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WHAT IS THE SMALLEST SIZE OF A FAMILY FARM THAT IS STILL ECONOMICALLY VIABLE. A STUDY IN THE ORCHARD INDUSTRY IN ISRAEL

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Abstract

In Israel, like in most other countries, there are primarily two types of farms: small family farms and large cooperatives. In recent years, with the development of technology which reduces the need for labor and increases the need for capital, the question arises, "in today's world, is there still a place for small family farms?" In order to answer this question, we designed a comprehensive study to test this subject from a number of perspectives (socially, culturally, etc.). This article looks at the economic aspect of this larger study and it deals with the question of the smallest possible size of a farm, that is still economically viable. The study was done for the citrus industry, one of the main agricultural industries in Israel. For the study, we estimated the partial elasticity of production for an orchard with respect to its size and found the point at which average production reached a maximum. According to accepted economic theory, this point shows the minimal size of an economically viable, independent agricultural unit. The results of the study show that in this industry, the minimum size for an economically viable farm is about 30 dunams (1 dunam = 1,000 m^2). In Israel, the size of about half of all family farms is larger than 30 dunams. The immediate conclusion is that there is no reason to assume that an orchard run by a small family operation must be economically unviable. If small family farms adopt the correct organizational structure, not only at the stage of growing the fruit but also at the stage of marketing, it might be possible for at least some of them to be profitable and economically justified. Owners of the smallest farms can partner with their neighbors in order to reach the desired farm size.

Key words**:** *family farm, the smallest farm size, economic viability, orchard industry, Israel*

INTRODUCTION

This study seeks to determine whether there is economic viability for family farms in Israel. The study is part of a larger project whose purpose is to determine the current and future state of the Israeli family farm. One feature that characterizes the Israeli agricultural industry is that most family farms are (considerably) smaller than non-family farms. According to the Ministry of Agriculture and Rural Development (2013) [6], 48% of family farms are no larger than 60 dunams, yet they only work 8% of the land which is called "family owned." On the other hand, 3% of family farms work land in excess of 1,000 dunams, which constitutes about 43% of land called "family owned."

In other parts of the world the situation is similar. The small family farm is the most common form of agricultural organization, the world over. According to Lowder, Skoet & Singh (2014) [5], among the 570 million farms in the world, about 475 million of them are farms no larger than 20 dunams. In many countries in the world, small farms are the primary producers of agricultural produce, on relatively small plots of land. For example, according to Lerman, Kislev, Kriss, & Biton (2002) [4], in Russia, family farms produce 55% of the agricultural produce on 11% of the land. In recent years, due to technological development which reduces the need for labor and increases the need for capital, the question arises, "in today's world, is there still a place for small family farms?"

In the literature, there is an age long discussion regarding the size of the optimal farm and whether economies of scale in agriculture exist. According to Deininger (2003) [2], 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) [4], 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) [1]. 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 determine the minimal size for a farm in Israel, that can exist as an independent agricultural unit and still be economically viable. The industry chosen for this study is the citrus fruit industry of northern Israel.

The orchard was, for many years, the symbol of Israeli agriculture. Citrus fruits have been grown in Israel since the end of the 18th century, growing in size and economic importance since the beginning of the 20th century. The Jaffa Orange, a leading brand name, is famous in many countries all over the world. Pictures of Zionist pioneers ("Halutzim") packing oranges for export were the symbol of the resurrection of Jews in the land of the Bible. A number of the towns and villages that were established by the Zionist movement include reference to orchards in their names, for example Pardes Hanna (literally: Hanna's Orchard; named in honor of Hanna Rothschild), or Pardesia (literally: the orchard of God). In a recent project of the Israeli Nature and Parks Authority, the orchards of the area north of Tel Aviv ("HaSharon") were identified as cultural landscapes of national importance. Old packaging houses of oranges and grapefruits, which are scattered in citrus groves all over Israel, were recently designated for preservation.

Notwithstanding their cultural value, orchards are also (or mainly) an economic industry, that supports the livelihood of the farming family. In the second half of the 20th century, orchards were a leading agricultural branch in Israel, spreading out over 40,000 hectares (about 10% of the farmland in Israel). During the 1990s, the industry experienced a severe crisis and by the early 2000's was reduced to about 15,000 hectares only. Around that time, an original variety of tangerine was developed by Israeli experts and named "Ohr" (Hebrew for light). This variety is especially successful due to a number of factors: early ripening (around February-April), being seedless, especially sweet, and easy to peel. Soon enough, the abandoned citrus groves of Israel were re-planted with "Ohr" trees. Today there are around 20,000 hectares of citrus groves all over Israel.

Eighty one percent of the citrus farms in Israel are family farms while the rest belong to Kibbutzim (cooperative villages) or corporate farms. This means that the future of citrus in Israel, both as a cultural landscape and an economic branch, depends on the competitiveness of the small family farm. In industries where there are economies of scale, family farms will have difficulty competing, since larger farms have an obvious advantage. Therefore, the question of whether or not there are economies of scale in the citrus industry is vital.

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.

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:

(i)We summed 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.

(ii)We then calculated the average yield per dunam for 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.

(iii)We then calculated the coefficient for each type of fruit with respect to the average total yield that we 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.

(iv)Then, for each farm, we summed up the weighted average yield of all the types of fruit and got the weighted average yield for each farmer.

(v)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 orchard size 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
Number of farms		50	2-

We can see that the output per dunam for family farms is higher than that of the larger farms. This finding suggests the hypothesis that there is a size whereby family farms can be efficient producers, and therefore it is important to determine the minimum size for efficient citrus production.

Determining the optimal size for a unit of production

In the literature there are different methodologies for determining the efficiency of farms. For example, Reznik (2013) [7] checked the economic efficiency, allocation efficiency, and the efficiency to size of milk farms in Israel using data envelopment analysis (DEA) and stochastic frontier analysis (SFA) approaches.

It is our intent to suggest an alternative methodology to measure economic efficiency – which in our opinion is more fitting for the proposed research – and that is to determine whether there is a minimum size a farm needs to be in order for it to be efficient. It has been suggested that the analysis should be done by estimating the production function of the citrus industry, which describes the relationship between output and orchard size. A characteristic production function is built such that for average output there are two regions. In the first region, where the amount of input (in our case, farm area) is low, the average output (AP) is increasing. In the second region, whereby the amount of input is larger, the average output begins to decline.

A producer in a competitive market does not choose to produce in the region where average output is rising, rather, only where average output is falling.[1] Therefore, we can say that the smallest possible farm size that is economically viable is found at the point where average output reaches a maximum. The maximum point of AP (which is the minimum size input) can be found with the help of the partial elasticity of production with respect to the input (which is farm area). In the region where AP is rising, the partial elasticity of production is greater than 1 and gets smaller as long as AP is increasing. At the point where AP is at a maximum, the partial elasticity is equal to 1. In the region where AP is declining, the partial elasticity of production is less than 1. Therefore, at the maximum AP point (the minimal size for an orchard that is economically viable), the elasticity will be equal to one. We will estimate the partial elasticity of production with the help of the production function:

$$(1) \quad Y = e^{\alpha} * X^{\beta} * X^{\beta} * e^{\beta_f D_f} e^{\beta_e D_e}$$

whereby:

Y is the output

X is the size of an agricultural unit

D_f is a dummy variable that takes the value of 1 for family orchards and 0 for non-family orchards.

D_e is a dummy variable that takes the value of 1 for orchards found in the geographic region of the eastern Galil and 0 for other regions.

For this production function, β is the partial elasticity of production with respect to the size of the orchard. We can estimate β with the help of a logarithmic transformation which appears in the following equation:

$$(2) \quad \ln(Y) = \alpha + \beta \ln(X) + \beta_f D_f + \beta_e D_e$$

As we saw earlier, in order to find the minimal size of an orchard that is still

[1] This can be seen with the help of the night regions

economically viable, we need to find the point at which $\beta = 1$. When the orchard area is small, β (the estimate of elasticity) is supposed to be greater than 1, and decreases as the area increases, until finally it equals 1. In order to find the desired point we initially ran a regression which included observations of farms whose areas were less than 20 dunams, and afterwards we increased the upper boundary (25 dunams, 30 dunams, etc.) and for each region we reran the regression. The expectation was that at the initial stage when the area is small, β would be greater than 1, but would decrease as the area increased, such that at some point we would get to a certain point where β =1, and afterwards β <1. As we said, the orchard size where β =1 is the minimal size for an orchard to be economically viable.

RESULTS AND DISCUSSIONS

The results of the regression appear in the Table 2.

Table 2. Partial elasticity of production for total output of the orchards with respect to orchard size[1]

Orchard size (In dunams)	Number of orchards	Partial elasticity of production - β	Adjusted R Squared
20	19	1.66	0.72
25	27	1.418	0.72
30	32	1.171	0.56
32	33	1.14	0.56
33	36	0.997	0.496
35	37	0.0987	0.5
37	39	1.046	0.55
45	40	1.045	0.57
47	41	1.045	0.589
48	42	1.027	0.595
50	43	0.992	0.59
52.5	44	1.005	0.61
62	46	1.017	0.65
65	47	1.004	0.66
77	49	1.02	0.7
87	50	1.01	0.715
106	53	0.937	0.7
123	56	0.86	0.67
Entire Sample	70	0.94	0.84

[1]The coefficients of the dummy variable for family farms and orchards in the eastern Galil were not statistically significant and hence removed from the regression.

As we can see, when the orchard size is smaller than 33 dunams, the partial elasticity with respect to area is greater than 1. In the region between 33 dunams and 87 dunams the partial elasticity is close to 1, and above that it begins to decline. These results show that the smallest possible size for an economically viable citrus orchard, in the region where the study was done, is 33 dunams. Another interesting result is the fact that the coefficient for the dummy variable for "family owned" is not statistically significant. This implies that in the region of production, family farms are differentiated from non-family farms in size only. In the following graph, data for the average output per dunam with respect to orchard size appears.

As we can see, here too when the area is small, the average output (AP) increases as orchard size increases. However, at a certain point the growth stops and afterwards average output begins to decline. Notice that the study focuses on the part of the production function and doesn't deal at all with production and marketing expenses.

It is entirely possible that regarding purchasing inputs or marketing, smaller farms will face operating difficulties in an independent and efficient capacity.

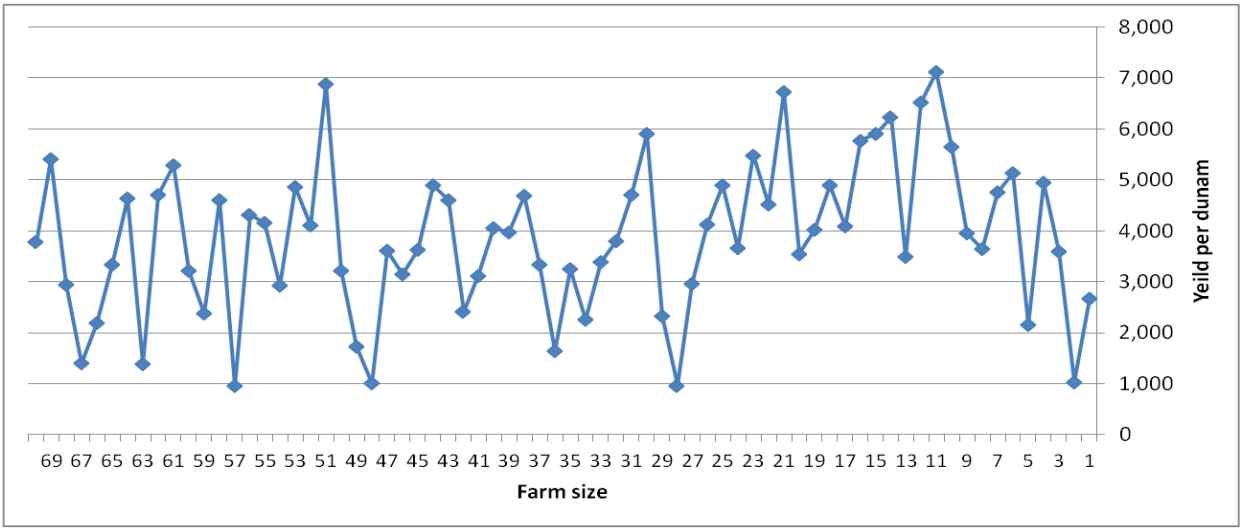

Fig. 1. Average yield per dunam

Therefore, it seems there is a need for outside intervention to help them organize and operate together. Organizations such as these exist in many places throughout the world. According to Helkis, Ginzburg & Kachel (2014) [3], in many different places in the world, agricultural organizations operate specifically in advertising, branding, production quality, R&D, market studies and environmental protection. In the United States, there are 30 such organizations for growers and in the European Union some 1,500 such organizations. The European Union encourages the establishment of growers' organizations and finances 50% of the cooperative agricultural ventures. It appears that there is room for similar actions such as these in Israel as well.

Fruit Quality

Like many other agricultural industries, the quality of the produce in the orchard industry has a large influence on the price the growers receive for their produce.

Table 3. Partial elasticity of production for the yield of type A fruit, with respect to orchard size[1]

Orchard size (In dunams)	Number of orchards	Partial elasticity of production - β	Adjusted R Squared
20	19	1.9	0.753
25	27	1.435	0.7
30	31	1.262	0.66
32	32	1.22	0.66
33	35	1.05	0.57
35	36	1.013	0.56
37	38	1.06	0.6
45	39	1.045	0.612
47	40	1.05	0.63
48	41	1.006	0.618
50	42	0.97	0.61
52.5	43	0.984	0.62
62	45	0.994	0.671
65	46	0.97	0.672
77	48	0.993	0.711
87	49	0.998	0.73
106	52	0.869	0.63
123	55	0.816	0.619
Entire Sample	69	0.868	0.814

[1]Here too the coefficients of the dummy variables for family farm and orchards in the eastern Galil were not significant and removed from the regression.

Therefore it is important to check the influence that farm size and type of farm (family or not) have on the quality of the fruit. Quality is determined at the packaging facility, where the fruit is sorted into two categories: type A (the higher quality, destined for packaging and export) and type B (the lower quality, usually sold to the juice industry or other industries). In this section we will check how the size and type of farm affects the yield of type A fruit.

Like in the section dealing with yield, here too we look at the weighted average yield. We calculated the weighted average yield of type A fruit according to the same stages described in the previous section. The natural logarithm of the weighted average yield of type A fruit is the dependent variable in the regression. The independent variables are the same as in regression (2) (the regression for yield size) and they are the natural logarithm of farm size, a dummy variable for family farm, and a dummy variable for farms found in the eastern Galil region. The results of the regression appear in Table 3.

As we can see, the partial elasticity of production with respect to farm size equals 1 when the size of the farm reaches about 48 dunams. This finding shows that regarding fruit quality, the minimal farm size required for an efficient farm is larger, and therefore a larger portion of the family farms (the smaller ones) are considered inefficient. This claim gets stronger if we compare the averages of family and non-family farms for two data types: quantity (which we saw in Table 2) and quality (Table 3). The results of the comparison appear in Table 4.

Table 4. Comparing family and non-family farms

Data type	Family farms	Non-family farms	Sig. (P-value)
Yield	3,944	3,676	0.25
Yield rate by type	0.58	0.63	0.01

As we can see, when looking at the amount of the yield, there is not a significant difference between family and non-family farms. When looking at the quality of the yield, the yield rate for type A fruit is significantly larger in non-family farms than family farms.

CONCLUSIONS

The purpose of the study was to determine whether there is economic justification for small family farms in Israel. To perform this study, we looked at 70 farms, 50 of which were small family farms and 20 cooperative farms, which are larger. The study was done with the help of the partial elasticity of production with respect to farm size. A typical production function is built such that for average output there are two regions. In the first region, where the input amount (in our case, farm size) is small, the partial production elasticity is greater than 1. In the second region, where the input size is larger, the partial elasticity of production is less than A producer operating in a competitive market will not produce in the region where the elasticity of production is greater than 1, but rather, only in the region where it is less than 1. Therefore, we can say that the smallest possible size for a farm to still be economically viable is found in the region where the partial elasticity of production is equal to 1 (or at least, very close to 1). The results of the study show that the minimal size for an orchard to be economically viable is about 33 dunams. Out of the 50 family farms in our sample, 18 of them have farms larger than 33 dunams and for 7 others, the size of the farm is very close to this size. Therefore, we conclude that close to half of the family farms are located in the efficient frontier. What we conclude from this is that we should not assume that small family farms are not economically viable. With the correct organizational structure, at the growing stages as well as marketing stages, family farms should be able to operate in a way that is economically viable and profitable.

It is important to point out that the study only looked at the production function and not

whether or not family farms are efficient, when also taking into account their expenses. Among those working in the industry, there is suspicion that, given the current circumstances, small farms that operate alone will face difficulty operating efficiently, both in purchasing inputs as well as marketing. Therefore, we see that there is a need for outside intervention which can help the smaller independent farms to operate together. Organizations like these exist in many places in the world. Another conclusion that comes out of this study is the fact that fruit quality from the family farms is lower than that of non-family farms. A growers organization which will allow them to purchase new technology and expertise can bring improvements in this area as well.

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