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Estimating the Economic Impact on the Supply of the Agricultural Sector due to Covid-19 in Ecuador

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Abstract
This research aims to estimate the economic impact that occurred on the supply of the agricultural sector due to COVID-19, which emerged at the end of 2019, becoming the strongest social and economic impact since the Second World War, and which, due to its accelerated level of expansion, in Ecuador a confinement phase was decreed in March 2020, taking the curfew as a priority measure, however, agri-food chains maintained their activities since their products are of great importance. To achieve the

objective, a quantitative scope methodology was applied, developing a Linear Regression model with polynomial trends, which related the relevant variables within the agricultural sector to determine the economic impact that occurred on the supply of the agricultural sector caused by confinement. of Covid-19, considering the period between January 2018 until April 2021. These variables are: Gross Agricultural Value Added and the price indices of Inputs, Fertilizers, Agrochemicals, Consumer and Producer. The findings of this analysis show that the COVID-19 lockdown did not directly affect the overall production of the agricultural sector, but rather certain factors. In turn, benefits were generated for the farmer, since the prices of inputs and agrochemical products decreased considerably, reducing production costs. It is concluded that Covid-19 caused changes in five of the six variables evaluated, that is, that confinement affected the most important price factors in the agricultural sector, but not total production.

Keywords: agricultural sector, production costs, economic impact, linear regression model, Covid-19.

1. Introduction

Throughout the economic and social history of Ecuador, the agricultural sector plays a key role in the national economy, since currently, 95% of internal demand is covered by the agricultural sector and in turn generates employment for 25% of the Economically Active Population (EAP). According to the Technical Bulletin published by the Instituto Nacional de Estadísticas y Censos (INEC, 2020), it is determined that the agricultural sector is one of the most important producers of foreign currency whose trade balance is favorable, contributing considerably to the Gross Domestic Product (GDP) and it is considered the backbone of the Ecuadorian economy. Likewise, it contributes an important aspect within the concept of food security based on approximately one fifth of the country's production of goods and services.

At the end of 2019, an unexpected event emerged worldwide: the COVID-19 virus (BBC, 2020). The initial ignorance of the magnitude of the situation caused the excessive spread of COVID-19, resulting in countless human losses and affecting all economic sectors (Escobar-Quiñonez et al, 2023). In mid-February 2020, the first case occurred in Ecuador and due to its accelerated level of expansion, on March 16, 2020, the government authorities decreed the phase of total confinement in the national territory, an event that generated uncertainty and discontent among all citizens since it caused direct effects in all areas of daily life.

However, the agricultural sector, being of great importance for feeding the population, did not stop its operations and continued with its normal production. Furthermore, with the significant drop in the price of oil, it was confirmed that advanced inputs such as fertilizers and machinery lowered their prices, mainly favoring the agricultural sector over the contributions of traditional inputs such as labor and land. Therefore, it is important to identify the sensitivity in the performance that the agricultural sector (agricultural producers) maintained in the face of price shocks originating at the time of the Covid-19 pandemic, using a quantitative strategy through the application of the econometric model. According to the authors Coluccia, Agnusdeib, Miglietta & De Leo (2020), they present that the pandemic caused by Covid-19 has generated a certain state of panic throughout the world. However, this cannot be an impediment to stopping economic activities that provide well-being to society, the main reason why the food sector kept its activities operational throughout the agricultural value chain to provide its food products to Ecuadorian families. In the study carried out by the aforementioned authors, it can be determined that the incidence rate of epidemics negatively affects the production process and the productivity of factors such as inputs, transportation, producers, but increases the input factors, that is, land, machinery and fertilizers to compensate for losses and somehow generate positive direct effects.

The food production sector faced one of the most significant risks due to the inevitable shortage of inputs and labor, which augured a global food crisis (Queiroz et al., 2022; Singh et al., 2020). In particular, food production is considered vital in agribusiness-based economies since numerous small and medium-sized enterprises (SMEs) depend on this sector (Granillo-Macías, 2021). Therefore, the purpose of the study is that, through the use of an econometric model, the performance obtained during this time by the agricultural sector can be identified, as well as the sector variables that influence the prices and costs of the products. In this way, know if the economic impact left by the pandemic was positive or negative for the agricultural sector.

To know the economic impact that the agricultural sector had during the time of confinement due to the Covid-19 virus, variables such as the Producer Price Index (IPP) and the Consumer Price Index (IPC) of the sector were analyzed agriculture and the Agrochemical Input Price Index (IPI), through real agricultural prices or the purchasing power of trend agricultural production. These variables indicate changes in profitability and extraction to productivity, as well as the Gross Agricultural Value Added (VAB), and in the case of inputs, the price is measured by two indicators: Agrochemical Price Index (IPA) and Production Fertilizer Prices Index (IPF). This made it possible to identify the importance of shocks within the agricultural sector, before and during the pandemic, and to develop an appropriate econometric model that fits the analysis of this research.

The paper is organized as follows: Section 2 presents the literature review associated with the study. In addition, Section 3 provides an overview of the methodology developed. Furthermore, Section 4 presents the results of the implementation and analyses the identified limitations. Finally, Sections 5 and 6 describe the conclusions and references.

2. Literature review

Despite the COVID-19 pandemic, which affects both supply and demand simultaneously, agricultural production contributes to the economy in general (Abilda et al., 2024). The agricultural sector is one of the most important components of the economy not only of Ecuador, but of many countries worldwide, since in addition to providing food and other goods necessary for people's lives, it is also a great generator of jobs and income. According to Beckman and Countryman (2021), given various macroeconomic impacts, GDP would have a severe drop. Likewise, various shocks will occur that will affect the sector, not only at the level of supply and demand (Prakash and Gilbert, 2011), but also negative externalities such as climate changes, excess of different agricultural products, impacts on financial markets, among others.

As for the aspect of supply, the crisis caused temporary production halts, supply chain disruptions, and labor shortages due to movement restrictions (Priyadarshini & Abhilash, 2021). En el contexto de la demanda, hubo una disminución en el consumo y el poder adquisitivo de la población (Rahman & Velayutham, 2020). The authors Cho et al. (2020), state in their study that unemployment was strongly visualized in urban areas in relation to rural areas, one of the main reasons why this area did not suffer serious effects, from there the production of the agricultural cycle begins, highlighting that the market focused on the agricultural/livestock sector remained stable in relation to other markets such as leisure, tourism/hospitality, whose activities predominate in the urban areas of a country.

In this sense, authors such as Zhang et al. (2020), state that Covid-19 strongly affected all sectors of the economy due to the interruption of various activities and strategic plans. The pandemic spread on a large scale and as one of the results, the world food system shows specific effects in less developed areas that are highly dependent on imports, which is why, faced with this face of global collapse, several exporting countries prohibited free circulation of certain agricultural products. The authors Coluccia, Agnusdeib, Miglietta & De Leo (2020), present a compilation of macroeconomic data from the agri-food industry with an overview of the producer, evaluating the level of resilience of the sector in the face of the Coronavirus pandemic, through the study of prices. of raw materials and focusing on both supply and value chains. In turn, it was presented that the healthiest products, whose production was carried out during the first wave of the Covid -19 pandemic, resisted the effects on the price level due to the stages of production vulnerability, transportation and logistics. In the process, the authors also use time series statistical methods to capture trends and then make comparisons of variables during the limitations of the first wave of Covid-19 and the 2019 period, presenting potential differences in view of the effects of the pandemic.

On the other hand, the authors Zhang et al. (2020) specify that to obtain the characteristics that define the impact of the pandemic on agricultural production, the dynamic approach panel model, Durbin spatial model and the growth accounting model are used. For the dynamic panel model, the variables are presented in logarithm and with lags, and in the case of the Durbin model, the effect of the pandemic on GDP, the epidemic variables and the provincial control variables in period t are investigated. using special implementation weighting of the matrix through cross-dependence. In addition, the production function model and growth accounting model work with a transcendental logarithmic model (translog) to obtain the mechanism of analysis of the epidemic in agricultural production through the indices of inputs, fertilizers and/or factors, which allows studying the transmission mechanism, both direct and indirect effects, or better yet, studying the positive or negative effects on supply. Finally, the authors propose that, to mitigate the negative impact on food rationing caused by Covid -19, certain policies must be applied that complement the establishment of a more prosperous society. The volatility of the oil price that has existed in recent periods translates into the price of food. This volatility corresponds to both transportation costs and the prices of fertilizers such as biofuels, the excessive use of agricultural products and raw materials, since production is carried out with this biofuel.

The author Morton (2020), raises the existence of potential impacts on agriculture and agricultural trade within the development of the country, in which more or less economically susceptible and socio-dependent people achieve greater vulnerability in peasant households, in prices and in the operation of the value chain, due to confinement measures due to Covid -19. In some ways, in countries like Ethiopia, trade has been disrupted by truck travel bans, reduced inputs imported from China, and labor shortages. In India, farmers were affected by the lack of buyers and restrictions on imports and transportation in general. For this reason, a model was presented that includes a direct effect of Covid-19, both in government and private sector decisions, short and long-term consumption options, and then, analyze the need to apply government actions, and thus, obtain greater opening in the global food supply chain.

3. Methodology

Source of information and data

The source of data and information to carry out this research was taken from the web portal of the Agricultural Public Information System (SIPA, for its acronym in Spanish), whose administration depends on the Ministerio de Agricultura y Ganadería (MAGAP). In this portal, all the statistical information, real and pertinent, was found to know the current state of the different issues concerning the agricultural sector, among others, within Ecuador.

It is important to highlight that the use of the website was very useful, since it is easy to access for the community and makes relevant data immediately available that enriched the study in question. In this way, the databases obtained have the correct and updated figures that emerged during the period in question.

Variables description

The variables considered for the study of the economic impact on the agricultural sector in the face of confinement due to Covid-19 are the following:

Table 1. Description of the variables under study

Indicator	Indicator representation	Description
Trend	trend	Linear degree trend variable (measured for each control variable)
Trend^2	trend2	Quadratic degree trend variable (measured for each control variable)
Trend^3	trend3	Cubic degree trend variable (measured for each control variable)
Gross Agricultural Value Added	VAB	Control variable that measures gross agricultural value added
Producer Price Index	IPP	Control variable measures the producer price index
Input Price Index	IPI	Control variable that measures the input price index
Agrochemical Price Index	IPA	Control variable that measures the price index of agrochemicals
Fertilizer Price Index	IPF	Control variable that measures the fertilizer price index
Consumer's Price Index	IPC	Control variable that measures the consumer price index
Dummy variable	dummy	Dichotomous variable that takes a value of 0, for the period from 2018 to February 2020 (period without confinement). And that takes a value of 1, for the period from March 2020 onwards (period with confinement)
Dummy Variable x vab	dum*vab	Variable that multiplies the dummy with the control variable "vab" to measure if there is an impact on the variable under study
Dummy Variable x ipp	dum*ipp	Variable that multiplies the dummy with the control variable "ipp" to measure if there is an impact on the variable under study
Dummy Variable x ipi	dum*ipi	Variable that multiplies the dummy with the control variable "ipi" to measure if there is an impact on the variable under study
Dummy Variable x ipa	dum*ipa	Variable that multiplies the dummy with the control variable "ipa" to measure if there is an impact on the variable under study
Dummy Variable x ipf	dum*ipf	Variable that multiplies the dummy with the control variable "ipf" to measure if there is an impact on the variable under study
Dummy Variable x ipc	dum*ipc	Variable that multiplies the dummy with the control variable "ipc" to measure if there is an impact on the variable under study

With these variables, the econometric regression model of linear development with polynomial trend (linear, quadratic and cubic) was executed. In it, each variable took dependent or independent roles, since the study was carried out to measure the impact of Covid-19 on each of the chosen variables. The analysis was based on the application of three models: Model one (basic model in which we work with trends and the dummy variable), Model two (augmented model in which we work with the basic model and the inclusion of all control variables) and Model three (full model in which we work with the augmented model and the inclusion of the multiplication of dummy variables by the control variables).

Operationalization of variables

The definitions used in the development of the study are the following:
The Gross Agricultural Value Added in an expanded manner is estimated by adding the Gross Agricultural Value Added and the value added related to agribusiness. Regarding the prices of agricultural products, it is recognized that cocoa, coffee and banana crops benefit the development of the agricultural economic sector with 17.5%, on the other hand, the conservation of meat is 13.1%, and finally, forestry activity represented 7.10%, these products generated favorable growth throughout 2019 and early 2020, in addition to climatic factors, such as the coastal climate was not favorable, causing losses in the agricultural sector in what was 2020.

For its part, the price of agricultural inputs is measured through two indicators: The Agrochemical Price Index (IPA), which measures agricultural productivity, with which growth was recorded in 2019, determining that cocoa yields , rice and dry hard corn, and makes the IPA obtain an undiminished trend. In addition, the Agricultural Input Price Index (IPI) is considered a national indicator that represents the measurement of the monthly variation over time in the prices of the 12 agrochemical inputs, which are sold in different retail stores, as long as they are duly authorized. by the authorities of each locality.

For its part, the Fertilizer Price Index (IPF) determines that fertilizers are measured by the price effect in the territory to obtain these indices and then analyze the behavior of the three fertilizers, highlighting urea as the most important. Urea is the fertilizer with the greatest demand in national and global agricultural production because its main benefit is the formation of foliage and the accelerated growth of crops. If rational use of this fertilizer is not made, it can cause pollution and leaching that lead to eutrophication, that is, it would increase nitrogen levels that destabilize aquatic ecosystems (Renteria et al., 2019, p. 16).

The Producer Price Index (IPP) are indicators established to determine prices and then obtain their variation, both for goods and services produced in the country for domestic consumption in the different productive sectors: agriculture, livestock, forestry and fishing. . In addition, the National Consumer Producer Price Index (IPP-CN) measures the evolution of the price of the good produced in the domestic market and especially in the marketing chain. This variable is obtained through interviews with representatives of manufacturing companies and agricultural producers located in the Agricultural Surface and Production Survey database.

Finally, the Consumer Price Index for Agricultural Products (IPC), which measures the variation in prices in the current period together with the reference period of the basket of goods and services purchased by households, also meets the measurement and inflation control. also maintaining the policy and registration of social benefits, credits in the tax systems. The descriptive statistics that reflected the selected variables are summarized in the following table:

Table 2. Data variables descriptive

Variables	Mean	Standard Deviation	Minimum	Maximum
VAB	705218,1	42541,81	599665,3	818891
IPP	91,2995	3,37483	83,82	99,244
IPI	102,2147	5,0356	92,69	110,72
IPA	13,08289	0,3424	12,406	13,643
IPF	66,2179	2,19076	62,311	69,44
IPC	105,832	1,26482	104,3	110,88

Method

The model incorporates linear, quadratic and cubic trends, and thus captures the different temporal effects that explain the behavior of the variables of interest, which is why it is considered polynomial. Firstly, for each of the variables, the time trend series was studied, in which the behavior or smooth movement in the long term was analyzed and which was selected according to the parsimony criterion. On the other hand, through the Portmanteau test or autocorrelation analysis, it is possible to model the dynamic dependence in the time series, where the length and strength of the memory of a stochastic process is measured (Wooldridge, 2010).

To verify and understand stationarity, an analysis of the variation of the series was carried out, which is not a function of time, being useful for making predictions, since it implies that the characteristics of the statistical series are the same over time. , both in the past and in the future. Therefore, the augmented unit root analysis of the Dickey-Fuller test (ADF) was carried out, in which the number of lags of the total natural logarithm of the observations (40) was studied, resulting in a lag very close to 4, and in the case that they are not stationary, the characteristics of the variable are found in the time series in which it shares a common stochastic trend.

Furthermore, in the presence of structural breaks, unit root tests are biased toward that root. In Table 3, the p value is presented for each of the variables of interest, where it is specified that *, **, *** refers to the confidence level of 90%, 95%, 99%, respectively, specifying in each column if it is at level, level with trend, gap or gap with trend.

Table 3. Data variables descriptive

Variable	Level	Level and Trend	Differentiated	Differentiated and Trend
VAB	0.1625	0.3363	0.0023***	0.0167
IPP	0.3661	0.7933	0.1431	0.2967
IPI	0.9396	0.6101	0.0255**	0.1162
IPA	0.7485	0.4897	0.0673*	0.3245
IPF	0.3499	0.7177	0.1248	0.4200
IPC	0.0700*	0.2195	0.0015***	0.0105**

$$\begin{aligned} &variable \text{ under } study \\ &\quad = \alpha + \beta_1 trend + \beta_2\, trend^2 + \beta_3\, trend^3 + \delta_1 dummy + \delta_2 dummy \\ &\quad * trend + \delta_3\, dummy * trend^2 + \delta_4 dummy * trend^3 + e \end{aligned}$$

"variable under study" represents each of the control variables (VAB, IPP, IPI, IPA, IPF, IPC).

The dummy variable for Y_1 is replaced when the confinement period existed (1) otherwise (0) to obtain the (Ŷ) average.

$$\begin{aligned} &E(Y|X, dummy = 1) \\ &\quad = \alpha + \beta_1\, E(trend) + \beta_2\, E(trend^2) + \beta_3\, E(trend^3) + \delta_1(1) + \delta_2(1) \\ &\quad * E(trend) + \delta_3\, (1) * E(trend^2) + \delta_4(1) * E(trend^3) + e \end{aligned}$$

$$\begin{aligned} &E(Y|X, dummy = 0) \\ &\quad = \alpha + \beta_1\, E(trend) + \beta_2\, E(trend^2) + \beta_3\, E(trend^3) + \delta_1(0) + \delta_2(0) \\ &\quad * E(trend) + \delta_3\, (0) * E(trend^2) + \delta_4(0) * E(trend^3) + e \end{aligned}$$

To obtain the value of the impact, the difference in the expected value of the series with and without the effect of the Covid-19 confinement must be calculated and then obtain the magnitudes that are presented in the Results section.

$$Impact = E(Y|X, D = 1) - E(Y|X, D = 0)$$

$$Impact = \delta_1 + \delta_2 E(trend) + \delta_3 E(trend^2) + \delta_4 E(trend^3)$$

The test to verify the existence of a structural break attributed to the measures derived from the pandemic is called the Chow Test and is a joint hypothesis test that evaluates the following null hypothesis:

$$Ho\!: \delta_1 = \delta_2 = \ \delta_3 = \delta_4 = 0$$

This test follows an F distribution with (q, n-k-1) degrees of freedom, where q is the number of restrictions that are tested, n is the number of observations and k is the number of regressions of the estimated model. The null hypothesis is rejected when the p-value to the right of the test value is less than 0.05.

"Model two" maintains the regression of the previous model where the dummy variable is added to evaluate the effect of the Coronavirus confinement and the control variables to collect effects not considered by the polynomial trend variables and thus reduce the probability of a potential omitted variable bias. Below is the regression that represents the study of the model in question.

$$\begin{aligned} &variable\ under\ study \\ &\quad = \alpha + \gamma_1 \text{VAB} + \gamma_2 IPP + \gamma_3\, IPI + \gamma_4\, API + \gamma_5\, IPF + \gamma_5 CPI + \beta_1 trend \\ &\quad + \beta_2\, trend^2 + \beta_3\, trend^3 + \delta_1 dummy + \delta_2 dum * trend \\ &\quad + \delta_3\, dum * trend^2 + \delta_4 dum * trend^3 + e \end{aligned}$$

"variable under study" represents each of the control variables (VAB, IPP, IPI, IPA, IPF, IPC).

$$E(Y|X, dummy = 1) = \alpha + \gamma_1 VAB + \gamma_2 IPP + \gamma_3 IPI + \gamma_4 IPA + \gamma_5 IPF + \gamma_5 IPC + \beta_1 E(trend) + \beta_2 E(trend^2) + \beta_3 E(trend^3) + \delta_1(1) + \delta_2(1) * E(trend) + \delta_3 (1) * E(trend^2) + \delta_4(1) * E(trend^3) + e$$

$$E(Y|X, dummy = 0) = \alpha + \gamma_1 VAB + \gamma_2 IPP + \gamma_3 IPI + \gamma_4 IPA + \gamma_5 IPF + \gamma_5 IPC + \beta_1 E(trend) + \beta_2 E(trend^2) + \beta_3 E(trend^3) + \delta_1(0) + \delta_2(0) * E(trend) + \delta_3 (0) * E(trend^2) + \delta_4(0) * E(trend^3) + \hat{\beta}^T X + e$$

To find the value of the impact or magnitude, it is necessary to calculate the difference in the expected value of the series with and without the effect of the Covid-19 confinement. The Chow test for structural breakage is constructed analogously to what was proposed in "model one".

$$Impact = E(Y|X, D = 1) - E(Y|X, D = 0)$$

$$Impact = \delta_1 + \delta_2 E(trend) + \delta_3 E(trend^2) + \delta_4 E(trend^3)$$

Finally, "model three" presents the same functional form as "model two", and additionally includes the multiplication of the dummy variable by all the control variables introduced in the "previous model"; with the purpose of testing the possible structural break through all the explanatory variables of the model. Below is the regression that represents the study of the model in question.

$$variable\ under\ study = \alpha + \gamma_1 VAB + \gamma_2 IPP + \gamma_3 IPI + \gamma_4 IPA + \gamma_5 IPF + \gamma_5 IPC + \beta_1 trend + \beta_2\, trend^2 + \beta_3\, trend^3 + \delta_1 dummy + \delta_2 dum * trend + \delta_3\, dum * trend^2 + \delta_4 dum * trend^3 + \varphi_1\, dum * IPC + \varphi_2\, dum * IPP + \varphi_3\, dum * IPI + \varphi_4\, dum * IPA + \varphi_5\, dum * IPF + e$$

"variable under study" represents each of the control variables (VAB, IPP, IPI, IPA, IPF, IPC).

$$E(Y|X, dummy = 1) = \alpha + \gamma_1 VAB + \gamma_2 IPP + \gamma_3 IPI + \gamma_4 IPA + \gamma_5 IPF + \gamma_5 IPC + \beta_1 E(trend) + \beta_2 E(trend^2) + \beta_3 E(trend^3) + \delta_1(1) + \delta_2(1) * E(trend) + \delta_3 (1) * E(trend^2) + \delta_4(1) * E(trend^3) + \varphi_1 (1) * \overline{IPC} + \varphi_2 (1) * \overline{IPP} + \varphi_3 (1) * \overline{IPI} + \varphi_4 (1) * \overline{IPA} + \varphi_5 (1) * \overline{IPF} + e$$

$$E(Y|X, dummy = 0) = \alpha + \gamma_1 VAB + \gamma_2 IPP + \gamma_3\, IPI + \gamma_4\, API + \gamma_5\, IPF + \gamma_5 IPC + \beta_1 E(trend) + \beta_2\, E(trend^2) + \beta_3\, E(trend^3) + \delta_1(0) + \delta_2(0) * E(trend) + \delta_3\,(0) * E(trend^2) + \delta_4(0) * E(trend^3) + \varphi_1\,(0) * \overline{IPC} + \varphi_2\,(0) * \overline{IPP} + \varphi_3\,(0) * \overline{IPI} + \varphi_4\,(0) * \overline{IPA} + \varphi_5\,(0) * \overline{IPF} + e$$

To obtain the impact value, it is necessary to calculate the difference in the expected value of the series with and without the effect of the Covid-19 confinement.

$$Impact = E(Y|X, D = 1) - E(Y|X, D = 0)$$

$$Impact = \delta_1 + \delta_2 * E(trend) + \delta_3 * E(trend^2) + \delta_4 * E(trend^3) + \varphi_1 * \overline{IPC} + \varphi_2 * \overline{IPP} + \varphi_3 * \overline{IPI} + \varphi_4 * \overline{IPA} + \varphi_5 * \overline{IPF}$$

The Chow structural break test for this model is proposed as follows:

$$Ho: \delta_1 = \delta_2 = \delta_3 = \delta_4 = \varphi_1 = \varphi_2 = \varphi_3 = \varphi_4 = \varphi_5 = \varphi_6 = 0$$

Subsequently, after making the estimates of the models and understanding the significance for each of the variables of interest, we proceeded to calculate the difference in the expected value of the estimated variable before and after the effect of the confinement by Covid -19 in Ecuador and thus obtaining the magnitude of the sequelae caused by the pandemic on each significant variable of interest in the models previously evaluated.

4. Results and analysis

As the first section in the "Results" section, the graphs obtained for each variable from the data collected from SIPA are presented, where the variable evolution in the period studied (January 2018 – April 2021) will be noted:

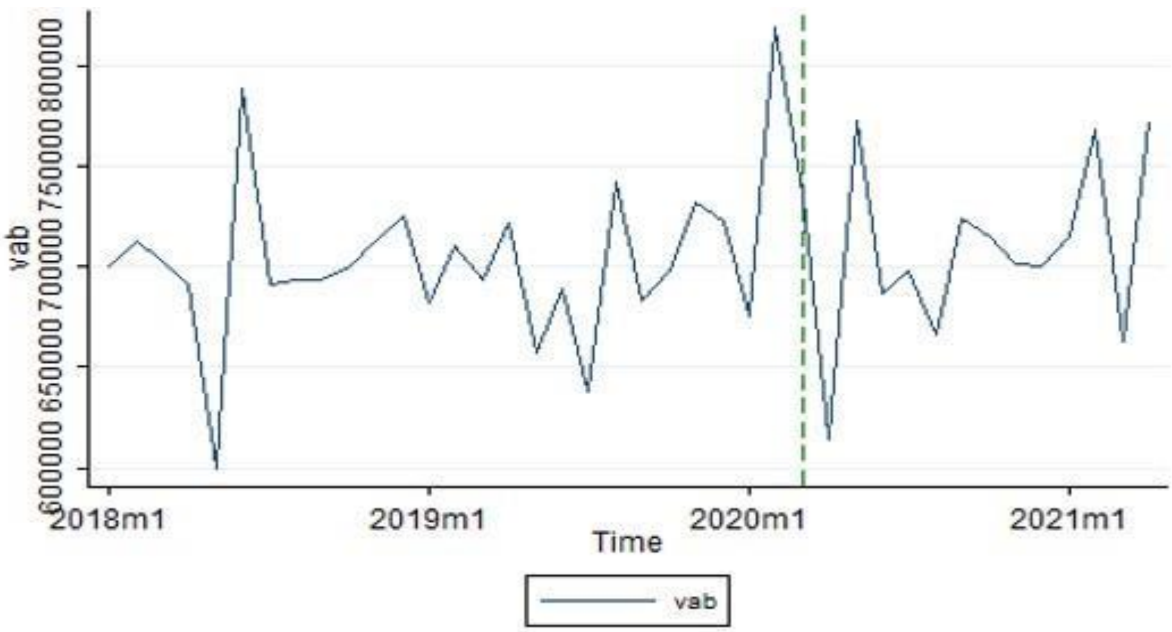


Figure 1 - Evolution of Gross Agricultural Value Added (2018-2021).

In Figure 1, it can be seen that, for February, the Gross Agricultural Value Added (VAB), presents the highest peak during the periods studied, followed by a sharp drop in the month of April, this is due to that. In the month of March 2020, the confinement was issued throughout the national territory, so for this month there were still no strategic plans to continue with production as happens in subsequent months.

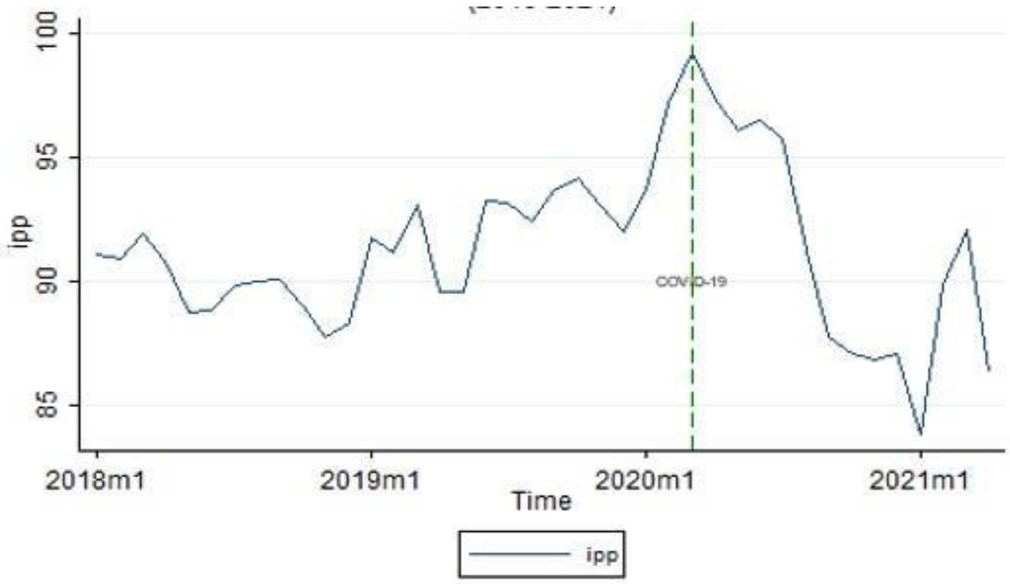


Figure 2 – Evolution of the Producer Price Index (2018-2021)

In Figure 2, a relationship similar to that shown in the illustration of the Producer Price Index (IPP) is considered, since the same reasons for the price increase are presented, which for this index had its highest peak in March 2020, since the supply side is the one that initially perceives the effects caused by the measures imposed in the face of the crisis caused by Covid -19, and has been in charge of increasing its production, even with measures that restricted the usual number of workers with whom the normal supply of food to families was achieved.

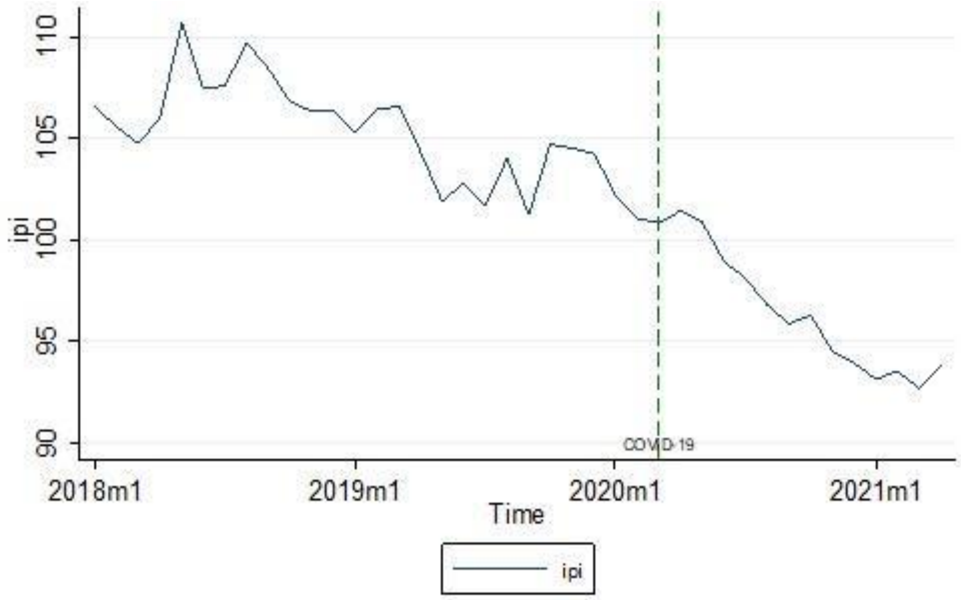


Figure 3 - Evolution of the Input Price Index

On the other hand, the Input Price Index (IPI), which is presented in Figure 3, shows a decreasing behavior since the end of 2019. During the most critical moment of the pandemic, there were no sudden changes in the price level of inputs. This may be because in this index the types of inputs refer to machinery and other types of tools or vehicles that are used to carry out agricultural production work.

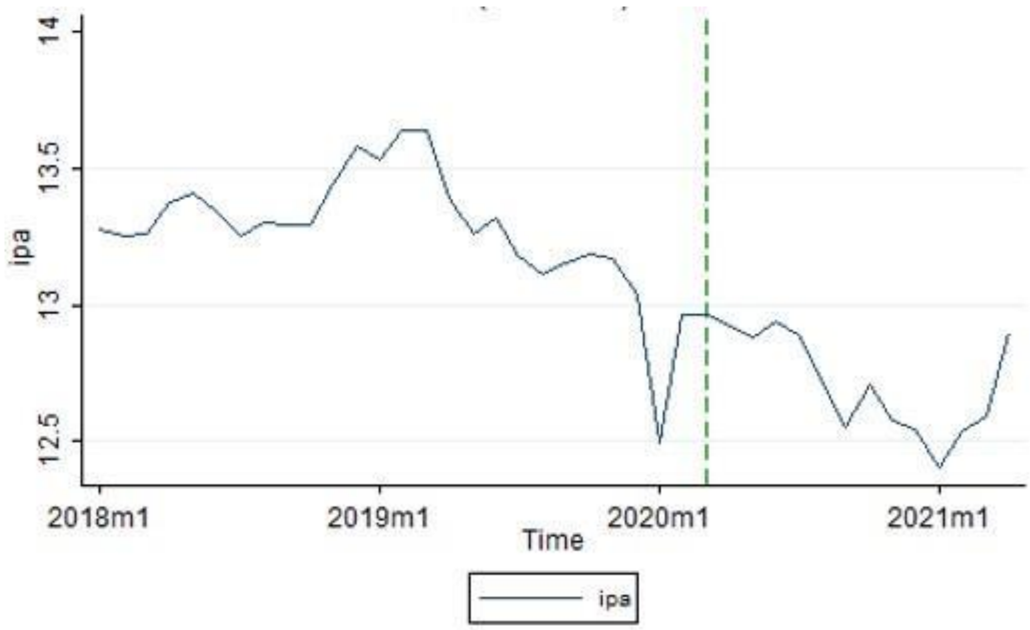
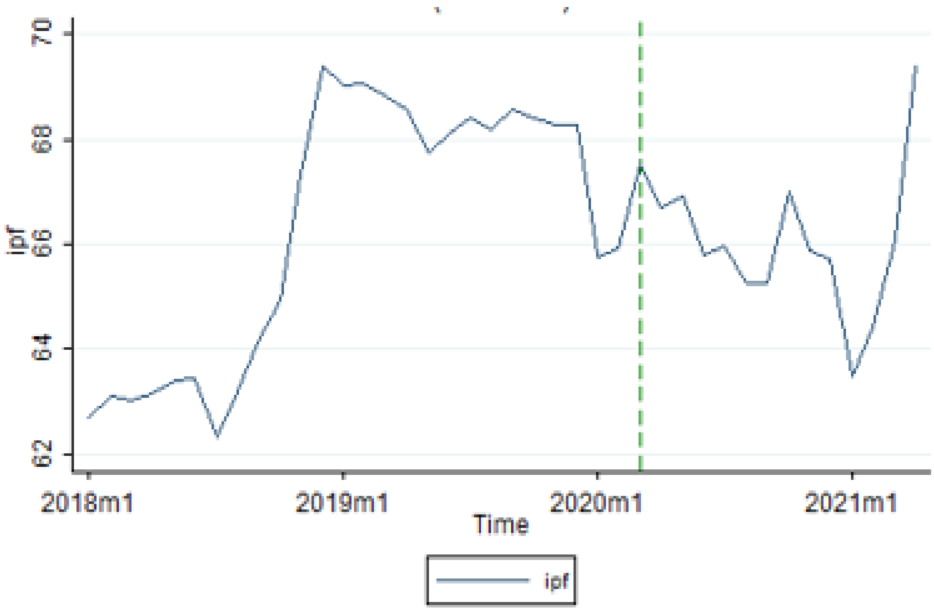


Figure 4 - Evolution of the Agrochemical Price Index

Figure 4, shows that, during the years of study, in the Agrochemical Price Index (IPA) variable a trend can be observed in which the prices of agrochemicals remain stable, without rising or falling sharply. The confinement period did not reflect any positive or negative effect on this index.



Fuente: SIPA

Figure 5 - Evolution of the fertilizer price index

From Figure 5, it can be inferred that to some extent during 2020, fertilizer prices (IPF) increased due to the abrupt drop in the global oil price during the month of April, however, these prices tended to decrease. low in the face of a stable scenario in the oil market since it positively influenced the price of fertilizers.

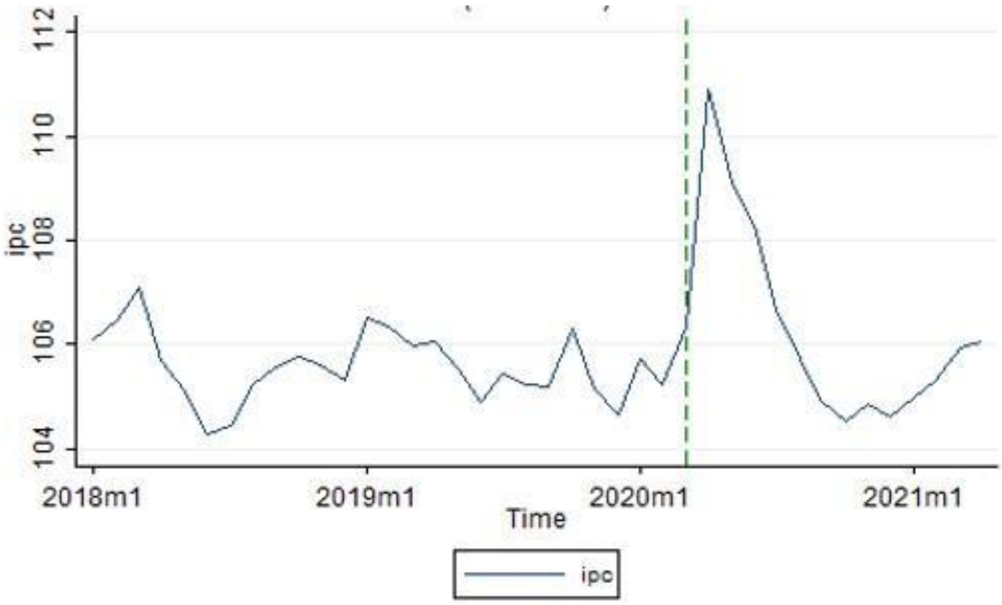


Figure 6 - Evolution of the Consumer Price Index

In Figure 6, in the month of April 2020, a high level in the IPC can be observed, this is due, as in most cases, to the measure of imposition of confinement at the national level to counteract the Covid virus. -19. In this period, it is important to highlight that one of the reasons why prices increased was the unexpected increase in demand for healthy foods; however, price levels were regulated as the months went by. The results obtained in the evaluated models are presented:

Table 4: Results of the three polynomial models for the IPI and IPA variables

	IPI			IPA		
	(i)	(ii)	(iii)	(i)	(ii)	(iii)
trend	1.185*** (0.4104)	0.8674* (0.4426)	0.6703 (0.5943)	0.2087 (0.03372)	0.02009 (0.03319)	0.02093 (0.0343)
trend^2	-0.1134** (0.03781)	-0.0827* (0.0469)	-0.0584 (0.0740)	0.00092 (0.00343)	-0.0029 (0.0036)	-0.00421 (0.00399)
trend^3	0.0025*** (0.0009)	0.00213 (0.0013)	0.0016 (0.0019)	-0.00009 (0.00009)	0.00003 (0.00009)	0.00008 (0.00011)
VAB	---	-5.82E-06 (7.20E-06)	-0.00001 (8.54E-06)	---	-4.87E-07 (4.81E-07)	5.38E-07 (6.34E-07)
IPP	---	-0.2516* (0.1465)	-0.4608 (0.4144)	---	0.0258** (0.01034)	0.0434*** (0.01897)
IPI	---	---	---	---	0.2312* (0.01153)	0.02423** (0.01391)
IPA	---	6.0123* (3.0912)	8.3011*** (4.4694)	---	---	---

IPF	---	-0.4103 (0.3002)	-0.6989 (0.6726)	---	0.0798*** (0.0138)	0.1035*** (0.0235)
IPC	---	0.04084 (0.21802)	0.08789 (0.6651)		-0.0078 (0.01520)	
dummy	-252.245*** (86.7357)	-129.5674 (202.274)	5.3982 (106.9926)	-54.998 (12.1971)	-17.7829 (12.5138)	-33.5034 (10.6229)
dum*trend	23.8686*** (7.7764)	14.2050 (19.1212)	-5.9136 (10.0096)	5.2072 (1.1164)	1.4378 (1.1629)	3.2244 (1.2256)
dum*trend2	0.702131*** (0.2332)	-0.45503 (0. 6074)	0.2052 (0.3247)	-0.1653 (0.0339)	-0.3800 (0.0360)	-0.09497 (0.03868)
dum*trend3	0.00596** (0.00246)	0.00382 (0.0067)	-0.00316 (0.0038)	0.00179** (0.00035)	0.000343 (0.00038)	0.00093 (0.00041)
dum*vab	---	---	0.00002* (8.66E-06)	---	---	-7.03E-07 (8.27E-07)
dum*ipp	---	---	0.4533 (0.4149)	---	---	-0.0323 (0.02063)
dum*ipi	---	---	----	---	---	0.01762 (0.05025)
dum*ipa	---	----	7.1096 (4.6908)	---	---	---
dum*ipf	---	---	0.94317 (0.6839)	---	---	-0.6179 (0.02769)
dum*ipc	---	---	0.34267 (0.6679)	---	---	0.03312 (0.04055)
Intercepto	104.3114*** (1.2946)	73.373* (38.696)	78.5609 (64.7162)	13.218 (0.0719)	3.9628 (2.106)	5.4988 (3.1435)
Covid-19 effect	YES***	YES**	YES***	YES***	YES*	YES**

For the study of the Input Price Index (IPI) variable, with the estimation of "Model 1" it was found that its significant variables are the polynomial trends (linear, quadratic and cubic), the multiplied fictitious variables are also significant for all the returners. Subsequently, performing the Chow test shows that the F Test is significant at 99% confidence, which determined the existence of a structural break for said variable.

In turn, for "Model 2", where the control variables are added, the trend variables lost significance, while the significant variables were the IPP and the IPA, considered as control variables that helped explain the behavior of the IPI variable. Regarding the Chow Test, a robust model is shown in which, although control variables and fictitious variables were included, these are no longer independently significant, since a joint test is carried out, with a level of confidence of 95%.

Finally, in "model 3", the other variables are added, although they did not present many changes in their structures. The F test, which tests the significance of the dummy that interacts with all the explanatory variables of the model, shows that there was actually a structural break caused by the Covid-19 confinement measures in the series of the IPI variable.

On the other hand, for the Agrochemical Price Index (IPA), "model 1" shows that the polynomial trends are not significant; However, when the dummy variables multiplied by the trend variables are added, it was found that, independently, only the dummy variable multiplied by the cubic trend is significant. When performing the Test jointly, the dummy with all its interactions is significant, that is, there is a structural change in the IPA series due to the Coronavirus confinement.

When the control variables are added for "model 2", the polynomial trend variables remained non-significant but the control variables such as IPP, IPI and IPF were significant in the model, which supports the initial hypothesis of the existence of a omitted variable effect, therefore, the F test of joint significance of the dummy variables is significant with 90% confidence. In the same way, "model 3", in which all the studied variables intervene, reflected that the joint test corroborates the results obtained in "model 1 and 2" being significant and rejecting the null hypothesis at 95% confidence.

Table 5 - Results of the three polynomial models for the VAB and IPP variables

	VAB			IPP		
	(i)	(ii)	(iii)	(i)	(ii)	(iii)
trend	11030.08 (9763.74)	9037.992 (11168.03)	12767.54 (12657.89)	-0.7735 (0.3112)	-0.5344 (0.3268)	-0.48893 (0.3164)
trend^2	-1192.048 (1023.135)	-1387.564 (1116.789)	-1773.57 (1327.182)	0.0587 (0.0299)	0.0642 (0.0388)	0.06969* 0.0362)
trend^3	34.301 (27.7601)	47.6797 (28.7868)	56.77 (37.156)	-0.0009 (0.00082)	-0.0011 (0.0011)	-0.00133 (0.0009)
VAB	---	---	---		-4.91E-06 (7.59E-06)	-1.34E-06 (7.00E-06)
IPP	---	-3535.012 (4699.184)	-1744.608 (8959.8)	---	---	---
IPI	---	-6033.35 (8049.16)	-7451.045 (8653.201)	---	-0.3624 (0.1940)	-0.25468 (0.2164)
IPA	---	131130.5 (83354.53)	133072.30 (116915.8)	---	9.6611*** (2.3276)	8.2200*** (2.2363)
IPF	---	-1752.669 (7249.307)	-695.253 (13435.95)	---	-1.0179*** (0.3813)	-1.0646*** 0.3315
IPC	----	-99937.67 (10520.75)	-8423.018 (20009.55)	---	0.42855 (0.3328)	0.9958*** (0.3414)
dummy	-275360.3 (6424193)	-482707 (8144620)	-1.00E+07 (1.10E+07)	-385.95 (450.3701)	-86.9109 (462.3729)	125.899 (416.201)
dum*trend	28691.76 (580353.3)	82767.6 (751656.1)	776363.7 (1172886)	42.229 (41.6931)	14.78 (42.7379)	-4.0519 (48.6932)
dum*trend2	-442.167 (17389.37)	-2558.74 (22911.03)	-22127.8 (36344.73)	-1.4629 (1.2765)	-0.6449 (1.2969)	-0.7507 (1.5409)
dum*trend3	-12.91 (174.257)	1.9334 (232.4612)	195.55 (372.678)	0.0163 (0.01295)	0.0081 (0.01289)	0.002567 (0.01601)

dum* vab	---	---	------	---	---	-6.89E-06 (0.00002)
dum*ipp	---	---	-161.811 (9676.616)	---	---	---
dum*ipi	---	---	90450.34 (36875.56)	---	---	-0.1904 (1.1043)
dum*ipa	---	---	-197553.1 (244984.3)	---	---	10.708 (8.8187)
dum*ipf	---	---	-22669.88 (18467.45)	---	---	-0.45 (0.9891)
dum*ipc	---	---	-35421.54 (25771.62)	---	---	-0.88737 (0.620134)
Intercepto	675.7777 (21101.82)	1068158 (1316382)	797160.7 (1999310)	92.349 (0.8373)	23.876 (44.0112)	-28.305 (50.2562)
Covid-19 Efect	NO	NO	NO	YES***	YES***	YES***

In the study of the estimation of “model 1”, “model 2” and “model 3” of the variable Gross Agricultural Value Added (VAB), no significance was found in the variables studied by model. One of the main reasons why this result was obtained is that the mandatory confinement at the national level did not directly affect agricultural production, since the activities carried out and the goods produced in this sector are of great importance in the contribution in the food supply chain for Ecuadorian households. Consequently, the joint test reaffirms the results obtained in these models since it is not significant even at 90%, 95% and 99% significance.

In the case of the Producer Price Index (IPP) variable, in the estimation of “model 1”, no significance was found in the variables studied, but the Chow test detailed the existence of joint significance at 99% confidence level. In “model 2”, the IPA and IPF variables are significant, where the interpretations reflect that if the Agrochemical Price Index increases by one unit, it causes an increase in the Producer Price Index of 9.66 points; while if the IPF decreases by one unit, the IPP will be reduced by 1.0179 points. Despite this, the dummy significance combined along with the trend variables was significant with 99% confidence. For "model 3" the IPC and the quadratic trend at 99% and 90% confidence are added as significant variables, respectively. Finally, the Chow test was performed, which shows that the F test is significant at 99% confidence, identifying that there was a structural break for each variable that makes up the model.

Table 6 - Results of the three polynomial models for the IPF and IPC variables

	IPF			IPC		
	(i)	(ii)	(iii)	(i)	(ii)	(iii)
trend	-0.18400 (0.3173)	-0.3023 (0.2592)	-0.2139 (0.2409)	-0.3369 (0.1551)	-0.1629 (0.1701)	0.0033 (0.1457)
trend^2	0.07202** (0.2703)	0.06015** (0.000)	0.054** (0.021)	0.0279 (0.0136)	0.0068 (0.01969)	-0.2098 (0.01847)
trend^3	-0.0023*** (0.00067)	-0.00149** (0.005049)	-0,001348 (0.00054)	-0.00067 (0.00033)	-0.00017 (0.00052)	0.00053 (0.00049)
VAB	---	-5.9E-06 (5.87E-06)	-1.65E-06 (3.19E-06)	---	-4.24E-06 (5.55E-06)	1.61E-06 (3.57E-06)
IPP	---	-0.2338*** (0.0805)	-0.3293* (0.154)	---	0.13146 (0.10126)	0.249 (0.1151)
IPI	---	-0.1358 (0.107572)	-0.1195 (0.1024)	---	0.1805 (0.09771)	0.0121 (0.0943)
IPA	---	6.8623*** (1.200)	6.059*** (1.20)	---	-0.8987 (1.6284)	-2,5156 (1.2022)
IPF	---	---	---	---	0.1557 (0.2059)	0.4986 (0.1917)
IPC	---	0.1150 (0.1650)	0 .6479 (0.22619)	---	---	---
dummy	-306.3735 (217.3942)	-7,3221 (174.67)	-0.29465 (215.059)	-402.110 (262.604)	-350.34 (278.7787)	-336.1055 (158.92)
dum*trend	30.3595 (19.7542)	3.2349 (16.1431)	-0.2793 (23.2195)	39.285 (23.1838)	33.439 (24.5823)	22.989 (18.5719)
dum*trend^2	-1.0378*** (0.5943)	-0.1.9761 (0.00504)	-0.04602 (0.71973)	-1.2618 (0.6787	-1.0469 (0.7211)	-0.6759 (0.5873)
dum*trend^3	0.01250** (0.0059)	0.00329 (0.556)	0.00155 (0.00738)	0.01346* (0.00659)	0.0108 (0.0071)	0.0067 (0.0061)
dum*ipp	---	---	0.2058 (0.1511)	---	---	-0.2417 (0.1209)
dum*ipi	---	---	1.3047* (0. 7068)	---	---	1.7149*** (0.3398)
dum*ipa	---	---	-0.30334 (4.044)	---	---	0.2299 (3.1057)
dum*ipf	---	---	---	---	---	-1.00092* (0.2872)
dum*ipc	---	---	-1.2244* (0.4201)	---	---	---
Intercepto	62.700 (1.0082)	-4.1541 (23.7898)	-40.1645 (28.495)	106.669 (0.4984)	97.7543 (15.2149)	85.489 (15.7409)
Covid-19 Efect	YES***	YES***	YES***	YES***	YES**	YES***

The Fertilizer Price Index (IPF) variable shows in "model 1" the significant variables, obtaining both 95% and 90% of the quadratic and cubic trends, as well as the interaction of the dummies with each mentioned trend. For "model 2", we have as significant variables the trends of model 1 and in addition to the control variables such as the IPP and the IPA, in this model the IPP causes a reduction of 0.2338 points in the IPF, while if the IPA increases by one unit, the IPF increases by 6.8623 points. For "model 3", the significant variables are the quadratic trend with 95% confidence, the IPP with 90% confidence and the IPA with 99% confidence. The F Test, which tests dummy significance with all explanatory variables, demonstrates significance and structural presence breaks for each of the models.

Finally, for the Consumer Price Index (IPC) of the agricultural sector, in "model 1" it was obtained that the dummy multiplied by the cubic trend is the only significant variable with a confidence level of 90%. While in "model 2" the existence of significance of the variables is not reflected. In "model 3", the Covid-19 confinement dummy interaction using the IPI control variable is significant at 99% confidence, as is the dummy interaction using the IPF control variable but at a 90% confidence level.

To complete the study, the Test was evaluated jointly in each model presented, where it was obtained that the dummy with all its interactions is significant with a confidence level of 90% for "model 1 and model 3", while for "model 2", the test is significant at 95% confidence, which allows us to conclude the structural change of existence in the IPC series due to the confinement due to Covid-19. The results obtained for this study are shown below:

Table 7 - Results of magnitude and percentage change of the three models

	Model 1	**Model 2**	**Model 3**	**Cambio porcentual ***
IPP	-59.333843	-4.896912*	41.343612	-5.36%
IPI	-51.303967*	-25.976495	-8.3947756	-48.72%
IPA	-9.6660076	-3.5655353	-6.0945896*	-45.91%
IPF	-48.260849	5.06798	13.288557*	20.05%
IPC	-68.857306	-65.033535	-36.164459*	-34.25%

*Model chosen according to Akaike information criteria.

To select the optimal explanation model for each variable, the Akaike information criterion (AIC) was used, which allows the information of each model to be evaluated relatively and then select the AIC with the lowest proportion. From this selection, the pandemic effect was compared with the average value of each variable analyzed, thus calculating the corresponding relative effect (percentage) of Covid -19. Consequently, the measures of impacts of the confinement of the absolute and relative effect on the variables of interest were calculated and it was found that the Producer Price Index (IPP), the Input Price Index (IPI), the Agrochemicals Index (IPA), the Consumer Price Index (IPC) had a drop of 5.36%, 48.72%, 45.91% and 34.25% respectively, while the Fertilizer Price Index (IPF) registered an increase of 20.05% as a result of the drop in the price of oil in April 2020. It is determined that for the Ecuadorian producer the pandemic has dignified it, since it receives a lower price index of 5.36% due to the existence of Covid-19.

On the other hand, in the case of inputs, they have a price deflation of approximately 50%, as well as the agrochemical variables index and the consumption index, which show a decrease of 45.91% and 34.25% respectively. which was due to the sole factor of confinement, although there are other factors that possibly influence these drops, such as: the fall in the price of oil, the climatic factor (ash, rain and heat), the increase in transportation costs, etc. The presidential decree of execution is considered a direct benefit in production costs for the farmer, but it becomes a detriment to the commercial agricultural product due to the decrease in demand and/or oversupply, thus causing the collapse of prices.

On the other hand, for the Fertilizer Price Index it increases numerically by 13.29 in model 3, which incorporates all the variables explained in said model, on the other hand, the Covid -19 effect on the price of fertilizers is revalued by 20.05%, however, this affects the production cost of farmers, that is, the agricultural producer pays a lower proportion for agrochemicals and inputs but receives 5.36% less if the producer makes wholesale sales. On the other hand, if you sell retail, you receive -34.25% due to Covid-19. It is worth mentioning that the Producer Price Indices are those that acquire the different factors for the agricultural sector specifically in the intermediate processing industry, for example, harvesters, stackers, etc.

5. Conclusions

The confinement caused by Covid-19 caused changes in five of the six variables evaluated, these being: IPP, IPI, IPA, IPF and IPC, that is, the confinement affected the prices of the most important factors in the agricultural sector, but not to the total production determined by the Gross Agricultural Value Added (VAB). This finding arises from the proposed methodology: Linear regression model with polynomial trend that consists of the estimation of the structural break incorporating the dummy variable multiplied by the trends and the control variables. After the estimation, a joint significance test was carried out. to evaluate the existence of a structural change in the variables of interest (Chow Test). The result found is robust to the different specifications of the proposed models: model 1, which consists of the analysis of the variable under study, dummy variable, trends and the dichotomous variables with the respective trends; Model 2 consists of the analysis of the variable under study, adding all the control variables, their trends and the fictitious variables; and, model 3, which consists of the analysis of the variable under study, adding all the control variables, their trends and the dummies interacting with the aforementioned variables.

It is recognized that the Covid-19 confinement causes two types of supply and demand shocks, causing prices to decrease because demand contracts, prices are reduced; On the other hand, prices can increase because the demand for fertilizers increased, or due to a contraction in supply, causing a shortage of agricultural products and increased prices. Active participation by the government agencies in charge of managing the productive sectors is recommended, so that immediate actions are proposed that allow satisfactory progress in productivity in the face of any type of crisis. Finally, in the long term, it is desired to evaluate the figures to determine the magnitude of new variables, which can emphasize the topic under study; as well as evaluate this type of indices in Latin American countries, thereby identifying whether patterns are met and building a more complete model.

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