Investigation note

Change in real gross income and risk in Mexican agriculture period 1980-1999 *versus* 2000-2019

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Abstract

Mexico has experienced adjustments in its agricultural structure induced by changes in economic policy; the most recent and relevant was carried out during the period 1980-2019. The transition from a closed to an open economy produced an unprecedented change in the productive structure that persists today. This work aimed to measure and compare the variation of real gross income and risk of the main agricultural export products, through the following financial instruments: continuous growth rates, normal distribution, critical values and investment portfolios. This analysis was carried out in two periods called closed economy (1980-1999) and open economy (2000-2019). Selected agricultural products were analyzed individually and grouped: berries, green vegetables, fruits and vegetables. The results show that the risks were lower in the period of open economy for all the products studied and in most of them, the growth rates were positive, which indicates that their real incomes registered an increasing trend. The analysis by group of products in the open economy period showed that berries and vegetables are the ones with the best growth rates with the lowest level of risk compared to the closed economy period. The odds of real incomes decreasing in the open economy decreased, so it is more advisable to invest in both groups of agricultural products in this economic environment compared to the closed economy period.

Keywords: critical values, growth rates, investment portfolios.

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Mexico, until the eighties, was one of the most closed and protected economies in the world. Among the most representative characteristics of that time, we can mention the following: there was a deep intervention of the state in the agricultural sector, mainly through support prices and the control of entry and exit of goods, the exchange rate was fixed and with wide levels of overvaluation. Pedroza (2018) mentions that, between 1980 and 1982, the Mexican Food System (SAM, for its acronym in Spanish) program was developed, whose objectives were to give a boost to the agrifood sector, improve the conditions of peasant families and of the sector itself for greater economic and social stability.

Then the SAM program was abolished and the exchange of imports and commercial exports with the United States of America increased, in addition, credit institutions were created to promote the modernization of the countryside. It was the beginning of the process of economic freedom in Mexico, although state control was still present (Uribe, 2014).

Cárdenas (2010) mentions that, in 1985, Mexico eliminated the protectionist scheme by eliminating most of the requirements of import permits and tariffs were reduced, in just three years the protectionist apparatus was ended and the institutionalization of the structural change towards a more open economy began.

Mella and Mercado (2006) mention that two conditions made possible the change of structure in Mexico: i) the signing of the North American Free Trade Agreement (NAFTA) in 1992; and ii) the deregulation and liberalization of the economy with a strong export orientation. The trade openness, initiated in the 80s and accentuated with the signing of NAFTA, made producers adapt to the prevailing economic, social and technological conditions, this led them to reconvert and modify their production processes and, consequently, the structure of agricultural production was modified by various factors such as the expansion of the agricultural frontier, crop yields and structure (Cruz *et al*., 2012).

These facts show that the main structural reforms have been determined by the stabilization and liberalization of the agricultural sector (Sánchez, 2014), so it is pertinent to measure the variability of the real gross income and the risk to which agricultural export products have been exposed, in order to have a basis that allows making an analysis of public policy and assessing a possible review of it. In order to assess the evolution of the financial conditions of the agricultural products analyzed, emphasis was placed on the contrast of two periods identified in Mexico: closed economy (1980-1999) and open economy (2000-2019).

The present work considers the economic theory that indicates that, when the economy opens, risk, understood as the probability that things will go wrong and the estimation of how much can be lost, increases, since there is greater volatility in the international market (Brambila, 2011). It is hypothesized that, in an open economy, it is more profitable and riskier to invest in agricultural products, with these characteristics being accentuated in the case of exportable products. The objective was to measure and compare the variability of the real gross income and risk of agricultural products in a closed economy (1980-1999) compared to an open economy environment (2000-2019).

This analysis considered the concept of risk as the probability of occurrence of an event below a defined threshold. Risk was measured from the assumption that the price of a good or service summarizes all the information on the market given factor costs. Therefore, the variable that is frequently used to measure the risk of a good, bond, stock or service is the behavior of the real price, which is the nominal price deflated for inflation.

Since the real income of the agricultural producer depends on the price and quantity produced, and because both variables are volatile, the study of growth rates gives information on the variation of real income and their average will measure its trend; if this is positive, the variable tends to grow depending on the study period, if it is negative, the variable tends to grow less. In addition, its risk, measured by the standard deviation of growth rates, shows which products perform better than others (Ross *et al*., 2005).

Brambila *et al*. (2014) conducted a study using continuous growth rates in which they determined that fruits and vegetables are in a preference zone with a positive income trend and low risk and showed that products with low risk have higher growth rates. In addition Domínguez *et al*. (2010) used the critical values to evaluate agricultural projects and found, in the same way, that vegetables and fruits have high critical values compared to cereals, so these products present greater investment risk. Also, Martínez *et al*. (2005) conducted a study on the comparison of estimated variances of price indices and found that this variance in fruit and vegetables is greater when compared with that of cereals; that is, investment in the production of fruits and vegetables has a higher level of risk compared to that made in cereals.

Cruz *et al*. (2012) found that fruits and vegetables have gained relevance in the agricultural sector, representing 35% of the value of national production, although they have a higher level of relative risk. This explains why cereal production has not decreased in the country, since the risk aversion of producers keeps them in the productive structure. The methodology of investment portfolios has been applied in multiple areas of knowledge; for example, León *et al*. (2015) applied it to select an agricultural portfolio, Trinidad *et al*. (2005) to assess an efficient portfolio in organic agriculture, Ramírez and Blanco (2012) in the optimization of portfolios with capital in limited risk and García and Sáez (2015) for the selection of an investment portfolio through the Markowitz model.

Risk, measured by price changes (volatility), was analyzed through the methodology of continuous income growth rates, previously used by Brambila (2011), and based on the following general formula: $FV= Iv(1+\bar{r})^n$. Where: $\bar{r}$= the average discrete motion rate; n= number of periods; FV= final value; Iv= initial value.

To measure the risk and calculate the critical values, initially the behavior of the real incomes (Y) of the products of greater export was obtained, the average rural price of each crop was used, and they were deflated with the general index of consumer prices (base June 2020), in addition, the yield obtained of each crop was used and the real income by crop per year-period was calculated. Subsequently, the growth rate of real income was calculated, which is the natural logarithm of the quotient of income year t divided by the income of the previous year (t-1), as follows: $\hat{r}= \text{Ln}\left(\frac{Fv}{Iv}\right)$. Where: $\hat{r}$= growth rate; Fv= real growth by crop in year (t); Iv= real income by crop in year (t-1). With these growth rates, the mean and variance of the products under study were calculated.

The average of growth rates was interpreted as the growth trend of real income, if this is positive, it is said that the product has a positive growth trend per ton. The standard deviation was used to measure the risk of the product.

Critical values

The objective of the critical value is to find a minimum value that is greater than the investment in the product in scenarios of volatility and risk, such that it indicates how much higher the value of the project must be than the investment so that there are no losses (Domínguez *et al*., 2010). To calculate the critical value of the project, the equations of Brownian motion, Ito's lemma and Bellman's equation are required, the full development of how the final formulas are reached can be found in (Dixit and Pindyck, 1994; Dominguez *et al*., 2010; Brambila, 2011). The critical value is given by $v= \frac{\beta}{\beta-1} I$. Where: β= beta value; I= investment in the product; v= critical value.

The beta value is calculated as follows: $\beta=\frac{-\left(\alpha-\frac{\sigma^2}{2}\right)\pm\sqrt{\left(\alpha-\frac{\sigma^2}{2}\right)^2+2\sigma^2(l)}}{\sigma^2}$. Where: α= average of the continuous growth rates of real income; σ^2= variance of the continuous growth rates of real income; l= discount rate; β= beta value. The value of β is related to the continuous growth rate of product prices. The critical value indicates the level of risk in the benefit/cost ratio to decide to invest in a project; that is, how many times higher the value of the project must be than the investment so that there are no losses.

Investment portfolios

The design of investment portfolios was carried out for export crops, forming the following groups of study: P1= all export products; P2= berries (blueberry, raspberry, strawberry and blackberry); P3= green vegetables (broccoli, cabbage, cauliflower and asparagus); P4= fruits (avocado, walnut, lemon and mango); P5= vegetables (tomato, green chili, cucumber and onion).

The growth rate of the portfolio ($\bar{\mu}_p$) was obtained with the sum of the averages of the rates of return of the products multiplied by x_i, proportion that is invested in product i. $\bar{\mu}_p=\sum_{i=1}^{n} x_i\alpha_i$. Where: $\sum_{i=1}^{n} x_i = 1$. The variance of the portfolio (σ_p^2) was calculated with the matrix of variances and covariances of the products that are included in each of the portfolios. $\sigma_p^2= \sum_{i=1}^{n}\sum_{j=1}^{n} x_i x_j \sigma_{ij}$. σ_p^2= variance of the portfolio. σ_{ij}= variance of product i, if i= j. σ_{ij}= covariance between product i and product j, if i≠ j. x_i and x_j = proportions assigned to each product.

To form a portfolio, all the desired products can be chosen, in the agricultural case, it is enough to have a dispersion of 10 products (Brambila, 2011). The critical value of β of the investment portfolio is solved with the following equation: $\beta= \frac{-\left[\alpha-\frac{1}{2}\alpha^2\right]\pm\sqrt{\left(\alpha-\frac{1}{2}\alpha^2\right)^2-4\left(\frac{1}{2}\alpha^2\right)(-l)}}{\alpha^2}$. Where: β= beta value that depends on α, σ^2, l. α= mean of the portfolio *n*. σ^2= variance of the portfolio n. Once the beta value was calculated, the critical value of the portfolio was obtained with the previously presented formula.

Normality of growth rates

The expected return of the investment portfolio is modeled as a random variable with normal distribution, with constant mean $E(\bar{u}_p)$ and variance (Bodie *et al*., 2005; Ross *et al*., 2005). In the present analysis, the importance of the normal distribution of data is undeniable, since it is an assumption underlying the use of means and variances in the analysis of the profitability and risk of investment projects.

Authors such as Brambila (2011); Walpole *et al*. (2012) consider that, in the risk analysis, the central limit theorem is applicable and that the growth rates obtained in this way, given the number of data that were worked, are sufficient to assume normality. The data for the period analyzed (1980-2019) were obtained from the Agrifood Information Consultation System (SIACON, 2019), which depends on the Agrifood and Fisheries Information Service (SIAP), for its acronym in Spanish, which collects agrifood information on the variables: sown area, harvested area, damaged area, production volume, yields, value of production and average rural price.

It was found that the real incomes of most products grew during the open economy period compared to the closed economy period. Specifically, blackberry, raspberry, cabbage and cauliflower have higher growth rates in the closed economy period, it was even observed that cabbage and mango had negative growth rates for the open economy period. According to the risk analysis, it is noted that, in the period of open economy, the investment risk decreased in most of the products analyzed and, in addition, they had positive growth rates in their real income. Blueberry and raspberry have risks of 49.59% and 49.96%, respectively, with positive rates of 12.57% and 2.54%, and strawberry and blackberry lowered their risk significantly to 12.08% and 28.41%, with positive growth rates in their income of 8.11% and 4.92%. This is how it was found that products with lower risk have better growth rates in their real income in the open economy period, while in the closed economy period, the products presented high risks and growth rates below 4% and negative in 7 products (Table 1).

Table 1. Individual analysis of selected products: growth rates of real gross income (%), risk (%) and critical values (%).

Product	Real gross income		Risk		Critical values	
	I	II	I	II	I	II
Avocado	0.35	0.82	29.37	20.69	1.73	1.58
Blueberry	-14.84	12.57	69.01	49.59	1.52	8.55
Broccoli	-0.06	1.82	19.54	8.24	1.24	1.16
Onion	0.4	4.29	35.48	17.6	1.9	1.78
Green chili	-0.93	5.72	22.72	18.12	1.3	1.39
Cabbage	1.22	-0.79	19.74	12.19	1.42	1.24
Cauliflower	1.17	0.18	22.92	9.89	1.38	1.14
Asparagus	1.99	3.64	32.84	10.87	2.46	1.29
Raspberry	8.88	2.54	63.97	49.96	4.11	2.12
Strawberry	1.62	8.11	35.05	12.08	1.83	1.73

Product	Real gross income		Risk		Critical values	
	I	II	I	II	I	II
Tomato	1.82	4.43	18.35	21.09	1.54	1.51
Lemon	-0.36	2.03	21.7	18.21	1.38	1.57
Mango	-4.2	-0.37	14.09	8.2	1.19	1.21
Walnut	-0.31	3.24	31.03	23.94	1.67	2.03
Cucumber	-0.79	5.55	23.19	12.3	1.4	1.64
Blackberry	18.19	4.92	89.33	28.41	3.04	1.52

Data from SIACON (2019). I= it corresponds to the closed economy period; and II= it corresponds to the open economy period.

These data are consistent with the results of Brambila *et al*. (2014), who observe an increasing trend in the real prices of fruits, green vegetables and vegetables and, in the case of strawberries, find a negative exchange rate. The investment decision includes in its analysis the study of price volatility, for which the critical values of export products were determined with a discount rate of 10%.

Critical values will increase if volatility is high; that is, the greater the risk, the higher the critical value required. In this way, it can be noticed that the blueberry has a high risk, therefore, the minimum required to invest in this crop is that it generates more than 8.5 times the investment; if it is lower, it is not a good decision to invest in the crop. Raspberry halved the investment risk, with the critical value going from 4.11 in the closed economy period to 2.12 in the open economy period.

On the other hand, walnuts, cucumbers, lemons, green chilies and mangoes increased their investment risk in the open economy period. The rest of the products decreased the investment risk.

These results are consistent with what was found when measuring risk by means of the standard deviation of growth rates, where it can be seen that, in the open economy period, the products that have the highest risk percentages are blueberry, raspberry, walnut, onion, strawberry and cucumber. The products that had medium risk are avocado, lemon, blackberry, tomato and green chili. Finally, the products that registered low risk are asparagus, cabbage, mango, broccoli and cauliflower, it should be noted that the products that present the best growth rates in income are those that have medium or low investment risk.

With respect to the construction of product portfolios, the results indicate that most of the investment portfolios studied decreased risk and grew more in the open economy period compared to the closed economy period; for example, the investment risk of the berry portfolio (P2) went from 30.69% in the closed economy period to 14.03% in the open economy period and in the same comparison, the growth rate of gross income went from 3.46% to 7.04%, so it can be seen that growth is higher and investment risk is lower in the open economy period compared to the closed economy period. The vegetable portfolio (P5) also showed an improvement in both variables when we compared the closed economy period and the open economy period; these two portfolios where the ones that showed the lowest investment risk and the greatest growth trend in real gross income (Table 2).

Table 2. Analysis of investment portfolios: risk (%), growth rates of real gross income (%) and critical values (%).

Portfolio	Closed economy period			Open economy period		
	Risk	Real gross income	Critical values	Risk	Real gross income	Critical values
P1	8.65	0.88	1.28	6.1	3.67	1.65
P2	30.69	3.46	2.68	14.03	7.04	3.82
P3	13.47	1.08	1.45	4.87	1.21	1.21
P4	14.28	-1.13	1.3	11.45	1.43	1.42
P5	19.02	0.12	1.54	10.42	4.99	2.2

These results reflect the current trend of the dynamics the market for berries and vegetables for export in Mexico; various authors González (2017); González *et al*. (2019); González-Ramírez *et al*. (2020; Rosales-Soto *et al*. (2020) point out that these agricultural products present a high profitability and a rapid return on investment, which favors their export potential and, therefore, reduces financial risk.

With respect to the critical values by study group, it can be noted that the variation is positive from the closed economy period to the open economy period in most groups. Berries (P2) have the highest critical value in the open economy period, so the minimum required to invest in berries is that it generates more than 3.8 times what is invested, with an investment risk of 14.03% and a growth rate in income of 7.04% (the best rate by group). In fact, in the last 8 years, Mexican strawberry shipments to the United States of America grew 17.3% annually, with a value of 842 million dollars in 2019, in blueberries, Mexico became the third world producer, while in 2012 it was the sixth (SIAP, 2019). In this sense (Rojas-Rojas *et al*., 2021) point out that a high critical value is associated with greater volatility in the price, so the risk of the investment is also higher.

The analysis by group shows that trade openness has benefited these products, as they have improved their growth trends, with an average risk of 11%, but the critical value, which is the minimum required for a product to generate to invest in them, has increased. The best investment groups are berries and vegetables.

Conclusions

In the analysis of the level of risk, what was proposed in the research hypothesis was not verified. The results of this research were in the opposite direction to what was theoretically expected, given that price volatility in the open economy period decreased with respect to the closed economy period. Trade openness has been positive for Mexican agriculture as, in most of the crops analyzed, investment risks decreased, growth rates in real gross income increased and the probabilities of income falling by 10% or more also fell with respect to the closed economy period.

This research not only analyzes the change of the agricultural structure, but measures that change, in this way it raises the need to continue with the analysis of the change of agricultural or livestock structure, through the measurement of risk. It is advisable to complement the results obtained with a market study (supply and demand) to know possible reasons for the behavior of risk in the open economy period and study why the expected results according to economic theory do not occur.

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