BRIEF NOTES FOR RURAL DEVELOPMENT: A TECHNICAL TEST USING HIGHWAY MESH IN BRAZIL

Guilherme Asai
Doctorate in Regional Development and Agribusiness

Abstract

Rural development and logistics are correlated over time, mainly due to the role that transport plays in draining the country's agricultural production. This study aims to analyze rural development, by state, using the road network as a proxy for the years 2008 and 2018. For this, an adaptation of traditional methodologies of regional science will be proposed, adapting the logistics (highways) to the rural development. As a result of the 10-year evolution, the road network has grown, enabling greater rural development in each state. This denotes the importance of highways for agriculture and, consequently, for rural development.

Keyword: rural development, logistics, highway mesh.

Resumo

O desenvolvimento rural e a logística estão correlacionados ao longo do tempo, principalmente pelo papel que o transporte tem em escoar a produção agrícola do país. O presente estudo tem como objetivo de analisar o desenvolvimento rural, por estado, usando a rede viária como proxy para os anos de 2008 e 2018. Para isso, uma adaptação de metodologias tradicionais da ciência regional será proposta, adequando a logística (rodovias) ao desenvolvimento rural. Como resultado da evolução de 10 anos, a malha rodoviária cresceu em tamanho possibilitando um maior desenvolvimento rural em cada estado. Isto denota a importância das rodovias para a agricultura e, consequentemente, para o desenvolvimento rural.

Keyword: desenvolvimento rural, logística, malha rodoviária.

JEL Codes: C00, O16, R49

Área temática: Desenvolvimento rural e local
1. Introduction

Brazilian rural development has been topic of study by several authors over time. Abramovay (2000), Veiga (2001), Navarro (2001) and Kageyama (2004) indicates that rural development is multidisciplinary and is linked to regional development and economic growth.

In Brazil, rural development began in 50’s decade, motivated by the economic growth guided by agricultural and livestock modernization plus a set of governmental measures. Subsequently, the concept of rural development goes through structural transformations of the agricultural production conditions to the improving welfare of rural populations (NAVARRO, 2001).

Complementing this idea, Abramovay (2000) designated that the rural development process is not limited to economic growth, but also the expansion and diversity of all set of activities and potential markets, present in the rural environment. According to Veiga (2001), the diversity of the forms of agricultural production are another way to improve rural development.

Groups of economic aspects, such as the level of family income, and social aspects, such as the level of living were commented by Kageyama (2004) as factors of rural development. These aspects affected developing regions in meaning of infrastructure services offer, employment, forest protection and the environment.

Several authors such as Capdeville (2010), Correa and Ramos (2010), Andrade (2011), Gonçalves et al. (2013), Castro (2014) and Almeida et al. (2016) indicate dependence and historical importance of roads transport in the transportation of goods, especially those of agricultural origin.

Within the context of rural development and infrastructure creation, is logistics question. According with Ferrão (2000), the logistic system must ensure regional development policies and be able to articulate relations between rural and urban areas that enable the development of both.

As a benefit of improving infrastructure the logistics sector gains prominence due to the need to flow agriculture and livestock products to the market. Highways, rural development and agriculture are related over time. Thinking about rural development is common to correlate with agriculture, especially with the production and the value for its production, especially with the consolidation of Brazil as one of the main grain producers and exporters over the 2010’s. To reach this position, it is important to the national economy and for the surplus on trade balance, generating currencies for national development. Meanwhile, this production must reach the market and consumers which mostly lives in urban areas, there is also the possibility to export this production, and for those the roads become an important part.

Cargo transportation within Brazil is done predominantly by highways. The importance of the highways is related to distribute the goods and services abroad. This is part of the logistic function as a link between producers and consumers, or vice versa, with ensure the flow of products and services from the point of origin to the point of consumption (BOSONA and GEBRESENBET, 2013; CROUCHER and BAKER, 2014).

To build an efficient logistics infrastructure, including highways, which enables the flow of agriculture production, some guidelines are given by Vieira Filho (2016) study, such increase in productivity, reduction of damage in environment and the maintenance of the development of agribusiness.

For Marsden et al. (2002) the food supply chain is important for rural development areas which increases the necessity of products flow between an area to another. Not so far, Dries et al. (2004) indicates that the necessity of supply supermarket network also increases the rural development due to the agriculture foods sector. But all those studies comment the relationship among logistics and rural development that is necessarily to supply the demand for food.
Knickel et al. (2009) indicates that the logistics is part of rural development as well as cultivation techniques. It is important to recognize that logistics is the responsible, not only to flow the rural production, but supply the inputs for those production as well, instead, the agriculture and livestock’s have their needs. To Caixeta Filho (2006), logistics in agribusiness is necessary to move inputs and products to the right places at the lowest cost.

Rural development, agribusiness, economic growth, and logistics walk together bringing benefits to the country. Thus, the present study aims to address rural development from a different perspective.

Updating Asai and Staduto (2017) study, the present paper will use the same methodology proposed at previously Asai and Staduto’s study. However, there will be a dismemberment by states, which has not happened before, comparing for the years 2008 and 2018. In addition, the calculated indexes will be used for structure a spatial distribution with geographic information system that will serve to analyze the rural development for each region. Therefore, the main objective is to analyze the rural development, by state, using the road network as a proxy of rural development.

To reach this objective, this paper will be divided in four sessions include this one of introduction. The session 2 will describe the methodology and calculation steps; session 3 will present the empirical approach for Brazilian states; for least, session 4 is about the final remarks.

2. Analytical approach

The Theil’s Index is a measure of inequality based on the information theory that used to redundancy in decomposition factors, initially use to measure income inequalities within a group of people or region (HOFFMANN, 1998). The Theil Index in its basic form is known as Theil-T Index and is given by Equation 1.

\[ T = \frac{1}{N} \sum_{i} \frac{\mu_i}{\bar{\mu}} \ln \frac{\mu_i}{\bar{\mu}} \]  \hspace{1cm} (1)

Where:
- \( \mu \) = Income of the tenth person of the population.
- \( \bar{\mu} \) = Income Average population.
- \( N \) = Population size

Instead of using this traditional method for regional science which considers social issues in this present study the proposal of the Theil’s Index adaptation is to reflect the characteristics of infrastructure, based in logistic sector.

Complementing the Theil’s Index method and to cause the index to be redundant is explained by the Equation 2:

\[ H = 1 - \exp (-L) \]  \hspace{1cm} (2)

The Theil’s Index is widely disseminated in the field of regional analysis and several authors such as Barros et al. (2001), Ferreira et al. (2006), Orlowski and Arend (2005), Arend and Orlowski (2012), Monteiro Neto (2014) and Resende and Magalhães (2013) used this methodology in studies focused on influences in regional development.

Furthermore, the characteristic of Theil’s Index allows changes in the main parameters (income) to do studies in regional development from another perspective. The present study proposes an adaptation of these index that will consist by replacing the population income for
the amount of highways (highway mesh in kilometers) as a way to analysis rural development based in logistics.

Thus, the $\mu$ of Theil’s Index will be calculated as indicated in the Equation 3.

$$\mu = MR_i$$  \hspace{1cm} (3)

The average, $\bar{\pi}$, is calculated by following Equation 4.

$$\bar{\mu} = \frac{MR_y}{N}$$  \hspace{1cm} (4)

Where:
$MR_i$ = Area Road Mesh size or state $i$.
$MR_y$ = Road mesh Size of the State or Country $y$.

Thereby, the proposal index to reflects the level of rural development using highways mesh as proxy is given by Equation 5.

$$T_{MR} = \sum \frac{MR_i}{(MR_y/N)} ln \left( \frac{MR_i}{(MR_y/N)} \right)$$  \hspace{1cm} (5)

In this calculation some assumptions must be assumed in order to closure the index: (a) highway mesh will transport most of the agricultural production from countryside to other regions and for export; (b) highways mesh includes freight transport roads, not counting urban transportation; (c) higher $T_{MR}$ indicates that region $i$ is more developed.

In a way to complement those analysis, will be calculate the Coefficient of Geographic Association (CGA) which, according Piacenti and Lima (2012), CAG, as well as the Theil’s Index is also used to regional science and, aims to investigate whether the spatial distribution of a sector is similar to another distinct sector.

The variables used to calculate the CGA will be the highway extension per state and the gross value of agricultural production either for state. With this kind of interaction will be possible to investigate the affinity between those two variables and infer the dependence of logistics for the rural development, due to mainly products are transported by highways in Brazil.

Equation 6 indicates the CGA calculation form.

$$CGA_{ik} = \sum_j \left( \frac{|j_{ei}-j_{ek}|}{2} \right)$$  \hspace{1cm} (6)

Where
$j_{ei}$ = Sector participation $i$ in the region $j$ reference region.
$j_{ek}$ = Sector participation $k$ in the same region $j$ reference region.

As an alternative to analyzing the $T_{MR}$ and the CAG another way will also be calculate which is the density of the highway mesh present in the Brazilian states. This calculation can be done on the basis of total area of the state or in the total planted area, where the latter reflects the level of rural development. The calculation of the density is given by Equation 7.

$$Density of highway mesh = \frac{Extension of the highway mesh}{Planted area}$$  \hspace{1cm} (7)
Therefore, the calculations described above will serve as a basis for inferring the degree of rural development of the different states of Brazil. In a comparative, use a highway mesh as a proxy of rural development will demonstrated the importance of the highways for each federative unit in the country, such as an importance to outflow the production.

3. Empirical approach

Because of the transport of agricultural cargoes are predominantly made by roads, the prospect of rural development through them becomes interesting. According to the National Transport Confederation (CNT, 2018), Brazil has about 1,720,700 kilometers of highways, but the division is not equal between all macro-regions.

The division can be illustrated in Figure 1.

![Figure 1. Distribution of highways in Brazilian macro-region. Source: National Confederation of Transport, 2018.](image)

Observing this structure, regions with more of more economic significance, or economic power, has more roads. Moreover, Brazilian Southeast with 31% of total road network is the most important region in Brazil and its expected more interconnection inside.

Following the principles of rural development based on the greater the number of highways – the better logistics infrastructure provides better flow of production and better income for the region – the Brazil Southeast and South Regions has been the region which has the largest highway mesh, while the Northern has the smallest network.

However, an analysis based only on the number of kilometers of highways may contain an unfairness impacted by the size of the region. Thus, to purge this type of bias, modified Theil Index makes presence.

Estimating the $T_{MR}$ for all Brazilian Regions, the result is an inequality in the distribution of the highway mesh throughout Brazil. Table 1 shows the $T_{MR}$ calculated for the North, Northeast, Southeast, South and Midwest.
Table 1. Index of Theil, $T_MR$, By region of Brazil

<table>
<thead>
<tr>
<th>Region</th>
<th>Index of Theil</th>
<th>$H$</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>-0.3629</td>
<td>-0.4375</td>
</tr>
<tr>
<td>Northeast</td>
<td>0.3338</td>
<td>0.2838</td>
</tr>
<tr>
<td>Southeast</td>
<td>0.6809</td>
<td>0.4938</td>
</tr>
<tr>
<td>South</td>
<td>0.1355</td>
<td>0.1267</td>
</tr>
<tr>
<td>Midwest</td>
<td>-0.3080</td>
<td>-0.3607</td>
</tr>
</tbody>
</table>

Source: research result.

The $T_MR$ calculated reflects predominance of highways as shown in Figure 1. There is an inequality and imbalance present in the road network between Brazilian regions. Some facts contribute to the highlight of the mesh is larger in the Southeast, such as the largest number of habitants, more industries and more economic development. The presence of large urban centers and metropolises, industrial concentration, product flow route, interconnection between south and north makes Brazilian Southeast the main economic and financial center.

If $T_MR$ is calculated over time, the gap between macro-regions decreases as indicated in Figure 2.

Figure 2. $T_{MR}$ for 2008 (left) and 2018 (right).
Source: research result.

Analyzing Table 1 and Figure 2, there is an unequal distribution of highways, whose states in Southeast have a predominance of the highways in relation to the other regions. Over the years, between 2008 and 2018, the roads network distribution became more equal, however Bahia, Minas Gerais and Rio Grande do Sul maintained their disparities through the rest of Brazil.

By linking the highway mesh with rural development, in state terms, the relationship between the extension of the mesh and the gross value of production calculated by the CGA, suggesting that the distribution of the two variables is similar.

Figure 3 denotes the CGA calculations by state.
When analyzing the values obtained from the CAG, in which sought to compare the relationship between the road network and the gross value, allowing inferences regarding the influence of the road logistics sector in rural development (given the premise of the higher gross value is better for rural development of the region), there is an affinity between these variables. This means that the extension of the road network and the vbp have similar spatial distribution.

According to Lima et al. (2006) the CAG has the following behavior: (i) if $0.35 < \text{CAG}$ represents a significant association; (ii) $0.68 < \text{CAG} < 0.34$, the association is considered in average; and (iii) $1.04 < \text{CAG} < 0.69$ indicates an association weak. This association is indicative of the predominance of cargo transportation, mainly agricultural livestock, as cited by the work of Caixeta Filho (2006) and Barat (2009).

In conduct a parameter to suggest that rural development is linked to the presence of the highway mesh in the states, is in density. Paying attention to the South, Southeast and Midwest Regions, where the country's largest agricultural and livestock production is concentrated, there is between 0.4 (Mato Grosso) and 16 (Rio de Janeiro) kilometers of highways for each hectare of planted land. This heterogeneous variation is due to the size of the territorial state in front of its agricultural and livestock production.

In the case of Mato Grosso and Mato Grosso do Sul, the lowest density values, represented by Table 3, may cause losses in the production flow as observed by Kussano and Batalha (2012). This also occurs in the Southern Region (Paraná and Rio Grande do Sul) with a low number of roads per planted area. Such losses compromise the efficiency of the transport of agricultural products, as described by Capdeville (2010), and thus obtaining income for the rural population, hinting its development.

Thus, there are indications that the road network is important for the Brazilian rural development, being important for the disposal of products of agricultural and livestock origin. Within the country, contributing to minimize post-harvest losses (in transport), generating efficiency, employment and foreign exchange for the rural population.

4. Final remarks
The present study aimed at addressing rural development under a different optical that consist in linked the rural development of Brazilian with the logistic sector, especially because the transportation of agriculture and livestock is mainly by highways. Thus, the study related the extension of the highway mesh in each Brazilian state with the gross values of the state production and the planted area to infer a relationship between them and how its linked with rural development.

Using traditional methods in regional science like Theil’s Index and Coefficient of Geographic Association that are knowing to social and spatial analysis the study propose an different approach of those two methods in order to capture the rural development by highway mesh.

As a result, it was observed that indicates Caixeta Filho (2006), Barat (2009), Capdeville (2010) and Kussano and Batalha (2012) on the logistics sector of Brazil is important for the flow of production, as the main modal transport of cargo, and that the inefficiency of the sector can cause losses to the national agribusiness.

By relating the variables of production (gross value and plant area) with the extension of the highway mesh, it is possible to infer a significant dependence between them, as demonstrated by the CAG. However, the density of the mesh brings a negative inference, because the low density of roads in producing regions such as the states of Mato Grosso, Mato Grosso do Sul, Paraná and Rio Grande do Sul, may cause losses in transport due to low inefficiency of sector.

Related to these facts to rural development, it can be inferred that the flow of production is dependent on the logistic sector, through this, Rural development goes through the variant of the road network as the main modal of cargo transport. This flow of production enables economic growth in rural areas, due to the generation of income, currencies and jobs that contribute to the Brazilian rural development.

5. References


CASTRO, D. M. Public policies and prioritization in the choice of transport modes for the flow of agricultural production Brazilian. 2014.115 F. Dissertation (Master's degree)-Master's degree in agribusiness, Federal University of the Great golds, Dourados, 2014.
CENTER FOR ADVANCED STUDIES IN APPLIED ECONOMICS. Agribusiness GDP and Total GDP. Piracicaba: Esalq/USP, 2016.
NATIONAL CONFEDERATION OF TRANSPORT (CNT). Anuário CNT do Transporte 2018: Estatísticas consolidadas. BRASILIA: CNT, 2018


