Chapter 45

The pandemic of COVID-19 and the occupation piauiense agricultural labor market

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ABSTRACT
The purpose of this study was to measure the effects of the Covid-19 pandemic on the occupation of labor in the agricultural sector in Piauí in the year 2020. The Probit binary regression model was used to measure the effects of this health crisis on this sector. The results showed the occupation of labor in the agricultural sector of Piauí was not significantly affected by the Covid-19 pandemic in the period analyzed. The marginal effects of the sociodemographic variables indicated that being white, male and residing in rural areas increases the probability of being employed in the agricultural sector. In this sense, it is expected that the evidence obtained in this study can contribute to the expansion of discussions on the subject.

Keywords: Rural occupations, Public health, *probit*, Piauí.

1 INTRODUCTION

The agricultural sector began to develop in the territory of Piaui at the beginning of its colonization. The first activity implemented was cattle raising, which required low investments, little manpower and large tracts of land, with the landholding being the basis of piauiense cattle. Initially, this activity was relatively profitable, but after the period of prosperity, livestock went into decline and, from there, agriculture began to develop, moving from subsistence agriculture to commercial agriculture, focused on exports. The export-based economy is characterized by times of high prices, which result in high temporary profits, and downsum, which generate losses for producers. Periods of high profits in this sector, due to the increase in *commodity prices*, have provided modernization, with changes in the productive structure, but that is recent, in part, of monitoring the improvement ofincome distribution (CEPRO, 2013; LIMA, 2016).

The export agenda, at the beginning of the 20th century, was composed of rubber, carnaúba wax and babassu, with a change in this composition from the 1990s, due to the exponential growth of soybean production in southwest Piauiense and, with this, soybeans gain greater representation in the decomposition of these exports. Grain production, more specifically soybean, was initially cultivated in the municipalities of Uruçuí and Ribeiro Gonçalves,but soon extended to other municipalities, such as: Sebastião Leal, Bom Jesus, Palmeira do Piauí, Currais, Monte Alegre do Piauí, Gilbués and Santa Filomena. The introduction of soybeans in piauiense territory and the installation of agro-industries aimed at processing products for the domestic and foreign markets have caused positive effects on other economic sectors, such as the trade and services sector, since it attracted people and new ventures to the region, generating economic growth (CEPRO, 2013).

The agricultural sector, in general, is associated with climate uncertainties, market fluctuations, changes in agricultural, commercial and regulatory policies and has recently experienced the effects of the public health health crisis caused by the Covid-19 pandemic. Epidemics often cause loss of human lives of all ages, with and without pre-existing diseases, and with this, a large part of the economically active population is affected, because contamination usually occurs through proximity to the infected person(s) and/or agglomerations of people. In this sense, the more the agricultural activity is labor intensive, the greater the risk associated with labor force and productivity losses, and this production factor is one of the main affected in the agricultural area in periods of pandemic (CEPEA, 2020; GONG *et al*., 2020).

Statistics show that the economicallyactive population of Piauí is strongly relatedto agriculture, due to the predominant participation of the rural population in agricultural activities. In 2000, for example, the population working in rural areas corresponded to 45% of the total economically active population, 81% of which corresponded to people who were in agricultural activities (BALSADI; SILVA, U.S.; STOREL JÚNIOR, 2001; SOUSA *et al*., 2006).

In this sense, the general objective of this study was to measure the magnitude of the Covid-19 pandemic affected the probability of individuals being occupied in the agricultural sector of piauiense in 2020.

In addition to this introduction, the following sections present a brief literature review on health and the labor market, the *probit* binary regression method used in this research to achieve the proposed objective, the results and discussions accompanied by the final considerations.

2 HEALTH AND LABOUR MARKET

Workers' health is related to their level of productivity and job supply, thus, diseases generate negative economic effects since they reduce working hours, reduce productivity and generate health care costs and costs associated with absences from work. According to the literature, the health status of workers also affects their decision to participate or not in the workforce (KASSOUF,1997; ARRAES; MARIANO; BARROS, 2008).

The relationship between health, labor supply and productivity was the object of study by authors such as Kassouf (1997), Grossman (1972) and Goryakin and Suhrcke (2017). Grossman (1972) built a health demand model thatincludes health as a measure of human capital, which differs from other forms of human capital, such as education. The author pointed out that this model had not been built until then, being necessary due to the health of workers being a determining factor of the time dedicated to work. Grossman's model assumes that the individual has an initial health stock that has the tendency to depreciate over time, but can rise from investments in health. In addition, the model admits that health is an endogenous variable and depends on the resources allocated in its production.

Health is considered, in grossman's model (1972), being a consumer good and a good investment, since it determines the amount of hours that the individual can dedicate to work. The optimal amount of health is obtained through the intersection between the marginal efficiency curve of health capital and the cost curve, represented by health investment. The model predicts that the demand for health is positively related to age and that, if a higher level of education increases investments in health, a higher level of education requires a higher health stock at the equilibrium point.

Kassouf (1997) used Grossman's model (1972)to smooth the relationship between health, income and the participation of men and women heads of household or spouses in the Brazilian labor market in 1989. The author used the method of estimation of ordinary square minimums (MQO) and estimated the equations of income, labor supply and health, relating health with salary and hours worked per week. Among the variables used by the author in the empirical study are: hours worked, hourly wage, experience, color or race and household situation (urban or rural). The results of the study showed that health has a positive effect on the labor supply of male people who are heads of family, a negative effect in the case of females who are spouses, and showed no significance in the case of female heads of families.

Goryakin and Suhrcke (2017) evaluated the impacts of poor health conditions on the supply of work in Russia using the ordinary least squares (MQO) model and the model with individual fixed effects. The authors used a binary variable that indicated whether the individual was busy or not, *dummy health variables* and sociodemographic exogenous variables that could be related to health and job supply such as: age, schooling, household situation (urban or rural), family size, access to water, etc. The results of the study showed that 80% of people in Russia who were old enough to work and in poor health were not working. In addition, the results indicated that people with fewer years of schooling and residents of the urban area are more likely to stop working due to health problems.

In contexts of health crises, workers' health is compromised by diseases such as Covid-19, which can directly affect the supply of work, since many workers can leave the workforce, influencing the level of occupation.

2.1 COVID-19 AND THE AGRICULTURAL SECTOR

According to Elias, Fronza and Mattei (2020), the agricultural sector shows to have been the least affected by the crisis in 2020, including increasing its share of national added value, which went from a contribution of 5.8% to 8.5%. According to Lucena, Holanda Filho and Bonfim (2020), agricultural activity has been the least affected by the Covid-19 pandemic. This can be attributed to the fact that this activity is essential for human survival. However, even if to a lesser extent, this sector will suffer from the effects of the current economic and sanitary crisis. Some changes may occur in the sphere of production and commercialization and, according to the authors, one of the main segments affected by the pandemic is family farming, which has already been suffering from the effects of the crisis.

In their study, Lucena, Holanda Filho and Bonfim (2020) sought to expose some of these effects on the sheep and goat sector in Brazil. According to the authors, the measures of social distancing imposed by the government restricted the commercialization of animals in fairs and agricultural exhibitions. In addition, this restriction has had negative effects on

sectors that demand this product, such as steakhouses and restaurants, which have also suffered from the reduction of consumption. They highlight the effects of distance measures on some municipalities of Piauí, such as Dom Inocêncio, Paulistana and Bethany do Piauí, which have suffered from marketing restrictions and the reduction of consumption. The authors point out that one of the consequences of these restrictions has been the increase in the stock of sheep and goats for slaughter, increasing supply and, consequently, reducing the prices paid to the producer.

Based on an empirical analysis, based on the input-product methodology, Dweck (2020) sought to analyze the sectoral effects of the pandemic of the new coronavirus from shocks in the component variables of demand. Based on the results,it concludes that the agricultural sector suffered a fall in the level of occupation and the wage mass, which can be attributed to the reduction of household consumption.

According to Barros, Castro and Almeida (2020), the number of people employed in the agricultural sector in Brazil decreased in the first months of 2020, reaching its peak in May, but from July of the same year showed a slight recovery. According to these authors,and ntre June and August, there is usually a seasonal increase in the population occupied in agriculture. In order to analyze the effects of the Covid-19 pandemic on the population occupied in Brazilian agriculture,the authors conducted an empirical study considering the seasonal effects on the population occupied in this sector. Twovariables were given, the number of people employed in the sector and the expected number of people employed, which is the estimated value of the employed population and taking into account seasonality. The effect of the pandemic on the population occupied in agriculture is the result of the difference between the number of people employed and the expected number of people employed. The results of the study conducted by Barros, Castro and Almeida (2020) showed that the difference between the number of people employed and the expected number was small in the period of seasonal increase of the occupied population, between June and August. Thus, the effects of the pandemic on occupation began to dissipate in the analyzed period.

The reduction in consumption in the agricultural sector had a lower participation in the decrease in added value. Exports in this sector, despite having suffered a fall, were not greatly affected by the pandemic when compared to other economic sectors. Moreover, it is assumed that agricultural goods increased participation in the Brazilian export agenda (DWECK, 2020).

According to Schneider *et al.* (2020), there was an increase in exports in the Brazilian foreign market, mainly soybeans and other foods and agribusiness raw materials. The authors highlighted that China is one of the largest importers of Brazilian products and increased imports in 2020, accounting for the consumption of 72.6% of Brazilian soybeans. According to Comex Stat (2021), between January and

February 2021, soybeans accounted for 30% of Piauí's export tariff, being the most exported product by the state.

3 METHODOLOGY

The aim of this study was to analyze how magnitude the Covid-19 pandemic affects the probability of individuals being occupied in the agricultural sector of Piaui in 2020. To achieve this objective, the *Probit* binary regression model *was used,* which uses a binary dependent variable in order to estimate the occupation or not of the labor force in this sector. This variable assumes a value equal to 0 (zero) for unoccupied individuals and a value equal to 1 (one) for busy individuals.

3.1 PROBIT MODEL

According to Davidson and Mackinnon (2004), *the Probit model* can be derived from a latent variable and, depending on the signal it presents, the binary variable assumes the value 1 (one), if the signal is positive, or 0 (zero) if the signal is negative, being expressed as follows:y^*

$$\boldsymbol{y_t = 1, se\ y^* > 0} \quad (1)$$

$$\boldsymbol{y_t = 0, se\ y^* \leq 0} \quad (2)$$

In it: y_t it is the binary variable and is the latent variable.y^*

According to Wooldridge (2010), the model of the latent y^*variable, from which the *Probit model is estimated,* is represented by the following equation:

$$\boldsymbol{y^* = \beta_0 + x\beta + e, y = 1\ [y^* > 0]} \quad (3)$$

In which: and are the parameters estimated by the model; represents the error term; is the latent variable and corresponds to the explanatory variable used. $\beta_0 \beta e y^* x$

From the equation of the latent variable model, it is possible to estimate the *Probit model*, represented by the following equation:

$$\boldsymbol{P\ (y = 1|x) = P\ (y^* > 0|x) = P[e > -(\beta_0 + x\beta)|x] = 1 - G[-(\beta_0 + x\beta)]} \quad (4)$$
$$\boldsymbol{= G(\beta_0 + x\beta)}$$

In that: is the probability of response. is the standard normal cumulative distribution function expressed by:$P\ (y = 1|x) G$

$$G(z) = \Phi(z) = \int_{-\infty}^{z} \Phi(v)\, dv \qquad (5)$$

In which: corresponds to the standard normal density. $\Phi(z)$

According to Coelho, Aguiar and Fernandes (2009), the analysis of *the coefficients of the Probit model* is not adequate to determine the effects of explanatory variables on the dependent variable because the coefficients do not provide the marginal effects of the explanatory variables on probabilities. Thus, it is necessary to calculate the marginal effects of the explanatory variables from the following equation (HILL; GRIFITHS; LIM, 2011):

$$\frac{dP}{dx} = \frac{d\Phi(t)}{dt} \cdot \frac{dt}{dx} = \Phi(\beta_1 + \beta_2 x)\beta_2 \qquad (6)$$

Where: corresponds to the marginal effect of the explanatory variable on probability $\frac{dP}{dx} xP$; β_1 and are the parameters estimated by the model β_2 and $t = \beta_1 + \beta_2 x$ and is the standard normal distribution density function. $\Phi(\beta_1 + \beta_2 x)$

After estimating the *Probit model*,the s *goodness-of-fit* test (Hosmer-Lemeshow) was performed in order to verify the quality of fit of the model, and the Wald test, in order to verify whether the coefficients of the explanatory variables are significant.

3.2 BASE OF DATA AND VARIABLES

The database used in this study was the National Continuous Household Sample Survey (Continuous PNAD) conducted by the Brazilian Institute of Geography and Statistics (IBGE). Microdata of continuous PNAD related to occupation in the agricultural sector of Piauí in the 4th quarter of 2018, 2019 and 2020 were used and related to the sociodemographic characteristics of the population sample, such as gender, color, age, education and household status. The variables used to pet the model are presented in Chart 1:

Table 1 - Description of the variables used in the *Probit model*

Variable	Description
Dependent variable	
Occupation	Binary variable that assumes value 1 if the individual is busy in the agricultural sector and assumes the value 0 when he is not busy or is busy in the other sectors.
Explanatory variables	
Covid-19	Binary variable that assumes the value 1 for the year 2020, which marks the beginning of the pandemic, and assumes the value 0 for the years 2018 and 2019, years before the pandemic.
Gender	Binary variable that assumes the value 1 if the individual is male and 0 if it is female.
Colour	Binary variable that assumes the value 1 if the individual is white and 0 otherwise.
Age	Continuous variable comprising individuals between 14 and 65 years.[1]
Age²	Variable age squared that captures the age effect and the return effects of experience.[2]
Years of study	Continuous variable that represents the schooling of individuals (0 to 16 years or more of study).
Household situation	Binary variable that assumes the value 1 if the individual is resident of the urban area and 0 if he is a resident of the rural area.

Source: self elaboration (2021).

4 RESULTS AND DISCUSSIONS

4.1 RESULTS OF THE ESTIMATION *OF THE* PROBIT MODEL FOR THE AGRICULTURAL SECTOR OF PIAUÍ IN 2020

The data used were adequate to the model, according to the *goodness of fit* test (Hosmer-Lemeshow), *presenting p-value* higher than the significance level of 5%, not rejecting the null hypothesis that the model is adequately adjusted. The Wald test was statistically significant at the level of 5%, rejecting the null hypothesis that the coefficients of the explanatory variables are equal to zero.

The results of *the Probit* model for the agricultural sector presented in Table 1 suggest that this sector may not have been influenced by the Covid-19 pandemic, in terms of occupation, in a significant way, given that the marginal effect and the coefficient of the variable Covid-19 did not present statistical significance. This may be related to the fact that the agricultural sector was one of the least affected by the pandemic due to the essentiality of the sector for human survival according to Lucena, Holanda Filho and Bonfim (2020). According to these authors, family farming is the most affected by the economic and health crisis caused by Covid-19 in Brazil.

In relation to the other variables that refer to the sociodemographic characteristics of individuals employed in the agricultural sector, the marginal effects indicated that if the individual is white, there is an increase in the probability of 0.01 percentage points of being employed in agriculture and, if it is male, there is an increase in the probability of 0.076 percentage points to be busy in this sector. According to Barros *et al.* (2021), the number of women employed in the agricultural sector was significantly reduced as an effect of the Covid-19 pandemic.

[1] 14 years is the minimum age allowed to work, as an apprentice, in Brazil and 65 is the minimum retirement age in Brazil, for this reason they were used as limit ages in the research (BRASIL, 2019; BRASIL, 1988).

[2] According to Gonzaga, Machado and Machado (2003), the variable age squared reflects the amount of hours worked by the individual according to their age group. According to the authors, the amount of hours worked would be a concave function of age, increasing to a certain age and the from this point the trend is to reduce the number of hours dedicated to work. Teixeira and Menezes-Filho (2012), in turn, stated that the variable age squared captures the returns of work experience of individuals.

Table 1 - Estimation of the *Agricultural Probit* model (4th quarter of 2018, 2019 and 2020)

Variables	Agricultural	
	Coefficient	**dy/dx (marginal effect)**
Covid-19	-0.037ns	-0.004ns
Gender	0,759*	0,076*
Colour	0,099***	0,010***
Age	0,060*	0,006*
Age²	-0,001*	0,000*
Years of study	-0,047*	-0,005*
Household situation	-0,977*	-0,098*
Constant	-2,055*	

Source: andown work (2021). Notes: * p<0.01; p< 0.1 and ns indicates no significance.

The marginal effects of the *Probit model* for the agricultural sector indicated that the older the age, the greater the chances of the individual being employed in this sector, with an increase in probability by 0.006 percentage points each year over age. The age effect and the individual's experience returns, represented by age squared, did not show significant influence on the probability of the individual being occupied in the agricultural sector. Regarding schooling, represented by years of study, them arginal effect of this variable showed a negative sign, indicating that each year more than study decreases the probability by 0.005 percentage points of the individual being occupied in agriculture. The marginal effect of the variable household situation indicates that living in the urban environment decreases the probability by 0.098 percentage points of the individual being occupied in the agricultural sector.

According to CEPRO (2020a), the agricultural sector of Piauí performed well in the second quarter of 2020, showing an estimated 8.31% growth in agricultural production compared to the previous year. CEPRO (2020a) points out that the restriction measures did not have a significant impact on the agricultural sector, which showed growth of 3.4% of the harvested area due to increased demand in this sector. Among the products that presented prominence in the period is soybean, the main product of the state's trade balance, whose percentage was equal to 50.21% of the total grain production of the state and showed growth of 2.94% of production. Piauí's grain production has a higher participation of agribusiness, responsible for 91.68% of production, while family farming accounts for 8.32% of production.

According to Barros *et al*. (2021), the category of workers without a signed license was the most affected by the Covid-19 pandemic in the agricultural sector in Brazil, since they are jobs most vulnerable to economic crises. In Piauí, the informality rate was 56.8% of the population occupied in 2020 according to Vargas *et al*. (2021). In terms of formal work, the agricultural sector of Piauí ended 2020 with a positive balance of 370 formal jobs, according to Caged (2021), indicating that this sector did not suffer much influence from the pandemic in terms of occupation of the category of workers with a signed portfolio.

5 FINAL CONSIDERATIONS

The present study aimed to measure the effects of the Covid-19 pandemic on the level of occupation in the agricultural sector of Piauí in 2020. According to the literature, health crises, such as the Covid-19 pandemic, are accompanied by economic crises that affect the occupation and performance of economic sectors, since they have impacts on the sphere of production and consumption. Health is linked to the labor market, since the health status of workers is directly related to their productivity and the supply of work.

Based on the marginal effects obtained from the *Probit model*, it was possible to verify that the occupation of labor inthe agricultural sector of Piaui was not significantly affected by the Covid-19 pandemic in the analyzed period. The marginal effect of sociodemographicvariables indicated the predominance of adult people from middle age or older, employed in this sector and, the higher the level of education, the lower the chance of the individual being employed in agricultural activities in Piauí.

On the other hand, the theme is broad, and one cannot lose sight of the limitation of the study regarding the category of formal workers living in rural areas, who may be more vulnerable, especially in times of health crisis; considering that these individuals were not contemplated in this study, but deserve attention and support from the public authorities, through social policies, of qualification for reintegration into the labor market.

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