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Article

Effects of the guaranteed price on the average rural price of beans in Mexico

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Abstract

Starting in 2019, the Government of Mexico has undertaken a set of priority programs, including the guaranteed price program for staple food products, with the aim of increasing the income of small and medium-scale agricultural producers. For beans, support is provided to producers of up to 30 hectares of rainfed land and up to five hectares of irrigated land and a limit of 15 t in both cases; with a purchase price of 14 500.00 $ t^{-1} in 2019 and a reached level of 17 344.00 $ t^{-1} in 2023. In order to understand the effects of the guaranteed price program on the level of the rural average price paid to bean producers, this paper models the intervention in the time series of bean prices in Mexico resulting from setting the guaranteed price in 2019. The estimated intervention model was of the ARIMA (1,1,0) type and shows an abrupt and permanent change in the time series of the average rural bean price at the beginning and during the subsequent years of said intervention, indicating that it improved the rural price and generated economic incentives, not only for small producers who market within the program, but in general, for all bean producers.

Keywords:

agricultural prices, intervention model, time series.

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Introduction

Beans rank third in importance by the total planted area of annual and perennial crops in Mexico, with 7.9% of the total area, after grain corn (34.5%) and grasses and pastures (12.9%) (SIAP, 2024). In terms of the value of primary production, they rank tenth in the value of national agricultural production, with a share of 2.4%, which represents an economic spillover of $13 969 million in 2023 (SIAP, 2024). As a reference, according to the Bank of Mexico, one US dollar was quoted at an average of 18.11 Mexican pesos in July 2024.

This legume represents a key crop in the national diet; annual *per capita* consumption is 9.9 kg, so national production covers almost all of the consumption requirements of Mexicans (SAGARPA, 2017). About 10% of the consumption of the legume in Mexico is satisfied with purchases from abroad. An average of 139 000 t is imported per year, from the United States of America (13%), Canada (8%) and China (2%) (SIAP, 2020). In 2023, Mexico ranked as the eighth largest producer of beans in the world, generating 3.5% of world production.

Bean production in Mexico is mainly destined for consumption and self-consumption, as well as for sowing and export (SIAP, 2024). Given that there is no reference price for beans in the international market, the behavior of the implicit price of bean exports from the United States to Mexico can be considered, in part because it is the main country supplying this grain in the country, especially of the pinto and black varieties (FIRA, 2024).

Mexico imports almost half of the food it consumes, as well as most of the inputs, machinery, equipment, and fuels for agriculture (SEGOB, 2019a). In this scenario, the Government of Mexico has undertaken a set of priority programs, including the program of guaranteed prices for basic food products, which includes corn, beans, bread wheat, rice, and milk, which is aimed at achieving two objectives: 1) to increase the income of small and medium-scale agricultural producers by acquiring the staple foods they produce at guaranteed prices and 2) contribute to the achievement of food self-sufficiency by increasing the production of basic foods such as corn, beans, rice, bread wheat, and milk (SEGOB, 2019a).

In this context, the public body called Mexican Food Security (SEGALMEX, for its acronym in Spanish) was created on January 18, 2019, the purpose of which is to coordinate the purchase of agrifood products at guaranteed prices and to promote the production, collection, supply, distribution, industrialization, and selling of basic foods and their derivatives (SEGOB, 2019b).

On September 30, 2019, the Government of Mexico, through the Secretariat of Agriculture and Rural Development (SADER, for its acronym in Spanish), announced the start of the guaranteed prices program for corn and beans of the spring-summer (P-V) 2019 cycle, with the operation of 553 collection centers in 31 states of the Mexican Republic. The guaranteed price program consists of defining fixed purchase prices for those producers who meet certain characteristics and who sell their production in the collection centers designated by SEGALMEX.

The program establishes that the participating producers will have a price guaranteed that will help them increase their income and continue with production; once the designated entity acquires the product, it is responsible for selling it at the market price without affecting the final consumer (Cruz *et al*., 2021). In the case of beans, support is provided to producers of up to 30 ha of rainfed land and up to 5 ha of irrigated land and with a limit of 15 t in both cases, with a purchase price of 14 500.00 $ t^{-1} in 2019, with annual increases (SADER, 2019).

The operational scheme of this program contemplates that the bean producer delivers the grain without intermediaries at a SEGALMEX collection center, where the reception, weighing, and payment is carried out. In the weighing process, the producer will be able to witness and corroborate and will receive a certificate of this and the quality of the grain received. In turn, the collected grain will be mainly directed to cover the supply of DICONSA (Spanish acronym for CONASUPO Distributor and Commercial Promoter) and in case of surpluses, it will be directed to other programs or to the market, where SEGALMEX will be in charge of setting prices (SEGOB, 2020).

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According to García (1979), the implementation of guaranteed prices in the Mexican countryside began in the 1930s with the creation of several organizations, such as the corn and wheat regulatory committee, the Mexican Export and Import Company, and the National Popular Subsistence Company (CONASUPO, for its acronym in Spanish), with the aim of influencing the functioning of the market.

The guaranteed price program is similar to the one applied in the 1950s since, at that time, minimum prices higher than equilibrium prices were used and it represented an important support for agricultural producers (Flores-De Jesús *et al*., 2022). The arrival of a buyer with a minimum purchase price, SEGALMEX in this case, modifies the structure of regional bean markets by generating greater competition for this grain and higher prices.

In any case, the guaranteed price becomes an obligatory reference price for all the actors participating in the bean market. Although this does not mean that market prices are necessarily equal to the guaranteed price (Cruz *et al*., 2021). From the point of view of economic theory, guaranteed prices can be considered an economic distortion. Economic distortions are events that temporarily or permanently alter the real flows of products-income-expenditure (Berumen, 2012).

Distortions, such as the setting of guaranteed prices, stabilizing income from the activity where they are applied and can occur in the long term (trend) or in the short term (cycle). Based on the above, this paper specifies the effects of the guaranteed price program on the level of the average rural price paid to bean producers. To this end, using econometric techniques, it analyzes the intervention of the time series of bean prices in Mexico derived from setting guaranteed prices in 2019.

Thus, the purpose is to establish the form and trend of the changes in the level of the average rural bean price resulting from the establishment of the guaranteed price. To this end, the following hypothesis is proposed: the bean guaranteed price program increases the average rural price of beans by positively impacting the value of the production of bean farmers and therefore causes an increase in their income, whether or not these producers are direct beneficiaries of the program.

Materials and methods

The estimation of the impact of the program on the average rural price of the grain used the guaranteed prices set by SEGALMEX from 2019 to 2023 and a historical series of the average rural bean price from 1994 to 2023 obtained from the Agricultural Production Statistics of the Agrifood and Fisheries Information Service (SIAP), for its acronym in Spanish; (SIAP, 2024). The average rural price is interpreted as the price paid to the producers in the first-hand sale on their farm or property or in the production area.

In the same way, we carried out a bibliographic review of different documents and authors related to setting guaranteed prices in Mexico from 1930 to 2024, which are cited in this work and referred to in the cited literature section, which made it possible to build the theoretical framework and know the importance of beans and the theoretical relevance of guaranteed prices, to define the most appropriate econometric model and to discuss the effect of this public policy on the average rural bean price paid to producers.

The data were analyzed with a time series intervention model. Intervention models of time series, originally proposed by Box and Tiao (1975), measure if, during a given period, the normal behavior of a time series is affected by an external shock, which is known as an intervention. Examples of interventions are the announcements and implementation of public policy measures, such as the program that is the subject of this analysis.

Intervention analysis is a stochastic transfer function model used to incorporate the effects of an interference in a time series with the aim of evaluating its impact on the behavior of the time series (Ferruz *et al*., 2011). In most cases, the period in which the intervention occurs is known, so it is possible to divide the series into two differentiated sections: one that corresponds to the normal progress of the series (which is normally modeled as an ARIMA process) and another where the effect of one or more interventions can be manifested.

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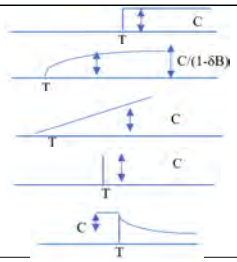
The first comprises the measurements before the intervention and the second is the measurements after the intervention; thus, a 'segmented regression' is carried out to measure the changes in level and trend (slope) between the post-intervention and pre-intervention period (response functions). The level is the point of intersection for the first moment and the value immediately after the intervention. This change can take different forms depending on the effect of the intervention, which is estimated with a response function as shown in Table 1.

Table 1. Five 'pulse' and 'step' type response functions.

Response function	Typical diagram
$V = CS_t$	
$V = (C/(1- \#B)S_t$	
$V = (C/(1-B))S_t$	
$V = CP_t$	
$V=(C/(1-X(B))\ P_t$	

The trend or slope is the rate of change of a measure during a moment. This change occurs when the intervention produces an increase or decrease that can be observed persistently over time; two types are distinguished: continuous or discontinuous. The first presents the result of the intervention that occurs immediately after the intervention and remains for a long period of time; the second indicates when the result of the intervention does not persist over time, so it reflects the completion of the intervention (León-Álvarez *et al*., 2017).

The intervention is then the new element that is added to the traditional time series analysis to be defined as an intervention analysis of time series, which is expressed in a general way as follows (Guerrero, 1991):

$$\nabla_S^D \nabla^d y_t = \sum_{\delta_1(L)}^{\omega_1(L)} L^{hi} \nabla_S^D \nabla^d I_{i.t} + \frac{\theta(L)\Theta(L)}{\emptyset(L)\Phi(L)} \varepsilon_t$$

equation 1; the parts of this equation are found in Table 2.

Table 2
Definition of the variables of equation 1.

Variable	Definition
∇_S^D and ∇^d	These are the seasonal and regular differences, respectively, necessary to seasonalize the time series.
y_t	It is the time series of the variable of interest (guaranteed price of beans).
$\frac{\theta(L)\Theta(L)}{\emptyset(L)\Phi(L)}\varepsilon_t$	It represents the behavior of the series in the absence of the intervention. It is usually defined as a potentially seasonal invertible stationary ARIMA model. With:
	$\theta(L) = \theta_1 L + \theta_2 L^2 + \ldots + \theta_q L^q$
	$\theta(L) = \Theta_1 L^s + \Theta_2 L^{2s} + \ldots + \Theta_Q \Theta^{QS}$
	$\phi(L) = I - \emptyset_1 L - \emptyset_2 L^2 - \ldots - \phi_p L^p$

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Variable	Definition
$\sum \frac{\omega_t(L)}{\delta_t(L)} L^{hi}$	$\emptyset(L)=I-\emptyset_1 L^{S}-\emptyset_2 L^{2S}-\ldots\emptyset_p L^{PS}$ and ε_t white noise It is the sum of response functions, each of which allows us to appreciate the changes that occurred in the time series, not only at the time when the intervention began or occurred, but also those that occur throughout or after it, where: $\omega(L)=\omega_0-\omega_1 L-\ldots-\omega_S L^{m}$, $\delta(L)=I-\delta_1 L-\ldots-\delta_r L^{r}$ y b b is the time it takes for the effect of the intervention to manifest itself on the behavior of the time series under study.
$I_{i.t}$	It is the intervention, represented by a dummy variable that takes values of 1 or 0 (dichotomous variable) to indicate the presence or absence of a certain characteristic or condition.
L	It is the lag operator of the time series of the economic variable under study: $L^{k}yt= y_{t-k}$

The dichotomous variable most commonly used in intervention analyses for response functions is called 'pulse' and 'step'. Table 1 shows five widely used response functions and the types of responses that the intervention implies, the first three response functions employ 'step' functions and the remaining 'pulse' functions.

The first function ($V= CS_t$) models an abrupt and permanent change. If it is known that the change is gradual and leaves a permanent change in the series, it is recommended to use the second function ($V= (C/(1-\delta B)S_t)$) and the third function ($V= (C/(1-B)S_t)$ can be used if it is known that the change is linear with no limit on time. The fourth function ($V=CP_t$) implies that the effect only occurs in the observation time T. On the other hand, if there is a change in time T and the level of the series gradually reaches its level before the change, the function ($V=(C/(1-X(B))\ P_t)$) is used.

A step function (P) models an intervention that modifies the series under study only at the moment when it is intervened (observation T):

0 If $t \neq T$ (before the intervention)

$P_t=$

1 If t=T (during and after the intervention)

A pulse function (S) models an intervention that affects the series under study based on the observation T:

0 If $t < T$ (before the intervention)

$S_t=$

1 If $t \geq T$ (during and after the intervention)

In a practical way, the general model of intervention is expressed according to equation 2, which is as follows:

$$Y_t= wP_t+\frac{E_t}{t-\emptyset L}$$

equation 2.

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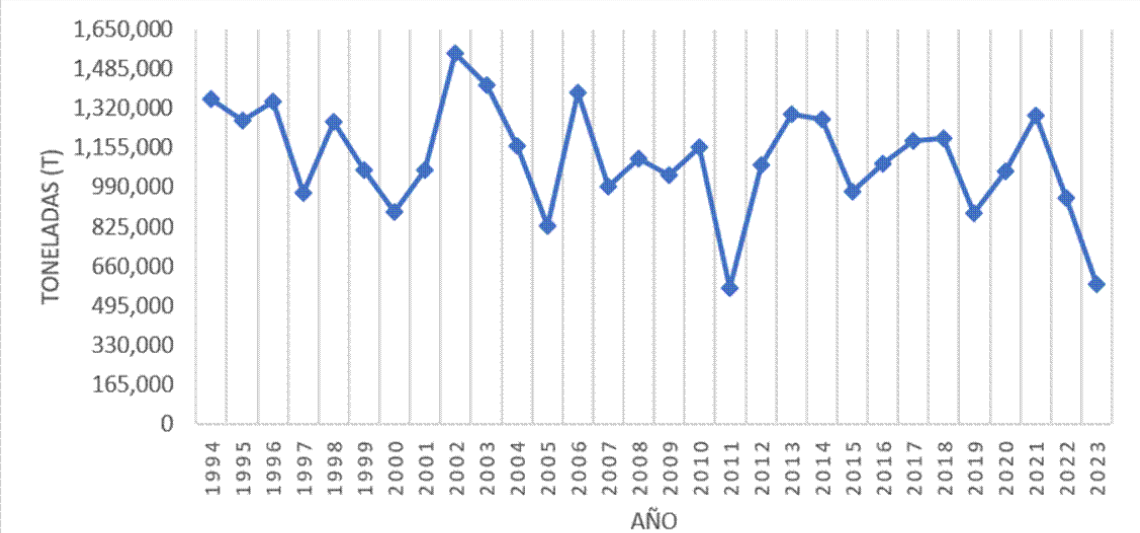
The parameter ø corresponds to the coefficient of the autoregressive process of order one that describes the normal behavior of the time series under study and the parameter ω measures the magnitude of the effect of the intervention corresponding to the intervention of the time series under study. These estimates used the statistical software package of SAS study version 3.81 (Enterprise edition) and the conditional least squares.

Results and discussion

In Mexico, beans are grown in different regions, both for self-consumption and selling. Beans are, after corn, the second crop with the largest planted area in Mexico, and most of it (88%) is established in rainfed conditions (SADER, 2021). In the 2019 agricultural year, the planted area was 1.7 million hectares, of which 17% corresponded to the autumn-winter cycle, mainly in Sinaloa, Nayarit, Chiapas, and Veracruz, and the remaining 83% were established in spring-summer, where Zacatecas, Durango, San Luis Potosí, Chihuahua, Chiapas, Guanajuato, and Puebla stand out.

These ten states concentrated 90.3% of the area sown with this crop and contributed 87.4% of the national bean production, where Zacatecas, Sinaloa, and Nayarit stand out, which together produced 52.5% of the beans harvested in Mexico (SIAP, 2022). A review of production levels in recent years (Figure 1) indicates that bean production grew by 4.6% on an annual average from 2000 to 2019, which represents an average annual production of 1.1 million tons.

Figure 1. Evolution of bean production (t) from 1994 to 2023. With data from the Agrifood Information Consultation System (SIACON); (SIAP, 2024).



It is worth noting that, in 2002, the highest level was reached with a production of 1.54 million tons; subsequently, production decreased to reach a minimum of 0.56 million tons for 2011. However, as of 2012, production establishes itself at levels above one million tons. As of 2019, the year that the implementation of the bean guaranteed price program begins, there is an upward production trend, reaching a level of 1.2 million tons in 2021.

Nevertheless, in 2023, production was 724 000 t, 25% less than the previous year, due to lower yields caused by delays and decreases in rainfall. The drought caused a reduction in sowings and an increase in losses, resulting in the lowest figure recorded in the last 30 years (SIAP, 2024). On the other hand, the average rural bean price paid to the agricultural producer (ARP) from 2000 to 2018 registered its maximum level in 2017 when paid at 13 484.00 $ t^{-1} (Figure 2). Nonetheless, due to the growth of production and imports, in addition to stable consumption in 2017 and 2018, the ARP decreased by 4.9% in 2018, to stand at 12 264.00 $ t-1.

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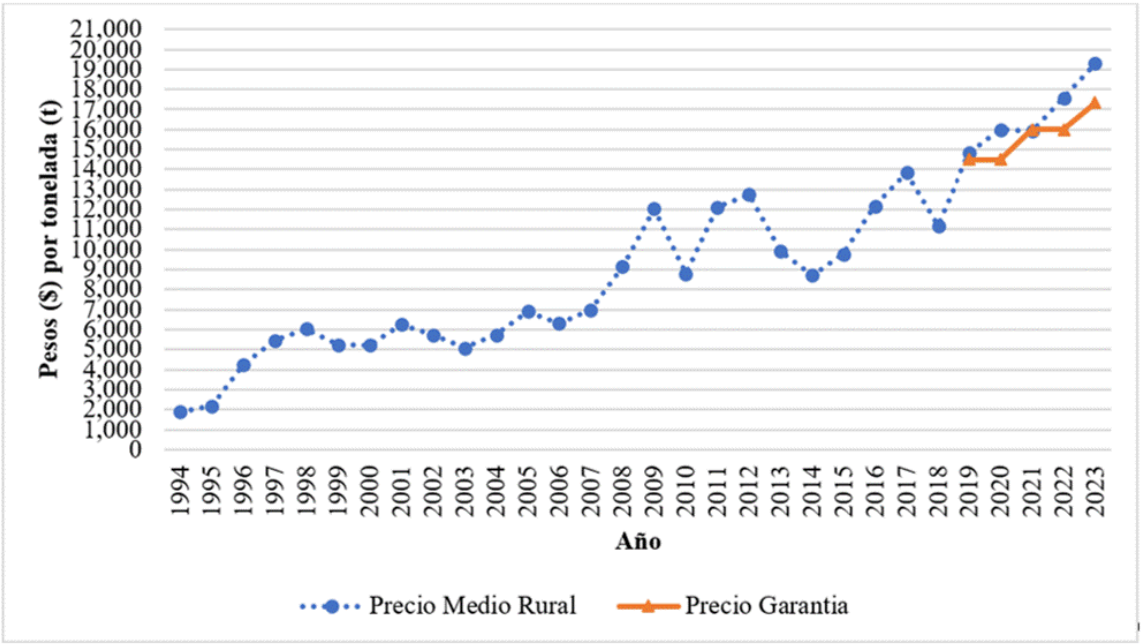
Figure 2. Evolution of the average rural price and guaranteed price of beans 1994-2023. With data from SIACON of SIAP (2022)



However, in 2019, the guaranteed price for beans was set at 14 500.00 $ t^{-1} and remained at that level in 2020, which caused the ARP to increase to 16 009.00 $ t^{-1}. In 2021, the guaranteed price was set at 16 000.00 $ t^{-1}, thus equaling the rural average price, which had a level of 15 918.00 $ t^{-1}. This implies that this year the guaranteed price and the average rural price will practically be equal.

The guaranteed price for 2021 remained the same in 2022 but the ARP reacted with an increase to 17 593.00 $ t^{-1}, the reaction effect of the ARP is similar to that occurred in 2020 when the guaranteed price policy began. For 2023, the guaranteed price increased again to 17 344.00 $ t^{-1} and the rural average price reacted upwards again, setting itself at 19 304.00 $ t^{-1}.

In 2019, SEGALMEX acquired 148 252 t of beans, which represents 25% of the volume produced in that cycle (CEDRSSA, 2020), which motivated, from that year onwards, small producers to the sell to the different SEGALMEX collection centers, thus causing a change in the trend and structure of the rural price of beans since the average rural price of beans from 2019 to 2023 remained equal to or above the guaranteed price set in the same period. In this context, the estimated intervention model was ARIMA (1,1,0) (Table 3).

Table 3.Estimated parameters of the intervention model of the bean price time series 1994-2021.

Parmeter	Estimation	Standard error	t-value	Approx. Pr>t	Lag	Variable	Shift
AR1	-0.074	0.20936	-0.35	0.7267	1	Price	0
NUM1	3514.7	1794.3	1.96	0.0614	0	Interior	0
		Variance estimation			29386969		
		Stand error estimation			1714.263		
		AIC			480.6686		

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When the estimated parameters were substituted in equation 2, the resulting model was as follows:

$$Y_t = 3{,}514.7\ P_t + \frac{E_t}{1 + 0.074}$$

The estimated intervention model indicates how the setting of guaranteed prices affects rural average prices by the determined 'impulse' response function, which shows an immediate and sustained effect over the years from 2019 to 2023, in which grain guaranteed prices have been set, with an initial estimated value of increase in the average rural price of 3 514.70 $ t^{-1}, an increase that can be explained in economic terms as the entry of a relevant player (company) into the bean market in Mexico, since when SEGALMEX enters as a new player in the purchase and sale of beans, it modifies the structure and conditions of this market.

This results in the 'game' of bean price setting, as defined by theorists of game theory (Nagle and Holden, 2010), since its success depends not only on the decisions that SEGALMEX makes about the price it would pay for the beans it acquires and the establishment of collection centers, but also on the reaction of small bean producers and competitors or grain collectors to those decisions.

The above is demonstrated by the behavior of the level of the average rural price, which has been equal to or higher than the guaranteed price set from 2019 to 2023. The resulting price increase in all regional markets, by improving the conditions of competition among buyers, benefited all bean producers and not only the participants in the program. In the same vein, Flores-De Jesús *et al*. (2022) found that the effect of guaranteed prices on the bean market in the Central Valleys of Oaxaca would represent an increase of just over 30% in the producer price.

This result indicates that the guaranteed prices in beans, as an economic policy for the agricultural sector, have a positive effect on the wellbeing of all bean producers in the country, regardless of whether they marketed their production with SEGALMEX or with the bean collectors and buyers located in the different producing regions.

The results show that the guaranteed prices of beans have been an economic distortion since they permanently alter the average rural price of beans upwards. According to economic theory, a minimum price is relevant as long as it allows positive income to the producer (Westreicher, 2021). Based on this, it was determined that the guaranteed prices of beans are relevant since they set, since their implementation in 2019, a minimum reference price that producers will receive for their beans, improving their access to the market and with a positive impact on their income and therefore on their wellbeing.

This government policy offers certainty of income to eligible producers for the sale of their beans in SEGALMEX collection centers. Similarly, dependence on collectors or buyers in the region decreases, a situation in which many small producers receive lower prices under unfair conditions. In this sense, Cruz *et al*. (2021) reports that the producer benefiting from the guaranteed price program receives an income greater than the market price for their crops, and dependence on intermediaries is eliminated.

Conclusions

The bean guaranteed price program established economic incentives that allowed the following effects on the bean market: the small bean producers beneficiaries of the program had certainty for the selling of their production and a higher rural average price was paid to the bean producers in the market.

The conditions of competition between local bean buyers increased and regional bean collectors and buyers, in order to access the volumes of beans needed and required in their market, had to equal or exceed their bean purchase price. There was a positive and permanent effect on the average rural price of beans upwards for the 2019-2023 period.

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On the other hand, SEGALMEX became a relevant player that changed the rules of the game in the purchase and sale of Mexican beans since, by acquiring 25% of the production, it caused a reduction in the traditional supply in rural bean markets, from which regional collectors and buyers made their purchases, and it caused a reaction from them to increase their price paid to the producer since 2019 to levels equal to or higher than the guaranteed price, the latter being considered as a minimum reference price that guides the bean producers of the minimum income that they would obtain from selling their beans. This effect of the guaranteed price on the rural price of beans most likely does not coincide with that of the other products that are part of this policy because they have very peculiar market conditions.

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