Colegio de Postgraduados

# Income variability and agricultural policy

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**ABSTRACT**

**Objective**: To compare producer income volatility under two types of policies (support prices and direct payments).

**Design/Methodology/Approach**: Producer income is understood as the result of multiplying price by yield; therefore, income is the product of two random variables modeled with a lognormal distribution, accounting for the covariance. After the subtracting trend, the cyclical component is subjected to a volatile analysis under each policy studied.

**Results**: Income volatility is systematically higher for support price programs than for the direct payment policy.

**Study Limitations/Implications**: Government programs have recently taken up support prices again; therefore, income variability should be reviewed.

**Findings/Conclusions**: Government programs aim to increase producer income by different means. However, they overlook possible volatility implications. By taking up support price programs again, producer income may be at risk of rebounding.

**Keywords**: Support prices, PROCAMPO, lognormal distribution, trend, cycle.

## INTRODUCTION

Since the second half of the 20th century and up to the present (2022), the government has applied, in separate but continuous periods, two alternate policies regarding the prices of selected agricultural products that affect the magnitude and stability of producer income: 1) the support price policy (PG) and 2) the direct payments to producers, better known as PROCAMPO (PC).

The first, as its name indicates, is focused on the price of agricultural output in the market; meanwhile, the second focuses on a complement to the producer income and is granted based on the area in which the selected crops have been planted (García *et al.* 2011). Each of these policies has a different effect on the producer income level. Hernández and Martínez (2009) have studied this phenomenon; however, they do not mention the problem caused by the variability or stability of the producer income. Income variability is important because it affects the welfare of resource recipients in the face of uncertainty. This phenomenon is the result of price variations in the market or the presence of factors that affect yield (pests, diseases, and other climatic or production process factors). In particular, a risk-averse decision-maker would be willing to pay a risk premium to trade an allocation under uncertain conditions for a risk-free allocation (Friedman and Savage, 1948).

Income variability has been studied from several points of view. Brambila *et al.* (2014) point out that, when prices are experiencing a downwards trend, income growth can only be achieved via intensive, but lower risk methods. Barry *et al.* (2000) studied the

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factors that can explain the movement of agricultural income (such as farm size and yield), in a cross-sectional and time series context, with divergent results for the type of adjustment employed. Mishra and Sandretto (2002) correlated the stability of producer income with off-farm income, concluding that it helps to stabilize agricultural income. Severini *et al.* (2016) found that direct producer support contributes to the reduction of agricultural income variability in Italy. Nitta *et al.* (2022) determined that a direct payment policy has helped to stabilize the income of Japanese rice farmers. Delgadillo *et al.* (2016) have separately established the trend behavior of yield the aforementioned staple crops in Mexico; this component of agricultural income can back up the support price policy. This research reviews agricultural income as the result of price times yield, when both are subject to uncertainty. Therefore, the objective is to determine which type of policy (PG or PC) produces a higher (lower) variability of agricultural income.

On the one hand, a PG policy only affects price, but has no relationship with yield; therefore, it eliminates price uncertainty, but not yield risk. On the other hand, a direct payment does not have a relationship, neither with price nor yield; consequently, price and yield uncertainty remain a problem, although it certainly has an additive and positive effect on producer income. The scale or coverage effect of the policy on producer income depends on the government resources allocated to each policy in question; therefore, policies can have a greater or lower effect on income level, depending on each situation. The specific objective is to research the effect of each policy on the variability of agricultural income, taking its variance as a measure. The analysis considers the following approach: producers are risk-averse and, therefore, greater variability harms their welfare. The hypothesis is whether income variability is or is not the same in each policy arrangement. This research is justified given the recent return to a support price policy in Mexico; therefore, it would be possible to infer the effects of the policy on income variability (Flores *et al.*, 2022).

## MATERIALS AND METHODS

In order to have more information (*i.e.*, replications), the price and yield for wheat and corn in each state were determined, using the average rural price reported by SIAP (2021). Wheat and corn were chosen because both products were subjected to the two policies under study. Their price was likewise used to obtain information on yield and quantity produced, enabling the estimation of the value of the total production and therefore the discrimination of those states to be included in the study. The average rural price was used to quantify the variability. This price is lower under a support price policy. However, in terms of variability, the wheat and corn support price used for the five states under study has approximately a 99% correlation with the said price and, therefore, no information is lost in this regard. The five producing states that contribute most to the value of national production were used in each case. Consequently, five replicates were chosen for both corn and wheat, which generates robust results. The period under study (1980-2018) was divided as follows: PG period (1980-1994) and PC period (1995-2018). Later years were not taken into consideration, because support prices were reinstated. According to the crop produced, the states were divided into two groups: 1) Sinaloa, Jalisco, Estado de México, Michoacán, and Chiapas (corn); and 2) Sonora, Baja California Norte, Guanajuato, Sinaloa, and Michoacán (wheat). Both groups were chosen under the criterion of greatest share of the value of the national production.

Using variance as a measure of variability, the objective is to contrast the following set of hypotheses:

$$Ho = \sigma^2_{PG} = \sigma^2_{PC} \quad vs \quad Ha: \sigma^2_{PG} \neq \sigma^2_{PC}$$

Specifically, this research seeks to determine whether the variance of income under GP is the same as the variance for PC (direct payments). On the one hand, it is well known that variance measurement is sensitive to scale; therefore, the scale effect (trend) is separated beforehand and the variability about that trend is used. In order to measure income, the average rural price (P) is multiplied by the yield per hectare (R), in order to determine the income per hectare. However, this is a product and, provided that income and yield are not independent, the covariance between both variables must be considered to calculate income variance. The distribution of the product of random variables can be difficult to obtain; therefore, a logarithmic transformation is employed to make the income a sum of variables in the logarithm, as suggested by Roy in the 1950s (Heckman and Sattinger, 2015). On the other hand, given their trend, the price and yield data as reported in the official information cannot be used in the analysis. The trend affects the scale of price or yield and therefore the measure of its variability (*i.e.*, variance). To address this problem, the Hodrick-Prescott filter for annualized series —*i.e.*, the frequency of the data in use. This filter decomposes a series in such a way that its value at time t is expressed as the sum of a trend component, a cyclical component, and an irregular component: $Y_t = YT_t + YC_t + \varepsilon_t$ (Cedillo and Martinez, 2019). The analysis interest is the $YC_t$ component, which is trend-free and summarizes the variability of the series around the $YT_t$ trend component. Therefore, the procedure consisted of estimating the cyclical component of both price and yield, based on their logarithmic transformations. With these estimates and by means of the sum, the logarithmically detrended income is determined. This income was fitted to a lognormal distribution. A random variable Z is said to have a lognormal distribution or Galton distribution, if its density function is:

$$f(Z) = \frac{1}{Z\sqrt{2\pi\sigma^2}} Exp\left[-\frac{(\ln(Z)-\mu)^2}{2\sigma^2}\right]; \quad Z \geq 0$$

If the random variable Z has lognormal distribution, then the $Y = \ln(Z)$ random variable has a $Y \sim N(\mu, \sigma^2)$ normal distribution The lognormal distribution is important because it can be fitted to variables with a multiplicative origin, such as income (Lubrano and Ndoye, 2016). Therefore, once the lognormal distribution of income was fitted, the variance homogeneity was tested between the PG period and the PC period.

## RESULTS AND DISCUSSION

For reasons of space, the graphical results for the trend and cyclical components are presented for only one state. Figure 1 and 2 show the trend component and the cyclical component of the average rural price logarithm and the corn yield logarithm, respectively, in the state of Sinaloa. Greater volatility can be detected around the trend in both price and yield in early periods, which correspond to the time during which the support price policy was applied.

The sum of the cyclical components in logarithms was used to obtain a measure the of the income per hectare without trend. Since data from five states per crop was used, the same treatment was applied ten times for prices and yields. The Shapiro-Wilk, Kolmogorov-Smirnov, Cramer-von Mises, and Anderson-Darling tests were used to confirm whether the logarithm of income per hectare fitted or not the normal distribution (Table 1). The laxest fit was recorded in the Estado de México for corn, while the best fit occurred for wheat in Baja California Norte.

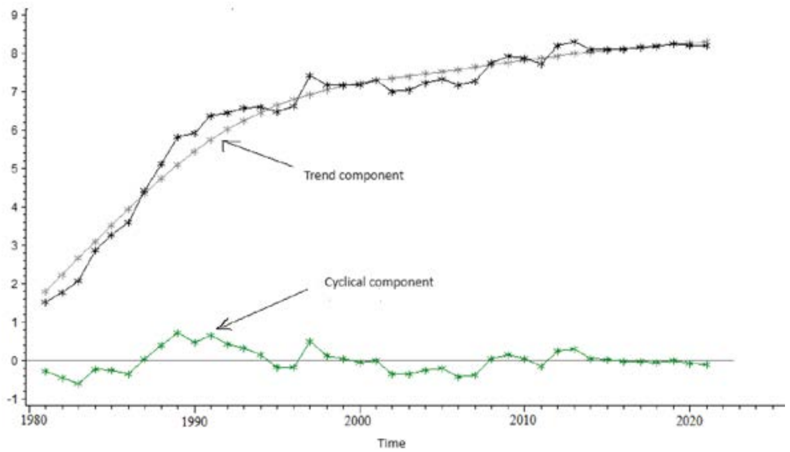


**Figure 1**. Cyclical component and trend of the average rural price of Sinaloa corn (logarithms).

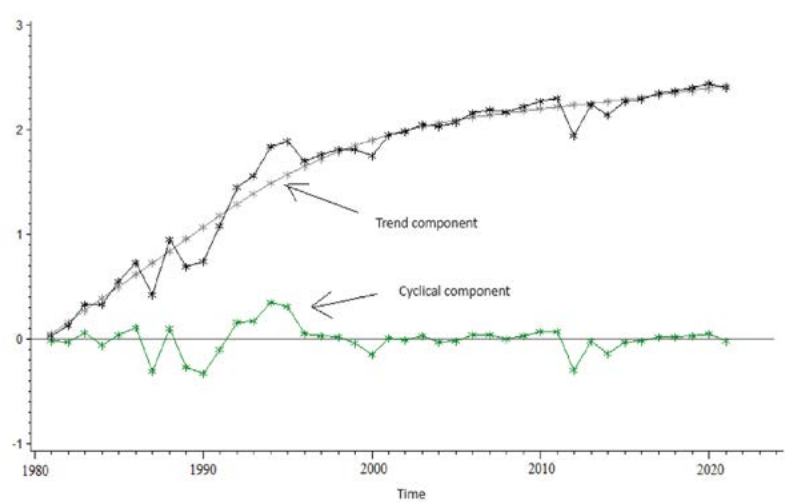


**Figure 2**. Seasonal and cyclical components for the yield of Sinaloa corn (logarithms).

**Table 1**. Fit of the cyclical component of the logarithm of income to the normal distribution.

| **State-Crop / Test** | **Test statistic** | | **Lowest fit** | |
|---|---|---|---|---|
| Edo. Méx-Corn | | | P. value | |
| Shapiro-Wilk | W | 0.945856 | Pr<W | 0.0501 |
| Kolmogorov-Smirnov | D | 0.108594 | Pr>D | >0.1500 |
| Cramer-von Mises | W-Sq | 0.098738 | Pr>W-Sq | 0.1156 |
| Anderson-Darling | A-Sq | 0.697095 | Pr>A-Sq | 0.0670 |
| Baja Calif. N-Wheat | | | Highest fit | |
| Shapiro-Wilk | W | 0.98679 | Pr<W | 0.9081 |
| Kolmogorov-Smirnov | D | 0.06155 | Pr>D | >0.1500 |
| Cramer-von Mises | W-Sq | 0.02784 | Pr>W-Sq | >0.2500 |
| Anderson-Darling | A-Sq | 0.19212 | Pr>A-Sq | >0.2500 |

Table 1 shows that, overall, the fit to the normal distribution of the logarithm of income per hectare (of cyclical components) is not rejected. With this information, the homogeneity of variance is checked for each period, using a variance homogeneity test for normally distributed random variables (Table 2).

In conclusion, the income variability is systematically higher and statistically significant for the support price policy (Table 2). Implicitly, a risk-averse producer would prefer a more stable policy in terms of income volatility. Although it was obtained with a different methodology, this result matches the findings of Severini *et al.* (2016) and Nitta *et al.* (2022).

Using wheat in Sonora as example, by recovering the variance of the cyclical income in its original units (and therefore the standard errors), the change in standard deviation is 0.493302913 for the support price period. In comparison, the change during the

**Table 2**. Income variability per hectare.

| **Corn cultivation** | | | | | |
|---|---|---|---|---|---|
| | **Sinaloa** | **Jalisco** | **Estado de México** | **Michoacán** | **Chiapas** |
| Variance PG | 0.182734558 | 0.206162311 | 0.181956029 | 0.15515793 | 0.12452835 |
| Variance PC | 0.047700009 | 0.031134217 | 0.062842767 | 0.033933596 | 0.04078124 |
| F statistic | 3.830912472 | 6.621727891 | 2.895417193 | 4.572398746 | 3.05356942 |
| P value | 0.002436299 | 4.65892E-05 | 0.012569486 | 0.000751056 | 0.00940477 |
| **Wheat cultivation** | | | | | |
| | **Sonora** | **Baja California norte** | **Guanajuato** | **Sinaloa** | **Michoacán** |
| Variance PG | 0.171150811 | 0.202103682 | 0.184970044 | 0.195872507 | 0.20139651 |
| Variance PC | 0.071175447 | 0.063224239 | 0.079733283 | 0.082057536 | 0.05813431 |
| F statistic | 2.404632755 | 3.196617076 | 2.319859869 | 2.387014242 | 3.46433136 |
| P value | 0.031897241 | 0.007266644 | 0.037625700 | 0.03300812 | 0.00453571 |

PG: Support price; PC: PROCAMPO payments.

direct payments period was 0.274600885. These changes result in a >55% variability in the support price period. Nevertheless, this does not imply that one of the two policies generated higher (lower) income, because the income scale effect has been subtracted. This analysis implies that the support price policy was characterized by higher income volatility. This volatility is a key factor, since a producer (as a credit subject) can be affected by a risk premium —*i.e.*, the credit they can have access to will be more expensive or those that seek agricultural insurance will also be charged a risk premium, resulting in a higher insurance cost.

## CONCLUSIONS

One of the objectives of agricultural policy is to enhance producer income, through the implementation of support price policy and direct payment policy. However, its effect on income variability has been ignored. With price and yield data, this research concludes that, based on previous experience, a support price policy results in higher income volatility, a phenomenon which may discourage risk-averse producers. Nevertheless, now that this type of policies has been taken up again, this information will be useful.

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