MEASURING THE CARTEL'S MARKET POWER
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Abstract
This article proposes a new technique using markup to measure the market power of producers. Markup is the correlation between price and marginal cost (calculated by dividing the price by the marginal cost). The technique used in this study is unique because it enables us to estimate the marginal cost without estimating the production function. Using this technique, the following assumptions can be empirically tested: If firms that are members of a cartel are small enough, and the restrictions applied by the cartel to its members concern the quantity of one of its inputs (and not the marketed quantity), the firms will produce a quantity where the marginal cost will equal the price. Performing such a test requires an exceptionally detailed data base. For this study, I am utilizing the detailed database generated by the banana industry in Israel to test this hypothesis.

Key word: Cartel, Mark up, Market power, price, marginal cost

Introduction
A firm's market power is very important for both the micro and the macro economy. According to Muller (2006), market power is one of the factors that can influence price levels and market response to the business cycle. Banerjee and Russell (2005) also examined the correlation between market power and inflation and Ruger and Kjartan (2010) examined the correlation between market power and salaries.

This article contributes to the debate about market power because of the method that it proposes using to empirically measure the market power of firms that are members of a cartel. In particular, this paper checks empirically the following hypothesis: if the cartel member firms are small enough, and the restrictions applied by the cartel to its member companies concern the quantity of one of the inputs (and not the marketed quantity), then the firms will produce the quantity that generates marginal costs equal to the price. The basis for this claim is that if the quotas are applied to one of the inputs, then under these restrictions the firms will try to maximize their profit. In addition, if the firms are small enough, they will accept the price as a given (price taker). Therefore, in order to earn maximum profit they must produce the quantity that generates marginal costs that are equal to the price. However, the limitations of a specific input can raise the curve of the marginal costs. This may cause the price balance may be different from a competition-based price balance, but this difference is generated by the cartel itself. The price and marginal costs must be equalized for each manufacturer.

If the cartel member firms are big enough to influence the price that the cartel receives then the demand curve which they face will not be totally inflexible. This situation generates a disparity between the marginal costs and the price. This disparity indicates the existence of a market power which I plan to measure in this study. The correlation between the price and the marginal costs, which is known as markup, will be used to make this measurement. As can be seen, in the markup competition, there is one [player] which will grow as long as market power grows. This study is notable because it enables to the marginal costs to be estimated without needing to estimate the production function or the expenditure function.

1 The Max Stern Academic College of Emek Yezreel, Emek Yezreel, Israel; tals@yvc.ac.il
2 To measure the market power of the cartel itself, it is necessary to repeat the process with the limited input, that is with the size of the area.
Firms that are members of the banana growers organization will participate in the test. This organization is comprised of the majority of banana growers in Israel and their membership covers the following aspects:

1. The entire crop grown by the member firms will be marketed in a concentrated manner.
2. The cartel imposes restrictions on the size of the growing area of each of the firms.

There are two reasons for imposing the restrictions on the size of the land and not on the marketed output:

a) Imposing limitations on the size of the growing area ensures that the land's output (which farmers regard as the most important aspect) will be optimally utilized.

b) Quotas on the quantity of product that goes to market almost inevitably involves destruction of part of the crop. Experience shows that it is difficult for farmers to bear this situation both because of their desire to make a profit, and because of the cognitive difficulty they have at the thought of destroying their harvest. Consequently, attempts to limit the size of the marketable harvest fail. Supervision of the size of cultivated land area is easier and more effective.

**Measuring Market Power of a Single Member Firm in the Cartel**

Firstly we can see that in order to measure the markup it is sufficient to check how the producer uses one input. The condition for maximum profit is:

\[ \text{MC} = \frac{p_j}{mp_j} \quad j=1,2,...,N \]

When \( j=1,2,...,N \) these are the inputs that can be changed, \( p_j \) represents the price of the input \( j \), and \( mp_j \) represent the marginal yield of the input \( j \). The desired markup is calculated according to the following formula:

\[ M = \frac{P}{MC} \]

when \( P \) represents the price for one ton of bananas. The above equation indicates that the markup can be calculated using each of the variable inputs. In other words, in the banana industry, only the size of the land is restricted. We can therefore use each of the other components in order to calculate the individual banana grower's markup.

**Markup Calculation**

Many studies tried to measure market power using the markup. Hall (1988) calculated markup by dividing production flexibility in proportion to labor in the labor share segment. Abbott, Griliches & Hausman (1988) and Eden & Griliches (1993) added to the regression that estimates production flexibility the rate of utilization of labor power. Domowitz, Hubbard & Petersen (1988) repeated Hall's technique while using the raw material input instead of the labor input. All these studies are forced to estimate the production function despite all the difficulties involved.

Another group of studies tried to avoid the need to estimate the production function. Instead, they tried to exploit the fact that usually data is available about the state of the market (prices and quantities) and about exogenous variables that may influence the firms' expenses. Bresnahan (1989)
reviewed studies performed under these conditions. An interesting development of this technique appears in a study by Finkelstain & Kachel (1996) in which they exploited data available on selling agricultural produce to two different markets in order to estimate the market power of branches of agriculture in Israel.

In this study, I intend to utilize the structure of the banana industry and the detailed database available in order to present a new technique which facilitates finding the approximate marginal costs without estimating the production function. To demonstrate this method, we will first present a number of aspects characteristic of the banana plant.

The banana plant is an annual that produces a crop of fruit at the end of each year and then dies. However, before it dies, each tree produces a number of seedlings that can be raised to produce fruit at the end of the following year. This process will repeat itself ad infinitum thus a particular plot of land will produce additional crops without any need for replanting (this also occurs when the banana grows wild in nature). However, the crop produced changes with the age of the plantation. In the year when the bananas are first planted, they do not produce any fruit at all. The first crop (produced during the second year) is very low (approximately 33% at its peak). In the following two years, the crop will be at its peak, and is then followed by a gradual reduction in crop size. The reason for this reduction is over-utilization of different elements in the soil, diseases that develop and so forth. To solve this problem, it is necessary to uproot the plants every few years, and grow at least one different crop, usually wheat, to dry out the soil. (The value of the wheat harvest is usually relatively small compared to that of the bananas and will therefore be ignored for the remainder of this study.) Following this process, the fields can be replanted and will produce a maximum yield. We will summarize the stages of this process:

- Stage 1: Planting the fields – no crop
- Stage 2: First crop – very low (approximately 33% of a peak crop)
- Stage 3: Second and third crops – peak yields
- Stage 4: Over the next years (until the plants are uprooted) – yield declines gradually
- Stage 5: Banana plants are uprooted – wheat grown instead for at least one year
- Stage 6: Plantation is replanted – the process goes back to the beginning.

The life span of the plantation is the time that passes from the time the plantation first produces a crop (Stage 2 above) until the year when the plants are uprooted. As we will see at a later stage in this study (from the data in Table 1), the shortened life span of the plantation is affected by two components:

1. **Increased expenditure**: The shorter life span requires the plantation to be replanted more frequently, which increases the expenses.
2. **Increased production**: The direction of influence on production is not entirely clear because on one hand there are more instances of first year harvest which is always particularly small, while on the other hand avoiding the later years which are also characterized by small harvests. An empirical test, which will be presented later in this paper, shows that within the relevant range, shortening the life span increases the output.

The above analysis indicates that shortening the life of the plantation increases both the expenses and the output, and can therefore be regarded as an input.

As we have seen, the planting stage is consequential over a number of periods. Both the expenses and output associated with this stage are spread over a number of years and both change significantly in accordance with the periods. This type of attribute generates a number of problems which can be overcome by using "permanent sizes". To begin with, we will explain the concept "permanent" using
permanent income as an example. Based on this example, we can then define the "permanent" concepts relevant to this paper (permanent expenses and permanent output).

**Permanent Income**: Let us assume that an individual receives a variable flow of annual income over a specific period. If the individual spends their permanent income every year, then the flow of income will be sufficient to exactly cover their expenses. Therefore, the current value of the variable income flow must be equal to the current value of the flow of expenditures which is comprised of a fixed annual expenditure, the amount of which is the "permanent income". In formal terms: when $\omega$ represents the capitalized value of the income flow, and $W_t$ represents the annual income in the year $t$, then

$$\omega = \sum_{t=0}^{\infty} \frac{W_t}{(1+R)^t}$$

When $R$ represents the cost of capital, $t$ represents the index for the years, and $W_p$ represents permanent income, then

$$\omega = W_p \sum_{t=0}^{\infty} \frac{1}{(1+R)^t}$$

The permanent income will be:

$$W_p = \frac{\omega}{\sum_{t=0}^{\infty} \frac{1}{(1+R)^t}} = \frac{\sum_{t=0}^{\infty} \{W_t/(1+R)^t\}}{\sum_{t=0}^{\infty} [1/(1+R)^t]}$$

We will now see how, with the help of permanent sizes, it is possible to calculate the marginal costs involved in producing a yield of another ton of bananas, when the additional quantity is attained by shortening the life of the plantation. The data relevant to this calculation are the expenditures and the yield. We will first characterize the data, and then define their permanent values.

As we saw in the explanation about the banana industry, expenditure and production data received from two different plots will not be identical if the number of years that have passed since the plots were planted is different. In other words, both expenditure and yield are dependent on the number of years that have passed since the planting. Consequently, when discussing data from a specific plot, it is necessary to know how many years previously it was planted (that is, what is the age of the planted plot). Therefore the following applies:

- The costs in year $t$ after planting will be represented by: $C_t$
- The quantity produced in the year $t$ after planting will be represented by: $Q_t$

Now we will define the permanent values. As previously mentioned, data regarding costs and quantity depend on the age of the planted trees in the plot. Therefore the permanent values for costs and quantity are also dependent on the period of time between planting and uprooting the banana trees. This period of time (which will be called the plantation life span) is represented by $T$. The permanent cost of the plot with a plantation life span of $T$ will be:

$$C(T) = \frac{\sum_{t=0}^{T} [C_t/(1+R)^t]}{\sum_{t=0}^{T} [1/(1+R)^t]}$$

When calculating the permanent cost, the amount on the counter starts at zero because there are also costs in year zero. In the other places, the amount starts at year one.
The permanent quantity produced will be:

$$Q(T) = \sum_{t=1}^{T} \left[ \frac{Q_t}{(1 + R)^t} \right]$$

Calculating the Marginal Costs
As mentioned previously, the advantage of the technique we are using here is the ability to find the approximate marginal costs while circumventing the need to estimate the production function. This is done by utilizing the fact that shortening the time that elapses between planting the plot and uprooting the trees will increase the quantity produced and also the costs. Thus, if the change in costs as the result of shortening the abovementioned period of time in one year is:

$$\Delta C(T) = C(T) - C(T + 1)$$

and the change in quantity produced is:

$$\Delta Q(T) = Q(T) - Q(T + 1)$$

It is possible to receive an approximation of the marginal cost (MC) on dividing $\Delta C$ by $\Delta V$. This marginal cost is generated when the plantation life span is shortened from $T+1$ years to $T$, and will be defined as:

$$MC(T) = \frac{\Delta C(T)}{\Delta V(T)}$$

This size can be found by taking the following steps:

a. Calculate the marginal cost for different $T$ values.

b. Check the average life span of the banana plantation.

c. The firm's marginal cost will be the marginal cost that corresponds to the banana plantation life span. For example, if the life span is 5, then the firm's marginal cost will be $MC(5)$.

Notes on MC Calculation:

1) Usually the younger the plantation the earlier in the season it will produce a crop. This means that the average price per ton of bananas in a specific plot will change according to the age of the plot. Using the quantity produced in the calculations that we have made is justified only when the price per ton of bananas is uniform. If it is not uniform, we must use the quantity produced weighted in price. The weighted adjustment will be calculated as follows:

$$Q_t = \frac{P_t}{\overline{P}} \tilde{Q}_t$$

$\tilde{Q}_t$ represents the weighted quantity produced in age $t$, $P_t$ is the price of one marketed ton in age $t$, and $\overline{P}$ is the average price for all the ages.
2) The quotas imposed by the cartel only apply to land that yields a crop; in other words, in the year that the plots are planted (before they yield any crop) these plots are not included in the land quota. Consequently the fact that the plantation must be uprooted from time to time does not necessarily result in a reduction in size. The following example will help us understand. The trees in a certain plot are to be uprooted at the end of 2009 (that is, the trees will be uprooted after the harvest from this plot ends in 2009); thus a different plot can be planted at the beginning of 2010. This system ensures the size of the fruit-producing land will be the same in 2010 as it was in 2009 despite uprooting part of the plantation. There are two reasons for this:

a. The plantation life span begins only when there is a harvest. Consequently when calculating the permanent sizes we refer to the planting year as the zero year.

b. Shortening the plantation life span means that it is necessary to plant a larger area of land every year. This means that it is necessary to increase the area of land allocated to the banana industry. This additional land generates an alternative cost which must be included in the calculation. For example, let's assume that the land allocated to the plantation is 100 dunams (approximately 25 acres). If the plantation life span is 5 years, then 20 dunams (approximately 4 acres) must be planted each year and the total area allocated to bananas 120 dunam (approximately 30 acres). If, on the other hand, the life span is 4 years, then 25 dunams (approximately 6 acres) must be planted each year and the total area allocated to bananas 125 dunam (approximately 31 acres). As can be seen, when the life span is 5 years, the ratio between the land and the land yielding fruit is 20%. When the life span is 4 years, the ratio is 25%. This means that shortening the plantation life span from 5 years to 4 generates an addition of land that constitutes 5% of the land quota. In other words, 0.05 of a dunam must be added for every fruit-bearing dunam. Thus if we multiply the alternative income by 0.05 of a dunam, it will give us "the increase in alternative costs per fruit-bearing dunam generated by the reducing the plantation life span from five to four years". This size will be denoted by a(5). If we calculate a(T) in the same manner for life span T, we can calculate MC as follows:

\[
MC(T) = \frac{\Delta C(T) + a(T)}{\Delta V(T)}
\]

The alternative crop to bananas is avocados. Therefore the alternative cost per dunam of bananas will be the income per dunam generated by avocados – NIS 407.

Table 1: Data required to calculate MC (by plantation age)

<table>
<thead>
<tr>
<th>Plantation Age (t)</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output ((\bar{Q}_t))</td>
<td>1.36</td>
<td>5.1</td>
<td>5.1</td>
<td>4.25</td>
<td>3.82</td>
<td>3.4</td>
<td>3.06</td>
<td>2.55</td>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td>Price per ton ((P_t))</td>
<td>554</td>
<td>724</td>
<td>653</td>
<td>635</td>
<td>596</td>
<td>596</td>
<td>537</td>
<td>574</td>
<td>574</td>
<td></td>
</tr>
<tr>
<td>Weighted Output ((Q_t))</td>
<td>1.21</td>
<td>5.91</td>
<td>5.33</td>
<td>4.32</td>
<td>3.65</td>
<td>3.24</td>
<td>2.63</td>
<td>2.34</td>
<td>2.02</td>
<td></td>
</tr>
<tr>
<td>Costs ((C_t))</td>
<td>1989</td>
<td>1211</td>
<td>1946</td>
<td>1946</td>
<td>1804</td>
<td>1710</td>
<td>1645</td>
<td>1582</td>
<td>1510</td>
<td>1423</td>
</tr>
<tr>
<td>(A(T))</td>
<td>203</td>
<td>68</td>
<td>34</td>
<td>20</td>
<td>14</td>
<td>9.7</td>
<td>7.3</td>
<td>5.6</td>
<td>4.5</td>
<td></td>
</tr>
</tbody>
</table>

1 Data taken from Eshet (1986)
Table 2 below shows MC(T) values based on life span. For this calculation we have assumed that the price of capital for the banana growers was 12% during those years as indicated by Eshet (1986), and as was accepted practice in other Ministry of Agriculture calculations during the same period.

<table>
<thead>
<tr>
<th>Life Span (T)</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC(T)</td>
<td>1865</td>
<td>957</td>
<td>576</td>
<td>488</td>
<td>446</td>
</tr>
</tbody>
</table>

As explained previously, after calculating the marginal costs for every life span, we must then identify the usual life span for each banana grower in the sample, and then find the marginal costs for each grower. Our sample includes 7 banana growers in the Western Galilee. During the period covered by this study, these growers produced approximately 20% of the cartel's total banana crop (during those same years the cartel itself produced approximately 70% of the banana crop in Israel).

The average life span for each grower in these years and the marginal costs derived from this life span are shown in Table 3.

Price Calculation: At this stage, we must calculate the average price received by each banana grower during the years in the sample. In other words, the price of bananas changes over the course of the year. Therefore the price calculation will be based on the proceeds received by the grower throughout all the years included in the sample, divided by output marketed by the grower during those same years. Data on each grower's average price is also included in Table 3.

We can find each grower's markup by dividing their average price by their MC(T). These results are also included in Table 3 below:

The average markup is 1.38 with a standard deviation of 0.14, in other words clearly greater than 1. It is important to note that the amount of marginal costs depends on the cost of the growers' capital and therefore the markup is also dependent on the cost of the growers' capital. The abovementioned calculation is based on the assumption that this cost is 12%. Table 4 shows markup values for different capital costs.

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4 As can be seen, the average life span for each grower is not necessarily a whole number. In such a case, the marginal costs are calculated as a relative average between C(T) and C(T+1). For example, if the life span is 6.8, then the marginal costs for that grower will be MC(6) - 0.7*(MC(6) - MC(7)).
Table 4: Markup Values for Different Capital Costs

<table>
<thead>
<tr>
<th>Capital Cost</th>
<th>9%</th>
<th>10%</th>
<th>11%</th>
<th>12%</th>
<th>13%</th>
<th>14%</th>
<th>15%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Markup</td>
<td>1.47</td>
<td>1.44</td>
<td>1.4</td>
<td>1.38</td>
<td>1.34</td>
<td>1.31</td>
<td>1.29</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.14</td>
<td>0.14</td>
<td>0.14</td>
<td>0.14</td>
<td>0.14</td>
<td>0.14</td>
<td>0.14</td>
</tr>
</tbody>
</table>

As can be seen, the markup is clearly greater than 1 with other capital cost values as well. One explanation of this situation claims that individual banana growers do not accept the price as a given, and instead are partners in the efforts of the cartel to make monopolistic profits.

Another probable explanation is the fact that a markup greater than 1 stems from the banana growers' risk aversion. We look to Sandmo (1971) to better understand this explanation. He claims that the approach in which the absence of market power leads to the marginal cost and the price being equal, is based on the assumption that market conditions are definitely known; or alternately, the banana grower is indifferent to the risk. If uncertainty exists and the grower is averse to the risks, then the picture will differ. To demonstrate this, Sandmo checks the case in which decisions on production quantity are made when the firm only knows the price division but still does not know the exact price. He claims that if the firm cannot influence this division then it can be said that the firm has no market power. Sandmo shows that under these conditions their strong risk aversion will lead to a reduction in the optimum number of growers.

We can therefore see that if there is uncertainty, and the growers' strong risk aversion then even if the growers do not have any market power, the price will be higher than the marginal costs and the markup will be greater than 1. The banana growing industry is risky because the plantations are particularly sensitive to weather conditions. It is therefore likely that the high markup is not indicative of monopolistic behavior on the part of the individual growers but rather of a high level of risk and/or a strong risk aversion.

Summary

In this paper, we have utilized the banana industry database to estimate the market power of the individual banana growers that are members of the cartel. We found that the markup used by these growers is markedly higher than 1, a phenomena that may stem from the fact that the banana growers do not take the price as a given or alternatively because the high level of risk that prevails in the banana industry forces them to reduce production to a level below that which equalizes the price with the marginal costs.

This study could be continued in two different directions:

a) The study could be repeated using other cartels with lesser risk factors. If the markup is smaller under the same circumstances then it may be concluded that the high markup in the banana industry stems at least partially from risk aversion.

b) The technique I have presented here may be applied to any branch in which the question of optimum life span is under debate, even if the branch is not organized in a cartel.

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