# IS THERE ECONOMIC JUSTIFICATION FOR ORCHARDS ON ISRAELI FAMILY FARM?

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**Abstract**

*In Israel there are a number of organizational models of agricultural farms. Two main models are small family farms and large co-operational ventures on "kibutzes," which are communities organized as communes. This article addresses whether or not there are economies of scale in farm size. The research was done using data about the citrus fruit industry. The importance of researching this topic stems from the notion that if there are economies of scale in farm size, then there can't be economic justification for the existence of small family farms.*

*The results of the study on the citrus orchard industry show that in this industry (and apparently also in part of the other agricultural industries), there is no economic advantage to farm size. From an economic perspective, there is no reason to reject out of hand the existence of small orchards, which are family owned.*

**Key words:** *family farms*, *economies of scale*, *Orchards*

## 1. INTRODUCTION

This research is part of a comprehensive project whose purpose is to examine the current plight of the Israeli family farm, as well as its future. In Israel there is a mix of organizational models for farms. For family farms, whether located in cooperative settlements or on private land, there are non-cooperative settlements, regional organizations for various issues (inputs, marketing, etc.) and corporations. In recent years, there is a sense of an increase of agricultural incorporation as a result of economies of scale, and sometimes even as a result of government policy. The Israeli Ministry of Agriculture mentions explicitly the strengthening of the family farm as a goal in the Ministry's strategic plan for sustainable development. To this end, a study was done on the various components that can help sustain the existence of the family farm. This article deals with one of these components: the existence of economies of scale in farm size. If there are economies to scale, over time, small and medium sized farms will disappear from the industry.

The most common organizational form of agricultural enterprises the world over is the small family farm. According to Lowder, Skoet & Singh (2014), among the 570 million farms in the world, 475 million of them are no larger than 20 dunams (20,000 sqm.). In many countries in the world, small farms produce most of the agricultural produce, while doing so on relatively small amounts of land. For example, according to Lerman, Kislev, Kriss & Biton (2002), in Russia, family farms produce 55% of the agricultural produce on 11% of the land. The Israeli Ministry of Agriculture and Rural Development (2013) reports that in Israel, the size of 48% of the family farms are no larger than 60 dunams (60,000 sqm.), yet they utilize only 8% of the land in the family farm sector. On the other hand, 3% of the family farms have lands upwards of 1,000 dunams and constitute 43% of the total land in the family farm sector.

One of the characteristics of agriculture in Israel is the fact that most of the family farms are small relative to the non-family farms. There are some large family farms, but they are the exception. This seems to imply that in industries where there are economies of scale, family farms will have difficulty competing. Therefore, one of the things that needs to be examined when looking at whether or not there is economic justification for the existence of small farms in a particular industry, is whether or not there are economies of scale in that particular industry.

1.1. *Economies of scale in farming*

In the literature, there is an age long discussion regarding the size of the optimal farm and whether economies of scale exist in agriculture. According to Deininger (2003), it is customary to distinguish between two types of farms—the large farm (individually or collectively owned) and the small or medium sized family farm. The advantages of the large farm include the ability to maintain machinery, access to capital or credit, and marketing advantages. Despite these advantages, family farms are usually more intensive and make better use of land and labor resources.

According to Lerman, Kislev, Kriss, & Biton (2002), the family sector specializes in produce which has greater value, whereas the larger farms produce a wide variety of produce. For farms managed by families there is an advantage due to savings in professional management and overseeing the workers. Therefore, there is the claim that small family farms which are supported by organizations which help in mechanization, finance, marketing and instruction are more efficient than large farms (Darwish 1975). In addition, there are a variety of unique goods and services in the family farm which don't necessarily have an advantage due to size, but rather an advantage due to uniqueness and reputation, such as tomatoes grown in greenhouses.

The purpose of this study is to examine the economic efficiency of units of various sizes in one of the agricultural industries. We have chosen the citrus industry, an important industry in Israeli agriculture. We will check whether production in large units is more efficient, which will determine whether or not there are economies of scale in the citrus industry.

We will use the relationship between the amount of land worked and the average output per dunam in determining whether or not there are economies of scale. If we find that an increase in farm size leads to an increase in average output per dunam, this would imply that the larger the farm, the more efficient the production, and therefore there are economies of scale, and no place for small or medium sized orchards. If an increase in the size of utilized land leads to a decrease in average output, we can conclude that there are no economies of scale, and therefore the optimal size of the orchard depends on the expenses and the price of the produce.

## 2. MATERIALS AND METHODS

The database includes data received from two packaging facilities for the citrus industry in northern Israel. The data includes different citrus fruits: various types of oranges, tangerines, grapefruit, pomelo, and others. For each farm there is data for the total area of the orchard for each kind of citrus grown, as well as the yield that was sent to the packaging facility. Similarly, there is data regarding the quality of the fruit: the percentage of fruit segregated as "type A," which is suitable to be sent to market.

The data for one packaging center are for the years 2013, 2014 and 2015. The data for the other packaging facility are for the years 2012 and 2013. For some of the farms there is only partial data. Similarly, in a few cases, a certain farm in a certain year for a certain type of fruit contains only data about the size of the orchard; there is no data pertaining to the yield. In these cases, the observation was removed from the database for the specific farm for that year. If for a different year the farm had complete data it remained in the data base. Note that the lack of uniformity of the data requires that we assume that there is no difference from year to year regarding the growth (weather, crop damage, etc.). The final number of farms in the sample is 70.

2.1. *Preparing the data*

In the region included in the sample, six types of citrus are grown. The proper way to approach the study is not to check each type of fruit separately using a separate regression, but rather to aggregate all types of fruit into one regression. The reason for this is that, in our opinion, the factor which determines the efficiency of the farm is the size of the whole growing area and not the size of the orchard for each particular fruit. In order to understand this decision, we will look at the following example.

Let's assume that there is a certain farmer with 95 dunams of a certain type of orange and 5 dunams of grapefruit. In this case, the farmer tends to both kinds of fruit tree together. That is, the amount of workers, machinery, and other inputs are suitable to tend to 100 dunams of fruit trees. Therefore, the yield of grapefruits is not the same as if the farmer only had 5 dunams of grapefruits and nothing else. Aggregation of the data for the various types of fruit was done in the following stages:

1. We sum up the yield of all of the farmers for all the types of fruit, in order to get the total yield of all the orchards for the entire area. We then did the same for land area, which gave us the total land area of all these orchards in the area. Dividing the "yield of all farmers" by "total land area of all farms" gives the average total yield (of all the farmers for all the types of fruit) per dunam.
2. We calculated the average yield per dunam of each type of fruit for all the farmers. To do so we calculated the total yield and the total area of each type of fruit for all the farmers. Then we divided one by the other.
3. We calculated the coefficient for each type of fruit with respect to the average total yield that calculated in step 1. For example, the average total yield per dunam (calculated in step 1 above) is 3,640 kg. Similarly, the average yield for one dunam of "Ohr" (a popular type of citrus in the industry) is 2,109 kg. Dividing 3,640 by 2,109 gives us the coefficient of 1.725. Afterwards, we multiplied the yield of "Ohr" of each farmer by this coefficient, which gives us the weighted average yield of "Ohr" for each farmer. This process was repeated for each type of fruit.
4. For each farm we sum up the weighted average yield of all the types of fruit and got the weighted average yield for each farmer.
5. For the last step in preparing the data, we calculated the weighted average yield for all the years for which there is data for a particular farmer, for each farmer. For most farmers there are three years of data, but for a portion there is data for only one or two years. The result of this step is the dependent variable in the regression.

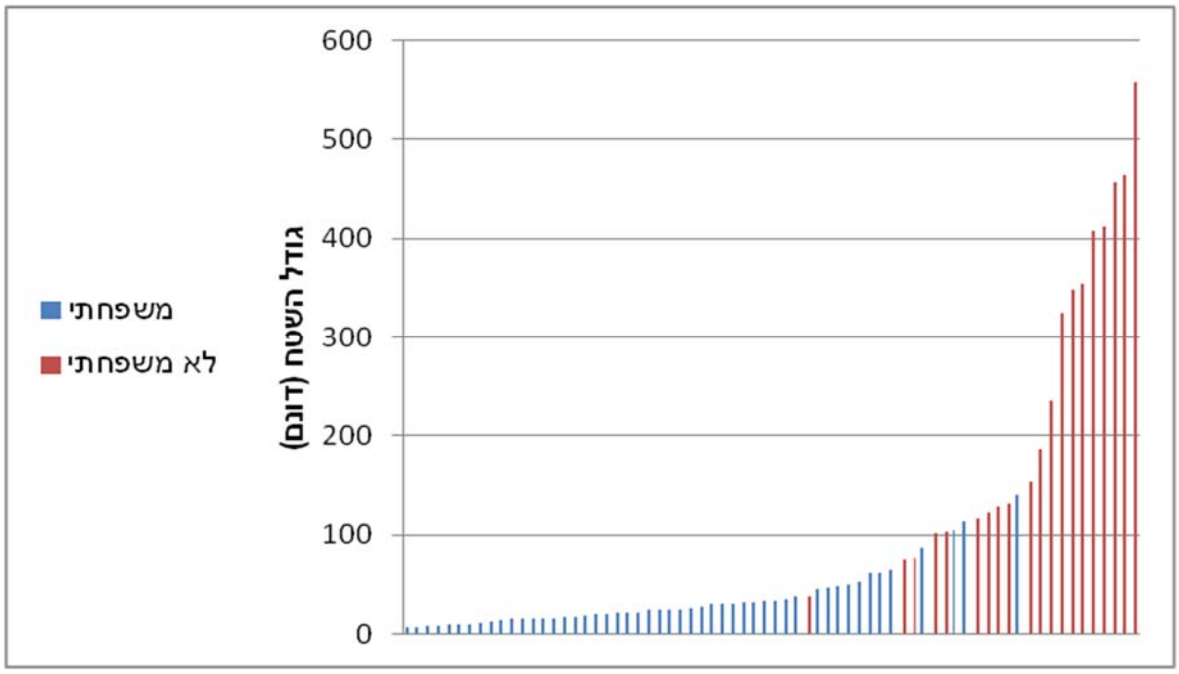
Note: We tried to run the regression whereby the data was handled differently. For example, we ran the regression for the data for "Sunrise" or "Ohr" alone (these are the types of fruit with the most farmers growing them). Similarly, we tried to run the regression without creating an annual average for each farm. The results of the regression were fairly similar. At the end of the day, we chose to work with the weighted average yield (the end result of the process of preparing the data) for two reasons: it seems the most theoretically correct way to operate and because the adjusted R-squared was significantly higher than the rest of the possibilities. In the following table a number of figures for the size of the area and the yield per dunam appear.

**Table 1:** Critical data for the area and yield per dunam according to type of farm

| | | Family | Non-family |
|---|---|---|---|
| Size of orchard (in dunams) | Average | 33 | 240 |
| | Minimum | 6 | 37 |
| | Maximum | 140 | 558 |
| | | | |
| Yield per dunam (in kg) | Average | 3,945 | 3,676 |
| | Minimum | 969 | 965 |
| | Maximum | 7,123 | 6,882 |

In the following graph, data for the size of orchard according to type of farm (family or non-family) appears:

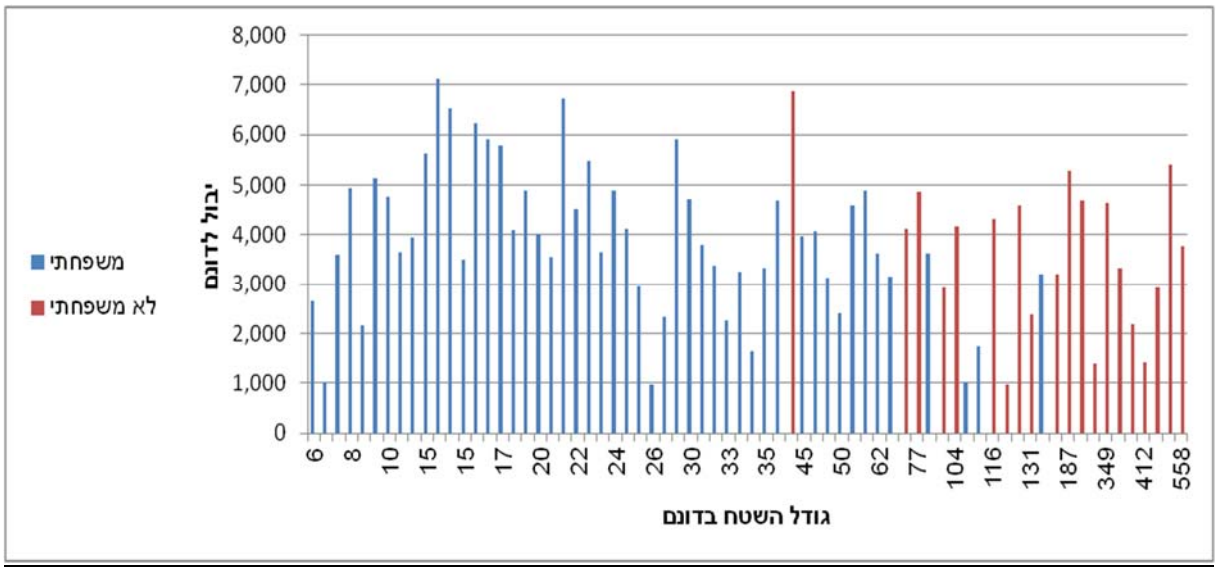
**Diagram 1:** size of the orchard (in dunams)




As expected, the area of the family farms is smaller, however there is a certain range between 75 and 140 dunams, where it is possible to find farms of both types with similar land areas.

In the following graph is data for the average yield per dunam.

**Diagram 2:** Average yield per dunam




As we can see, there is substantial variance in average yield per dunam, but in general, we see that in the smaller farms, the yield per dunam is larger. In the next section we will determine whether the reason for this is because of orchard size or simply that smaller farms are family farms (and not non-family farms).

*2.2. Determining the optimal size of one fruit unit production*

In the literature, there are different methodologies for testing the efficiency of farms. For example, Reznik (2013) checked the economic efficiency, allocation efficiency, and the size efficiency of dairy farms in Israel. We wanted to offer a different methodology for measuring economic efficiency, which in our humble opinion is more befitting to the suggested research goal, which is to determine the minimal size of a farm that can still operate efficiently. We suggested this because our analysis is done by estimating the production function of the citrus fruit industry, which describes the relationship between the average output per dunam and the size of the orchard.

The hypothesis of the research is that the relationship between average output per dunam and orchard size is shaped like an inverted "U". For a relationship of this type there are the following implications: up to a certain size, an increase in the orchard size results in an increase in average output that is, in this range there are economies to scale in farm size. Beyond this size orchard, the average output (per dunam) begins to fall. In this case, orchards whose size is located within this range where average output (per dunam) is falling should not be viable. In the case with perfect competition, market powers will cause farms below this size to cease to exist on their own. On the other hand, if the size of the orchards is determined by the government, the government should not allow farms below this "optimal size" to operate.

For this empirical study of a "U" shaped function (whether regular or inverted), the accepted method is via the following squared regression:

$$(1) \quad Y = \alpha + \beta_1 X + \beta_2 X^2 + \beta_3 D_f + \beta_4 D_m$$

whereby "Y" is the average output (per dunam), "X" is the size of an agricultural unit, "$D_f$" is a dummy variable for family farms and "$D_m$" is a dummy variable for orchards in the geographic area known as "east Galilee." If $\beta > 0$ andthen the function will generally take the shape of an $\gamma < 0$ inverted "U." If $\beta < 0$ andand if both coefficients "U,"then the function will take the shape of a $\gamma > 0$ have the same sign, then function is monotonic (and either rises or falls, depending on the sign).

If the function takes the shape of an inverted U (that is, if the function has a maximum) then we need to check to see if that maximum point is found within the relevant range of the study. For example, if the size of an agricultural unit is between 33 and 140 dunams, but the function begins to decline only at a size of 200 dunams, then we say that within the relevant range of our study, the function is rising.

In order to determine whether the maximum is in the relevant range, we must look at the first derivative of the function at two points. One point is where the size of the agricultural unit is smallest (where "X" is smallest) which is denoted by "$X_L$." The second point is at the size of the largest production unit (where "X" is at a maximum) which is denoted by "$X_H$." For a function whose shape is an inverted U, the derivative of the lower values must be positive (where the function is increasing) and the derivative of the higher values must be negative (where the function is decreasing). From the regression function, the derivative of "Y" with respect to "X" is $\beta + 2\gamma X$ and therefore if

$$(2) \quad \beta + 2\gamma X_L > 0 > \beta + 2\gamma X_H$$

then the function is shaped like an inverted "U" in the relevant range. Sasabuchi's measurement as presented by Lind & Mehlum (2010) checks the level of statistical significance of the results. If the conditions for equation (2) do not exist (that is, if the maximum point for average output is found outside the range of what is a typical orchard size for family farms), then we can conclude that for family farms of this typical size, the average output is increasing. The implication is that there are

economies of scale in orchard size, and therefore in this industry family farms should not be economically viable. If most of the family farms in Israel are smaller than 140 dunams, and the maximum point is larger than this, then it is not worthwhile for family farms to grow citrus. But if it turns out that the maximum is not greater than 140 dunams, then family farms are economically feasible in the citrus industry, provided that they are managed efficiently.

## 3. RESULTS AND DISCUSSIONS

The results of the regression appear in the following table:

**Table 2:** Regression results for factors which affect the yield[1]

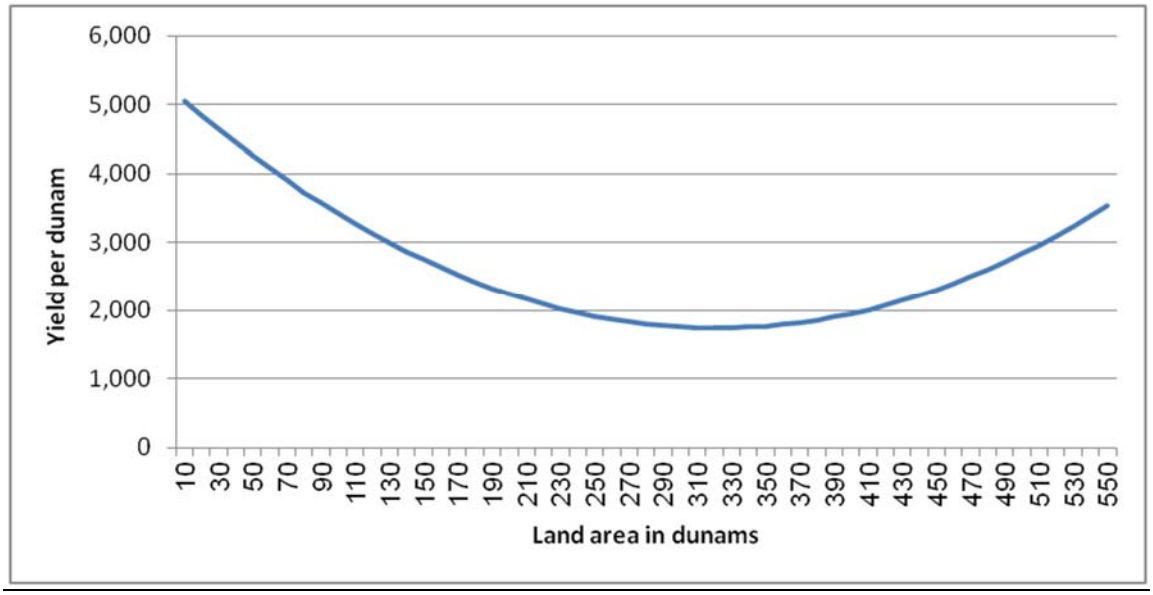
| Variable | Coefficient | Level of statistical significance - α |
|---|---|---|
| Intercept | 5,272 | 0.000 |
| Land area | -21.98 | 0.001 |
| Land area squared | 0.034 | 0.005 |
| Dummy variable for family farm | -1,276 | 0.047 |
| Dummy variable for farms in the east Galilee | 924 | 0.024 |
| Adjusted R-squared | 0.15 | |

[1]The coefficient for the area of "Emek Harod" was not statistically significant and was removed from the regression.

### *3.1 Analysis of the effect of land area on yield*

The most pertinent results of the regression are that the coefficient for land size is negative while the coefficient for land size squared is positive. The first implication of this finding is that when the initial land area is small an increase in land size will cause a decrease in average output, but as the land size increases, the rate of decrease falls. This continues until at a certain point, average output ceases to decline and begins to increase. We can see this in the following graph which depicts the relationship between average output and land area.

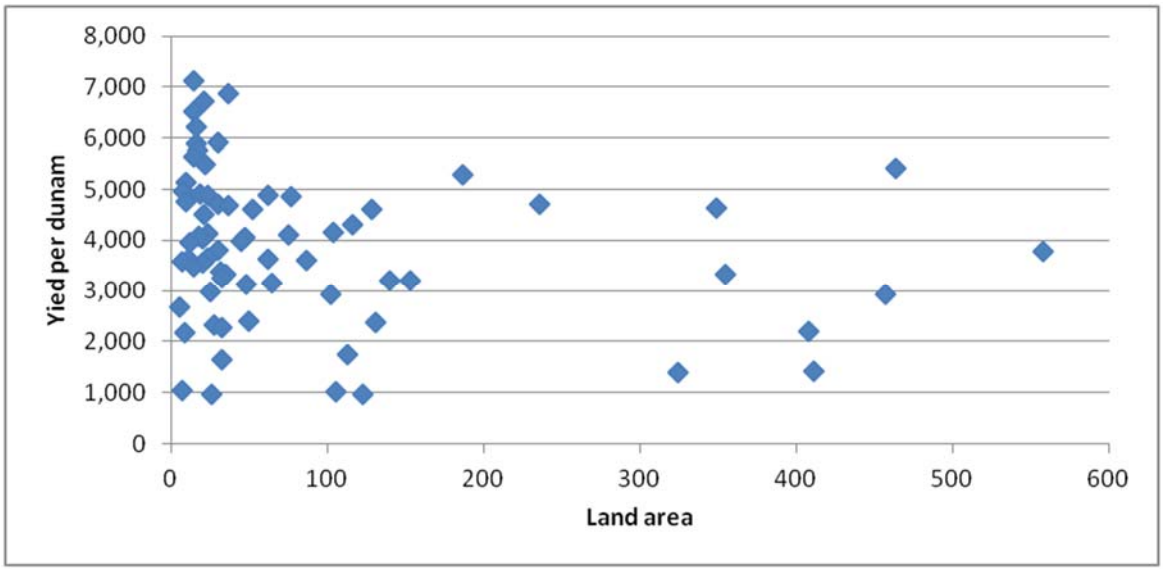
**Diagram 3:** The relationship between land area of the orchard and average output per dunam




According to economic theory, there are three shapes for showing the behavior of average output: (1) the average output increases over the entire relevant range; (2) The average output increases and then decreases over the relevant range; (3) the average output decreases over the entire relevant range. The situation whereby average output decreases and then increases contradicts the basic assumptions of accepted economic theory, and therefore the results of the study demand additional thought in the search for an acceptable explanation.

One possibility is that there are actually two production functions: one for small farms, the majority of which are family operated, and a second one for larger farms, the majority of which are not family operated. This hypothesis gets stronger if we look at the graph which shows the relationship between land area and the yield per dunam.

**Diagram 4:** The relationship between land area and yield per dunam



As we can see, the data points are highly scattered (one of the reasons for this is that the adjusted R-squared for the regression is too low). However, as long as orchards are smaller than 153 dunams, we can see a trend of sorts. With orchards larger than 153 dunams the points are completely random.

In order to check the hypothesis that there are two different production functions we simply divide the sample into two groups. One group contains farms where land area is 153 dunams and less and the other group contains farms where land area is greater than 153 dunams. In the second group there are only non-family farms. The results are in diagram 4 below:

**Table 3:** the relationship between land area and average output per dunam for farms 153 dunams and smaller[1]

| Variable | Coefficient | Level of statistical significance - α |
|---|---|---|
| Intercept | 5,455 | 0.00 |
| Land area | -23.5 | 0.00 |
| Dummy variable for family farm | -1,358 | 0.03 |
| Dummy variable for farms in the east Galilee | 947 | 0.02 |
| Adjusted R-squared | 0.21 | |

[1]The coefficient for "land area squared" was not statistically significant and therefore was removed from the regression.

As we can see from the data for farms with land area of 153 dunams or less, the coefficient for "land area squared" was not statistically significant and the coefficient for "land area" is negative. This implies that the average output is decreasing and therefore, in this range, there are no economies of scale. For the farms larger than 153 dunams where there are no family farms, there is no significant relationship between land area and yield per dunam.

### *3.2. Comparison of family and non-family farms*

The dummy variable for family farms is negative, implying that family farms are less efficient (than non-family farms). Notice that the dummy variable in the regression compares two different populations while holding the rest of the variables identical. From our perspective, the fact that the dummy variable is negative means that if we compare two farms, one family and one non-family, whereby their farm size is identical, the yield of the family farm will be smaller. This implies that it is impossible to claim that the family farm is less efficient because of land size. Rather, family farms are simply less efficient in their method of operation and it should be possible to help them operate more efficiently.

The difference between family and non-family farms can be illustrated in the following way: if we make a regular comparison of the averages, it turns out that the weighted average per dunam for a family farm is 1,861 kg and the weighted average for a non-family far is 1,805. This difference is too small.

By checking the t-statistic, we see that the difference between the averages is not statistically significant. It would seem that this finding contradicts the fact that the coefficient for the dummy variable for family farms is negative and statistically significant. However, this is not the case, for according to the results of the first regression (for farms of 153 dunams and smaller), there is an inverse relationship between land size and average yield per dunam. Therefore, it is expected that the yield per dunam for family farms (which are smaller) will be greater. In this case, the fact that there is not a statistically significant difference between the averages of the two groups means that the family

farms are less efficient. This is exactly what we see from the coefficient of the family farms in the regression.

The purpose of the coefficient of the dummy variable for family farms is to compare family farms to non-family farms of identical sizes. Therefore, if the coefficient is negative, we can conclude that for family farms, there are factors which constitute barriers to improving the yield per dunam that are related to characteristics of a family farm, yet unrelated to farm size. We conclude that efficient operation of family farms requires cooperation among the farmers.

As we can see from Helkis, Ginzburg & Kachel (2014) in different countries in the world there are farmers associations which cooperate regarding advertising, branding, product quality, research and development, market research, and environmental protection. In the United States there are about 30 such organizations and in the European Union there are about 1,500 such organizations. The European Union encourages the establishment of cooperative farming organizations and subsidizes about 50% of such cooperative farming ventures.

Geographic effects: As we can see from Table 2, the coefficient of "east Galilee" is positive and that of "Emek Harod" is not statistically significant. This implies that the orchards in the eastern Galilee achieve better results in terms of yield per dunam. The most reasonable conjecture (which needs to be checked via agricultural, and not statistical, analysis) is that the east Galilee region has a more suitable growing climate for orchards.

### *3.3. Division of fruit species by farm type*

Another important question that arises is whether or not there is a difference between the species in which family farms specialize and those in which non-family farms specialize. Table 4 shows how much area each farm type allocates to each species of fruit.

**Table 4:** Land allocation for fruit species by farm type

| Fruit type | Family farm | | Non-family farm | | Total land area for each type of fruit |
|---|---|---|---|---|---|
| | Land area (in dunams) | % | Land area (in dunams) | % | |
| Ohr (orange) | 658 | 39.9% | 1,961 | 39.5% | 2,619 |
| Sunrise (orange) | 784 | 47.5% | 2,171 | 43.7% | 2,955 |
| Grapefruit | 0 | 0.0% | 25 | 0.5% | 25 |
| Pomelo | 76 | 4.6% | 109 | 2.2% | 185 |
| Sandler (orange) | 11 | 0.7% | 0 | 0.0% | 11 |
| Mineola (orange) | 46 | 2.8% | 390 | 7.9% | 436 |
| Mandor (orange) | 0 | 0.0% | 27 | 0.5% | 27 |
| Hadas (orange) | 60 | 3.6% | 283 | 5.7% | 343 |
| New Hall (orange) | 15 | 0.9% | 0 | 0.0% | 15 |
| Total | 1,650 | | 4,966 | | 6,616 |

The two main types of fruit grown are Sunrise and Ohr. The allocation of land for Sunrise is slightly larger for family farms than non-family farms. The allocation of land for Ohr is virtually identical for both types of farms.

### *3.4. Quality of the fruit*

Like many other agricultural sectors, quality of produce is a major factor in determining the price the farmer receives for the produce. Therefore, it is important to check the effect of land size and type of farm (family or not) on the quality of the fruit. Quality is determined at the packaging facility where the fruit is segregated into two types: type "A" (the higher quality type, fit for packaging and export) and type "B" (lower quality type usually sold for juicing or other uses). In this section we'll check how the size of the orchard and farm type affects the amount of type "A" fruit as a percentage of total yield.

Just like in the section on size of the yield, here too we use the weighted average yield per dunam. To this end, the weighted average yield per dunam of type "A" produce was calculated according to the same steps described in the previous section. Then, the weighted average yield per dunam of type "A" was divided by the total weighted average yield per dunam (as calculated in the previous section), which gives the yield of type "A" produce. This is the dependent variable in the regression. The independent variables are the same variables which were in the previous regression (the regression for size of the yield): land area, land area squared, dummy variable for family farm, and a dummy variable for the east Galilee region.

**Table 5:** Regression coefficients which check the factors which affect the yield of type "A" produce

| Variable | Coefficient | Level of statistical significance – α |
|---|---|---|
| Intercept | 0.639 | 0.000 |
| Land area | -0.00018 | 0.1 |
| Adjusted R-squared | 0.1 | |

[1]The rest of the variables were not statistically significant and were removed from the regression.

Conclusions from the regression:

A. The coefficient for "land area" is negative and the coefficient for "land area squared" is not statistically significant. This implies that as the size of the orchard increases, the percentage of type "A" produce decreases. However, the coefficient for "land area" is only -0.00018. Practically, if the orchard increases in size by 100 dunams, the percent of type "A" produce decreases by only 1.8%. Similarly, the adjusted R-squared of the regression is too low and therefore it is difficult to say that the results of the regression show a clear advantage in produce quality for small farms. On the other hand, we can reject with a high degree of certainty the claim that there is an advantage in quality to large orchards.

B. The coefficient for family farms is not statistically significant. This implies that there is no difference between family and non-family farms, which are identically sized, as far as fruit quality is concerned. Also, the coefficient for the east Galilee is not statistically significant which means that there is no difference in fruit quality as far as where fruit was grown.

## 4. CONCLUSIONS

This study sought to determine if there are economies of scale in the Israeli citrus industry, insofar as it pertains to the economic justification for small family farms. The study included data from 70 farms, some of which were small family farms and some of which were large cooperative farms ("kibutzes").

The study was done using a squared regression where "yield per dunam" is the dependent variable and "land area" is the main independent variable. The variable "land size" appears in the regression twice: once where the relationship to yield per dunam is linear and once where the relationship is squared. This regression allows for a situation whereby, up to a certain orchard size (as per "land area"), an increase in the size of the farmed land causes an increase in average output (that is, in this range there are economies to scale). However, beyond this orchard size, the average output begins to decline. In such a case, orchards of this size whose average output is declining (that is, in the range where there are economies of scale) are not economically viable.

The results show that in the Israeli citrus industry there are no economies of scale pertaining to the size of the orchard. This result means that from an economic perspective, we cannot reject out of hand the existence of small orchards. Through proper organization, for growing the fruit as well as bringing the produce to market, family farms can increase their profitability such that their existence can be economically justified. Another independent variable in the regression was a dummy variable for "family farms" which is supposed to determine if there is a difference in output between family and non-family farms, for identically sized farms. This variable was negative and therefore means that family farms are less efficient, and therefore, in order to be economically viable, the farm owners must make organizational changes such as increasing their agricultural knowledge, common use of certain inputs, and marketing.

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