000 were favored by labor productivity gains, for example, agriculture, most of the manufacturing industry sectors showed a poor performance. Using data from IBGE manufacturing survey (PIM-IBGE), between the years of 2003 and 2011, a period of intense appreciation of the real exchange rate, the industry labor productivity increase only 21%. In particular, labor productivity performance in intermediate and capital goods sector presented a cumulative growth of 18%, while the sectoral exchange rate appreciated 57%.

Whether these segments of economists are correct, we expect that the relationship between import penetration and productivity would be negative and high correlated. Therefore Figure 2(a) presents the dispersion between the log difference of import penetration and the log difference of labor productivity for all sectors highlighted here. In fact, a preliminary analysis of the data in Figure 2 reveals that the relationship between these variables are strongly negative. The correlation coefficient is -0.57 for the group of 17 sectors. The same occurs with the two groups of sectors as seen by Figure 2(b) and Figure 2(c). In the case of intermediate and capital goods sector the correlation coefficient is -0.65 and for consumption good sector its value is -0.40.

Figure 2: Dispersion between the annual difference of the import coefficient (vertical axis) and the annual growth rate of labor productivity (horizontal axis) for 17 manufacturing sectors between 1997-2011.



The role of productivity seems to be more important than exchange rate for explaining the recent process of raising in import penetration of manufacturing goods. The stylized facts presented here reveal that this difference may be related to the presence of intermediate and capital goods imports. Apparently, these group of sectors do not present any association between import penetration and exchange rate. As a consequence it weakens the relationship for the whole manufacturing sector. We have the impression that the absence of association in this specific group may be explained by deeply structural dependence of foreign inputs in the domestic production when compared to consumption good sectors.

As we may see in the next section, the hypothesis that foreign input dependence weakens exchange rate impact is reasonable when analyzed through a simple micro-funded model. In empirical terms, it is not possible to draw robust conclusions by a simple analysis of correlation. The reverse causality between variables and unobserved sectoral and time effects may be a problem. Furthermore, import penetration may also depend on other important factors as we could see in the theoretical model. Thus, all theses aspects demand different econometric treatments.

3 Theoretical Model

This section proposes a simple theoretical model in order to motivate and discuss the main propositions to be tested in this paper. We assume that there are two countries, a domestic and a foreign country, and that the production function of domestic and foreign firms are given, respectively, by:

$$Y = \alpha L \; and \; Y^* = \alpha^* L^* \tag{1}$$

where Y and Y^*denote the quantities produced in each country and α and α^*represent the labor productivity in the domestic and foreign industries. We assume that the labor supply is inelastic, so that the L and $L^*$are both exogenous variables. Given the price of the domestic good (in national currency), P, the firm's profit is given by:

$$\pi = P\alpha L - wL \tag{2}$$

where w is the nominal wage. Assuming that there is free entry in the industry, the profit of all active firms should be zero. Therefore, the equilibrium price is given by:

$$P = \frac{w}{\alpha} \tag{3}$$

Note that the term $\frac{w}{\alpha}$ represents the unit labor cost. Similarly, we have that the equilibrium price of the foreing good (in foreign currency) is given by: $P^* = \frac{w^*}{\alpha^*}$.

Next, suppose that the domestic demand for both the domestic and foreign goods can be derived based on the choices of a representative consumer with CES utility function given by:

$$U(Q, Q^*) = (Q^\rho + Q^{*\rho})^{1/\rho} \tag{4}$$

where $\rho \leq 1$ is the elasticity of substitution between domestic and foreign goods. Suppose also that the representative consumer has income $R > 0$, which he spends all in consumption. Suppose, without loss of generality, that $R = 1$, so that his budget constraint is given by:

$$PQ + EP^*Q^* \leq 1 \tag{5}$$

where E is the nominal exchange rate. The consumer chooses Q and Q^*in order to maximize (5) subject to (6). The solution to this problem yields the following relationship between the quantitites consumed in equilibrium of the foreign and domestic goods:

$$\frac{Q^*}{Q} = \left(\frac{\frac{w}{\alpha}}{\frac{Ew^*}{\alpha^*}} \right)^{1/1-\rho}, \tag{6}$$

i.e. the participation of imported goods in the domestic market, $\frac{Q^*}{Q}$, depends on the ratio between the unit labor cost of foreign and domestic firms. Specifically, a reduction in the unit labor cost of the domestic firms, i.e. an improvement in the competitiveness of the national industry, leads to a decrease in the local demand for the foreign good relative to domestic good. Moreover, note that the above equation can be re-expressed as:

$$log\left(\frac{Q^*}{Q}\right) = \frac{1}{1-\rho}\left[log\left(\frac{w}{\alpha}\right) - log\left(E\right) - log\left(\frac{w^*}{\alpha^*}\right)\right] \tag{7}$$

Thus, it follows that a 1% exchange rate depreciation has the same impact on $\frac{Q^*}{Q}$ as an increase of the same magnitude in the labor productivity. This result provides theoretical justification for those policy-makers and economists who argue that domestic competitiveness can be improved by simply engendering an exchange rate depreciation. But does this result make sense? How robust is it?

According to Lisboa and Pessoa (2013), exchange rate depreciation increases the competitiveness of the domestic industry, but at the same time raise the cost of imported inputs. The model presented above does not capture such adverse effects of exchange rate depreciation due to the simplistic format assumed for the production function of domestic firms. In order to make our analysis more realistic, we extend the previous model, now assuming that the production function of domestic firms are given by a Leontief function of the following form:

$$Y = \alpha.min\left\{L, \frac{1}{\phi}\iota\right\} \quad with\, \phi > 0, \tag{8}$$

where ι is the quantity of an imported input used in the domestic production, i.e. we are now assuming that the production of the domestic good requires the use of a certain quantity of a foreign production factor. Note that the optimal production requires that:

$$\iota = \phi L \tag{9}$$

since any other combination of production factors would imply in waste of resources. Note that the larger the value of the parameterϕ, the higher the dependence of the domestic industry on the foreign input. Assuming, without loss of generality, that the price of the imported production factor is equal to one and imposing the optimality condition $\iota = \phi L$, it follows that the profit of domestic firms is given by:

$$\pi = P\alpha L - (w + \phi E)\, L \tag{10}$$

Thus, from the zero profit condition, it follows that the equilibrium price of the domestic good is now given by:

$$P = \frac{w + \phi E}{\alpha} \tag{11}$$

Finally, assuming, for simplicity, that both the production structure of the foreign industry and the utility function of the representative consumer remain unchanged, we have that, in equilibrium, the ratio between the demanded quantities of foreign and domestic goods is given by:

$$\frac{Q^*}{Q} = \left(\frac{\frac{w+\phi E}{\alpha}}{\frac{Ew^*}{\alpha^*}}\right)^{1/1-\rho}, \tag{12}$$

which can be re-expressed as:

$$log\left(\frac{Q^*}{Q}\right) = \frac{1}{1-\rho}\left[log\left(\frac{w+\phi E}{\alpha}\right) - log\,(E) - log\left(\frac{w^*}{\alpha^*}\right)\right] \tag{13}$$

Thus, as long as$\phi > 0$, the effect of an increase in labor productivity on the relative demand for the foreign good, $\frac{Q^*}{Q}$, is larger (in absolute terms) than that of an exchange rate depreciation. Formally, we have that:

$$\frac{\partial log\left(\frac{Q^*}{Q}\right)}{\partial \alpha} = -\frac{1}{1-\rho} \tag{14}$$

and

$$\frac{\partial log\left(\frac{Q^*}{Q}\right)}{\partial E} = -\frac{1}{1-\rho}\left(1 - \frac{\phi}{w+\phi E}\right), \tag{15}$$

where $\left(1 - \frac{\phi}{w+\phi E}\right) < 1$. Moreover, it is interesting to note that the larger the dependency of the domestic industry on the foreign input, the lower the impact of an exchange rate depreciation on $\frac{Q^*}{Q}$, i.e.

$$\frac{\partial log\left(\frac{Q^*}{Q}\right)}{\partial E \partial \phi} = \frac{1}{1-\rho}\frac{w}{(w+\phi E)^2} > 0 \tag{16}$$

Thus, it follows that the effectiveness of a policy of currency devaluation in terms of improving the competitiveness of the domestic industry depends crucially on the production structure of domestic firms and, in particular, on the degree to which they rely on the use of imported inputs.

4 Empirical Model

In order to observe whether the effects of productivity labor and exchange rate indeed differ, as expected by the theoretical model, we estimate the elasticities related to each variable in the equation (13). Different from the model in the last section, our empirical analysis requires additional treatment. Firstly, the data consist of annual information for manufacturing sectors considering a specific period. Thus, it is necessary to control for unobserved sectoral effect and time effects that is not treated in the micro model. Secondly, disturbances may be possibly autorregressive given that import penetration shocks may have persistent effect over the years. Third, the ratio between the demand of foreign and domestic goods is proxied by the coefficient of import penetration. By the end, due to the impossibility of obtaining foreign wage data for the highlighted period, we assume that these variables are captured by fixed and time effects.

The empirical model, therefore, is considered by the following expression:

$$\begin{gathered} ip_t = \beta_\alpha \alpha_{it} + \beta_E E_{it} + \beta_w w_{it} + \beta_{\alpha *} \alpha^*_{it} + \gamma_t + (\mu_i + v_{it}) \\ v_{it} = \delta v_{it-1} + \varepsilon_{it} \; |\delta| < 1 \; \varepsilon_{it} \sim i.i.d \end{gathered} \tag{17}$$

where, ip_{it} is the log of coefficient of import penetration i in the year t, α_{it} is log of domestic labor productivity, E_{it} is the log of effective exchange rate, w_{it} is log of domestic manufacturing wages by sector, α_{it} is the log of a proxy for foreign labor productivity, γ_t is time effect. Of the error components, μ_i is the fixed effect and v_{it} is an autorregressive shock.

The presence of persistent shocks v_{it} indicate that model (1) may also be described by a dynamic representation according to the following expression:

$$\begin{gathered} ip_{it} = \pi_1 ip_{it-1} + \pi_2 \alpha_{it} + \pi_3 \alpha_{it-1} + \pi_4 E_{it} + \pi_5 E_{it-1} + \pi_6 w_{it} + \pi_7 w_{it-1} \\ + \pi_8 \alpha^*_{it} + \pi_9 \alpha^*_{it-1} + \tilde{\gamma}_t + \tilde{\mu}_i + \varepsilon_{it} \end{gathered} \tag{18}$$

where, $\pi_1 = \delta$, $\pi_2 = \beta_\alpha$, $\pi_3 = -\delta\beta_\alpha$, $\pi_4 = \beta_E$, $\pi_5 = -\delta\beta_E$, $\pi_6 = \beta_w$, $\pi_7 = -\delta\beta_w$, $\pi_8 = \beta_{\alpha *}$, $\pi_9 = -\delta\beta_{\alpha *}$, $\tilde{\gamma}_t = \gamma_t - \delta\gamma_{t-1}$ and $\tilde{\mu}_i = \mu_i(1-\delta)$. The model (2) is the unrestricted model that has a dynamic process that includes a autorregressive component of the import penetration coefficient. These aspect associated to the possibility of reverse causality between variables demand a method of estimation different from Ordinary Least Squared (OLS) and Fixed Effect (FE). The OLS estimator is inconsistent estimator given that ip_{it-1} is correlated to the error term due to the presence of the fixed effect. Hence, the estimator tend to be biased upward.

On the other hand, the FE estimator corrects this inconsistency by removing the fixed effect. However, it promotes a non-negligible correlation between the transformed autorregressive component of dependent variable and the transformed error term. In addition, OLS and FE estimators do not eliminate the problems of inconsistency generated by reverse causality between variables. Notice that the error term may be also correlated to the others variables, for example, shocks in import penetration may contemporaneously influence labor productivity given that both variables were constructed from the value of industrial production. Furthermore, the effective exchange rate variable E_{it} is calculated by weighing up real exchange rate of Brazilian trade partners and their participation on the total of imports. Needless to say that real wage may be strongly correlated to the labor productivity. Thus, given those aspects, it is possible that reverse causality may also be a problem in terms of estimation consistency.

In this sense, we also estimate the coefficients of equation (2) by Arellano and Bond (1991) or first-differenced Generalized Method of Moments (GMM). This method yields consistent estimators for dynamic panel models. It relaxes the hypothesis of strong exogeneity of variables assuming that they are endogenous, i.e., the variables are correlated to the shocks in t and previous shocks. However, they are not correlated to forward shocks. Assuming that, it is possible to use the sequence of lags of the variables in level as instruments, after taking the equation in first difference to eliminate the fixed effect.

However, the estimator proposed by Arellano and Bond (1991) may have lagged instruments that is weakly correlated with subsequent first differences variables. This is a case of weak instruments that may cause bias as well as imprecision when explanation variables are very persistent. According to Bond (2002) it happens when the estimated autorregressive coefficient of the dependent variable in first-differenced GMM is near to the within groups coefficient. Blundell and Bond (1998) achieve this result by simulation exercises revealing that, when instruments are weak, first-differenced GMM results tend to be biased in the direction of within group estimation.

To solve this problem, Arellano and Bover as well as Blundell and Bond (1998) suggest additional moment conditions by using lagged first-differenced instruments for the equation in levels. The system GMM method, therefore, combines lagged level as instruments in the first-differenced equation with lagged first differences variables as instruments in the level equation. Hence, it is expected that system GMM may cause a dramatic reduction of finite sample bias.

However, our interest lies in the restricted parameters $(\beta_\alpha, \beta_E, \beta_w, \beta_{\alpha^*}, \delta)$. Given the estimated coefficients in (2) and the system of equation originated by the autorregressive shocks process, we estimate the restricted parameters by minimum distance method suggested by Blundell, Bond and Meghir (1996).

In possession of these results, we may verify whether our empirical findings are in concordance with the theoretical model discussed previously.

5 Data

Our data covers the period between 1996 and 2011 as well as 17 manufacturing sectors classified in Table 1. It yields 255 observations. Apart from information about Brazilian manufacturing sectors, our empirical analysis also demands information from its foreign trade partners.

The sources of trade partner's information are: World Bank Database (consumer index price and exchange rate) as well as Penn World Table (GDP at chained PPPs and the number of employees). The manufacturing data are obtained from Monthly Manufacturing Survey from Brazilian Institute of Statistics and Geography – PIM/IBGE (index of the number of employees associated to production. index of real payroll per worker and manufacturing production index). Annual Manufacturing Survey from Brazilian Institute of Statistics and Geography PIA-IBGE (number of employees associated to production and manufacturing value of production) and Aliceweb (Brazilian imports and exports by sector).

From this data we constructed four variables present in the theoretical model: import penetration coefficient, real effective exchange rate, Brazilian labor productivity and an index of foreign productivity. Additionally, the real payroll index, also provided by IBGE, served as a proxy for real wage.

The import coefficient was conventionally constructed as the ratio of imported value and the apparent consumption. The latter consists of the sum of the industrial production value and imports value subtracted from the exports. All measures are expressed in terms of constant prices.

Table 1: Manufacturing Sector Classification

1	Beverage and Food	CG	10	Rubber and Plastic	ICG
2	Tobacco	CG	11	Non-Metallic Minerals	ICG
3	Textile	CG	12	Basic Metallurgy	ICG
4	Retail	CG	13	Metal Products, except Capital Goods	ICG
5	Footwear and Leather Products	CG	14	Capital Goods, except 16	ICG
6	Wood	ICG	15	Capital Goods - Electrical Electronics and Communication	ICG
7	Paper and Printing	CG	16	Capital Goods - Transportation	ICG
8	Coke. Petroleum and Alcohol	ICG	17	Furniture	CG
9	Chemicals and related products	ICG			

Note: Classification based on CNAE 1.0, CG - Consumption Goods Sector, ICG - Intermediate and Capital Goods Sector

The proposed real effective exchange rate is calculated by weighting the real exchange rate (R\$ / LCU) of the trading partners in relation to their participation on the total imports of all 17 manufacturing sectors. The construction of real exchange rate is based on consumer prices[2].

Labor productivity was built from the ratio of the value of industrial production, at 2006 prices, and the number of employees. We also propose a foreign productivity index as a proxy for trade partner's sector labor productivity. In a similar way to effective real exchange rate, this variable is constructed by weighting the labor productivity of trading partners in relation to their import's share on the total imports of all sectors.

A detailed description of these variables is following described considering i as a indication of manufacturing sector and t for year.

- $ip_{it} = log(imports_{it} \ / \ (industrial\ production\ value_{it} + imports_{it} - exports_{it})$
- $\alpha_{it} = log(industrial\ production\ value_{it} / number\ of\ employees\ associated\ to\ production_{it})$
- $E_{it} = log(real\ exchangerate\ (R\$/LCU)_t \times the\ import's\ share\ of\ trading\ partners\ on\ the\ total\ imports_{it})$
- $\alpha^*_{it} = log(trading\ partners\ labor\ productivity_t \times the\ import's\ share\ of\ trading\ partners\ on\ the\ total\ imports_{it})$

[2]The real exchange rate is calculated for each trading partner through the ratio of the country's consumer price indexes and the Brazilian consumer price index.

Table 2: Descriptive Statistics (1996-2011)

	ip_{it}	$\triangle ip_{it}$	$\triangle \alpha_{it}$	$\triangle E_{it}$	$\triangle w_{it}$	$\triangle \alpha^*_{it}$
All Manufacturing industries - 17 sectors						
n	272	255	255	255	255	255
mean	0.106	0.071	0.007	-0.033	0.001	0.022
median	0.075	0.073	0.007	-0.036	0.002	0.020
standard deviation	0.100	0.271	0.123	0.193	0.072	0.043
min	0.001	-1.057	-0.420	-1.281	-0.410	-0.420
max	0.434	1.298	0.492	0.452	0.254	0.268
Consumption Goods industries - 7 sectors						
	ip_{it}	$\triangle ip_{it}$	$\triangle \alpha_{it}$	$\triangle E_{it}$	$\triangle w_{it}$	$\triangle \alpha^*_{it}$
n	112	105	105	105	105	105
mean	0.058	0.062	0.002	-0.048	0.005	0.024
median	0.052	0.062	0.008	-0.035	0.005	0.023
standard deviation	0.042	0.251	0.096	0.237	0.086	0.061
min	0.001	-0.521	-0.269	-1.281	-0.410	-0.420
max	0.219	1.049	0.263	0.452	0.254	0.268
Intermediate and Capital Goods industries - 10 sectors						
	ip_{it}	$\triangle ip_{it}$	$\triangle \alpha_{it}$	$\triangle E_{it}$	$\triangle w_{it}$	$\triangle \alpha^*_{it}$
n	160	150	150	150	150	150
mean	0.139	0.078	0.011	-0.022	-0.002	0.020
median	0.101	0.081	0.007	-0.039	0.000	0.019
standard deviation	0.114	0.284	0.138	0.154	0.060	0.024
min	0.008	-1.057	-0.420	-0.518	-0.160	-0.056
max	0.434	1.298	0.492	0.428	0.190	0.088

A descriptive statistics of the variables, given by Table 2, reinforces the stylized facts about the relationship between import penetration, exchange rate and productivity. The average coefficient of import penetration, in the period between 1996 and 2011, was 10.6%. Note, however, that its average growth rate was 7% per year reflecting a substantial increase of manufacturing imports participation on domestic consumption. It is a similar result when compared to the two large groups of sectors (consumptions goods as well as intermediate and capital goods).

Otherwise, the average rate of the annual labor productivity did not strictly follow the import penetration performance. Considering all sectors, its growth rate was only 0.7% per year. For the sectors of consumption goods, the percentage is even lower, equal to 0.2%, whereas the group of intermediate and capital sectors had an annual growth rate of 1.1%.

Real effective exchange rate, by the other hand, had a distinct dynamic. As we may see, Brazilian currency strongly appreciated, in real terms, against the currencies of its trading partners. In average, the annual rate was -3.3% for all sectors. Considering the group of consumption goods sectors this rate is even inferior, reaching -4.8% per year.

Note that these facts are also compatible with the discussion presented in section 2. The increase of import penetration seems to be related to the low performance of productivity in manufacturing sectors and the trajectories appreciation of the exchange rate.

On the other hand, additional aspects deserve attention and may also be important for explaining the advance of import penetration in domestic consumption. The index of foreign productivity indicates that the partners had a better performance in terms of labor productivity. In general, the annual average growth rate for all sectors was about 2.0%. Even when segmented by the two broad groups of sectors the performance per year continues to be practically the same.

By the end, it is seems that wages do not have a large influence on the recent diffusion of imports on domestic market. It is expected that real wage would have had an increase in this period impacting negatively the Brazilian manufacturing competitiveness favoring imports. However, the average growth rate of our proxy for real wage was near zero. Specifically for the group of intermediate and capital goods sectors, the annual rate was nevertheless negative.

6 Empirical Results

The restricted model described by equation (1) and the unrestricted model (2) are estimated by different methods. The estimation of (1) made use of four approaches in order to evaluate whether the results is influenced by the presence of some specific bias as discussed before: Ordinary Least Squares (OLS), Fixed Effect (FE), GMM in differences (DIFF-GMM) proposed by Arellano and Bond (1991) as well as System GMM (SYS-GMM) proposed by Arellano and Bover (1995) and Bover and Blundell (1998). After that, the method of minimum distance is applied for estimating the structural elasticities (2) through the coefficients obtained from unrestricted models.

In the first part of Table 3 we present the estimation of unrestricted models coefficients considering 17 sectors. We estimate a total of ten models. All models include year dummies for controlling time effects. The first two columns present the estimation by OLS and FE. In the following columns we report the coefficients estimated by GMM. The difference between them basically lies in the number of system equation and the composition of instrumental variables.

Table 3: Unrestricted and Restricted Models Estimates - all sectors

Dependent Variable: ip_{it}			E_{it} and α^*_{it} as exogenous instruments				E_{it} and α^*_{it} as endogenous instruments			
	OLS	FE	DIFF-GMM $(t-2)$	DIFF-GMM $(t-3)$	SYS-GMM $(t-2)$	SYS-GMM $(t-2)$	DIFF-GMM $(t-2)$	DIFF-GMM $(t-3)$	SYS-GMM $(t-2)$	SYS-GMM $(t-2)$
α_{it}	-0.840***	-0.947***	-0.816***	-0.761***	-0.733***	-0.767***	-0.868***	-0.816***	-0.754***	-0.782***
	(0.135)	(0.134)	(0.139)	(0.145)	(0.124)	(0.127)	(0.151)	(0.165)	(0.126)	(0.132)
α_{it-1}	0.851***	0.734***	0.526***	0.484***	0.742***	0.752***	0.552***	0.438**	0.758***	0.766***
	(0.138)	(0.136)	(0.105)	(0.140)	(0.112)	(0.111)	(0.136)	(0.173)	(0.115)	(0.113)
E_{it}	-0.272***	-0.252*	-0.283**	-0.275**	-0.292***	-0.267***	-0.286***	-0.297***	-0.263***	-0.260**
	(0.094)	(0.121)	(0.128)	(0.126)	(0.092)	(0.100)	(0.117)	(0.106)	(0.100)	(0.112)
E_{it-1}	0.126	-0.073	0.030	0.082	0.190	0.225	-0.071	0.139	0.171	0.179
	(0.232)	(0.439)	(0.389)	(0.405)	(0.415)	(0.395)	(0.423)	(0.348)	(0.393)	(0.370)
w_{it}	0.483**	0.574*	0.422	0.420	0.662*	0.533*	0.534*	0.637**	0.566*	0.521*
	(0.221)	(0.288)	(0.313)	(0.321)	(0.379)	(0.311)	(0.272)	(0.320)	(0.325)	(0.288)
w_{it-1}	-0.479**	-0.265	-0.160	-0.206	-0.646***	-0.468**	0.027	0.048	-0.590***	-0.482***
	(0.222)	(0.311)	(0.202)	(0.181)	(0.223)	(0.231)	(0.242)	(0.257)	(0.181)	(0.185)
α^*_{it}	1.451***	1.566***	0.976***	0.976***	1.525***	1.424***	1.252***	1.137**	1.254***	1.278***
	(0.524)	(0.354)	(0.350)	(0.327)	(0.357)	(0.378)	(0.354)	(0.516)	(0.209)	(0.262)
α^*_{it-1}	-1.430**	-0.984	-1.051**	-1.027*	-1.518***	-1.441***	-0.747	-0.887*	-1.197***	-1.265***
	(0.576)	(0.642)	(0.525)	(0.526)	(0.582)	(0.540)	(0.518)	(0.532)	(0.421)	(0.448)
ip_{it-1}	1.001***	0.800***	0.759***	0.743***	0.994***	0.998***	0.735***	0.696***	0.995***	0.998***
	(0.012)	(0.043)	(0.055)	(0.079)	(0.023)	(0.019)	(0.046)	(0.063)	(0.024)	(0.017)
n	255	255	238	238	255	255	238	238	255	255
Instruments			201	185	241	240	208	192	274	273
Sargan Statistic			215.431	191.793	251.793	245.986	217.713	202.960	275.886	265.084
p-valor (Sargan)			0.029	0.055	0.058	0.086	0.050	0.038	0.135	0.245
p-valor (Diff-Sargan)					0.635	0.831			0.743	0.951
p-valor $(AR(1))$			0.015	0.012	0.017	0.021	0.023	0.018	0.019	0.021
p-valor $(AR(2))$			0.136	0.133	0.127	0.145	0.147	0.147	0.127	0.148
β_α	-0.866***	-0.902***	-0.851***	-0.813***	-0.782***	-0.805***	-0.779***	-0.707***	-0.783***	-0.796***
	(0.130)	(0.104)	(0.113)	(0.117)	(0.105)	(0.101)	(0.103)	(0.113)	(0.113)	(0.101)
β_E	-0.219***	-0.321***	-0.316***	-0.300***	-0.248***	-0.229***	-0.403***	-0.364***	-0.213***	-0.203***
	(0.075)	(0.077)	(0.087)	(0.099)	(0.053)	(0.038)	(0.093)	(0.086)	(0.039)	(0.038)
β_w	0.419***	0.640***	0.106***	0.223***	0.528***	0.429***	0.405***	0.352***	0.621***	0.357***
	(0.206)	(0.181)	(0.124)	(0.122)	(0.170)	(0.153)	(0.161)	(0.177)	(0.139)	(0.103)
$\beta_{\alpha*}$	1.761***	1.746***	0.616***	0.753***	1.093***	1.573***	1.280***	0.860***	1.424***	1.430***
	(0.471)	(0.246)	(0.160)	(0.173)	(0.191)	(0.210)	(0.311)	(0.392)	(0.135)	(0.185)
ρ	0.986***	0.789***	0.795***	0.833***	0.974***	0.984***	0.737***	0.712***	0.982***	0.982***
	(0.005)	(0.026)	(0.041)	(0.047)	(0.004)	(0.004)	(0.026)	(0.032)	(0.005)	(0.004)
p-valor (COMFAC)	0.220	0.862	0.309	0.379	0.136	0.554	0.526	0.767	0.255	0.391

Notes:
(i) DIFF-GMM indicates that the models is GMM in differences and SYS-GMM indicates that models is system GMM.
(ii) the models in columns 3 and 7 include $t-2$ and earlier lags as instruments and models in columns 4 and 8 include as instruments $t-3$ and earlier lags.
(iii) the models in columns 5 and 9 include $t-2$ and earlier lags as instruments in equation in differences and $t-1$ as instruments in the equation in level.
(iv) the models in columns 6 and 10 include $t-2$ and earlier lags as instruments in equation in differences and $t-1$ as instruments in the equation in level, with exception of labor productivity variables where we consider $t-2$ as instrument in equation in levels.

In the case of the models among the third and six columns we consider the micro-model hypothesis. It is assumed that the real effective exchange rate and the foreign labor productivity index are exogenous, i.e., there is no sequence of lag instruments related to these variables in the first difference equation as well as in the equation in levels when the SYS-GMM is considered.

However, the construction of these two variables, as discussed earlier, involves measures that may be correlated to the others variables. The exogeneity of trading partner's exchange rate and their labor productivity, that are used for constructing the variables, is less controversial especially because we are dealing with a level analysis based in manufacturing sectors. Thus, we expect that sector shocks on Brazilian import penetration do not influence contemporaneous partner's exchanges rates and labor productivity. However, despite of this fact, these two variables also depends on the trading partners import's participation on total sector imports that may impose simultaneity bias. For this reason, the models in columns 7 to 10 consider all variable in the system as endogenous.

Furthermore, the composition of instruments is also changed according to the sequence of lags. It may influence the validity of instruments as reported by Sargan test of over-identifying restriction, shown in the second part of Table 3. In the DIFF-GMM models of the columns 4 and 8, we impose the structure of lags inferior to t–3 in the equation in first difference. Taking into account SYS-GMM, we do not change the sequence of instruments in the first difference equation, imposing lags dated t–2 and earlier. However, in the level equation, the lags of labor productivity ($\Delta log(\alpha_{it})$) instruments is changed from t–1 to t–2.

In this context, the estimation of all unrestricted models reveals firstly that there is no problem of residual serial correlation in lag 2. The null hypothesis is rejected at 10% validating the assumption that import penetration shocks may be described by an autoregressive process. However, the Sargan tests indicate that there is poor evidence that instruments are valid in DIFF-GMM models even when the composite of instruments is dated to t–3 and earlier. The null hypothesis that instruments are valid is rejected at conventional levels. In addition, our results also suggest that these instruments are weak.

According to Bond (2002) when the estimated lag coefficient of dependent variable in DIFF-GMM models is near to the same coefficient estimated by FE give us evidence that instruments are highly persistence or close to random walk processes. As discussed in section 4, it may generate downward bias on the estimator. On the other hand, SYS-GMM exploits additional moment conditions by using lagged first differences as instruments for the equations in levels. As a result, the autoregressive coefficient of dependent variable is higher and lies between FE and OLS estimator as predicted by Bond (2002). In general, OLS estimator gives an upward bias on the autoregressive coefficient of dependent variable by the presence of sector-specific effect.

Generally, our SYS-GMM estimation model improves the power of Sargan tests. Nevertheless, only two models reported in columns 7 and 8 of Table 3 have a p-value superior than 10%. Furthermore, the difference Sargan test reveals that additional first difference instruments present in SYS-GMM models are valid at level superior to 10%. Note further that the most improvement on p-value of Sargan test occurs when we change the lag of labor productivity first difference instruments to t–2 in level equation.

In light of this econometrics aspects, unrestricted model estimated by SYS-GMM appear to be reasonable, especially in the case where E_{it} and y^*_{it} are assumed to be endogenous. It may be explained by the presence of simultaneous correlation between import penetration variable and trading partners import's participation on total sector imports used as a weight in E_{it} and y^*_{it} construction.

Despite of the fact that the last SYS-GMM model in Table 3 is preferred to the model in column 6, it does not impact decisively the coefficients of restricted model. Different from unrestricted models, they are estimated by minimum distance method as proposed by Bond (2002). Only the coefficient associated to the real wage has changed, but not in expressive magnitude. Thus, regardless the assumption that is made about E_{it} and y^*_{it}, it does not influence our conclusion about the impact of exchange rate and labor productivity on import penetration. Furthermore, according to COMFAC test, presented in the end of the Table 3, the restrictions imposed by minimum distance estimation are easily accepted.

As predicted by the micro-model, the impact of domestic labor productivity on import penetration is negative and superior to exchange rate. Considering only the SYS-GMM models, the value of productivity coefficient is at least three times larger than the exchange rate coefficients. It is the preliminary evidence supported by the micro-model, i.e., the presence of foreign inputs in the domestic production implies that labor productivity play a superior role in import penetration when compared to effective real exchange rate.

Some additional aspects of results deserve attention. Our real wage proxy estimator is significant and as expected has a positive impact on import penetration. In absolute terms, its impact is also superior to the of exchange rate. More interesting is the fact that the index of foreign labor productivity has the highest impact on the import penetration. Generally, the estimated elasticity is superior to the unity while domestic labor productivity has a value near to 0.8. Considering the last model, the ratio between domestic and foreign labor productivity elasticity is around 0.56, a representative percentage.

Our argument that foreign inputs matters to explain why exchange rate is less important than labor productivity lies in the fact that the participation of intermediate and capital goods in the domestic market is inelastic to effective exchange rate of the sector. At the moment that national manufacturing industry is deeply dependent of some foreign goods for producing, it is less likely that changes in the exchange rate may affect their consumption in domestic market. It seems the case of intermediate and capital sectors. Table 4 presents the model estimation for these group that includes 10 sectors. We impose the exactly structure of lags for instrumental variables presented in all sectors regression shown previously.

Table 4: Unrestricted and Restricted Models Estimates - Intermediate and Capital Good Sectors

Dependent Variable: ip_{it}			E_{it} and α^*_{it} as exogenous instruments				E_{it} and α^*_{it} as endogenous instruments			
	OLS	FE	DIFF-GMM $(t-2)$	DIFF-GMM $(t-3)$	SYS-GMM $(t-2)$	SYS-GMM $(t-2)$	DIFF-GMM $(t-2)$	DIFF-GMM $(t-3)$	SYS-GMM $(t-2)$	SYS-GMM $(t-2)$
α_{it}	-0.852***	-1.091***	-1.090***	-1.112***	-0.802***	-0.826***	-1.114***	-1.032***	-0.790***	-0.791***
	(0.174)	(0.169)	(0.151)	(0.160)	(0.205)	(0.227)	(0.156)	(0.182)	(0.230)	(0.234)
α_{it-1}	0.885***	0.337	0.348	0.264	0.811***	0.812***	0.276	0.117	0.804***	0.802***
	(0.181)	(0.279)	(0.234)	(0.230)	(0.215)	(0.215)	(0.248)	(0.293)	(0.237)	(0.237)
E_{it}	-0.143	-0.135	-0.136	-0.205	-0.167	-0.173	-0.262	-0.317	-0.178	-0.233
	(0.376)	(0.380)	(0.325)	(0.374)	(0.393)	(0.443)	(0.407)	(0.423)	(0.463)	(0.499)
E_{it-1}	0.671	0.718	0.703	0.554	0.754	0.710	0.627	0.421	0.568	0.616
	(0.532)	(0.727)	(0.659)	(0.574)	(0.724)	(0.779)	(0.613)	(0.615)	(0.771)	(0.756)
w_{it}	0.371	0.486	0.528	0.595	0.43	0.450	0.451	0.521	0.528	0.457
	(0.316)	(0.322)	(0.356)	(0.407)	(0.492)	(0.399)	(0.292)	(0.370)	(0.422)	(0.373)
w_{it-1}	-0.316	0.014	0.040	0.142	-0.492	-0.405	0.284	0.301	-0.403	-0.389
	(0.371)	(0.454)	(0.425)	(0.439)	(0.489)	(0.475)	(0.370)	(0.351)	(0.447)	(0.431)
α^*_{it}	1.975	2.318	2.294	1.856	2.179	2.147	1.767	0.863	1.842	1.922
	(1.353)	(1.755)	(1.548)	(1.688)	(1.651)	(1.788)	(1.556)	(1.978)	(1.851)	(1.714)
α^*_{it-1}	-2.085	-2.801	-2.778	-2.726	-2.161	-2.208	-2.432	-2.094	-2.018	-2.034
	(1.425)	(2.492)	(2.155)	(2.264)	(1.682)	(1.730)	(2.199)	(2.056)	(1.793)	(1.651)
ip_{it-1}	0.965***	0.622***	0.628***	0.604***	0.918***	0.932***	0.600***	0.579***	0.934***	0.933***
	(0.020)	(0.103)	(0.090)	(0.103)	(0.021)	(0.024)	(0.104)	(0.118)	(0.023)	(0.026)
n	150	150	140	140	150	150	140	140	150	150
Instruments			129	120	173	172	129	120	195	194
Sargan Statistic			112.2	108.08	130.77	129.5	108.886	104.583	146.490	143.690
p-valor (Sargan)			0.322	0.208	0.869	0.874	0.404	0.282	0.921	0.937
p-valor (Diff-Sargan)					1.000	1.000			0.998	0.999
p-valor $(AR(1))$			0.043	0.041	0.054	0.06	0.04	0.032	0.061	0.061
p-valor $(AR(2))$			0.166	0.162	0.153	0.167	0.188	0.144	0.146	0.165
β_α	-0.663***	-0.857***	-0.810***	-0.741***	-0.783***	-0.948***	-0.808***	-0.507***	-0.983***	-0.585***
	(0.134)	(0.106)	(0.092)	(0.080)	(0.088)	(0.104)	(0.081)	(0.097)	(0.107)	(0.122)
β_E	0.041	0.042	0.233	0.230	-0.061	-0.100	0.233	-0.562***	1.324***	-0.382
	(0.351)	(0.147)	(0.168)	(0.186)	(0.328)	(0.302)	(0.177)	(0.137)	(0.322)	(0.409)
β_w	0.265	0.051	-0.116	0.040	0.206	0.332	0.168	0.602***	-0.623***	0.787***
	(0.302)	(0.162)	(0.153)	(0.150)	(0.214)	(0.215)	(0.164)	(0.216)	(0.245)	(0.250)
$\beta_{\alpha*}$	1.696***	1.682***	1.862***	1.554***	1.919***	1.417***	1.495***	0.895***	2.454***	1.828***
	(0.501)	(0.523)	(0.470)	(0.408)	(0.375)	(0.201)	(0.388)	(0.383)	(0.219)	(0.224)
ρ	0.980***	0.870***	0.888***	0.861***	0.961***	0.955***	0.864***	0.839***	0.951***	0.992***
	(0.012)	(0.059)	(0.054)	(0.040)	(0.007)	(0.006)	(0.044)	(0.039)	(0.007)	(0.010)
p-valor (COMFAC)	0.267	0.000	0.000	0.014	0.060	0.110	0.025	0.000	0.000	0.000

Notes:
(i) DIFF-GMM indicates that the models is GMM in differences and SYS-GMM indicates that models is system GMM.
(ii) the models in columns 3 and 7 include $t-2$ and earlier lags as instruments and models in columns 4 and 8 include as instruments $t-3$ and earlier lags.
(iii) the models in columns 5 and 9 include $t-2$ and earlier lags as instruments in equation in differences and $t-1$ as instruments in the equation in level.
(iv) the models in columns 6 and 10 include $t-2$ and earlier lags as instruments in equation in differences and $t-1$ as instruments in the equation in level, with exception of labor productivity variables where we consider $t-2$ as instrument in equation in levels.

Our estimated models related to these group have also evidenced that lagged instruments are weak in first difference equation on the method of GMM in differences given that coefficient of dependent variable is near to the fixed effect coefficient. On the other hand, Sargan tests do not indicate that the over-identifying restrictions are valid for all GMM models. Additionally, difference Sargan test also reveals that additional moment condition used in system GMM is accepted at 10% level.

All this aspects reveals that system GMM again yields preferable estimates. However, different from all sectors models, the composition of instruments may change considerably the results of restricted models. Notice that, the validity of the restrictions imposed by minimum distance estimation is conditioned to it. Basically the model that only accepts the imposed restriction is the model in column 6. In that case, we assume that E_{it} and y^*_{it} are exogenous variables.

Even if we take account the last model described in column 10 where the structure of lags is identical to the model in column 6, but all variables are considered endogenously, there are no substantial changes on the mainly results. The domestic productivity impact is significant and negative. The estimated coefficient of the foreign productivity index is positive and significant at 10% level and again has the largest impact among variables. The unique difference is related to the proxy of wage coefficient that is not significant in the model described in column 6.

The relevant aspect is the fact that although exchange rate impact is negative as expected, its coefficient is not significant at 10% level. It is means that import penetration of the intermediate and capital good sectors is insensitive to the exchange rate. This explain why, when we consider all manufacturing sectors, exchange rate has a limited impact on import penetration coefficient when compared to the labor productivity.

Notice that, although the fact that the impact of exchange rate is inelastic for these group of sectors is an important empirical finding and reveals that the presence of imported inputs may explain this aspect, it does not confirm that the second order effect of the theoretical model is valid. The confirmation that imported input is relevant for explaining the differential of labor productivity and exchange rate impacts demands that, additionally, the exchange rate elasticity have to be conditioned to the the some measure for the ratio of imported inputs on total inputs used in these sectors. In empirical terms, it means that we also should incorporate to the model a variable that is the interaction between exchange rate and the imported input ratio measure. Consequently, it is expected that the coefficient of these interaction will be positive, i.e., as long as imported input ratio increases it necessarily reduces the impact of exchange rate on the import penetration.

Table 5 presents the results of the restricted models[3] and include in its specification the interaction between effective real exchange rate variable and the ratio between the total value of imported input and the value of total inputs (domestic and imported) used in the production by the sector as a whole obtained by input-output matrices data estimated by three different sources, Freitas et al (2012), Guilhoto and Sesso Filho (2010) and Martinez (2015). All authors estimate the input-output matrices for the period among 2000 and 2009 for several sectors inclusive those treated here. Only the matrices of 2000 and 2005 are official and provided by IBGE. The imported input ratio ϕ_i therefore is computed as the average of the available ratios, thus, it means that it is fixed along the years and varies according to the sector [4].

According to the tests of adequacy associated to unrestricted models in Table 5 we may not find further problems related to serial correlation as well as problems related to the validity of instruments. Again, SYS-GMM demonstrated being the preferable model given that the p-values of Diff-Sargan tests reveals that the hypothesis of additional set of instruments is not rejected.

In general, the addition of the variable of interaction do not change considerably the impacts of other variables specially the differential of elasticity between domestic labor productivity and exchange rate. Otherwise, the models estimated by data from Guilhoto and Sesso Filho (2010) tend to overestimate the coefficient of interaction as shown in columns 3 and 6 as well as it makes the real wage coefficient insignificant in the former model. Nevertheless, the COMFAC test reveals that the imposed restriction is not valid for these models as well as for all models that consider exchange rate and foreign labor productivity as exogenous variables.

On the other hand, COMFAC tests also reveals that imposed restriction is accepted for models that consider exchange rate and foreign labor productivity as endogenous and make use of input-output matrices database from Freitas et al (2012) and Martinez (2015). Interesting to note that the results are practically identical between the two models.

That said, through the results of Table 5 it is possible to confirm our preliminary hypothesis that the reduced elasticity of exchange rate on import penetration is related to the participation of imported input on the total

[3]To save space the estimated coefficients of unrestricted model that are estimated by SYS-GMM is not shown on Table 5.

[4]Our option for using a fixed imported input ratio based on the avarage ratios of the period among 2000 and 2009 is explained by the fact that there is no input-output matrix estimation for 2010 and 2011. Furthermore, despite the fact that Guilhoto and Sesso Filho (2010) have estimated input-output matrix for the first 4 years (1996-1999), they just only cover 13 sectors. Given this aspects, we have prefered to proxied imported input ratio by a fixed value along all the period in analysis than lose precious information related to the sectors and time.

Table 5: Restricted Models Estimates - iteration between exchange rate and imported input ratio

	E_{it} and α^*_{it} as exogenous instruments			E_{it} and α^*_{it} as endogenous instruments		
	Input Imported Ratio by sector - ϕ_i					
	Freitas et al (2012)	Martinez (2015)	Guilhoto and Sesso Filho (2010)	Freitas et al (2012)	Martinez (2015)	Guilhoto and Sesso Filho (2010)
n	255	255	255	255	255	255
Instruments	244	244	244	288	288	288
Sargan Statistic	241.89	242.09	244.64	263.41	263.16	272.69
p-valor (Sargan)	0.138	0.136	0.113	0.481	0.486	0.328
p-valor (Diff-Sargan)	0.993	0.993	0.992	0.993	0.994	0.964
p-valor ($AR(1)$)	0.024	0.024	0.021	0.025	0.025	0.021
p-valor ($AR(2)$)	0.167	0.166	0.154	0.161	0.160	0.146
β_α	-0.619***	-0.619***	-0.600***	-0.799***	-0.800***	-0.826***
	(0.113)	(0.113)	(0.110)	(0.114)	(0.114)	(0.112)
β_E	-0.378***	-0.374***	-0.390***	-0.386***	-0.390***	-0.415***
	(0.037)	(0.039)	(0.059)	(0.043)	(0.043)	(0.063)
$\beta_{E\times\phi}$	1.280**	1.252***	2.571***	2.152***	2.188***	3.230***
	(0.519)	(0.510)	(0.798)	(0.491)	(0.489)	(0.918)
β_w	0.468***	0.463***	0.209	0.398***	0.391***	0.316**
	(0.164)	(0.162)	(0.155)	(0.140)	(0.139)	(0.130)
$\beta_{\alpha*}$	1.807***	1.782***	1.518***	1.232***	1.230***	1.148***
	(0.200)	(0.198)	(0.184)	(0.104)	(0.101)	(0.116)
ρ	0.996***	0.996***	0.996***	0.979***	0.979***	0.978***
	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.004)
p-valor (COMFAC)	0.001	0.001	0.000	0.225	0.190	0.021

(i) All models are estimated by SYS-GMM.

(ii) All models include t-2 and earlier lags as instruments in equation in differences and t-1 as instruments in the equation in level, with exception of labor productivity variables as well as the interation between exchange rate variable and imported input ratio where we consider t-2 as instrument in equation in levels.

inputs. As expected, the coefficient of the interaction between effective real exchange rate and input imported ratio by sector ($\beta_{E\times\phi}$) is positive and significant for all models. Thus, a higher level of imported inputs ratio in a specific sector implies that exchange rate is less sensitive to import penetration. For instance, the sectors of consumption goods, on average, has an imported input ratio of about 0.08 meaning that the elasticity of exchange rate is near to -0.21 considering models in column 4 e 5. On the other hand, the group of intermediate and capital good sectors has a ratio of 0.16. As a consequence, the elasticity of exchange rate is near zero, equal to -0.04, a much smaller value than the group of consumption goods. It is in line with the results of Table 4 where the elasticity of exchange rate is small and statistically non-significant. In fact, the level of imported inputs ratio matters for explaining the differential of elasticities.

Notice that when the imported inputs ratio is null, the influence of exchange rate on penetration coefficient is still lower than the impact of labor productivity. Considering again the model in column 4, even when the imported inputs ratio is zero the elasticity of exchange rate is -0.386 against -0.799 from labor productivity, i.e., the values differs.

At first moment, these aspect does not invalidate our results though it means that could exist other factors that influence the sensitiveness of exchange rate on import penetration than the participation of imported input in total input used in the final production. In this sense, we just only confirm that the presence of imported inputs on production partially influence the impact the exchange rate and most relevant in substantial way.

Furthermore, it is important to point out that although theoretical model predicts that those elasticities have the same magnitude, it depends on the functional form that we initially assume. Thus, what is important here is that our empirical findings are in accordance with the mainly results of the micro model that is independent of initial conditions, i.e., the signs of all estimated elasticities is coherent with the theory and that imported input ratio matters for explaining the differential of impacts between exchange rate and labor productivity.

7 Final Considerations and Policy Analysis

According to our empirical findings labor productivity is more important than exchange rate for explaining import penetration given the period in the recent years. This aspect confirms the view supported by Bonelli and Pessoa (2010) and Ferreira and Fragelli (2011) that the recent progress of imports on Brazilian domestic market is broadly related to the productivity. As we presented before, labor productivity elasticities are considerably superior to the elasticity of exchange rate. The effect of domestic labor productivity on import penetration is at least three times larger than the exchange rate, a huge difference. Foreign labor productivity, on the other hand, has the prevalent influence indicating that there are other distinguished aspects that helps to explain the presence of imported goods on domestic market that do not depend on national economic policies.

Most important is that the differential of impacts is a consequence of the inelasticity of exchange rate to the coefficient of imports from intermediate and capital goods sectors. These inelasticity is supported by the fact that intermediate and capital goods sectors group have a higher level of imported inputs in the final production. Our results revealed that exchange rate elasticity is lower as higher is the participation of imports in the total inputs of the sector.

The consequences of the reduced exchange rate effectiveness may be observed when we make an exercise of simulation by using the coefficients estimated from unrestricted model described in the last column of Table 3. We have simulated trajectories of productivity and exchange rate that is required to generate different import penetration scenarios considering the period after 2003. As we said before it is a distinct period and deserves attention because exchange rate suffered an intense process of appreciation of about 62%. Associated to this, Brazilian manufacturing labor productivity had a poor growth performance. A combination of huge appreciation with poor productivity performance promoted a massive increase of imports on domestic market.

Scenario 1 consists of forecasts of average levels of import penetration for 2004-2011 considering a constant annual growth rate for labor productivity of 2.5% and of 0% for exchange rate. Scenario 2 is the opposite, i.e., a constant annual growth of 0% for labor productivity and 2.5% for exchange rate. In all scenarios we made use of the observed wage and foreign labor productivity indexes series for the period as well as the estimated fixed effect. The statistics of the simulations are shown in Table 6.

As expected, when we impose the same annual growth rate for both variables considering scenarios where the opposite variable is fixed during all the period, the average level of import penetration is lower when domestic labor productivity has a positive and constant growth. In these hypothetical scenario the difference in terms of average levels of import penetration is about 1.4% and 2.7% in terms of final value.

Otherwise, it is also interesting to calibrate the labor productivity or exchange rate path that is necessary to reach some specific average level of import penetration. This is an important feature in terms of policy. In other words, given that government has two variables of policy it should find out what are more efficient for reducing the

Table 6: Different Scenarios

	Import Penetration (/ 100)			Labor Productivity (% p.y.)		Exchange Rate (% p.y.)		
	Mean	SD	Final Value	Mean	SD	Mean	SD	Final Value (in level)
Actual import penetration (1996-2003)	0.088	0.019	0.110	0.5	4.2	8.3	17.2	1.9
Actual import penetration (2004-2011)	0.123	0.009	0.148	1.4	8.7	-10.9	8.7	0.7
Scenario 1 (2004-2011)	0.096	0.012	0.084	2.5	0.0	0.0	0.0	1.9
Scenario 2 (2004-2011)	0.110	0.008	0.111	0.0	0.0	-2.5	0.0	0.4
Scenario 3 (2004-2011)	0.110	0.009	0.066	4.5	0.0	-10.9	8.7	0.7
Scenario 4 (2004-2011)	0.110	0.013	0.066	1.4	8.7	-4.0	0.0	1.3
Scenario 5 (2004-2011)	0.088	0.012	0.079	11.2	0.0	-10.9	8.7	0.7
Scenario 6 (2004-2011)	0.088	0.018	0.111	1.4	8.7	8.3	0.0	3.6

Notes: SD standard deviation of simulations

participation of manufacturing imports on domestic market. This is the case of further scenarios.

Scenarios 3 and 4 are assumed respectively that labor productivity as well as exchange rate are exogenous and have a constant annual growth rate that is enough to generate an average level of import penetration compatible with a 2003 value, i.e., a mean of 0.11 (a target of 11% in the import penetration index) for the period between 2004 and 2011. It means an reduction superior than 1 percentage point in the actual import penetration average level of 0.123. In the case of Scenario 3 where no restriction on the exchange rate growth rate is imposed it was necessary that labor productivity should have had a constant growth of 4.5% per year. When we execute the same exercise considering now only exchange rate as the policy variable it would be necessary a annual appreciation rate of only 4.0% per year for achieving the 2003 imports participation target as we observe in the results of scenario 4.

Imposing a more constrained scenarios, i.e., an average level target of 1996-2003 in import penetration (8.8 percentage points), the labor productivity growth should had been 11.2% per year according to Scenario 5 whereas exchange rate should have had an appreciation rate of 8.3% each year as observed in Scenario 6.

Notice that different from Scenarios 3 and 4 the last two scenarios are not feasible in terms of policy. It is very difficult to promote policies that yield a labor productivity growth of about 11.2% per year. This is also true and more complicated in the case exchange rate. During the period of analysis we have seeing a huge appreciation of the Brazilian real exchange rate. In this case, not only should the government had made real exchange rate devaluation but with a magnitude of about 90 percentage points if we consider the final value of 2011 against the 2003 value. Certainly this policy would had perverse consequences in terms of all economy especially if the nominal exchange rate was the variable of policy.

A huge reduction on import penetration would have demanded not feasible actions when we consider labor productivity or exchange rate as exclusive variables of policy. There are other aspects that explain the invasion of imports on Brazilian domestic market as we said before, foreign labor productivity and fixed effects of sectors that is not manageable in terms of policy. The average growth of foreign labor productivity was 3.3% per year between 2004-2011. For instance, whether instead the foreign labor productivity have had a growth of 0% per year, the average level of Brazilian import penetration would have been almost 2 percentage points lower.

8 Conclusion

This paper evaluated the influence of Brazilian labor productivity and exchange rate on the participation of imports on the domestic consumption of manufacturing sectors measured by import penetration. We evidenced empirically that the importance of labor productivity is superior to real exchange rate. Furthermore, as predicted by our theoretical model, differences of impacts may also be explained by the presence of foreign inputs in the Brazilian manufacturing production. As long as the sector has a higher participation of imported input on the total of inputs used in production lower is influence of exchange rate on the import penetration is reduced.

The import penetration of the sectors of intermediate and capital goods is a special case given that the group is inelastic to the real exchange rate. As we pointed out, these sectors has the largest participation of foreign input in domestic production when compared to the sectors of consumption goods.

In light of our empirical findings it is possible to conclude that economic policies based on real devaluation influence the level of import penetration in a moderate way when compared to a policy of increasing domestic labor productivity. This conclusion challenges the view that the principal problem faced by Brazilian manufacturing industry was the appreciation of national currency (real) in relation to the others trade partner currencies. Furthermore, our results also confront the policy prescription for solving this problem.

It is strictly recommended a discretionary policy of currency exchange rate devaluation until a optimum specific value. However, there are some drawbacks regarding to this prescription. It is commonly accept that making a real devaluation by an discretionary increase of nominal exchange rate is not easier because of exchange rate pass-through to final prices. In other words, it is not easy make a real devaluation of a currency through nominal devaluation.

Secondly, an extension of our results indicates that for such economic policy be effective it should focus specially on sectors with low imported input ratio which is extremely difficult. Otherwise, whether that policy also impacts the sectors associated to the group of intermediate and capital goods, the impact over import penetration is practically zero and may only affect their input costs. As a results, the elevation of the cost of capital goods could cause a decline in the level of investment on the economy.

Finally, not only are labor productivity and exchange rate responsible for the massive increase of import penetration. Factors as trade partner productivity and other fixed effect related to sectors are also import. In this sense, some policy target could be not feasible as for example reaching again the average level of import penetration of the period 1996-2003 as we demonstrated previously.

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