Essay

Efficiency of corn producers in Sinaloa: a methodological proposal

Luis Fernando López Reyes[1§]
Luis Armando Becerra Perez[1]

[1]Faculty of Economic and Social Sciences-Autonomous University of Sinaloa. University Blvd. and Av. De Las Americas unit 3 s/n, University City, Culiacán, Sinaloa, Mexico. CP. 80010. Tel. 01 (667) 7161128. (becerra@uas.edu.mx).

[§]Corresponding author: Fernando_lopezreyes@hotmail.com.

Abstract

Given the importance that the state of Sinaloa has in corn production at a national level, it is necessary to analyze the conditions under which the Sinaloa producer participates in the market and estimate its level of technical efficiency. The relevance of knowing the technical efficiency of the producer lies in the fact that a lack of this implies a waste of resources that affects the yield and the reduction of average costs. This essay analyzes the disadvantageous situation in which the producer participates in the market, since the price of corn increases at a comparatively lower rate than that of input prices. In addition, there are other actors in the value chain that obtain a higher income with a lower financial risk. The stochastic frontier model is proposed to estimate the level of efficiency and a literature review is offered that supports the choice of the econometric model. Likewise, the equation to be estimated is presented considering the cultivation practices in force in the state of Sinaloa. It is concluded that it is of interest to estimate the technical efficiency to know the available improvement space given the current technology in the study region and that the stochastic frontier model is a viable alternative to achieve said objective.

Keywords: corn production, stochastic frontier model, technical efficiency.

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Introduction

Like not all companies are successful in maximizing their income; not all producers are successful in managing their inputs in a way that maximizes their profits. Therefore, the search for efficiency is critical for any organization, including those involved in the agricultural sector. In this sense, the present essay focuses on proposing a method to estimate the technical efficiency (ET) of corn producers in the state of Sinaloa, given that it is one of the leading producers in the country with a production of around five million tons per year, which is equivalent to 22% of national production (SAGARPA, 2014). For the purposes of this work, efficiency is the optimum level of production that results from the use of a set of inputs with a given technology.

Assuming that all producers in a given geographical region have access to the same technology, it is expected that the variations in the level of efficiency obey specific factors of each production unit (eg. the amount of irrigation water used per hectare, carried out), so that producers who optimize their resources better will be more efficient.

In the 2014 agricultural year, the area sown with corn in Mexico was 7.4 million hectares. It should be noted that this area has not increased significantly in the last 15 years, but not their yield per hectare, which has been increasing, especially in the area of irrigation. The volume of corn production for the same year was 23.3 million tons with a total value of 72 518 million pesos.

The importance of water in the productivity of corn is evident. For the 2014 agricultural year, in irrigation, the yields were 8.83 t ha^{-1} and 7.34 t ha^{-1}, in the Autumn-Winter (A-W) and Spring-Summer (S-S) cycles, respectively; while in temporary, the yields were 1.9 t ha^{-1} and 2.34 t ha^{-1}, in the same cycles respectively. Sinaloa stands out for its importance in the cultivation of corn. For the 2014 agricultural year in this entity 408 thousand hectares of corn were planted, harvesting 3.7 million tons. Its yield in A-W, in irrigation (seasonal maize is not sown), which is the cycle in which it sowed most of it, was 10.63 t ha^{-1}, a very acceptable yield with respect to those obtained nationally (SIAP-SAGARPA, 2016).

With a per capita consumption of 253 kg, Mexico is the eighth largest consumer of corn worldwide. According to Turrent (2005), Mexico is apt to reach a production that oscillates around 32 million tons per year, considering the same area destined for this crop of the last 5 years. Even so, Mexico ranks as the fourth producer of corn worldwide, only behind the United States of America (USA, 280 million tons), China (136 million tons) and Brazil with 44 million tons. However, total production does not meet domestic demand, so Mexico imports around 10 million tons of corn each year, mainly from the US. UU, your main commercial partner.

According to Becerra (2014), apparent domestic consumption of corn in Mexico was 30.5 million tons in 2010, of which approximately 25% was supplied via imports. Even recognizing that most of the imports are for animal and industrial consumption (yellow corn and not always the best quality), which in the end ends up becoming human consumption when transformed into food products (eg. meats, cereals), this deficit of grain compromises food sovereignty by placing Mexico in a position of dependence on one of its basic products in the diet of the population.

In addition to the economic impacts and the dependency implications of the exterior, recent studies (Mendoza-Cano *et al*., 2016) have found that the import of corn into Mexico from the United States has negative effects on the environment and human health. These authors found evidence that environmental impacts, measured by life cycle analysis (ACV), and effects on human health, as measured by disability adjusted life years (AVAD), are higher when corn is imported compared to corn produced in Mexico.

The above facts indicate the feasibility that in case of an increase in national production, via an increase in efficiency, the placement in the national market is guaranteed and is positive, not only from the perspective of food sovereignty, but economically, environmentally and public health. In this sense, the national and international experience of Sinaloa in the production and commercialization of corn, which by the way, is equal or greater in terms of productivity with the corn belt of the United States of America is usable. The aforementioned, potentiates the opportunities of placing a tentative increase in production and that would contribute to the complex problem of commercialization of production that each cycle faces local farmers.

This essay is divided into five parts. The first is this introduction that places the reader in the subject of analysis. The second justifies the problem to be addressed and the advantages of knowing the efficiency of corn producers in Mexico and Sinaloa. In the third part, we review the literature that has analyzed the issue of the efficiency of corn production worldwide and in Mexico. In the fourth part, a methodological proposal is made to determine the ET of the corn producers, which although it is contextualized to Sinaloa, it can be replicated to any region of Mexico and other crops. In the fifth and last part, the conclusions are offered.

The problem of corn producers

The problem in the case of corn producers is that they face serious difficulties through the productive process and economic cycle of the crop. Although they have been able, through the implementation of good practices and agricultural management, to control the damage by pests to their minimum expression and are, at the same time, highly productive with yields above the national average, if they face financing problems, liquidity, rising prices of inputs, strong competition at the international level and commercialization. The increase in production costs does not grow parallel to the increase in the market price of agricultural products. This situation has against the wall the corn businessmen who are unprotected before such circumstance.

Given this situation of great threat to corn producers by the excessive increase of some inputs such as seed and fertilizer, it is important to design strategies to determine their performance and avoid further decapitalization. Currently the producers are sharing the utility with sellers of inputs whose risks are extremely minor and their financial advantages are very high. In addition, the marketers of the grain also obtain a higher income. Faced with this bleak panorama, producers need to innovate to bring about a change that allows them to face the challenges of the environment in a better position. For this reason, the estimation of efficiency is very important to know in what way the producers are drifting and from that starting point, to know the scope that could be achieved through the implementation of new policies aimed at increasing efficiency.

Several studies have tried to justify why efficiency in agriculture is important especially in developing countries. Considering the social, economic and cultural factors of a region, the increase in productive efficiency does not necessarily depend on the adoption of new technologies, but on the effective use of available technologies.

The analysis of the efficiency of a sector of agricultural producers can offer important observations on the competitiveness of the same ones; as well as the potential to increase productivity and use of resources. A producer that is inefficient is wasting resources because it does not obtain the maximum possible production, given the amount of inputs used in the production process, thus compromising the possibility of reducing average costs. A high efficiency in the production of corn will place Sinaloa on the right path to improve its competitiveness in the markets of destination, as well as in the international level, where it is faced with the threat of grain production abroad susceptible to import into the national territory.

The estimation of the ET also yields relevant information for decision-making at the business level (eg. producer) that leads to the optimal use of resources and capabilities. As highlighted by Abdulai and Tiejte (2007), the analysis of efficiency allows obtaining valuable information on the competitiveness of producers and their potential to increase productivity. Considering all of the above, it is necessary to estimate the efficiency of corn producers in Sinaloa, this estimate will serve as spearhead, first, to determine the magnitude of the degree of improvement available. That is, the difference between the current efficiency of the Sinaloa producers and the maximum possible, given the technology, prices and environmental factors that prevail in the region.

Once the causes have been identified, we will be in a better position to infer the probable scenarios resulting from the implementation of specific policies and reforms to favor the revitalization of the corn product system. Since efficiency can be ambivalent, that is, greater efficiency can be achieved both by increasing production with the same inputs, and by producing the same using fewer resources, policies can also be aimed at reducing costs, for example.

Literature review in efficiency analysis

The study of efficiency in the production of corn has been a recurring theme among agricultural researchers. Due to its global importance in terms of generating staple foods, generating jobs and other socio-cultural factors, it is not surprising that corn has been the subject of a large number of studies.

The development of the estimation and analysis of efficiency dates back more than seven decades (Koopmans, 1951) with significant improvements from the theoretical and empirical point of view during the second half of the seventies of the previous century (Aigner *et al*., 1977).

Variations in the ET in agriculture have been studied mainly in Asian countries such as India (Ali and Gupta, 2011), China (Chen and Song, 2008) and in African countries particularly in South Africa (Pauw and Punt, 2007) and Kenya (Kibaara and Kavoi, 2012).

In their study, Kibaara and Kavoi (2012) estimated the ET of the maize production in Kenya and explained the variations of this among the producers; these differences are derived from the socio-economic and demographic characteristics of the producers and their management capacities. The authors calculated the specific efficiency of the producers using 2 017 observations from a survey with cross-sectional data. The results show that, overall, the average efficiency is 49%, therefore, there is a large space to improve production using the same technology. The use of certified hybrid seed, machinery and soil preparation, the level of education, the interaction between the level of education and income outside agriculture, access to credit and the age of the entrepreneur, were the main determinants of efficiency.

Using cross-sectional data from a sample of 218 production units, Amor and Muller (2010) estimated the ET of the vegetable, fruit and cereal producers in Tunisia. According to their results, cereal producers in that country have an efficiency level of 77%. What implies a space of increase in the production of 23% using the same technology. Education, age, irrigation techniques and land tenure were found as determinants of efficiency.

Kelemework *et al*. (2012) estimated the level of agricultural efficiency of 29 different countries in Africa and Asia for the period 1994-2000. The results show that the average efficiency of the countries in the sample is 86%, with discrete increases during the period in question. This suggests that there is a significant space for improvement in productivity and reallocation of existing resources (14%). Research and development and education were the main determinants of efficiency.

In Pakistan, Ayaz and Hussain (2012) estimated the level of efficiency of farmers in the province of Punjab. Using data from 300 production units, they concluded that the level of efficiency prevalent among the producers of the sample was 84% or, what is the same, 16% of technical inefficiency. Producer experience, education and size of the production unit were the determinants of efficiency; outstandingly, access to credit was the most important variable in said estimation.

Yabe *et al*. (2012) estimated the efficiency of corn producers in Sayaboury province in the Lao People’s Democratic Republic, southwest of China. Through the use of surveys, they obtained data from 178 entrepreneurs. The average efficiency of the producers was 85%. The level of education, experience, size of the production unit, membership of an agricultural association and access to credit were the main determinants of efficiency.

Based on a survey with 387 observations, it was concluded that the level of efficiency of irrigation agriculture in Iran was 76% (Burki and Shah, 1998). The variables positively related to the level of efficiency, according to this study, were schooling, irrigation and fertilizers, while the size of the production unit and the age of the employer are negatively related to efficiency.

In China, Chen and Huffman (2003) estimated the efficiency of grain producers. The results indicate that the average level of efficiency 86%. Machinery, size of the production unit and age of the entrepreneur were determining variables.

With a total of 32 efficiency studies using data at the level of production units in 15 developing countries, Bravo-Ureta *et al*. (2001) concluded that the average efficiency was 68%. Of the sample, 8 studies were corresponding to the production of corn from different countries such as Nepal, China and Guatemala. In a subsequent meta-analysis, Bravo-Ureta *et al*. (2007), concluded that the countries with the highest efficiency averages were those of Western Europe and Oceania. In contrast, the lowest levels of efficiency in agriculture are found in Eastern Europe, followed by countries in Asia, Africa, Latin America and North America.

As regards studies on the efficiency of maize production in Latin America, the amount of formal research is somewhat reduced. In Guatemala, Kalaitzandonakes and Dunn (1995) calculated that the ET in the production of corn prevailing on that date was 73% on average. Education, technical assistance and experience were statistically significant variables. Result consistent with that of Bravo and Pinheiro (1997), in their study on the efficiency of 60 producers in the region of Dajabon in the Dominican Republic, concluded that the ET was 70%.

In his research, Solis *et al*. (2009) studied to what extent the efficiency of producers in the Salvador and Honduras was related to natural resource improvement programs implemented in Central America. With data from 639 producers, they concluded that efficiency is positively related to financial improvements for agricultural entrepreneurs and that in turn contributes to the sustainable management of the environment and increased productivity. In Colombia, Janssen and Ruiz (1994) calculated that the efficiency of small producers was 56%. And that this level of efficiency contributes 42% to the increase in economic gain.

On the other hand, in a study conducted in the USA and based on 3 341 observations of spaces with rural influence and 1 405 of urban influence, Nehring *et al*. (2006) concluded that agricultural producers settled in rural communities were more efficient than their counterpart producers with influence or proximity to urban areas. In the corn belt (corn belt: Iowa, Illinois and Indiana), efficiency was 63% for the study period. They also highlight that efficiency is related to return on investment and productivity.

Of the few formal investigations carried out so far in relation to the estimation of efficiency in corn production in Mexico, the one by Yúnez-Naude *et al*. (2006). In this work, the authors estimate the overall efficiency by geographic regions, dividing the national territory based on productive regions. That is, the southern, central, west central, northwest and northeast regions. Taking information from the National Survey of Rural Households in Mexico (ENHRUM) of the year 2002, the authors concluded that overall, corn production in the national territory is inefficient, both for subsistence and business agriculture.

The most inefficient regions, according to the authors, are the central and southern zones. In addition, they found that in subsistence agriculture, producers use inputs that are less efficient (eg. seeds and agrochemicals) compared to business producers. In short, they conclude that the least efficient producers are those who are immersed in subsistence agriculture, plant an area of less than 1 hectare, are indigenous and base their production on creole seeds.

Although these results represent a first effort to estimate the efficiency of corn producers in Mexico, the work has certain limitations. As the estimates are based on a national survey that collects information, in part; through the community authorities, the information collected may contain important biases and omissions. In addition, many of the small producers may not keep accurate records of their expenditures, which complicates the estimation of actual efficiency. To obtain more useful data and with a lower risk of bias, it is necessary to obtain the information directly from the producer. Table 1 shows the literature cited in this work, highlighting the variables considered by different authors.

Table 1. Main efficiency studies of maize production around the world.

Author	Place	Methodology applied	Cultivation analyzed	Observations	Variable	Efficiency found
Kibaara and Kavoi (2012)	Kenia	MFE[1]	Corn	2 017 observations cross-sectional data	Seed machinery, education, credits	49%
Amor and Muller (2010)	Tunisia	MFE	Corn and fruits	218 production units	Education, age, irrigation, land tenure	77%
Kelemework *et al*. (2012)	Asia and Africa (29 countries)	Meta analysis	Corn	-	Research and development and education	86%
Solis (2009)	Center America	MFE	Corn	639 observations	Government programs, agricultural association, total expenditure	62%
Ayaz and Hussain (2012)	Pakistan	MFE	Corn	+300 production units	Experience, education, access to credit	84%
Yúnez-Naude *et al*. (2006)	Mexico	MFE	Corn	776 observations	Seeds, Agrochemicals	3%
Chen and Huffman (2003)	China	MFE	Corn	64 public companies	Machinery, size, age	86%
Kalaitzandonakes and Dunn (1995).	Guatemala	MFE	Corn	+200 observations	Education, assistance	73%
Nehring *et al*. (2006)	USA	MFE	Corn	+4 000	Productivity, return on investment	63%

Source: elaboration based on the reviewed literature. [1]Model of stochastic frontier.

Estimation of the efficiency level of corn producers: methodological proposal

As it currently appears in the literature, the stochastic frontier model (MFE) was originally developed by Aigner *et al*. (1977). In this model, technical efficiency is defined as the ability of the organization to achieve the maximum amount of production given a series of inputs and technology. In other words, the estimation of the ET allows inferring the space that results from the comparison between the producers with extraordinary results (benchmark) and therefore they are placed on the frontier line, and the producers that are placed below the line of border; the border function represents the best technology in practice and against which other organizations within an industry will be compared to measure efficiency (Batesse and Coelli, 1995, Figure 1). For this reason, and in contrast to a regular production function, the MFE allows inefficiency measures to be taken since it does not assume that all farmers or production units are achieving the best possible production.

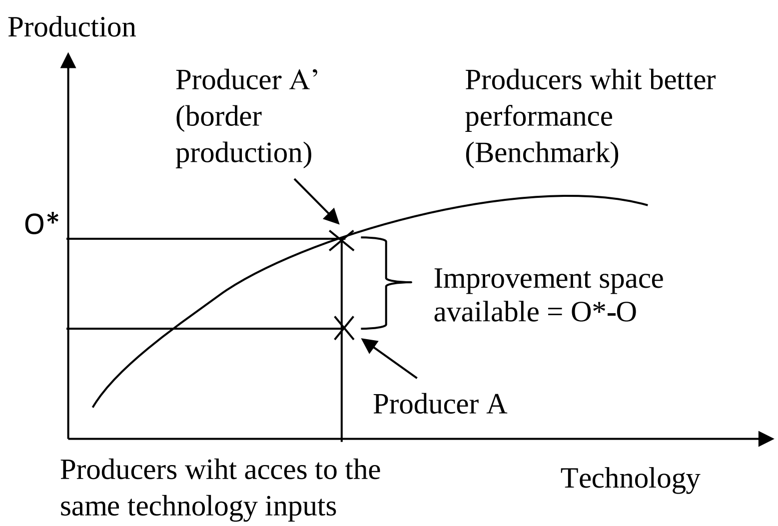

Figure 1. Illustration of the available improvement space based on the best performing producers. elaboration based on Luo y Homburg (2008).

The MFE can be classified into two basic categories: parametric and non-parametric. The main difference is that parametric stochastic frontier (MFE) models are based on a specific functional form that implies an econometric form Aigner *et al*. (1977), while non-parametric data envelopment analysis (DEA), are not based on such form Amor and Muller (2010) and incur the use of linear programming (Charnes *et al*., 1978). It is proposed to use the parametric form of the MFE since it has some advantages over its counterpart, the DEA model, for example the nonparametric model assumes that the variations in the performance of the producers are attributed in their entirety to the inefficiency. Assuming this leads to problems, since it ignores the error measure (eg. statistical noise), omitted variables and exogenous shocks during the parameter estimation process (Iliyasu *et al*., 2016). Likewise, the MFE allows hypothesis testing of the estimated parameters. For these reasons, the MFE is the one proposed in this essay.

The main advantage of the MFE over the traditional ordinary least squares (MCO) model is that the latter offers estimates based only on the average producer; while the MFE estimate is mostly influenced by the best performing producers and therefore reflects the benefits of the technology they are using. Following Chávez *et al*. (2012), the essential form of the MFE is:

$$y_i=f\left(\beta^{'}X_i\right)+e_i \qquad 1)$$

Where: y_i is the production of producer i in the sample (i=1, 2, … I), X_i is a vector (1×k) of quantity of production inputs used by production unit i; β is vector (k×1) of parameters to be estimated, $f\left(\beta^{'}X_1\right)$ is the parametric form of the technology used, and e_i is a stochastic error term used by Batesse and Coelli (1995) and is composed of:

$$e_i=v_i-u_i \qquad 2)$$

Where: v_i is the asymmetric component and considers the random variation of production due to factors beyond the farmer's control (eg. amount of rainfall, extreme weather); then, v_i is a component of two-sided statistical noise and is assumed to be independent and identically distributed in $N(0,\ \sigma_v^2)$ and independent of u_i. And u_i is a nonparametric random variable, associated with technical inefficiency. Distributions such as gamma, exponential and truncated-normal have been proposed in the stochastic frontier production literature, in the proposal of this essay, the asymmetric component u_i is a non-negative random variable and it is assumed that it is independently distributed with truncations (at zero) of the semi-normal distribution with mean μ_i and variance $\sigma_u^2[N(\mu_i,\ \sigma_u^2)]$ (Kumbhakar and Lovell, 2002) and therefore captures the notion of asymmetry between the two components of e_i. Following this logic, the effects of the average technical inefficiency, μ_i, can be specified as:

$$\mu_i-\sum \delta_k Z_k \qquad 3)$$

Where: Z_k is a vector (1×m) of specific variables of each production unit associated with the ET, and δ_k is a vector (m×1) of unknown parameters to be estimated.

Therefore, the variance of e_i es $\sigma^2=\sigma_u^2+\sigma_v^2$, and the standard error is calculated in: $\gamma=\frac{\sigma_u^2}{\sigma_v^2}$,: where the gamma parameter (γ) it determines if indeed the MFE is preferable over the traditional production function model (Kalirajan, 1981). If we fail to reject the null hypothesis $H_0\colon \gamma=0$ would imply the absence of a stochastic frontier in terms of production. In this horizon, ET can be written as:

$$ET_i=\frac{y_i}{f(X_i\beta)\exp(v_i)} \qquad 4)$$

This is the radius of the observed production and the maximum possible output given a technology characterized by $\exp\{v_1\}$. And y_i reaches its maximum in $\left[f\left(X_{i,}\beta\right)\exp\{v_i\}\right]$, only at this point do we have the result ET_i=1. If ET_i < 1 then we have a space between the observed production of the production unit i, and the maximum possible production characterized by $\{v_1\}$. Equation 1 can be rewritten as:

$y_i=f(\beta X_i)\exp\{v_i\}\exp\{-u_i\}$ 5)

In equation (5), $ET_i = \exp\{-u_i\}$, for the simplification of the analysis, this is the structural form proposed in this paper. Assuming that $f(\beta X_{i,})$ behaves like a Cobb-Douglas type function, the MFE is transformed to:

$\mathrm{Log}y_i= \beta_0+\sum \beta_n \mathrm{Log}X_{ni} +v_i-u_i$ 6)

For the purpose of this research the empirical model takes the form:

$\mathrm{Ln}Y_i= \beta_0+\beta_1 \ln x_1+\beta_2 \ln x_2+\beta_3 \ln x_3+\beta_4 \ln x_4+\beta_5 \ln x_5+\beta_6 \ln x_6+(v_i-u_i)$ 7)

Where: Y_i is the observed production of producer i. x_1 is labor, measured in hours of work per day. x_2 is spending on water, in the cultivation of corn, under the current scheme in the study area, this variable is paramount. A lack of, or bad administration of the risks of both pre-sowing and relief, would negatively impact the level of production. x_3 is amount of fertilizer. This variable is measured in total kilograms of fertilizers applied per hectare during the crop cycle, regardless of the type of fertilizer, the most common being urea, anhydrous ammonia and other liquid fertilizers. x_4 is the amount of herbicides applied per hectare. x_5 is the producer’s capital level.

The more capital, the producer is in a better position, since the capital includes aspects such as machinery, better equipment and agricultural implements, access to laboratories for specialized analysis, greater technical assistance and even silos, among other things. x_6 is the total amount of money invested per hectare during the entire cycle. This variable is introduced to the model in part to capture operational expenses. These include transportation costs, fuel, maintenance and repair of equipment, spending on agricultural insurance, telephony expenses, etc. Although it would have been better to use data for each particular input, a reasonable number of producers do not have detailed information (Batesse and Coelli, 1996). The β’s are the parameters to be estimated.

Estimation of the determinants of efficiency

In the second step of the model, the MCO is used to estimate how the variables considered in the model correlate with the estimated efficiency in the first step of the model. Based on the methodology described by Batesse and Coelli (1996) to estimate ET, the model is specified as:

$u= \delta_0+\delta_1 z_1+\delta_2 z_2+\delta_3 z_3+\delta_4 z_4+\delta_5 z_5+\delta_6 z_6+\delta_7 z_7+ e_1$ 8)

In equation (8), u is the effect of inefficiency, or the variance of the nonnegative random variable of equation (2). z_1 is a variable dummy= 1 when the producer i is a member of a producer organization, in our case the confederation of agricultural associations of the state of Sinaloa (CAADES), 0 if it is not. CAADES is an agency whose primary objective is to help increase the level of productivity of agricultural producers in the region. Therefore, it is expected that entrepreneurs who are members of that agency are in a better position than those who do not have ties to it.

z_2 is the level of education of the producer, measured in years of formal education received. A positive relationship with efficiency is expected, since the producers with more education are more inclined to make better decisions, innovate and adopt new technological packages for their own benefit.

z_3 is the age of the producer, the model is incorporated to investigate two questions, first, if it has influence on the level of efficiency of the employer and second, if that influence is positive or negative. Age has been related in other works positively with efficiency, since it is a proxy for experience. Older producers are assumed to have gained experience over time. Although they are also related to being more conservative and exhibit less willingness to adopt new technologies. On the other hand, the literature also reports cases where younger producers have been found more efficient. Presumably because of its tendency to adopt new technologies.

z_4 is a dummy variable on land tenure. The motivation is to establish whether owning the production unit influences the ET. A positive relationship is expected; that is, the producers who own the land will be more efficient than their counterpart, the producers who incur lease contracts. z_5 is a dummy variable that differentiates entrepreneurs by classifying them among those who produce corn and their main source of income. A positive relationship is expected; that is, the producers who perceive the main income from corn cultivation will be more efficient, since their full-time dedication to the cultivation of the grain is assumed.

z_6 is a dummy variable that differentiates married and single entrepreneurs. A positive relationship with efficiency is expected. This is because married producers are presumably older and, therefore, have a greater accumulation of knowledge than single entrepreneurs. z_7 is a dummy variable that indicates whether the entrepreneur performed soil analysis prior to the planting process. A positive correlation with efficiency is expected. The reason is that the analysis of soil allows to determine with greater degree of certainty the requirements of the soils in terms of fertilization, irrigation and management in general. δ's These are parameters to be estimated (Table 2) for a description of all the variables. The statistical analysis can be done with the help of two econometric software: logit 5/Limdep 10 and Frontier 4.0.

Table 2. Description of the variables.

Variable	Description
Production	Total production per hectare
Workforce	Hours of work per man per day
Water	Water expenditure per hectare
Fertilizer	Amount of fertilizer applied per hectare in kilograms
Cost	Total amount of money spent per hectare during the agricultural cycle
CAADES	Variable dummy= “1” if the producer is a member of CAADES, “0” if it is not
Education	Level of education of the producer, 1= primary, 2= secondary, 3= preparatory, 4= degree
Age	Age of the producer
Tenure	Variable dummy= “1” if the producer owns the land, “0” if it is not

Conclusions

This paper proposes a methodology to estimate the ET of corn producers in Sinaloa, although this example can be replicated for other regions of the country and for other crops. Sinaloa is one of the main producers of corn nationwide. Clearly, the conglomerate of producers and the close integration with other actors in the value chain have contributed to the consolidation of the corn entrepreneurs in Sinaloa. However, it is the producers who carry a greater risk in the performance of their activity. The transnational companies that produce the seed and the trading houses of inputs and agricultural machinery, with a lower risk, obtain a higher income. In addition, intermediaries in the marketing phase also participate with a risk comparatively lower than the producer, obtaining higher profits than the producer.

Consequently, corn producers in Sinaloa must innovate their production processes, in order to face the current and future challenges, derived mainly from the transition from the protectionist approach to commercial opening, in a better position. For this reason, the estimation of the level of efficiency prevalent in the region is of particular interest.

From the estimation of the efficiency can be inferred the available space of improvement given the technology and the current form of organization of the corn production in Sinaloa. It is concluded that the stochastic frontier model (MFE) is relevant for this objective, since its validity has been proven in multiple agricultural studies and particularly in maize production in different regions of the world. In this sense, this essay documented the state of the art in terms of measuring agricultural efficiency and concluded by proposing a specific methodology to determine the ET of the corn producer in Sinaloa.

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