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Two essays assessing the agribusiness labor market

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Thesis presented to obtain the degree of Doctor in Science Area: Applied Economics

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SUMÁRIO

RESUMO

Dois ensaios de análise do mercado de trabalho do agronegócio

As mudanças causadas pelos processos de globalização e internacionalização nas últimas décadas estimularam a modernização da agropecuária e fortaleceram a dependência entre a agropecuária e as atividades a montante e a jusante de sua produção, consolidando o agronegócio. A medida em que os elos do agronegócio se tornaram fortemente relacionados, as dinâmicas do mercado de trabalho em cada um de seus segmentos também se conectaram. No entanto, apesar da importância do agronegócio para a economia e a sociedade no Brasil, e essa interrelação entre as dinâmicas do mercado de trabalho de seus segmentos, não há uma avaliação de emprego que considere o agronegócio como um todo no Brasil. Até por esse motivo, são escassos na literatura, técnica ou científica, estudos que analisam o mercado de trabalho desse setor. Essa tese buscou oferecer uma primeira contribuição no sentido de preencher essa lacuna. No primeiro capítulo, no qual também se cria a base para o desenvolvimento do segundo, é proposto um novo procedimento que permite que seja mensurado o mercado de trabalho do agronegócio brasileiro, considerado como um todo. Adicionalmente, como exercícios empíricos, são analisadas algumas características adicionais da força de trabalho do setor e estimados os efeitos de importantes determinantes dos rendimentos do trabalho sobre o diferencial de rendimentos entre os trabalhadores do agronegócio. Como principal base dados, são utilizados os microdados da Pesquisa Nacional por Amostra de Domicílios Contínua (PNAD-C) e, adicionalmente, informações da Relação anual de Informações Sociais (RAIS) e cálculos do Cepea. Os principais resultados do capítulo são: 19 milhões de pessoas, ou 21% da população ocupada no Brasil, trabalharam no agronegócio em 2014; os trabalhadores do agronegócio são predominantemente pouco ou não qualificados com baixo nível de educação formal; parte relevante dos trabalhadores do setor não possui carteira de trabalho assinada; e, existe elevada heterogeneidade entre o mercado de trabalho dos diferentes segmentos do agronegócio – com o primário apresentando um perfil destoante – e um diferencial de rendimentos significativo associado às diferentes posições na ocupação e categorias de emprego e à localização geográfica. No segundo capítulo da tese, analisa-se o expressivo crescimento dos rendimentos do trabalho no agronegócio entre 2004 e 2015 com base na produtividade do trabalho, no custo unitário real do trabalho (CURT) e na relação entre as variações dos deflatores do PIB setoriais e do IPCA. Para isso, aplica-se o procedimento desenvolvido por Barros (2016) para analisar a mesma questão para a economia brasileira como um todo. Para encontrar o número de ocupados no agronegócio e seus segmentos, e então calcular a produtividade do trabalho, implementou-se uma adaptação do procedimento desenvolvido no primeiro capítulo da tese. Como principais resultados, encontrou-se que, para o caso do agronegócio, diferente do que Barros (2016) observou para o Brasil como um todo, não houve papel preponderante do distanciamento entre os deflatores e o IPCA para amenizar o efeito da valorização real dos rendimentos do trabalho sobre o CURT. Ainda assim, esses ganhos de rendimentos ocorreram sem influenciar o CURT devido, principalmente, ao crescimento da produtividade no setor – impulsionada, por sua vez, pelo segmento primário. Sem esse crescimento de produtividade, o CURT teria crescido a uma taxa anual de 3,4%, afetando negativamente ou mesmo inviabilizando os ganhos simultâneos para empregados e empregadores do agronegócio no período.

Palavras-chave: Agronegócio; Equação de rendimentos; Custo unitário do trabalho; Mercado de trabalho; Produtividade do trabalho

ABSTRACT

Two essays assessing the agribusiness labor market

Changes caused by globalization and internationalization in recent decades have stimulated the modernization of the agriculture and strengthened the interdependence between primary (farm) production and upstream and downstream activities, consolidating the so-called "agribusiness". This closer relationship between the links of the agribusiness chain connects the dynamics of the labor market in its segments. However, despite the importance of agribusiness to the Brazilian economy and society and the interrelationship between the labor markets of its segments, there is no employment evaluation approach that considers agribusiness as a whole in Brazil. Studies that analyze the labor market in this sector are also scarce in the literature, technical or scientific. This thesis sought to make a first contribution towards filling this gap. In the first chapter, where we also created the basis for the second, we provide a new approach that allows to measure the Brazilian agribusiness labor market considered as a whole. Additionally, as empirical exercises, we analyzed some additional characteristics of the sector labor force and the effects of some employment-related income determinants on income differences among agribusiness workers. Our main database was the 2014 quarterly microdata of the Pesquisa Nacional por Amostra de Domicílios Contínua (PNAD-C [Continuous National Household Sample Survey]). We also used information from the Relação Annual de Informações Sociais (RAIS [Annual Social Information Report]) and Cepea calculations. Our main findings are: 19 million people, 21% of the country's workforce, worked in the Brazilian agribusiness sector in 2014; agribusiness workers were predominately unskilled or semi-skilled with little formal education; much of the sector workforce was not formally employed; and there is an extreme labor market heterogeneity among agribusiness sector segments – with the primary segment presenting a noticeably dissimilar profile – and a significant income differential associated with different employment statuses and job market locations. In the second chapter, we analyze the significant increase in employment-related income in agribusiness based on labor productivity, real unit labor cost and the relationship between the GDP sector deflator and the IPCA, between the years 2004 and 2015. For that, we apply the procedure that Barros (2016) developed to analyze this issue for the Brazilian economy as a whole. To find the total number of employees in agribusiness (and sub-segments) in the analyzed period and to calculate labor productivity in the sector, we implemented an adaptation of the methodology developed in the first chapter of the thesis. As main results, we found that in agribusiness, there was no preponderant role of the relationship between the sector deflators and the IPCA to mitigate the effects of employment-related income growth on labor cost to the employer, as occurred in Brazil as a whole. Nevertheless, real labor income gains practically did not influence labor costs, mainly due to productivity gains in the sector, boosted by its primary segment. Without this productivity growth, real labor costs to the employer would increase at the annual rate of 3.4%, adversely affecting or even rendering unfeasible the simultaneous gains of agribusiness employers and workers in the period.

Keywords: Agribusiness; Earnings regression; Labor market; Labor productivity; Real unit labor costs

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1 INTRODUCTION

This thesis, composed of two chapters, is based on the concept of agribusiness developed by Davis and Goldberg (1957) in which the agricultural activity is considered part of a broader economic structure. In the last decades, markets for agricultural products have expanded rapidly with the processes of globalization and internationalization. This scenario has enabled the use of advanced technologies in the field, while agribusiness was consolidated as an agroindustrial and services complex. Therefore, agriculture dynamics is now linked to the upstream and downstream segments of production.

Graziano da Silva (2002) highlights that before this process of transformation, agriculture could be characterized as a relatively autarchic productive sector, with its own labor market and internal equilibrium. With the advent of agribusiness and the integration of primary production sector to other economic sectors, it is no longer possible to separate agriculture from suppliers of inputs and / or buyers of its products or to treat agriculture as a strictly rural activity. Therefore, a relevant research agenda is opened for studies that consider the dynamics of these activities in a systemic way or under the analytical framework of agribusiness.

Agribusiness plays a relevant role in the Brazilian economy and in the international scenario. Between 1995 and 2016, the agribusiness GDP accounted, on average, for 22.5% of the Brazil’s GDP (Center for Advanced Studies on Applied Economics [Cepea], 2016). Agribusiness also acts as a foreign exchange generator for Brazil, greatly reducing the deficit in the trade balance caused by other economic sectors. Between 1989 and 2015, agribusiness exportations accounted for 40.7% of Brazil's total exportations and the trade balance of the sector was always positive, increasing, and expressively representative in the country's total trade balance (Ministry of Agriculture, Livestock, and Food Supply [MAPA], 2016).

Besides its role in income generation and trade balance, agribusiness has also been relevant in wealth distribution in Brazil since 1990. The sector significant productivity gains have enabled a scenario of increasing production in recent decades, even in a scenario where prices decreased. According to Silva et al. (2015) and Barros and Silva (2011), these dynamics significantly influenced the reduction of inflation and income inequality in the country. This trend of increasing production associated with declining prices represented a loss of potential income for agribusiness, which was transferred to the Brazilian society (SILVA, 2010).

This information shows the representativeness and the prominent role of agribusiness for the Brazilian economic growth and development. We believe that this contribution is currently widely recognized in Brazil. However, the impacts of intense structural changes of the Brazilian economy, and even within agribusiness, on agents and activities that compose this sector are less discussed in the literature. This statement is the main motivation for this thesis. Overall, the next two chapters will assess aspects of the Brazilian agribusiness labor market and its activities and agents, from different perspectives.

A brief historical summary in the last decades shows that, according to Buainain et al (2013), in the period after 1965, the most promising roots of Brazilian agricultural modernization were created based on subsidized rural credit, rural extension and agricultural research by public institutions. Staduto, Shikida and Bacha (2004) complement that, in the same period, technification and industrialization of agriculture advanced rapidly, with the purpose of replacing labor force. For these same authors, in the 1990s, there was a new phase, when mechanization became widespread. Barros (2018) argues that the strong growth of agricultural exports in 1990s and 2000s was instrumental for the strong growth in agriculture based on productivity. Exports were essential to avoid that excessive price decreases (associated with productivity growth) made modernization unviable. For Buainain et al. (2013), since late 1990s, the accumulation pattern of agricultural development has changed radically, with the source of formation and appropriation of wealth becoming the capital, not the land. In this new scenario, the driving force to obtain the evident results of agriculture and livestock was the improvement of an environment of innovations in which knowledge and new technical devices are diffused with a continuous search for productivity (BUAINAIN et al., 2013). From the 2000s, this process was boosted once again. This time, according to Garcia (2014), due to the commodities market extremely favorable conjuncture, to the new stimuli of the agricultural policy and to the maturity achieved by some productive chains that were restructured in the 1990s.

All these changes that Brazilian agriculture has undergone resulted not only in significant productivity gains, but also in transformations in factor markets, particularly in the labor market – not only regarding the mechanization of production itself, but also increased professionalism and entrepreneurial character of the sector stakeholders (GARCIA, 2014; STADUTO; SHIKIDA; BACHA, 2004). For Garcia (2014), with the closer relationship between the agricultural sector and the upstream and downstream activities – the new structural organization synthesized in the expression "agribusiness" – the rural labor market

also became a response to a set of institutional changes that permeated this sector in an aggregate way.

Focusing on incomes in the labor market, according to Maia and Sakamoto (2014), the productivity growth of the last decades did not occur homogeneously among producers, resulting in a great heterogeneity of the sector development, with consequent high levels of inequality in income distribution and access to social rights guaranteed by legislation. At the same time, according to these authors, the average agricultural income expanded expressive 51% between 2001 and 2012. This was due not only to labor productivity gains, but also to the valuation of the minimum wage, changes in the structure of occupations in favor of workers with a formal contract and the pressure on wages resulting from the reduction of the rural Economically Active Population (EAP). Regarding the severity of income concentration in agriculture, Alves and Rocha (2010) mention that 73% of growers produced only 4% of the Value-of-production (VBP) in Brazil in 2006; while 8.2% of the producers accounted for 85% of the VBP, according to the Agricultural Census. Looking at the labor market directly, according to Barros (2014), in 2012, 92.2% of agricultural workers had incomes below two minimum annual wages, with 47.9% receiving less than a quarter of the minimum wage.

Therefore, this thesis is motivated by the fact that these various changes in the Brazilian economy and agribusiness in recent years have greatly affected the labor market dynamics of the sector. Moreover, few studies in both technical and scientific literature evaluate the labor market in the agribusiness as a whole. We emphasize that the thesis proposal is not to exhaust the subject, but to contribute to the understanding about the subject of study and offer results that support future research and analyses.

More specifically, in the first chapter, we proposed a new procedure for measuring the agribusiness labor market in Brazil that follows methodological definitions used by Cepea to calculate the sector GDP (Cepea, 2017). Despite the importance of this sector and the interrelationship between the labor markets dynamics of each of its segments, there is no employment evaluation approach that considered agribusiness as a whole sector in Brazil – as it already existed for GDP and foreign trade of the sector. The objective of the study was to fill this gap and create a methodology to support further studies and technical analyses on the subject. As main database, we used the 2014 quarterly microdata from the Pesquisa Nacional por Amostra de Domicílios Contínua (PNAD-C [Continuous National Household Sample Survey]) carried out by the Brazilian Institute of Geography and Statistics (IBGE). We also used information from the Annual Social Information Report (RAIS) and Cepea calculations.

In a second phase of this first chapter, as empirical exercises based on the developed methodology, we analyzed some additional characteristics of the sector labor market, employment status and level of schooling of the labor force, as well as the effects of some employment-related income determinants on income differences among agribusiness workers.

In the first chapter, as part of the empirical exercise, we analyzed labor incomes in agribusiness with a disaggregated approach and from the perspective of the distribution of these among the sector workers. The second chapter also focuses on agribusiness labor incomes, but with a macroeconomic, aggregated and dynamic approach.

According to Barros (2016), employment-related income in Brazil increased 31.2% over the IPCA between 2004 and 2011. This increase occurred without pressure or, in most cases, followed by reduction of labor costs for the employer. The author affirms that this scenario was supported mainly because of the gap between IPCA and the country's GDP deflator growth and, also, because of productivity gains in the period.

The agribusiness sector, in addition to having higher employment-related income gains than the economy in the period, its deflator depreciated in relation to the national GDP deflator. Therefore, in the second chapter of the thesis, we sought to explain the recent dynamics of employment-related income in agribusiness by applying the same procedure of Barros (2016) to this sector. In summary, we explain the increase in employment-related income based on the trends in the following variables: sectoral labor productivity, sectoral unit labor cost, and the relation between sectoral GDP deflator and IPCA.

While Barros (2016) used labor productivity series in Brazil calculated by Barbosa Filho and Pessôa (2014), in this study, we start from the calculation and analysis of labor productivity for agribusiness and its segments, and the economy as a whole – considered secondary objectives. To find the total number of employees in agribusiness (and sub-segments) in the period analyzed and to calculate labor productivity in the sector, we implemented an adaptation of the methodology developed in the first chapter of the thesis. We made adaptations to the procedure to make it applicable to the annual Pesquisa Nacional por Amostra de Domicílios (PNAD [National Household Sample Survey]) microdata, since the PNAD-C only exists from 2012 and we needed a longer period of analysis.

The two chapters of this thesis, conceived in the form of scientific articles, although complementary, can be read independently. However, as the articles have been developed under a common theme, there are repetitions and redundancies in some parts of the chapters, mainly in the introductory parts.

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2 MEASUREMENT OF THE BRAZILIAN AGRIBUSINESS SECTOR'S LABOR MARKET: A NEW METHODOLOGICAL APPROACH

Abstract

Although the Brazilian agribusiness sector's relevance to the country has been widely recognized nowadays, to date, no methodology has been developed to evaluate the level of employment in this sector. Therefore, the objective of this study is to provide a new approach that is able to measure the Brazilian agribusiness labor market as a whole. As an econometric exercise, the agribusiness worker's income differentials were also contrasted with income differentials in the aggregated non-agribusiness workforce. The main results from the study are as follows: a) 19 million individuals, 21% of the country's workforce, worked in the Brazilian agribusiness sector in 2014; b) agribusiness workers were predominately unskilled or semi-skilled with little formal education; c) a large proportion of the sector's workforce were not formally employed; and d) there is an extreme labor market heterogeneity among agribusiness sector segments – with the primary presenting a noticeably dissimilar profile – and a significant income differential associated with different employment statuses and job market locations.

Keywords: Agribusiness; Earnings regression; Labor market; Methodological approach

2.1 Introduction

Changes related to globalization and internationalization and related modernization of the agricultural sector over recent decades have altered the relationship between Brazilian agricultural and industrial activities, affecting the character of the country's agricultural sector. More explicitly, globalization and modernization brought the agroindustrial complex to Brazil, a business model that links the primary production segment with upstream and downstream activities, creating what Davis and Goldberg (1957) termed "agribusiness."

It is well known that agribusiness is of great importance to Brazil, having a major impact on the country's gross domestic product (GDP), trade balance, technological innovation, and productivity. In 2016, agribusiness as whole accounted for about 20% of the country's GDP (Center for Advanced Studies on Applied Economics - Cepea, 2018) and 46% of the country's total exports (Ministry of Agriculture, Livestock, and Food Supply – MAPA, 2017). Agricultural labor productivity increased at an average annual rate of 4.5% between 1995 and 2009, more than five times the entire Brazilian economy's 0.8% average annual rate of productivity growth (Squeff, 2012).

Given that vertically coordinated agribusinesses augment the relationships between the agricultural sector's various segments, each segment's labor market has also become more strongly related. The expressive growth of agricultural productivity is strongly linked with

technological change, and synchronized with this change, there have also been significant changes in the agricultural factors markets, particularly in the labor market (Staduto, Shikida, and Bacha, 2004; Gasques et al., 2015).

Garcia (2014) points out that important changes in the rural labor market since the mid-1990s are strongly linked to technological modernization, not only due to the mechanization of production processes but also to the growing professionalism and entrepreneurial character of the sector's stakeholders. For Garcia (2014), with the closer relationship between links in the agribusiness chain, the set of institutional changes that permeated the sector in an aggregate manner affected the rural labor market. Therefore, if agricultural activity could be characterized as an autarkic sector with its own labor market and internal equilibrium, it was no longer possible to separate this sector from its input suppliers and/or its product buyers (Graziano da Silva, 2002; Garcia, 2014).

Despite the importance of this sector and the interrelationship between the labor markets dynamics of each of its segments, there is no employment evaluation approach that considers agribusiness as a whole in Brazil – as it already exists for GDP and foreign trade of the sector.

Data and publications from the Brazilian Institute of Geography and Statistics (IBGE) guide the analysis of occupations and employment in Brazil. Since February 2016, the Continuous National Household Sample Survey-Quarterly Edition (Continuous PNAD) became the only IBGE household survey focused on the production of short-run Brazilian labor force indicators, which form the basis of his type of analysis. In this research, sectoral assessments are made for grouped economic activities: a) agriculture, livestock, forestry, fishing and aquaculture; b) general industry (and the processing industry sub-group); c) construction; d) trade, repair of motor vehicles and motorcycles; e) transport, storage and mail; f) accommodation and food; g) information, communication and financial, real estate, professional and administrative activities; h) public administration, defense, social security, education, human health and social services; i) other service; j) domestic Service (IBGE, 2017).

Agribusiness is not an individual grouping, but if it were it would certainly contain occupations in the primary sector grouping of agriculture, livestock, forestry, fishing and aquaculture. In addition, agribusiness would take in occupations included in other grouping, such as industry commerce, transport, and other services.

Our study is novel in that it was designed to propose a methodology for measuring the agribusiness labor market as a whole and allows subsequent monitoring and analysis of these measurements. This methodology follows methodological definitions used by Cepea[1] to calculate agribusiness sector GDP. A 2015 paper by Morais et al., measures the sector's labor market using data from an annual edition of the National Household Sample Survey (PNAD). Their calculations were based on estimated coefficients from input-output matrices (MIP) and tables of resources and uses (TRUs) that Cepea provided for the research. These coefficients, however, are calculated using production value and / or value added data, which is not exactly related to labor and employment measures. In addition, Cepea does not continuously update of these coefficients, which makes it difficult to continuously monitor the measurements. We discussed this issue in section 3.

Our study then contributes with the literature and the field of study by advancing in three different aspects. The Brazilian agribusiness labor market is measured in accordance with Cepea methodological definitions; disaggregation coefficients specific and suitable for employment data are determined; and procedures are developed that allow the continuous monitoring of this labor market, not only to address change in its aggregate size, but also highlighting changes in its workers' profiles, some aspects of their social well-being, and the market's structure.

In a second phase of the study, we implement two empirical exercises based on the developed methodology. First, we analyze some additional characteristics of the sector's labor market, specifically, the employment status and the level of schooling of its labor force. Then, we analyze the effects of some of the main determinants of employment-related income on income differentials among agribusiness workers and compare these effects with those in the aggregated Brazilian non-agribusiness economic sectors. As Tansel and Bodur (2012) have pointed out, wages are the largest component of most individuals' income, and understanding wage dynamics is of great importance to the understanding of issues such as poverty, inequality, welfare and internal migration.

The rest of this article is organized as follows: the next section presents methodological aspects, data source and definitions, and the theoretical basis and specification for the earnings equation, while section 3 presents the procedure developed to measure the

[1]The Center for Advanced Studies in Applied Economics (Cepea) carries out research, related to agribusiness, structured according to productive chains, considering also its economic interconnections. Cepea/Esalq/USP is also the Brazilian institution responsible for the calculation and monitoring of Brazilian agribusiness GDP.(http://cepea.esalq.usp.br/cepea/)

agribusiness labor market. Section 4 presents the main results and those from our empirical exercises. Concluding remarks are presented in section 5.

2.2 Materials and Methods

2.2.1 Data source and definitions

This research employed the definition of agribusiness used by Cepea for the Brazilian context, which are briefly described in the following subsection. As its main database for the measurement and characterizations of the Brazilian agribusiness labor market, this study uses the 2014 quarterly microdata from Continuous PNAD, survey carried out by the IBGE. Specifically, the study's earnings equations make use of that database's quarterly microdata from 2012 through 2014. In addition, the database from the Brazilian Ministry of Labor and Employment's (MTE) 2016 Annual Social Information Report (RAIS) was employed to refine labor statistics, and data were also taken from Cepea calculations.

Several studies related to the labor market in Brazil traditionally make use of the annual PNAD. However, the Continuous PNAD (research that had first official data from 2012 released in 2014) has some characteristics that make it more suitable for this research than the annual PNAD. First, since the data are quarterly rather than annual, as in the annual PNAD, seasonal effects can be compensated for in the evaluation. Furthermore, the Continuous PNAD investigates a larger number of households in its sample than the annual PNAD, which allows for considerable improvement in estimation accuracy, especially with regard to rural areas (IBGE, 2014).

The Continuous PNAD considers people fourteen years old and older to be of working age. People of working age are then classified as "occupied" or "unoccupied" during a specific reference week using an IBGE definition, a definition that is used this study.

The Continuous PNAD defines "occupational status," occupied or unoccupied, based on information provided by an individual for the week immediately prior to the week of the interview. Persons are considered "occupied" in the reference week if they were paid in cash, goods, merchandise, or benefits for a least one hour of work in the reference week; had unpaid work for at least one hour in the reference week helping a household member who was self-employed or an employer; or had unpaid work for at least one hour in the reference week helping a household member who was an employee but independent of the employee's production activity.

Using the Continuous PNAD definition of occupational status, people who have worked in production only for home consumption (subsistence farmers) are not considered occupied. So, this exclusion was also applied in our study. The definition of “occupied” adopted by the Continuous PNAD differs from the one used in the annual PNAD and in the Brazilian Agricultural Census, which both include production for home consumption as an occupation but coincides with the definition used in the Brazilian Monthly Employment Survey (PME). This exclusion has particular relevance for the agricultural sector since there are many Brazilian subsistence farmers: using data from the annual PNAD, we calculated that between 2012 and 2015, 30.4% of the persons occupied in agriculture were subsistence farmers (IBGEb, 2017).

This study only considers persons classified as occupied in the Continuous PNAD microdata. These individuals were divided into two classes — those occupied in the agribusiness sector and those occupied in non-agribusiness sectors.

In addition to the filters noted in section 3, two filters were added to the studied sample when executing the estimation of earnings equations. This was done to make the sample more homogeneous. We considered only individuals aged between 18 and 65 and with a declared level of formal schooling. In addition, those with earnings at the extremes (more than R$ 100,000.00 per month or less than R$ 100.00 per month) were also excluded.

2.2.2 Earnings equation: theoretical basis and empirical strategies

According to Menezes-Filho (2002), earnings equations are attempts to empirically relate the income earned by a worker with his personal characteristics and the characteristics of his work, as we intended to do in this study. More specifically, we estimate earnings equations using Mincer’s (1974) contributions to Human Capital Theory. According to Cirino and Lima (2012), Schultz (1961) and Becker's (1962) pioneering articles on Human Capital Theory posit that an individual's salary can be represented as a function of their professional qualities, expressed by years of schooling, training, and experience. According to Cirino and Lima (2012), to put the theory of investment in human capital into an empirical context compatible with economic theory, Mincer (1974) proposed an equation that considers the influence of education and experience on the individual’s salary: The Mincer Wage Equation (also known as the Mincer earnings function).

Mincer's regression model (1974) emphasizes the life cycle dynamics of earnings and the relationship between observed earnings, potential earnings and investment in human

capital (whether formal education or on-the-job training). If P_t is the potential earnings at age t, we can express C_t, the cost of investments in training and or education, as fraction k_t of potential earnings: $C_t = k_t . P_t$. Taking ρ_t as the average return on training investments made at age t, we can express the potential earnings at t using equation (1) (Heckman, 2006):

$$P_t = P_{t-1}(1 + k_{t-1}.\rho_{t-1}) \equiv \prod_{j=0}^{t-1}\left(1 + k_j.\rho_j\right).P_0 \quad (1)$$

Assuming additional propositions, and with some algebraic manipulation, one arrives at the relation between observed earnings and formal education and observed earnings and experience in the labor market through use of the Mincer Equation (2):

$$lnY(s,x) \approx \alpha_0 + \rho_s.s + \beta_0 x - \beta_1 x^2 \quad (2)$$

where: $lnY(s,x)$ are the observed earnings, x is the amount of work experience as of age t and s equal to the years of formal education. In (2) the Napierian logarithm of earnings is linear with respect to years of formal education, and linear and quadratic with respect to years of experience in the labor market (Heckman, 2006).

Other variables in addition to those presented in Human Capital Theory (education and work experience) are included in our specification to give a more complete range of factors influencing earnings. The specification of our earnings equations model is based on both the theoretical framework presented above and empirical literature, and can be summarized as in Equation (3).

$$lnincome_i = \alpha + \delta_j H_i + \beta_s X_i + \varepsilon_i \quad (3)$$

In (3), we have as the dependent variable for each ith worker the Napierian logarithm of monthly real income from the main job, $lnincome_i$, while income is the same variable before the log is taken. H_i is the vector of explanatory variables presented in Human Capital Theory (education and work experience), with δ_j being the associated coefficients; X_i is the vector of additional control variables of socio-demographic characteristics and job characteristics, with β_s being the associated coefficients; α is the constant parameter; and ε_i represents random errors with the usual properties.

The option for the logarithmic model is justified because there is a high income distribution asymmetry and because the effects are approximately multiplicative or proportional to income (Hoffmann & Ney, 2004).

Table 2.1 presents the complete description of all variables $(s + j)$ considered by the study's empirical model. The variables age and age-squared are used as proxies for work experience, with the use of the quadratic term intending to capture this relation's nonlinearity.

Table 2.1 - Description of the variables used in the empirical model

Variable	Description
- Dependent variable:	
lnincome	Natural logarithm of monthly real income from the main job
- Formal education:	
de1	1 for no instruction and 0, otherwise (base category)
de2*	1 for incomplete basic schooling and 0, otherwise
de3*	1 for complete basic schooling and 0, otherwise
de4*	1 for incomplete secondary schooling and 0, otherwise
de5*	1 for complete secondary schooling and 0, otherwise
de6*	1 for incomplete college education and 0, otherwise
de7*	1 for complete college education and 0, otherwise
-Age and gender:	
I	Individual's age (years)
I2	Squared individual's age (years)
Gender	1 if is women and 0, otherwise
- Employment status:	
*poseca***	1 for employed with a formal contract and 0, otherwise (base category)
*posesc***	1 for employed without a formal contract and 0, otherwise
posemployer	1 for employer and 0, otherwise
posce	1 for self-employed and 0, otherwise
posothers	1 for military/statutory servants/auxiliary family workers and 0, otherwise
- Geographic region:	
ufco (Midwest)	1 for the Center-West region and 0, otherwise (base category)
ufn (North)	1 for the North region and 0, otherwise
ufne (Northeast)	1 for the North-East region and 0, otherwise
ufse (Southeast)	1 for the South-East region and 0, otherwise
ufs (South)	1 for the South region and 0, otherwise
- Time control:	
dutri1	1 if January–March quarter and 0, otherwise (base category)
dutri2	1 if April-June quarter and 0, otherwise
dutri3	1 if July-September quarter and 0, otherwise
dutri4	1 if October-December quarter and 0, otherwise
duyear1	1 if 2012 and 0, otherwise (base category)
duyear2	1 if 2013 and 0, otherwise
duyear3	1 if 2014 and 0, otherwise

* Highest level of instruction achieved; ** both in the private and public sectors and also as domestic workers

2.3 A methodological approach for measurement of the Brazilian agribusiness sector's labor market

This section details the filtering procedures developed to distinguish which businesses among the diverse categories in the Classification of Economic Activities–Domicile 2.0

(CNAE-Domicile 2.0) – classification of activity categories delineated in the Continuous PNAD – are to be considered agribusiness, which are to be considered partial agribusiness, and which are considered to be non-agribusiness. The filtering was accomplished using agribusiness activity definitions created by Cepea for their calculation of sectoral GDPs.

Cepea (2017) defines agribusiness as a chain system, with both upstream and downstream linkages to agricultural activities. Thus, this sector involves not only agricultural and livestock production, but also the production of inputs for such production; product processing, trade and transportation; and other services necessary to make the products available to the final consumer, whether domestic or foreign. Based on this definition, Cepea calculates the agribusiness GDP. For analytical purposes, Cepea divides the sector's GDP into four contributing segments: inputs, agriculture and livestock production (primary activities), industry (agricultural or livestock product processing), and agro-services. This Cepea division is adopted for use in our study.

Cepea (2017) determined which economic segments are related to agribusiness in its calculation of agribusiness GDP. The relationship is established according to the intensity of an activity’s linkage with agriculture and livestock and is based on the Brazilian Input-Output Matrices (IPM) shown in IBGE’s Brazilian National Accounts. Box 2.1 presents the activities Cepea associates with agribusiness, their respective codes in CNAE 2.0, and the agribusiness segment they are linked with. Note that the codes are from CNAE 2.0 and are different than those in the CNAE-Domicile used in the Continuous PNAD and in this study.

Box 2.1 - Activities and segments of agribusiness and respective CNAE 2.0 code

CNAE 2.0	Segment	Activity
2012; 2013	Inputs	Fertilizers and soil correctives
20517	Inputs	Agricultural pesticides
10660	Inputs	Animal feed
21220	Inputs	Veterinary medicines
283	Inputs	Agricultural machinery
011; 012; 013; 014; 02	Primary	Agriculture and forestry
015; 017; 03	Primary	Livestock, fishing and aquaculture
101; 102	Industry	Meat and fish slaughter and preparation
105	Industry	Dairy products
107; 193	Industry	Sugar and ethanol
108	Industry	Coffee industry
103	Industry	Canned fruit and vegetables
104	Industry	Oil and fat
106 (except 10660)	Industry	Grinding and starch products (except animal feed)
109	Industry	Other food products
11	Industry	Beverage
12	Industry	Tobacco industry
1311; 1312; 1321; 1322	Industry	Natural-based textiles
14	Industry	Clothing and clothing accessories (natural-based)*
1510; 1529; 1531	Industry	Leather goods and leather footwear
16	Industry	Wood products
17	Industry	Pulp, paper, and paper products
3101	Industry	Wooden furniture
46, 47, 49 to 53, 55, 56, 58 to 66, 68 to 75, 77 to 82, 84	Agro-services	Several* **

Source: Cepea (2017) using CNAE 2.0 category definitions. * For "Clothing and clothing accessories" and "agro-services," only a percentage of the CNAE defined activities are considered to belong to agribusiness. ** CNAE 2.0 activities defined as services: wholesale & retail trade, excepting vehicles; transport; storage & mail; food services; information & financial services; real estate activities; legal, accounting, & consulting services; architectural, engineering, testing, analysis; R & D; other scientific & technical activities; non-real estate rentals; other administrative activities; surveillance, security; public administration, defense & social security; telecommunications; media activities; editing & printing; food service.

Without adjustment, some Continuous PNAD data could not be transferred from one CNAE-Domicile category to the corresponding CNAE 2.0 subcategory, and the number of workers occupied in agribusiness activities could not be determined. For example, Continuous PNAD data may show that 1,000 persons work in the broad CNAE-Domicile activity category "chemical industry," but no subcategory exists that distinguishes workers making agricultural inputs (e.g., fertilizer) from those making beauty products. In this instance, worker data cannot be ascribed to either the CNAE 2.0 chemical industry subcategory "fertilizer mixer," an agribusiness activity, or to the sub-category "beauty product fabricator." This problem was encountered when attempting to transfer data from the following categories: grinding and starch products (except animal feed); animal feed; natural-based

textiles; clothing and clothing accessories; wooden furniture; and all industries in the inputs segment.

To resolve the difficulty, labor data available in the Brazilian Ministry of Labor and Employment's Annual Social Information Report (RAIS) database were used to create a coefficient that was applied to Continuous PNAD data. Through application of the coefficient, Continuous PNAD data could be transferred from a broad CNAE-Domicile category to a more disaggregated CNAE 2.0 subcategory, permitting determination of the number of workers occupied in an agricultural activity in that particular category.

The RAIS database was selected because it is the only Brazilian workforce-oriented survey that separates data into CNAE 2.0 categories. RAIS data consists of the same types of labor market data as does the Continuous PNAD, with one significant difference: the RAIS database considers working individuals to be only those that are formally employed. To rationalize Continuous PNAD data on informally and formally occupied persons in terms of the RAIS data on formally occupied persons, the Continuous PNAD data were adjusted using the assumption that the percentage of individuals in a RAIS CNAE-2.0 category that are shown to occupied in an agribusiness sector activity is the same as the percentage of people occupied in an agribusiness activity in the Continuous PNAD CNAE-Domicile category. In our study, this percentage is called the "category coefficient" and in cases when Continuous PNAD data ascribed to a CNAE-Domicile category must be adjusted to coincide with a CNAE 2.0 category, the category coefficient is applied to the data.

Table 2.2 shows the average values of the category coefficients for the year's 2012–2014. These coefficients were applied to the Continuous PNAD microdata that needed to be further disaggregated to ensure compatibility with the CNAE 2.0 definitions used by Cepea in this study.

Table 2.2 - Category coefficients used to disaggregate the CNAE-Domicile

Agribusiness activity /CNAE-Domicile activity category	Coefficient
Fertilizers and soil correctives / Manufacture of other chemical products.	0.184
Agricultural pesticides / Manufacture of other chemical products n.e.c.	0.041
Animal feed / Grinding and starch products and animal feed	0.354
Veterinary medicines / Manufacture of pharmaceutical products	0.088
Agricultural machinery / Manufacture of machinery and equipment	0.19
Grinding and starch products (except animal feed) / Grinding and starch products and animal feed	0.646
Natural-based textiles / Preparation of fibers, spinning and weaving	0.395
Clothing and clothing accessories (natural-based)*/ Clothing and clothing accessories	0.357
Wooden furniture / Manufacture of furniture	0.733

Sources: author' results. Based on Cepea (2017) and MTE (2016). *For "Clothing and clothing accessories (natural-based)," the disaggregation could not be made even by the CNAE that reaches the classes level. This category coefficient is the same coefficient Cepea (2017) uses to calculate agribusiness GDP.

Although RAIS data and the aforementioned procedure were successfully used to disaggregate data in many broad CNAE-Domicile categories, the "clothing and clothing accessories (natural-based)" industry could not be transposed using RAIS data, nor could the categories in the agro-service segment. In the case of the clothing and clothing accessories subsegment, we applied the category coefficient calculated by researchers at Cepea using the 2009 Brazilian National Accounts (information obtained upon request) — 0.357 —which means that out of every 100 people working in the clothing and clothing accessories industrial subsegment, 36 are in considered to be working in an agribusiness activity. For the agro-services segment, a category coefficient of 0.145 was applied to the Continuous PNAD data. This percentage represents the agribusiness sector's share of final demand for services as a percentage of total final demand for service as determined by Cepea (information obtained upon request) in its Brazilian agribusiness GDP calculations. Based on this information and these procedures, it was possible to measure and characterize the Brazilian agribusiness labor market in 2014.

The procedure used to construct a coefficient structure based on employment information and described above is the main methodological difference between the present research and that by Morais et al. (2015). These authors applied coefficients provided by Barros, Silva and Fachinello (2014) when calculating the Brazilian agribusiness GDP. These coefficients were used to disaggregate the value added by broader activities among the components of agribusiness GDP generation to isolate the value added by specific agribusiness sectors. The coefficients were calculated from production information (value added, industrial

transformation value, value of production and, in the last case, mass wage) and not by numbers of workers. In our study, we developed a construct of specific employment relationships that can be updated annually.

The following is only applicable to the earnings equations stage of analysis. The category coefficients presented in Table 2.2 could not be simply applied to CNAE-Domicile activity categories that were not directly reconcilable because all information related to each worker needed to be allocated to either the agribusiness group or non-agribusiness group. To remedy this difficulty, if the activity categories were not reconcilable, the CNAE-Domicile activities were allocated among the agribusiness and non-agribusiness groups according to their Table 2.2 calculated coefficients predominance. If the activity's coefficient was greater than 0.5, it was it considered to be an agribusiness activity. The worker activities added to the agribusiness sector were in the "Manufacture of furniture" category and the "Grinding and starch products and animal feed" category. The data for the other Table 2.2 categories that had not already been directly allocated to agribusiness were allocated to the non-agribusiness group.

The multitude of extremely heterogeneous activities in the services segment also made the accurate separation of individuals into the agribusiness or non-agribusiness groups a task beyond our capabilities. For this reason, data regarding all members of the services segment workforce were included in the non-agribusiness group and not included in the earnings equations for the agribusiness group.

2.4 Results and discussion

2.4.1 Dimension of the agribusiness labor market and distribution among its segments and activities

By following the developed procedure presented in Section 3, it was found that agribusiness accounted for 21% of the total number of occupied persons in the Brazilian economy in 2014, or 19 million people. The primary segment occupied by far the greatest number people in the sector, retaining 47.2% of the sector's workforce and almost 10% of the Brazilian labor market in 2014. As summarized in Table 2.3, the primary segment, which occupied the largest number of workers, was followed by the agro-services segment; the agro-industrial segment; and finally, the inputs segment.

Table 2.3 - Agribusiness Labor Market composition - 2014

Segment	Occupied Persons	%
Inputs production	223,961	1.2%
Primary activities	9,006,251	47.2%
Industry	4,150,813	21.8%
Agro-services	5,686,030	29.8%
Agribusiness	**19,067,054**	

Source: author' results.

In the agriculture subsegment of the agribusiness primary segment, the cereal and coffee crops occupied the most individuals —12% and 11% of that workforce, respectively. In addition, a heterogeneous group of "other crops" stood out, employing an impressive 44.54% of the people active in this subsegment. In the "other crops" classification, the CNAE includes banana, cassava, and other crops not already specified. Value-of-production (VBP) data from the IBGE Municipal Agricultural Production survey (PAM) from 2016 were used to make a connection between the distribution of workers among crops and the generation of value among crops. The values of the sugarcane, soybean, and corn harvests were the highest among agriculture subsegment crops, contributing 33.6%, 16.8%, and 10.3% of this primary activity's total production value, respectively (IBGE, 2017b). Given the significant number of persons occupied in the "other crops" grouping, it is evident that job generation differs significantly from value generation in Brazilian agriculture, which is related to transformations that have occurred over recent decades within the primary segment. Technical progress and intensified mechanization have made some crops extremely important as value producers but less important as job creators. Labor-intensive crops, instead, are important job creators but much less relevant as value producers.

In the livestock, poultry, and fisheries subsegment of the Primary agribusiness segment, it was estimated that 67% of occupied individuals work with cattle (steers and cows). Using data from IBGE's Animal Slaughter, Milk, Leather, Chicken, & Eggs survey (IBGE, 2017b), Cepea calculated that 62% of the value of production derived from the livestock, poultry, and fisheries subsegment is related to cattle. We note the predominance of the bovine herd in the generation of both income and jobs.

In the agribusiness industry segment, the greatest labor participation was found to be in the agriculture-based subsegment, accounting for 75% of the segment's workforce. Within this subsegment, the following industries occupied the most individuals: clothing and natural-based clothing accessories (20.4%); wood furniture (15%); and other wood products

(12.63%). A high percentage of the workforce is informally occupied in these industries. According to Galinari et al. (2013), the barriers to entry in these relatively labor-intensive industries, which require little financial, technological, or intellectual investment to begin production, are low. The agribusiness Industry segment's livestock-based subsegment accounted for 24.1% of the segment's active workforce, with the slaughtering industry accounting for 49.25% of this total.

Regarding the agribusiness inputs segment, many of the industries represented in it — such as the fertilizer production industry, where workers are, for the most part, operating imported raw material mixers — are not labor intensive.

Having presented results from the measurement of the many segments and subsegments of the agribusiness labor market, we now move to a characterization of their workers.

2.4.2 Profile of the agribusiness worker

Besides distinguishing agribusiness workers from non-agribusiness workers, measuring the entire agribusiness labor market, and verifying its size in the context of the entire Brazilian economy, the developed procedure also allows analysis of other important agribusiness related characteristics. In the following empirical exercise, the first of two, we isolate agribusiness workers' characteristics regarding employment status and level of schooling and contrast these agribusiness worker characteristics with same characteristics of the entire Brazilian labor force.

Table 2.4 shows the distribution of workers in each segment of the agribusiness sector and in the amalgamated Brazilian non-agribusiness sectors by "employment status" classifications and by level of schooling. Of note was the disparity between the percentage of those employed with a formal work contract in the agribusiness sector, 36.8%, and in the non-agribusiness sectors, 43.3%, and the relative higher percentage of self-employed persons working in agribusiness, 31.5%, when compared with all other Brazilian sectors, 23.1%. The high percentage of self-employed persons working in agribusiness-related activities is linked with the large weighting of the primary segment in the number of individuals occupied in the sector, with 45.6% of those occupied in agribusiness working in the primary segment as farmers.

Table 2.4 - Distribution by employment status and by level of schooling (Brazil, agribusiness, and its segments)

	Agribusiness					Brazil
	Inputs	Primary	Industry	Agro-services	Agribusiness	
Employment status						
Employed with a formal contract	63.3%	15.3%	66.9%	48.5%	36.8%	43.3%
Employed without a formal contract	7.1%	18.9%	10.3%	13.3%	15.2%	18.1%
Employers	2.2%	2.8%	3.1%	5.2%	3.6%	4.1%
Self-employed	14.9%	45.6%	17.2%	20.0%	31.5%	23.1%
Other	12.5%	17.4%	2.4%	13.0%	12.8%	11.4%
Final level of education						
No instruction	6.6%	18.8%	4.3%	2.6%	10.7%	5.0%
Incomplete elementary education	29.4%	54.0%	29.0%	17.3%	37.5%	25.5%
Completed elementary education	9.0%	9.8%	13.7%	10.0%	10.7%	10.8%
Incomplete secondary education	6.5%	4.6%	8.0%	6.7%	6.0%	6.4%
Completed secondary education	29.3%	10.5%	34.5%	37.6%	23.9%	31.3%
Incomplete college education	4.6%	0.7%	3.7%	7.0%	3.3%	5.3%
Completed college education	14.7%	1.6%	6.7%	18.8%	7.9%	15.7%

Source: author' results.

Data in Table 2.4 show that the primary segment differs sharply from the other agribusiness segments regarding employment status. In the inputs, industry, and agro-services segments, about two-thirds of the jobs are formal. The situation is reversed in the primary segment, in which informally employed and self-employed workers account for about 65% of the total number of occupied individuals.

As for the educational level, it turns out that almost 60% of the persons occupied in agribusiness activities do not have a high school education, well above the national average of about 40% (Table 2.4). We also note that the educational differences between Brazilian agribusiness and non-agribusiness workers are largely at the extremes of the educational level range: 59% of the persons occupied in agribusiness have no secondary-level education and only 11.2% have attended an institute of higher education; for all other Brazilian economic sectors, 59% have at least some secondary-level education and 21% have attended an institute of higher education. Among the segments, the primary agribusiness segment exhibits the most discrepant results in relation to all the other economic sectors in Brazil; more than 80% of the primary agribusiness segment's occupied individuals have no secondary education.

Some studies have pointed out that the level of education in Brazil's primary agribusiness segment is traditionally low. However, a recent increase in mechanization and the implementation of newer technologies in the segment combined with the spread of large, multinational agroindustrial concerns have led to a demand for farm labor that is more skilled. These changes have caused a corresponding reduction in the demand for unskilled workers in the countryside (Moraes, 2007). Hoffmann and Ney (2004) note that the low educational level of a great number of those employed in agriculture has been an obstacle to the increase of labor productivity in the segment. The authors also point out that it could be argued that agriculture demands a less skilled labor force than other economic sectors, because it is less sophisticated and dynamic. However, the authors' note that a large part of the difference in educational level between those employed in agriculture and those employed in other sectors is the fact that there are fewer opportunities for advanced education in rural Brazil than in the urban areas.

The low educational level of those working in Brazil's primary agribusiness segment and the high percentage of informal work in that segment, shown by data presented in Table 2.4, have had a direct impact on worker remuneration. These two conditions not only make it difficult to obtain higher incomes but have deprived agricultural workers of the advantages inherent in formalized employment.

As a second empirical exercise, the effects of important income determinants on Brazilian agribusiness worker income were estimated and the dispersion of a particular calculated income from a base level was ascertained. The agribusiness worker income differential caused by a particular income determinant was also contrasted with income dispersion in the aggregated Brazilian non-agribusiness workforce caused by the same income determinant.

2.4.3 Earnings equation estimation results

Table 2.5 presents the descriptive statistics of the selected income determinant variables for two different groups: agribusiness workers and non-agribusiness workers. The income determinant variables are years of formal education, gender, age, employment status, and geographic location. In this table, except for the variables income and gender, since all other variables are binary, the values express the proportion of individuals in each category. Note that the sample of agribusiness workers does not include data from those working in the

agro-services segment and in some industrial segments for reasons discussed in the Methodology section.

As verified in the previous section, there are significant differences between the observable characteristics of the individuals that comprise each group. In summary, there are more individuals in the agribusiness sector that fall into the low-education categories (de1 & de2), especially in the primary segment, than in the non-agribusiness economic sectors. As we move toward higher levels of education, the disparity between the two groups' worker education levels is reversed, with a relatively higher participation of non-agribusiness workers than agribusiness workers in the d6 and d7 categories (incomplete and complete college education respectively).

There is also a significant difference between female participation in the agribusiness labor market and female participation the non-agribusiness sectors. In addition, the average age of individuals in the sample of agribusiness workers is higher than the average age of sampled workers in other sectors. As for employment status, the percentage of those employed with formal contracts was heavily tilted toward the non-agribusiness sector, and the percentage of self-employed workers was substantially higher in the agribusiness sector. The most noticeable effect of geographic location on regional workforces, a variable not analyzed in the previous section, was a higher percentage of agribusiness workers in Brazil's Northeast region and a relatively higher percentage of non-agribusiness workers in the Southeast region.

Table 2.5 - Descriptive statistics of the sample of each group (other sectors and agribusiness) and t test of means between groups

	Agribusiness (means)		Non-agribusiness (means)	
Variable/statistic	Mean	Std. Dev.	Mean	Std. Dev.
Income - Brazilian Reals	1235.27	1844.69	1897.62	2645.59
de1 (schooling)	0.15	0.35	0.03	0.18
de2	0.48	0.50	0.22	0.42
de3	0.11	0.31	0.11	0.31
de4	0.05	0.22	0.06	0.23
de5	0.17	0.38	0.34	0.47
de6	0.02	0.13	0.06	0.24
de7	0.03	0.17	0.18	0.38
Gender (gender)	0.24	0.43	0.46	0.50
I (age) - years	39.49	12.53	37.79	11.86
Poseca (employment status)	0.33	0.47	0.46	0.50
Posesc	0.17	0.37	0.18	0.38
Posemployer	0.03	0.16	0.04	0.20
Poscp	0.35	0.48	0.20	0.40
Posothers	0.13	0.33	0.11	0.32
ufco (region)	0.08	0.26	0.08	0.27
ufn	0.12	0.32	0.07	0.25
ufne	0.31	0.46	0.23	0.42
ufse	0.30	0.46	0.47	0.50
ufs	0.20	0.40	0.15	0.36

Source: author' results.

Table 2.5 shows that there is a difference between the average worker incomes in the two groups considered. Comparing agribusiness with the rest of the economy, the average worker in the non-agribusiness sectors earns a 54% higher monthly wage (R$ 662/month higher) than the average agribusiness worker.

Table 2.6 presents earnings equation estimates for agribusiness workers and non-agribusiness workers, as well as Wald test results regarding the equality of the coefficients estimated for the variables between the two groups[2]. The table also shows the percentage difference between the expected return at the different category levels and the expected return at a category's base level for the binary variables, excluding the effects of the other explanatory variables. These results are used to evaluate the effects of the chosen income determinants on each group's income and the income differential tied to the levels of each of these determinants. The magnitude of these effects can be determined through an examination of the coefficients estimated for each group. The variables included in the regression explain about 45%-47% of the variation in the dependent variable. According to Hoffmann and Ney (2004), this result is satisfactory, considering that many factors that affect individual income, such as ambition and creativity, are unquantifiable — and some that are quantifiable are absent from the Continuous PNAD.

[2] To facilitate the visualization, we do not present the control variables' coefficients by years and quarters in the table.

Table 2.6 - Earnings equation estimates and Wald test of coefficients equality results

	Agribusiness	Percentage difference[a] Agri.	Non-agribusiness	Percentage difference[a] non-agri	chi-squared	p-value
de2	0.2008***	22.24	0.1807***	19.81	19.37	0.0000
	(0.0002)		(0.0001)			
de3	0.3820***	46.52	0.3427***	40.87	46.1	0.0000
	(0.0003)		(0.0001)			
de4	0.4222***	52.53	0.3931***	48.16	16.43	0.0001
	(0.0003)		(0.0001)			
de5	0.5569***	74.53	0.5372***	71.12	11.75	0.0006
	(0.0002)		(0.0001)			
de6	0.8141***	125.71	0.7673***	115.39	14.25	0.0002
	(0.0005)		(0.0001)			
de7	1.2584***	251.98	1.2845***	261.29	4.4	0.0359
	(0.0004)		(0.0001)			
gender	-0.3613***	-30.32	-0.4140***	-33.90	232.42	0.0000
	(0.0002)		(0.0000)			
I	0.0426***		0.0466***		29.76	0.0000
	(0.0000)		(0.0000)			
I2	-0.0004***		-0.0004***		0.94	0.3321
	(0.0000)		(0.0000)			
posesc	-0.4141***	-33.91	-0.3274***	-27.92	591.68	0.0000
	(0.0002)		(0.0001)			
posemployer	0.5829***	79.12	0.5667***	76.24	1.91	0.1669
	(0.0003)		(0.0001)			
poscp	-0.4728***	-37.67	-0.1819***	-16.63	6800.8	0.0000
	(0.0002)		(0.0001)			
posothers	0.0000	0.00	0.1385***	14.85	4364.48	0.0000
	(.)		(0.0001)			
ufn	-0.4286***	-34.86	-0.2060***	-18.62	1963.58	0.0000
	(0.0003)		(0.0001)			
ufne	-0.7288***	-51.75	-0.3674***	-30.75	6803.6	0.0000
	(0.0002)		(0.0001)			
ufse	-0.1429***	-13.32	-0.0571***	-5.54	414.16	0.0000
	(0.0002)		(0.0001)			
ufs	0.0160***	1.61	-0.0108***	-1.00	40.2	0.0000
	(0.0002)		(0.0001)			
Constant	6.0433***		5.9005***			
	(0.0007)		(0.0003)			
r2	0.4662		0.4505			
F	0.0000		0.0000			

Source: author' results. Standard error in parentheses. * $p < 0.10$. ** $p < 0.05$. *** $p < 0.01$. [a] Percentage difference compared to base category income. If b is the coefficient the difference is calculated as 100[exp(b)-1]% (Hoffmann; Ney. 2004).

For both groups, the higher the individual's educational level, the higher the income obtained (

Table 2.6), as expected. When comparing the groups, we verified that the percentage income gains in relation to the increase in educational level are slightly (and significantly) higher in the agribusiness sector than in other economic sectors.

Hoffmann and Ney (2004) note that the explanation found in literature for the fact that the educational level of farmers is lower than that of people employed in industry and services is that the rate of return for each additional year of study for those working in primary agricultural activities is lower than in the other segments and sectors. Faced with this possible explanation, these authors estimated earnings equations using annual PNAD data for the years 1999, 2001 and 2002 to analyze if the returns on investment in education are actually lower in the agriculture sector. To simplify the analysis, the authors combined the industry and services sectors, calling this group the "non-agriculture sector." Their results showed that the higher economic return from education for those in the non-agriculture sector relative to those in the agriculture sector is essentially a specification error: the proportion of individuals with a low level of education is higher in agriculture, and the returns due to education are lower for lower levels of schooling (less than a total of nine years of education). When a variable was included to capture the effect of education polygonically (not considering a constant rate of return for education), the percentage return from secondary education and advanced education was higher in the agricultural sector.

Our study analyzes the effect of education in a nonconstant way by including different binaries to capture the effect. The results obtained show that the aggregated average return due to education expressed as a percentage is higher for all those occupied in the agribusiness sector then for those occupied in the non-agribusiness sectors, similar to what was observed for Hoffmann and Ney (2004) for those occupied in agriculture.

From another perspective, a greater income differential related to schooling is observed in the agribusiness sector, with the income differential between those with more and less schooling being greater than that observed in the other economic sectors, except at the highest educational level, de7.

For the study's gender variable, negative coefficients were observed in relation to the base category (male), as expected. Thus, ceteris paribus, the income of women is lower than that of men, 30.32% lower in the agribusiness sector and 33.09% lower in the non-agribusiness sectors. Although there is a statistically significant difference between these two effects, it is rather unimpressive. The income effect of age and the square of age (proxies for work experience) for both groups corroborate the hypothesis that income is influenced by age

but at a decreasing rate, corresponding with the human capital theory. Notice that the maximum return occurs at age around 53 years in the agribusiness and 58 in the other sectors.

Regarding employment status, with formally employed workers in the public or private sectors as the base category, agribusiness employers were found to earn 79.12% more compared to the base category, while self-employed individuals occupied in the agribusiness sector and the average agribusiness employee working informally earned, respectively, 37.67% and 33.91% less than those in the base category. A similar result was observed for those employed in non-agribusiness sectors without a formal contract and the self-employed relative to the base category; however, the separation between these three classes of workers' incomes was of a much lower, statistically significant magnitude when compared with those having the same employment status in the agribusiness group. This result shows that employment status has a more intense effect on the income differential in agribusiness than in non-agribusiness.

With Brazil's Center-West as the base category, only in the country's South were agribusiness incomes higher than in the base region. We highlight the significant income gap between agribusiness worker income in the base region and in the Northeast region: it was approximately 51.75% smaller in the Northeast. Comparing agribusiness to the non-agribusiness sectors, we verified that regional earnings inequality is significantly higher in the agribusiness sector. Among the non-agribusiness sectors, the South, Southeast and Central-West regions presented similar income averages, while North and Northeast incomes were 18.62% and 30.75% below the base, respectively.

2.5 Conclusion

There were 19 million people — 21% of the country's workforce — working in the various segments of Brazilian agribusiness in 2014. The primary agribusiness segment occupies 47.2% of the total sector's workforce. Agribusiness activities that are important in generating income do not generate an appreciable number of jobs, while those activities that generate little added value, require little technical ability, and offer the least remuneration generate the largest number of jobs.

Relative to workers in Brazil's other economic sectors, the average Brazilian agribusiness sector worker was found to be less educated, more likely to be working on an informal basis, and more apt to be male. These results are largely linked to the high proportion of primary segment workers in the total number of persons occupied in

agribusiness and the very different profile that this segment presents in relation to the sector's other segments.

Analysis of worker income data shows a significant difference in the incomes of the average agribusiness sector worker and the average non-agribusiness sector worker that strongly favors the non-agribusiness worker. The average agribusiness worker earns R$1,235 per month while the average non-agribusiness worker earns R$1,897 per month. The lack of education, acceptance of informal employment, and low average salary make it difficult for agribusiness workers to obtain incomes commensurate with those received by workers in the non-agribusiness sectors and lessens the agribusiness worker's chance of securing formal employment and the security that implies.

Our results show that the economic returns due to continued education tend to be proportionally greater in the agribusiness sector than in the non-agribusiness sectors, albeit rising from a lower baseline. This result, which had been verified for the agriculture segment worker for Hoffmann and Ney (2004), is also valid for the average agribusiness sector worker. In addition, the income differential among the five employment status classifications was found to be higher in agribusiness in relation to other sectors, most likely due to the relatively low income earned by the self-employed. Across geographic regions, agribusiness worker remuneration varied more than remuneration for the non-agribusiness worker. Persons occupied in agribusiness activities in Brazil's Northeast and North regions were found to earn an average income significantly less than that obtained by agribusiness workers in other regions.

A limitation inherent in the present study should be pointed out: the service segment could not be included in the agribusiness sector worker income calculations. Even though this segment has significant participation in the generation of income and jobs in the sector, which could raise the average sector income, the task of separating the many different types of services provided and allocating a reasonable portion of those services directly to agribusiness was beyond our capabilities using the available data sets.

Despite the limitations pointed out, this study is a pioneer in dimensioning and analyzing the Brazilian agribusiness labor market and should add relevant insights to the sector's literary foundation. More importantly, by adding applicable new data to the existing database, the developed methodology permits constant monitoring and reevaluation of the agribusiness sector's labor market as it evolves.

This study certainly did not exhaust the subject, but hopefully will support and provide important data for future studies and public policies related to the sector.

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3 THE RECENT DYNAMICS OF EMPLOYMENT-RELATED INCOME IN AGRIBUSINESS, AN AGGREGATE ANALYSIS

Abstract

Between 2004 and 2011, Brazilian employment-related incomes increased 31.2% more than the country's Extended National Consumer Price Index (IPCA) increased. According to Barros (2016), in most cases this increase was followed by reduction in employer labor costs without consequent pressure on employment levels—a very favorable situation for both workers and employers. This scenario was made possible by the gap between growth in the IPCA and growth in the GDP deflator combined with productivity gains (BARROS, 2016). During the period, incomes gains in the Brazilian agribusiness sector were even greater than income gains in the economy as a whole, and the sector's deflator depreciated relative to the national GDP deflator. The present study is designed to determine how this increase in incomes affected the dynamics of agribusiness. As a necessary first step in this analysis, total agribusiness and agribusiness segment labor productivity was calculated for each year from 2004 through 2015. As main results, we find that the gap between agribusiness sector deflators and the IPCA did not play a preponderant role to mitigate the effect of employment-related income growth of 3.5% annually on real unit labor costs (CURT), which only increased 0.2% annually. For the most part, unit labor costs were contained by productivity gains of 3.2% in the sector, boosted mainly by agriculture and, also, by agroindustry. Without this productivity growth, CURT would have increased at the annual rate of 3.4%, negating the possibility of simultaneous agribusiness employer and worker gains of over the period.

Keywords: Agribusiness; Labor market; Labor productivity; Real unit labor costs; Relative prices

3.1 Introduction

A change in the sectoral structure of a country's Gross Domestic Product (GDP) over time tends to follow a typical sequence. Initially, as the economy grows, the agricultural sector's share of GDP falls with strong industrial expansion offseting this decline. After this initial stage, the service sector's share of GDP slowly and continuously increases (BONELLI; PESSÔA, 2010). This pattern largely characterizes the dynamics of sectoral GDP in Brazil. Specifically, the agricultural share of GDP has declined substantially over recent decades, moving from a 23% share in the 1950s to a 12% share in the 1970s and then stabilizing at about 6% from the 1990s on, according to data from the Brazilian Institute of Geography and Statistics - IBGE (2017a).

On the other hand, agribusiness[3] in aggregate has a significant share of the national GDP. On average, agribusiness has accounted for 22% of national GDP over the 1996 to 2016 period, as can be seen in Figure 3.1.

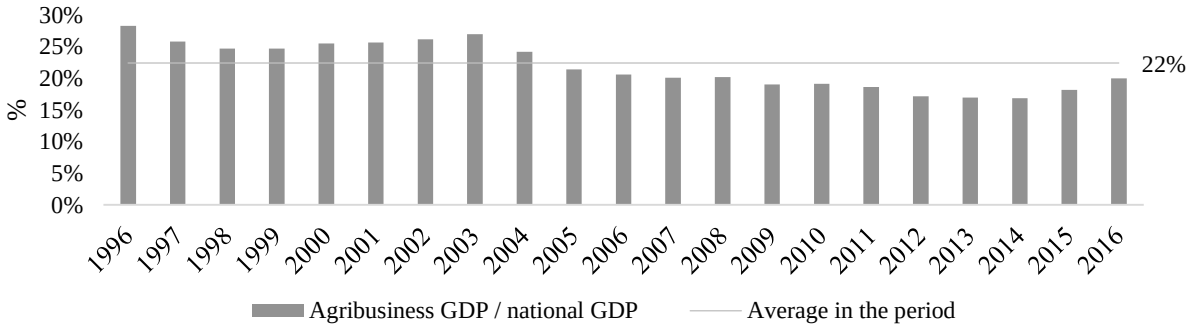

Figure 3.1 - Agribusiness share of Brazilian GDP between 1995 and 2016 (%).
Source: Center for Advanced Studies on Applied Economics – CEPEA (2017b)

Analysis of Figure 3.1 shows that the agribusiness share of Brazilian GDP has followed an oscillating trend over the years, but generally downward since 2004. These oscillations result from the comparative dynamics of prices, productivity, and volumes of capital and labor applied between this sector and the rest of the economy. According to Barros (2016), agribusiness has played a fundamental role in the national economy over the last two decades, producing increasing volumes of food and raw materials in a scenario of reduced relative prices. These circumstances sustained the government's intended policy goals: to reduce domestic poverty and inequality and generate foreign currency— objectives often considered incompatible.

From the sector perspective, this fortuitous situation was brought about by advances in agricultural productivity and efficiency, and one can assume that agribusiness and rural producers transferred some of their gains to society (BARROS, 2016). However, Barros (2016) found that the success of agribusiness was not reflected in the sector's relative GDP. On the contrary, at the height of the commodity boom in the first decade of the new century and with production increasing, agricultural GDP fell in relative terms (Figure 3.1).

[3] In this work, we adopt the concept of agribusiness developed by Davis and Goldberg (1957), in which agricultural activity is part of a broader economic structure.

According to Barros (2016), between 2004 and 2011 the relative price of agribusiness products decreased by 5%. Over the same period, agribusiness labor's remuneration saw a real increase of 31.2% in relation to the Extended National Consumer Price Index (IPCA). Two crucial questions immediately come to mind at this point: Why was the change in the relative prices so modest in the face of this real growth of labor remuneration; and how did this increase influence the agribusiness' dynamics?

In an effort to better understand the factors that led to this unusual scenario, Barros (2016) developed an analysis of labor remuneration over the 2002 to 2012 period to uncover the factors that resulted in the large increase in real labor income relative to IPCA. The analysis considered the Brazilian economy in its entirety rather than sectorally. Barros (2016) based his analysis on three variables: unit labor costs borne by employers; labor productivity; and the ratio between the IPCA (price index relevant to wage earners when valuing remuneration) and the GDP deflator (price index relevant to the employer when calculating production costs). The author found that from 2005 through 2011 the significant real increase in labor remuneration occurred without pressure and, in most cases, followed by unit labor cost reductions, a dynamic very favorable for both worker and employer, made possible by the fact that the GDP deflator rose more rapidly than IPCA and an increase in labor productivity (BARROS, 2016).

This extremely favorable combination of factors began to change in 2012 as it became evident that further increases in labor remuneration would impact production costs and employment levels. According to Barros (2016), the de-coupling between the IPCA and the GDP deflator could not continue and was unlikely to return. In this new scenario, productivity—which grows slowly in Brazil— becomes the dominant factor determining future sustainable wage advances (BARROS, 2016).

The primary goal of our study is to analyze and explain the behavior and pattern of labor income in Brazil's agribusiness sector and its segments over the 2004 through 2015 period using the procedure Barros (2016) developed to address the entire Brazilian economy. Specifically, Barros' procedure is used to analyze the interaction among agribusiness unit labor costs, labor productivity, the sectoral GDP deflator, and IPCA over time. The study begins with a calculation of labor productivity in the Brazilian agribusiness sector, its segments, and in the country's total economy.

In his analysis, Barros (2016) used Barbosa Filho and Pessôa's (2014) Brazilian labor productivity series. In our study, we calculate labor productivity in agribusiness and its segments using an adaptation of the methodology developed in the first article of this thesis so

that micordata from the annual National Household Sample Survey (Pesquisa Nacional por Amostra de Domicílios [PNAD]) could be input.

Agribusiness has its own structure and dynamics. The sector has always played a pivotal role in the Brazilian economy, having the capacity to influence the country economically and socially. It is hoped that our study will provide a more complete understanding of the interactions between agribusiness employment-related income, productivity, and labor costs, and the implications of these interactions on the sector's dynamics.

3.2 Labor productivity - concepts, definitions and previous analyzes

Productivity is usually defined as the ratio of a measure of product volume to a measure of input volume. In this research, we calculate and analyze a single factor productivity measure that relates labor with value added (VA), showing how productive work is used to generate value added over time. This measure of productivity only partially reflects labor factor productivity in terms of the worker's personal capacities and intensity of effort; rather, it depends largely on the combined influence of other inputs, such as changes in capital, technology, organizational system and efficiency, and is affected by measurement errors and economies of scale (OECD, 2001).

A comparison between labor productivity and total factor productivity (TFP) can help in understanding the first measure limitations and specificities, which must be taken into account when it is analyzed as in our study. For Messa (2014), labor productivity is a simple quotient between the product and some measure of labor, and can be expressed by Y/L, with Y being the quantity of product produced and L being labor. Starting from Solow (1957), and assuming an aggregate production function with neutral technical change, one can construct equation (3.0):

$$Y_t = A_t f(K_t, L_t) \tag{3.0}$$

with Y_t the quantity of product produced, K_t and L_t capital and labor and A_t the state-of-the-art technologies at time *t*. Differentiating eq. (3.0) in relation to time and dividing it by *Y*, one has equation (3.1):

$$\frac{\dot{Y}}{Y} = \frac{\dot{A}}{A} + \frac{\partial Y}{\partial K}\frac{K}{Y}\frac{\dot{K}}{K} + \frac{\partial Y}{\partial L}\frac{L}{Y}\frac{\dot{L}}{L} \tag{3.1}$$

According to Messa (2014), assuming that marginal products remunerate the production factors, normalizing the price of the product to unity and making r and w the prices of capital and labor, respectively, one arrives at $\frac{\partial Y}{\partial K} = r$ and $\frac{\partial Y}{\partial L} = w$ and can construct equations (3.21) e (3.22):

$$\frac{\partial Y}{\partial K}\frac{K}{Y} = \frac{r.K}{Y} = s_K \tag{3.21}$$

$$\frac{\partial Y}{\partial L}\frac{L}{Y} = \frac{w.L}{Y} = s_L \tag{3.22}$$

where s_K and s_L are the shares of capital and labor in the product's value. Adding equations (3.21) and (3.22) to equation (3.1), and assuming for each variable X that $\bar{X} = \dot{X}/X$, one can obtain eq. (3.3):

$$\bar{A} = \bar{Y} - s_K\bar{K} - s_L\bar{L} \tag{3.3}$$

In (3.3), the term on the left represents TFP (calculated as residual) as the share of product variation that input growth does not explain. Messa (2014) admits that there are constant returns to scale ($s_L = 1 - s_K$), so that equation (3.3) can be rewritten as (3.4).

$$\bar{Y} - \bar{L} = \bar{A} + s_K(\bar{K} - \bar{L}) \tag{3.4}$$

In (3.4), the term on the left expresses the growth of labor productivity decomposed into two parts: one part is technical progress ($\bar{A}$) and the other is an increase in the level of capital per worker [$s_K(\bar{K} - \bar{L})$]. In addition to technical progress, the increase in labor productivity also reflects the deepening of capital, or the increase in the capital-labor ratio (MESSA, 2014).

More practically, according to Ellery Jr. (2014) the labor productivity indicator does not distinguish gains related to the use of new techniques or technologies from the gains coming from the substitution of capital for labor. Then, if a company reduces the number of hours worked and manages to increase production due to the use of new equipment, there will be an increase in labor productivity. Moreover, this increase will occur even if the equipment uses obsolete technology.

We see in the previous paragraphs that variations in labor productivity must be interpreted cautiously. The following paragraphs discuss results from the main published studies that have analyzed labor productivity in Brazil. In addition to providing an overview

of the possible ways labor productivity can be calculated, this review intends to summarize the main results from existing studies to validate the current analysis and allow comparisons.

Galeano and Feijó (2013) conducted a regional and sectorial analyses of industrial labor productivity between 1996 and 2007 using data from IBGE's Annual Industrial Research survey (PIA-IBGE) applied to a shift-share model. The authors adopted the concept of "productivity-man," dividing the annual value of industrial transformation by the stock of workers as of December 31. They observed that Brazil's economic opening over the 1990s provoked transformations in country's industries' productive structure. Given Brazil's comparative advantage in natural resource intensive sectors, the opening would have led to the increase in the specialization of the production of industrial commodities. The authors point out that labor productivity can be used to signal changes in a country's productive structure and found that the average growth rate of Brazilian labor productivity between 1996 and 2007 was close to zero (-0.62%). Total employment increased by 41.46% and the value of industrial transformation (ITV) increased by 40.58%. These results show that the changes in Brazil's macroeconomic scenario from the mid-1990s did not favor the growth of industrial productivity nor did it induce an evolution in industry's technological level (GALEANO; FEIJÓ, 2013).

Galeano and Feijó (2013) also calculated labor productivity growth between 1996 and 2007 by sector and for some agribusiness-related industries that they considered low-tech. For these industries, the results pointed to productivity growth in the manufacture of tobacco products (68.26%), of wearing apparel and accessories (77.95%), of wood products (17.36%) and of cellulose, paper and paper products (10.69%). On the other hand, they found that productivity decreased in the following agribusiness manufactures: Food products and beverages (-17.8%), textiles (-5.42%), leather, travel articles and footwear (-3.32%), furniture and miscellaneous industries (-0.12%).

Cavalcante and De Negri (2014) analyzed the recent dynamics of several productivity indicators in Brazil. For this, the authors systematized the results obtained by previous analyzes and collected additional information. Focusing specifically on labor productivity, options 1) to 4) summarize what the authors found to be the most commonly used indicators when analyzing labor productivity in Brazil (CAVALCANTE; DE NEGRI, 2014):

1) Aggregate measures that relate GDP to the total employed population using IBGE data;

2) For sector analysis, the quotient between value added and total employed population calculated using data generally obtained from the national accounts. The authors emphasize that the deflators selected for series elaboration significantly impact their trajectories.
3) The quotient between the value of industrial transformation (VTI) or VA and employed population with data from the IBGE Annual Survey of Industry (PIA) and the IBGE Annual Survey of Services (PAS). In these cases, the industrial and service sectors are emphasized.
4) The quotient between physical production and hours worked with data gathered from the IBGE Monthly Survey of Industry–Physical Production (PIM-PF) and the IBGE Monthly Survey of Industrial Employment and Wages (PIMES).

PIMES data contains a measure of hours worked, which is a better indicator than employed population when analyzing labor productivity. However, PIM-PF data uses physical production as the measure of output, ignoring intermediate consumption and, consequently, the sector's VA. In periods when the relation between production value and intermediate consumption is changing, this measure of productivity becomes less precise (CAVALCANTE; DE NEGRI, 2014).

Using the aggregate productivity calculation method, 1) above, the authors found that the average rate of annual growth of Brazilian labor productivity was 1.09% between 1992 and 2001, and 1.17% between 2001 and 2009. Cavalcante and De Negri (2014) point out that there are different methods of adjusting the employment series and varying the time period aggregations, both of which can lead to different results: Bonelli and Bacha (2013) found that the average rate of annual growth of Brazilian labor productivity was 0.36% between 1993 and 1999, rising to 0.67% for the period between 2000 and 2009; Bonelli and Veloso (2012) found that the average annual rate of labor productivity growth was 1.2% over the 2003 to 2009 period; Squeff (2012) concluded that between 2000 and 2009, average annual productivity growth was 1% but with high intersectoral heterogeneity.

Cavalcante and De Negri (2014) analyzed industrial sector productivity from 1996 to 2011 using indicator 3). Squeff's (2012) earlier study had found that the manufacturing industry is the sector with the worst productivity performance, showing negative annual average growth (0.8%) between 2000 and 2009. The authors used different deflators to calculate VTI at constant prices: IPA – Wholesale Price Index 2nd stage (Sectorial; Preços por Atacado, segundo Estágio de Processamento [IPA]), GDP deflator; and IPCA. Their results indicate that the overall trajectory of the indicators was a fall over the period between

2000 and 2011, although the magnitudes are sensitive to the choice of deflator. In summary, the majority of the average annual rates of labor productivity growth the authors found were negative: -1% using IPA- Sectorial; -1.3% using IPA-EP; -1.2% using the GDP deflator; and +0.5% using IPCA. The atypical results obtained using the IPCA is due to this indicator's lower growth relative to the other price indices over the period. Barros (2016) also verified that the GDP deflator and IPCA followed different paths in the 2000s, with the GDP deflator growing more than the IPCA.

Cavalcante and De Negri (2014) also analyzed the variation of labor productivity from December 2000 to June 2013 using indicator 4) and found that labor productivity in the manufacturing industry increased over the period by an average of 2.13% annually. Nevertheless, the authors emphasize that physical production is a proxy for production value, not value added.

Barbosa Filho and Pessoa (2014) calculated Brazilian labor productivity and TFP for the years from 1982 to 2012. Two relevant advances were implemented in this work in relation to the studies noted previously. First, the authors consider a series of hours worked rather than number of employed individuals, but still considered GDP as the measure of output, not production value measures. This consideration is more relevant to studies of the 1980s and 1990s, when working hours oscillated markedly. In addition, the authors created a monthly series of hours worked that is compatible throughout the period of analysis. One of their study's main results was that previous estimates of productivity based on employed population underestimated the labor productivity growth rate in Brazil for some periods due to reductions in working hours. The authors then reexamined the dynamics of labor productivity in Brazil between 1982 and 2012 and determined that the fall in labor productivity in the 1980s was the result of a fewer hours worked in a daily basis and not due to a reduction in hourly productivity. They determined that over the full period (1982-2012), Brazilian labor productivity increased by 35.8% if based on hours worked.

Studies addressing labor productivity in Brazil's agricultural sector are less abundant that those directed toward labor productivity in Brazil in aggregate or in the country's industrial sector; but the Brazilian agricultural sector has not been ignored. The sector was addressed in a study by Cavalheiro (2003) as part of a sectoral analysis of labor productivity during the 1990s. The author subdivided the decade into three periods: 1990 to 1994, 1994 to 1998 and 1998 to 2000. The first sub-period was characterized by an accelerated reduction of import rates, economic deregulation, and the privatization of state enterprises. The second

sub-period featured introduction of the “Real Plan” to stabilize the country’s currency, control inflation, and foster currency appreciation. In the third sub-period, actual restructuring of monetary, fiscal and exchange-rate policies began in earnest, with the adoption of inflation targeting, adjustment of public accounts and implementation of a flexible exchange rate. In short, these guidelines have led to an exposure of the country to international competitiveness. Cavalheiro (2003) used the national accounts to provide both value added and employed population data for Brazil’s economic sectors. The study’s results for labor productivity growth in the agriculture sector were + 8.73% between 1990 and 1994; + 24.58% between 1994 and 1998 and + 8.99% between 1998 and 2000, or 47.63% over the full period. These figures for agricultural productivity compare well with labor productivity growth in the country’s entire economy of 11.96%.

Squeff (2012) used the ratio between VA and employed population with the VA figures corrected by the respective sector deflators to eliminate the price effect. The author found that labor productivity in agriculture grew at an average annual rate of 4.5% between 1995 and 2009 while the average labor productivity growth rate for the entire Brazilian economy was 0.8%. The author states that this growth in agriculture resulted from a large increase in value added (63.2%) and a negative variation in total employment (-12.2%). It is worth mentioning that Squeff's calculations (2012) disregard the working time in agricultural pursuits. In the case of Brazil in general, the working time variable had significant relevance, as pointed out by Barbosa Filho and Pessoa (2014).

Freitas (2014) summarized agricultural productivity results from previous research focused on Brazil. Besides this results summary, the author’s work included definitions, methods and the databases used in the earlier studies. Freitas (2014) noted TPF measures were used by the great majority of these studies, among them those by Barros (1999), Gasques et al. (2012a), Fuglie and Wang (2012), Gasques et al. (2012b).

Barros (1999) determined that the Brazil’s agricultural product grew 3.26% annually between 1975 and 1995, with land productivity increasing by 2.47% and labor productivity by 3.26%. The calculations also indicated that two-thirds of the production growth in the period was due to an increase in the amount of inputs used and one-third due to an increase in TFP. Brigatte and Teixeira (2012) found that agricultural TFP grew 0.47% annually between 1974 and 2005, and Gasques et al. (2012b) found that between 1995 and 2006, 68% of agricultural product growth was due to productivity gains.

3.3 Methods and sources of data and information

3.3.1 Concepts of labor and agribusiness

This chapter uses microdata from PNAD for the years 2004 through 2015 as the base of the analysis. This is a change from the earlier chapter's use of the Pesquisa Nacional por Amostra de Domicílios Contínua (PNAD-C [Continuous National Household Sample Survey]), a quarterly rather than annual survey that was first released with data from 2012. In this chapter's expanded study, we take a longer view of the study subject making the annual data from PNAD more appropriate. To estimate the size of the agribusiness sector and the agribusiness segments' workforces we adapted the procedure developed in Chapter 2 and input annual PNAD data.

In the following paragraphs, we sequentially detail the definition of employment adopted in this study; the definition of agribusiness, which is the one used by the University of São Paulo's Center for Advanced Studies on Applied Economics (CEPEA) in the calculation of the sector's GDP, and the adapted procedure used to distinguish people employed in agribusiness from people employed other sectors.

As in Barbosa Filho and Pessôa (2014), we calculate labor productivity from a series of hours worked, not from the number of individuals employed. This approach is relevant because data analysis demonstrates a consistent reduction in time at work in Brazil between 1982 and 2012 that affects productivity calculations (BARBOSA FILHO; PESSÔA, 2014). However, unlike these authors, we use an annual series in our study, which does not require the use of Monthly Employment Survey (PME) data, and our data series begins in 2004 so that procedures to rationalize changes in PNAD methodology are not needed, especially to compensate for the 1992 change in labor classification categories.

Due to other methodological changes in PNAD survey, we chose 2004 as a starting point. In 2002, PNAD changed its activity classification categories to those used in the National Classification of Economic Activities-Domicile(Classificação Nacional de Atividades Econômicas-Domiciliar [CNAE-Domiciliar]). Prior to 2002, the survey used a different group of classifications that had a low degree of sectoral desegregation, making it difficult to reliably separate agribusiness sector activities from other sector activities. In addition, data from the rural areas of Brazil's North region were first included in the PNAD survey in 2004, and we wanted to include these areas in the analysis—in 2015, 12.7% of the agricultural workforce was in the North region.

In this research we follow employment definitions contained in IBGE's (2015) PNAD:

i) PNAD evaluates the employment based on individual information from the research reference week, the last full week of September.

ii) The population investigated on the employment topic refers to people who are ten years of age or older;

iii) The people employed in the reference week are those who have paid employment and received money, products, merchandise or benefits from work; those who were unpaid but worked for at least one hour a week to aid a household member who was self-employed or an employer, a household member who was employed (case in the production of primary goods), or a religious, charitable or cooperative institution; those who worked to produce for self-consumption or in construction for their own use; and those who were only temporarily not at work during the reference period.

CEPEA (2017b) defines agribusiness as a chain system with both upstream and downstream linkages to agricultural activities. Thus, this sector involves not only agricultural and livestock production, but also the production of inputs for such production, product processing, trade and transportation, and other services necessary to make the products available to the final consumer, whether domestic or foreign. For analytical purposes, CEPEA divides the sector's GDP into four contributing segments: inputs; agriculture and livestock production (primary activities); industrialization (agricultural or livestock product processing); and agro-services. As in the previous chapter, CEPEA's division of the agribusiness sector is adopted.

As discussed in the previous chapter, to calculate agribusiness GDP, CEPEA computes the value added by activities according to the intensity of their linkage with the sector. To determine these intensities, CEPEA uses different proxies and makes calculations using information coming from diverse types of IBGE research and data gathered by other institutions. In this study, we made calculations using other proxies specifically related to work and employment to identify the agribusiness sector and its segments' labor markets (details in the next subsection).

For the calculation of the agribusiness services segment GDP, CEPEA computes the value added by the transportation, trade and other-services sectors' agribusiness distribution activities. To calculate the intensity of the connection between agribusiness and the trade and transportation sectors, CEPEA employs the commercial and transport margins used by agricultural and agroindustrial enterprises in the final distribution of the product. For the other-services activities, they use the share of the final demand for agribusiness products

(agricultural and agroindustrial products) in total domestic final demand (DFD) (CEPEA, 2017). Specifically, to measure the agro-services segment's labor market, due to the impossibility of using a labor based binding coefficient, we adopted a procedure similar to that used by CEPEA to calculate the linkage with agribusiness. However, as we want to analyze the series' dynamic over time, we estimated the linkages annually. For this, we follow the procedure suggested by CEPEA (2017) but using the annual input-output matrix made available by Guilhoto and Sesso Filho (2005) and Guilhoto and Sesso Filho (2010).

In summary, CEPEA's (2017) definition of the sectors related to agribusiness, within the range of possibilities expressed by the sectors described in the Brazilian input-output matrix, is presented in Box 2.1 of the previous chapter.

3.3.2 Filtering of employment in agribusiness, an adaptation

In this subsection we present an adaptation of the procedure developed in the previous article to filter PNAD data into people employed in agribusiness from those employed in other economic sectors. In this study, the number of individuals employed in agribusiness is determined using PNAD microdata organized into CNAE-Domicile activity classifications. In some cases, the PNAD employment data assigned to a particular CNAE-Domicile classification can be immediately recognized as agribusiness related employment and directly applied in our study. However, some broad CNAE-Domicile classifications group agribusiness activities with non-agribusiness activities, such as individuals working as pesticide fabricators being grouped with paint fabricators at one broad CNAE-Domicile chemical industry employment classification.

For some classifications, this lack of disaggregation makes it impossible to distinguish agribusiness employment data from non-agribusiness employment data. In this case, one method to resolve the difficulty is to use Brazilian employment data sources other than PNAD, especially ones that use the more disaggregated CNAE 2.0 activity classifications. Although the broad CNAE 2.0 classifications are identical to those used by CNAE-Domicile, they are disaggregated into more sub-classifications. Since employment data in the disaggregated CNAE broad classifications can be directly identified as related to agribusiness or non-agribusiness activity, the percentage of individuals engaged in agribusiness activities in the broad classification can then be estimated. This percentage can be converted into a coefficient that is applied to PNAD employment data in an overly broad CNAE-Domicile classification to estimate of the number of agribusiness employees in that classification. As

mentioned in the previous subsection, we calculated proxies different from those of Cepea and related to labor and employment specifically for the identification of the labor market of the sector.

For the activity categories that were not entirely agribusiness activities, we used three different procedures to separate out the PNAD agribusiness employee data in overly aggregated CNAE-Domicile activity classifications. Table 3.1 shows the agribusiness classification used in these instances. The description and codes from the CNAE-domicile are in the first two columns, the specific agribusiness activity in the third column, and the way of the data was obtained is in the last column.

As in the first article, to separate out the “clothing and clothing accessories (natural-based)” agribusiness workers from the broad category “clothing and clothing accessories,” we applied the category coefficient calculated by CEPEA researchers from data in the 2009 Brazilian National Accounts. That coefficient was 0.357%.

To measure the “agro-services” segment employment, we calculated annual coefficients of linkage intensity for the trade, transportation and other services segments using the annual input-output matrices from Guilhoto and Sesso Filho (2005) and Guilhoto and Sesso Filho (2010), as discussed above. The choice of activities of which percentages are linked to agribusiness within the full range of service activities of the economy followed CEPEA (2017). The following service categories are not linked with agribusiness: education; human health and social services; arts, culture, sport and recreation; other activities and services; domestic services; and international organizations and other extraterritorial institutions.

Table 3.1 - Agribusiness classification (description and codes of the CNAE-domicile, agribusiness activity and way of obtaining)

Description in CNAE-domicile (PNAD)	CNAE-domicile code	Agribusiness activity	Calculation procedure
Manufacture of pharmaceutical products	24020	Veterinary medicines	Coefficients
Manufacture of chemical products	24090	Fertilizers and pesticides	Coefficients
Manufacture of machinery and equipment - except household appliances	29001	Agricultural machinery	Coefficients
Agriculture, forestry, livestock, fishing and aquaculture	1101 a 5002	Agriculture, forestry, livestock, fishing and aquaculture	Direct
Food products and beverages	15010 a 15055	Food products and beverages	Direct
Manufacture of tobacco products	16000	Manufacture of tobacco products	Direct
Manufacture of textiles	17001 e 17002	Natural-based textiles	Coefficients
Clothing and clothing accessories	18001 e 18002	Natural-based clothing and clothing accessories	Coefficients
Manufacture of footwear and leather and fur articles	19011,19012 e 19020	Leather articles and leather footwear	Coefficients
Manufacture of wood products	20000	Manufacture of wood products	Direct
Manufacture of cellulose, paper and paper products	21001 e 21002	Cellulose and paper	Direct
Alcohol production	23400	Alcohol production	Direct
Manufacture of furniture and miscellaneous manufacturing industries	36010	Wooden furniture	Coefficients
Wholesale & retail trade; repair of personal and household goods.	53010 a 53113	Agribusiness trade	Coefficients
Land, water and air transportation	60010 a 62000	Agribusiness transportation	Coefficients
Editing, printing and reproduction of recorded media	22000	Other agribusiness services	Coefficients
Accommodation and food	55010 a 55030	Other agribusiness services	Coefficients
Auxiliary transport and travel agency	63010 a 63030	Other agribusiness services	Coefficients
Post offices and telecommunications	64010 e 64020	Other agribusiness services	Coefficients
Public administration	75011 a 75020	Other agribusiness services	Coefficients
Other activities	65000 a 74090	Other agribusiness services	Coefficients

Source: author' results.

In regard to the other activities besides the services ones' and the clothing and clothing accessories, as in the first chapter, we used the Annual Social Information Report (RAIS) database from the Brazilian Ministry of Labor and Employment (MTE) to calculate

disaggregation coefficients. Table 3.2 shows the agribusiness activity and the coefficients linked with those activities by year.

Table 3.2 - coefficients to filtering of employment in agribusiness

Agribusiness activity	Coefficients (%)											
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Food products and beverages	100	100	100	100	100	100	100	100	100	100	100	100
Man. of tobacco products	100	100	100	100	100	100	100	100	100	100	100	100
Natural-based textiles	66	66	68	68	66	66	65	64	64	65	65	67
Natural-based clothing and clothing accessories	36	36	36	36	36	36	36	36	36	36	36	36
Leather articles and leather footwear (19011 e 19012)	100	100	100	100	100	100	100	100	100	100	100	100
Leather articles and leather footwear (19020)	74	74	71	69	70	67	68	66	64	62	61	60
Manufacture of wood products	100	100	100	100	100	100	100	100	100	100	100	100
Cellulose and paper	100	100	100	100	100	100	100	100	100	100	100	100
Alcohol production	100	100	100	100	100	100	100	100	100	100	100	100
Wooden furniture	77	75	75	75	75	74	73	73	73	73	74	75
Veterinary medicines	8	8	8	8	8	8	8	9	9	9	9	9
Fertilizers and pesticides	19	19	18	18	19	18	19	20	20	23	24	24
Agricultural machinery	23	20	20	22	22	24	24	24	24	26	26	26
Agribusiness trade	25	24	24	23	24	26	23	22	23	24	24	24
Agribusiness transportation	18	17	17	16	16	17	21	20	20	21	21	21
Other agribusiness services	16	15	14	14	14	14	13	13	13	13	13	13

Source: author' results, based on Cepea (2017), MTE (2017) and Guilhoto and Sesso Filho (2005) and Guilhoto and Sesso Filho (2010).

Based on these procedures, we find for each year of the study period the number of individuals employed in agribusiness activities, their average working hours and, consequently, the historical series of total hours worked in the sector.

3.3.3 Labor productivity series

In this research, we estimate labor productivity for agribusiness—not just for agriculture—using the quotient between value added, measured by GDP, and hours worked by the employed population as the indicator. We used value added because this is a more accurate product measure to indicate productivity than physical production (CAVALCANTE; DE NEGRI, 2014); and the use of a series of hours worked is intended to eliminate bias

related to variations in working time (BARBOSA FILHO; PESSOA, 2014; CAVALCANTE; DE NEGRI, 2014).

Therefore, first, we calculate the total hours worked in agribusiness, its segments and the entire economy. Following an adaptation of the Barbosa Filho and Pessôa's (2014) procedure, the total hours worked in the month of September each year ($Hours_{j,t}$) is obtained by adding up the total hours worked of all remunerated and unpaid "employee" individuals and expanding them by each observation's IBGE assigned weighting in the working population according to (3.5):

$$Hours_{j,t} = \sum_{i=1}^{Nj} p_{it} HT_{it} \tag{3.5}$$

where t represents the years ($t = 2004, \ldots, 2016$), i the individuals considered in the sample (with sample size N), p_{it} are the individuals weights, HT_{it} the total hours worked by the individual in the month of September of the year t, and j the different groups for which the series is calculated ($j =$ agribusiness, primary segment, inputs segment, industry segment, agro-service segment and economy as a whole). Based on the total hours worked, we calculate labor productivity according to (3.6):

$$PT_{j,t} = GDP_{j,t} / Hours_{j,t} \tag{3.6}$$

According to Barbosa Filho and Pessôa (2014), the working time has an essential role in productivity analysis in Brazilian studies of the decades of 1980 and 1990. After the year 2000, working time fluctuated much less. In this research, we chose to consider the working time because there is no previous knowledge about the dynamics of this variable for agribusiness in the analyzed period.

To summarize, the following data have been employed through this stage of our analysis: We use the annual National Household Sample Survey (PNAD), predominantly, information from RAIS, IBGE - National Accounts (IBGE, 2017a), and CEPEA for hours worked; Brazilian GDP data came from IBGE's (2017a) National Accounts supplemented with agribusiness and agribusiness segment GDP data from CEPEA.

3.3.4 The determinants of the aggregate dynamics of employment-related income at the sectoral level

With the labor productivity series calculated, we move to an analysis of the determinants of the aggregated dynamics of employment-related income. This stage of the work is based on the procedure developed by Barros (2016). According to the author, trends in three different variables can explain the dynamics of employment-related income (REND): real unit labor costs (CURT), the costs borne by employers; labor productivity (PT); and relative behavior of the IPCA against the GDP deflator.

According to Barros (2016), the unit labor cost (CUT) is the ratio between employment-related income (REND) and labor productivity (PT, with $PT_{j,t} = GDP_{j,t}/Hours_{j,t}$). As Mello and Barbosa-Filho (2014) point out, CUT will increase if wages increase more than productivity and fall if productivity increases exceed wage increases. For the different sectors j, CUT can be expressed by (3.7):

$$CUT_{j,t} = \frac{REND_{j,t}}{(\frac{GPP_{j,t}}{Hours_{j,t}})} \tag{3.7}$$

In turn, dividing CUT by the GDP deflator (DEF) generates CURT, the real unit labor cost (BARROS, 2016):

$$CURT_{j,t} = \frac{REND_{j,t}}{DEF_{j,t}} . \frac{Hours_{j,t}}{GDP_{j,t}} = \frac{REND_{j,t}}{DEF_{j,t}} . \frac{1}{PT_{j,t}} \tag{3.8}$$

with GDP expressed as a volume indicator. Barros (2016) includes the relation with the consumer deflator (IPCA) in (3.8), so that we have (3.9):

$$CURT_{j,t} = \frac{REND_{j,t}}{IPCA_t} . \frac{Hours_{j,t}}{GDP_{j,t}} . \frac{IPCA_t}{DEF_{j,t}} \tag{3.9}$$

From (3.9) it is possible to analyze the movements of employment-related income explained by CURT, productivity, and the relationship between the deflator's variations, as seen in (3.10):

$$\ln\left(\frac{REND_{j,t}}{IPCA_t}\right) = \ln(CURT) + \ln\left(\frac{GDP_{j,t}}{Hours_{j,t}}\right) + \ln(\frac{DEF_{j,t}}{IPCA_t}) \tag{3.10}$$

We use this decomposition of the dynamics of employment-related real incomes as a basis in the present study. We found a similar procedure in Mello and Barbosa-Filho (2014), but their study did not consider the relationship between the deflator and IPCA—CUT could

vary due to changes in the average wage in the economy and/or average labor productivity. These authors assessed whether the relative loss of Brazil's competitiveness position vis-à-vis other countries is due to higher costs or reduced productivity and calculated the unit labor cost (CUT) for Brazil and its states. The authors emphasize that CUT is relevant only to relative analyzes, with its absolute level making little sense.

To conclude this stage of the work, some additional information was necessary in addition to the data used in the previous section. We calculated employment-related income using PNAD predominantly and followed procedures similar to those used to find hours worked in the country and those specific to agribusiness. The national GDP deflator was obtained from IBGE National Accounts (2017a) and CEPEA made the GDP deflators for agribusiness and its segments available. In addition, IPCA was obtained from the National System of Consumer Price Indexes produced by IBGE (2017b).

3.4 Results and discussions

The analysis of our results is conducted in three stages, according to the research objectives. First, we present the results of the measurement of the Brazilian labor market, the agribusiness labor market and the agribusiness segments' labor markets from 2004 through 2015. These measurements include total hours worked by the employed population and respective average time worked by each employee in a week (working time). We then discuss the recent labor productivity dynamics of Brazil's labor force, its agribusiness labor force, and its agribusiness segments' labor force. Finally, we analyze the evolutionary pattern of real employment-related income based on labor productivity, unit labor cost, the IPCA, and the GDP deflator.

3.4.1 Employed population, working time and employment-related income

Table 3.3 presents the number of people employed in agribusiness, its segments and the total Brazilian economy annually from 2004 through 2015. In 2015, the agribusiness workforce (24.39 million) accounted for 25.4% of the Brazilian employed persons total. Of the agribusiness workforce, almost half (12.8 million individuals) were employed in the sector's primary segment. The remainder of the agribusiness workforce was broken down as follows: the services segment accounted for about 29% (6.9 million people); the

agroindustrial segment for 18% (4.3 million), and the input segment for only 1% (230 thousand).

Using the PNAD definition of employed people, employment in the agribusiness input segment was relatively stable over the 2004 to 2015 study period while the sector's services segment saw a 17.4% increase in employment, mainly from 2008. Employment fell in both the agroindustrial and agriculture segments, especially in the primary sector, between 2004 and 2015. Faced with this dynamic, the total number of employed persons in agribusiness was 13.3% less in 2015 than in 2004. Between those two years, the total number of employed people in Brazil increased by 12.7% while the number of people employed in agribusiness as a proportion of that total number decreased 7.6 p.p, from 33% in 2004 to 25.4% in 2015.

Table 3.3 - People employed in agribusiness, its segments and the total economy (000s) and agribusiness participation in total Brazilian employment - 2004 to 2015

	Employed People ('000)					
Year	Inputs	Primary	Industry	Agro-services	Agribusiness	Agrib. / Brazil
2004	230	17,395	4,509	5,924	28,058	33.0%
2005	209	17,433	4,800	5,779	28,221	32.2%
2006	200	17,086	4,847	5,857	27,990	31.0%
2007	243	15,997	4,867	5,838	26,944	29.8%
2008	186	15,609	5,067	6,128	26,989	29.0%
2009	249	15,143	4,837	6,350	26,579	28.5%
2011	216	14,159	4,560	6,350	25,284	26.9%
2012	204	13,263	4,790	6,617	24,873	26.1%
2013	231	13,443	4,717	6,971	25,363	26.1%
2014	234	13,934	4,653	7,191	26,012	26.0%
2015	230	12,804	4,349	6,955	24,338	25.4%
2015/2004	0.1%	-26.4%	-3.5%	17.4%	-13.3%	

Source: author' results.

As already mentioned in the methodological section, we emphasize that these agribusiness labor market numbers differ from those presented in the previous chapter. In the first chapter we used quarterly data provided in the PNAD-Continuous (PNAD-C); in this chapter we use annual data provided in the PNAD. The PNAD-C does not consider persons engaged in production of goods for their own household consumption to be employed while the PNAD does. Over the years studied, there were between 3.5 and 4.5 million people employed for their own consumption, depending on the specific year the data were taken. If

we disregard this category of employment, the share of agribusiness in the total economy in terms of employed people (EP) would decrease to 30.2% in 2004 and 22.4% in 2015.

The number of EP in primary segment (agriculture and livestock) shrank consistently over the study period, falling 26.4% between 2004 and the end of 2015. According to Maia and Sakamoto (2014), the most significant changes in the number of people employed in the primary segment occurred in the second half of the first decade of the 2000s. This dynamic was mainly a result of the significant reduction of number of people employed in the agriculture segment in Brazil's Northeast region, which holds the most significant agricultural contingent in the country. The rural emptying in this region is associated with the infeasibility of small rural properties and the better opportunities in the urban environment (MAIA; SAKAMOTO, 2014; BUAINAIN ET AL., 2013). In addition to the Northeast, Maia and Sakamoto (2014) highlight that at the same time farmers and farm workers were deserting the northern Brazil, a significant number were also leaving Brazil's South region. The greatest relative reduction of primary segment employed people occurred in this region. As to the possible causes for this dynamic, the authors point to the intensification and concentration of production to the detriment of small farms.

In the agroindustrial segment, the number of EP was relatively stable over the study period when compared with the upstream primary segment. Agroindustrial employment tended to increase between 2004 and 2008 and retreat thereafter. Analyzing RAIS data, which allows for greater sectoral desegregation, we verified that the increase in the number of employees in agroindustry up to 2008 is mainly related to the expansion of jobs in the slaughter, sugar and alcohol, clothing and accessories industries (MTE, 2017). After the emergence of bi-fuel vehicles in 2003, the sugar-energy subsegment experienced significantly expanded production and a concurrent increase in employment opportunities (GILIO; MORAES, 2016)—a movement that ended in 2008 as an economic crisis weakened the subsegment.

The decline in agroindustrial jobs from 2008 through 2015 observed in RAIS data was mainly due to the reduction of jobs in the textiles and clothing, footwear, and wooden products industries (MTE, 2017). During this period, these subsegments' production also declined significantly. According to industrial physical production data from IBGE (2017c), between December 2008 and December 2015, textile production fell by 40%, clothing and accessories manufacturing fell 25%, leather preparation and leather goods production fell 16%, and the production of wooden products stagnated.

Not only did the number of those employed in the agribusiness sector fall 13.3% between 2004 and the end of 2015, there was also 4.8% reduction in time those employed spent at work, or about 1.8 hours a week per employed person. In Brazil as a whole, the reduction of weekly working time was similar: 4.6% (Figure 3.2). In Figure 3.2, one can see that agribusiness working time was at a relatively lower level than the country's average, although showing similar behavior. When analyzing the agribusiness segments separately, their levels of time spent at work are divergent. Average working time for an employed person in the primary segment fell 8.2% (about 2.8 hours a week), much more than in other segments.

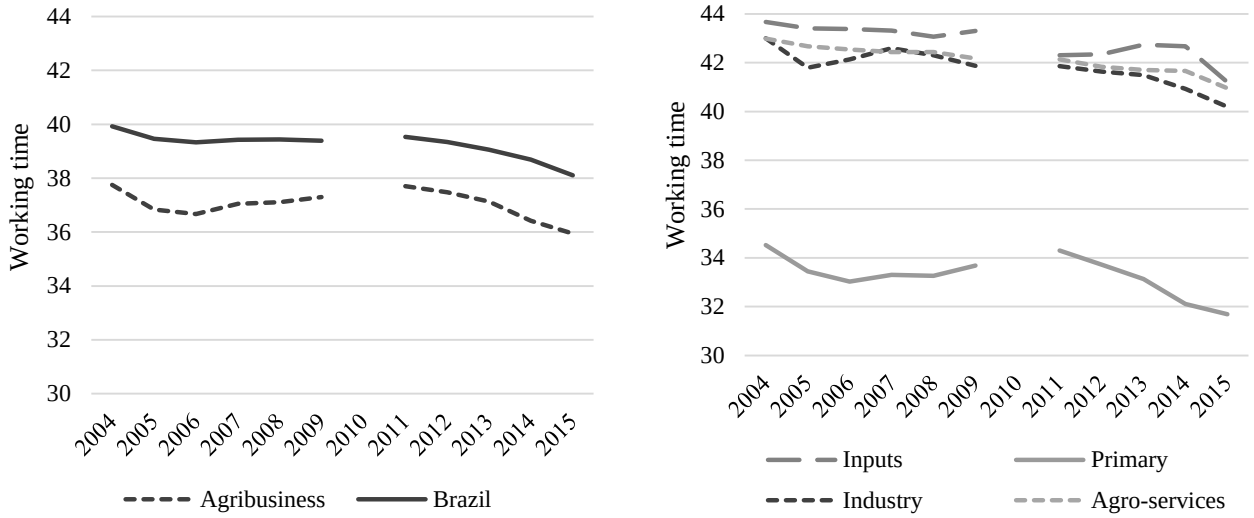

Figure 3.2 - Working time in Brazil, its agribusiness sector (left) and in its agribusiness segments (right) Working time in Brazil and agribusiness (on the left) and agribusiness segments (on the right)

Source: author' results.

Barbosa Filho and Pessôa (2014) found that weekly hours of employment in Brazil fell from 40 to 39 between 2004 and 2012, following a trend that was stronger between 1982 and 1992—these results for Brazil are similar to those from our analysis presented in Figure 3.2[4]. Although time working varied relatively little during the period analyzed by our study, it did not remain stable. Thus, given the reduced number of hours employed per week, labor

[4] The average working day presented here is slightly shorter than that from Barbosa Filho and Pessôa (2014) since these authors excluded unpaid workers who worked for less than 15 hours a week from their sample—aiming at making the series compatible with the years before and after 1992. In our study this exclusion was unnecessary.

productivity calculations that considered only the number of those employed would underestimate productivity variations.

Table 3.4 presents the average annual employment-related income for the entire Brazilian agribusiness sector, its segments, and the entire economy. The average income level is much lower in agribusiness when compared with the entire economy's average. In 2004, the average monthly income in agribusiness, R$ 865.00, represented less than 70% of the average for all employees in the Brazilian economy. This difference diminished over the analyzed period, with the average agribusiness employed population incomes rising to 73.5% of the average in Brazil in 2015 (Table 3.4).

Table 3.4 - Average employment-related income (REND) usually earned in the main work, in R$ of 2016*, in Brazil, agribusiness and its segments

Year	Inputs	Primary	Industry	Agro-services	Agribusiness	Brazil
2004	1.975	452	1.122	1.601	865	1.238
2005	2.254	453	1.110	1.630	875	1.280
2006	2.403	473	1.265	1.727	952	1.373
2007	2.261	508	1.275	1.784	1.002	1.430
2008	2.363	543	1.366	1.822	1.066	1.487
2009	2.459	560	1.381	1.837	1.093	1.529
2011	2.640	644	1.474	2.009	1.213	1.685
2012	2.819	689	1.546	2.103	1.312	1.796
2013	2.748	717	1.587	2.154	1.363	1.856
2014	2.675	685	1.647	2.145	1.361	1.867
2015	2.649	707	1.522	2.012	1.316	1.791
2015/2004	34%	56%	36%	26%	52%	45%

Source: author' results. * deflated by the IPCA.

The low average income in agribusiness reflects the unfavorable situation in the sector's primary segment. In 2015, the average income in this segment was 60% lower than the average in the economy. Given its significant weight in the number of people employed in agribusiness (almost half the EP in 2015), the sector's relatively low average is largely a reflection low incomes in the primary segment. The agroindustrial segment also showed a lower average income than that in the economy. The input and agro-services segments have the highest average agribusiness incomes—higher than the economy's average.

The unfavorable average income situation of those employed in the agribusiness sector actually ameliorated over the period, mainly due to the real gain of 56% in income earned in the agriculture segment, higher than the average 45% gain in the rest of the economy. This

segment's average real appreciation relative to the IPCA of income was consistent from 2004 to 2013, interrupted only in 2014. Maia and Sakamoto (2014) point out some factors that influenced the positive evolution of agriculture incomes between 1992 and 2012: increase in the mandatory minimum wage (the basis for payment of a relevant part of agricultural remuneration); an increase in the percentage of employees in total employment that were formally contracted; agricultural productivity gains, especially in the South and Midwest regions (more intensive use of capital); and the pressure on wages stemming from the reduction of the rural Economically Active Population (EAP).

From Table 3.4, we verify the expressive gains in employment-related income in Brazil. According to Barros (2016), this income increase relative to the IPCA can be explained by trends in three different factors: reduction of the real unit labor cost (beneficial to employers), reduction of the IPCA in relation to the economy's deflator, and increased productivity.

Data in Table 3.4 show that income gains were even more significant in agribusiness, especially in the primary segment, than in the entire economy, which leads to the question, how did the dynamics of the sector enable and absorb this increase? A first step in understanding this issue is to know the behavior of productivity in the sector over the period studied, a topic to be addressed in the next subsection's analyzes of labor productivity in agribusiness, its segments, and in the total economy.

3.4.2 Agribusiness labor productivity

As discussed earlier, during periods when working time fluctuates, calculating labor productivity by considering an hours worked series is ideal. Figure 3.3 graphically illustrates a total hours worked and a EP series for the studied period. The Figure shows that during the 2004 to 2015 period, agribusiness EP fell 13% and total hours worked fell by 17%, due to the concomitant reduction of the working time. Over the same period, EP in the entire economy increased 13% and total hours worked increased 8%.

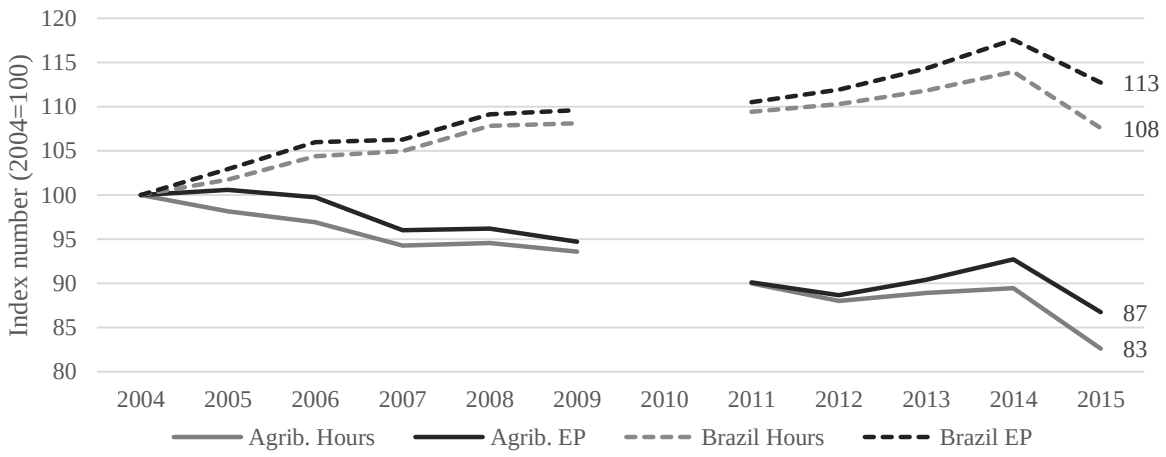

Figure 3.3 - EP and total hours worked - agribusiness and the total of the economy (Index number 2004 = 100).
Source: author's results based on information from PNAD, IBGE (2017d) and from RAIS, MTE (2017).

For comparative purposes, Table 3.5 shows the dynamics over time of labor productivity in agribusiness and in Brazil based on two series: one calculated from EP data and one based on hours worked data (Hours) using 2004 as the basis year. In addition, the Table presents the results obtained by Barbosa Filho and Pessôa (2014) for Brazil. The slight difference between our series calculated for Brazil and those of Barbosa Filho and Pessôa (2014) probably is derived from the differences in the definition of EP.

Table 3.5 - Labor productivity (EP and hours worked) in agribusiness and Brazil, and Brazilian labor productivity by Barbosa Filho and Pessôa (2014) – Index number 2004 = 100

	Productivity (EP)			Productivity (Hours)		
	Agribusiness	Brazil	Brazil*	Agribusiness	Brazil	Brazil*
2004	100,0	100,0	100,0	100,0	100,0	100,0
2005	99,2	100,2	100,6	101,7	101,4	101,3
2006	103,7	101,2	102,1	106,7	102,7	103,1
2007	110,9	107,0	106,3	113,0	108,4	107,3
2008	114,6	109,5	108,4	116,5	110,9	109,7
2009	114,8	108,9	107,4	116,2	110,4	109,3
2010			114,7			117,0
2011	129,5	116,2	117,2	129,6	117,4	119,7
2012	130,5	119,3	111,6	131,4	121,1	120,1
2013	135,4	119,1	-	137,7	121,7	-
2014	132,0	119,3	-	136,8	123,1	-
2015	139,9	125,0	-	146,9	131,0	-

*data from Barbosa Filho and Pessôa (2014).
Source: author's results based on information from PNAD - IBGE (2017d), RAIS - MTE (2017), National Accounts– IBGE (2017a) and Cepea (2017).

As expected, productivity growth would be underestimated if we only considered the employed population rather than total hours worked for calculations (Table 3.5). For agribusiness, cumulative growth would be underestimated by 7p.p. and by 6p.p. for Brazil. Brazilian labor productivity dynamics determined during our study's period are similar to those calculated by Barbosa Filho and Pessôa (2014). According to these authors, productivity stagnated in the 1980s, grew slightly in the 1990s, and accelerated after 2004. The productivity dynamic was important for the growth of national GDP in the 2004 through 2015 period.

From the Table 3.5, it is also noted that agribusiness productivity grew more than the country's average in every year except for 2012 and 2014. As a result, agribusiness productivity gains exceeded the average economic gain over the full period by 16p.p., 46.9% and. 31% respectively.

The agribusiness segments' productivity variations over time is shown in Table 3.6. An increase in the primary segment's productivity was the main cause of the increase in the entire sector's productivity level. Accumulated growth for the other segments was generally lower than that observed for the total economy.

Table 3.6 - Labor productivity - Productivity (Hours) - in agribusiness and its segments – Index number 2004 = 100

	Productivity (Hours)				
	Inputs	Primary	Industry	Agro-services	Agribusiness
2004	100,0	100,0	100,0	100,0	100,0
2005	97,3	101,0	98,4	103,8	101,7
2006	100,5	113,4	99,2	105,6	106,7
2007	96,6	120,5	101,0	109,2	113,0
2008	137,2	134,4	98,4	106,6	116,5
2009	97,5	141,0	101,5	101,0	116,2
2010					
2011	134,3	158,1	114,9	108,1	129,6
2012	145,4	165,2	110,2	104,5	131,4
2013	135,7	187,2	113,6	104,3	137,7
2014	133,5	188,9	115,8	100,9	136,8
2015	131,4	221,8	121,0	104,0	146,9

Source: author's results based on information from PNAD - IBGE (2017d), RAIS - MTE (2017), and Cepea (2017)

Productivity in the primary segment grew 121.8% over the study period, an annual average growth rate of 6.9%, with consistent year-on-year growth. Other studies have estimated the agriculture segment's productivity growth rate during earlier periods: Squeff (2012) estimated that, between 1995 and 2009, agricultural labor productivity grew at an average annual rate of 4.5% while the entire economy's annual productivity growth rate was 0.8%; Barros (1999), estimated that agricultural labor productivity increased by 3.26% annually between 1975 and 1995; Brigatte and Teixeira (2012) calculated that agriculture TFP increased by 0.47% annually between 1974 and 2005; and Gasques et al. (2012b) state that 68% of agricultural output growth was due to productivity gains between 1995 and 2006 (FREITAS, 2014).

Overall, agricultural labor market was characterized by EP reduction and increases in employment-related income and productivity – movements related to each other and with a generally higher intensity than those observed in the other segments and in Brazil. Rezende (2006) discusses the reasons that led Brazilian agriculture to adopt this technological standard, of mechanization to replace the less qualified labor force typically found in agriculture (and abundant in Brazil) by the intensive use of capital and qualified work (factors that are scarce in the economy). This author points out that this process began in the 1960s and that, in face

of a distortion of the production factors' relative prices caused by land, labor and credit policies, there was excessive mechanization in agriculture.

Agro-services labor productivity fluctuated over the entire study period, increasing from 2004 to 2007, in 2011, and 2015, while declining in 2008 and 2009 and from 2012 to 2014. According to Arbache (2015), who studied labor productivity in the Brazilian general services sector, the sector's productivity was quite low and variable. Jacinto and Ribeiro (2015) point out that Brazilian productivity studies emphasize the industrial sector, with few directing their attention to the service sector.

Accumulated agroindustrial productivity growth was 10p.p. below that of the economy over the study period. Productivity in this segment stagnated between 2004 and 2009 then remained at a relatively higher level. Squeff (2012) pointed out that processing industry productivity had the worst performance of the economic sectors between 2000 and 2009, registering a negative annual average growth of 0.8%.

Figure 3.4 presents a summary of the results for the agribusiness sector and for its segments. It shows the evolution of productivity indicators, total hours worked and GDP for the agribusiness sector and for its segments over the study period. In the primary segment, productivity gains are a result of the combined movement of the segment's GDP growth and reduced hours worked. This dynamic was constant throughout the analyzed period.

Gasques et al. (2012) found that the Brazilian agricultural production index increased by 30.3% between 2004 and 2011—a period similar to that analyzed in this study. Over this same period, the input index, which includes land, labor and capital, fell by 17.9%. The input index's low growth reflects reductions of 12.7% and 6.2% in the labor and land indexes, respectively, and relative stability in the capital index (+0.3%). That is, the increase in production during this period occurred concurrently with a reduction of land and labor use resulting from the introduction of technologies that increase these factors' productivity. If the capital index remained relatively stable from 2011 to 2015, maintaining the 2004 to 2011 period's trend, and considering the reduction in the employed population, we can infer that the increase in estimated labor productivity must result from both technical progress and the deepening of capital or the replacement of labor by capital.

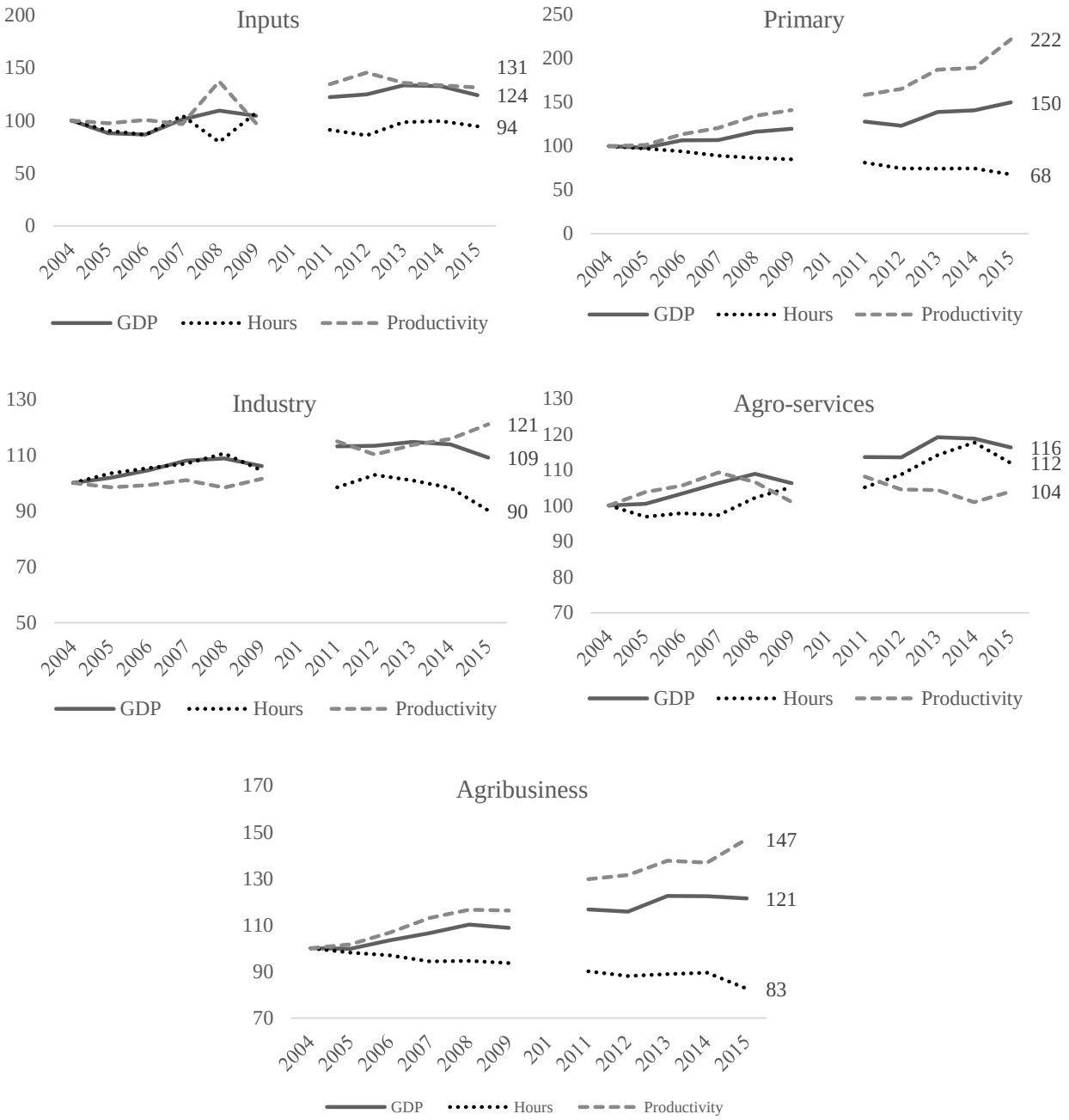

Figure 3.4 - Productivity (prod), hours worked (hours) and GDP for agribusiness and its segments (index numbers 2004 = 100)
Source: author's results based on information from PNAD - IBGE (2017d), RAIS - MTE (2017), and Cepea (2017).

For agroindustry, the stagnation of productivity between 2004 and 2009 resulted from a dynamic in which segment's GDP growth practically matched the increase of hours worked in the segment (Figure 3.4). Between 2013 and 2015, a fall in hours worked (-11%) greater than the segment's GDP reduction (-5%) indicates the increase in productivity. In agro-

services, the only period of a more consistent productivity growth occurred between 2004 and 2007. Over this period, the segment's GDP growth coincided with relative stability in the number of hours worked. The decline in productivity between 2012 and 2014, on the other hand, is due to a more pronounced increase in total hours worked than the segment's GDP growth. Productivity in the inputs segment fluctuated annually. These fluctuations should be analyzed with caution because the population employed in this segment is relatively small and the hours worked series is quite susceptible to variations resulting from the PNAD survey's sample questions.

From the results already presented, it is possible to perform a decomposition of GDP growth broken down into labor productivity growth based on the employed population—Productivity (EP)—and the actual growth of the employed population—EP. In turn, Productivity (EP) can be decomposed into labor productivity based on the hours worked—Productivity (hours)—and the annual average working time (BARBOSA FILHO; PESSÔA, 2014) [5]. Table 3.7 and Figure 3.5 present these results for Brazil, agribusiness, and the agribusiness segments from 2004 through 2015.

Table 3.7 - Decomposition of GDP growth for Brazil, agribusiness, and agribusiness segments, 2004 thru 2015 (annual %)

	GDP	Productivity (EP)			EP
		Productivity (hours)	Working time	Total	
Inputs	1,8%	2,3%	-0,5%	1,8%	0,01%
Primary	3,4%	6,6%	-0,7%	5,9%	-2,6%
Industry	0,7%	1,6%	-0,6%	1,0%	-0,3%
Agro-services	1,3%	0,3%	-0,4%	-0,1%	1,3%
Agribusiness	1,6%	3,2%	-0,4%	2,8%	-1,2%
Brazil	2,9%	2,3%	-0,4%	1,9%	1,0%

Source: author's results based on information from PNAD - IBGE (2017d), RAIS - MTE (2017), and Cepea (2017).

Between 2004 and 2015, Brazilian agribusiness GDP grew at an annual rate of 1.6%. This growth can be attributed to hourly productivity gains of 3.2% reduced by a fall in average working time (-0.4%) and a decline in the agribusiness EP (-1.2%). Figure 3.5

[5] Adapted from Barbosa Filho e Pessôa (2014):

$$\frac{1}{N}\ln\left(\frac{GDP_{(t+N)}}{GDP_t}\right) = \frac{1}{N}\ln\left(\frac{Prod\_hours_{(t+N)}}{Prod\_hours_t}\right) + \frac{1}{N}\ln\left(\frac{Working\ time_{(t+N)}}{Working\ time_t}\right) + \frac{1}{N}\ln\left(\frac{EP_{(t+N)}}{EP_t}\right)$$

illustrates the proportional effect of the reductions in average working time and the number of employed persons on the positive effect of hourly productivity gains.

As expected, the dynamics observed in agribusiness are smaller but similar to the dynamics of the sector's primary segment. This segment's GDP annual growth of 3.4% was a response to an hourly productivity increase of 6.6%; however, this growth was softened by relatively high reductions in both EP (-2.6% annually) and working time (-0.7% annually). A similar scenario, but with more modest rates, was verified for the agroindustrial segment. In the input segment, the number of EP was stable over the analyzed period and the hourly productivity increase, reduced from the annual average decrease of 0.5% of the working time, reflected in the GDP growth. In the agro-services segment, in contrast, an increase in EP accounted for most of the segment's GDP growth, with a modest average gain in hourly productivity (0.3%) being offset by a reduction in average working time (-0.4%).

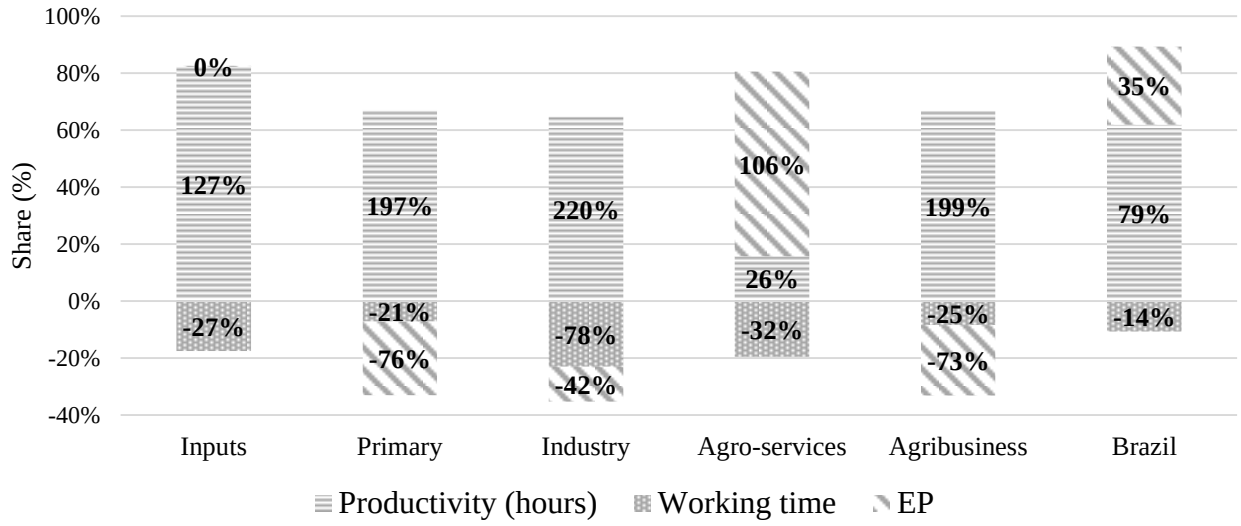

Figure 3.5 - Decomposition of GDP growth – Brazil, agribusiness and its segments
Source: author's results based on information from PNAD - IBGE (2017d), RAIS - MTE (2017), and Cepea (2017).

For Brazil as a whole, productivity growth largely explains the growth of the Brazilian GDP. This result is close to the one obtained by Barbosa Filho and Pessôa (2014) analyzing Brazil from 2002 through 2012.

3.4.3 Determinants of the recent dynamics of agribusiness employment-related income

The Brazilian agribusiness sector and each of its segments were analyzed to reveal the dynamics of the sector's employment-related income. The analysis was based on the behavior of labor productivity, unit labor cost, and the relationship between the IPCA and GDP deflator using results found in the previous subsections. Figure 3.6 illustrates the components of real employment-related income (REND) average annual growth rates in Brazil, agribusiness, and agribusiness segments, comparing 2004 with and 2015.

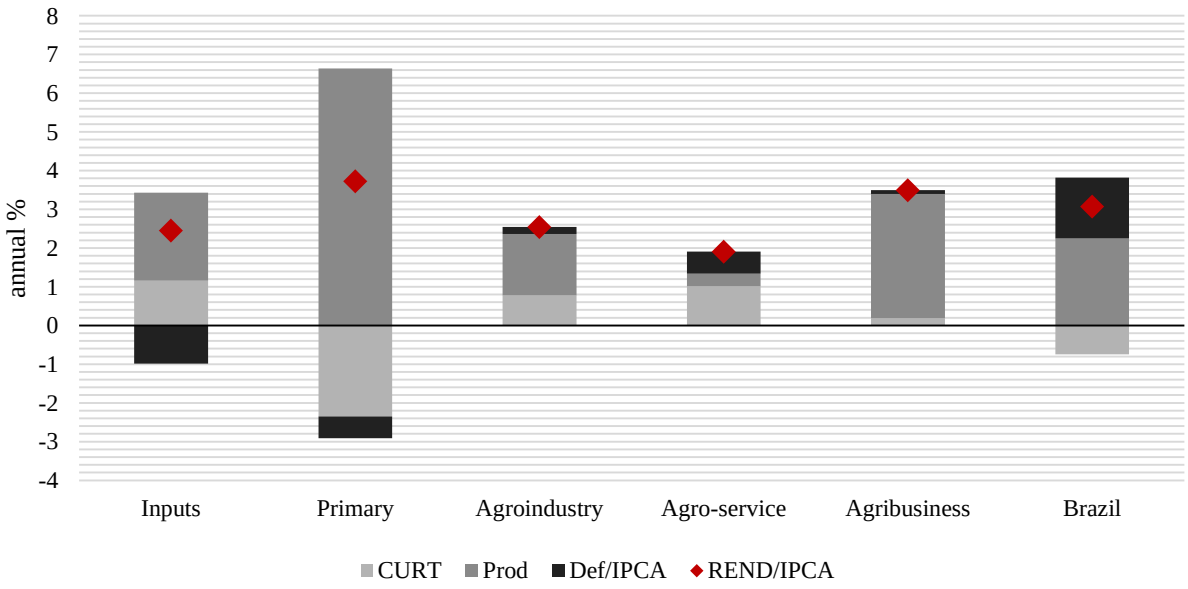

Figure 3.6 - Components of real increase employment-related income in Brazil, agribusiness and its segments - comparison between 2015 and 2004 (in % per year).
Source: author's results based on information from National Accounts - IBGE (2017a), National System of Consumer Price Indexes - IBGE (2017b), Cepea (2017), PNAD-IBGE (2017d) and RAIS-MTE (2017).

Analyzing Brazil between 2002 and 2012, Barros (2016) verified the relevant role of the relationship between the GDP deflator, IPCA, and productivity to allow the real increase in incomes without equivalent pressure on employer costs. If in the period under study the deflator and the IPCA had increased by the same magnitude, the real income increase of 35.4% would have been accompanied by a 10% increase in real unit labor costs (CURT), when in actuality, CURT shrank by 8% over the period (BARROS, 2016).

From Figure 3.6, we can see that the average annual income growth of 3.1% relative to the IPCA in the Brazilian economy was accompanied by an annual CURT reduction of 0.7%. The average annual growth of 2.3% in productivity and 1.6% in the indicator that relates the deflator and the IPCA (or faster deflator growth than IPCA growth) enabled this result. Over the same period, if the deflator and the IPCA had grown by the same magnitude, CURT would have grown 0.8% per year; and, if productivity had not grown, CURT would have grown 1.5% per year.

The agribusiness results are quite different from those for Brazil. First, in general, the relation between deflators and the IPCA did not play a preponderant role in the dynamics. This relationship, in fact, played a negative role in the input and primary segments since IPCA increased at higher rates than the segment's deflator. In fact, there was a fall in relative prices for all agribusiness segments, especially the primary and input segments, when compared to the total economy over the analyzed period. This dynamic can be seen in Figure 3.7.

Barros (2016) found that international commodity prices grew 9.8% annually between 2003 and 2011; however, with the Brazilian currency's strong appreciation relative to the USD, domestic commodity prices grew only 4% a year. With the growth of exports, mainly agribusiness products, sector exporters transferred income to goods and services importers, so that the IPCA grew less than the economy's deflator (BARROS, 2016). A comparison of the economy's deflator and the agricultural deflator shows that relative agricultural product prices fell over the period, even though the sector deflator appreciated over the IPCA.

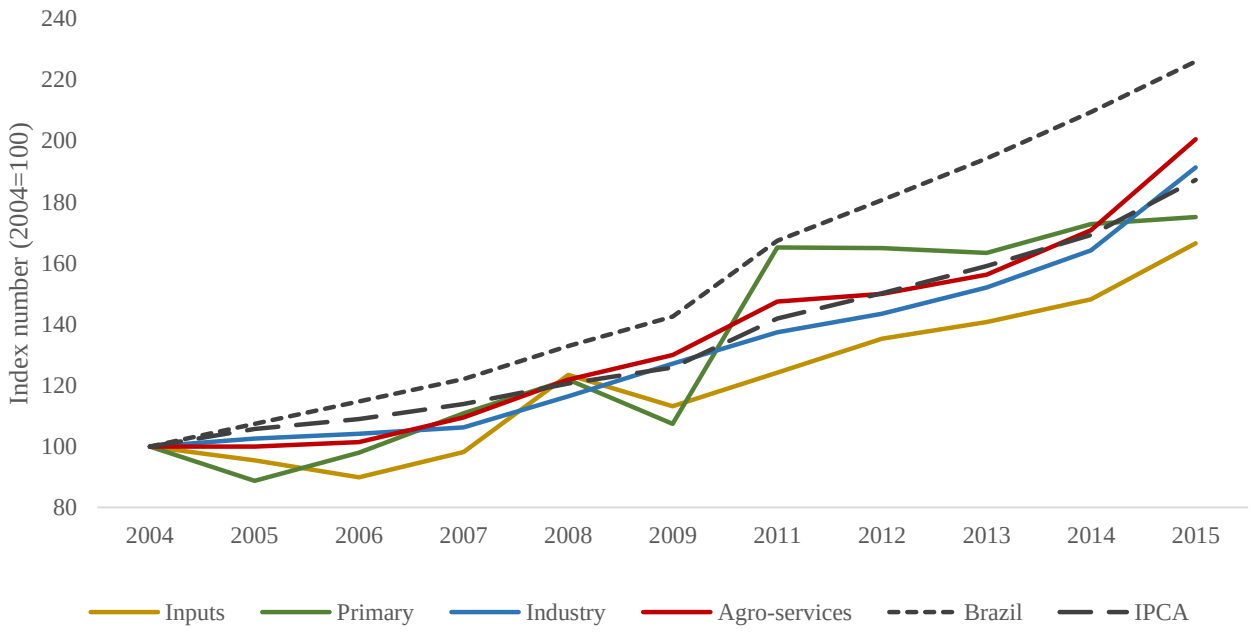

Figure 3.7 - Index numbers of the deflators of the national GDP (Brazil) and agribusiness' segments, and IPCA, between 2004 and 2015.
Source: author's results based on information from National Accounts - IBGE (2017a), National System of Consumer Price Indexes - IBGE (2017b), Cepea (2017), PNAD-IBGE (2017d) and RAIS-MTE (2017).

In the primary segment, the deflator / IPCA ratio's fall of 0.6% annually had relatively little effect on CURT, which was much more significantly reduced by productivity growth of 6.6% a year. Even with a 3.7% annual average real income increase, this productivity growth led to a 2.3% yearly CURT decrease (Figure 3.6). Without the significant productivity growth in this segment, the income increase would have pushed CURT up, annually increasing it by 4.3%. The successive increases in CURT, in turn, could lead to an increase in unemployment in the sector, with the intensification of the technological advance process aimed at the replacement of labor.

According to Greenway, Upward and Wright (2000), the magnitude in which workers are affected when they must move to different sectors depends on how specific their skills are for the declining employment sector. So, the adjustment cost for agricultural workers should be high, either because of the greater difficulty of workers with low levels of human capital endowment relocating to other activities, or because of locational difficulties related to the availability of opportunities in other sectors in the more agricultural areas of Brazil.

In the input segment, productivity gains of 2.3% a year were not sufficient to offset the annual 1% decline in the ratio between the segment's deflator and the IPCA. As a result, the

annual real increase in employment-related income of 2.4% (over the IPCA) was reflected in a CURT increase of 1.2% a year. Without the productivity growth, the increase in income would have led to an annual 3.4% increase in CURT.

In the agroindustry segment, the real annual increase of 2.5% in incomes is not fully reflected in CURT because labor productivity grew by 1.6% a year. However, since the ratio between the deflator and the IPCA for this segment had little effect on the observed dynamics, CURT still grew at 0.8% a year over the period. Analogously to the other segments, without the productivity gains, CURT would have grown 2.4% per year.

Focusing on these agroindustrial segments, it can be said that, according to Pastore, Gazzano and Pinotti (2012), the increase in the unit labor cost affects the processing industry in general leading to a reduction in the use of installed capacity and production relative to its trends. In addition, as the industry is open to international trade, unlike the services sector, it is largely a price taker. In this way, the transfer of the labor cost increase to prices is compromised, leading to margin reduction, discouraging production and probably affecting employment level.

In the agro-services segment, change in productivity had the least influence on the observed change in CURT. The effect of real income gains (1.9% per year), slightly softened by the minimal de-coupling between this segment's deflator and IPCA (+ 0.6% per year), caused an average annual 1% increase in CURT over the study period.

According to Pastore, Gazzano and Pinotti (2012), in response to the 2008 crisis, Brazilian government acted aiming at stimulating aggregate demand. The expansion of the service sector's demand resulting from this stimulus then raised the demand for labor and was responsible for the drop in unemployment and the growth of real wages. As the services sector, as well as agro-services, are generally closed to international trade, the increase in costs resulting from the increase in the unit labor cost can be passed on to prices, with a magnitude depending on the price elasticity of demand (PASTORE; GAZZANO; PINOTTI, 2012). In fact, between 2008 and 2015, while prices of tradable products increased by 55.7%, non-tradable products, especially in the service sector, increased by 80.7% (BANCO CENTRAL DO BRASIL-BCB/ DEPARTAMENTO ECONÔMICO – DEPEC, 2018).

Real average annual income gains of 3.5% in the aggregated agribusiness had little overall impact on CURT, which only increased +0.2% annually over the period, mainly due to sectoral productivity gains of + 3.2%. Without this productivity growth, notably in the

primary and also in the agroindustrial segments, CURT would have increased at an annual rate of 3.4%.

3.5 Conclusions

The agribusiness workforce decreased by 13.3% over the 2004 through 2015 period. This reduction was mainly driven by job losses in the primary segment, but there also was a decline in the agroindustrial workforce, especially after 2008. On the other hand, employment in agro-services segment increased, more intensively after 2008. The average time spent working in the primary segment decreased more than in the other agribusiness segments and in Brazil over the period. In agribusiness sector as a whole, the reduction in average working time was similar to that in the other Brazilian economic sectors.

Over the same period, while employment and working time decreased in the agribusiness sector, average employment-related income increased, mainly driven by real income gains in the primary segment. From 2004 through 2015, employment-related income increased by 56% in the primary segment and by 45% in the Brazilian economy.

Analyzing Brazil from 2002 through 2012, Barros (2016) showed that the increase in labor incomes occurred, in general, without raising unit labor costs (CURT) and, therefore, prejudiced the employment level. This was most possibly due to the gap between the growth of the IPCA and of the GDP deflator. As of 2012, however, this extremely favorable conjunction of factors began to change; and a new period of decoupling between the IPCA and the GDP deflator is unlikely. Future increases in labor remuneration over this factor productivity will most likely impact production costs and thus employment levels and prices.

On the other hand, annual average increases in agribusiness sector incomes (+3.5%) were higher than those in the general economy, but our findings show that agribusiness CURT only rose .02% over the period. The CURT increase that would be expected to coincide with higher labor incomes was almost entirely negated by increased labor productivity (+3.2%), especially in the primary segment, combined with a slightly favorable relationship between the sector's deflator and the IPCA. In this sense, future increases in employment-related income over the IPCA will raise CURT unless the income increases are offset by continued productivity growth.

The agroindustrial agribusiness segment has always faced problems when attempting to increase competitiveness and productivity, making increased labor costs a disincentive to production and employment. Barros and Castro (2017) point out that one of the causes for this

difficulty is that Brazilian exports of higher value-added products to higher income countries is severely restricted by strong protectionist policies and the Brazilian currency's frequent appreciation relative to the USD. In the recent past, even with the reduction of the interest rates as a reaction to the 2008 economic crisis, the rise in wages and the stagnation of labor productivity, with a consequent increase in unit labor costs, led to a fall in capacity utilization by Brazilian industry (PASTORE; GAZZANO; PINOTTI, 2012).

Although the primary agribusiness segment is open to international trade and is a price taker, an increase in unit labor costs would increase the incentive to substitute capital for labor and mechanize since there is greater technological flexibility in this segment than in the agroindustrial segment (REZENDE, 2006). This substitution, in turn, could lead to drop in number of employees in the segment and increase the rural exodus to urban centers. Given the relatively low level of human capital endowment quite specific to agribusiness' primary sector, rural workers have problems entering into other activity sectors, which often increases urban poverty.

In the agro-services segment, like in the general services sector of the economy, productivity traditionally grows quite slowly. Therefore, increases in wages must raise in greater magnitude the unit labor cost.

Since the service sector predominantly produces non-tradable goods, the transmission of potential labor cost increases to prices is facilitated; however, since this sector is very labor intensive, there is both a technological limit to labor substitution and great difficulty transmitting cost increases to prices particularly when the economy is in recession and demand is weak. Additionally, service sector dynamics directly and indirectly affect employment and income generation in the other economic sectors. As the service sector is the major Brazilian employer (PASTORE; GAZZANO; PINOTTI, 2012), and services represent an important direct cost for companies in general, especially those in the manufacturing industry (ARBACHE, 2015), wage increases in this sector should raise salaries and costs in other sectors.

In general, future increases in agribusiness employment-related income above productivity increases should negatively impact the unit cost of labor and the level of employment in the sector. The persistent increase in the Brazilian agriculture segment's productivity should be able to maintain or even improve its already excellent competitive position, but there is a cost from the perspective of the worker, especially the less skilled, as agriculture's modernization continues to favor increased mechanization as a substitute for

labor. For the agribusiness industry and services segments, increasing productivity will be essential if the effect of employee-related income increases is to be mitigated. In this case, as for public policies, it is crucial that Brazil progress efficiently in international negotiations to boost exports of agro-industrial products, that with a not very appreciated currency can be competitive, and maintain programs that successfully lessen the effect of job losses among agriculture's rural workforce.

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