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The relationship between poverty and the agricultural sector in Mexico

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ABSTRACT

Objective: To determine how the planted area, the harvested area, and the value of agricultural production affect poverty, moderate poverty, extreme poverty, and the lack of access to nutritious and quality food in Mexico.

Hypothesis: The planted area, the harvested area, and the value of agricultural production affect poverty, moderate poverty, extreme poverty, and the lack of access to nutritious and quality food in Mexico.

Methodology: Eight data panels were conducted (four with fixed effects and four with variable effects) comparing planted area, harvested area, and the value of agricultural production with poverty, moderate poverty, extreme poverty, and the lack of access to nutritious and quality food in Mexico. Natural logarithms of the variables were used.

Results: In general, the natural logarithms of planted area, the natural logarithms of harvested area, and the natural logarithms of the value of agricultural production had an impact on the natural logarithms of poverty, the natural logarithms of moderate poverty, and the natural logarithms of extreme poverty. The only exception was the natural logarithms of the lack of access to nutritious and quality food.

Limitations on study/implications: The government should work on transmission mechanisms so that the planted area, the harvested area, and the value of agricultural production could help reduce poverty in Mexico. One limitation is that the states were not characterized.

Conclusions: Agricultural production in Mexico (measured through planted area, harvested area, and the value of production) affects the types of poverty in Mexico.

Keywords: poverty, agricultural sector production, food shortages, supply and demand, economic laws.

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INTRODUCTION

The agricultural sector of a country can be a pole for economic growth and development, since, among other things, it has an impact on poverty. This is why in Mexico, agricultural production has been promoted through different government programs, such as the Program for Direct Support to the Farmland (*Programa de Apoyos Directos al Campo*, PROCAMPO), which would later become PROAGRO. These programs have several objectives, among them: to increase or maintain agricultural production with the aim of

satisfying the domestic demand and lowering product prices for consumers; and to impact the poverty levels of the rural population (Morales and Mideros, 2021; Roitbarg, 2021; Intriago, 2018; Pérez and Villafuerte, 2018; Martínez, 2008).

Regarding the impact of agricultural production on poverty, it can happen mainly by two paths. The first is that, according to economic laws, an increase in production, while keeping the demand constant, would cause a shift in the supply that would lower the price of the agricultural product. This would increase the purchasing power of people and positively impact poverty levels. Likewise, if there is a decrease in production in the agricultural sector, and the demand is kept constant, prices of products from the agricultural sector would increase, causing a loss in the purchasing power of consumers and increasing poverty levels. The second path is wealth generation in the rural population, which tends to be greater than in urban regions. This not only applies to Mexico but is also repeated in several countries of Latin America (Roitbarg, 2021; Pindyck and Rubinfeld, 2009; Bula, 2021; Adelaida, 2018; Ibáñez, 2016; Cardona *et al.*, 2007; Villafuerte, 2014; Escobal and Ponce, 2000).

Regarding the first path, studies point out that in Mexico economic laws do not apply to the agricultural sector. More precisely, they indicate that prices do not react to variations in production in the agricultural sector. This means that production in the agricultural sector does not have an impact on the purchasing power of consumers and does not affect the poverty levels in Mexico (Cruz *et al.*, 2023; Guzmán *et al.*, 2012).

About this point, Reyes *et al.* (2022), De la Rosa (2021), and Tanconi (2015) indicate that, in Mexico, prices do not react immediately to variations in production because of the sector's characteristics. They also add that, in Mexico, imports are the ones that have an impact on the price of agricultural products.

Regarding the second path, it has been suggested that in an open and dysregulated economy, agricultural producers would increase their wealth by increasing their production when prices are high. This is because their profit margin would increase (Fernández, 2008; Guzmán *et al.*, 2012; De Grammont, 2010; Acosta, 2005).

Based on this, poverty in the agricultural sector would decrease when the profit margin increases. However, in Mexico, this is not always the case, due to the conditions of producers. In this regard, in Mexico there are two types of producers: those who have infrastructure, technology, and economic resources; and those who do not have access to these resources. The latter might not benefit from high prices, and therefore, no effect would be seen on wealth levels (Benítez, 2022; García, 2020; Tonconi, 2015; Brambila *et al.*, 2014; OCDE-FAO, 2011).

The wealth of producers in rural zones takes on importance because rural poverty is higher compared to urban zones. This has been shown by the National Institute of Statistics and Geography (*Instituto Nacional de Estadística y Geografía*, INEGI), which has found that, in Mexico, since the first trimester of 2005, the percentage of people who are in working poverty in the rural sector is higher than in the urban sector; likewise, from January 2010 to August 2025, the lines for poverty and extreme poverty in monetary value are lower in rural zones compared to urban zones (INEGI, 2025 a b).

It is worth mentioning that a person who is a situation of poverty in Mexico is defined as someone who has at least some social scarcity and has an income that allows them to purchase at the least the products from the basic food basket (CONEVAL, 2019).

Regarding social scarcities, they are measured by indicators, which are six: educational lagging, access to health services, access to social security, quality and space of housing, basic services in the household, and lastly, access to food. When a person does not have access to one of these six indicators, they will be determined to be in a situation of poverty. In turn, with minimum wages, there is not a specific amount, just the condition that they can purchase products from the basic food basket (CONEVAL, 2019, 2025 a).

Likewise, in Mexico, there are several types of *poverty*, such as: poverty, which is when the person has at least one social scarcity and has an income that allows purchasing at the least the products from the basic food basket; *moderate poverty*, which refers to an individual who has worse conditions than a poor person but without reaching extreme poverty, and is calculated by subtracting the population in extreme poverty from the population in poverty; *extreme poverty*, which is when an individual has three or more social scarcities, in addition to their income being under the poverty line and their income being so low that they cannot purchase foods that satisfy their nutritional needs; *poverty from lack of access to nutritious and quality food*, which is the level of food security and is when people have limitations in being able to purchase quality and nutritious foods (CONEVAL, 2019, 2025 a).

Therefore, if agricultural production in Mexico impacts poverty, whether from its effect on prices of by generating wealth in rural zones, as indicated by authors such as Rivera *et al.* (2021), Berdegué and Escobar (2001), De la Rosa (2021), Roitbarg (2021), Bula (2021), and Villafuerte (2014), this would affect the types of poverty: poverty, moderate poverty, extreme poverty, and lack of access to nutritious and quality food. However, if authors like Cruz *et al.* (2025), De la Rosa (2021), López *et al.* (2020), and Vargas *et al.* (2016), are correct in that agricultural production does not affect the prices of agricultural products, then agricultural production would have no effect on the types of poverty mentioned before.

This is because, even if producers were to increase their prices, it would not impact the people's purchasing power, since product prices from the agricultural sector react to other factors and not to agricultural production itself (Cruz *et al.*, 2025; Cruz *et al.*, 2023; López *et al.*, 2020; Guzmán *et al.*, 2012).

Therefore, and based on what has been exposed, the research objective is to determine if the planted area, the harvested area, and the value of agricultural production affect poverty, moderate poverty, extreme poverty, and lack of access to nutritious and quality food in Mexico. Furthermore, the hypothesis set out is that the planted area, the harvested area, and the value of agricultural production affect poverty, moderate poverty, extreme poverty, and the lack of access to nutritious and quality food in Mexico.

MATERIALS AND METHODS

The methodology presented has the purpose of reaching the research objective and proving the hypothesis, for which databases on poverty will be used that were extracted from the National Institute of Statistics and Geography (INEGI, 2025 c), and they include: poverty, moderate poverty and extreme poverty. In turn, data for the lack of access to nutritious and quality food was obtained from the website of the National Council for the Evaluation of Social Development Policy (*Consejo Nacional de Evaluación de la Política de Desarrollo Social*, CONEVAL, 2025 b). These databases are biennial, they come in thousands of people, and correspond to the years 2018, 2020, 2022 and 2024. However, data for the lack of access to nutritious and quality food only has temporality of 2018, 2020 and 2022.

In this study, the following were used to measure agricultural production and to evaluate its impact on poverty: planted area, harvested area, and value of agricultural production. These databases on agricultural production were obtained from the webpage of the Service for Agrifood and Fishery Information (*Servicio de Información Agroalimentaria y Pesquera*, SIAP, 2025). Specifically, from the statistical yearbook of agricultural production from SIAP (2025).

The databases of planted area and harvested area are presented in hectares, while the value of agricultural production is presented in thousands of pesos. Furthermore, the three databases are annual, so to maintain consistency, the same years were used as the databases for poverty, moderate poverty and extreme poverty, which are years 2018, 2020, 2022 and 2024. In turn, for data of the lack of access to nutritious and quality food, the three databases are used in temporality of 2018, 2020 and 2022.

Agricultural production is presented in thousands of pesos, so the database was deflated using the National Consumer Prices Index (*Índice Nacional de Precios al Consumidor*, INPC), which was extracted from the National Institute of Statistics and Geography (INEGI, 2025 d). This was done with the aim of having the information on agricultural production in real terms.

It must be added that, extra data was projected in order to strengthen the analysis for poverty, moderate poverty, extreme poverty, and planted area, harvested area, and value of agricultural production; in this case, it would be the year 2026, by performing a regression where the variable is time. In turn, for the case of the lack of access to nutritious and quality food, it was only projected for year 2024.

In this way, the databases for poverty and agricultural production of the 32 states in Mexico were obtained, and their natural logarithms were estimated (including the projected data). Due to the conditions of the database, the decision was made to use panel data analysis (160 panel-type data for the case of poverty and 132 data for the lack of access to nutritious and quality food).

The theoretical base of the relationship between variables was presented in the theoretical framework. It indicates that agricultural production affects the prices of agricultural products, which impacts the purchasing power of consumers of products from the agricultural sector. The latter would affect the levels of poverty mentioned before, which are the ones that will be analyzed in the study (Benítez, 2022; Roitbarg, 2021; García, 2020; Tonconi, 2015; Brambila *et al.*, 2014; OCDE-FAO, 2011; Pindyck and Rubinfeld, 2009; Fernández, 2008).

In addition, when prices in the agricultural sector increase and production in the agricultural sector reacts, by increasing production, poverty in the rural sector will decrease, affecting poverty, moderate poverty, extreme poverty, and the lack of access to nutritious and quality food in Mexico (Benítez, 2022; Roitbarg, 2021; García, 2020; Tonconi, 2015; Brambila *et al.*, 2014; OCDE-FAO, 2011; Pindyck and Rubinfeld, 2009; Fernández, 2008).

Panel data models

Using panel data models with fixed effects and variable effects, it will be determined whether the planted area, the harvested area, and the value of agricultural production affect poverty, moderate poverty, extreme poverty and the lack of access to nutritious and quality food. In this regard, four panel data models with fixed effects and four with variable effects will be conducted (see Table 1).

To estimate the panel data models with fixed and variable effects, the Eviews software will be used, and the methodology proposed by Gujarati and Porter (2010), and Woolgridge (2009). Therefore, according to the authors, unit root tests must first be performed in order to establish that the variables in the panel data models do not have unit roots. In this regard, the Levin, Lin and Chu tests will be used, which will be applied to the six variables of the panel data models with fixed and variable effects that will be estimated (see Table 1). The values from the results of using the Levin, Lin and Chu tests will be examined. Thus, if the values of the Levin, Lin and Chu tests are lower than 0.05, it means that the variables do not have unit roots and, if they are higher, the variables have unit roots.

Once it has been determined that the variables of planted area, harvested area, poverty, moderate poverty, extreme poverty, and lack of access to nutritious and quality food, do not have unit roots, the next step is to estimate the panel data models presented in Table 1, which will have the shape of Equations 1, 2, 3, 4, 5, 6, 7, and 8.

$$Y = \beta_1 + \beta_2 X_{1it} + \beta_3 X_{2it} + \beta_4 X_{3it} + \nu_{it} + u_{it} \quad (1)$$

Where, in Equation 1: Y is the natural logarithm of poverty in a State; β_1 is the intercept value; β_2 is the vector of parameter X_{1it}; X_{1it} is the natural logarithm of the planted area

Table 1. Panel data models.

Model	Dependent variable	Independent variables	Effects
PT-SS-SC-VP-F	Natural logarithm of poverty	Natural logarithm of the sown area Natural logarithm of the harvested area Natural logarithm of the value of agricultural production	Fixed
PT-SS-SC- VP-V	Natural logarithm of poverty		Random
PM-SS-SC- VP-F	Natural logarithm of moderate poverty		Fixed
PM-SS-SC- VP-V	Natural logarithm of moderate poverty		Random
PE-SS-SC- VP-F	Natural logarithm of extreme poverty		Fixed
PE-SS-SC- VP-V	Natural logarithm of extreme poverty		Random
CPA-SS-SC- VP-F	Natural logarithm of the lack of access to nutritious and quality food		Fixed
CPA-SS-SC- VP-V	Natural logarithm of the lack of access to nutritious and quality food		Random

in State i at time t; β_3 is the vector of parameter X_{2it}; X_{2it} is the natural logarithm of the harvested area of State i at time t; β_4 is the vector of parameter X_{3it}; X_{3it} is the natural logarithm of the value of agricultural production; ν_{it} is the fixed value for State i at time t; and, u_{it} is the model's error through time.

$$Y = \beta_1 + \beta_2 X_{1it} + \beta_3 X_{2it} + \beta_4 X_{3it} + \nu_{it} + u_{it} \tag{2}$$

Where, in Equation 2: Y is the natural logarithm of poverty in a State; β_1 is the intercept value; β_2 is the vector of parameter X_{1it}; X_{1it} is the natural logarithm of the planted area in State i at time t; β_3 is the vector of parameter X_{2it}; X_{2it} is the natural logarithm of the planted area of State i at time t; β_4 is the vector of parameter X_{3it}; X_{3it} is the natural logarithm of the value of agricultural production; ν_{it} is the random value for State i at time t; and, u_{it} is the model's error through time.

$$Y = \beta_1 + \beta_2 X_{1it} + \beta_3 X_{2it} + \beta_4 X_{3it} + \nu_{it} + u_{it} \tag{3}$$

Where, in Equation 3: Y is the natural logarithm of moderate poverty in a State; β_1 is the intercept value; β_2 is the vector of parameter X_{1it}; X_{1it} is the natural logarithm of the planted area in State i at time t; β_3 is the vector of parameter X_{2it}; X_{2it} is the natural logarithm of the planted area of State i at time t; β_4 is the vector of parameter X_{3it}; X_{3it} is the natural logarithm of the value of agricultural production; ν_{it} is the fixed value for State i at time t; and, u_{it} is the model's error through time.

$$Y = \beta_1 + \beta_2 X_{1it} + \beta_3 X_{2it} + \beta_4 X_{3it} + \nu_{it} + u_{it} \tag{4}$$

Where, in Equation 4: Y is the natural logarithm of moderate poverty of a State; β_1 is the intercept value; β_2 is the vector of parameter X_{1it}; X_{1it} is the natural logarithm of the planted area in State i at time t; β_3 is the vector of parameter X_{2it}; X_{2it} is the natural logarithm of the planted area of State i at time t; β_4 is the vector of parameter X_{3it}; X_{3it} is the natural logarithm of the value of agricultural production; ν_{it} is the random value for State i at time t; and, u_{it} is the model's error through time.

$$Y = \beta_1 + \beta_2 X_{1it} + \beta_3 X_{2it} + \beta_4 X_{3it} + \nu_{it} + u_{it} \tag{5}$$

Where, in Equation 5: Y is the natural logarithm of extreme poverty of a State; β_1 is the intercept value; β_2 is the vector of parameter X_{1it}; X_{1it} is the natural logarithm of the planted area in State i at time t; β_3 is the vector of parameter X_{2it}; X_{2it} is the natural logarithm of the planted area of State i at time t; β_4 is the vector of parameter X_{3it}; X_{3it} is the natural logarithm of the value of agricultural production; ν_{it} is the fixed value for State i at time t; and, u_{it} is the model's error through time.

$$Y = \beta_1 + \beta_2 X_{1it} + \beta_3 X_{2it} + \beta_4 X_{3it} + \nu_{it} + u_{it} \tag{6}$$

Where, in Equation 6: Y is the natural logarithm of extreme poverty of a State; β_1 is the intercept value; β_2 is the vector of parameter X_{1it}; X_{1it} is the natural logarithm of the planted area in State i at time t; β_3 is the vector of parameter X_{2it}; X_{2it} is the natural logarithm of the planted area of State i at time t; β_4 is the vector of parameter X_{3it}; X_{3it} is the natural logarithm of the value of agricultural production; ν_{it} is the random value for State i at time t; and, u_{it} is the model's error through time.

$$Y = \beta_1 + \beta_2 X_{1it} + \beta_3 X_{2it} + \beta_4 X_{3it} + \nu_{it} + u_{it} \tag{7}$$

Where, in Equation 7: Y is the natural logarithm of the lack of access to nutritious and quality food of a State; β_1 is the intercept value; β_2 is the vector of parameter X_{1it}; X_{1it} is the natural logarithm of the planted area in State i at time t; β_3 is the vector of parameter X_{2it}; X_{2it} is the natural logarithm of the planted area of State i at time t; β_4 is the vector of parameter X_{3it}; X_{3it} is the natural logarithm of the value of agricultural production; ν_{it} is the fixed value for State i at time t; and, u_{it} is the model's error through time.

$$Y = \beta_1 + \beta_2 X_{1it} + \beta_3 X_{2it} + \beta_4 X_{3it} + \nu_{it} + u_{it} \tag{8}$$

Where, in Equation 8: Y is the natural logarithm of the lack of access to nutritious and quality food of a State; β_1 is the intercept value; β_2 is the vector of parameter X_{1it}; X_{1it} is the natural logarithm of the planted area in State i at time t; β_3 is the vector of parameter X_{2it}; X_{2it} is the natural logarithm of the planted area of State i at time t; β_4 is the vector of parameter X_{3it}; X_{3it} is the natural logarithm of the value of agricultural production; ν_{it} is the random value for State i at time t; and, u_{it} is the model's error through time.

It is worth mentioning that the panel data models of Equations 1, 3, 5 and 7 are for fixed effects; and the panel data models of Equations 2, 4, 6 and 8 are for random effects (both presented in Table 1). Fixed-effects and variable-effects panel data models differ in the treatment that the ν_{it} value receives, which can be random or fixed. In this regard, in Equations 1, 3, 5 and 7, the treatment is fixed; while in Equations 2, 4, 6 and 8, the treatment is random.

Once Equations 1, 2, 3, 4, 5, 6, 7 and 8 are estimated, the next step is to examine the results, with the objective of validating the models and establishing whether the independent variables affect the dependent variables. As part of the analysis, the Durbin-Watson values of the panel data models will first be examined. If they are higher than the critical values (with their respective K and n values), then, it is established that the models do not have first-order positive serial correlation problems.

Next, the R^2 values are examined, where it is considered that only those panel data models with values above 0.80 are valid. Additionally, the p value of the F value will be checked, which, if less than 0.05, will determine that the model is valid. Thus, in the case that the model complies with the validation conditions, the p values will be analyzed, of the following variables: natural logarithm of the planted area (X_{1it}), natural logarithm of the harvested area (X_{2it}), and natural logarithm of the value of agricultural production (X_{3it}).

In this same order of ideas, when the p values of the variables natural logarithm of the planted area (X_{1it}), natural logarithm of the harvested area (X_{2it}), and natural logarithm of the value of agricultural production (X_{3it}), are lower than 0.05, it will be considered that they have individual significance in the explanation of the dependent variable; that is, they have a statistically significant impact on the explanation of the dependent variable (Y) of the model; and if the p values are higher, then the independent variables do not have statistical significance, so they do not have a statistically significant impact on the explanation of the dependent variable.

Therefore, in Equations 1, 2, 3, 4, 5, 6, 7 and 8, when the values of the variables natural logarithm of the planted area (X_{1it}), natural logarithm of the harvested area (X_{2it}), and natural logarithm of the value of agricultural production (X_{3it}), are lower than 0.05, it is considered that they have individual significance in the explanation of the dependent variable. In Equations 1 and 2, it is the natural logarithm of total poverty; while in Equations 3 and 4, it is moderate poverty; in Equations 5 and 6, it is extreme poverty; and, in Equations 7 and 8, it is the lack of access to nutritious and quality food.

Next, to strengthen the analysis, in the case when the fixed-effects and variable-effects panel data models are valid (R^2, the p value of F value and the Durbin-Watson statistics), the Hausman test will be applied, following the procedure described by Gujarati and Porter (2010) and using the Eviews software. This is done with the aim of defining which model is preferable to analyze the relationship between variables, when the p value of the statistics of the test is lower than 0.05; meanwhile, the variable-effects panel data model is better when the value is higher than 0.05. With the objective of further strengthening the results, the redundant fixed effects test will be used, which will determine whether the fixed effect is redundant in the panel data models with fixed effects.

RESULTS AND DISCUSSION

Table 2 presents result from the Levin, Lin and Chu tests of the variables examined, which are: natural logarithms of the planted area; natural logarithms of the harvested area; natural logarithms of the value of agricultural production; natural logarithms of poverty; natural logarithms of moderate poverty; natural logarithms of extreme poverty; and natural logarithms of the lack of access to nutritious and quality food.

Table 2. Levin, Lin and Chu tests.

Variable	Values	It has a unit root
Natural logarithm of the sown area	0	No
Natural logarithm of the harvested area	0	No
Natural logarithm of the value of agricultural production	0	No
Natural logarithms of the number of people living in poverty (thousands of people)	0	No
Natural logarithms of the number of people living in moderate poverty (thousands of people)	0	No
Natural logarithms of the number of people living in extreme poverty (thousands of people)	0.007	No
Natural logarithms of the number of people lacking access to nutritious and quality food	0	No

Table 2 shows that all the *p* values of the Levin, Lin and Chu tests are lower than 0.05. Therefore, the variables do not have unit roots and can be used to calculate the panel data models with fixed and variable effects of the natural logarithms of poverty, moderate poverty, extreme poverty, and lack of access to nutritious and quality food with the natural logarithms of the planted area, the harvested area, and the value of agricultural production.

Thus, Table 3 presents the panel data models of the natural logarithms of poverty with the natural logarithms of the planted area, the natural logarithms of the harvested area, and the natural logarithms of the value of agricultural production.

Table 3 shows that the Durbin-Watson value is higher than the critical value in the two panel data models, which is why there is no evidence of first-order positive serial correlation. Furthermore, it shows that the model that has validity is the one of fixed effects, because it has an R^2 of 0.986 (while the panel data model has an R^2 of 0.311). In addition, the *p* value of the *F* value in both models is zero, which is lower than 0.05.

Thus, the fixed-effects panel data model was analyzed, which is valid. Therefore, the *p* values of the variables natural logarithms of the planted area, natural logarithms of

Table 3. Panel data models with fixed and variable effects of poverty with natural logarithms of the planted area, natural logarithms of the harvested area, and natural logarithms of the value of agricultural production.

Variable	Data panel template with fixed effects	Panel data model with random effects
Natural logarithm of the harvested area	−0.419	−0.767
Natural logarithm of the sown area	0.664	1.727
Natural logarithm of the value of agricultural production	0.361	−0.222
Beta value of the constant.	−1.880	−1.665
Standard error of the natural logarithm of the harvested area.	0.180	0.292
Standard error of the natural logarithm of the sown area.	0.208	0.302
Standard error of the natural logarithm of the production value.	0.128	0.148
Standard error of the constant.	2.031	2.169
t-statistic of the natural logarithm of the harvested area.	−2.328	−2.628
t-statistic of the natural logarithm of the sown area.	3.200	5.715
t-statistic of the natural logarithm of the production value.	2.825	−1.498
t-statistic of the constant.	−0.926	−0.767
* p-value of the natural logarithm of the harvested area.	0.022	0.009
* p-value of the natural logarithm of the sown area.	0.002	0.000
* p-value of the natural logarithm of the production value.	0.006	0.136
p-value of the constant.	0.356	0.444
R^2	0.986	0.311
F-value	217.242	23.492
p-value of the F-value	0.000	0.000
Durbin-Watson	1.856	1.793
Durbin-Watson (n=150 and k=3)	1.774	1.774

The *p* values under 0.05 of the fixed-effects models are signaled with a *.

the harvested area, and natural logarithms of the value of agricultural production, are lower than 0.05, indicating that they have individual significance. This means that these variables have a statistically significant impact on the natural logarithms of poverty.

In turn, in the variable-effects panel data model, the *p* value of the variables natural logarithms of the planted area and natural logarithms of the harvested area, are lower than 0.05; while the *p* value of the variable natural logarithms of the value of agricultural production is higher than 0.05.

Now, Table 4 presents the panel data models of the natural logarithms of moderate poverty with the natural logarithms of the planted area, the natural logarithms of the harvested area, and the natural logarithms of the value of agricultural production.

Table 4 shows that the Durbin-Watson value is higher than the critical value in the two panel data models, so there is no evidence of first-order positive serial correlation. Likewise, it shows that the model which has validity is the fixed-effects model, because it has an R^2 of 0.984 (while the panel data model with random effects has an R^2 of 0.312). In addition, the *p* value of the *F* value in both models is zero, which is lower than 0.05.

Table 4. Panel data models with fixed and variable effects of moderate poverty with natural logarithms of the planted area, natural logarithms of the harvested area, and natural logarithms of the value of agricultural production.

Variable	Data panel template with fixed effects	Panel data model with random effects
Natural logarithm of the harvested area	−0.280	−0.603
Natural logarithm of the sown area	0.560	1.584
Natural logarithm of the value of agricultural production	0.346	−0.244
Beta value of the constant.	−2.231	−1.738
Standard error of the natural logarithm of the harvested area.	0.179	0.291
Standard error of the natural logarithm of the sown area.	0.206	0.301
Standard error of the natural logarithm of the production value.	0.127	0.146
Standard error of the constant.	2.017	2.137
t-statistic of the natural logarithm of the harvested area.	−1.569	−2.074
t-statistic of the natural logarithm of the sown area.	2.717	5.268
t-statistic of the natural logarithm of the production value.	2.724	−1.668
t-statistic of the constant.	−1.106	−0.813
p-value of the natural logarithm of the harvested area	0.119	0.040
* p-value of the natural logarithm of the sown area.	0.008	0.000
* p-value of the natural logarithm of the production value.	0.007	0.097
p-value of the constant.	0.271	0.417
R^2	0.984	0.312
F-value	198.375	23.573
p-value of the F-value	0.000	0.000
Durbin-Watson	1.842	1.776
Durbin-Watson (n=150 y k=3)	1.774	1.774

The values under 0.05 of the fixed-effects models are signaled with a *.

Thus, the fixed-effects panel data model was analyzed, which is valid. So, the *p* values of the variables natural logarithms of the planted area and natural logarithms of value of agricultural production, are lower than 0.05, indicating that they have individual significance. This means that these variables have a statistically significant impact on the natural logarithms of moderate poverty. In turn, the variable natural logarithm of the harvested area is higher than 0.05, which indicates that it does not have individual significance.

On the other hand, in the variable-effects panel data model, the *p* value of the variables natural logarithms of the planted area and natural logarithms of the harvested area, are lower than 0.05; while the *p* value of the variable natural logarithm of the value of agricultural production is higher than 0.05.

Now, Table 5 presents the panel data models of the natural logarithms of extreme poverty with the natural logarithms of the planted area, the natural logarithms of the harvested area, and the natural logarithms of the value of agricultural production.

Table 5. Panel data models with fixed and variable effects of extreme poverty with natural logarithms of the planted area, natural logarithms of the harvested area, and natural logarithms of the value of agricultural production.

Variable	Data panel template with fixed effects	Panel data model with random effects
Natural logarithm of the harvested area	−1.209	−1.690
Natural logarithm of the sown area	1.249	2.432
Natural logarithm of the value of agricultural production	0.557	−0.156
Beta value of the constant.	−4.481	−2.078
Standard error of the natural logarithm of the harvested area.	0.346	0.437
Standard error of the natural logarithm of the sown area.	0.399	0.446
Standard error of the natural logarithm of the production value.	0.246	0.197
Standard error of the constant.	3.909	2.608
t-statistic of the natural logarithm of the harvested area.	−3.490	−3.866
t-statistic of the natural logarithm of the sown area.	3.127	5.457
t-statistic of the natural logarithm of the production value.	2.264	−0.790
t-statistic of the constant.	−1.146	−0.797
* p-value of the natural logarithm of the harvested area.	0.001	0.000
* p-value of the natural logarithm of the sown area.	0.002	0.000
* p-value of the natural logarithm of the production value.	0.025	0.431
p-value of the constant.	0.254	0.427
R^2	0.972	0.205
F-value	109.757	13.384
p-value of the F-value	0.000	0.000
Durbin-Watson	2.244	1.842
Durbin-Watson (n=150 and k=3)	1.774	1.774

The values under 0.05 from the fixed-effects models are signaled with a *.

Table 5 shows that the Durbin-Watson value is higher than the critical value in the two panel data models, so there is no evidence of first-order positive serial correlation. Likewise, it shows that the model which has validity is the fixed-effects model, because it has an R^2 of 0.972 (while the panel data model has an R^2 of 0.205). In addition, the *p* value of the *F* value in both models is zero, which is lower than 0.05.

Therefore, the fixed-effects panel data model was analyzed, which is valid. So, the *p* values of the variables natural logarithms of the planted area, natural logarithms of the harvested area, and natural logarithms of the value of agricultural production, are lower than 0.05, indicating that they have individual significance. This means that these variables have a statistically significant impact on the natural logarithms of extreme poverty.

In turn, in the random-effects panel data model, the *p* value of the variables natural logarithms of the planted area and natural logarithms of the harvested area, are lower than 0.05; meanwhile, the *p* value of the variable natural logarithms of the value of agricultural production is higher than 0.05.

Now, Table 6 presents the panel data models of the variables natural logarithms of the lack of access to nutritious and quality food, with natural logarithms of the planted area, natural logarithms of the harvested area, and natural logarithms of the value of agricultural production.

Table 6 shows that the Durbin-Watson value is higher than the critical value in the two panel data models, which is why there is no evidence of first-order positive serial correlation. Likewise, it shows that the model that has validity is the fixed-effects model, because it has an R^2 of 0.91 (while the panel data model has an R^2 of 0.063). In addition, the *p* value of the *F* value in both models is zero, which is lower than 0.05.

Therefore, the fixed-effects panel data model was analyzed, which is valid. Thus, the *p* value of the variables natural logarithms of the planted area and natural logarithms of the value of agricultural production, are higher than 0.05, indicating that the variables do not have individual significance. This means that these variables do not have a statistically significant impact on the natural logarithms of the lack of access to nutritious and quality food. It should be added that the *p* value of the natural logarithms of the value of agricultural production is 0.073, and that if the alpha value were to increase to 0.08, it would have individual significance.

In turn, in the panel data model with random effects, the *p* values of the variables natural logarithms of the planted area, natural logarithms of the harvested area, and natural logarithms of the value of agricultural production, are higher than 0.05, indicating that the variables do not have individual significance.

Next, because the fixed-effects panel data models are the ones that present a more robust validity, the decision was made to use the redundant fixed effects test in every case. This was done with the aim of making those models more robust. Thus, Table 7 presents the redundant fixed effects tests of the natural logarithm models of poverty, moderate poverty, extreme poverty, and lack of access to nutritious and quality food.

Table 7 shows the results of the redundant fixed effects tests of the four panel data models, where it can be seen that the *p* values of the crossed section, period, and crossed/period, are lower than 0.05 in every case. This indicates that the fixed effect is not redundant.

Table 6. Panel data models with fixed and variable effects of the lack of access to nutritious and quality food with natural logarithms of the planted area, natural logarithms of the harvested area, and natural logarithms of the value of agricultural production.

Variable	Data panel template with fixed effects	Panel data model with random effects
Natural logarithm of the harvested area	−0.717	−0.519
Natural logarithm of the sown area	0.469	0.672
Natural logarithm of the value of agricultural production	0.568	0.139
Beta value of the constant.	0.589	2.297
Standard error of the natural logarithm of the harvested area.	0.457	0.441
Standard error of the natural logarithm of the sown area.	0.572	0.456
Standard error of the natural logarithm of the production value.	0.313	0.159
Standard error of the constant.	5.345	1.700
t-statistic of the natural logarithm of the harvested area.	−1.570	−1.176
t-statistic of the natural logarithm of the sown area.	0.819	1.475
t-statistic of the natural logarithm of the production value.	1.814	0.874
t-statistic of the constant.	0.110	1.351
p-value of the natural logarithm of the harvested area.	0.120	0.242
p-value of the natural logarithm of the sown area.	0.415	0.143
p-value of the natural logarithm of the production value.	0.073	0.384
p-value of the constant.	0.913	0.179
R^2	0.910	0.063
F-value	24.642	2.772
p-value of the F-value	0.000	2.772
Durbin-Watson	1.886	1.781
Durbin-Watson (n=100 and k=3)	1.736	1.736

The values under 0.05 from the fixed effects models are signaled with a *.

Table 7. Redundant fixed effects tests.

Data panel section	Natural logarithms of the number of people living in poverty (thousands of people)		Natural logarithms of the number of people living in moderate poverty (thousands of people)		Natural logarithms of the number of people living in extreme poverty (thousands of people)		Natural logarithms of the number of people lacking access to nutritious and quality food	
	Statistical	P-value	Statistical	P-value	Statistical	P-value	Statistical	P-value
Cross-section F	169.133	0	159.647	0	76.202	0	23.010	0
Cross-section Chi-square	606.671	0	597.651	0	483.446	0	280.182	0
Period F	65.380	0	64.825	0	27.457	0	2.958	0
Period Chi-square	184.159	0	183.227	0	103.341	0	12.037	0
Cross-Section/Period F	159.607	0	151.766	0	70.757	0	21.254	0
Cross-Section/Period Chi-square	616.592	0	608.707	0	490.643	0	281.659	0

This means that it should be considered in every model, which supports the fact that the relationship between variables should be analyzed through the panel data models with fixed effects.

DISCUSSION

The results from the four panel data models with fixed effects (which were validated), indicate that, in general, the natural logarithms of the planted area, the natural logarithms of the harvested area, and the natural logarithms of the value of agricultural production had an impact on the natural logarithms of poverty, the natural logarithms of moderate poverty (except for the natural logarithms of harvested area), and the natural logarithms of extreme poverty. Similar evidence was found in the panel data models with random effects.

Meanwhile, no statistical evidence was found in the panel data models with fixed effects of an impact of natural logarithms of the planted area, natural logarithms of the harvested area, and natural logarithms of the value of agricultural production on the natural logarithms of lack of access to nutritious and quality food. Similar evidence was found in the panel data models with random effects.

This is statistical evidence that the agricultural production, in general, impacts poverty levels in Mexico (with the exception of the lack of access to nutritious and quality food). Regarding this, it has been indicated that agricultural production can affect poverty levels through two paths, which are: its impact on the price of products, because according to the laws of economics, when the supply increases (keeping the demand constant), that is, by increasing production, the prices would decrease. This would impact the purchasing power of consumers, and the generation of wealth in the rural population, which tends to be higher than in urban regions (Rivera *et al.*, 2021; De Grammont, 2010, Ibáñez, 2016; Berdegué and Escobar, 2001; Reyes *et al.*, 2022; De la Rosa, 2021; Adelaida, 2018; Roitbarg, 2021; Bula, 2021; Villafuerte, 2014).

For the first path to work, agricultural production must influence the prices of agricultural products; this would then impact on the purchasing power of people. This would imply, for example, that an increase in prices could make people move towards a situation of poverty (Roitbarg, 2021; Pindyck and Rubinfeld, 2009; Cardona *et al.*, 2007; Tonconi, 2015; Fernández, 2008; García, 2020; Benítez, 2022; OCDE-FAO, 2011; Brambila *et al.*, 2014).

Regarding the second path of transmission of agricultural production on poverty, for the production to impact the levels of poverty in rural zones, it is necessary for these to take advantage of the variations in the prices of products. Therefore, agricultural producers would seek to increase their wealth by increasing their production when the prices are high. This way, when the prices increase and the production from the agricultural sector reacts, poverty of the rural sector would decrease, affecting the levels of poverty (Tonconi, 2015; Fernández, 2008; García, 2020; Benítez, 2022; OCDE-FAO, 2011; Brambila *et al.*, 2014).

In this regard, the results indicate that these two transmission mechanisms are present in Mexico. In general, evidence was found that the natural logarithms of the planted area, the natural logarithms of the harvested area, and the natural logarithms of the value of agricultural production, impacted the natural logarithms of poverty, moderate poverty, and extreme poverty (the exception was the lack of access to nutritious and quality food).

These results do not support what has been described by some authors such as Rivera *et al.* (2021), López *et al.* (2020), De la Rosa (2021), Cruz *et al.* (2025), Cruz *et al.* (2023), Vargas *et al.* (2016), De Grammont (2010), Guzmán *et al.* (2012), and Acosta (2005). These authors indicate that economic laws do not apply to the agricultural sector, so prices do not react to variations in the production of the agricultural sector. This would mean that production of the agricultural sector would not impact on the purchasing power of people and, therefore, would not affect poverty levels.

Furthermore, the results also do not support the conclusions from authors such as De Grammont (2010), Guzmán *et al.* (2012), and Acosta (2005), who point out that not all producers are capable of taking advantage of variations in prices, and, therefore, can also not increase their wealth. According to the authors, this is because of the characteristics of the sector, such as types of producers, since in Mexico it has been found that there are two types of producers in the agricultural sector: those who have infrastructure, technology and economic resources; and those who do not have access to novel technology or economic resources.

CONCLUSIONS

The objective was to determine that the planted area, the harvested area, and the value of agricultural production affect poverty, moderate poverty, extreme poverty, and the lack of access to nutritious and quality food in Mexico. The hypothesis was that the planted area, the harvested area, and the value of agricultural production affect poverty, moderate poverty, extreme poverty, and the lack of access to nutritious and quality food. The results indicate that the planted area, the harvested area, and the value of agricultural production affect poverty, moderate poverty and extreme poverty. The conclusion is that the objective was reached and the hypothesis is accepted. A limitation was that the study did not characterize each state.

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