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The effect of technological intensity of exports on the economic growth of Brazilian microregions: A spatial analysis with panel data[☆]

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Abstract

The objective of this study was to analyze empirically the effects of exports segmented into technological levels on the economic growth of Brazilian microregions during the period 2000–2010 in light of the Crespo-Cuaresma and Wörz's (2005) model. The hypothesis is that exports increase economic growth due to the productivity differential existing between the exporting and non exporting sectors and the positive externality generated by the exporting in the non exporting sector. Theoretically, the higher technology the exported goods have, the stronger these effects are. By classifying the exports into technological levels and estimating the empirical model using the spatial data panel technique, with fixed effect, the two central hypotheses in the Crespo-Cuaresma and Wörz's (2005) model were validated, with a productivity differential in all exporting segments, and also with a subsequent effect of externalities on the economic dynamism. This effect might go beyond territorial limits mainly when the goods exported belong to the low and mid-low technology industry. Also, a differentiated effect was observed regarding the external insertion in the economic growth of the regions with high exports vs. those with low participation in the international trade. In the former, the most intense indirect effect is mainly related to products with higher aggregated value, while in the latter more effects are seen mainly linked to the exportation of non-industrial products.

JEL classification: F14

Keywords: Economic growth; Exports; Technological intensity; Microregions

1. Introduction

There is a vast number of works in the literature, both theoretical and empirical, showing that exports are one of the economic growth conditions in a country or region (Balassa, 1978, 1985; Feder, 1982; Salvatore and Hatcher, 1991; Crespo-Cuaresma and Wörz, 2005).

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The positive effects of exports on the growth can be divided into two paths: the direct or the indirect effect. Direct effects occur because exports are one component of the Gross Internal Product of a country; therefore, an increase in exports is followed by increase in the product (Balassa, 1978). While the indirect effects are harder to be seen, since they derive from the positive effects on the economy of scale, use capability growth and productivity gains, among others (Feder, 1982; Crespo-Cuaresma and Wörz, 2005).

An important issue to be considered, and which is debated in literature, refers to the fact that the exports effect on the economic growth might be distinct, depending on the composition of the exporting agenda. The hypothesis tested in the empirical literature is that exporting more sophisticated products promotes higher product growth than exporting less sophisticated products. The explanation for that is that the production of these goods has higher potential to generate economies of scale, productivity gains and knowledge (Crespo-Cuaresma and Wörz, 2005).

The view that the composition of the exports agenda creates distinct trajectories for the economic growth is defended by Hausmann et al. (2007, p. 2). For these authors "*. . ., countries that specialize in the types of goods that rich countries export are likely to grow faster than countries that specialize in other goods*". In an attempt to confirm empirically this statement, the authors built an index of exports productivity and, later on, correlated it to the economic growth of countries. The authors found evidence that the economic growth is influenced by the composition of the exports agenda, and the high productivity (more sophisticated) exports are associated to higher economic growth rates.

Developing the same line of thought, Crespo-Cuaresma and Wörz (2005) evaluated the indirect effects of exports on the economic growth, taking as a differential the disaggregation of exports considering the technological intensity of the exported products, classifying them into: non-manufactured products, low technology manufactured products and high technology manufactured products. The data used by the authors was collected from 45 countries in the period between 1981 and 1997. In the aggregated analysis, among other results, the authors verified that the productivity of the low technology sector was lower than that of the domestic sector, and the opposite occurred in the high technology sector. Regarding the externality effect, the results were not significant. Next, those authors re-evaluated the estimates considering two sampling groups, OECD (Organization for Economic Cooperation and Development) countries and non OECD countries. The new results showed that the productivity differential previously observed remained only for the non OECD countries and, once more, the exports sector externality effects were not observed in the economy. Therefore, a general conclusion of this study was that indirect effects of exports on growth resulted from the productivity differential existing between the exports and the non exports sectors, rather than externality; moreover, the productivity differential was higher in countries that did not belong to the OECD.

Supported by recent literature, this study aimed at evaluating the effects of the composition of the exports agenda of Brazilian microregions on their economic growth rates. More specifically, it proposes to disaggregate the Brazilian microregion exports into non industrial, low technology, medium technology and high technology products and to analyze how the exportation of this kind of products influences the economic growth rate. The hypothesis guiding this study is that more sophisticated products have higher influence on the economic growth than less sophisticated ones in light of the Cuaresma and Wörz's (2005) theoretical model.

It seems important to highlight that the innovation sought by this study is not based on theoretical advances or techniques to estimate the empirical model, but rather on the object of analysis, namely the Brazilian microregions. The choice for this geographical focus is mainly motivated by the intention to consider the local heterogeneities in the discussion about the international trade effects on growth, following the ideas put forward by Perobelli and Haddad (2006). In addition, by using microregional data it is possible to identify the presence of two important spatial effects: spatial dependence and spatial heterogeneity.

Spatial dependence occurs due to the presence of spatial agglomerations, and these occur due to the not random spatial distribution of exports in the microregions. While spatial heterogeneity occurs because each microregion has intrinsic characteristics that make them distinct one from another, making it possible to identify different spatial patterns in exports, as well as in the economic growth (Perobelli and Haddad, 2006).

In addition to this introduction the article presents other four sections. Section 2 describes briefly the Cuaresma and Wörz's (2005) theoretical model, which provides the theoretical background to this study. The following section (Section 3) discusses the empirical strategy to be used to achieve the objective proposed; in this case, the econometric model and the parameter estimation strategy are specified. Section 4 presents the results of the empirical model estimation. Finally, in section five the final considerations are presented.

2. Theoretical background: Crespo-Cuaresma and Wörz's (2005) model

The Cuaresma and Wörz's (2005) model can be seen as a continuation to the Feder's (1982) growth model. In Feder's (1982) model, which is part of a neoclassical production function ($Y = f(K, L)$) and divides the economy into two sectors, an exporting (X) and a non exporting (N) sector, the economic growth process of a country is influenced by the exports growth, since they, through spillover effects stimulate the productivity of the non exporting sector.

Regarding the Cuaresma and Wörz's (2005) model, the idea is similar, there is an attempt to identify the effects of exports on the economic growth, but the main contribution of these authors was to consider the exports structure, not only the exports in an aggregated manner. The hypothesis developed is that the industries which are more intense in technology present higher productivity potential and spillovers than the lower intense technology industries and, therefore, they tend to stimulate more the economic growth process in the country.

Therefore, the central contribution of this model is exactly to assume that there are i ($i = 1, 2...S$) exporting sectors separated into technological levels, according to Eq. (1).

$$X(t) = \sum_{i=1}^{S} x_i(t) \tag{1}$$

The production in the non exporting sector (N) is a function of the capital [$K_n(t)$] and the work [$L_n(t)$] allocated in this sector, as well as the exports of the S sectors, that is:

$$N(t) = F(K_n(t), L_n(t), X_1(t), X_2(t), \ldots, X_S(t)) \tag{2}$$

While the production of the *i-th* exporting sector is a function of the capital [$K_i(t)$] and the work [$L_i(t)$] used in this sector only:

$$X_i(T) = G_i(K_i(t), L_i(t))\ i = 1, \ldots S \tag{3}$$

It is also assumed that the factor productivities differ between the non exporting sector and each of the exporting sectors due to some specific factors in the sector ($\delta_i > -1$):

$$\left(\frac{\partial G_i/\partial K_i}{\partial F/\partial K_n}\right) = \left(\frac{\partial G_i/\partial L_i}{\partial F/\partial L_n}\right) = 1 + \delta_i\ i = 1, \ldots, S \tag{4}$$

Taking into consideration that:

$$\frac{dN}{dt} = \frac{\partial F}{\partial K_n}\frac{dK_n}{dt} + \frac{\partial F}{\partial L_n}\frac{dL_n}{dt} + \sum_{i=1}^{s}\frac{\partial F}{\partial X_i}\frac{dX_i}{dt} \tag{5}$$

And the identity $Y = N + \sum_{i=1}^{S} X_i$, and after some algebraic manipulations, it is possible to write:

$$\frac{dY/dt}{Y} = \frac{\partial F}{\partial K_n}\frac{dK/dt}{Y} + \frac{\partial F}{\partial L_n}\frac{dL/dt}{Y} + \sum_{i=1}^{S}\left(\frac{\partial F}{\partial X_i} + \frac{\delta_1}{1+\delta_i}\right)\frac{dX_i/dt}{X_i}\frac{X_i}{Y} \tag{6}$$

where: $K = K_n + \sum_{i=1}^{S} K_i$ e $L = L_n + \sum_{i=1}^{S} L_i$

Considering the hypothesis that there is a linear relation between the work marginal productivity and the average production per worker in economy, then $\frac{\partial F}{\partial L_n} = \frac{\gamma Y}{L}$. With this assumption, Eq. (6) can be rewritten as:

$$\frac{dY/dt}{Y} = \beta\frac{dK/dt}{Y} + \gamma\frac{dL/dt}{Y} + \sum_{i=1}^{S}\left(\frac{\partial F}{\partial X_i} + \frac{\delta_1}{1+\delta_i}\right)\frac{dX_i/dt}{X_i}\frac{X_i}{Y} \tag{7}$$

Eq. (7) allows the evaluation of both the direct and indirect effects of exports, resulting from the exports externality $\frac{\partial F}{\partial X_i}$ and the productivity differential $\left(\frac{\delta_i}{1+\delta_i}\right)$ of each sector i on the country economic growth.

If the function for the non exporting sector is parameterized, as $N = F(K_n, L_n, X, X_2, \ldots, X_s) = \left(\prod_{i=1}^{S} X_i^{\psi i}\right) \tilde{F}(K_n, L_n)$, this implies that $\frac{\partial F}{\partial X_i} = \psi^{N}/_{X_i}$. Thus, Eq. (7) can be rewritten as:

$$\frac{dY/dt}{Y} = \beta\frac{dK/dt}{Y} + \gamma\frac{dL/dt}{Y} + \sum_{i=1}^{S}\left[\psi_i\frac{dX_i/dt}{X_i} + \left(1 - \frac{\sum_{i=1}^{S} X_i}{Y}\right) + \frac{\delta_i}{1+\delta_i}\frac{dX_i/dt}{X_i}\frac{X_i}{Y}\right] \quad (8)$$

It seems relevant to emphasize that Eq. (8) can be tested empirically, capturing both the externality effect of exports on the product growth and the productivity differential of the exporting sector in relation to the non exporting sector. Eq. (8) will be used to specify the econometric model, to be described in Section 3 in this paper.

3. Methodology

3.1. Initial considerations

As already outlined in the introduction, the analysis in this study has a geographical focus on the 558 Brazilian microregions. In the classification by IBGE (Geography and Statistics Brazilian Institute) (1991), the cities were grouped into microregions according to the interactions existing between the production and the local processing, along with the centrality of wholesale or retail commerce, and the basic sectors. Therefore, the existing productive structure is the main point to define microregional spaces.

In addition to being spaces with high homogeneity degree (Breitbach, 2008), the option for microregions, instead of cities, aimed at smoothening overestimations or underestimations of the actual value exported. Many times, the production of certain goods is carried out in peripheral cities, but the register of exportation occurs in the city where the exporting company is located. Therefore, by considering microregions, these particularities are minimized preserving the analysis results.

Since the theoretical background used in this study is based on the principle that the composition of the exports agenda might generate distinct effects on the economic growth, the Brasilian microregions[1] exports were classified into technological levels (Chart 1), following the taxonomy applied by Furtado and Carvalho (2005). It seems important to highlight that in the exploratory analyses of the distribution of exports throughout Brazil, the five classifications in Chart 1 were used, however, for the econometric estimates high technology was added to the mid-high, while the low technology was added to the mid-low. This procedure was employed due to the small number of exporting microregions, mainly of high technology products. In addition, some authors such as Lamonica and Feijó (2011), advocate the aggregation of the technology high intensity with the mid-high sector since both are intensive in capital and technology, which makes them different from the remaining groups.

3.2. Spatial data exploratory analysis (SDEA)

Due to the nature of the data used in this study (spatial), a spatial data exploratory analysis (SDEA) will be carried out regarding both the exports distribution and the economic growth of Brazilian microregions.

The use of SDEA aims at describing the spatial distribution of the economic growth and the exports segmented in the Brazilian microregions, identifying spatial association patterns. To implement SDEA it is necessary to adopt a spatial weighting matrix (W). This is a square matrix of order $n \times n$, whose elements show the spatial connection degree existing between the microregions under analysis, following some contiguity criterion (Almeida, 2012).

This criterion is based on the contiguity (with a tower, queen and nearest neighbor type convention), assuming that neighboring microregions have stronger interaction than the ones that are not so close. This interaction might either stimulate spreading or lead to the refusal of the variable under analysis (economic growth and exports). Thus, the w_{ij}

[1] Exports data obtained from the site Aliceweb. Originally, this data is available per cities, but for the purposes of this study they will be aggregated per microregions.

Classification	Description
High technological intensity	Sectors: Aerospace; pharmaceutical; computing; electronics and telecommunications.
Mid-high technological intensity	Sectors: electrical material; automotive vehicles; chemistry, including pharmaceutical; railroad and transportation equipment; machinery and equipment.
Mid-low technological intensity	Sectors: naval construction; rubber and plastic products; coke, petroleum processed products and nuclear fuel; other non-metallic products; basic metallurgy and metallic products
Low technological intensity	Other sectors and recycling; wood, paper and cellulose; editorial and graphics; food, beverages and tobacco; textile and confection, leather and shoes.
Non industrial products	Live animals; live plants and flower products; fruit, citric fruit and melon skin; cereals; *in natura* products; art, collection and antiques objects; special transactions; etc.

Chart 1. Disaggregation of exports according to the product technological level.
Source: Adapted from Furtado and Carvalho (2005).

element of the spatial weighting matrix (W) is worth 1 when two microregions are contiguous, and 0 if they are not. When implementing SDEA univariate and bivariate global spatial autocorrelation tests are used.

3.2.1. Global spatial autocorrelation (univariate)

The global spatial autocorrelation allows the identification of whether the spatial distribution of certain variable occurs randomly or not. If considered random, then the behavior of this variable in the *i* region is not influenced by the behavior of the same variable in region *j*. This analysis was carried out by applying the Moran *I* statistics (9).

$$I = \frac{n}{S_0}\frac{z'Wz}{z'z} \tag{9}$$

where *n* is the number of microregions; *z* is the GDP (Gross Internal Product) growth rate value in the microregions or the value of exports classified according to their technological intensity (both standardized); *Wz* represents the microregions GDP growth rate average values or the microregions exports average values (both standardized in the neighbors), and defined according to the spatial weighting matrix (*W*) adopted; S_0 is the sum of all elements in the spatial weighting matrix (*W*).

The null hypothesis to be tested is that the spatial distribution of the variable is random. An *I* value higher than the expected one indicates positive spatial autocorrelation, while an *I* value lower than the expected one corresponds to a negative spatial autocorrelation.[2]

[2] A positive spatial autocorrelation means that one microregion with high (low) GDP growth rate is surrounded by microregions that also present high (low) GDP growth rate. When there is negative spatial autocorrelation, a microregion with high (low) GDP growth rate is surrounded by microregions with low (high) GDP growth rate. The same logics is applied to the exports.

3.2.2. Global spatial autocorrelation (bivariate)

The global spatial autocorrelation in a bivariate context seeks to find out whether the values of a variable being observed in certain region has a systematic relation with the values of another variable observed in neighboring microregions. In formal terms, it is possible to calculate the Moran *I* statistics for two different variables, *y* e *x*.

$$I^{yx} = \frac{n}{\sum_i \sum_j w_{ij}} \frac{\sum_i \sum_j (x_i - \bar{x}) w_{ij} (y_i - \bar{y})}{\sum_i (x_i - \bar{x})^2} \tag{10}$$

Positive and negative Moran *I* values demonstrate spatial concentration and dispersion, respectively. Regarding this study, *y* was defined as the microregions economic growth rate, while *x* corresponded to each technological level exports value.

3.3. Empirical model, data source and parameter estimation strategy

The growth model proposed by Crespo-Cuaresma and Wörz (2005) assumes that exports in themselves are not only important for the economic growth, but also their composition is important, that is why they are classified according to the technological intensity.[3] The central hypothesis is that industries with higher technological level present a high productivity level, leading the economy to a higher economic growth rate, comparatively to other industries of lower technological intensity.

These authors' theoretical model is based on the neoclassical function of production, separating the more efficient sector (exporting) from the less effective one (non exporting). Moreover, the more efficient sector is divided into sub-sectors: high technology manufacturing, low technology manufacturing and finally the non manufactured products, as presented in (8). Thus, from this theoretical background, the following empirical model was constructed:

$$\begin{aligned} \mathrm{TPIB_{j,t}} &= \beta_0 + \beta_1 INCF_{j,t} + \beta_2 FTRAB_{j,t} + \beta_3 (CRESX_{j,t,NI} * PARTX_{j,t,NI}) + \\ &\beta_4 (CRESX_{j,t,BT} * PARTX_{j,t,BT}) + \beta_5 (CRESX_{j,t,AT} * PARTX_{j,t,AT}) + \\ &\beta_6 [(CRESX_{j,t,NI}(1 - PARTX_{j,t,NI})] + \beta_7 [CRESX_{j,t,BT}(1 - PARTX_{j,t,BT})] + \\ &\beta_8 [CRESX_{j,t,AT}(1 - PARTX_{j,t,AT})] + \beta_9 KH + \beta_{10} DC + u_{j,t} \end{aligned} \tag{11}$$

where: $TPIB_{j,t}$ is the Gross Internal Product (GDP) of the *j-th* microregion in time *t*; $INCF_{j,t}$ is the investiment in physical capital in relation to the GDP of the *j-th* microregion in time *t*; $FTRAB_{j,t}$ is the population growth rate in the *j-th* microregion in time *t*; $CRESX_{j,t}$ is the exports growth rate in the *j-th* microregion in time *t*; $PARTX_{j,t}$ corresponds to the participation of exports in the GDP of the *j-th* microregion in time *t*; DC refers to a crisis *dummy* ("one" for 2008, 2009 and 2010, and "zero" for the remaining years[4]); *NI* is the exports of non industrialized goods; KH refers to human capital; *BT* is the exports of low technology products added to that of the mid-low technology; *AT* is the high technology exports added to the mid-high technology exports, and; u_{jt} is the random error term.

It seems relevant to emphasize that the *proxy* for the "externality" of each technological level ("X") is represented by $\mathrm{CRES.X_{j,t,''X''}}(1 - \mathrm{PARTX_{j,t,''X''}})$, and the "productivity differential" component is given by$\mathrm{CRESX_{j,t,''X''}} * \mathrm{PARTX_{j,t,''X''}}$. Crespo-Cuaresma and Wörz (2005) define externality as the result between the growth rate of each exported level and the participation of the domestic sector in the GDP formation, assuming that exports would generate effects of income and linkage that would heat the domestic sector economy. Therefore, the better the result of this product, the higher the economic growth in this region. Regarding productivity, the authors build this variable by aggregating each exporting sector growth with their participation in the GDP, starting from the hypothesis that exporting segments tend to be more dynamic than internal sectors (due to their higher productivity), generating exports growth and, consequently, higher participation in the GDP.

[3] It seems relevant to mention that the variable used to capture the economic growth might have some effect on the exports, reversing the relation of the empirical model estimated in this study. As an attempt to mitigate this effect, some variables which capture the external insertion were lagged in one period.

[4] Taking into consideration that from 2008 on the countries in general have been affected by the world financial crisis, we opted for the inclusion of a *dummy* in the estimate (11), seeking to identify the impact that the crisis provoked in the Brazilian microregions economic growth.

The variable $TPIB_{jt}$ was measured based on the percentage variation of the GDP in the year *t* in relation to the GDP of the year *t-1*; the microregions GDP data were collected from the IPEADATA data base (2017) for the period 2000 to 2010, with deflated values for 2010. To measure the variable that represents the fixed capital in relation to the GDP ($INCF_{jt}$), the values of establishments[5] in relation to the GDP were used as *proxy*. The $FTRAB_{jt}$ was collected from the IPEADATA (2017). KH was measured through the workers' average schooling, with data from RAIS (2017).[6] The variable $CRESX_{jt}$ was measured based on the exports percentage variation in the year *t* in relation to the exports of the year *t-1* of each technological level; and the exports data were obtained from the Aliceweb site (2017) originally for cities, and then aggregated into microregions. The variable $PARTX_{jt}$, which is the participation of exports in the GDP of the *j-th* microregion, was obtained by dividing the exports of each technological level by the GDP. Therefore, it was necessary to transform the exports from dollar into Brazilian real (deflated 2010 = 100). Consequently, the exports values used for both the productivity and the externality calculations were in Brazilian currency. We would like to emphasize that data was collected up to 2014–which was the most recent year presenting international insertion information, using such data in the exploratory analysis, while for the estimates the data used was up to 2010, due to the availability of the remaining variables.

Taking into consideration the hypothesis that the externality effect of exports (either via income or linkage) does not occur immediately, and that there might be a gap between international insertion and economy spillovers, new estimates were provided (11) with a one-year gap for externalities (11′).

$$\begin{aligned}
\mathrm{TPIB_{j,t}} &= \beta_0 + \beta_1 INCF_{j,t} + \beta_2 FTRAB_{j,t} + \beta_3 (CRESX_{j,t,NI} * PARTX_{j,t,NI}) + \\
&\beta_4 (CRESX_{j,t,BT} * PARTX_{j,t,BT}) + \beta_5 (CRESX_{j,t,AT} * PARTX_{j,t,AT}) + \\
&\beta_6 [(CRESX_{j,t-1,NI}(1 - PARTX_{j,t-1,NI})] + \beta_7 [CRESX_{j,t-1BT}(1 - PARTX_{j,t-1BT})] + \\
&\beta_8 [CRESX_{j,t-1,AT}(1 - PARTX_{j,t-1AT})] + \beta_9 KH + \beta_{10} DC + u_{j,t}
\end{aligned} \tag{11'}$$

As an empirical strategy to (11) and (11′), a data panel was built considering the 558 Brazilian microregions, in the period from 2000 to 2010. The idea of building up a data base as a panel is supported by the specialized literature. According to Elhorst (2003) and Hsiao (2005) such methodology presents more robust results than the cross-section methodology, mainly for the fact that the data panel is more informative for containing more variation and less co-linearity between the variables and for increasing the degrees of freedom and resulting in higher efficiency of estimates.

The data panel method assumes that the cross-section units are independent one from another, however, when the cross-section observations are spatial units (such as the microregions) this hypothesis is not suitable, since the data are susceptible to the presence of observable and unobservable specific effects, making the residues of one-cross section unit to be correlated to the residues of another cross-section unit (Driscoll and Kraay, 1995). Thus, it is necessary to adapt the data panel model to a probable spatial dependence between the cross-section spatial units.

The estimation of an empirical model through spatial data panel controls the unobservable spatial heterogeneity which is manifested in regression parameters, mainly in the intercepts. This occurs because the unobservable spatial heterogeneity ends up influencing the intercept, making it vary according to the microregion. In addition, the unobservable spatial heterogeneity can also influence the random error term (Almeida, 2012). Thus, the spatial heterogeneity must be controlled either through the use of fixed effect models or random effect models, and the choice between models is carried out based on the Hausman[7] test. Also, in addition to the statistical proof of the model spatial dependence (Moran I test calculated in the a-spatial model disregarding space—Appendix A), several authors who investigated economic growth determinants at a regional level [e.g. Barreto et al. (2010), Curran (2009) and Bai et al. (2012), among others] also used spatial econometrics as a method of investigation.

[5] The number of establishments in each region was taken from the RAIS. Considering the total number of establishments in the country and dividing it by the total investment, the classification was carried out, through which the physical capital of each microregion was measured. It seems important to highlight that a correlation was established between this variable and the country actual physical capital and the result was a 0,98 correlation.

[6] This variable is not in the original Crespo-Cuaresma and Wörz's model (2005); however, since this model was built from the Solow's model and as some authors [e.g. Mankiw et al., 1992] include human capital in the Solow's model, to improve empirical evidence, we decided to include human capital in the Brazilian microregions estimates.

[7] Value obtained for the *Hausman* test in the estimate (11) corresponded to 450, indicating the fixed effect model as the most suitable.

The general specification of the spatial fixed effect model can be represented by (12).

$$\begin{aligned} y_t &= \alpha + \rho W_1 y_t + X_t\beta + W_1 X_t \tau + \xi_t \\ \xi_t &= \lambda W_2 \xi_t + \varepsilon_t \end{aligned} \tag{12}$$

While the general specification of the spatial random effects can be formalized through (13).

$$\begin{aligned} y_t &= \rho W y_t + X_t\beta + W X_t \tau + \xi_t \\ \xi_t &= \alpha + \lambda W \xi_t + \varepsilon_t \end{aligned} \tag{13}$$

where: α is the unobserved heterogeneity; ρ and λ are scalar spatial parameters; τ is a vector of spatial coefficients; W is the spatial weighting matrix; $W_1 y_t$ corresponds to the dependent variable spatial discrepancy; $W_1 X_t$ are the spatially discrepant exogenous explaining variables; $W_2 \xi_t$ represents the spatially discrepant error term. From these general models and imposing some restrictions on the behavior of parameters ρ, τ and λ, different forms of fixed and random spatial effect models can be specified.

In this study, four specifications were tested: spatial discrepancy (SAR), spatial error model (SEM), spatial Durbin model (SDM) and the General Spatial Model (SAC). In the case of SAR, changes in the explaining variable of a region were indicated to affect not only that region through the direct effect, but that they can also affect the dependent variable in all regions through indirect effects (Almeida, 2012). These indirect effects are interpreted as spatial overflow, represented by ρ. In SEM models, the spatial dependence is manifested in the error term, highlighting that the errors associated to any observation are an average of the errors in the neighboring regions, added to a random component. Therefore, this model informs that the effects on the dependent variable do not only result from the shock (represented by the error term) of a region, but from the overflow of shocks coming from other neighboring regions, which are captured by λ. The SAC model is similar to the spatial gap model, however, the existence of a spatial process that involves the error term is x considered simultaneously. Finally, the SDM model incorporates the idea of overflow through the discrepancy of explaining variables (WX) with the dependent variable discrepancy added.

When choosing the most suitable model to the data in this study, the quality criterion used was based on the quality of the model adjustment according to the information criteria by Akaike and Schwarz, considering the best model as the one presenting the lowest information criterion value. In such case, the Spatial Durbin model (SDM) was the one presenting the best adjustment and, therefore, shall be used as reference for the analysis.

Regarding econometric problems, the presence of heteroscedasticity was identified [Wald test equal 7497 for (11) and 6569 for (11′)] and serial autocorrelation problems [Woolridge test equal 26,9 for (11) and 26,0 for (11′)], therefore, all spatial model specifications were modified to accommodate both problems, using the Disccoll–Kraay[8] robust standard error.

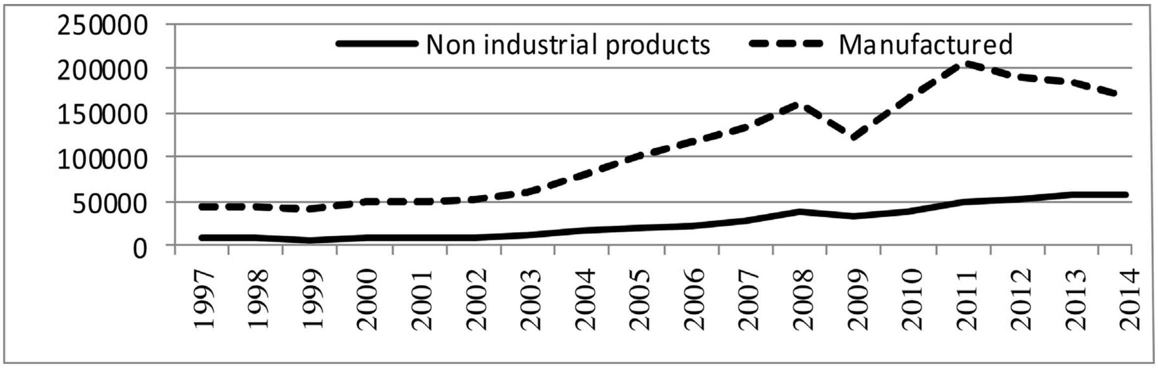
Therefore, note that (11) was re-estimated for two groups or microregions: Southeast/South and Center-West/North/Northeast. This procedure was adopted seeking to identify whether there are no result differences given the heterogeneity of the exports distribution throughout the Brazilian territory. This aggregation occurred because the regions Southeast and South concentrate over 70% of the country exports and, moreover, have more similar exportation agendas than those observed in the other regions.

4. Composition of exports in the Brazilian microregions and its effect on the economic growth

In the period between 1997 and 2014, Brazil intensified its foreign insertion, promoted by the extremely favorable foreign scenery (Graph 1). In addition to the increased demand for several agricultural and mineral commodities, stimulated by the intense Chinese growth, several Latin American countries also benefitted from these international gains, and started to import more from Brazil, intensifying the demand mainly for manufactured products. In this period, the Brazilian exports annual average growth[9] rate was 12,04%, and the non industrial products were the leaders of this

[8] The Driscoll–Kraay standard errors are robust to the heteroscedasticity problems and general forms of residue dependence (such as spatial and temporal), they can be applied to panels.

[9] All the average growth rates were estimated through an exponential model. lnY = f(T). Where Y refers to the variable to which the growth rate is to be obtained, ln is the logarithm, T is the time (years).



Graph 1. Brazilian exports of manufactured and non industrial products—1997–2014 (millions US$).
Source: ALICEWEB (2017), organized by the researchers.

Table 1
Moran I coefficient for Brazilian microregion exports—2014.

Type of product exported	Convenção				
	Queen	Tower	4 neighbors	5 neighbors	6 neighbors
High technology	0,36[a]	0,40[a]	0,42[a]	0,41[a]	0,40[a]
Mid-high technology	0,36[a]	0,37[a]	0,37[a]	0,37[a]	0,36[a]
Mid-low technology	0,32[a]	0,33[a]	0,32[a]	0,31[a]	0,30[a]
Low technology	0,30[a]	0,30[a]	0,30[a]	0,30[a]	0,29[a]
Non industrial products	0,36[a]	0,36[a]	0,35[a]	0,34[a]	0,33[a]

Source: Estimated by the authors, with research data, through the software GEODA (2017).
Note: Empirical pseudo-significance based on 999 random permutations.
[a] Significant at a 1% significance level.

insertion (15,6% annual average growth), but Brazilian manufacturing companies also managed to evolve positively in the external market (11,3% year).

Within the non industrial product group, the commodities are presented as the vector of exports expansion (18% growth/year), at the same time there was low penetration of more technological products (mainly high technology) among the manufactured products: 7,7% annual average growth for high technology industrial products; 9,1% mid-high technology; 15,6% mid-low technology and; 9,2% low technology.

It was possible to verify that the Brazilian exports of all types of goods grew, but presented lower development in higher technology products. Also, when analyzing the exports spatial distribution, not all Brazilian microregions were seen to include these goods in their exports agenda (Fig. 1). Considering 2014, only 197 microregions exported high technology products, 394 low technology and 363 “non industrial” products. Therefore, it was seen that the more intense in technology the good is, the lower the number of exporting microregions is.

Another point to be emphasized regarding the maps in Fig. 1 refers to the proximity between the exporting regions, mainly, in relation to the high technology products; that is, the existence of some exports clusters is noticed. To confirm the evidence that the exports distribution is not random, the Moran I statistics was calculated, which is available in Table 1. According to the results obtained, regardless of the convention used, the spatial randomness hypothesis is rejected for all kinds of exported products. In addition, the higher the technology of the products is, the higher the Moran I coefficient is, which signalizes a more marked concentration of the Brazilian spaces responsible for these products exports.

It is important to mention that the exports spatial concentration, mainly high technology, occurs in the regions South and Southeast. The data reported in Table 2 shows that, respectively, 97% and 95% microregions located in the regions South and Southeast export manufactured products, and from this total 68¨and 63% exported high technology goods; values which are much ahead than the regions North and Northeast, whose coverage was only 9% and 15% of their microregions, respectively.

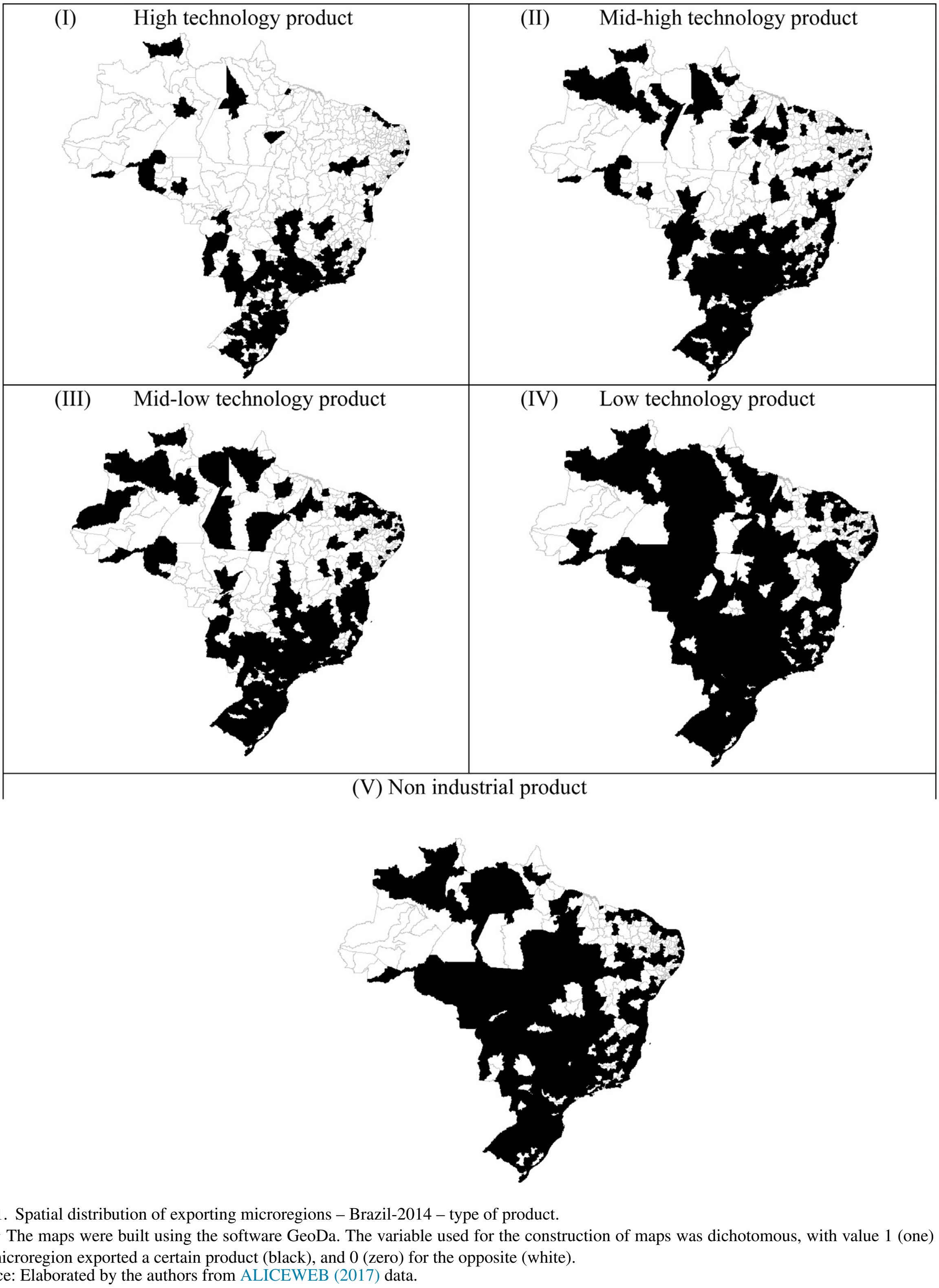


Fig. 1. Spatial distribution of exporting microregions – Brazil-2014 – type of product.
Note: The maps were built using the software GeoDa. The variable used for the construction of maps was dichotomous, with value 1 (one) when the microregion exported a certain product (black), and 0 (zero) for the opposite (white).
Source: Elaborated by the authors from ALICEWEB (2017) data.

Table 2
Percentage of exporting microregions – Brazilian regions – 2014 (%).

Region	Non industrial	Manufactured	Manufactured (type of product)			
			High	Mid-high	Mid-low	Low
Center-west	83	86	25	46	42	80
North	57	68	15	26	39	55
Northeast	38	60	9	24	36	49
South	90	97	68	87	85	96
Southeast	77	95	62	77	84	86

Source: ALICEWEB (2017), with data organized by the researchers.

Table 3
Moran I coefficient—Brazilian microregions.

Variable		Convention				
		Queen	Tower	4 neighbors	5 neighbors	6 neighbors
GDP average growth rate (between 2000 and 2010)		0,20[a]	0,21[a]	0,16[a]	0,17[a]	0,16[a]
Moran I Bivariate average economic growth (2000–2010) and:	Total exports	0,10[a]	0,12[a]	0,14[a]	0,12[a]	0,12[a]
	High technology exports	0,05[b]	0,05[b]	0,06[b]	0,05[b]	0,05[b]
	Mid-high tech. exports	0,08[b]	0,08[b]	0,09[a]	0,09[a]	0,09[a]
	Mid-low tech. exports	0,05[b]	0,05[b]	0,06[b]	0,05[b]	0,05[b]
	Low technology exports	0,11[a]	0,12[a]	0,12[a]	0,10[a]	0,10[a]
	Non industrial exports	0,14[a]	0,14[a]	0,16[a]	0,13[a]	0,12[a]

Source: Estimated by the authors with research data using the software GEODA (2017).
Note: Empirical pseudo-significance based on 999 random permutations.
[a] Significant at a 1% significance level.
[b] Significant at 5% significance level.

The information reported in this study highlights the spatial discrepancies existing in the Brazilian international trade, which can be determined by different factors. Among these factors, Perobelli and Haddad (2006) pointed out that the regions South and Southeast presented better infrastructure (transportation system), great number of average sized cities, universities and research centers. These factors provide the microregions with competitive advantages, favoring the attraction of companies.

This differentiated location of the exports might interfere in the economic dynamics of Brazilian spaces. By specializing, the region promotes capital and workforce migration, having dominant effects on the region economic growth. The exporting base theory infers the existence of multiplying effects originated in this external insertion, leading to the expansion of other segments, which are non exporting segments (North, 1955).

Basically, two paths promote these results: the productive process backwards and forwards linkage, leading to the promotion of other industrial activities; and the income effect, which impacts the commerce, the services sector and other local market consumer goods producing industries (Souza, 2012). Both paths influence positively the final demand, as a function of income and employment growth, stimulating production destined to the domestic market. These inter-sector externalities are generated with the external insertion of a region are directly linked to the dynamic gains of the exporting sector. Moreover, even productivity might be affected as a result of the international competitiveness (Feder, 1982; Crespo-Cuaresma; Wörz, 2005).

In such context, the spatial distribution of Brazilian exports might influence the economic dynamism of its regions. Table 3 shows that the distribution of the Brazilian microregion economic growth rate is not random, and that there is a distribution pattern. The statistically significant Moran I value indicates that those microregions with high growth rate are surrounded by other microregions that also present high growth rates; and that microregions presenting low dynamism are also surrounded by other regions with reduced dynamism. To sum up, exportations do not present random distribution (as seen in Table 1) and neither does the economic growth.

Also, in Table 3, the Moran I bivariate was evaluated. The bivariate analysis made it possible to see that the microregions that presented high (low) values of certain variable Y (economic growth) are surrounded by other microregions which present high (low) values of another variable X (exportation). The results revealed that the economic growth of microregions is influenced by the performance of the micrgregion exports and its neighboring areas. That is, the hypothesis that higher economic dynamism is mainly centered in those regions where exports growth is greater is confirmed, which strengthens an effect of result overflow around these regions. It is interesting to note that the Moran I bivariate value is higher when the exported goods present less intense technology; this result disagrees with Crespo-Cuaresma and Wörz's (2005) growth model. This model defends the hypothesis that sectors which are more intense in technology provide higher productivity gains and externality than those obtained in less sophisticated sectors. However, it is only possible to evaluate this model hypothesis more deeply after estimating the econometric model, which will be accomplished below.

4.1. Effects of exports segmented into technological levels on the economic growth of Brazilian microregions: econometric estimates

A deeper investigation of the central hypothesis of the Crespo-Cuaresma and Wörz's (2005) model is carried out through the estimation of the econometric model specified in (11). It is relevant to bear in mind that in this model the GDP growth rate of each microregion is related to the proxy used for productivity and externality of each exporting segment, with the addition of other control variables.

Another important point to highlight is the existence of a spatial autocorrelation between the variables (confirmed in Tables 1 and 3), this factor demands the use of spatial econometric techniques.[10] Thus, before reporting the model estimation results, a thorough analysis of residues was carried out, in order to verify the presence of spatial dependency and, also, investigate the most suitable spatial model (Appendix A).

When choosing the Fixed Effects (FE) or Random Effects model, the former was shown more suitable to the data and, therefore, only the results obtained from it are reported in this study (Table 4). Later on, the definition of the most suitable Fixed Effects model was carried out by observing the model adjustment quality according to the information criteria by Akaike and de Schwarz. In this case, the Durbin Spatial Model (DEM) was the one presenting the best adjustment and, therefore, used as reference for the analysis (Table 4—Model IV)

The main results showed a positive effect of the physical and the human capital on the GDP growth and a negative effect for the crisis dummy. In relation to the exports effect, the productivity differential was shown positive and statistically significant for the three exporting segments, with higher impact of higher technological intensity products. Such results are similar to those found by Crespo-Cuaresma and Wörz (2005), who reported a positive productivity differential for high technology manufactured products and for the non industrial ones.

Regarding externalities, only more technology intensive exports (high and mid-high technology) presented statistically significant coefficient, however, it showed a negative signal which had not been expected. That is, the exports in this segment contribute directly to the formation of the regional product, however, their indirect effects are negative.

Among the elements that might justify such result is the lack of linkage of more intense technology regions, which depend on the importation to produce, without presenting technological diffusion and/or an employment multiplier or high income. Reinforcing these arguments, Lemos et al. (2003) pointed out the existence of productive drawbacks in the exporting agglomerates with higher technology, mainly in the Brazilian Northeast, which is regionally isolated, without a sectorial complement.

Empirical evidence by Crespo-Cuaresma and Wörz (2005) did not find significant effects of externalities for any type of exportation. Even when they separated the samples from OECD countries and those not belonging to OECD, they could not identify an expressive effect of externalities on the economic growth either, showing a result close to the one obtained in this study. The Crespo-Cuaresma and Wörz's (2005) hypothesis is that spillover effects might be more sensitive to imports than to exports. Such argument cannot be proved due to the character of the estimated model, which is offer oriented.

The parameter ρ presented positive and significant effect, demonstrating a positive overflow of GDP growth in the economic dynamics of neighboring microregions. This demonstrates that when some region growths, part of this

[10] As presented in Tables 1 and 3, which show that neither the economic growth nor the exports present random distributions within the Brazilian microregions. It seems relevant to emphasize that the convention used for the estimates was the "tower" type, for presenting in general, the highest values in the Moran I statistics.

Table 4
Result of the estimation of the Crespo-Cuaresma and Wörz's (2005) model for the Brazilian microregions with the spatial data panel technique—2000–2010 Eq. (11).

	Model			
	EF–SAR (I)	EF–SEM (II)	EF–SAC (III)	EF–SDM (IV)
$INCF_{jt}$	9492.36[a] (0,00)	**10 418,27[a] (0,00)**	**7129,63[a] (0,00)**	**11 604,77[a] (0,00)**
$FTRAB_{jt}$	0,045 (0,42)	0,03 (0,41)	0,06 (0,12)	**0,07[a] (0,02)**
KH	**0,96[a] (0,00)**	**1,05[a] (0,00)**	**0,70[a] (0,00)**	**0,76[a] (0,00)**
$CRES.X_{j,t,NI}(1-PARTX_{j,t,NI})$	0,0001 (0,10)	0,0001 (0,07)	0,00004 (0,39)	0,0001 (0,20)
$CRES.X_{j,t,BT}(1-PARTX_{j,t,BT})$	0,00002 (0,74)	0,0001 (0,35)	−0,0001 (0,14)	0,00003 (0,99)
$CRES.X_{j,t,AT}(1-PARTX_{j,t,AT})$	**−0,001[a] (0,00)**	**−0,001[a] (0,00)**	**−0,001[a] (0,00)**	**−0,001[a] (0,00)**
$CRESX_{j,t,NI} * PARTX_{j,t,NI}$	**0,05[a] (0,00)**	**0,05[a] (0,00)**	**0,05[a] (0,00)**	**0,045[a] (0,00)**
$CRESX_{j,t,BT} * PARTX_{j,t,BT}$	**0,028[a] (0,00)**	**0,025[a] (0,00)**	**0,03[a] (0,00)**	**0,026[a] (0,00)**
$CRESX_{j,t,AT} * PARTX_{j,t,AT}$	**0,07[a] (0,00)**	**0,08[a] (0,00)**	**0,05[a] (0,03)**	**0,07[a] (0,00)**
DC	−0,16 (0,75)	−0,20 (0,84)	**−0,18 (0,42)**	**−4,8[a] (0,00)**
ρ	**0,43[a] (0,00)**	–	**0,70[a] (0,00)**	**0,44[a] (0,00)**
λ	–	**0,45[a] (0,00)**	**0,50[a] (0,00)**	–
$WINCF_{jt}/PIB_{JT}$	–	–	–	**−4752,66[a] (0,00)**
$WFTRAB_{jt}$	–	–	–	0,02 (0,92)
WKH_{jt}	–	–	–	**−0,76[a] (0,03)**
$WCRES.X_{j,t,NI}(1-PARTX_{j,t,NI})$	–	–	–	**0,0002[a] (0,05)**
$WCRES.X_{j,t,BT}(1-PARTX_{j,t,BT})$	–	–	–	**−0,001[a] (0,05)**
$WCRES.X_{j,t,AT}(1-PARTX_{j,t,AT})$	–	–	–	**−0,0007[a] (0,00)**
$WCRESX_{j,t,NI} * PARTX_{j,t,NI}$	–	–	–	0,04 (0,08)
$WCRESX_{j,t,BT} * PARTX_{j,t,BT}$	–	–	–	0,02 (0,20)
$WCRESX_{j,t,AT} * PARTX_{j,t,AT}$	–	–	–	−0,04 (0,24)
Inf. Crit. Akaike	39 876	39 890	39 798	**39 757**
Crit. Schwarz	39 935	39 951	39 858	**39 817**

Source: Estimated by the authors with research data.
Note: In the parenthesis, the Drisccoll-Kraay standard error is reported. $INCF_{jt}$ is the investment in physical capital in relation to the GDP in the j-th microregion in time *t*; $FTRAB_{jt}$ is the population growth rate in the j-th microregion in time *t*; $CRESX_{jt}$ is the exports growth rate in the j-th microregion in time o *t*; $PARTX_{jt}$ corresponds to the exports participation in the GDP of the j-th microregion in time *t*; DC refers to a crisis dummy ("one" for 2008, 2009 and 2010, and "zero" for the remaining years); *NI* is the non industrial goods exports; *BT* is the low technology goods exports added to the mid-low; and *AT* is the high technology goods exports added to the mid-high technology products; KH refers to human capital.
[a] Significant at a 5% significance level.

growth is also beneficial to the neighboring regions, creating a virtuous cycle of growth; this result is in accordance to the Moran I analysis (reported in Table 3).

Regarding the spatial discrepancies of explaining variables, the participation of physical capital in the GDP, human capital and externalities of low and high technology and the externality of non industrial products presented statistical significance. However, only the latter presented positive effect, so that the externalities generated by the exportation of non industrial products impacted directly the growth rate of neighboring towns. Considering the remaining discrepant variables, their coefficients were seen to present negative signal, which had not been expected. Regarding physical capital, the hypothesis for that result is that when a microregion increases its physical capital in relation to its GDP, it attracts human capital from neighboring regions, due to higher salaries, and also acts as a centripetal force of physical capital investments, weakening the neighboring regions. This means that instead of generating positive effects for the neighboring regions, the encouragement of physical capital in specific spaces tends to intensify regional inequalities (Myrdal, 1965). Similar reasoning can be applied to the human capital, considering that when a microregion increases its workforce, it can be assumed that it has higher productivity, with higher salaries, which potentially attract human capital from neighbouring cities, weakening their economic dynamism.

Likewise, the negative effect of externalities of higher technological intensity exported goods and lower technological intensity products (both are processed goods) on the economic growth of neighboring areas might share the explanation above, with leakage of productive factors (human and physical capital) to regions of higher productive dynamics, that is, to areas which are potentially internationally inserted.

Table 5
Results of the estimation with Crespo-Cuaresma and Wörz's model (2005) for the Brazilian microregions using the spatial data panel technique – 2000–2010 – Model (11′).

	EF–SAR (I)	EF–SEM (II)	EF–SAC (III)	EF–SDM (IV)
$INCF_{jt}$	9576,68[a] (0,00)	**10 480,36[a] (0,00)**	**7228,81[a] (0,00)**	**11 683,68[a] (0,00)**
$FTRAB_{jt}$	0,05 (0,37)	0,043 (0,32)	0,06 (0,12)	**0,08[a] (0,01)**
KH	**0,98[a] (0,00)**	**1,07[a] (0,00)**	**0,72[a] (0,00)**	**0,78[a] (0,00)**
$CRES.X_{j,t,NI}(1-PARTX_{j,t-1,NI})$	**0,0001[a] (0,00)**	**0,0002[a] (0,00)**	**0,0001[a] (0,00)**	**0,0001[a] (0,00)**
$CRES.X_{j,t,BT}(1-PARTX_{j,t-1,BT})$	**0,0001[a] (0,01)**	**0,00001[a] (0,00)**	**0,0001[a] (0,01)**	**0,0001[a] (0,00)**
$CRES.X_{j,t,AT}(1-PARTX_{j,t-1,AT})$	0,000001 (0,10)	**0,000001[a] (0,03)**	**0,00001[a] (0,01)**	**0,00001[a] (0,01)**
$CRESX_{j,t,NI} * PARTX_{j,t,NI}$	**0,05[a] (0,00)**	**0,046[a] (0,00)**	**0,047[a] (0,00)**	**0,045[a] (0,00)**
$CRESX_{j,t,BT} * PARTX_{j,t,BT}$	**0,029[a] (0,00)**	**0,026[a] (0,00)**	**0,027[a] (0,00)**	**0,027[a] (0,00)**
$CRESX_{j,t,AT} * PARTX_{j,t,AT}$	**0,07[a] (0,00)**	**0,08[a] (0,00)**	**0,06[a] (0,04)**	**0,071[a] (0,00)**
DC	−0,14 (0,78)	−0,19 (0,85)	**−0,16 (0,47)**	**−4,9[a] (0,00)**
ρ	**0,43[a] (0,00)**	–	**0,70[a] (0,00)**	**0,44[a] (0,00)**
λ	–	**0,45[a] (0,00)**	**0,50[a] (0,00)**	–
$WINCF_{jt}/PIB_{JT}$	–	–	–	**−4672,32[a] (0,00)**
$WFTRAB_{jt}$	–	–	–	0,005 (0,97)
WKH_{jt}	–	–	–	−0,09 (0,81)
$WCRES.X_{j,t-1,NI}(1-PARTX_{j,t-1,NI})$	–	–	–	0,000008 (0,86)
$WCRES.X_{j,t-1,BT}(1-PARTX_{j,t-1BT})$	–	–	–	−0,0002 (0,09)
$WCRES.X_{j,t-1,AT}(1-PARTX_{j,t-1,AT})$	–	–	–	**−0,00001[a] (0,00)**
$WCRESX_{j,t,NI} * PARTX_{j,t,NI}$	–	–	–	0,041 (0,08)
$WCRESX_{j,t,BT} * PARTX_{j,t,BT}$	–	–	–	**0,02[a] (0,00)**
$WCRESX_{j,t,AT} * PARTX_{j,t,AT}$	–	–	–	−0,02 (0,20)
Crit. inf. Akaike	39 879	39 896	39 800	**39 768**
Crit. Schwarz	39 938	39 956	39 860	**39 828**

Source: Estimated by the authors with research data.
Note: In the parenthesis, the Drisccoll-Kraay standard error is reported. $INCF_{jt}$ is the investment in physical capital in relation to the GDP in the j-th microregion in time *t*; $FTRAB_{jt}$ is the population growth rate in the j-th microregion in time *t*; $CRESX_{jt}$ is the exports growth rate in the j-th microregion in time o *t*; $PARTX_{jt}$ corresponds to the exports participation in the GDP of the j-th microregion in time *t*; DC refers to a crisis dummy ("one" for 2008, 2009 and 2010, and "zero" for the remaining years); *NI* is the non industrial goods exports; *BT* is the low technology goods exports added to the mid-low; and *AT* is the high technology goods exports added to the mid-high technology products; KH refers to human capital.
[a] Significant at a 5% significance level.

Finally, new estimates (11) were presented, with a time gap for the externalities [Eq. (11′)]. Such procedure was adopted due to the lack of infrastructure, investment in R&D and lack of specialized workforce all over the Brazilian territory. There are some microregions that present favourable characteristics, however, these are the minority (Lemos et al., 2003). In such context, exporting does not necessarily result in immediate indirect productive effects, and some time is needed so that the domestic industry is organized and such linkage can be seen. Therefore, externalities were given a one-year-gap, seeking to capture this subsequent effect of exports on the economic growth.

Results are shown in Table 5. Regarding the remaining variables, the effect was the same found in the original estimates (Table 4), with positive influence for physical and human capital, keeping a positive effect for the productivity differential in all exporting segments, with negative effect of the crisis dummy, and economic growth positive spatial effect.

Considering externalities, with the time gap, positive and significant influences were found for all exports classifications. Therefore, the effects of externalities are not seen immediately throughout the country (as shown by the estimates in Table 4), and some time is needed so that the region can adapt and obtain economic growth gains.

Also, a positive spatial influence of externalities of low and mid-low technology products was seen, which affected the economic dynamism of neighboring microregions. The most advanced technological intensity exports remained with the same effect (negative) on the neighboring areas, but the products of the technology less intensive industry changed their impact, influencing positively the neighboring regions.

Table 6
Result of the Crespo–Cuaresma and Wörz's model estimates (2005) for group of Brazilian regions using the spatial panel technique – 2000–2010 – Model (11).

	Fixed effect—SDM (I) South/Southeast	Fixed effect—SDM (II) Center-West/North/Northeast
$INCF_{jt}$	13 361,5[a](2230)	**10 062,3[a](1514)**
$FTRAB_{jt}$	0,17 (0,11)	**0,06 (0,04)**
KH	0,23 (0,60)	**0,87[a](0,41)**
$CRES.X_{j,t,NI}(1-PARTX_{j,t,NI})$	0,00005 (0,00005)	**0,0003[a](0,00007)**
$CRES.X_{j,t,BT}(1-PARTX_{j,t,BT})$	0,000007 (0,00006)	−0,001 (0,001)
$CRES.X_{j,t,AT}(1-PARTX_{j,t,AT})$	**0,0007[a](0,0001)**	−0,0006 (0,002)
$CRESX_{j,t,NI} * PARTX_{j,t,NI}$	**0,07[a] (0,02)**	**0,03[a] (0,02)**
$CRESX_{j,t,BT} * PARTX_{j,t,BT}$	**0,02[a](0,01)**	**0,05[a](0,007)**
$CRESX_{j,t,AT} * PARTX_{j,t,AT}$	**0,08[a](0,02)**	−0,07 (0,05)
DC	−0,33 (0,42)	**−42,40[a] (11,24)**
ρ	**0,44[a] (0,05)**	0,46[a](0,05)
$WINCF_{jt}/PIB_{JT}$	**−5123,0[a] (2212)**	**−4852,6[a](1554)**
$WFTRAB_{jt}$	**−0,20[a](0,10)**	0,18 (0,14)
WKH_{jt}	−0,55 (0,58)	0,24 (0,45)
$WCRES.X_{j,t,NI}(1-PARTX_{j,t,NI})$	0,0001 (0,0001)	**0,0003[a](0,00008)**
$WCRES.X_{j,t,BT}(1-PARTX_{j,t,BT})$	**0,0004** (0,0002)**	−0,001 (0,002)
$WCRES.X_{j,t,AT}(1-PARTX_{j,t,AT})$	0,0006 (0,04)	−0,004 (0,006)
$WCRESX_{j,t,NI} * PARTX_{j,t,NI}$	0,015 (0,03)	**0,06*(0,02)**
$WCRESX_{j,t,BT} * PARTX_{j,t,BT}$	**0,02[a](0,01)**	0,01 (0,01)
$WCRESX_{j,t,AT} * PARTX_{j,t,AT}$	0,03 (0,04)	0,08 (0,13)

Source: Estimated by the authors with research data.
Note: In the parenthesis, the Drisccoll-Kraay standard error is reported. $INCF_{jt}$ is the investment in physical capital in relation to the GDP in the j-th microregion in time *t*; $FTRAB_{jt}$ is the population growth rate in the j-th microregion in time *t*;
$CRESX_{jt}$ is the exports growth rate in the j-th microregion in time o *t*; $PARTX_{jt}$corresponds to the exports participation in the GDP of the j-th microregion in time *t*; DC refers to a crisis dummy ("one" for 2008, 2009 and 2010, and "zero" for the remaining years); *NI* is the non industrial goods exports; *BT* is the low technology goods exports added to the mid-low; and *AT* is the high technology goods exports added to the mid-high technology products; KH refers to human capital.
[a] Significant at a 5% significance level.

In this sense, a productivity differential was seen in all exporting segments, which also had a subsequent effect of externalities on the economic dynamism. Such effect might overcome territorial limits mainly when considering the exports of low and mid-low technology industries.

As it can be seen in Fig. 1, exports are not distributed homogeneously throughout the country, and are mainly concentrated in the regions Southeast and South. This heterogeneity might result in differentiated effects of exports on the economic growth of each region. Thus, aiming at capturing this heterogeneity, the model described in (11) was re-estimated, obtaining a model for the regions Southeast and South and another model for the regions Center-West, North and Northeast.[11]

Therefore, the results (Table 6) corroborate this hypothesis, so that in the regions Southeast and South [Table 6, column (I)] the externality of the high/medium technology exports is positive and statistically significant and the productivity of all segments also have positive effect on the economic growth, with greater effects for the levels which are more intense in technology, as proposed by the theory.

In the Center-West/North/Notheast, only the externality of non industrial products have a statistically significant effect on the economic growth rate, justified by the lower incidence of industrialization and the chain effects it generates in these regions. Also, the productivity differential was only obtained for exports of non industrial products and those with low technology.

For the explaining variables spatial discrepancy, the low technology presented effect on the productivity and on the externality of the economic growth of neighboring regions in Southeast and South. While for the Center-West, North

[11] The most suitable model for both estimates was SDM, since it presented the lowest value for the Akaike information criteria (Southeast/Sout: SAC with 17690; SAR 17697; SEM 17969; SDM 17652. Center-West/North/Northeast: SAC com 22344; SAR 22366; SEM 22376; SDM 22297). Moreover, the estimate was through fixed effect, according to the Hausman test result (Southeas/South: 141; Center-West/North/Northeast: 160).

and Northeast, both the productivity and the non industrial product externality presented an effect on the neighboring economic dynamics.

Therefore, it becomes clear that the heterogeneity between Brazilian spaces generates differentiated effects of exports on the economic growth, with predominant influence of industrial products (mainly with higher aggregated value) in the Southeast/South, and non industrial in the Center-West/North/Northeast.

5. Final remarks

As the technological intensity of the export goods is altered, differentiated effects on the economic growth are expected. This hypothesis was tested in this study, verifying the influence of exports classified into technological intensity on the economic growth of Brazilian microregions, in the period between 2000 and 2010 by employing the Crespo-Cuaresma and Wörz's (2005) theoretical model.

Basically, two indirect effects on the economic growth can be obtained with exports. The first results from the productivity differential existing between the exporting sector and the non exporting one. The second refers to the externalities generated by the exporting sector in the economy as a whole. The hypothesis is that when the exports are more intense in technology, the product growth is higher due to higher gains in externality and productivity.

Regarding the Brazilian microregions, the results confirmed the theoretical expectation. In all technological segments, exports presented productivity differential when compared to the domestic sector. This is extremely important, since it demonstrates the increase in competitiveness of Brazilian microregions with international insertion. This means that the higher the international insertion is, the higher the internal productivity seems to be. In this sense, favoring exports might lead to the country productive efficiency, making activities more competitive, and showing the great relevance of exporting higher technology products, which presented higher productivity differential when compared to the remaining segments.

When externalities were considered, some effect on the economic growth was also seen as a result of spillovers of technology, knowledge, etc. This phenomenon might be associated to the higher productivity that exporting sectors presented, creating efficiency in the segments linked to them. In addition, other segments might have gained for being close to the exporting sectors, since it tends to generate income effects. The issue raised was that exports effects via externality do not occur immediately. Potentially, this results from lack of infrastructure and specialized workforce throughout the country, which require some time for the productive units to adapt and start to benefit from externality gains.

Therefore, it is necessary to establish a process of dynamic comparative advantage throughout the country, aiming at building a technological environment, providing the workforce with qualification and also focusing on the improvement of the internal infrastructure, so that better linkage with all exporting segments is created, generating more productive effects to the economic dynamism of the Brazilian microregions.

In general, it seems important to confirm the relevance of exports of all technological levels in the economic growth dynamics, due to the resulting impact to the products of each microregion via productivity and externality.

As some heterogeneity was seen regarding the distribution of exported products throughout the country, the effects between Brazilian spaces were also differentiated. In regions whose external insertion, mainly of higher aggregated value products, occurs in a mildest way, the indirect effects of exports are mainly noticed for non industrial products. However, those regions in which there is more exports, mainly of industrial products – for concentrating more industrialization – the influence of exports in the economic growth occurs due to the international trade of these goods (industrial), mainly products with more intense technology.

Therefore, there are differences in the effect of exports on the economic growth depending on the level of development of each Brazilian region. Working the difficulties of each space, fostering infrastructure, productive agglomerates and their efficient segments, might result in higher international insertion and better effects on the economic growth in the future.

It seems relevant to observe that despite all the methodological effort employed in this study, it does not exhaust the discussion involving exports and economic growth. It is necessary to investigate which elements impact the formation of exporting spaces, seeking to identify the motivating elements to the formation of more exporting agglomerates in the Brazilian microregions.

Appendix A. Moran I—Model (11) and Model (11′)

Source: Research results.

MQO	Years									
	1	2	3	4	5	6	7	8	9	10
Model (11)	0,20[a]	0,18[a]	0,33[a]	0,33[a]	0,39[a]	0,27[a]	0,30[a]	0,15[a]	0,20[a]	0,15[a]
Model (11′)	0,25[a]	0,25[a]	0,17[a]	0,24[a]	0,26[a]	0,30[a]	0,42[a]	0,27[a]	0,19[a]	0,21[a]

Note: The empirical pseudo-significance based on 999 random permutations.
[a]Significant at 1% significance level

Appendix B. Descriptive statistics – Brazilian microregions – 2000–2010

Source: Research results

	Average	Standard deviation
GDP growth rate (%)	4,99	10,34
Population growth rate (%)	1,44	3,10
Thousand establishments/GDP	0,003	0,001
Average schooling	9,10	1,36
High + mid-high technology exports (thousand USS)	58.345	392.078
Low + mid-low technology exports (thousand USS)	117.969	469.562
Non industrial exports (thousand USS)	37.383	163.117

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