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IS THE PRICE OF RAW MILK, AS SET BY THE ISRAELI GOVERNMENT THE OPTIMAL PRICE?

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Abstract

This study examines the question of how the price of milk is determined in Israel. As in many countries, the Israeli government intervenes in the raw milk industry. This intervention is expressed as the setting of production quotas as well as the establishing of the price which farmers will receive for the raw milk. According to accepted economic theory, the optimal price is that which is established in the free market, which is to say, the price which is equal to the marginal cost. If the price is set above the marginal cost, then the producers have excess profit at the expense of the consumers. The purpose of this study is to determine if the price of raw milk which has been set by the Israeli government is a reasonable price. A previous study conducted in this field examined this issue using the number of cows the farmers raise. This study examines the same question using a different input, which is the amount of dry matter which is fed to the cows. The results of this study show that the price of raw milk is less than the marginal cost. Therefore, it appears as if the price of raw milk is too low, or that the farmers are not efficiently making use of the feed which is given to the cows.

Key words**:** *dry matter, government intervention, Israel, marginal cost, price, raw milk*

INTRODUCTION

According to accepted economic theory, the optimal price for a good or service in any economy, which will bring the maximum social benefit, is the price as reflected in a competitive market. This price should equal the marginal cost. If the price is above the marginal cost, the profit of the producers is greater than the normal profit, which comes at the expense of the consumers and decreases social benefit.

The issue of discrepancy between the price and the marginal cost is usually discussed within the context of monopoly and market power. However, it is also applicable in cases where the government intervenes in determining prices. In this case, the power of the producers doesn't stem from their behavior in the market. Rather, it stems from the public or political power through which the farmers can exercise any influence they have over the government, in order to set the price as high as possible. Stigler wrote an article which dealt with a situation in which a cartel develops due to government involvement. One of Stigler's basic assumptions is that government intervention in certain industries derives from political considerations, not from economic or social ones. In accordance with this method, the political party in power takes administrative steps (like granting subsidies, rationing production quotas, limiting imports, etc.) which enable the industry to accumulate excess profits. In exchange, the firms which operate in that industry grant the political party support, which is expressed as votes during elections, organizational help, and financial contributions to campaigns [13].

Contrary to Stigler's assumption is the claim that the goal of government intervention, in industries such as the raw milk industry, is the guarantee of the regular availability of essential dairy products. In this case, the government is supposed to set the prices in accordance with what they would be in a free market. Under conditions of market certainty the price will equal marginal cost.

In Israel, as in many countries, the government intervenes in the raw milk[6]

[6] Raw milk is the milk that comes directly from cows and has yet to undergo any type of processing.

industry. According to the Dairy Farming Planning Law of the Israeli Knesset [9], the dairy farming industry in Israel functions by way of government intervention. There are two aspects of this intervention: one aspect is a determination of production quotas and the second is the determination of the price that the dairy-farmers receive for the raw milk. Therefore the question of how the government of Israel determines the price of raw milk is critical.

The purpose of this study is to examine whether the price of raw milk in Israel is equal to the marginal cost of production. One possible way to examine this question is by looking at "markup." The "markup" is the ratio between the price and the marginal cost. If the price is equal to the marginal cost, as we would expect from a competitive market, the markup will be one. If the price is higher than the marginal cost, the markup will be greater than one. The question this research study seeks to answer is: "what is the size of the markup in the raw milk industry in Israel?" Determining the relationship between the price and marginal cost is done with the assumption of full certainty in the market. In reality, raw milk producers function with uncertainty. When there is uncertainty and producers are risk averse, the price should be higher than the marginal cost (in order to compensate for the uncertainty) [10]. Therefore, we don't expect that the price will be equal to the marginal cost, but we also don't expect that the difference will be too great.

Measuring the market power

At first glance, in order to measure the markup it is enough to check how the manufacturer uses one input. The condition for maximum profit is:

$$MC = \frac{p_j}{mp_j} \quad , \quad j=1,2,...,N \tag{1}$$

where j=1,2,...,N are the variable inputs, p_j is the price of input j and mp_j is the marginal output of input j. The desired markup is given by:

$$M = \frac{P}{MC} \tag{2}$$

where P is the price of one unit of output. From the above equation, the markup is able to be calculated with the help of each one of the variable inputs. In this study we assume that in the dairy farming industry, the most suitable input is the amount of dry matter [12].

Dry Matter

According to Jensen L. M. et al. feed intake in dairy cows has a large effect on performance in terms of milk production and body condition. In addition feed is the single most important factor to the economy in the dairy herd and typically constitutes 70% of the variable costs [8] [7]. Measuring the amount of food is a problematic subject because there are many types of food and each one has a different value. Therefore the measurement of a unit of weight or volume isn't relevant. For example, for 100 grams of a concentrated food "mixture" there is more nutrition than 500 grams of hay or 1,000 grams of straw. For this reason, the food was measured by the amount of dry matter, which is the basic part of the feed, which we get after removing from the food the wet matter (mostly water) and other materials which have no nutritional value to the cow. The dry matter is an indicator of the amount of nutrients that are available to the animal in a particular feed. In other words one can say that the nutrients in feeds, required by the animal for maintenance, growth, pregnancy, and lactation, depend on the dry matter portion of the feed.

MATERIALS AND METHODS

The study was conducted for the years 2013 and 2014 (each year separate from the other). The sample we were able to work with in this industry consists of data from 40 collective dairy farms in the northern region of the country. The data was gathered from The Organization of the Dairy Farmers of the Valley Agricultural Center, which operates for the instruction and development for the dairy industry in the northern region of the country. Within this framework, the

organization gathers detailed data about the larger collective dairy farms which are in the region. The average number of cows per dairy farm is 436, ranging from 250 cows in the smallest dairy farm to 1,175 cows in the largest dairy farm. The database does not include information about the family dairy farms whose herd size stands at only a few tens of cows. For reasons which will be explained in the section detailing the regression below, in order to run the regression for the years 2013 and 2014, data from the two previous years (2011 and 2012) are also required.

Calculating the markup

Many studies have attempted to measure market power with the help of the markup. Hall calculated the markup by dividing the elasticity of production with respect to work by the labor share [6]. Eden & Griliches added the utilization rate of labor to the regression which estimated the elasticity of production with respect to work [4]. Domowitz, Hubard & Petersen repeated the technique of Hall by using the raw materials inputs instead of labor inputs [3]. In all of these studies there is the problem of having to estimate the production function.

A different group of researchers tried to avoid the need to estimate the production function using available data about the state of the market (such as prices and amounts), as well as data on exogenous variables that can influence the firms' expenditures. Bresnahan pored over studies that were done according to the above conditions, with no need to estimate the production function, whereby the required data is known [2]. An interesting development in the aforementioned technique appears in a study by Finkelstein & Kachel. They used data on the marketing of agricultural products for two separate markets in order to estimate the market power of the agricultural industry in Israel [5]. In this study we will estimate the ratio between the price of the raw milk and the marginal cost by estimating the markup using a technique based on Hall, whereby the markup is:

$$M = \frac{P}{MC} \quad (3)$$

We will see that the markup can be estimated by dividing the production elasticity with respect to any factor by the share of this factor in the final sale [6].

In a previous study by Shahor & Drori the input which was used in calculating the markup was the number of cows [11]. In this study the production factor that we will use in order to calculate the market power is the amount of dry matter. In this study the dry matter will be denoted by F (for "feed"). Specifically, we will define the production elasticity with respect to the amount of dry matter as:

$$\beta_F = \frac{\Delta V/V}{\Delta F/F}, \quad (4)$$

where V is the output (which will be defined more precisely later). In addition, we will use S_F to denote the share of the dry matter in the revenue, which constitutes the ratio between the cost of food and the economic revenue of the farm, which is calculated as follows:

$$S_F = \frac{P_F * F}{P * V}, \quad (5)$$

whereby P_F is the price of one kg of dry matter and P is the price of one liter of raw milk. This calculation will also be further defined later. With the help of the above definition we can see that:

$$\frac{\beta_F}{S_F} = \frac{\frac{\Delta V/V}{\Delta F/F}}{\frac{P_F * F}{P * V}} = \frac{P}{\frac{P_F}{\Delta V/\Delta F}}. \quad (6)$$

The expression $\frac{\Delta V}{\Delta F}$ is the marginal output. Therefore

$$\frac{P_F}{\Delta V/\Delta F} = MC. \quad (7)$$

If we substitute (7) into (6) we get

$$\frac{\beta_F}{S_F} = \frac{P}{MC} = M \quad (8)$$

The production function of raw milk:

The dependent variable – the value of the raw milk (denoted as V):The output of the dairy farming industry is not measured only by the amount of milk, but also by the percent of fat and amount of protein it contains. The higher the fat percentage and protein content are, the better the price the farmer gets for the milk. However, there is a trade-off between the percentage of fat and the amount of milk: the more the dairy farmer increases the percentage of fat in the milk (by way of altering the diet), the less milk there is. Therefore we need find the appropriate weighted average for the amount of milk that is produced with a certain amount of fat. The best way to do this is by using the price of milk since, from the perspective of the producer, the effect of the fat percentage on his income is what matters. In order to calculate this weighted average we divide the price that each producer receives in each year by the average price of milk for that year. If $\bar{p}_t$ is the average price of the whole industry in year *t*, and p_t^n is the average price of producer *n* in year *t*, then by multiplying $p_t^n / \bar{p}_t$ by the amount of milk that farmer *n* in year *t* produced, we get the weighted amount of raw milk, in terms of its price.

The inputs

A. Dry matter per cow (denoted as F): Dry matter is what remains after all of the water is evaporated out of a feed. It is an indicator of the amount of nutrients that are available to the animal in a particular feed. This variable is measured in kg
B. The number of cows (denoted as K): includes the cows which gave milk in the same period (and therefore does not include calves and cows about to give birth).
C. Labor costs per cow (denoted as L): If the cow is managed in an efficient manner, a larger amount of labor and labor cost is considered to result in better care for the cows, which should increase the amount of milk.
D. The fertility rate of the previous year (denoted as Z): This variable shows the rate at which the cows became impregnated during the course of the previous year. Immediately after the birth, cows give their maximum amount of milk, and after a few months the amount of milk begins to fall. Therefore, the dairy farmers try to impregnate the cow (that is, to cause them to become pregnant), as soon as possible. During the pregnancy the cow continues to give milk until a few weeks before the birth, so the dairy farmers "dry out the cow" by not milking her in order to allow her to rest. After the birth the regular process resumes. Impregnating the cows is no simple matter and requires taking a few steps, which has a cost. Therefore, we can address the issue of fertilization (which is the percentage of cows that were impregnated in the same year) as a type of input. It takes nine months from the time of impregnation until birth, and therefore the fertilization affects the output of the next year. For this reason, last year's fertility rate appears in the production function.
E. Breeding (denoted by e^{τ}): One of the characteristics which stand out in the Israeli raw milk industry is the cultivation of the genetic material of the cowherds. The cultivation is done in two steps:
   (1) Strict selection of the fathers: since most of the cow inseminations in Israel are artificial, a few tens of bulls are enough to inseminate all the cows in the country. Therefore, it is possible (and highly recommended) to invest great effort in order to ensure that the bulls are the best available. These bulls are chosen, firstly, according to the quality of their mothers, and then there is an additional selection process according to the quality of their daughters.
   (2) Choosing the calves: not all calves which are born in a dairy farm are raised to be dairy cows. Those which are not are raised for meat. When the

dairy farmers choose the calves which they intend to raise, they consider the quality of their mothers.

As a result of both of these actions, there is a process which improves the quality of the cows which is expressed as an increase in the quantity of milk. This increase occurs at a fixed rate, and therefore we can express the trend using the variable e^{τ} where τ takes a value of 1 for the first period, a 2 for the second, etc.

Conclusion: The production function for the dairy farm industry is:

$$(9)\quad V = e^{\alpha}(e^{\tau})^{\beta_\tau} F^{\beta_f} K^{\beta_k} L^{\beta_L} Z^{\beta_z}.$$

A logarithmic transformation of the production function yields the following equation:

$$(10)\quad \ln(v) = \alpha_n + \beta_\tau \ln(\tau) + \beta_f \ln(F) + \beta_k \ln(K) + \beta_L \ln(L) + \beta_z \ln(Z)$$

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

$$(11)\quad dv = \beta_\tau + \beta_f df + \beta_k dk + \beta_L dl + \beta_z dz + \varepsilon$$

where $dx = \ln(X_t) - \ln(X_{t-1})$. The reason for using the differences across time is to eliminate α_n. In addition, as we previously defined, the variable τ increases in value each year by 1. Therefore, if we take the difference between the years, this variable disappears and we are left with its coefficient β_τ.

In order to perform the check, we will recall, that from equation (8) we get:

$$(12)\quad \beta_f = M \cdot S_F$$

If we substitute β_F into equation (11) we get:

$$(13)\quad dv = \beta_\tau + M*(S_F * df) + \beta_k dk + \beta_L dl + \beta_z dz$$

In this equation, the second independent variable is the product of S_F and *df*, and the coefficient *M* is the required markup.

Noise in the regression: The cows are, perhaps surprisingly, very sensitive as a production factor. Therefore, each "malfunction" in care has the possibility of causing significant damage. For example, the cows are fed a number of times each day at fixed hours. A delay in feeding time has an immediate, negative impact on the amount of milk the cow will produce. Improper care at the time of milking also results in an immediate loss of milk, as well as long term damage. During the day to day operations there are many setbacks, some of which are caused by external factors. These factors include problems with the tractors, problems with the milking machines, and human error. Since we are unable to put these setbacks into our production function, they appear as noise in the regression. These setbacks are not connected to any of the independent variables in the regression and therefore we can assume that the noise of the regression and the independent variables are independent of one another.

RESULTS AND DISCUSSIONS

The results of the regression of equation (13) appear in the table below:

Table1. Regression results

Variable	Coefficient 2014	Coefficient 2013
Intercept	***	-0.03
$S_F * df$	**0.48**	**0.53**
The number of cows	***	***
Labor costs per cow	0.1	0.10**
The fertility rate	0.09	***
Adjusted R-squared	0.28	0.27

*** The degree of statistical significance was greater than 0.1 and therefore the variable was removed from the regression.

** The level of statistical significance is between 0.01 – 0.05.

The important (and surprising) result is the coefficient of $S_F * df$, which shows the ratio between the price and marginal cost. As we can see, this ratio is less than 1, which means that the marginal cost is greater than the price of the raw milk. There may be a few explanations for such a surprising result.

The first explanation is economic. If the assumption that the marginal production of the food is decreasing, the implication is that the amount of food that each cow receives is too much. In this case, the expected reaction would be that the farmers reduce the amount of food, and therefore the amount of milk. If this explanation is correct, within a relatively short period of time there will be a shortage of milk and in order to prevent this, the price of milk must be increased. However, it does not appear that this explanation in and of itself is enough to explain the relatively large difference between the price and the marginal cost. In fact, it seems like the farmers would very quickly reduce the amount of milk they produce, given the difference between price and marginal cost.

The second explanation is agricultural. The ability of each cow to process the food given to it varies from cow to cow. Therefore, the marginal production and the marginal cost to make a liter of raw milk is not the same for each cow. As a result, the amount of food which will cause the marginal cost to equal the price is different for each cow. In such a situation, we can only reach equality between price and marginal cost if we give each cow the specific amount of food that it needs. There are two obstacles standing in the way of a farmer who wants to operate in this way.

(i)The technology available to the farmers does not allow them to track how much food each cow eats. Therefore, it is impossible to check exactly the amount of food eaten against the amount of milk produced [14].

(ii)The farmers don't have control over the amount of food cows eat. Usually the stronger cows eat first and the weaker cows eat what is left. Therefore, even if the farmers were to limit the amount of food available, the stronger cows would still eat too much (that is, they will still be in the range where the marginal cost is above the price), and the weak cows will still get too little food. In the short run, the weaker cows will give very little milk, while in the long run their health will suffer, such that their ability to reproduce could be at risk. Therefore, the farmers must give the cows very large amounts of food so that each cow has enough to eat. According to Ber, on most of the dairy farms in Israel, the farmers try to give the cows as much food as possible [1]. If this explanation is correct, it seems that the farmers in Israel ought to invest in technology that is better able to monitor the amount of food the cows receive and to strive to give each cow the proper amount of food, according to its individual dietary needs.

An additional interesting result that came out of the regression is that the fact that the coefficient of K, the number of cows, is not statistically significant. This means that any increase in the number of cows does not affect the average production. This means that for the dairy farms in this study, the marginal production of the number of cows is fixed. In competitive markets, producers will increase the amount of inputs to the point where marginal production decreases. Therefore, the fact that the dairy farms produce in the range where marginal production is fixed, might mean that the dairy farms are too small. A situation where the farms are too small seems to occur as a result of the market being controlled: there are production quotas placed on each farmer, such that the farmers cannot choose for themselves the optimally sized farm. The results of the study might show that for the quotas given out to farms which are too small, it might be better to consolidate them into one (or more) large dairy farm.

CONCLUSIONS

In this study we examined the ratio between the marginal cost of feed and the price of raw milk in Israel. The raw milk industry is particularly interesting since the price of raw milk that the farmers receive is set by the government. There are two types of policies the government can choose from in order to achieve its policy goals. If the main goal is to maximize the efficiency of the markets, according to accepted economic theory, the government must set the price at a point where it equals the marginal cost. If the goal of the government is to help the farmers (because they live in rural areas, or because they want to guarantee a supply of dairy products, or because of other political

reasons) then the price will be set above the marginal cost of feed.

The results of this study show that against all expectations, the price of raw milk is significantly below the marginal cost of the feed. Determining why this situation arises requires further research, but there are two possible explanations. One explanation is that the price of milk is too low and therefore if the government won't raise the price, there could be a shortage of milk in the future. The second explanation is that because of technological constraints, the farmers are not able to make the most efficient use of the feed. In this case, it is important for the farmers (with the help of the government) to invest time and resources in the improvement of controls for the feeding process, or to invest time , effort and creativity thinking in other directions in order to solve the problem of in efficiency in the feeding process.

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