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Productive dynamics in the Western amazon: An analysis of Agricultural Production in the state in Rondônia

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***Keywords*— Agricultural production, Western Amazon, Rondônia, Shift-Share.**

***Abstract*—** *This study sought to analyze the agricultural productivity dynamics of three relevant crops developed in the Western Amazon, specifically in the state of Rondônia. Thus, the productive variations of banana, coffee, and passion fruit for the period from 1997 to 2016 were studied. Also, the analysis of passion fruit was highlighted through the analysis of variations in Annual Production Growth Rates-TACP by state micro-region. The theory of modernization, based on the model of individual innovation, elicits the elaboration of the study. To measure the TACP of each culture, use the shift-share method. As a matter of principle, the factors that influence the TACP are the Efeito Erea-EA and Efeito Rendimento-ER. Coffee presented a negative growth rate in the period (-0.52%) while, banana and passion fruit showed positive growth, respectively 15.62% and 1.91% in the period. Exclusively as for passion fruit, it showed great fluctuations in its rates, but in most cases presenting a negative rate for the ER. Coffee presented a negative growth rate in the period (-0.52%) while, banana and passion fruit showed positive growth, respectively 15.62% and 1.91% in the period. Thus, it appears that the cultivation of passion fruit in Rondônia still has a low degree of technology, which harms the fruit's TACP. Quanto a análise das TACP do maracujá por microrregiões, Alvorada do Oeste foi a que apresentou maior percentual.*

I. INTRODUCTION

Agricultural production is one of the activities that has most concluded in the last decade with the Brazilian economy. The great territorial space favored the exploration of diverse cultures in Brazil in addition to the country has experienced the process of modernizing its

crops at the end of the 1960s, which further contributes to the increase in production volume. The history of Rondônia, a state belonging to the Western Amazon and one of the youngest Brazilian states, is marked precisely by occupation due to the forest and agricultural exploitation of the region, like the rubber cycles (while it was still called the Federal Territory of Guaporé) (Nunes, 1996).

Currently, agribusiness is one of the sectors that most contribute to the formation of the Gross Domestic Product - GDP of the state. Among the cultures explored in Rondônia, following the national trend, the production of bananas, coffee, and passion fruit stands out. These three crops together have great productive representativeness when observing the universe of plantations of permanent crops explored in the state (IBGE, 2018). Although the rural sector has great relevance in the state's economic context, it is conjectured that Rondônia still has a low degree of agricultural modernization because it is a province still in development and because it is geographically disadvantaged from other producing statesThus, it appears that technological restriction can negatively impact agricultural production in the state.

Some works have already been carried out in Brazil to analyze a productive dynamic in the rural sector using the shift-share model. For example, the studies carried out by Mendes and Fernandes (1976) in the state of Minas Gerais stand out; Igreja, Carmo, Galvão and Pellegrini (1983) who analyzed the evolution of agriculture in the state of São Paulo; Moreira (1996) investigated the sources of growth of the main cultures of Rio Grande do Norte; the sugarcane sector in the state of Paraná was the object of study by Shikida and Alves (2001); whereas Oliveira, Gomes, Rufino, Silva Junior and Gomes (2008) studied the structure and dynamics of coffee production in Mina Gerais; Santos and Araújo (2014) analyzed the performance of the main crops in the state of Paraná; and Bittencourt and Gomes (2014) analyzed the sources of growth in sugar cane production in the Midwest and Southeast regions of Brazil.

In this context, the objective of this study was to identify and analyze the growth dynamics of agricultural production of three important permanent crops in the state of Rondônia: bananas, coffee, and passion fruit, from 1997 to 2016. To achieve the results the shift-share method was used, which, in addition to contributing to obtaining the growth rates of crop production, can also assist in the analysis of the determining factors for variations in growth rates.

Thus, the relevance of the present study is due especially to the fact that no specific studies have been identified in the literature using the shift-share model in the state of Rondônia, which may contribute to the adoption of relevant local public policies to maximize production and consequently promote economic development for the Western Amazon.

To achieve the purposes of the present study, the work was structured in four more sections. The second section deals with the theoretical sources that support the research; next, the methodology and data sources are established, emphasizing the shift-share analytical model; in the fourth section, the results obtained are presented and discussed; and finally, the main conclusions reached in the study are presented.

II. MODERNIZATION OF AGRICULTURE

Similar to what occurs in industries, in agriculture, changes in production structures are also constantly perceived. And this gradual substitution over time of rudimentary production techniques with more advanced techniques with technological use aims, most of the time, to increase agricultural productivity (Oliveira, 2007; Bittencourt; Gomes, 2014). However, it is undeniable that social, political, and especially economic issues have influenced the process of modernizing agriculture (Graziano Neto, 1985; Oliveira, 2007). Thus, the process of modernization of agriculture tends to contain affections of the capitalist model itself, and at certain times, although it aims at increasing agricultural production, it ends up on the one hand favoring certain products and producers to the detriment of the others, issues which are intrinsically related to economic problems (Teixeira, 2005).

In the understanding of Bittencourt and Gomes (2014), according to the theory of agricultural modernization - in particular, the high return input model attributed to Schultz (1965) - the supply and quantity of production inputs will only be available when the elements technologies are sufficiently capable of providing satisfactory economic gains through productive. In his thesis, Curi (1997) comments that some factors are essential for the process of modernization of agriculture, and without them, the advance of productivity would be compromised. According to Curi (1997), the improvement in the industry of manufacturing inputs for agricultural production; investments in teaching and research; immersion of more agricultural professionals; and the institution of strategic plans for agricultural development on the part of the State are some basics elements for effecting the modernization process in agriculture.

In this way, the present study will be based on the modernization theory, especially on the neoclassical model

of inductive innovation. In the neoclassical perspective, the means of production are considered fixed in the short term, and conversely, variable in the long term time horizonIn the neoclassical view, production inputs may or may not be limited, with technological elements being applied, especially in production to have greater production, with the adoption of the same amount of inputs. This would cause a sharp reduction in costs, mainly due to the effect of the economy of scale (Padrão; Gomes; Garcia, 2012).

The main studies on inductive innovation were those developed by Hayami and Ruttan (1971) and those by Araújo Schuh (1975). The model of induced innovation, according to the researchers, can subsidize, especially the interpretation of the shifts of technological changes and in the identification of the obstacles encountered during the modernization processes experienced in practice. Also, in this perspective, according to Hayami and Ruttan (1988), technological and institutional changes would be elements endogenous to economic systems. Such a modernization process would be triggered, on the one hand, from the economic perception of the analysis of the supply of factors, and on the other, the demand for products. With that, it would be possible to theoretically support the technological delineations of certain regions in a different way in relation to other regions given the specific economic characteristics. This would make technology as an endogenous factor in production linked to market mechanisms (Oliveira, 2007).

For Alves, Lopes, and Contini (1999) and Faria (2002), the inductive innovation model is fragmented into four major groups of technology: biochemical technologies - linked to land savers through the use of fertilizers, corrective materials, etc .; mechanical technologies - characterized by labor savers through the use of instruments, such as tractors, sprayers, harvesters, etc .; product-saving technologies - by reducing waste between production and the consumer; and organizational technologies - with the search for efficiency between the use of product savers and land technologies. In this way, the real development of rural activity will occur when there are analyses and appropriate technological applications of the scenario, that is, the implementation of a technological alternative that seeks to equalize a real deficiency of a scarce resource. Thus, in areas lacking labor in the application of mechanical technologies such as the use of tractors, machines, and other types of equipment, this would be ideal to optimize production as well as the development of new seeds, fertilizers, and pesticides, that would be a biochemical technological alternative in scenarios where the land is not abundant or deficient.

However, Hicks (1932), cited by Padrão, Gomes, and Garcia (2012), emphasizes that for the inductive innovation process to work, some factors mustn't be absent. Initially, the price systems must express the reality of the market so that the analysis of supply and product demands is not distorted and consequently does not lead to the promotion of wrong technological investments. As a result, it is necessary to have a good engagement between farmers and research institutions without the existence of information asymmetry. It is also essential that public investments take place in a targeted and assertive manner regarding the necessary and appropriate technologies for certain regions and in certain periods. Quadra (1994) emphasizes that some of the main criticisms of the model are precisely the possibility of producing technology for resources that already exist in abundance and the state generation of technology for interest groups, excluding the technological benefits to producers who need the technology.

However, for Bittencourt and Gomes (2014), with the correct and current reading of these scenarios, coupled with the constant implementation of technological actions, it can provide a continuous dynamic of optimization of production and consequently of economic development. Also, inductive innovation is established as a relevant tool for analyzing rural productive variations in certain regions and, or in certain temporal spaces (Padrão; Gomes; Garcia, 2012).

III. METHODOLOGY AND DATA SOURCE

3.1 The Shift-Share Model

In the present study, the analytical model used was the shift-share, also known as structural-differential. One of the works that made the use of the model more intense was developed by professor Edgar Dunn in 1960. Andrade (1980) mentions that the shift-share has a significant empirical use, especially by economists. For Dunn (1960), the elementary emphasis of the model is based, on geographic location, making it possible, for example, to verify the comparative advantages in the production of certain agricultural products based on their locational advantages - when applied in the rural scope. It occurs through the analysis of production variations between periods and regions, thus establishing the variables responsible for the growth or decrease in the production of certain crops.

In Brazil, as already highlighted, there are some works developed that used the *shift-share* model in the rural context, such as the studies carried out by Mendes and Fernandes (1976) in the state of Minas Gerais; Igreja et al. (1983) who analyzed the development of São Paulo

agriculture; Moreira (1996) who addressed the sources of growth of the main cultures of Rio Grande do Norte; Shikida and Alves (2001) who carried out a study on the sugar cane sector in the state of Paraná; Bittencourt and Gomes (2014) who analyzed the sources of growth in sugar cane production in the Midwest and Southeast regions of Brazil; Bini and Canaver (2015) evaluated the growth in the value of the production of beans and soybeans in Rio Grande do Sul (RS); Garcia and Buainain (2016) investigated the dynamics of occupation of temporary crops in the Cerrado Nordestino; and Ponciano, Castro, Souza, Nogueira and Ney (2017) studied the productive dynamics of the main cultures in the State of Espirito Santo. However, no specific studies were identified in the literature using the model in the state of Rondônia, focusing on the production of passion fruit

As perceived and highlighted by Haddad and Andrade (1989), the shift-share is normally used for originating descriptive analysis at the regional level, using the variables of interest in the study in the desired period. In the present study, the objective is to analyze the performance of passion fruit production in the state of Rondônia, together with the production of bananas and coffee, from 1997 to 2016[1], emphasizing the rate of productive growth.

Thus, the analysis was brok en down into three effects (or components), which were: Area Effect (EA), Yield Effect (ER) and the Geographic Location Effect (ELG). In the EA, the variations of production concerning the productive area (increase or decrease of the cultivation area) are analyzed, keeping the ER and ELG unchanged; in the ER, variations are identified based on oscillations exclusively due to productivity (expansion of production due to the application of production technologies, for example), with the EA and ELG not changing; and finally, the ELG that analyzes the variations in production due to the existence of geographical locational advantages (State, Country ...), which in the specific case of the study, will be the variations among the micro-regions of the state of Rondônia.

3.1.1 Mathematical Description and Variables Used

In the sequence, the version of the shift-share adopted in this study is considered in detail, proceeded from the adequacy of the versions used by Igreja et al. (1983) and Santos and Araújo (2014), especially the establishment of the sub-indices, variables, coefficients and consecutive equations used.

[1] According to IBGE data, the sum of the production of the three crops is equivalent to approximately ¾ of the agricultural production of the period in the State of Rondônia, specifically considering permanent crops.

Sub-indices used:

c represents each of the three cultures analyzed in the study (passion fruit, banana, and coffee), varying from 1 to k (being $k = 3$);

m represents each region (municipality) of the state of Rondônia, being of 1 and n (being $n = 52$);

t represents the period that varies between i and f, portraying, respectively, the initial period and the final period analyzed.

Variables used:

Q_{ct}: quantity produced of the c-th crop in the state of Rondônia, in the period t;

A_t: total area cultivated with the three crops in the state of Rondônia in the period t;

A_{ct}: total area cultivated with the c-th crop in the state of Rondônia, in the period t;

A_{mt}: total area cultivated with the three crops in the m-th region of the state of Rondônia, in the period t;

A_{cmt}: total area cultivated with the c-th crop, in the m-th region of the state of Rondônia, in the period t;

R_{cmt}: average yield of the c-th crop, in the m-th region of the state of Rondônia, in the period t;

γ_{cmt}: proportion of the total cultivated area of the c-th culture of the m-th region in the total cultivated area of the c-th crop in the state of Rondônia (A_{cmt}/A_{ct}), in the period t;

λ: coefficient that measures the change in the total cultivated area with the set of crops studied in the state of Rondônia between the initial period and the final period (A_f/A_i).

The quantity produced of the c-th crop in the state in the period t is represented by the following equation:

$$Q_{ct} = \sum_{m=1}^{n} (A_{cmt} R_{cmt}) \quad (01)$$

The quantity produced of the c-th crop in the state in the initial period $(t = i)$ is given by:

$$\begin{aligned} Q_{ci} &= \sum_{m=1}^{n} (A_{cmi} R_{cmi}) \\ &= \sum_{m=1}^{n} (\gamma_{cmi} A_{ci} R_{cmi}) \end{aligned} \quad (02)$$

The quantity produced of the c-th crop in the state in the final period ($t = f$), in turn, is given by:

$$Q_{cf} = \sum_{m=1}^{n} (A_{cmf} R_{cmf}) = \sum_{m=1}^{n} (\gamma_{cmf} A_{cf} R_{cmf}) \quad (03)$$

If in the period considered there is a change only in the total area cultivated with the c-th crop in the state, production in the final period, Q_{cf}^{A}, will be represented by:

$$Q_{cf}^{A} = \sum_{m=1}^{n} (\gamma_{cmi} A_{ci} R_{cmi}) \quad (04)$$

If the area and yield vary, and the geographical location of the crops in the state remains unchanged, the quantity produced of the c-th crop at the end of the period Q_{cf}^{AR} can be represented by:

$$Q_{cf}^{AR} = \sum_{m=1}^{n} (\gamma_{cmi} A_{cf} R_{cmf}) \quad (05)$$

Varying the geographical location of the c-th crop in the state's regions, along with the cultivated area and yield, the amount produced of the c-th crop at the end of the period will be given by:

$$Q_{cf}^{ARL} = \sum_{m=1}^{n} (\gamma_{cmf} A_{cf} R_{cmf}) = Q_{cf} \quad (06)$$

In this way, the total change in the quantity produced of the c-th crop of the c-th crop between the initial period and the final period is given by $Q_{cf} - Q_{ci}$ being:

$$Q_{cf} - Q_{ci} = (Q_{cf}^{A} - Q_{ci}) + (Q_{cf}^{AR} - Q_{cf}^{A}) + (Q_{cf} - Q_{cf}^{AR}) \quad (07)$$

on what:

$Q_{cf} - Q_{ci}$: total variation in the production of the c-th crop between the initial and final period;

$Q_{cf}^{A} - Q_{ci}$: total variation of the quantity produced of the -th crop between the initial and final period, when only the cultivated area changes, being called Area Effect (EA);

$(Q_{cf}^{AR}) - Q_{cf}^{A}$: total variation in the quantity produced of the -th crop between the initial and final period when the yield varies and the other variables remain constant, being called the Yield Effect (ER);

$Q_{cf} - (Q_{cf}^{AR})$: total variation in the quantity produced of the -th crop between the initial and final period when the geographic location of the crop varies within the state keeping the other variables constant, being called the Geographic Location Effect (ELG).

The above results - EA, ER, and ELG - can also be presented in the form of annual growth rates to facilitate the interpretation of the results. Thus, dividing both sides of equation (07) by $Q_{cf} - Q_{ci}$ and multiplying them by:

$$r = \left(\sqrt[p]{\frac{Q_{cf}}{Q_{ci}}} - 1 \right) 100 \quad (08)$$

where, root index, represents the number of years of the period under analysis, given by $t_f - t_i$ and r corresponds to the average annual percentage rate of variation in production, also called the annual production growth rate (TACP) of the -th crop, where if:

$$r = \frac{(Q_{cf}^{A} - Q_{ci})}{(Q_{cf} - Q_{ci})} r + \frac{(Q_{cf}^{AR} - Q_{cf}^{A})}{(Q_{cf} - Q_{ci})} r + \frac{(Q_{cf} - Q_{cf}^{AR})}{(Q_{cf} - Q_{ci})} r \quad (09)$$

on what:

$\frac{(Q_{cf}^{A} - Q_{ci})}{(Q_{cf} - Q_{ci})} r =$ Area Effect (EA), expressed in annual growth rate (in%);

$\frac{(Q_{cf}^{AR} - Q_{cf}^{A})}{(Q_{cf} - Q_{ci})} r =$ Yield Effect (ER), expressed in annual growth rate (in%);

$\frac{(Q_{cf} - Q_{cf}^{AR})}{(Q_{cf} - Q_{ci})} r =$ Geographic Location Effect (ELG), in annual growth rate (in%).

3.1.1.1 Area Effect (EA) decomposed into Scale and Substitution.

In the analysis of the EA, one can also analyze the variations that occurred especially in two ways: by the Scale Effect (EE) and the Substitution Effect (ES). In this, the incorporations (or losses) of areas of culture are observed within the total area within the system itself (participation in the system). On the other hand, it is analyzed in association with the variations of the culture to the variation of the total area of the system, keeping the participation of such culture in the total of cultures unchanged.

Thus, by defining A_{cf} the area cultivated in the state with the c-th crop in the final period, and being A_{ci} the area cultivated in the state with the c-th crop in the initial period, the variation in the area occupied by this c-th crop (EA represented in hectares[2]) can be expressed by $(A_{cf} - A_{ci})$.

Considering λ the coefficient that measures the change in the size of the system (in this work considered as the set of cultures analyzed) between the initial and the final period (that is, $\lambda = A_f/A_i$), the variation in the area occupied by the c-th crop between the initial period and the final can be decomposed into two components, according to formula 10:

$$(A_{cf} - A_{ci}) = (\lambda A_{ci} - A_{ci}) + (A_{cf} - \lambda A_{ci}) \quad (10)$$

on what:

$\lambda A_{ci} - A_{ci}$ corresponds to the EE expressed in absolute value (in hectare), that is, it expresses the variation in the cultivated area of the c-th crop attributed to the variation in the size of the system, keeping the participation of this culture in the system constant;

$(A_{cf} - \lambda A_{ci})$ is the ES expressed in absolute value (in hectare), that is, it represents the variation in the cultivated area gives c-th crop attributed only to the change in the participation of the culture in the system.

Thus, a positive value for $(A_{cf} - \lambda A_{ci})$ represents that the value observed for the area cultivated with the c-th crop at the end of the period (A_{cf}) exceeded that expected value if the variation in the area with the crop had been exactly the same proportion as the variation in the size of the system (λA_{ci}), and therefore it would represent that the c-th culture absorbed area of other culture (s) inserted in the system. Conversely, a negative value for $(A_{cf} - \lambda A_{ci})$ represents that the value identified for the area cultivated with the -th crop at the end of the period was less than the expected value if the variation in the area with this crop had been precisely the same proportion as the variation in the size of the system, therefore, it would represent that the c-th crop yielded area for another crop (s) inserted in the system.

Assuming that all the crops that yielded the area did so only for other crops that are part of the system, it can be said that the entire area provided by one crop was consumed by another crop (s) belonging to the system. Therefore, it is deduced that, when considering the complete system, the sum of the identified substitution effects, expressed in absolute value (in hectare), will be null, that is:

$$\sum_{c=1}^{k} (A_{cf} - \lambda A_{ci}) = 0 \quad (11)$$

These effects can also be expressed in annual growth rates. Thus, dividing both sides of equation (10) by $(A_{cf} - A_{ci})$ has:

$$1 = \frac{(\lambda A_{ci} - A_{ci})}{(A_{cf} - A_{ci})} + \frac{(A_{cf} - \lambda A_{ci})}{(A_{cf} - A_{ci})} \quad (12)$$

Multiplying both sides of the equation 12 EA expressed in growth rate (%), we have:

$$EA = \frac{(\lambda A_{ci} + A_{ci})}{(A_{cf} - A_{ci})} EA + \frac{(A_{cf} + \lambda A_{ci})}{(A_{cf} + A_{ci})} EA \quad (13)$$

being that

$\frac{(\lambda A_{ci} - A_{ci})}{(A_{cf} - A_{ci})} EA$ it is the scale effect, in the annual growth rate (in%);

$\frac{(A_{cf} - \lambda A_{ci})}{(A_{cf} - A_{ci})} EA$ it is the substitution effect, in annual growth rate (in%).

3.1.1 Data Source and Treatment Form

The basic data used for the present study were obtained through electronic information provided by the IBGE Automatic Recovery System - SIDRA of the Brazilian Institute of Geography and Statistics - IBGE. The data refer to the Municipal Agricultural Production Report - PAM 2016 (table 1613) related to the passion fruit, banana, and coffee crops in the state of Rondônia, which are used for own calculations and consecutive obtaining the growth rates of the crops through the shift-share modelThe results found were presented in the form of tons (when related to production), in hectares (in situations involving area), and in percentages (especially for the presentation of growth rates, EA, EE, ES, ER, and ELG).

[2] Unit of measure represented by "ha", commonly used in the agrarian field. It corresponds to an area of 10,000 m².

As mentioned, the analysis period covered the interval between the years 1997 to 2016. In addition to the total period, shorter intervals were also calculated, corresponding to half a decade (5 years). This segregation served to observe the productive variations in different economic and political periods experienced by the country and the state of Rondônia.

Finally, it is worth noting that, in addition to the global calculation of annual growth rates, rates were also determined by micro-regions of the state of Rondônia, specifically for the production of passion fruit. The state of Rondônia, belonging to the Western Amazon and the Northern region of Brazil, and currently (2018) has 52 (fifty-two) municipalities. Thus, the municipalities of the state, according to the IBGE, are distributed in 8 (eight) microregions: Alvorada do Oeste, Ariquemes, Cacoal, Colorado do Oeste, Ji-Paraná, Vilhena, Guajará-Mirim, and Porto Velho. The analysis of the micro-regions served to observe the production behavior of each one and the trends of productive vocation.

IV. RESULTS ANALYSIS

4.1 The behavior of the Agricultural Production Series in the state of Rondônia

Initially, the historical series of agricultural production in the state of Rondônia (production in quantity/tons) will be presented, as well as the respective evolutionary information in percentage terms. Thus, figures 1 to 3 represent, respectively, the evolution of the quantity (in tons) produced in the state of Rondônia during the period 1997 to 2016 for the three crops analyzed: banana, coffee, and passion fruit, with the following being, emphasized the growth of the main rate (positive or negative) of the crops.

Analyzing the figure 1, representant of banana production, an upward trend can be observed in the series, when considering the entire period, that is, there was an expansion of production, mainly in the years after 2000, a year that marks a change in the level from the series. Thus, the production of bananas, in the period from 1997 to 2016, in percentage terms grew at an average rate of 15.62% per year, due to this structural change. However, when considering only the period after the change in level (2001 to 2016), it appears that the average rate of growth is 2.11% per year.

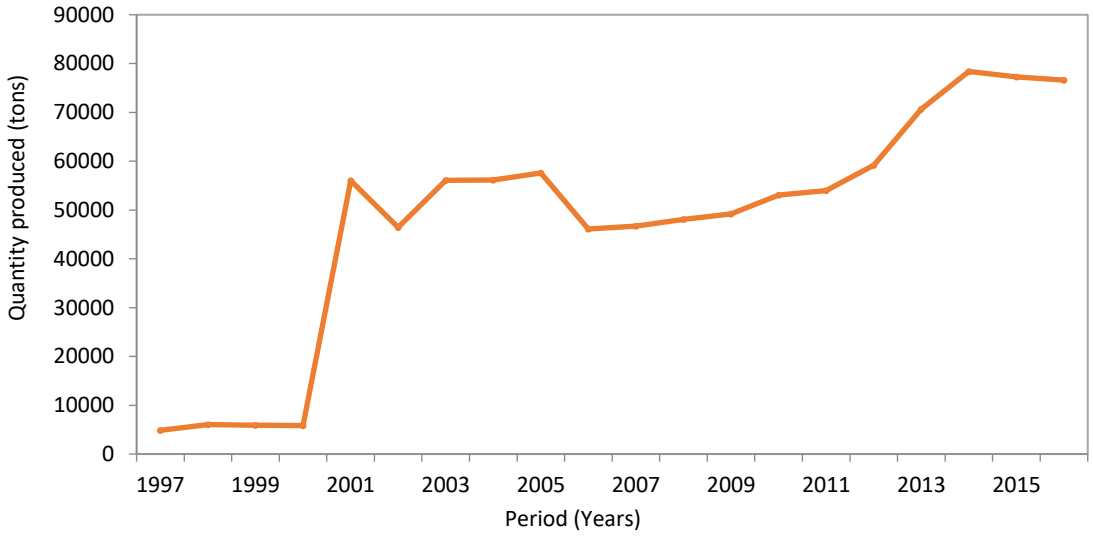

Fig.1: *Graphical representation of the quantity (in tons) of bananas (bunches) produced in the state of Rondônia from 1997 to 2016.*

Source: Research results

As for the coffee culture, shown in figure 2, there is a retraction in production when considering the entire period. The series up to 2001 shows an upward trend, with an annual growth rate of 27.72%. In 2002 there was a sharp drop in coffee production, establishing a growth rate of -0.25% per year for the period from 2002 to 2016.

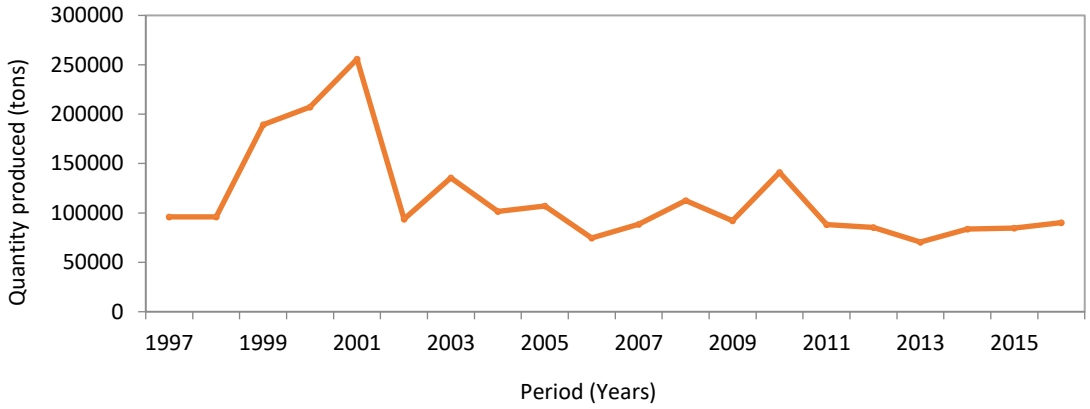

Fig.2: Graphical representation of the quantity (in tons) of coffee (in grain) produced in the state of Rondônia from 1997 to 2016

Source: Search results

In figure 3, the upward trend for the production of passion fruit is revealed during the period from 1997 to 2016. The fruit presented a growth rate of 1.91% per year in the period. However, this rate is not representative of the interstice since the passion fruit culture has undergone several changes over that time. Between 1997 and 2001, there was a drop in production, with a growth rate of -31.69% per year. Between 2001 and 2006, production remained costly. In the final analysis periods, 2006 to 2009, fruit production started to grow again, and from 2009 to 2011, it suffered a retraction again. Finally, from 2011, the production of passion fruit showed significant growth, with a rate of 35.96% per year for the period from 2011 to 2016.

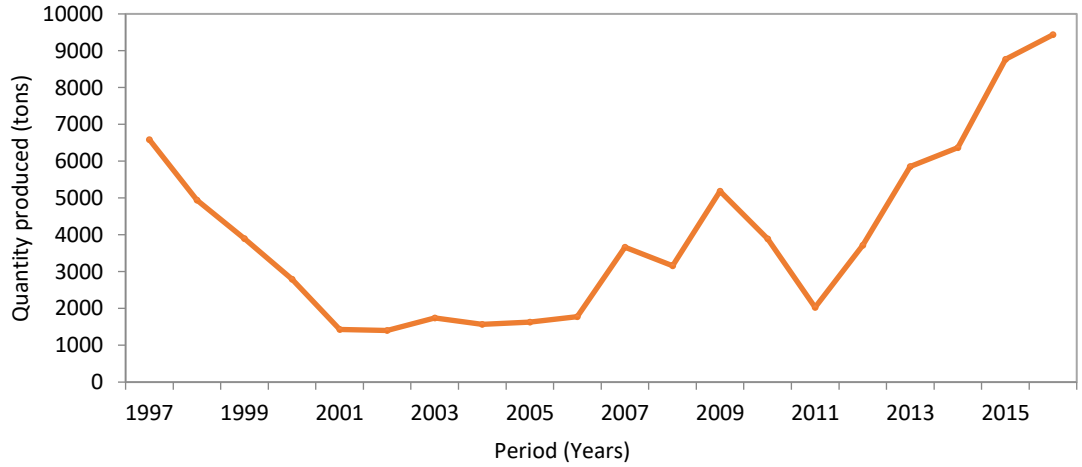

Fig.3: Graphical representation of the quantity (in tons) of passion fruit produced in the state of Rondônia from 1997 to 2016.

Source: Search results

Thus, in summary, it is observed that the production of banana and passion fruit has been growing in the last analyzed periods, with banana-growing through a controlled rise since 2002 and passion fruit with strong growth after 2011. On the other hand, coffee, after the peak of production (among the analyzed period) in 2001, has been losing productivity until maintaining a certain stability since 2011.

Thus, to better show the reasons for the productivity variations mentioned above for the crops, the growth rates are presented in the sequence considering the EA (total and decomposed into EE and ES), ER, and ELG for the passion fruit, banana, and coffee for the period from 1997 to 2016.

4.2 Analysis of Agricultural Production Growth Rates in the State of Rondônia

In this section, the TACP findings for the analyzed cultures will be presented through the application of the shift-share model. The calculation of the TACP is accompanied by the presentation of its fragmentation into EA (subdivided into EE and ES), ER, and ELG for the period from 1997 to 2016 and five-year intervals. In the end, growth rates exclusively for the passion fruit culture in the period and the specific rates by micro-region of the state of Rondônia are also presented.

Thus, as can be seen in figure 1, the crop that obtained the highest growth rate among the complete period of analysis (1997 to 2016) was banana, which perceived an annual growth rate of 15.62%, followed by passion fruit with annual growth in the order of 1.91 and lastly coffee, with a rate of -0.32%.

Table 1: Annual Production Growth Rate (TACP), Total Area Effect (EA) decomposed into Scale Effect (EE) and Substitution Effect (ES), Yield Effect (ER), and Geographic Location Effect (ELG) for the state of Rondônia, in the period from 1997 to 2016.

Culture	TACP (%)	Effects (%)				
		Area Effects (Total and Decomposed)			ER	ELG
		EA	EE	ES		
Banana	15,62	0,32	-0,24	0,56	14,31	1,00
Coffee	-0,32	-1,44	-1,25	-0,19	0,46	0,66
Passion Fruit	1,91	23,27	-1,02	24,28	-22,27	0,92

Source: Search results

The overriding factor for the result obtained by the banana was the yield effect, responsible for 91.61% of the period's TACP. Passion fruit, on the other hand, although there was a moderate growth within the full period of analysis, there is a significant counterpoint between EA (and this one, especially due to the absorption of passion fruit from areas of other crops - achieved exclusively by ES) and ER, or that is, if the passion fruit culture had not expanded its planting area, it would certainly perceive a negative growth for the period due to the fall in production yield.

Table 2 shows the TACP for the period from 1997 to 2002. In this period, the expressive growth rates of banana (positive) and passion fruit (negative) stand out.

Table 2: Annual Production Growth Rate (TACP), Total Area Effect (EA) decomposed into Scale Effect (EE) and Substitution Effect (ES), Yield Effect (ER), and Geographic Location Effect (ELG) for the state of Rondônia, in the period from 1997 to 2002.

Culture	TACP (%)	Effects (%)				
		Area Effects (Total and Decomposed)			ER	ELG
		EA	EE	ES		
Banana	57,07	-0,62	3,34	-3,96	60,48	-3,06
Coffee	-0,52	6,16	5,78	0,38	-6,50	-0,18
Passion Fruit	-26,60	9,74	9,67	0,07	-36,35	0,0026

Source: Search Results

For both cultures, the main elements responsible for the TACP were obtained in the period outside the ER. However, for the banana positively (60.48%) and the passion fruit negatively (-36.35%). On the other hand,

coffee, as in the analysis of the complete period, noticed a small drop in the growth rate for the period from 1997 to 2002, highlighting the loss of productivity (RE) and the gain with the planted area (EA) practically equivalent, as shown in figure 2.

It is also noted that for all cultures from 1997 to 2002, there was positive growth in production due to EE (subitem of EA). One of the possible reasons for the rate increase through the Scale Effect is because the state of Rondônia is one of the youngest in the Brazilian Republic and thus could have new internal agricultural frontiers yet to be explored in the period.

Therefore, table 3 shows the TACP for the period from 2002 to 2007. In this interstice, there is stability in the growth rates of the banana, coffee, crop, and strong growth in the TACP of the passion fruit.

Table 3: Annual Production Growth Rate (TACP), Total Area Effect (EA) decomposed into Scale Effect (EE) and Substitution Effect (ES), Yield Effect (ER), and Geographic Location Effect (ELG) for the state of Rondônia, in the period from 2002 to 2007.

Culture	TACP (%)	Effects (%)				
		Area Effects (Total and Decomposed)			ER	ELG
		EA	EE	ES		
Banana	0,11	-0,53	2,56	-3,09	0,19	0,44
Coffee	-1,09	2,73	2,63	0,11	-4,11	0,28
Passion Fruit	21,16	13,65	1,69	11,97	4,34	3,17

Source: Search results

In this period from 2002 to 2007, it is the only one that shows a certain stabilization in the rate of banana cultivation (0.11%). Coffee again showed a negative growth rate of -1.09%, influenced once again by the loss of productivity (ER). The passion fruit culture, on the other hand, reached an intensive growth of 21.16%. The main reason for the positive growth of the passion fruit culture in the period from 2002 to 2007 is mainly due to the EA, and this by the ES (responsible for 87.69% of the TACP), that is, among the analyzed cultures, the passion fruit absorbed to the planting area of the others.

Table 4: Annual Production Growth Rate (TACP), Total Area Effect (EA) decomposed into Scale Effect (EE) and Substitution Effect (ES), Yield Effect (ER) and Geographic Location Effect (ELG) for the state of Rondônia, in the period from 2007 to 2012.

Culture	TACP (%)	Effects (%)				
		Area Effects (Total and Decomposed)			ER	ELG
		EA	EE	ES		
Banana	4,84	5,17	-4,36	9,53	-0,95	0,62
Coffee	-0,72	-4,49	-4,17	-0,32	3,33	0,44
Passion Fruit	0,31	-2,37	-4,09	1,72	-0,50	3,19

Source: Search results

Table 4 shows the TACP for the period from 2007 to 2012. Thus, it can be seen that among the periods analyzed, this is the one with the lowest growth rates if the set of the three cultures is analyzed. The crop with the highest TACP in the period was banana, with a rate of 4.84%. It should also be noted that coffee for the third consecutive period has a negative growth rate (-0.72%). Although, differently from the periods from 1997 to 2002 and 2002 to 2007, which showed a reduction in production due to yield (ER), in the period from 2007 to 2012 coffee

managed to obtain a positive yield rate, however, in the final total of the growth rate, presented a negative rate due to the reduction of the planting area (EA).

Finally, in table 5, the last five-year period analyzed is presented: 2012 to 2016. In table 5, it is observed that for the first time, during the analysis period, all three cultures showed positive growth rates.

Table 5: Annual Production Growth Rate (TACP), Total Area Effect (EA) decomposed into Scale Effect (EE) and Substitution Effect (ES), Yield Effect (ER), and Geographic Location Effect (ELG) for the state of Rondônia, in the period from 2012 to 2016.

Culture	TACP (%)	Effects (%)				
		Area Effects (Total and Decomposed)			ER	ELG
		EA	EE	ES		
Banana	6,68	3,00	-7,53	10,53	4,59	-0,91
Coffee	1,40	-8,88	-8,14	-0,74	8,29	1,99
Passion Fruit	26,21	29,16	-5,67	34,83	-4,37	1,43

Source: Search results

In this period, the recurring positive growth rate of the banana crop, 6.68%, is verified. For the first time, a positive growth rate is perceived for the coffee crop (1.40%), mainly achieved by productivity gains. Passion fruit had an important growth in the last analyzed period, in the order of 26.21%. The growth in passion fruit production is primarily a credit to ES, which includes EA.

A specific analysis was also carried out on the TACP of passion fruit production among the micro-regions of the state of Rondônia for the period from 2007 to 2016, shown in table 6.

Table 6: Annual Growth Rate of Passion Fruit Production TACP (r) by Microregion of the state of Rondônia for the period from 2007 to 2016.

Microregion	TACP (%)
Alvorada do Oeste	32,31
Ariquemes	13,22
Cacoal	21,43
Colorado D' Oeste	11,50
Guajará-Mirim	-9,41
Ji-Paraná	11,42
Porto Velho	23,77
Vilhena	-0,63

Source: Search results

With that, it can be seen that the microregions of Guajará-Mirim[3] and Vilhena[4] were the only ones that had a negative growth rate in the period (-9.41% and -0.63%, respectively). The micro-region of Alvorada do Oeste[5] had the highest TACP in the period under analysis, with a growth of 32.31%.

[3] Microregion formed by the municipalities of Costa Marques, Guajará-Mirim and São Francisco do Guaporé.

[4] Microregion formed by the municipalities of Chupinguaia, Parecis, Pimenta Bueno, Primavera de Rondônia, São Felipe d'Oeste andVilhena

[5] Microregion formed by the municipalities of Alvorada do Oeste, Nova Brasilândia do Oeste, São Miguel do Guaporé and Seringueiras.

Although the micro-region of Alvorada do Oeste congregates small municipalities (with a total estimated population of 72 thousand inhabitants in 2017), and therefore, inferred that there is little demand for the product, the passion fruit can be transformed into a semi-elaborated and commercialized product in the form of fruit pulp, which after frozen can be stored for a long time. These situations favor the production of passion fruit in more distant locations of large consumer centers.

Finally, table 7 presents a synthesis of TACP exclusively for the passion fruit culture from 1997 to 2016 and the four five-year subperiods analyzed.

Table 7: Annual TACP Production Growth Rate, Total Area Effect (EA) decomposed into Scale Effect (EE) and Substitution Effect (ES), Yield Effect (ER) and Geographic Location Effect (ELG) for the passion fruit culture in the state of Rondônia for the periods 1997 to 2016, 1997 to 2002, 2002 to 2007, 2007 to 2012, 2012 to 2016

Culture	TACP (%)	Effects (%)				
		Area Effect (Total and Decomposed)			ER	ELG
		EA	EE	ES		
1997-2016	1,91	23,27	-1,02	24,28	-22,27	0,92
1997-2002	-26,60	9,74	9,67	0,07	-36,35	0,00
2002-2007	21,16	13,65	1,69	11,97	4,34	3,17
2007-2012	0,31	-2,37	-4,09	1,72	-0,50	3,19
2012-2016	26,21	29,16	-5,67	34,83	-4,37	1,43

Source: Search results

Thus, there are strong fluctuations in the TACP of passion fruit production, when there is a significant negative rate as in the period from 1997 to 2002 (rate of -26.60%), and in other opportunities, significant positive growth rates, such as those in the periods from 2002 to 2007, and from 2007 to 2012 (21.16% and 26.21%, respectively). However, as noted, in general throughout the period, it shows a small growth of 1.91%.

Also, it is observed that passion fruit, except for the period from 2007 to 2012, always perceives a positive AE, mainly due to the ES. It demonstrates that among the analyzed crops, producers are believing, in this crop, making their planting area absolve those of other crops. However, the increase in production across the area is not matched by the effective productivity (RE) of the fruit, which in most periods of analysis was negative (with the exception of the period 2002 to 2007).

V. CONCLUSION

The main objective of this study was to identify and analyze the growth dynamics of agricultural production of three important permanent crops in the state of Rondônia: banana, coffee, and passion fruit, with emphasis on this one. In addition, it also sought to quantify these production variations between the period 1997 to 2016 and in five-year subperiods.

In this way, it was possible to verify that the variations in the production of the crops occurred basically due to the AE and the RE, both in a positive and negative way. Regarding the EA, in the first cycles of analysis, it was noticed that the EE was largely responsible for the results, which is believed because the state of Rondônia has not yet reached its full agricultural frontier. In the last ten years, the main responsibility has become ES. ELG, on the other hand, practically did not significantly influence the results of any of the cultures, remaining practically constant during the analysis period.

As for the banana crop, it was the only crop that always had positive TACP throughout the analysis cycle, driven mainly by the ER. Coffee, on the other hand, was the crop that lost the most productive in the period, with a negative TACP of -0.52%. What contributed most to the bad result of coffee was the loss of planted area (EA), and in some periods there was also a loss of productivity (ER). However, it is possible to sustain the situation experienced by the coffee culture for macroeconomic issues and also for regional public policy issues.

In the 1990s, the state government had a large project to support farmers in the state of Rondônia called “Plante Café”. From the 2000s onwards, there were no more significant state investments in the culture in the state, which may have discouraged the planting of the grain and, consequently, provided the results obtained, mainly

regarding EA. However, it is estimated that there may be a new increase in coffee productivity in the state in the coming harvests (until the 2020 harvest) due to the recent resumption of new state projects linked to coffee culture, such as the project called "Plante Mais".

Passion fruit, on the other hand, had a negative result for the first cycle of analysis, including a significant drop, but with recovery in the sequence. In the penultimate period of analysis, some stability in the TACP was perceived and finally presented a strong growth rate, in the order of 26.21% for the period from 2012 to 2016. The TACP obtained by the passion fruit was also marked by the influence of the EA and the ER. However, as for the AE, the striking gain in planting area obtained by the fruit was verified (except for the period from 2007 to 2012), obtained mainly due to the ES. On the other hand, the negative results regarding the ER did not allow the culture to obtain a more expressive growth rate. With this result, it is inferred that the state of Rondônia still suffers from the low degree of technology used in the cultivation of passion fruit, which directly influences the yield of fruit production.

However, such a scenario experienced by passion fruit (ER) is reversible. According to Resende (2017)[6], the cultivation of passion fruit in the state of Rondônia requires greater attention than in other regions due to the humid climate typical of the Amazon region. Such a scenario is conducive to the attack of insects, an example that directly interferes with the fruit's productivity. Public investments in research/studies that can identify more resistant fruit varieties for the region, or increase the availability of technical assistance for preventive action against pests, are examples that can contribute to the increase in the passion fruit productivity in Rondônia.

It is also noteworthy that, except for the microregions of Guajará-Mirim and Vilhena, all other microregions achieved positive TACP of passion fruit production within the analysis period. It should be noted that the micro-regions of Alvorada do Oeste and Cacoal, even though they are far from the largest consumer centers, were some of those that had the highest positive growth rate.

Finally, it should be noted that the main limitation of the work was the number of cultures analyzed. Thus, it is suggested to build future research with the inclusion of other cultures, mainly temporary cultures. As a main consequence of the work, it is conjectured that it is the identification of technological deficiencies in agricultural production in the state of Rondônia, mainly for passion fruit, and consequently being an alert instrument the need for public investment to reverse the scenario.

[6] Speech given by Agronomist Huigor Fernando Lobo Resende at the State Seminar on Culture of Passion Fruit, President Médici, 08 Apr. 2017.

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