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The impact of agricultural policy in Brazil and Germany: a comparative approach between the Western Mesoregion of Paraná and Nordrhein-Westfalen State

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Abstract. In Brazil, agriculture has fulfilled its basic functions, being strongly linked to economic dynamics and food security. It has thus contributed to economic growth. In the European Union (EU) agriculture has played a prominent role which, after The Second World War, has unfolded in the formulation of a Common Agricultural Policy (CAP) which has been mainly based on providing food security. The study is included in this context. It aims to measure the incentives of agricultural policy for cereal production in the Western Mesoregion of Paraná and the State of Nordrhein-Westfalen from 2005 to 2017. This was accomplished through an index, which measured the proportional participation of subsidies in the Gross Value Added (GVA) of agriculture in each region. The results showed that agricultural subsidies for Germany and Nordrhein-Westfalen were on average 29% of GVA. While for Paraná and West Mesoregion the value was around 8%. The result allows us to conclude that agricultural subsidies for the German regions were about three times higher than those of the Brazilian regions, demonstrating high participation of subsidies in the producer's income.

Keywords: cereal production, farmer, agricultural policy, rural credit, index.
JEL codes: Q14, Q18.

1. INTRODUCTION

Agriculture plays a key role in society, both in developed and developing economies. In Brazil, it has fulfilled its basic functions, being strongly linked to economic dynamics and food security. It has thus contributed to economic growth, whether it is linked to production focused on the foreign market or to domestic consumption.

In the European Union (EU) agriculture has played a prominent role and after The Second World War this has unfolded in the formulation of a Common Agricultural Policy (CAP) which was mainly based on providing food security within its territory. However, its trajectory was strongly influenced by the interests of its member countries related to commercial issues, which

were important components in the decisions taken in the economic aspect of agricultural policy (Carvalho, 2016; Contini, 2004). This has raised the economic relevance of agriculture internally in the EU and externally on trade relations in global agricultural markets.

In the Brazilian case, the current agricultural policy was systematized around the National Rural Credit System (SNCR), created in 1965 (Do Brasil, De Agronegócio, 2014). This policy was based on rural credit, aiming at the modernization of agriculture, and reduction of the risk of agricultural activity through rural insurance, thus having its incentives strongly related to these objectives, which were absorbed by grain producers focused on the international market, fulfilling the classical functions of agriculture (Pintor, Silva, Piacenti, 2015). Nevertheless, incorporation of the new targets for agriculture has occurred through specific programmes, which have partially affected farmers.

For the EU and Germany, on the other hand, the CAP began with a view to food security and as part of the political bargaining between member countries. The developments of this negotiation based its initial incentives on a system of agricultural price support that provided food security, even at high costs for the bloc, thus needing to be reformed in its trajectory. Reforms that culminated in structural change in the CAP in 1992 (Carvalho, 2016; Abramovay, 2002).

This reform modified the main incentive system established so far, from sustaining agricultural prices to direct payments per hectare. This change deepened in the 2003 reform, which provided for a gradual reduction in incentives until 2013. After this year, the policy's incentives were exclusively linked to direct payments per hectare.

It is in this context of different countries and agricultural and international trade policies that cereal-producing farmers are inserted, both in the Western Mesoregion of Paraná, Brazil and in the State of Nordrhein-Westfalen, Germany. From 2000 to 2018, both regions had their agricultural production specialized in cereals. The study thus aims to investigate the impacts of agricultural policy incentives for cereal production in the Western Mesoregion of Paraná and Nordrhein-Westfalen State from 2005 to 2017.

Examining the literature on the subject, it is common to find studies aimed at measuring the impact of agricultural policies in the countries of Europe and South America. For Germany there are studies with the aim of quantifying the incentives promoted by the CAP to farmers (Zhu, Lansink, 2010; Giannakis, Bruggeman, 2015; Tranter *et al.*, 2007). For Brazil there is also a range of studies aimed at measuring the effects of rural credit for agriculture (Capellesso, Cazella, Búrigo, 2018; Do Brasil, De Agronegócios, 2014; Feijó, 2014; Gasques *et al.*, 2014) However, there is a lack in the study literature that seeks to comparatively measure the impact of agricultural policies in different countries.

Thus, the paper also aims to contribute to the international literature by using a methodology that allows the incentives of agricultural policy in countries of different continents to be measured. To achieve the proposed objective, an index was elaborated, which has the objective of measuring the percentage of agricultural subsidy in relation to the Gross Value Added of agriculture, calculated from 2005 to 2017 for both regions. This was chosen due to its ability to represent the relationship between the total wealth generated in agriculture and the subsidies received by the sector in each country, using the local currency as a measure without the need to resort to monetary or exchange rate corrections.

The paper is structured in six sections, including this introduction. The second and third discuss the role and objectives of agricultural policy in both Brazil and the European Union. The fourth discusses the main variables commonly used in the measurement of agricultural research. The fifth presents the methodology developed and used in the research. The sixth discusses the results of the indexes elaborated to measure the impact of public policy on agriculture in the respective territories. Lastly, the final considerations discuss the results.

2. STRUCTURE AND OBJECTIVES OF AGRICULTURAL POLICY IN BRAZIL AFTER 1990

Law 8.171 of 1991 establishes the way in which agricultural policy should be implemented in Brazil. It assigns to the National Council of Agricultural Policy the prerogative to elaborate the instruments of agricultural policy, among them the Harvest Plan. It is the instrument by which the main lines of financing for agriculture and livestock are dispersed at the national level each year. It specifies volumes of resources for each agricultural activity, payment terms, multiple interest rates, depending on the producer and crop framework to be produced or marketed (MAPA, 2019).

The policies mentioned are mainly operationalized through the provision of credit for financing planting, trading, and investment in rural properties. In general, incentives occur through subsidies in the interest rates of these financings and via rural insurance. The financing is operationalized through the National Rural Credit System (SNCR), created in 1965, and the basis on which Brazilian agricultural policy has encouraged the cultiva-

tion, expansion and modernization of agriculture, having as main objective to promote the technological modernization of agriculture (Do Brasil, De Agronegócios, 2004).

Regarding the SNCR, there is segmentation by type of activity, volume of financing, among others in the Brazilian agricultural policy. Therefore, the system has several funding programmes encompassing the various crops grown in the country. Among these, the main programmes in force for the financing of grain production are the National Programme for Support to The Middle Rural Producer (Pronamp), the Programme for Strengthening Family Agriculture (Pronaf) and the category called other modalities, in which the large producers are framed. These programmes also include soybean, corn and wheat crops and reach the Western Mesoregion of Paraná (Santana *et al.*, 2014).

In the case of Pronaf, it should be emphasized that this differentiated line for small farmers was created only in 1996. Until then, this category of farmers did not have a specific funding line. This fact may be intrinsically linked to the process of agricultural modernization based on the parameters of the green revolution (Aquino, Gazolla, Schneider, 2017). Buainain *et al.* (2014) also highlighted the importance of Pronaf for agriculture but argue that the Brazilian agricultural policy lacked giving attention to the agricultural development agenda of the 21st century, being restricted to the financial scope, and its performance is reduced in terms of new agricultural functions.

Regardless, Gasques *et al.* (2014) showed that agricultural policy has been efficient in promoting and expanding agriculture in Brazil. From 1975 to 2012, total factor productivity (PTF) of production for agriculture grew at a rate of 3.52% per year. Such a measure can be considered high when compared to countries such as the USA, Australia, and Argentina. The authors also pointed out that the increase in productivity after the 2000s was leveraged by the resumption of investments in agriculture due to rural financing policies at subsidized interest. Painter, Silva and Piacenti (2015) also showed that rural credit causes a positive response in the GVA of agriculture for the whole of Brazil, thus sustaining its efficiency.

Measures that would encourage sustainable practices include the creation of the Low Carbon Agriculture Programme (ABC) in 2010. This programme aims to finance agricultural activities related to the reduction of greenhouse gas emissions, made possible through subsidized interest rates (Aquino, Gazolla, Schneider, 2017). Nevertheless, the resources allocated to the ABC are small compared to the other programmes mentioned.

In the same sense, actions for family farming began in 2003. Thus, the following lines were created: Pronaf forest (2003), Pronaf agroecology (2005) and Pronaf ECO (2007). These modalities aim to encourage the adoption of sustainable and conservation practices, as well as the implementation of technological alternatives, thus reducing the impact of agriculture on the environment (Aquino, Gazolla, Schneider, 2017; MDA, 2020).

In 2003 the line Pronaf young was also created, aimed at young people from 16 to 29 years. Operationalized in the same way as the other, the line requires a consideration of professional qualification on the part of the young farmer. The Pronaf young has the objective of improving the conditions of young people in the field aiming at their maintenance and considering the social bias of Pronaf (Barcelos, 2017).

In relation to the main consolidated programmes such as Pronaf, it is known that this policy managed to reach about 30% of rural owners in Brazil from 1996 to 2013. Since most of its subsidies serve farmers focused on the foreign market, i.e., small producers of soybeans, corn, and coffee. However, when observing the values for the Southern region of Brazil, we notice an increase in the importance of this policy, because the percentage of establishments reaches 60%, revealing the profile of ownership and production for the Southern region of Brazil (Capellesso, Cazella, Bulgarian, 2018).

It can therefore be understood that the trajectory of Brazilian agricultural policy was based on rural credit, the modernization of agriculture, and reduction of the risk of agricultural activity. Its incentive measures were designed based on these objectives without major changes in the recent period. These incentives were absorbed by grain producers focused on the international market, fulfilling the classical functions of agriculture. On the other hand, the incorporation of other objectives for agriculture with the intention of solving the new challenges to be faced by farmers is in the early stages.

3. OBJECTIVES AND REFORMS IN THE COMMON AGRICULTURAL POLICY (CAP)

After World War II, the EU began discussion on its Common Agricultural Policy (CAP), which was launched in 1962 (Contini, 2004). Article 39 of the Treaty on the Functioning of the European Union (TFEU) (2006) clearly defines the key objectives for the CAP, namely: 1) to increase agricultural productivity, fostering technical progress, ensuring the rational development of production factors, in particular labour; 2) ensure a fair standard of living for the agricultural population; 3)

stabilize markets; 4) ensure the security of supplies; 5) ensure reasonable prices for consumers (UE, 2019).

Based on these objectives, CAP action programmes were designed, which were structured in two pillars. The first is based on the Common Market Organisation (CMO) of agricultural products and direct payments to farmers and the second is linked to rural development actions. Notified about the first pillar and the CMO, it has the objective of minimizing the effects of agricultural crises and frustrations that may affect production and distribution. Around 75% of the CAP budget is directed to this (European Parliament, 2021).

The second pillar of the CAP addresses rural development policy focused on three priority strands, they are: a) making agriculture more competitive; b) ensuring the sustainable management of natural resources and climate action; and c) achieving territorial development of rural communities, focusing on the creation and maintenance of jobs. This pillar has the objective of promoting sustainable rural development through actions that provide an improvement of climatic and economic conditions, facilitating the permanence of the farmer in the field. About 25% of the CAP budget is allocated to carry out its actions (European Parliament, 2021).

Historically, since the beginning of its implementation, the CAP has focused its attention on sustaining the supply of products, with the main incentive policy being the support of price mechanisms in the CMO. Based on the pricing system, the CAP has failed to reduce disparities in productivity and property size. Thereby, regional and local income disparities persisted and structural changes in agricultural areas were postponed. Thus, initially implementation of the CAP was more influenced by a cluster of individual demands of the member states than in a harmonization strategy for the EEC agricultural markets (Carvalho, 2016).

Based on this scenario, it was not long before the CAP's price support system began to be criticized. One of the factors contributing to both reforms and divergences between EU member countries was the budget. From 1965 to 1970, the percentage of the EEC budget directed to the CAP went from 8.5% to 86.9% of the total (Spence, 2012). Soon after, between the mid-1970s and 1980s, CAP expenditure reached about 90% of the total budget (Guirao, 2010).

Thus, from 1980 to 1992, the CAP began to undergo incremental changes, which aimed to contain overproduction for some foods and reduction of the budget cost. These reforms culminated in structural reform to the CAP in 1992, which modified the price system, the backbone of the CAP, to a system of direct aid through deficiency payments (Carvalho, 2016)

The 1992 reform also caused the so-called mismarriage between production and income for the farmer. Since the transfers would not be linked to direct subsidies per unit produced, but to the size of the area. This mismarriage and transparency of payments made to farmers were the main motivating factors of policy change. However, during the implementation of this policy, transfers have gone from provisional to permanent, as they have become essential to maintain the income of European farmers. In addition, with the system of direct payments there was a real increase in agricultural income, of approximately 12% after the reform (1991 to 1995) (Abramovay, 2002).

In terms of the financial volume passed on by the CAP, after the 1992 reform there was a concentration of resources for grain cultivation, which began to receive 43% of the total CAP resources, whose previous concentration was 29%. Thus, despite the change in the form of subsidies, there was no major change in the division of resources (Abramovay, 2002).

As a result, the system of direct payments was eventually indispensable for the maintenance of income on farms. In 2017 the system of income transfers reached 90% of total land in the EU and accounted for 46% of total agricultural income. In addition, these transfers are carried out based on land area, which tends to concentrate transfers to large and medium-sized farmers (Comissão Europeia, 2017).

On the concentration of CAP payments, it can be said that there was no relevant change. Before the 1992 reform, about 20% of producers concentrated 80% of CAP transfers (Abramovay, 2002). In 2017 about 20% of farmers received 80% of the resources from direct payments. This is one of the reasons that has been pressurizing the EU to discuss new arrangements for the CAP (Comissão Europeia, 2017).

In 2000 there was another reform, which made changes to the reduction of intervention in the prices of agricultural products, mainly cereals and beef (Contini, 2004). In the 2003 reform, the main changes were in relation to subsidy payments to farmers, limiting most of them to an annual transfer unlinked to the amount produced. It also provided for a gradual reduction in transfers to be implemented from 2005 to 2013. After this period, the subsidies would be completely unlinked from production (Da Silva Carvalho, Godinho, 2011)

The 2013 reform, which took effect from 2014 to 2020, aimed to provide greater equity in the transfers of CAP resources, improve the support and income of the most vulnerable farmers and improve environmentally sustainable agricultural practices. Such measures include, for example, crop diversification and the main-

tenance of ecologically rich landscape characteristics (Conselho Europeu, 2019).

After 2013, the system of direct payments to farmers began to adopt a targeting posture and to use multifunctional criteria centered on seven components: 1) base payment per hectare, based on economic and administrative criteria; 2) ecological component, thought to indemnify the provision of public goods in the environmental area; 3) additional payments to young farmers; 4) redistributive support, enabling support to be strengthened for the first hectares of a farm; 5) additional support to areas with natural limitations; 6) help linked to the production of certain areas or crops for economic or social reasons; and 7) support to farmers with annual receipt lower than € 1,250.00 (European Parliament, 2021) .

According to the European Parliament (2021), the criteria for the first four are mandatory membership for EU member states, while the last three are optional. Among the mandatory, the second has great prominence representing 30% of the total payments to farmers. The other 70% are distributed among the other criteria, the former being one of the most important and of greater weight, increasing its share percentage as EU member states decrease the margins of the other criteria to the legal limits established by the EU regulation.

Concern about the environmental issue is one of the main strands of influence for the future of the CAP. Recently, cross-compliance measures have been introduced to direct payments of the policy to comply with mandatory and optional measures intrinsically with both the first and second pillars. Thus, the granting of support to farmers is partially conditional on the adoption of environmental and climate practices (Comissão Europeia, 2017). In addition, for the future of the CAP (2021-2027), the participation and weight of environmental policies was reinforced, as well as an objective of integration between environmental and agricultural policy (De Castro, Miglietta, Vecchio, 2020).

It is therefore understood that the CAP in its trajectory was influenced by rural producers and their organizations, and the commercial policy practiced among EU members. It can also be said that it has succeeded in pursuing and fulfilling the main objectives on which it is based. Thus, the CAP can be understood as the result of a social pact between governments and citizens to fund the modernization of agriculture, the supply of food to the population, the agricultural landscape, agricultural income, and maintenance of the farmer in the field. However, in its most recent reforms, the policy has attracted criticism from society about the value of its expenditures and the fate of its benefits, as well as the social outcry for a strengthening of environmental and sustainable bias.

4. A DISCUSSION ON THE SYSTEMATIZATION OF EXPLANATORY VARIABLES IN AGRICULTURE

Public policy is shaped in order to direct the behaviour of economic agents, aiming at fulfilling the objectives outlined by the policy itself. Nevertheless, in addition to the incentives provided by public policy there are a range of external policy factors that overlap in this process. In general, quantitative studies on the agricultural theme tend to correlate economic, social, demographic and institutional variables as a *proxy* to measure such performance.

For example, De Souza Filho *et al.* (2011) showed that there are a range of factors that can influence the technology used in the field, reporting that the most common factors in the literature are related to property size, risk and uncertainty, human capital, form of land dominance, availability of credit, work, and other inputs. It also groups these factors into four categories, including: 1) socioeconomic characteristics and producer status; 2) characteristics of production and rural property; 3) technology features; and 4) systemic factors.

De Souza Filho *et al.* (2011) held a long debate on these factors, demonstrating that controlling them does not guarantee success in the propagation of policies oriented towards technological diffusion. They mention that a possible solution would be to design flexible policies adaptable to the specificities of communities, considering the technical, social and economic conditions.

Paustian and Theuvsen (2017) analyzed the adoption of a technological standard in German agriculture. In this case, the central hypothesis of the work discussed the adoption of precision agriculture (PA) by German farmers. For this, they used an econometric model to find out what would be the factors that most influence German farmers to adopt PA. The mathematical model pointed out factors that positively influence such as: property size, access to agricultural advice, having up to 5 years of experience in agriculture and having other activities besides farming. It also showed factors that negatively influence such as: properties smaller than 100 ha that produce barley.

Antonini *et al.* (2018) used a multivariate analysis model to understand the perception, degree of adoption and profile of farmers about the implementation of precision agriculture in their properties in the northeast region of Rio Grande do Sul. For this purpose, variables were used such as number of hectares cultivated, land,

schooling and age of the farmer, time of use of precision agriculture, degree of difficulty in using precision agriculture. Both land ownership and educational level and experience stood out in the analysis.

Launioa, Luisa and Angeles (2018) used an econometric model to evaluate peanut producers in the Philippines. Their work aimed to evaluate the socioeconomic profile and decision-making of the rural producer regarding the adoption of technologies for peanut cultivation. In the socioeconomic field, the study used variables such as: gender, age, household size and experience in the farmer's activity, as well as access to rural extension organizations. In the technological scope, variables such as: use of inoculants in seeds, treatment of seeds, chemical fertilizers and pesticides were used. They concluded that the adoption of technologies has a positive impact on production but is still little adopted by farmers.

Viana and Waquil (2014) also used a *Logit* model to analyze the sheep farmers in Rio Grande do Sul and Uruguay. The research hypothesis was the importance of institutional and evolutionary variables in increasing sheep production in Brazil and Uruguay. They used variables such as succession in property, level of technology, external sources of income, motivation for production, age of the producer, experience in the activity, among others.

Giannakis and Bruggeman (2015) conducted a study to identify differences in the economic performance of European agriculture. Variables were used such as: agricultural area used of the property, annual hours worked, number of head of cattle per property, age of the farmer over 55 years, percentage of farmers who have formal training in the area, formation of fixed capital applied in agriculture, productivity of wheat and tomato, percentage of property on less favoured lands, direct payments made by the CAP (Euro/hectares). Among the main factors that increase the likelihood of success of farms are human capital, fixed capital investment in properties and high direct payments made by the CAP.

Specifically on Germany it is possible to highlight its status as a producer with high agricultural performance, with an average annual return of the farm between 40 and 60 thousand euros per year. In addition, only about 30% of its farmers are over the age of 55, compared to 54% on average for EU countries. Farmers in Germany also exhibited a high rate of formal education in agriculture, reaching 70% of the total against about 20% on average for the EU. Only this last factor may represent a nine-fold higher probability of increasing farm efficiency than in low-development countries (Giannakis, Bruggeman, 2015).

Vliet *et al.* (2015) examined the intensification and reduction of land use in Europe. The intensification was based on expansion of the use of the agricultural area and on greater investment in land. The reduction was verified based on the same variables, including land abandonment. To measure these results, they searched for articles aligned with the theme from 1945 to 2013, selecting 218 articles on land use change in the EU in English. In their results they realized that technological factors are more important for intensification in land use, while social, cultural and demographic factors are linked to the reduction in land use in Europe.

Kageyama (2004) developed a set of indexes to measure rural development of the municipalities of the State of São Paulo. The indexes sought to measure economic, demographic, social and environmental dimensions. In the economic area, variables such as *per capita* household income, labour productivity in agriculture and pluriactivity in agriculture were used. In the demographic field, demographic density, variation of the population living in rural areas, rural population and rural migration were used. In the social field, the schooling of the rural population, the percentage of children living in the rural area enrolled in school, among others, were used. In the environmental area, an indicator was elaborated for the absence of monocultures and another containing the percentage of municipalities that adopted soil conservation practices.

Melo and Parré (2007) also use a set of indicators to classify rural development of the municipalities of Paraná. For this purpose, a range of variables was used in the economic, population and social themes in order to commend an economic development index for the municipalities, calculated by the factor analysis technique. These variables include land productivity and rural labour, rural *per capita* income, and specialization in commodity production.

As demonstrated, it is possible to notice that factors such as property size, production specialization, gender, age, experience in activity, education and formal education in the area are observed in most of the studies presented, in both Brazil and Europe. Nevertheless, in addition to these factors, it is also important to investigate the capacity of agricultural policy to influence the production model of these crops in each territory. Since the institutional arrangement for agriculture in force in the EU, and consequently in Germany, has differences from that current in Brazil.

In this sense, Silva, López and Constantino (2016) comparatively analyzed the contribution of agricultural policies to family farmers in Spain, Alicante, and Brazil, in Mato Grosso do Sul. They found that agricultural policies converge in the regions analyzed, however they have greater effectiveness in Spain than in Brazil. Factors such as little adequate infrastructure and deterritoriali-

zation (not belonging to the place) weighed negatively on Brazil. While in Spain the educational level of the farmer, the strong connection to the place, social capital and good infrastructure conditions were pointed out as positive differentials.

Macedo da Silva (2017) conducted his research using a comparative analysis between Brazil and the EU. For this, the study focused on three main themes. The first, in a comparative descriptive analysis of the territories; the second on the governance structure in each site; and the third on public policies aimed at territorial development in Brazil and the EU. Its results confirm that in both areas the territorial development policy is influenced by the local governance in force and may influence rural development.

Thus, there is a range of variables used in an attempt to measure the evolution of agriculture in different territories. Most of them were aggregated into a set of statistical data to measure the impacts or significance of the set of variables on the behaviour of agriculture. In the case of this study, we chose to use indexes with a lower level of aggregation, but to capture the relationship between subsidies directed by agricultural policy and wealth generation in each territory.

5. EMPIRICAL STRATEGY

In order to measure the impact on agricultural policy among the selected territories, an index was elaborated to measure the percentage of agricultural subsidy in relation to the Gross Value Added of agriculture (GVA). This measure was chosen due to its ability to represent the relationship between the total wealth generated in agriculture and the subsidies received by the sector. Due to the uniformity in the calculation of the GVA of agriculture in different countries, the index is also capable of replication in the regions studied, as well as for other regions.

Regardless, due to the various means by which agricultural policy is operationalized in the territories studied it was necessary to use different calculation formulas to obtain a standard unit of measure of subsidies. For Germany and Nordrhein-Westfalen, the index was calculated based on equation (1), because, in this case, it was not necessary to adjust the monetary values captured from the CAP.

$$S_{ji}=\left(\sum Rp_{ji} \Big/ \sum GVA_{ji}\right)*100 \quad (1)$$

Where:
S_{ji} is the percentage of agricultural subsidy received by the territory *j* in year *i*;
Rp_{ji} is the total amount in euros passed on by the CAP to the territory *j in* year *i;*
GVA_{ji} is the Gross Value Added of agriculture in the territory *j* in the year *i*.

In the case of the State of Paraná and West Mesoregion, it was necessary to estimate the total amount in monetary terms of subsidies received by farmers through rural credit. This was necessary because rural credit is subsidized by reducing interest rates, and there is no direct transfer of resources as in the case of the CAP. After this adaptation, a comparison able index was obtained, calculated based on equation (2), that is:

$$S_{ji}=\left(\frac{[\sum Cp_{ji}*(r_i-rp_i)]+[(\sum Ct_{ji}-\sum Cp_{ji})*(r_i-rt_i)]}{\sum GVA_{ji}}\right)*100 \quad (2)$$

Where:
S_{ji} is the percentage of agricultural subsidy received by the territory *j* in year *i*;
Cp_{ji} is the total rural credit value of the Pronaf line received by the territory *j* in year *i;*
Ct_{ji} is the total amount of rural credit received by the territory *j* in year *i;*
rp_i is average interest rate for Pronaf in year *i;*
rt_i is average interest rate for rural credit in year *i;*
r_i is reference interest rate in year *i*;
GVA_{ji} is the Gross Value Added of agriculture in the territory *j* in the year *i*.

The rural credit values from Pronaf were separated due to the difference in interest rates. They were obtained by summing the amount of costing and investment for Paraná and West Mesoregion for each year. The total rural credit value was obtained by the sum of rural credit for costing, investing and marketing for the same regions in each year.

From 2008 to 2018 the interest rate for Pronaf was calculated by the average of the nominal interest rates offered for the Pronaf costing and investment lines (MDA, 2020a; 2020b). From 2005 to 2007, the average rate of Pronaf A, C, D and E categories was used, because they are equivalent to the Pronaf costing and investment lines. These Pronaf lines were used due to their better representativeness of the profile of cereal producers who gain credit in Paraná and West Mesoregion[1]. The rate related to costing and marketing was calculated by the average between the nominal interest rate

[1] Feijó (2014) used a methodology to measure the implicit subsidies in Pronaf. In one of the work steps, the weighted average interest rate for all credit lines in the 2005-2012 program is calculated. The rate obtained by the author is similar to that used in this study.

of general costing and the nominal interest rate of costing for Pronamp (MAPA, 2019; 2016).

The reference interest rate was set at 15.39% per year. This rate was stipulated considering interest rates used in exchange contracts carried out by farmers in Paraná. These exchange contracts are often used by farmers as a form of financing of the cost. They are a tool of the agricultural market provided by the establishments (agricultural resales, agricultural stores) that carry out the sale of agricultural inputs and the purchase of grains from the producer.

Such exchange contracts are also known as exchange operations or barter operations.[2] They are contracts in which the farmer acquires the package of supplies needed to carry out the harvest fixing a quantity of product (commodities) to be delivered at a future date as payment. Therefore, in this process there will be the incidence of pre-fixed interest, which is higher than the official rural credit provided by the government in Brazil. However, from the perspective of the producer, this type of production financing has greater agility due to lower transaction costs (bureaucratic) for the producer, being considered a viable alternative (Arakawa, 2014).

It is also worth mentioning that the rate adopted of 15.39% per year is close to the average Pronaf self-sufficiency rate of 16.25% per year found by Feijó (2014). In addition, this rate was slightly below the average credit cost indicator for the entire Brazilian economy calculated by Banco Central, which was 20.7% per year, on average, from 2013 to 2019 (BACEN, 2020b).

Data for Paraná and West Mesoregion on area harvested from temporary crops, workforce employed in agriculture, GVA of agriculture, Gross Domestic Product (GDP), and number of tractors were collected from the Instituto Brasileiro de Geografia e Estatística[3] (IBGE).

Data on rural credit and the estimated population for Paraná and West Mesoregion were collected at the Instituto Pananaense de Desenvolvimento Econômico e Social[4] (IPARDES). The rural credit related to Pronaf was obtained from the Central Bank of Brazil (BACEN). Information for the calculation of interest rates for rural credit was obtained from the Annual Harvest Plans of the Ministry of Agriculture Livestock and Supply (MAPA). Pronaf interest rates were obtained from the harvest plans for family farming issued by the Ministry of Agrarian Development (MDA) and in Feijó (2014).

Data for Germany and Nordrhein-Westfalen on cereal growing area for grain production, number of farmers and workforce used in agriculture, GVA of agriculture, GDP and fixed capital consumption in agriculture were collected from the European Statistics (EUROSTAT). The amounts of direct payments passed on by the CAP and the number of tractors to Germany and Nordrhein-Westfalen were obtained from the Bundesministerim für Ernährung und Landwirtschaft[5] (BMEL).

6. INDEXES OF PARTICIPATION OF SUBSIDIES IN THE GVA OF AGRICULTURE

To compare the impact of agricultural policy on the regions, a set of indices were drawn up. Tables 1 and 2 show the results of the indexes for measuring subsidies. They allow the weight of the subsidies values in the total added by agriculture in each region studied to be measured and the results compared without the need for further adjustments, since the index is calculated proportionally[6]. Therefore, it is not necessary to make monetary or exchange rate adjustments[7]. As this is a comparison between different countries, monetary and exchange rate adjustments may not adequately reflect the internal price structure for agriculture.

Table 1 shows the total value of CAP subsidies and the total GVA for Germany and Nordrhein-Westfalen from 2005 to 2017[8]. In the last column of the table the result of the index is displayed for each region, being expressed by the percentage of CAP transfers in relation to the GVA of agriculture. In general, it was possible to see that the percentages of subsidies are high in both regions, and the value of the subsidy is higher for Germany. Meanwhile, when a relationship is observed between the GVA of Nordrhein-Westfalen and Germany and the values received per hectare (Fig. 1), it appears that Nordrhein-Westfalen has a GVA for agriculture that is proportionally higher than Germany.

In addition, there is a downward trend in the subsidies passed on by the CAP, occurring since the 2003 reform and deepening with the 2013 reform. This is vis-

[2] For more information on definitions of operations of Barter see Arakawa (2014) and Cançado (2019).
[3] Brazilian Institute of Geography and Statistics.
[4] Paraná Institute for Economic and Social Development.
[5] Federal Ministry of Food and Agriculture of Germany.
[6] Gasques *et al.* (2014) showed that the PTF (Total productivity of production factors for agriculture) calculation methodology follows a similar logic where it is not necessary to deflate the data for calculation of the index.
[7] However, as Tables 1, 2 and Figure 1, they also show monetary values of subsidies and GVA for each region so it was considered necessary to deflate them. Thus, the values for the Brazilian territories were deflated by the *Índice Nacional de Preços ao Consumidor Amplo* (IPCA) collected from the Instituto de Pesquisa Econômica Aplicada (IPEA, 2020). The figures for Germany and Nordrhein-Westfalen were deflated by the Harmonized Index of Consumer Prices (HICP) calculated for Germany and obtained from EUROSTAT (2020c).
[8] This period was specified due to the availability of data regarding the transfers of CAP values.

Tab. 1. CAP subsidies participation index in Gross Value Added of agriculture for Germany and Nordrhein-Westfalen from 2005 to 2017.

Year	Germany (in thousand €) [1]			Nordrhein-Westfalen (in thousand €) [1]		
	CAP[3] subsidy amounts	GVA[2]	Subsidy	CAP[3] subsidy amounts	GVA[2]	Subsidy
2005	6,144,779	15,062,604	*40.79%*	587,858	2,034,298	*28.90%*
2006	6,624,645	15,440,583	*42.90%*	633,766	2,085,516	*30.39%*
2007	6,531,337	16,936,623	*38.56%*	624,839	2,011,450	*31.06%*
2008	6,414,162	18,970,359	*33.81%*	613,629	2,360,565	*26.00%*
2009	6,421,279	14,492,538	*44.31%*	622,620	2,015,327	*30.89%*
2010	6,346,081	16,182,090	*39.22%*	614,344	2,373,842	*25.88%*
2011	6,183,506	21,290,290	*29.04%*	598,393	2,966,596	*20.17%*
2012	6,132,245	18,935,077	*32.39%*	585,232	2,656,663	*22.03%*
2013	6,020,329	22,008,804	*27.35%*	574,551	3,084,745	*18.63%*
2014	4,958,090	21,418,225	*23.15%*	472,539	2,854,780	*16.55%*
2015	4,967,880	15,027,415	*33.06%*	477,521	2,131,889	*22.40%*
2016	4,917,284	16,117,227	*30.51%*	470,758	2,168,252	*21.71%*
2017	4,802,324	20,882,000	*23.00%*	453,495	3.018,620	*15.02%*
Average	5,881,842	17,904,910	*33.70%*	563,811	2,443,273	*23.82%*

Source: Search result based on EUROSTAT (2020a) and BMEL (2020c; 2020d; 2020e).
Note: [1]Values at constant prices in 2017 (EUROSTAT, 2020c), calculated based on equation (1). [2]Gross added value of agriculture. [3]The amounts of the subsidies paid by the CAP to Nordrhein-Westfalen from 2005 to 2008 were estimated based on the average rate of transfers from 2009 to 2017.

ible because subsidies are reducing at an average annual rate of 2.7%, resulting in a drop of approximately 30% from 2005 to 2017 in both regions. On the other hand, in the same period the GVA of agriculture increased by 28% for Germany and 33% for Nordrhein-Westfalen. This behaviour may be related to the need to increase production, therefore the farmer's income, aiming to meet the reduction in subsidies, which in the case of CAP are a direct supplement of income.

On the subsidies it is interesting to note that in addition to the direct transfers of the CAP, farmers receive other tax incentives from the German government (federal and state), such as: interest subsidies for investment, remuneration on financed agricultural diesel, among others (BMEL, 2019), which do not make up the proposed index. According to BMEL (2019), these subsidies accounted for about 15% of the incentives per hectare in Germany from 2013 to 2018. These incentives added to the direct transfers of the CAP and environmental payments represent on average 50% of the income of the farms. From 2013 to 2018 this percentage ranged from 44% to 59% of the average income of German farms.

Table 2 shows the total value of the estimated subsidies[9] and GVA of agriculture for Paraná and West Mesoregion from 2005 to 2017. It also presents the results of the participation index of subsidies in the GVA of agriculture for the same regions and period, estimated by the equation (2). The results showed that the amounts of the subsidies were lower for Paraná than for the West Mesoregion. Overall subsidies have increased, but in the last two years there has been a slight reduction. On average, the subsidies were around 6.5% for Paraná and 9.5% for the West Mesoregion.

In the period analyzed, it is also possible to highlight that the amounts of subsidies practically doubled for both regions. The GVA of agriculture followed this behaviour, but with less intensity, because it showed a growth of about 70% for the same period and regions. This behaviour was different from that observed for the regions of Germany, which showed a reduction in subsidies and an increase in GVA, but at a lower intensity, being around 30%.

Once the results of the indexes were compared, it was found that for Germany and Nordrhein-Westfalen they were higher than for Paraná and West Mesoregion. Between Germany and Paraná the difference is five times greater, reducing this value by half when the relationship between Nordrhein-Westfalen and West Mes-

[9] Indemnity programmes, such as rural insurance (PROAGRO), were not included in the calculation of the index, because they have the purpose of reducing risk to the activity by not configuring subsidies production. They also occur sporadically, aiming to mitigate production costs due to harvesting difficulties.

Tab. 2. Rural credit subsidy participation index in Gross Value Added of agriculture for Paraná and Western Mesoregion of Paraná from 2005 to 2017.

Year	Paraná (in thousand R$) [1]			West Mesoregion (in thousand R$) [1]		
	Subsidy amounts[2]	GVA[3]	Subsidy	Subsidy amounts [2]	GVA[3]	Subsidy
2005	934,275	20,067,099	*4.66%*	212,962	3,334,665	*6.39%*
2006	832,260	18,879,280	*4.41%*	200,436	2,964,131	*6.76%*
2007	1,296,623	23,052,863	*5.62%*	330,835	4,144,132	*7.98%*
2008	1,767,125	28,004,325	*6.31%*	432,034	4,985,182	*8.67%*
2009	1,789,327	23,850,956	*7.50%*	472,999	3,667,576	*12.90%*
2010	1,730,109	27,385,025	*6.32%*	440,397	4,507,229	*9.77%*
2011	1,896,928	29,950,258	*6.33%*	460,437	4,971,138	*9.26%*
2012	2,487,964	30,338,572	*8.20%*	601,650	4,507,966	*13.35%*
2013	3,081,940	38,548,380	*7.99%*	726,040	6,972,534	*10.41%*
2014	3,172,325	34,634,153	*9.16%*	752,009	6,463,301	*11.64%*
2015	2,300,934	32,167,241	*7.15%*	624,352	5,707,923	*10.94%*
2016	2,111,724	35,692,326	*5.92%*	549,939	6,564,024	*8.38%*
2017	1,847,377	34,454,307	*5.36%*	423,822	5,768,597	*7.35%*
Average	1,942,224	29,001,907	*6.53%*	479,070	4,966,030	9.52%

Source: Search result based on BACEN (2020a; 2020c), IBGE (2020e) and IPARDES (2020a).
Note: [1]Values at constant prices for 2017 (IPEA, 2020); R$: Brazilian Real; [2]Estimated values based on equation (2). [3]Gross Value Added of agriculture.

oregion is observed. Thus, it is evident that subsidies are higher in Germany and Nordrhein-Westfalen.

In addition, it is worth mentioning that in the case of the German regions the subsidy is a net and guaranteed income for the farmer. For Brazilian regions, on the other hand, it is a benefit deriving from incentives to finance production dedicated mainly to exports, which focus on all the risks between planting and harvesting. As such, they cannot be understood as guaranteed net income, as the subsidies will only constitute an economic benefit for the farmer after the harvest has been done. This reinforces the advantages offered by the CAP to German farmers through its subsidies.

To analyze how the distribution of subsidies against the territories occurs, Graph 01 was elaborated, in which the average values of the subsidy received per hectare are displayed, both for the Brazilian (R$) and German regions (€) from 2015 to 2017. In Germany and Nordrhein-Westfalen there has been a clear downward trend since 2006, deepened by the reform of the CAP in 2013. For Paraná and The West Mesoregion, there was a rise in subsidies from 2006 to 2014, followed by a drop after that year. It is also observed that Nordrhein-Westfalen and West Mesoregion receive values on average 8% and 27% higher, respectively, than those received by Germany and Paraná.

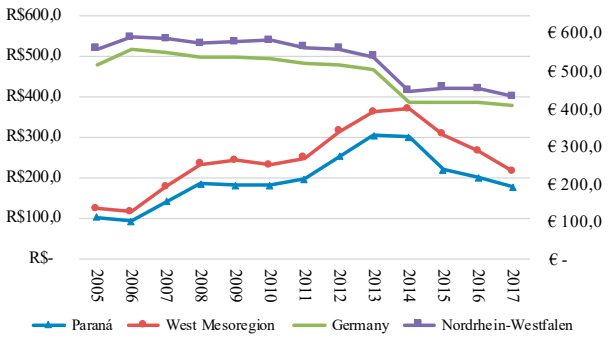
With the intention of demonstrating the capacity of each region to finance its agricultural policies, Table 3 was prepared, which shows in the first column of each region the weight of subsidies in total GDP. This index was obtained through the ratio between the subsidies and the value of GDP for each selected region.

Thus, it can be understood that even though the total of CAP subsidies passed on to Germany and Nordrhein-Westfalen is comparatively high, they have a lower representation in relation to GDP (average of 0.2% and 0.09%, respectively) than Paraná and West Mesoregion (average of 0.53% and 1.11%, respectively). Thereby, the weight of support of the rural credit policy can be considered higher for Paraná and West Mesoregion than for Germany and Nordrhein-Westfalen.[10]

The second index in Table 3 shows the percentage of GVA of agriculture in relation to GDP and can be understood as a measure of the degree of importance of agriculture for the economic activity of each region. Based on the values obtained, it was possible to verify that for the Brazilian territories there is greater importance of this activity than for the German regions. This represents a greater dependence on primary activities in Paraná and the Western Mesoregion. On the other hand, it also draws attention to the low dependence of agriculture on the economy of Germany and Nordrhein-Westfalen, showing values below 1% of GDP.

[10] It should be explained that the resources that subsidize these incentives are controlled by the federal government. Thereby, in practice, the relationship between the financing effort would not be direct from Paraná, but from Brazil.

Fig. 1. Average real value of subsidies per hectare for selected regions from 2005 to 2017.



Source: Search result based on EUROSTAT (2019a), BACEN (2020a; 2020c), BMEL (2020c; 2020d; 2020e), IBGE (2019a; 2020e) and IPARDES (2020a). Note: Constant price values for 2017 based on EUROSTAT (2020c) and IPEA (2020).

In addition, it is also observed that the Western Mesoregion of Paraná has a greater dependence on agriculture both on its economic activity and on subsidies. This is due to two factors. The first is the greater weight of this activity in the total economy. The second due to subsidies increases as funding for agricultural activity increases, a modality widely used in the financing of cereal crops, in which the region specializes. Therefore, the West Mesoregion has a higher degree of specialization, representing about 20% of Paraná's cereal production, as well as receiving on average 27% more subsidies per hectare when compared to Paraná.

In the case of Nordrhein-Westfalen, the behaviour is the opposite. The weight of agricultural subsidies and GVA are lower than for Germany. This is linked to the fact that Nordrhein-Westfalen's GDP is high, representing about 22% of the German total. This makes the index relatively lower, even if Nordrhein-Westfalen has a GVA of agriculture and a proportionally higher volume of subsidies than for Germany.

On the other hand, the behaviour of the variable is the opposite to that observed in Brazilian regions, being correlated with two other factors. First, the subsidies are distributed off the production. Second, this distribution occurs according to the number of hectares and number of measures adopted by the producer based on the objectives established in the last CAP reforms, especially after 2013. Thereby, the form of distribution of subsidies has little relation to the production area and a strong relationship with the ownership and size of the properties.

Another factor that cannot be ignored is the difference in the population of each region. In 2019 the population of Germany was 83 million, of whom 17.9 million resided in Nordrhein-Westfalen. Between 2000 and 2018 it remained stable (EUROSTAT, 2020d). For Paraná, the population was about 11.4 million in 2019, of whom 1.3 million were in the Western Mesoregion. Between

Tab. 3. Weight of agricultural policy subsidies in the GVA of agriculture and GDP for the selected regions from 2005 to 2017.

Year	Germany		Nordrhein-Westfalen		Paraná		West Mesoregion	
	SBU/GDP[1]	GVA/GP[2]	SBU/GDP	GVA/GDP	SBI/GPD[3]	GVA/GDP	SBI/GDP	GVA/GDP
2005	*0.22%*	*0.55%*	*0.10%*	*0.34%*	*0.38%*	*8.12%*	*0.74%*	*11.56%*
2006	*0.24%*	*0.55%*	*0.10%*	*0.34%*	*0.32%*	*7.30%*	*0.65%*	*9.63%*
2007	*0.23%*	*0.59%*	*0.10%*	*0.32%*	*0.44%*	*7.75%*	*0.95%*	*11.88%*
2008	*0.23%*	*0.67%*	*0.10%*	*0.37%*	*0.56%*	*8.87%*	*1.18%*	*13.63%*
2009	*0.24%*	*0.53%*	*0.10%*	*0.33%*	*0.56%*	*7.44%*	*1.30%*	*10.04%*
2010	*0.22%*	*0.57%*	*0.10%*	*0.38%*	*0.50%*	*7.90%*	*1.18%*	*12.09%*
2011	*0.21%*	*0.74%*	*0.09%*	*0.47%*	*0.51%*	*8.06%*	*1.14%*	*12.26%*
2012	*0.21%*	*0.66%*	*0.09%*	*0.43%*	*0.64%*	*7.78%*	*1.38%*	*10.30%*
2013	*0.21%*	*0.76%*	*0.09%*	*0.49%*	*0.72%*	*8.97%*	*1.45%*	*13.96%*
2014	*0.16%*	*0.71%*	*0.07%*	*0.44%*	*0.75%*	*8.22%*	*1.50%*	*12.88%*
2015	*0.16%*	*0.49%*	*0.07%*	*0.32%*	*0.56%*	*7.80%*	*1.22%*	*11.12%*
2016	*0.15%*	*0.51%*	*0.07%*	*0.32%*	*0.51%*	*8.63%*	*1.02%*	*12.13%*
2017	*0.15%*	*0.64%*	*0.07%*	*0.44%*	*0.44%*	*8.18%*	*0.80%*	*10.83%*
Average	*0.20%*	*0.61%*	*0.09%*	0.38%	0.53%	8.08%	1.11%	11.72%

Source: Search result based on EUROSTAT (2020a; 2020b), BACEN (2020a; 2020c), BMEL (2020c; 2020d; 2020e), IBGE (2020e) and IPARDES (2020a).

Note: [1]Total subsidies paid by the Common Agricultural Policy (SBU). [2]Gross Value Added of agriculture at current prices. [3] Total implicit subsidies in rural credit (SBI). Gross Domestic Product at current prices (GDP).

2000 and 2019 it showed an increase of 18% (IPARDES, 2020b).

In this sense, it is understood that the need to feed the population is much higher in the German regions than for the Brazilian ones, as well as its capacity to produce goods and services. Based on this configuration, one can understand the importance of agriculture for Germany in terms of food security. This may be reflected both on the *modus operandi* of subsidies and productivity of the land.

In order to investigate the possible similarities between the production factors in the regions, data were collected on the use of labour and capital in agriculture. Table 4 shows the average amount of work per hectare for the studied regions from 2005 to 2017.

Based on this it is possible to understand that there was a reduction in the amount of average work per hectare, which occurred for all regions. Thus, it can be interpreted that on average one unit of work was used for every 10 hectares for the regions of Paraná in 2006, moving to 15 ha in 2017. This ratio for the German regions went from one unit of work on average every 16 ha in 2005 to 21 ha in 2016.

Figure 2 shows the average investment volume consumed per hectare for Germany and Nordrhein-Westfalen from 2005 to 2017, which was calculated based on fixed capital consumption divided by total hectares for both regions. There is a growth trend in the real value of the investment per hectare, as the compound annual growth rates were 2.1% for Germany and 2.3% for Nordrhein-Westfalen. For the entire period analyzed there was an increase of approximately 25% of the relationship between capital per hectare.

Figure 3 shows the average volume per hectare of rural credit for investment for Paraná and the West Mesoregion from 2005 to 2017. This variable was chosen as a *proxy* for investment in agriculture for Brazilian regions. This was accomplished due to the availability of the data and its ability to jointly measure investments in infrastructure, machinery, equipment and soil improvement. However, it should be emphasized that it is possible that these data underestimate the investment values for Brazilian regions, because the variable computes only the amounts financed via the SNCR, failing to account for investments made with farmers' own resources.

Figure 3 shows that the amount of investment per hectare showed a growth trend in the period studied, increasing from 2007 to 2014 and then falling after that year. This behaviour is related to the variation in interest rates for rural investment credit, which increased after 2014. However, even with the variation, there was a significant growth in the average real value of investments per hectare, which showed compound annual growth rates of 10% in both regions. In absolute terms, even with the fall, the value of the investment per hectare increased by about 75% from 2005 to 2017.

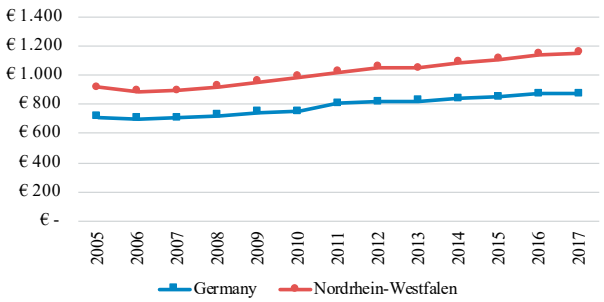
When comparing Figures 2 and 3, it is possible to notice that there was a tendency to increase the capital ratio

Tab. 4. Average amount of work per hectare for Germany, Nordrhein-Westfalen, Paraná and West Mesoregion from 2005 to 2017.

Years[1]	2005	2007	2010	2013	2016	Rate[2]
Germany	0.054	0.051	0.046	0.044	0.042	*-23%*
Nordrhein-Westfalen	0.071	0.064	0.060	0.056	0.057	*-20%*
Years[1]	2006	2017				
Paraná	0.124	0.086				*-30%*
West Mesoregion	0.079	0.056				*-29%*

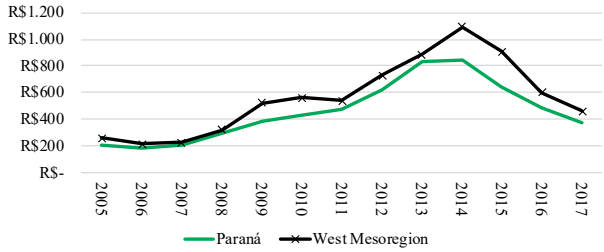
Source: Search result based on EUROSTAT (2019a; 2019d) and IBGE (2019a; 2019d).
Note: [1]Calculated from the total number of rural workers divided by the total area in hectares. [2]Change rate from 2005 to 2016 for Germany and Nordrhein-Westfalen.

Fig. 2. Average fixed capital consumption per hectare for Germany and Nordrhein-Westfalen from 2005 to 2017.



Source: Search result based on EUROSTAT (2019a; 2020a). Note: Values at constant prices for 2017 based on EUROSTAT (2020c).

Fig. 3. Average value of rural investment credit per hectare for Paraná and West Mesoregion from 2005 to 2017.



Source: Search result based on IBGE (2019a; 2020a). Note: Values at constant prices for 2017 based on IPEA (2020).

per hectare in all regions studied. And there was a higher rate of growth of this variable in the West Mesoregion and Paraná. Meanwhile, the values found for Germany and Nordrhein-Westfalen were higher than the Brazilian regions, as well as showing a constant and uninterrupted growth, thus demonstrating a higher level of investments in these regions. Indeed, it is possible to understand that the increase in production in the selected regions is positively correlated with the increase in investments.

Increases in productivity through intensive investment are linked to technological factors. These, in turn, are correlated with factors such as: investments in modern inputs (fertilizers and chemical pesticides), improvements in the production process, investment in soil improvement, investments in machinery and genetic improvement (biotechnology). Therefore, to identify how agricultural mechanization has influenced the productive dynamics, Tables 5 and 6 were elaborated.

Table 5 shows the number of tractors in Paraná and West Mesoregion in 2006 and 2017. It can be noted that there was an increase of around 40% in the number of tractors in both regions. For the West Mesoregion there was relatively higher growth for tractors above 100 Hp. In relation to mechanization, both regions intensified the use of tractors per hectare, because in the period analyzed, the average ratio of tractor per hectare went from one tractor to 80 hectares to one every 65 hectares.

In addition, the number of wheeled tractors sold in Paraná from 2006 to 2017 was higher than the increase in the fleet, indicating that there was a partial renewal of existing tractors. Based on this amount, one can point out a percentage of renewal of the existing fleet in 2006 of approximately 17%. This means that 43% of the tractor fleet in 2017 had 10 years or less of use (ANFAVEA, 2020).

The German regions, on the other hand, have been exhibiting contrary behaviour on the number of tractors. From 2008 to 2017 there was a reduction in the fleet of wheeled tractors of 50% for Germany and 40% for Nordrhein-Westfalen. Nevertheless, even with the reduction, the fleet of tractors remained high mainly for Germany, which in 2017 had about three times the fleet of Paraná. Table 6 presents the information.

Table 6 shows that there was a reduction in the number of tractors per hectare, which was higher in the State of Nordrhein-Westfalen. However, even with the reduction, the ratio of tractors per hectare in the German regions remained higher than the Brazilian ones, indicating that the German regions have higher production mechanization than the Brazilian ones.

It is also interesting to note that in 2017 about 40% of the total tractors in Germany had more than 95Hp, a figure 10 percentage points higher than those found for Paraná. This signals that the power of tractors used in agriculture for Germany has increased, a fact reinforced

Tab. 5. Number of tractors in Paraná and West Mesoregion in 2006 and 2017.

Tractors	Paraná		West Mesoregion		Variation	
	2006	2017	2006	2017	Paraná	West Mesoregion
Number	113,718	166,393	21,215	29,513	*46%*	*39%*
Greater than 100 Hp[1]	33,816	48,898	5,754	8,716	*45%*	*51%*
Tractors per hectare	79	64	81	67	*-20%*	*-17%*

Source: Search result based on IBGE (2019a; 2020h; 2020i).
Note: [1] Horsepower measure.

Tab. 6. Number of tractors in Germany and Nordrhein-Westfalen from 2008 to 2017.

Regions	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Rate[1]
Nordrhein-Westfalen	53,941	50,674	47,532	42,787	40,450	38,371	36,353	30,202	28,819	27,190	*-50%*
Germany	832,124	797,495	765,979	707,690	681,156	658,139	634,363	551,952	534,650	516,781	*-38%*
Tractors per hectare											
Nordrhein-Westfalen	20	21	22	25	26	28	29	35	36	38	*94%*
Germany	14	15	15	17	17	18	19	21	22	23	*59%*

Source: Search result based on BMEL (2020f) and EUROSTAT (2019a).
Note: [1]Rate of change from 2008 to 2017.

by the trend of reduction in the amount of work used in both regions. It also corroborates the increase in capital investments per hectare found in Figures 2 and 3.

7. CONCLUSIONS

Based on the variables analyzed, in Germany and Nordrhein-Westfalen the CAP has helped farmers mainly in economic issues. The index calculated from 2005 to 2017 with the objective of measuring the percentage of subsidies received by farmers in relation to the AGRO-VA of agriculture in the respective regions showed that subsidies for Germany and Nordrhein-Westfalen were, on average, 29% of the GVA. For Paraná and West Mesoregion, the subsidy amount was around 8%. This result confirms that the subsidies for the German regions were about three times higher than in the Brazilian regions, thus demonstrating a high participation of subsidies in the producer's income, which may represent about half of the revenue on German farms.

The results of the index also showed that regions specialized in cereal production, such as Nordrhein-Westfalen and West Mesoregion, have received relatively higher volumes of subsidies than those with lower specialization, such as Germany and Paraná. This indicates that specialization in cereal production is linked to the receipt of greater subsidies and related to a modern and technical agriculture that tends to grow through the use of modern techniques and processes and capital-intensive investments, as shown by the investment trajectory and use of labour.

In addition, it can be pointed out that for the German regions the subsidy constitutes a net and guaranteed income for the farmer, received by means of monetary payments. While for Brazilian regions, the subsidy is a benefit derived from the financing of production, focusing on risks and cannot be understood as guaranteed net income. Moreover, rural credit in Brazil does not reach all farmers, who, when it is not possible to access subsidized rural credit, must use private financing or their own resources to finance production. The factors presented help to reinforce the advantages contained in the subsidies paid by the CAP to German farmers.

On the other hand, the indexes that seek to relate society's ability to finance agricultural policy and the relative weight of the primary sector in economic activity showed that agricultural policy, for Brazilian regions, has a greater impact on economic activity and greater weight on financing capacity than in German regions. As such, the financing capacity of the CAP in German regions can be considered greater than in the Brazilian regions studied. In addition, they can be considered of greatest need when observing the population of both Germany and the State of Nordrhein-Westfalen.

Regardless of this, it should be noted that Germany is the EU's most economically expressive economy, and the State of Nordrhein-Westfalen is Germany's most important economy and population economy. Thus, if the study is applied to other EU countries or regions, the relationship of the CAP's maintainability in relation to the EU member country may change. This is since Germany historically pays a greater monetary contribution to the CAP than the return obtained by its farmers.

This study contributes in an unprecedented way to the literature by proposing a new methodology to measure the impact of agricultural policy between the EU and Brazil. Nevertheless, the study does not exhaust the theme and there is a need for replication of the method to other regions to compare the results and enrich the literature on the subject. It is also possible to use countries on other continents to compare the effects of political arrangements on agriculture in different contexts.

Therefore, based on the data presented, both regions showed a similar trajectory to the reduction of workers employed in agriculture, increased investments per hectare and access to subsidies provided by public policies. Both trajectories were based on the participation of national states as inducers and funders of agriculture in their respective territories.

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