INTRA-INDUSTRY TRADE: ANALYSIS OF THE SMOOTH ADJUSTMENT HYPOTHESIS WITH RESPECT TO BRAZIL[1]

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The aim of this study is to analyze the smooth adjustment hypothesis (SAH) for the Brazilian economy during the period from 1997 to 2008. This study incorporates two approaches to the construction of the variable for labor market adjustment. Theoretically, we expect an inverse relationship between marginal intra-industry trade and the movement of workers in the industries that engage in foreign trade. Therefore, we use the econometric approach and dynamic panel data. The empirical results show that the hypothesis does not hold true for Brazil in the period examined.

Keywords: intra-industry trade; trade flows; displacement of workers; dynamic panel data.

COMÉRCIO INTRA-INDÚSTRIA: ANÁLISE DA HIPÓTESE DE AJUSTE SUAVIZADO PARA O BRASIL

O trabalho tem como objetivo analisar a hipótese de ajustamento suavizado (SAH) para a economia brasileira no período entre 1997 a 2008. Este estudo incorpora duas abordagens para a construção da variável de ajustamento do fator trabalho. Teoricamente, espera-se uma relação inversa entre o comércio intraindústria marginal e o movimento de trabalhadores nas indústrias engajadas no comércio externo. Para tanto, utilizou-se a abordagem econométrica de dado em painel dinâmico. Os resultados empíricos mostram que a hipótese de ajustamento suavizado não se confirma para a economia brasileira no período analisado.

Palavras-chave: comércio intraindústria; fluxo de comércio; deslocamento de trabalhadores; dados em painel dinâmico.

JEL: F12; F16; J62.

1 INTRODUCTION

The impact of greater trade openness or an adverse shock in an economy means that there is a reallocation of employment in industries in the short-term. Balassa (1966) was one of the pioneers to discuss this issue by showing that when there is greater trade openness, industries with intra-industrial characteristics have an advantage due to the lower cost of adjustment. Considering that intra-industry trade flow is characterized by the low cost of adjustment in the pre-existing productive structures (Brülhart and Elliott, 2002), the intra-industry trade expansion implies

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a soft reallocation of resources and, therefore, low cost of transition. According to these authors, considering two small and open economies that suffer a demand shock due to a reduction in trade protection, their relative prices would be impacted and would act as a signal for resources to move from one sector to another. If this shock provokes an increase in imports in the competition of a certain industry, this will cause a reduction in the demand for factors of production of this sector. Thus, assuming work as the factor that most reacts in the short term, it will tend to feel the first effects of the cost adjustment pressure. The exact impact will depend on the structure of the labor market, but overall it will be a combination of a change in wages and employment. Since this observation, several authors such as Brülhart (1999, 2002), Brülhart and Thorpe (1999), Cabral and Silva (2006), Erlat and Erlat (2006), Faustino and Leitão (2009), and Thorpe and Leitão (2011), among others, have investigated the smooth adjustment hypothesis (SAH).[5]

A question that seeks a better understanding of the hypothesis is the establishment of a measure for evaluating adjustment costs, which has led to disagreements about the implications of intra-industry trade (IIT). In particular, Cabral and Silva (2006) proposed a new variable of adjustment cost in order to ascertain a less biased analysis.

The analysis is guided by IIT, particularly in manufacturing industries, and the importance of this industry in the development of Brazil has been growing over time. In this context, considering that empirical evidence for the SAH with respect to the Brazilian economy was not found in the reviewed literature, the objective of this study is to assess the impact of trade on the intra-industry adjustment of workers in sectors from the manufacturing industry in Brazil from 1997 to 2008.[6] Specifically, the purpose is also to discuss adjustment costs by focusing on a new variable to measure the effects of job change in the Brazilian industry, as proposed by Cabral and Silva (2006). To achieve the proposed objectives, we adopt a dynamic panel methodology to conduct a longitudinal analysis over a period of 12 years, following the movement of workers within the same sectors of the manufacturing industry throughout the analysis period.

This study is expected to expand the understanding of the subject in the context of the national and international literature *i*) by bridging the gap in the literature on the SAH in Brazil, which is a country with great potential for growth and ranks among the 20 largest exporters and global importers, and *ii*) by broadening its scope and comparing the two measures of the evaluation of adjustment cost by using the variable proposed by Cabral and Silva (2006) and Brülhart and Elliott (1998).

5. The SAH assumes that the higher the proportion of IIT type, the shorter is the distance of the movement of workers and the lower is the cost of adjustment resulting from this stream of commerce.

6. The period considers the maturing of the process of trade liberalization from the productivity growth in the beginning of the 1990s to until the beginning of the international financial crisis in 2008.

The remainder of the paper is organized as follows: in Section 2, the theoretical framework and a review of the empirical literature on the hypothesis-related adjustment are presented. Section 3 describes the methodology and the database used, while Section 4 presents the main results. Lastly, the concluding remarks are provided in Section 5.

2 THEORETICAL AND EMPIRICAL FRAMEWORK

In the model of monopolistic competition with production specialization in different varieties of products, each country will export different kinds of products to each other. Therefore, this type of flow of commerce trade is referred to as intra-industry (Dixit and Stiglitz, 1977; Krugman, 1981). Complete specialization and IIT do not occur in the Heckscher–Ohlin model with two sectors: Countries can produce the same sectors, but export or import occurs in each industry or sector and not in both sectors/industries.[7]

According to Brülhart (2002), the flow characteristic of IIT is the low cost of the adjustment of pre-existing productive structures. Hence, instead of having sectoral specialization across countries, as provided by the Heckscher–Ohlin model, national economies seem to preserve their broad industrial structures and predominantly specialize at an intra-sectoral level.

According to Brülhart and Elliott (2002), the expansion of IIT implies a smooth reallocation of resources, and thus low cost adjustment factors resulting in the movement of this stream of commerce. This proposition is known in the literature as the SAH.[8] According to these authors, the understanding of the SAH can be obtained when it assumes a demand shock (e.g., a reduction of tariff barriers) in two small open economies. This shock can affect relative prices, acting as a flag to the movement of resources from one firm to another within the same industry.[9] With reduced rates, there is an increase in imports by some firms and exports by others. The first factor that will experience the effects will work, because it is the factor that responds to changes in the short-term. The actual impact will depend on the structure of the existing market, but, in general, this will be a combination of the change in earnings and employment.

7. Moreover, from the analysis of the Heckscher–Ohlin model of continuous goods, in the case of real numbers greater than factors, we have complete specialty products at different prices when the factors are not equal (Feenstra, 2004, chap. 3).

8. Balassa (1966) studied the trade of the European Economic Community and realized that the adjustment was more understated where IIT prevailed, because the capital/labor ratio is likely to be more similar to inter-industry than intra-industrial structures.

9. For this work, we consider the industry classification CNAE with a maximum of three digits; however, in the compatibility of databases, there exist some industries with four digits. These firms are part of an industry.

The central idea of the SAH is the assumption that the greater the proportion of new commerce, intra-industry type, the smaller is the relative cost of adjustment. Brülhart (2002) explained that adjustment costs arise from temporary inefficiencies when there are changes in demand or supply. More specifically, adjustment costs that are studied in the context of expanding trade are those for which the welfare loss is temporary unemployment due to labor market rigidities in the factor prices or costs incurred by job search relocation or the retraining of workers.

The analysis of the SAH lists three possible reasons for IIT implying a lower cost of adjustment: *i*) labor mobility between firms and occupations may be greater within industries than between industries; *ii*) relative wages are more flexible within industries than between industries; and *iii*) other factors of production can be more mobile within industries than between them.

With respect to the empirical verification of the SAH, Brülhart and Thorpe (1999) analyzed the expansion of trade in the high-growth period 1970–1994 in Malaysia and its implications in labor market adjustment. An econometric methodology was adopted to analyze panel data with fixed effects. The main conclusion was that the data for Malaysia did not support the notion that high marginal intra-industry trade (MIIT) is negatively related to job changes.

Brülhart (2000) investigated the dynamic aspects of the SAH associated with MIIT in Ireland during the period 1977–1991, aiming to clarify three important points on the subject. First, to review the importance of using MIIT rather than the traditional IIT index to analyze the adjustments to conclude that the signs of the MIIT estimates agree with those expected in the literature and are significant, and that the IIT index is not statistically significant. Second, to discuss the appropriate choice of the time horizon to calculate MIIT both conceptually and on the basis of the empirical results, reaching the conclusion that the data are best with the least amount of time – year after year intervals. Third, to investigate the relative time of trade and changes in the labor market, assuming different lag structures, with the results suggesting that the labor market effects follow changes in trade structure with a one-year lag.

Greenaway, Haynes, and Milner (2002) studied the relationship between the flow of foreign trade and the labor market of the United Kingdom between 1982 and 1998 and found the occurrence of relative changes when considering employment at the industry, firm, occupation, and regional level. They then related this incidence of job adjustment "within industries/sectors" on any of these dimensions to the characteristics of the labor market indicators and trade exhibition. To do this, they used a panel approach with a fixed effects model. The main findings of their work are that the overall result is not consistent with the notion that there is a systematic relationship between the type of trade expansion (inter-or intra-industry) and type of adjustment (adjustment between or within industries). Further, there is less adjustment in the labor market associated with intra-industry than the associated inter-industry.

Brülhart and Elliott (2002) studied the link between trade and labor market changes in the manufacturing industry in the United Kingdom during the period 1979-1991. For this purpose, they used measures to evaluate the variability of unemployment at the industry level and variability of wages, relating these measures to IIT. Their evidence supported the SAH.

Brülhart, Murphy, and Strobl (2004) investigated the SAH with respect to Ireland and used the turnover of workers in IIT as the dependent variable. Their study covered the period from 1979 to 1990 with 64 Irish manufacturing industries. To estimate the model, they used panel data with fixed effects and GMM to lag behind the dependent variable and include in the model. The results showed a positive and statistically significant MIIT with the dependent variable, giving empirical support to the SAH.

Brülhart, Elliott, and Lindley (2006) tested whether the expanding intra-industry in the United Kingdom was related to the displacement of intra-sectoral workers during the period from 1986 to 2000. They used both IIT and MIIT as indexes, and in both cases, the sign was found to be negative, confirming the SAH.

Erlat and Erlat (2006) investigated the SAH for manufacturing industries in Turkey during the years 1974-1999. The study periods were divided into 1974-1975 and 1998-1999. For the adjustment of the cost proxy, the same variable proposed by Brülhart and Thorpe (2000) was used; however, the study result contradicted the SAH, obtaining a positive MIIT with a statistically significant cost adjustment. To perform the estimation methodology, the authors used panel data with fixed effects.

Cabral and Silva (2006), while looking for evidence of the SAH for manufacturing industries in Portugal, found that various studies of the subject have been inconclusive due to the improper use of a measure of cost adjustment. Thus, the authors proposed an alternative measurement of the variable cost of employment adjustment. The motion variable is most appropriate for capturing the possibility that adjustment costs are lower with IIT. According to the authors, the expansion of trade may entail a variation not only in total demand for labor, but also in the composition of labor demand in each industry. Thus, the new variable considers the proposed relocation on the job due to the change in the composition of the workforce in each industry and changes in the level of total employment in each industry, eliminating the labor movement that is not associated with the changes induced by trade.

Faustino and Leitao (2009) tested the SAH for manufacturing industries in Portugal from 1996 to 2003. They employed the MIIT index used by Brülhart (1994) as the dependent variable and the change in the total employment of manufacturing industries and developed a dynamic panel model to perform the data analysis. The results obtained in some analyses confirmed the SAH and not others, considering the contemporaneous effects, and the findings did not support the SAH. However, when considering one- and two-year lag effects, the results were different and sensitive to the size of the gap. The comparison of the results of empirical studies by these authors suggested that the validity of the SAH depends on the choice of variable cost index adjustment work, the structure of the time lag, and the set of control variables.

Rasekhi and Ghaderi (2012) investigated the SAH by using a panel for manufacturing industries in Iran for the period 2001-2006. They made the distinction between total vertical and horizontal IIT and used the variable proposed by Cabral and Silva (2006) as a proxy for cost adjustment. Their results did not show statistical significance for the country, as confirmed by the SAH study; however, when there was differentiation between vertical and horizontal IIT, the hypothesis was confirmed.

Through this literature review, it was observed that in developed economies such as Ireland, Portugal, and United Kingdom, the SAH is verified, while it is not supported in developing economies such as Iran, Malaysia, and Turkey. One way to understand this likely dichotomy is that developing economies benefit from trade through a greater structural change of exports and that advanced economies may be closer to their technological frontier. The analysis of another developing economy (i.e., Brazil) strengthens the motivation to broaden the basis of studies contributing to an increased empirical understanding of the topic.

3 METHODOLOGY

3.1 Empirical model

Initially, to test the SAH due to the flow of trade to the Brazilian economy, we analyze the following relationship:

$$ET_{j,t} = f(MIIT_{j,t}, GA_{j,t}, GA\_MIIT_{j,t}, AD_{j,t}, S_{j,t}) \quad (1)$$

where the subscript j represents the industry, t denotes time analysis, ET_j is the total effect of the variation of workers, $MIIT_{jt}$ is MIIT, GA_{jt} is the degree of the exposure of the economy, GA_MIIT_{jt} is the interaction between degree of exposure and MIIT, AD_{jt} is the variation in apparent demand, and S_{jt} is the share of skilled workers relative to the total workforce. As a proxy qualification, this work uses the schooling of the worker with a college degree.

Cabral and Silva (2006) proposed measuring the magnitude of the cost adjustment, which is the total effect (ET_j) of the reallocation of workers. That is,

$$ET_{jt} = DE_{jt} + CE_{jt} \tag{2}$$

where DE_j denotes the effect size and represents net workers in the industry and CE_j indicates the effect of composition, that is, the net of workers in the industry as an absolute value. Thus, in Eq. (3) the cost adjustment will be equal to the sum of the net changes in workers with qualifications (in absolute value) weighted by the average total number of workers employed in the industry in the period:

$$ET_{jt} = \frac{\left|L_j^1 - L_j^0\right|}{\left(L_j^0 + L_j^1\right)\times 0.5} + \frac{\left(\sum_k \left|L_{jk}^1 - L_{jk}^0\right|\right) - \left|L_j^1 - L_j^0\right|}{\left(L_j^0 + L_j^1\right)\times 0.5} = \frac{\sum_k \left|L_{jk}^1 - L_{jk}^0\right|}{\left(L_j^0 + L_j^1\right)\times 0.5} \tag{3}$$

where L corresponds to workers and the subscripts j and k represent the industry workers (j = 1,...,81) and qualifications (k = full graduation, incomplete graduate, and high school), respectively. The 1 and 0 superscripts correspond to year 1 and year 0, respectively. L_{jk}^1 and L_{jk}^0 are the number of skilled workers (k) of industry j who were present in the initial and final years, respectively. This variable will be zero if there is no change in skilled workers from one year to another.

Regarding the independent variables of the specified empirical model, Eq. (1), must comprise two elements: a variable representing the MIIT index and a set of variables to control for other exogenous influences on ET_{jt}. According to Brülhart (1994; 2000) MIIT is more appropriate for the analysis of the SAH than the traditional static intra-industry trade index IIT developed by Grubel and Lloyd (1975). Thus, considering the literature on the subject in this work, we used only MIIT.

The construction of this variable is based on that described by Brülhart (1994; 2000). That is,

$$MIIT_j = A_j = \sum_{i=1}^{j} \left(w_i \times A_i\right) \tag{4}$$

and

$$w_i = \frac{\left|\Delta_I X_t\right|_i + \left|\Delta_I M_t\right|_i}{\sum_{i=1}^{j}\left(\left|\Delta_I X_t\right|_i + \left|\Delta_I M_t\right|_i\right)};\ A_i = 1 - \frac{\left|\Delta_I X_{ti} + \Delta_I M_{ti}\right|}{\left|\Delta_I X_t\right|_i + \left|\Delta_I M_t\right|_i} \tag{5}$$

where Δ denotes changes in constant prices, t indicates the base year, I indicates the length of the time interval between the base and end years; i denotes the level of industry disaggregation,[10] and X and M represent exports and imports, respectively.

MIIT has the same interpretation as IIT, that is, when the MIIT index is zero, marginal trade is exclusively inter-industry, and when the index is one, it is entirely intra-industry. According to Brülhart (2000), one methodological issue is the choice of the time interval for the calculation of MIIT measures. The author stated that "there is no systematic relationship between the A index calculated over a certain time interval and A indices calculated over constituent subintervals" (Brülhart, 2000, p. 243). A way to mitigate this issue is to work with the smallest possible interval. Therefore, we calculate Eq. (5) over one-year intervals.

According to theory, it is expected that its sign is negative, that is, the higher the proportion of MIIT, the lower is the cost of labor market adjustment. To measure this, the type of trade is assumed to be an intra-industry commerce variable, which is marginally more recommended for this type of study, as proposed by Brülhart (1994).

For the set of variables to control for other exogenous influences on ET_{jt}, the following is a description of these variables as well as their expected signs.[11]

3.1.1 GA_{jt}

This variable, suggested by Brülhart and Elliot (2002), represents the degree of the exposure of the economy and measures the intensity of total trade (exports plus imports) to GDP. That is,

$$GA_j = \frac{\left[\left(X_j + M_j\right)^1 + \left(X_j + M_j\right)^0\right]}{ITV_j^1 + ITV_j^0} \tag{6}$$

where ITV denotes the industrial transformation value, which is a proxy for the production of sector j.

Moreover, the strategy of using this variable allows inferences about other additional assumptions such as higher intensity in trade openness, which affects the cost adjustment in the same way as that presupposed by the SAH (Cabral and Silva, 2006). For this variable, we expect a positive sign, because a higher exposure of economic openness means more competition, which will lead to an increase

10. The industry i was disaggregated in the four-digit level – or denomination "class" – of the CNAE 1.0.

11. No theoretical model is defined in the literature as the best specification. Brülhart and Thorpe (2000) worked with variables in log; however, in the present study, we adopted the variables in levels because this way fit the data better. This sensibility analysis was not included in the text to save space.

in the pressure adjustment of industries (Brülhart, 2000). The studies by Cabral and Silva (2006) and Thorpe and Leitão (2011) showed a positive sign for this variable, corroborating the theory.

3.1.2 GA_MIIT_{jt}

This variable was suggested by Brülhart and Elliot (2002), and it represents the interaction of MIIT with trade exposure. The variable allows the analysis of other additional hypotheses, because a major change in the structure of the stream of commerce exchange affects the cost adjustment in the same manner as that presupposed by the SAH (Cabral and Silva, 2006). This variable is expected to have a negative value, because trade expansion can strengthen MIIT and hence result in a lower cost adjustment.

3.1.3 AD_{jt}

For this variable, which represents apparent industry demand, a negative relationship with the domestic expansion of the movement of workers is expected (Brülhart, Elliot and Lindley, 2006; Cabral and Silva, 2006). Eq. (7) shows the measurement of the variation of AD:

$$\Delta AD_j = \frac{\left[\left(ITV - X_j + M_j\right)^1 - \left(ITV - X_j + M_j\right)^0\right]}{\left[\left(ITV - X_j + M_j\right)^0 + \left(ITV - X_j + M_j\right)^1\right] \times 0{,}5} \tag{7}$$

3.1.4 S_{jt}

This variable represents the share of unskilled workers in the total workforce. That is,

$$S_j = \frac{H_j}{L_i} \tag{8}$$

where *H* and *L* denote the unskilled and total workforce, respectively.

Cabral and Silva (2006) and Brülhart *et al.* (2004) used this variable as a reverse proxy for technological intensity; thus, we expect a positive relationship with labor movement.

3.2 Econometric model

The empirical strategy used was the panel data method often employed in this type of study. This methodology also allows us to analyze manufacturing over time and provides an increase in estimation accuracy because it gives a greater amount of information over time (Cameron and Trivedi, 2005).

This method also allows us to obtain estimators of the variables *MIIT*, *GA*, *AD*, *S*, and *MIIT_GA*, which are consistent even in the presence of unobserved variables that are related to the characteristics of the manufacturing sectors. The no-observed-effect model can be described as shown in Eq. (9):

$$ET_{jt} = \beta_0 + \beta_1 MIIT_{jt} + \beta_2 GA_{jt} + \beta_3 GA\_MIIT_{jt} + \beta_4 AD_{jt} + \beta_5 S_{jt} + c_j + u_{jt} \quad (9)$$

where ET_{jt} represents the dependent variable in sector *j* during year *t*; $MIIT_{jt}$, GA_{jt}, GA_MIIT_{jt}, AD_{jt}, and S_{jt} are the observed explanatory variables that do not change over time, but assume heterogeneous characteristics across industries; c_j is the observed explanatory variable that does not change over time, but assumes heterogeneous characteristics between industries (it is observed that the term is not related to the characteristics of the manufacturing sectors that do not change over time (also known as unobserved heterogeneity)); and u_j corresponds to the idiosyncratic error term.

The econometric strategy for this study consists of an analysis with a static model (which does not allow us to consider the time lag of the dependent variable) and panel data with fixed and dynamic effects compared with a dynamic panel model. This is because the analysis of economic behavior often involves the specification of dynamic econometric models, that is, models with lagged dependent variables. Such time series in which the model is dynamic and estimation methods are based on the ordinary least squares (OLS) method using lags rarely allow estimators to maintain good properties (Harris, Matyas and Sevestre, 2008). Therefore, the dynamic model seems to have an advantage over the other models discussed earlier, and it allows us to analyze the total displacement of workers in an earlier period, affecting the displacement current in the context of the analysis of the SAH.

The dynamic panel used for the analysis is shown in Eq. (10):

$$ET_{jt} = \delta ET_{j,t-1} + \beta_0 + \beta_1 MIIT_{jt} + \beta_2 GA_{jt} + \beta_3 GA\_MIIT_{jt} + \beta_4 AD_{jt} + \beta_6 S_{jt} + c_j + u_{jt} \quad (10)$$

where $j = \{1, ..., 81\}$ and $t = \{1,...,6\}$. The construction $ET_{j,\ t-1}$ is correlated with the no-observed effect of each industry (c_j).

Regardless of the pattern of c_j (being a fixed or a random effect), the OLS estimation of δ and β is inconsistent because the regressor $ET_{j,t-1}$ is correlated with c_j and thus with the composition of the error term ($c_j + u_{jt}$) (Cameron and Trivedi, 2005).

The term c_j could be a random effect, as stated earlier, but the choice of the fixed effects model is generally more appropriate. Judson and Owen (1996) proposed two reasons for this choice: (1) the effects of individual industries represent omitted variables; as a result, specific features of industries may be correlated with other independent variables; and (2) a macro panel is likely to contain more industries of interest, that is, if all the industries of interest in this study were present, no a random sample of the universe of manufacturing industries could be made.

Thus, the first-difference model (10) can be represented by Eq. (11):

$$ET_{j,t} - ET_{j,t-1} = \delta\left(ET_{j,t-1} - ET_{j,t-2}\right) + \left(Z_{j,t} - Z_{j,t-1}\right)\beta + \left(u_{j,t} - u_{j,t-1}\right) \qquad (11)$$

For simplification, Z denotes the regressors $MIIT_{jt}$, GA_{jt}, GA_MIIT_{jt}, AD_{jt}, and S_{jt}, and $t = 1,\ldots,6$. This transformation removes the unobserved effect, keeping only the correlation effect of the lagged variable with the error term in an earlier period. However, without the no-observed effect, the lagged variable becomes a strong instrumental variable estimator (Baum, 2006).

To circumvent the problem of bias in the estimations for OLS (i.e., inconsistent and biased), fixed effects (which is biased), and random effects (also biased), it is necessary to use instrumental variables and instruments for equations in the first-difference predetermined lagged explanatory variables, as proposed by Arellano and Bond (1991).

However, Arellano and Bover (1995), similar to Blundell and Bond (1998), showed that models estimated in first differences by using instruments in levels may be weak instruments. To reduce potential bias generated by the difference estimator GMM, Arellano and Bover (1995) and Blundell and Bond (1998) suggested an estimator that is more sophisticated than that proposed by Arellano and Bond (1991), namely the system GMM. They showed that there is bias in finite samples when using the first-difference estimator and that the system GMM presents stronger results.

The proposed changes include lag level as well as lag difference. The estimation is carried out by combining system-level regressions and instruments are the explanatory variable lags of endogenous differences, that is, ($y_{j,t-1} - y_{j,t-2}$) is the instrument with the regression level.

The second step in the GMM estimation of the standard errors of the difference GMM has shown bias. Hence, to fix this problem, a correction to the Windmeijer finite sample and the standard errors was made.

Importantly, Roodman (2009a) noted that there are two important issues in the estimation. The first is with respect to using time dummies to prevent a recurrence of more correlation across individuals – contemporary effects. The second is that the test depends on the assumption that the sample size (N) is large. The meaning of "large" is not very accurate, but estimates with a panel of N = 20 is a concern.

3.3 Database

The database contains information on 81 Brazilian manufacturing industries.[12] To calculate the number of workers in the sectors used, the entire population of the Annual Report of Social Information[13] (RAIS) for industries, classified as manufacturing according to the criteria of the National Classification of Economic Activities[14] (CNAE) 1.0 and 2.0, totaling 918,310 workers a year, was considered and the data were balanced so that all workers could be observed at any time.

Exports and imports were obtained from the Aliceweb system of the Ministry of Development, Industry, and Foreign Trade (MDIC, 2011). The analysis was restricted to the Brazilian manufacturing industry and the period from 1997 to 2008 due to data availability in RAISMIGRA after trade liberalization. Data for production (industrial transformation value) were obtained from the website of the Brazilian Institute of Geography and Statistics (IBGE, 2011) from the Annual Survey of Industries.

To estimate the econometric model, first it was necessary to ensure that the Aliceweb CNAE 1.0 and 2.0 databases for the period 1997–2008 were compatible. Six two-year periods were generated (1997-1998, 1999-2000, 2001-2002, 2003-2004, 2005-2006, and 2007-2008). To make the Aliceweb system, CNAE 1.0 and CNAE 2.0 were made compatible, and the changes were made to the CNAE 1.0 as the base. The IBGE provided a table of correspondence for CNAE 1.0 with CNAE 2.0. The MDIC had a translator to transform the Mercosur Common Nomenclature for CNAE 1.0.

To build the database, first we withdrew the Aliceweb system's values of exports and imports from Brazil to the rest of the world, and then used the MDIC (2011) translator to select the products that were considered to be manufacturing industry, according to the criteria of CNAE 1.0.

After the separation of the products of the Harmonized System that corresponded to the manufacturing sector, it was found that some products were exported but not imported and vice versa. Thus, we proceeded to ensure the compatibility of imports and exports in order not to lose information from any database.

With the data organized, exports and imports departed from the compatibility of the Harmonized System with CNAE 1.0, with reference to the translator of the MDIC. Compatibility was made with 3903 Brazilian products in international

12. According to CNAE (2003), the manufactoring industry corresponds to the activities that involve the significant mechanical, physical or chemical transformations of materials, substances or components in order to obtain new products.

13. The base RAISMIGRA includes the Ministry of Labor and Employment.

14. The CNAE was structured with reference to the International Standard Industrial Classification of All Economic Activities of the United Nations.

trade. The four-digit CNAE 1.0 had 245 sectors for manufacturing. Thus, the products of the Harmonized System were aggregated within these 245 sectors. For 2007 and 2008, it was necessary to match CNAE 1.0 with CNAE 2.0, and to this end, the board's conversion MTE (2011) was used.

The final compatibility was made from the four digits of CNAE 1.0 to reach 81 three-digit industries.[15] Exports and imports were used in current values, and therefore, to make the conversion from VTI, the average exchange rate for each year of sales, obtained from Ipeadata (Ipea, 2011), was used.

4 RESULTS

4.1 Characterization of Brazilian trade flows

To start the trade analysis, we used the Grubel-Lloyd index (1975). This index allows us to calculate IIT when considering the trade flow for a specific time period. Figure 1 presents an overview of the flow behavior of commercial industries. Throughout the series, the percentage of industries that showed higher IIT than inter-industry trade occurred only in 2006.[16] Therefore, there is a predominance of inter-industry trade flows for the 81 industries analyzed in the Brazilian economy for the period examined.

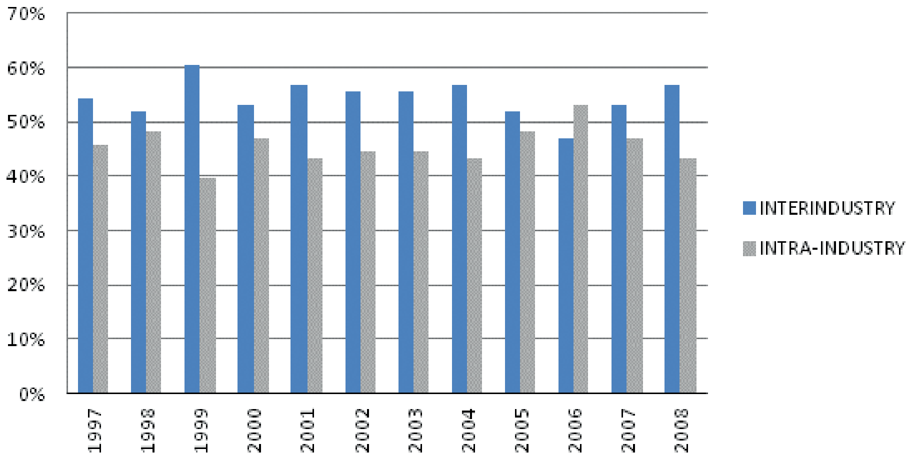
As the static index does not explain the dynamics of the periods and as the focus of this study was to analyze the dynamics of employment in different industries, a descriptive analysis of MIIT was necessary. The same static index showing predominant inter-industry behavior, in general, did not show large differences in the amount of industries whose flows were characterized by IIT and in those that had a characterization of inter-industry. Unlike the static index, the index showed that trade industries in MIIT, compared with the dynamism of time, are much greater than those in inter-industry trade. Figure 2 clearly shows that Brazil is a country with an inter-industry characteristic.

Importantly, from figures 1 and 2, the general behavior of industries can be observed, and even those exhibiting intra-industry-type behavior in a given period may not present the same characteristics in the following period. Fifty-four industries, or 66.67% of the total, had, at some point, intra-industrial characteristics, but none presented continuous behavior in the period 1997-2008.

15. The tables of compatibility and list of 81 sectors are available from the authors.

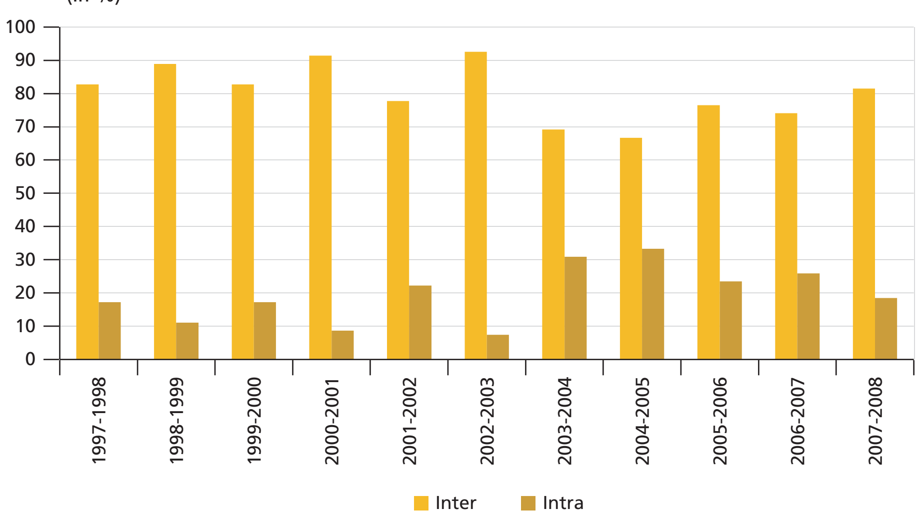
16. The behavior change of the Grubel-Lloyd index in 2006 is due to the excellent performance of exports of manufactured and semi-manufactured products in that year. Consequently, given the volume of imports of manufactured and semi-manufactured products, the growth of exports of this type of products increases the intra-industry trade.

FIGURE 1
Representation of the types of trade in the Brazilian manufacturing industry with the rest of the world – Grubel-Lloyd Index (1997-2008)
(In %)



Source: MDIC/Aliceweb – raw data.
Authors' elaboration.
Publisher's note: Figure displayed in low resolution and whose layout and texts could not be formatted and proofread due to the technical characteristics of the original files.

FIGURE 2
Amount of manufacturing industries that were classified as inter- or intra-industry by MIIT
(In %)



Source: MDIC/Aliceweb – raw data.
Authors' elaboration.

4.2 Results of the economics models

The test of the SAH was carried out by using the dynamic model with the estimators proposed by Arellano and Bover (1995) and Blundell and Bond (1998). Table 1 shows a descriptive analysis of the correlation of the variables. Although no inference can be made based on it, one can get a hint of how the variables tend to behave. The Spearman coefficient[17] was chosen because it considers the order of the data and not the intrinsic value, and this is an advantage when there are outliers among the variables (if openness denotes discrepant values of the other variables). The variable MIIT showed a statistically significant correlation with the variable ET; this variation was positively correlated and it did not demonstrate convergence for the SAH. An important issue to note is that the positive magnitude is very low. The correlation between the variables openness (GA) and skilled labor (S) indicates that they are positively correlated with the variable ET. This finding indicates that initially the variables are as expected in the literature review.

TABLE 1
Spearman's correlation

	ET	*ETB*	*ET_{t-1}*	*ETB_{t-1}*	*MIIT*	*GA*	*AD*	*S*	*MIIT_GA*
ET	1								
ETB	0.3643*	1							
ET_{t-1}	0.4415*	0.2090*	1						
ETB_{t-1}	0.2722*	0.1605*	0.3949*	1					
MIIT	0.0751*	-0.0513	-0.0145	-0.1076*	1				
GA	0.1967*	0.1212*	0.2095*	0.1664*	0.0175	1			
AD	0.1086*	-0.0101	0.027	-0.007	0.0227	0.0699	1		
S	0.3342*	0.0044	0.1171*	0.0714	0.1086*	0.0147	0.0348	1	
MIIT_GA	0.1616*	0.0252	0.1074*	-0.0127	0.8015*	0.5067*	0.0641	0.0738	1

Authors' elaboration.
Obs.: 1. ETB is the effect of the variation of works measured as in Brülhart (2000).
2. * represents 10% significance.

Table 2 shows the behavior of the variables. On average, the variable that represents the total effect of the displacement of skilled manufacturing workers varies by 5.2%. MIIT and its interaction with degree of openness have a greater variation static compared with the variable ET. The variable with the highest average of variation is degree of openness, explaining the greater trade openness that occurred over the study period.

17. Brülhart (2002) and Greenaway, Haynes and Milner (2002) also used such a correlation.

TABLE 2
Characteristics of the variables

Variable	Obs.	Average (%)	Standard deviation	Min	Max
ET	486	5.2	0.119	0.00012	1.346
MIIT	486	26.9	0.267	0.00000	0.992
GA	486	86.4	0.835	0.00005	8.955
GA_MIIT	486	23.3	0.397	0.00000	3.566
DA	486	0.20	2.258	-25.227	23.703
S	486	2.10	0.090	-0.418	1.834

Authors' elaboration.

Table 3 presents the main estimated results. It shows all the main steps to reach the result shown in Eqs. (9), (10), and (11). First, we estimated the pooled OLS model with the same variables proposed by Cabral and Silva (2006), and the difference in the model specification of this work occurred at the level of the variables. As the literature does not have a standard analysis method, we chose to work with all level variables.

Subsequently, the test was reset to verify that the linear regression model was well specified. The flaw in the specification may be due to omitted variables, incorrect functional form, the problem of simultaneous equations, and heteroskedasticity. The results in table 3 show that one should reject the null hypothesis that the template has no fault in the specification, giving an indication that there is a need to improve the model specification.

Subsequently, two tests were carried out: the Breusch-Pagan test indicated that the best econometric model would be the unobserved effects and the Hausman test indicated that we cannot reject the null hypothesis, suggesting using the random effects model (table 3).

It is noteworthy that in the fixed effects model, as in the random effects model, the hypothesis that MIIT implies a movement of workers was not statistically significant. It was found that there was heteroskedasticity in the fixed effects model for such controls, turning the robust model.

Considering that the model needs further information due to the RESET test, as explained earlier, the test was carried out again for a pooled OLS model with the inclusion of the lagged dependent variable. The results did not allow us to reject the null hypothesis that the model has no omitted variable at the 5% significance level, indicating that the phase variable movement of industrial workers in an earlier period can affect the model.[18]

18. Table 3 reports the main results of the estimation and the variations of the estimates, including the one that includes the lag. These results are available from the authors.

Another fact that indicates that the model should have the lag as an explanatory variable on the dependent variable is the main objective of the work, which is a dynamic issue by nature. Arellano and Bond (1991), when deriving employment equations estimated by using unbalanced data for a panel of 140 UK companies for the period 1974–1984, used two lags to explain employment in companies in each year of the analysis. In the present study, for the calculation of the dependent variable (which represents variation in employment), we chose to use only one lag.

The dynamic model also did not confirm the SAH (table 3). However, before we explore these results, a brief explanation of the statistics is necessary. The Arellano-Bond test is appropriate to verify the existence of serial autocorrelation (table 3 – Arellano-Bond AR), and this is especially important when lags are used as instruments. This test rejects the null hypothesis that there is no first-order autocorrelation; however, there is no evidence of second-order autocorrelation, and hence, it is not possible to reject the null hypothesis.

The analysis was carried out by testing various instruments. The Hansen test and Sargan test, which examine the validity of the joint GMM instruments, did not reject the hypothesis that the instruments are valid and they had high p-values. Roodman (2009b) stated that there is a debate among researchers regarding the notion that a high p-value validates the test results of Hansen. As the "difference in Hansen" test, which analyzes subsets of instruments, also does not reject the hypothesis of exogeneity instruments, one can conclude that the estimation is efficient.[19] It is known that the reliability of the tests cited earlier may be affected if the number of instruments is greater than that of the units of cross-sections. However, the number of instruments in this study is 16 and the number of cross-sections is 81.

The main model was the dynamic model proposed by Arellano and Bover and Blundell and Bond, with the two-stage estimator, correcting the variance and covariance matrix to treat heteroskedasticity and presenting estimates of the standard errors corrected for finite samples (Arellano–Bover). Table 5 shows that MIIT is not statistically significant for explaining the variation in intra-industry workers, while the other estimators (fixed effects, random effects, and OLS) were used to verify the robustness of the result, which was maintained. This finding shows that the SAH is not valid for Brazil. The result finds support in the empirical literature, because Brazil has little intra-industrial characterization. The result of the study by Brülhart and Thorpe (2000) for Malaysia, a country that has little intra-industrial characterization, to determine the validity of the SAH was also not statistically significant.

19. These results are available from the authors.

Degree of openness had a positive coefficient and was statistically significant for the dynamic model. It was noted that there was a difference in the coefficient found for the Arellano-Bover (1995) and Blundell-Bond (1998) estimators compared with the other estimators (fixed effects, random effects).

The variable that represents apparent demand (AD) and the participation of skilled workers in relation to the total workforce of the manufacturing industry (S) was not statistically significant, similar to the results of the fixed effects and random effects models. The interaction coefficient (MIIT_GA) was not statistically significant in any model (table 3). Similar to the variable MIIT at low characterization, the Brazilian intra-industry may have affected the statistics of this index.

TABLE 3
Results of OLS, FE, AE, and dynamic model

Variables/dependent variable	OLS	FE (ROB)	AE (ROB)	Dynamic
				A-Bover
	ET	ET	ET	ET
Instruments (endogenous/exogenous)				ET_{t-1}/year
ET_{t-1}	-	-	-	0.445*
				(0.239)
MIIT	-0.00721	0.00995	-0.00145	-0.702
	(0.0274)	(0.0225)	(0.0302)	(0.452)
GA	0.0425***	0.0291	0.0387	0.035*
	(0.0085)	(0.0313)	(0.0281)	(0.020)
AD	0.00432*	0.000511	0.00257	-0.062
	(0.00234)	(0.00288)	(0.00275)	(0.047)
S	-0.0255	-0.0225	-0.0239	-0.368
	(0.0588)	(0.0777)	(0.0719)	(2.371)
MIIT_GA	-0.0358	-0.025	-0.0293	0.133
	(0.022)	(0.0308)	(0.036)	(0.179)
Constant	0.00995	0.0126	0.00969	0.138
	(0.0151)	(0.0259)	(0.0216)	(0.101)
Observations	486	486	486	405
R-squared	0.1	0.056		
Sector No.	-	81	81	81
Test Reset (Prob>F)	0.0000	-	-	-
Breusch–Pagan (Prob>Chibar2)	-	-	0.0000	-

(Continues)

(Continued)

Variables/dependent variable	OLS	FE (ROB)	AE (ROB)	Dynamic A-Bover
	ET	ET	ET	ET
Hausman (Prob>chi2)	-	0.078	-	-
Test Heteroskedasticity (Prob>Chi2)	-	0.0000	-	-
Arellano–Bond AR(1) : z	-	-	-	-1.71*
Arellano–Bond AR(2) : z	-	-	-	-0.05
Hansen Test	-	-	-	2.97 0.685+
Sargan Test	-	-	-	3.10 0.705+
No. of instruments	-	-	-	16
Hansen Test – groups exclusion	-	-	-	0.13
Difference (h_0 = exogenous)	-	-	-	2.97
Hansen Test – groups exclusion	-	-	-	2.43
Difference (h_0 = exogenous)	-	-	-	0.67

Authors' elaboration.
Obs.: 1. *, **, and *** represent 10%, 5%, and 1% significance, respectively.
2. ET: dependent variable proposed by Cabral and Silva (2006).
3. Values in parentheses correspond to the standard error corrected for each variable.
4. In all models, year dummies were estimated.
5. The + sign indicates the p-value of the test.

To check the robustness of the sensitivity analysis, analyses were performed by removing the control variables, and the results are shown in table 4. The results of the sensitivity analysis for the fixed effects and dynamic models suggested that there is robustness in the results found in column 4, dynamic model, of table 4. The result of the random effects model was significant, and this finding is in agreement with that presented in the literature. This result is important because it does not contradict the hypothesis, although this model cannot be accepted for the explanation presented this study, as mentioned earlier when using the Hausman test.

In addition to removing the variables, other sensitivity analyses were also performed. Roodman (2009b) suggested the withdrawal of the instruments to verify that the analysis would be sensitive, because a large number of instruments can make the analysis invalid; thus, the "gold standard" dynamic model would be fewer instruments than cross-section units (sector number). This study used fewer instruments (16) than the sector number (81), as can be seen in table 4. Thus, instead of removing the instruments, lags of all the explanatory variables were added as instruments to calculate the sensitivity of the dynamic model, generating 86 instruments. The result that there is no significant relationship between labor movement and IIT remained marginal, but in the model with instruments greater than the number of sectors, degree of openness (GA) was not significant, which may have occurred as a result of excessive instruments.

To check for changes in the results compared with the variable proposed by Cabral and Silva (2006), the SAH was also tested with a variable that represents the gross variation of workers in the manufacturing industry. This variable was used by Brülhart and Elliott (1998) and it represents a part of the composition of the index proposed by Cabral and Silva (2006), the "size effect." It can be seen from table 4 that the coefficient of MIIT was not statistically significant, reinforcing, once again, the idea that there is evidence for the hypothesis that Brazil's adjustment costs have softened. In particular, according Cabral and Silva (2006), because of the "global" variable, ETB would be biased toward accepting the SAH.

Degree of openness, GA, was not statistically significant for the variable "gross"[20] (column 2 of table 5). This finding can be understood by the fact that trade liberalization affects more skilled workers, implying a statistically non-significant variable that considers total workers. The variables S, AD, and MIIT_GA were not significant, corroborating the estimate made earlier with the variable ET (table 5).

It can be recalled that the results to verify the model specification were good, as shown in table 5. The test to check for the presence of autocorrelation did not reject the null hypothesis that there is no first-order serial autocorrelation in residual variation and did not reject the hypothesis for second-order serial autocorrelation, implying the validity of the instruments.

20. The variable "gross" referred to in this work is the variable that does not compute the level of skill/occupation.

TABLE 4
Sensitivity analysis of the model estimated by using OLS, EF, EA, and dynamic model

Variables	FE			AE			Dynamic model (A-Bover)			
	ET	ET	ET	ET	ET	ET	ET	ET	ET	ET
Instruments (endogenous/ exogenous)	-	-	-	-	-	-	ET_{t-1}/ano	ET_{t-1}/ano	ET_{t-1}/ano	ET_{t-1}, $MIIT_{t-1}$, S_{t-1}, AD_{t-1}, GA_{t-1}, $MIIT\_GA_{t-1}$
ET_{t-1}	-	-	-	-	-	-	0.445*	0.120	0.108	-0.030
MIIT	0.010	-0.016	-0.003	-0.001	-0.0267*	-0.044**	-0.702	-0.315	-0.05	-0.123
GA	0.029	-	-	0.038	-	-	0.035*	-	-	0.023
AD	0.001	-	-	0.002	-	-	-0.062	-	-	0.010*
S	-0.023	-	-	-0.023	-	-	-0.368	-	-	0.901*
MIIT_GA	-0.025	-	-0.015	-0.029	-	0.019***	0.133	-	-0.09	0.01
Constant	0.013	0.034***	0.034***	0.009	0.037***	0.037***	0.138	0.114	0.072	0.053
No. of Sectors	81	81	81	81	81	81	81	81	81	81
Arellano–Bond AR(1) : z	-	-	-	-	-	-	-1.71*	-2.33**	-2.13**	-2.75***
Arellano–Bond AR(2) : z	-	-	-	-	-	-	-0.05	-0.7	-0.29	-0.090
Hansen Test/(p-value)	-	-	-	-	-	-	2.97/ 0.685	9.99/ 0.351	4.480	0.496
Sargan Test	-	-	-	-	-	-	3.1	20.39**	22.58**	0.394
Number of instruments	-	-	-	-	-	-	16	16	16	86
Hansen test – groups exclusion	-	-	-	-	-	-	0.13	2.98	1.64	53.78
Difference (h_0 = exogenous)	-	-	-	-	-	-	2.97	7.01	2.84	20.67
Hansen test – groups exclusion	-	-	-	-	-	-	2.43	7.53	4.45	70.87
Difference (h_0 = exogenous)	-	-	-	-	-	-	0.67	2.46	0.03	3.57

Authors' elaboration.
Obs.: 1. *, **, and *** indicate the values with 10%, 5%, and 1% significance, respectively.

TABLE 5
Results of estimating the dynamic model with Windjmeijer's correction

Variables	Dynamic models	
	A-Bover	
	ET	ETB
	(1)	(2)
Instruments (endogenous/exogenous)	ET_{t-1}/year	ET_{t-1}/year
ET_{t-1}	0.445*	0.096
	(0.239)	(0.078)
MIIT	-0.702	-0.705
	(0.452)	(0.786)
GA	0.035*	-0.150
	(0.020)	(0.188)
AD	-0.062	-0.005
	(0.047)	(0.006)
S	-0.368	2.397
	(2.371)	(2.139)
MIIT_GA	0.133	0.61
	(0.179)	(0.759)
Constant	0.138	0.174
	(0.101)	(0.170)
Observation	405	405
Sector No.	81	81
Arellano–Bond AR(1)	-1.71*	-1.41
Arellano–Bond AR(2)	-0.05	-0.750
Hansen Test	2.97	2.840
Sargan Test	3.1	2.490
Number of instruments	16	16
Hansen test – groups exclusion	0.13	0.60
Difference (h_0 = exogenous)	2.97	2.24
Hansen test - groups exclusion	2.43	2.61
Difference (h_0 = exogenous)	0.67	0.23

Authors' elaboration.
Obs.: 1. *, **, and *** indicate the values with 10%, 5%, and 1% significance, respectively.
2. Values in parentheses correspond to the corrected standard error of each variable.

The Hansen test did not reject the null hypothesis of the joint validity of the GMM instruments. The second test (difference) to check if the instruments were exogenous also did not reject the null hypothesis, confirming the exogeneity of the instruments. Furthermore, there was no problem with the "golden rule" of the model, ensuring that the instrument number was lower than that of the sectors.

After the tests were performed, it was not possible to demonstrate the SAH with respect to Brazil. It should be noted that the models used to test the hypothesis were robust to purge the heterogeneity present in the model; that is, the results from these models were constrained to accept the hypothesis.

5 CONCLUSION

The aim of this paper was to analyze the effects of the expansion of MIIT on the variation in skilled labor in the Brazilian manufacturing industry in the period 1997-2008. The most important results showed that the hypothesis is not fit for Brazil in the examined period.

There were several specifications to assess the robustness of the model and, largely, the result of the specifications was not significant. Only three analyses, namely two OLS and one random effects results, confirmed the SAH, but these results may be biased. The important point to note is that in all tests, the result was significant and positive, which is contrary to the hypothesis, in this case.

The study found answers with the sign expected in the literature for the control variables, such as degree of openness and interaction between degree of openness and MIIT. As noted in the descriptive analysis of the Brazilian trade flow in various industries, greater openness largely implies inter-industry characteristics, which is consistent with the results found in the literature. Degree of openness was found to be associated with lower rates of MIIT, which suggested a positive association with the displacement of workers.

The results, in fact, were expected due to reduced Brazilian IIT (from the marginal perspective) and also considering that the analysis of trade flows was with the rest of the world, which makes IIT lose its characteristics. The perspectives of future studies can be developed from this initial study of the SAH with respect to Brazil. Analysis of economic partners with characteristics more similar to Brazil is important to state whether the SAH is confirmed for Brazil.

This study aimed to evaluate the variation in shift workers with MIIT, expanding the scope by incorporating two approaches to the construction of the dependent variable. It is argued that the cost ratio smoothed adjustment with the structure of trade flows does not support the hypothesis that an expansion of IIT implies a lower cost adjustment, suggesting that the hypothesis is not valid for Brazil in the period analyzed, confirming the work of Brülhart and Thorpe (2000).

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