HIPPER INFLATION AND MARKET POWER IN AGRICULTURE. A CASE STUDY IN THE BANANA INDUSTRY IN ISRAEL.

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Abstract
In a competitive market, the marginal cost is equal to the production price. On the other hand, if firms have market power, then production price is higher than the marginal cost. The purpose of this study is to test the hypothesis that hipper inflation influences market power. I make the application to the banana industry where a cartel exists but each member firm is a price taker. The present article is unique in testing the hypothesis using direct data on capacity. The results of this study lead to the conclusion that, in the banana industry, there is no relationship between hipper inflation and market power.

Key word: Capacity, Cartel, Inflation, Mark up, Market power, Panel Data.

1. Introduction

In a competitive market, the marginal cost is equal to production price and the allocation of resources is efficient. On the other hand, in a market where firms have market power, production price is higher than marginal cost and there is inefficient resource allocation. The purpose of this study is to test the hypothesis that hipper inflation influences market power. If hipper inflation increase market power, then the importance of fighting inflation increases. The measure of market power used here is the markup. This is the ratio between the price and the marginal cost.

Under competitive conditions and risk neutrality, the markup equals one and increases with the market power of the firms. Over the years 1972-1992, inflation in Israel has varied greatly from 40% to 400% a year, and this makes it a highly suitable location for the study of the impact of hipper inflation on the market. It is my intention to discuss the above issue within the context of the banana industry in Israel. I chose this industry because the banana industry in Israel is centralized thus facilitating a relatively orderly data collection, and the building up of a database for about 50% of banana growers in Israel for the years 1972-1992.

1.1 Theories on the relationship between inflation and market power

Models that consider the relationship between market power and inflation do not agree about the direction of this connection. The models of Benabou (1988, 1992), suggest that inflation decreases market power. These models assume that the following strategies are being employed by producers and consumers:

> Consumer strategy: The consumer decides where to purchase the product after a search process. Based on this process, the consumer develops expectations about the prices in different shops and calculates the expected return from continuing the search. The consumer will continue searching if this return is greater than the cost of continuing the search.
>
> Strategy of the firms: The strategy of the firms is (S,s) (Sheshinski & Weis 77), where firms face fixed cost of adjusting price, and operate in an environment of steady inflation. Optimally, they then keep their nominal price constant while their real price declines from a ceiling **S** to a floor **s<S**, and then readjusts to **S** for a new cycle. As inflation rises, **S** increases and **s** decreases. According to Benabou (1988, 1992), the prices of different firms are scattered on the spread between **s** and **S**.

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Therefore an increasing gap between **s** and **S** translates into a greater price dispersion of the same product by different sellers and increases the return to the search.

The response of the consumer to this situation will be to lengthen the search process. This whole process creates two opposing effects. On the one hand, the increase in price dispersion decreases the amount of information available to the consumer but on the other hand, the increase of search time increases it. According to Benabou, if the market is not completely competitive and if the cost of searching is sufficiently low, the process described above will reduce real price S and s. This will result in a decrease in market power.

Tommasi (94) takes a very different approach. According to Tommasi, a consumer's perspective ranges over more than just one period. From the consumer point of view, the most important aspect is that he or she is uses information about prices in one period to predict prices in the next. The relevant effect of inflation for the consumer is that it decreases the relationship between the prices in a certain store in one period and the prices in the same store in the following period. Hence, Tommasi claims that an increase in the search effort will not improve the level of relevant information for the consumer because, though it increases information about the present situation, it tells the consumer nothing about what will happen in the future. Thus, inflation produces a decrease in the expected return to search. As a result, search efforts decrease as dose the level of information available to the consumer. This in turn enables firms to increase their markup.

2. Measuring Market Power

As mentioned previously, market power will be measured by the mark-up, i.e. the ratio between price and marginal cost. In order to construct the appropriate technique to measure mark-up in the banana industry, we must note that the production function of this industry (as in many other industries) consists of a two-stage process. The first stage is the production process. The quantity of product produced during this stage will be called the capacity (henceforth denoted by **V**). Marketing is the second stage of this process. At this point, the producer must decide what is the proportion of the capacity he or she wants to market. This quantity will be called the output. The costs of this type of model can be divided into two categories:

(a) Capacity Production Costs: These are the costs generated during the first stage, before the demand has been realized.

(b) Operating Costs: These are the costs generated by the second stage, i.e. after a decision has been made about the quantity of product to actually be marketed.

When we wish to measure market power using this type of production function, we must distinguish between two main cases: In the first case, the quantity of product to be marketed (henceforth the output) is a definite known, and it is possible to control the quantity that will be produced. In this case, the quantity that will be produced matches the marketed quantity. Consequently the marginal costs generated by the production of the output correspond with the marginal costs of capacity production. In this case, market power can be estimated using the following formula:

(2.1) $$\mathbf{m} = \frac{\mathbf{p}}{\mathbf{mc}}$$

whereby **P** denotes the price of one marketed unit, and **mc** denotes the marginal costs generated by the production of the output or the marginal costs of the capacity production.

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However, if the desired quantity to be marketed is uncertain when the decision is being made about the quantity to be produced, the decisions required regarding production quantity and marketable quantity must be made separately. In this case, measuring market power must take both factors into account, but this will require an appropriate model.
The Peak-load Pricing model, as presented in an article by Williamson, enables us to measure mark-up under the above-mentioned production technology conditions. This model assumes that there are only two means of realizing demand. Low demand (low) and high demand (peak) whereby the probability of peak demand is α and the probability of a low demand is $(\mathbf{1-\alpha})$. It is assumed that operational costs per unit (henceforth denoted by **b**) are fixed, and the capacity production function has constant return to scale. The marginal capacity costs will be denoted by **MCC**. Williamson shows that if there is a competitive market, then during a peak period the entire capacity will be sold at a price $\mathbf{b+\frac{MCC}{\alpha}}$. However, during low periods only part of the capacity will be sold, and the price will be equal to the operational costs, i.e. **b** (all fixed costs will be covered during peak periods). It should be noted that, according to this model, even in a competitive market, it is likely that a proportion of the yield will not be marketed.
I will show that the above-mentioned situation is congruent with competition (i.e. the producers' expected profits are stand at zero). According to the following equation the producer's expected costs will be:

$$\text{(2.2)} \qquad \mathbf{TC = V*MCC+\alpha*b*V+(1-\alpha)*b*Q_L}$$

whereby **V** denotes capacity, and $\mathbf{Q_L}$ denotes the marketed output during a low period. The expected revenue is given by

$$\text{(2.3)} \qquad \mathbf{TR = \alpha*V*(\frac{MCC}{\alpha}+b)+(1-\alpha)*Q_L*b = V*MCC+\alpha*b*V+(1-\alpha)*b*Q_L}$$

This implies, **TR = TC**.

2.1 Measuring Market Power according to Peak-loading Pricing Model

According to this model, there are two decisive points for the firm. The first is when determining the capacity, and the second is during the marketing process when the producer must decide what proportion of the capacity will be marketed. The following procedure enables us to measure market power at the deciding point regarding capacity. From the previous equation, we can also receive the following:

$$\text{(2.4)} \qquad \mathbf{TR = V*MCC+b[\alpha*V+(1-\alpha)*Q_L]}$$

The expression $\mathbf{\alpha*V+(1-\alpha)*Q_L}$ is the expected output. We denote it by **Q**.
If we divide both sides of the equation by **Q**, we will get

$$\text{(2.5)} \qquad \mathbf{p = MCC*\frac{V}{Q}+b}$$

where **p** denotes the expected revenue per unit of output. By re-arranging the equation we will receive

(2.6) $$\frac{\mathbf{Q}}{\mathbf{V}} * (\mathbf{p} - \mathbf{b}) = \mathbf{MCC}$$

The expression $\frac{\mathbf{Q}}{\mathbf{V}}$ is the probability that output unit will be sold. It follows, therefore, that the left side of the equation denotes the net expected revenue per unit of capacity (net, deduction of operational costs). We denote it by $\boldsymbol{\pi}$. From the previous equation we find that $\boldsymbol{\pi}$ should be equal to **MCC**.

In order to measure the market power in this model we will divide the net expected revenue per unit of capacity by the marginal capacity costs. This will give us the "capacity mark-up" (henceforth the markup):

(2.7) $$\mathbf{M} = \frac{\pi}{\mathbf{MCC}}$$

As can be seen, in order to measure the capacity mark-up we require data about capacity size. Usually researchers only have access to data on the output and in fact, studies that wished to estimate the markup were forced to use a proxy for the capacity. See Abott,Griliches & Hausman (88), Eden & Griliches (93), Dana (1999), Eden (2001),and Puller (2007).

. My data set is unique in that it includes direct rather then proxy statistics for the capacity.

3. The Banana industry

Structure of the Market: During the period covered by this study, most Israeli banana growers were members of a cartel "The Association of Banana Growers" (henceforth "The cartel") which produces and markets most of the bananas in Israel. The cartel controls production by setting the area that each grower may plant. However, since the growers are small in proportion to the size of the market, they take the price as a given. This means that they choose the capacity according to the equality between "the expected net revenue per unit of capacity" (π) and "the marginal capacity costs" (**MCC**). This has two consequences:

1. We assume that the cartel knows the cost function and the revenue expectation of each individual grower. Consequently the cartel also knows the capacity each grower will chose for each dunam. Therefore when the cartel fixes the area to be planted and π, it also determines the level of capacity.
2. The growers all equate their **MCC** to the same π. Therefore **MCC** of all the growers are equal.

The area planted by various growers is not equal therefore the cartel must ensure that relative sizes are maintained each season, to prevent growers who feel they have been discriminated against in this respect from resigning their membership in the cartel. It follows that when the cartel wishes to change by a certain percentage the overall area to be planted in a certain year, the area allocated to each grower for planting must also be adjusted by the same percentage. It should be noted that the Association is comprised of only part of the total number of banana growers in Israel. The other banana growers are small farmers (members of cooperative farming communities - *Moshavim*) who function independently and who decide whether or not to enter the industry according to the market situation. Entry into the banana industry entails certain cost and this fact grants the Association some protection from competition, in the short run. However, if the industry produces high enough profits over a long time, more small growers may enter the industry. It follows from the above, that the cartel is not a pure monopoly but only a price leader which, despite its efficient and centralized structure, may have just low market power.

4. Estimating the Market Power of the Banana Growers' Association

We estimate the market power of the Banana Growers' Association by estimating the markup of the capacity using the technique suggested by Hall. As previously stated, the markup of the capacity, in short the markup, is given by equation (2.7) above. We shall show that we can estimate the markup by dividing the elasticity of capacity with respect to any factor by the share of this factor in the expected net revenue. Because the size of the cultivated area is the factor that the cartel decides upon, we use this factor in our estimation process. Denote the cultivated area by **K**. The production capacity elasticity with respect to the area planted is defined as:

$$(4.1) \quad \beta_k = \frac{\Delta V/V}{\Delta K/K}$$

where **V** denotes the capacity. In addition, **Sk** denotes the share of the cultivated area in the expected net revenue as in the next equation:

$$(4.2) \quad Sk = \frac{rK}{\pi V}$$

where r is the cost of growing bananas on one dunam for one season (Details on the calculation of Sk are provided in Shahor - available on request). . Using the above definitions it can be seen that

$$(4.3) \quad \frac{\beta_k}{Sk} = \frac{\frac{\Delta V/V}{\Delta K/K}}{\frac{rK}{\pi V}} = \frac{\pi \Delta V}{r \Delta K} = \frac{\pi}{\frac{r}{\Delta V/\Delta K}}$$

The expression $\frac{\Delta V}{\Delta K}$ represents the marginal capacity production of K. r represent the price of K. Therefore,

$$(4.4) \quad \frac{r}{\Delta V/\Delta K} = MCC$$

If we integrate (4.3) and (4.4) we get

$$(4.5) \quad \frac{\beta_k}{Sk} = \frac{\pi}{MCC} = M$$

4. 1 Empirical test of the effect of inflation on the markup under the assumption that elasticity of capacity with respect to K (β_k) is constant

In the first instance, we assume that the size of β_k is constant. Equation (4.5) shows that under this assumption, an inverse relationship between **Sk** and the markup exist. Thus, in order to test the influence of inflation on the markup, it is sufficient to test its influence on **Sk**.

Data Base

The sample we use in this research consist of 16 banana growers from the Jordan Valley, Israel. The research period is 1972 – 1992. During this period the growers from the Jordan Valley produced about half of Israel's bananas. Altogether the research is based on 320 observations. The data was gleaned from regional and national annual reports published by the banana growers in cooperation with the Ministry of Agriculture.

During the period studied there were great fluctuations in the levels of inflation. We are therefore able to divide the sample into three sub-periods according to different inflation levels. The twenty years period can be divided as follows:

1972-79 - inflation rates ranged between 35%-68%.
1980-85 - inflation rates ranged between 117%-380%.
1987-92 - inflation rates ranged between 16%-18%.
(1986 was a transition year and is not included in any of these groups).

- The averages and standard deviations of **Sk** for each period appear in table (1). (Details on the calculation of Sk are provided in Shahor - available on request.)

Table 1: The influence of inflation on Sk in the banana industry

Year	Inflation	Sk	Std. Dev. of Sk
73-79	35%-68%	0.60	0.15
80-85	117%-380%	0.52	0.08
87-92	16%-18%	0.47	0.09

This table shows that there is no relationship between **sk** and inflation. In addition, I computed the correlation coefficient between annual **Sk** and inflation for the years 1973 - 1992. The result is 0.09. This reinforces the conclusion that under the assumption that β_k is constant, inflation has no relationship with the markup.

4. 2. Empirical test of the effect of inflation on the markup without the assumption that the elasticity of capacity with respect to K (β_k) is constant

In this instance, changes in markup are caused not only by changes in the value of **Sk** but also by changes in the value of β_k. In this case it is possible to test the influence of the inflation on the markup by using the capacity production function, which appears in the following equation (Details on the construction of this function appear in Shahor):

(4.6) $$\mathbf{V = (e^{\tau})^{\beta_\tau} e^{\alpha_n} K^{\beta_k} U^{\beta_u} A^{\beta_a} L^{\beta_l}}$$

where

- **V** denotes capacity (Details on the calculation of V are provided in appendix 1).
- α_n denotes the individual effect of each banana grower.
- e^{τ} denotes the trend variable that reflects technological improvements when τ equal 1 for the first period, 2 for the second period and so on.
- **K** denotes the area cultivated.
- **A** denotes the average age of the plantation (the younger the plantation, the greater the yield).
- **L** denotes the labor to create capacity.
- **U** denotes the rate of capacity utilized in the previous year. It reflects damage caused by natural disasters in the previous year. (Natural disasters that reduce the utilization of capacity in a previous year also damage the banana plants and thus reduce the capacity of the current year).

If we take the first differences of ln over time, we get

(4.7) $$\mathbf{dv = \beta_\tau + \beta_k dk + \beta_u du + \beta_a da + \beta_L dl + \varepsilon}$$

where

(4.8) $$\mathbf{dx = \ln X_t - \ln\ X_{t-1}}$$

Note that taking the first difference of the firm observations over time, eliminates α_n (the individual effect).

In order to carry out the test, we should be reminded that it follows from equation (4.5) that:

(4.9) $\boldsymbol{\beta_k = M \cdot Sk}$

Inserting $\boldsymbol{\beta_k}$ into the regression formula (4.8) we get:

(4.10) $\boldsymbol{dv = \beta_\tau + M \cdot (Sk \cdot dk) + \beta_u du + \beta_a da + \beta_L dl + \varepsilon}$

In this equation, the second independent variable is the product of **Sk** by **dk** and its coefficient **M** is the markup. In order to test the hypothesis that inflation influences the markup note that

(4.11) $\boldsymbol{M = \tilde{M} + \theta inf.}$

where $\tilde{M}$ denotes the markup when the price are stable, and **inf**. denotes inflation. If we substitute (4.10) into (4.11) we get

(4.12) $\boldsymbol{dv = \beta_\tau + \tilde{M} \cdot Sk \cdot dk + \theta(inf \cdot sk \cdot dk) + \beta_u du + \beta_a da + \beta_L dl + \varepsilon}$

Testing the hypothesis that $\boldsymbol{\theta}$ differs from zero is identical to testing the hypothesis that the size of **M** is dependent on inflation. In order to perform the test we have to run the equation (4.12) as a regression.

While one would expect to make this estimation using a time series of data obtained for the entire cartel, the number of observations in such a series will be too small and therefore will not provide enough degrees of freedom.

We can solve this problem by using observations of the firms that comprise the cartel. As shown below, it can be seen that even if we use the observations of the members of the cartel, the coefficient **M** in (4.10) is still the estimator for the markup of the cartel and $\boldsymbol{\theta}$ in (4.12) still shows the affect of the inflation on the markup of the cartel. This will be correct if we add three assumptions:

Assumption 1: The production capacity elasticity of each individual grower is equal.

Assumption 2: The cartel functions with the following restriction: every change that the cartel makes in the size of the cultivated area needs to be distributed among the growers such that the ratio between their areas remains the same. This means that when the cartel changes the size of the cultivated area then the rate of the change of each grower is equal to the rate of change of the whole cartel.

The above assumptions lead to the conclusion that the elasticity of capacity with respect to the area at the disposal of each of the individual firms is identical to the elasticity of capacity with respect to the area of the cartel as a whole.

Assumption 3: The size of **Sk** is fixed by the cartel. **K** and π are fixed by it directly, **r** is given exogenously and if the growers are price takers then it follows that if the cartel chose $\boldsymbol{\pi}$ it also fixed the capacity.

To conclude: as shown previously, $\boldsymbol{\beta_k}$ of the individual growers is equal to β_k of the cartel. Furthermore, the size of **Sk** is fixed by the cartel. Thus using the observations of the cartel members, the coefficient **M** in (4.10) is the estimator for the markup of the cartel, and $\boldsymbol{\theta}$ in (4.12) shows the affect of the inflation on the markup of the cartel.

(Note: if we use factors whose size is not fixed by the cartel, then **M** and θ do not indicate the behavior of the cartel).

When we ran (4.12) as regression for the years 1974-92 we received the following outcome (standard deviations in parentheses):

$$\mathbf{dv = \underset{(0.009)}{0.021} + \underset{(0.18)}{1.93}\,(sk \cdot dk) - \underset{(0.18)}{0.29}\,(inf \cdot sk \cdot dk) + \underset{(0.05)}{0.63}\,du - \underset{(0.08)}{0.37}\,da + \underset{(0.05)}{0.08}\,dl}$$

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where $\mathbf{R^2 = 0.57}$(Appendixes 2 and 3 review some problems that arise when using panel data). It can be seen that the $\boldsymbol{\theta}$ (the coefficient of the variable $\mathbf{inf \cdot sk \cdot dk}$) is 0.29 with a standard deviation 0.18. Therefore, we reject the hypothesis that $\boldsymbol{\theta}$ is difrent from zero. This implies that the hypothesis that inflation influences the markup is also rejected.

The markup is 1.93, significantly greater than the competitive level 1. This outcome raises the following question: Why does such a large markup not cause other potential growers to enter the industry.

One possible explanation for this can be found in Sandmo. He claims that the approach whereby in a free market the marginal costs should be equal to the price is based on the assumption that the conditions of the market are known with certainty, or alternatively, that the producer is risk neutral. If there are conditions of uncertainty and the producer is risk averse then the markup is expected to be greater then one unit. To show this Sandmo assumes that decisions about the quantity are taken when the producer only knows the distribution of the price and not the exact prices. Sandmo shows that even when the firm is a price taker, risk aversion will cause a lowering of the optimal quantity produced by the producers. It follows that if there is uncertainty in the system and producers are risk averse then the expected price will be higher than the marginal cost even if the producers are price takers.

If potential producer is risk averse then he has a certain risk premium. Therefor a potential producer will only enter the industry if $\boldsymbol{\pi}$ equals at least the sum of $\mathbf{MCC}$ and the risk premium. Therefore the fact that $\boldsymbol{\pi} > \mathbf{MCC}$ may not be sufficient to induce new firms to enter the industry. Furthermore, we must remember that additional potential growers (members of cooperative farms - *moshavim)* are smaller than cartel members and therefore it is reasonable to expect that their aversion to risk would be higher. This factor would increase their risk premium and decrease their tendency to enter the industry.

5. Conclusion

The results of the study show that there was no significant relationship between the rate of inflation and the size of the markup. In surveying the literature, I related to a number of models that predict that markup is influenced by inflation (Benabou predict that inflation decreases the markup, while Tommasi predicts that it increases it).To explain this contradiction it should be noted that in the above models, the changes in the markup are caused by the increasing gap between **s** and **S** which is caused by the increase in the cost of adjusting the price. In the banana industry (as in any agricultural industry) the main reason for changes in price is supply shocks not inflation. Thus a rise in inflation does not increase the cost of price adjustment. In order to check if there is a relationship between inflation and markup, further research should examine this relationship in an industry where inflation is the main cause of price fluctuations.

In this study, I also estimated the markup of the banana industry which was 1.92 with a standard deviation of 0.18. Under conditions of certainty and/or risk neutral this result suggests that the producers have market power. However, under uncertainty and risk aversion, the gap between $\boldsymbol{\pi}$ and $\mathbf{MCC}$ may result from the risk aversion of the producers and their risk premium. Further exploration should therefore estimate the markup in industries with the same cost and market structure but with less risk, in order to assess whether their markup is lower.

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6. Appendix

6.1 Appendix 1: Calculating the independent Variable of Capacity Production Function – V

The calculation of **V** raises two problems:

(1) Calculating the weight of the capacity: The banana growers chose the capacity at the beginning of the period. It is highly likely that some of the capacity will not supply to the **market because weather conditions may damage some product, thereby reducing the weight of bunches, or may completely destroy some of them. Consequently we do not have direct data about the capacity weight. The data is available refers to the number of bunches in the capacity, denoted by B, and the average planned weight of those bunches denoted by W. The product of B multiplied by A is the weight of the capacity.**

(2) Weighed the weight by the relative price of each grower: In the banana industry, as in other agricultural industries, prices change during the season. In mid-season, prices are

low, and at the beginning and end of the season, prices are higher. Bananas can not be stored, but the growers can use some agro-technical activities to influence ripening time which then affect the supply of the fruit to the market. Marketing the bananas in high price implies low bunch weight because bunches that ripen at the beginning and end of the season (when prices are high) are small. This means that if the grower use some agro-technical activities to ripen the crop for mid-season marketing, when the weight of bunches will be at is highest, the grower will receive a low price.

The producer's target is maximum profit not maximum quantity. It is plausible that some of the agro-technical activities that the grower use to increase profit will actually reduce the weight of bunches. Therefore the weight can't be the dependent variable in the capacity production function. On the other hand, the dependent variable cannot be the revenue because the banana price is fixed by the cartel and not by the individual producers. However, by controlling the banana ripening time, the grower may cause his average annual price to be different from the average annual price of the cartel. Thus the grower can influence the relative price. The above discussion implies that the dependent variable of the capacity production function is calculated by:

(6.1) $$\mathbf{V_t^n = \frac{P_t^n}{P_t} B_t^n W_t^n}$$

where **t** is the index of the years, **n** is the index of the growers, $\mathbf{P_t^n}$ is the average price per ton of bananas grower **n** in year **t**, and $\mathbf{P_t}$ is the average price of all the sample in year **t.**

6.2 Appendix 2: Unit Root Test

The theory behind panel data estimation is based on stationary time series. In order to test if series is stationary, consider first an AR (1) process

(6.2) $$\mathbf{y_t = \mu + \rho \cdot y_{t-1} + \varepsilon_t}$$

where $\mathbf{\mu\, and \rho}$ are parameters and $\mathbf{\varepsilon_\aleph}$ is assumed to be white noise. **Y** is stationary series if $\mathbf{-1 < \rho < 1}$. The null hypothesis is

(6.3) $\mathbf{H_0 : \rho = 1}$.

Since explosive series do not make much economic sense, this null hypothesis is tested against the one sided alternative

(6.4) $\mathbf{H_0 : \rho < 1}$.

In Eviews program, the test is carried out by estimating the equation:

(6.5) $$\mathbf{\Delta y_t = \mu + \gamma y_{t-1} + \varepsilon_t}$$

Where

(6.6) $\mathbf{\gamma = \rho - 1}$,

and the null and alternative hypotheses are

(6.7) $\mathbf{H_0 : \gamma = 0 \quad H_1 : \gamma < 0}$

While it may appear that the test can be carried out by performing a t-test on the estimated $\mathbf{\gamma}$, the t-statistic under the null hypothesis of a unit root does not have the conventional t-distribution. Therefore Eviews uses the Mackinnon critical values for the unit root test.

In our research the test is carried out on the lagged difference series that I use in the regression, that is, if the basic series is $\mathbf{X_t}$ then the test is carried out on the series $\mathbf{dx = X_t - X_{t-1}}$.

Our database includes 4 variables and 16 producers, thus we must test 64 series. The results of this test provide in table 2.

Table 2: Examination of the stationarity in the bananas' industry

Producers	Variables			
	dv	dk	Da	Du
1	-4.9	-3.6	-5.9	-3.6
2	-3.9	-2.6	-4.4	-3.2
3	-4.1	-5.33	-7.2	-3.7
4	-3.4	-3.06	-6.6	-3.6
5	-3.9	-1.97	-6.1	-3.2
6	-4.5	-4.0	-3.0	-3.2
7	-4.1	-1.98	-6.6	-4.0
8	-3.9	-2.5	-3.8	-3.3
9	-3.93	-2.97	-3.9	-2.8
10	-4.9	-3.2	-4.1	-3.0
11	-3.7	-3.3	-4.2	-3.5
12	-3.3	-4.2	-3.3	-3.3
13	-4.2	-3.2	-5.2	-3.0
14	-3.8	-4.4	-3.4	-4.1
15	-3.5	-3.8	-3.5	-3.1
16	-4.2	-3.1	-5.3	-4.1

The MacKinnon critical values for rejection of a unit root are:
1% critical value -2.7
5% critical value -1.96
10% critical value -1.62

The null hypothesis of a unit root is rejected against the one sided alternative if the t-statistic is less then the critical value. It can be seen from table 2 that in our case, the test rejects the null hypothesis of all the series at the 5% level of significance.

6.3 Appendix 3: Homogeneity of the growers

If we want to pool the data and estimate a single equation, we must test whether or not slops and intercepts simultaneously are homogeneous among different individuals at different times. To start, we assume that parameters are constant over time, but can vary across growers. Thus, we can postulate a separate regression for each grower:

$$\text{(6.8)} \quad \mathbf{Y_{nt} = \alpha_n + \beta_n ' X_{nt} + u_{nt}}$$

The sum of squares in this unrestricted case is

$$\text{(6.9)} \quad \mathbf{S_1 = \sum_n Rss_n} ,$$

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where RSS_n denotes the residual sum of squares of group **n.** In the restrictions we want to impose on (6.8) both slope and intercept coefficients are the same, that is:

$$(6.10) \qquad \mathbf{Y_{nt}} = \alpha + \beta \mathbf{X_{nt}} + \mathbf{u_{nt}} \, .$$

The residual sum of squares of (6.10) is denoted by $\mathbf{S_2}$. Under the assumption that $\mathbf{U_{nt}}$ are independently distributed over **n** and **t** with mean zero and variance σ_u^2, *F* test can be used to test the restrictions postulated by (6.10). In effect, (6.10) can be viewed as subject to **(K+1)(N-1)** linear restrictions:

$$(6.11) \qquad \begin{aligned} \mathbf{H_2} : \alpha_1 &= \alpha_2 = \ldots = \alpha_N \\ \beta_1 &= \beta_2 = \ldots = \beta_N \end{aligned}$$

The *F* statistic,

$$(6.12) \qquad \mathbf{F} = \frac{(\mathbf{S_2} - \mathbf{S_1})/(\mathbf{N}-1)(\mathbf{K}+1)}{\mathbf{S_1}/\{\mathbf{NT} - \mathbf{N}(\mathbf{K}+1)\}} \; .$$

can be used to test H_2. If this *F* statistics with **(N-1)(K+1)** and **N(T-K-1)** degrees of freedom is not significant, we can pool the data and estimate a single equation of (6.10) with OLS.

In our research **T = 19, K = 3, N = 16,** $\mathbf{S_1 = 5.716}$ and $\mathbf{S_2 = 7.24}$, thus $F = 1.066$ with 60 and 240 degrees of freedom. The 5% significance point is 1.32. Thus, the above value of *F* is not significant and we do not reject the hypothesis that both slope and intercept coefficients are the same. This means that we can pool the data and estimate a single equation with OLS.