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THE PERTINENCE OF THE MACRO-THÜNIAN ANALYSIS: THE CASE OF ISRAEL

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INTRODUCTION

The classical rent theory by von Thünen (1826) emphasized rent factors related to urban areas such as market prices for agricultural products and farm-to-city distance (Peet, 1969; Muller, 1973). The macro-model extended the Thünian rationale to Megalopolitan urban areas and their nation-wide rural hinterlands and has been tested in the United States (Duncan et al., 1960; Jones, 1976; Kellerman, 1977; Lozano, 1968; Muller, 1973; Peet, 1969).

In a recent paper by Kellerman, a version of the Thünian macro-model was tested on the coterminous United States. This yielded poor results and it was concluded that the Thünian theory does not seem to explain rents at the macro-scale. It was also suggested that regional specialization of agricultural production may replace distance to markets as the major rent factor (Kellerman, 1977), a hypothesis which has been shown to be true (Winsberg, 1980). Since the United States covers a large area and has a large population, it is appropriate and necessary to test the Thünian macro-model in advanced agricultural systems of smaller size, in order to see whether the macro-Thünian model is pertinent to such systems or whether regional specialization and other rent factors should be considered as major rent factors in advanced agricultural economies regardless of their size.

ISRAEL — RURAL AND AGRICULTURAL BACKGROUND

The Israeli agricultural system has been chosen for this study. While this system has already been described and analyzed elsewhere (e.g. Boyce, 1978) some of the major aspects of the Israeli system will be outlined here. The largest metropolitan area, Tel-Aviv including remote suburbs, consists of approximately 1.5 million inhabitants, out of about 3.8 million Israelis. This could tentatively call for the hypothesis that the Israeli agrigultural system is organized around the major urban market, Tel-Aviv, and around the two other major urban markets, namely Jerusalem and Haifa. In terms of the macro-Thunian model this would mean decline of rents from Tel-Aviv outwards with high-rent enclaves around Jerusalem and Haifa.

This supposedly Thünian landscape is distorted by some other factors. The country enjoys a variety of climates, which, together with the most efficient agricultural production system, permits the production of almost all crops so that a Ricardian rent landscape may fit better spatial rent variations. In addition, geopolitical considerations in the construction of new villages, especially in peripheral areas, may contribute to distortions from a Thünian rent landscape. These new villages have, until recently, been based almost solely on agriculture. The villages, built along the eastern border (with Jordan) enjoyed a desert climate (in the lower Jordan Valley in the Arava) which permitted the development of highly intensified and specialized agriculture of out-of-season fruits and vegetables. These highly priced and mainly exported crops yield a high net income per unit of cultivated land, without any reference to distance from major domestic or international urban markets.

AN AMERICAN — ISRAELI COMPARISON

A general comparison of United States and Israeli circumstances reveals a few differences and similarities. Among the differences, the most striking ones are the differences in size and shape. While the different areal and population sizes are tested here in order to find out whether they have a potential impact on the creation or prevention of a macro-Thünian model, the different shape of the two countries is not supposed to interfere with the following analysis since it cannot be assumed that the shape of a country has any impact on agricultural production and income from agricultural land.

Among the similarities between the two countries, one could count, first, the highest level of current agrigultural technology enjoyed by the agricultural production systems in both countries. Secondly, both countries have one extremely large urban system relative to the population size of each country, Megalopolis comprised 20 percent of the American population in 1970; adding the coterminous Lower Great Lakes Urban Region increased the percentage to 35. The Tel-Aviv conurbation consists of around 40 percent of the Israeli population. A third similar quality is the spatial coincidence between major agricultural areas and major urban areas. The analysis of this coincidence in the United States has been outlined elsewhere (Kellerman, 1977), and in Israel the coastal plain serves as both the most important agricultural area and the most urbanized area (including the conurbations of Tel-Aviv and Haifa). Further regional-agricultural analysis of Israel will follow later in this article. This spatial coincidence led, in the study of the United States, to the conclusion that regional specialization might be more important than urban factors in determining rents from agricultural land, and the same question is presented when studying here the Israeli agricultural landscape.

A fourth rather partial similarity between the two countries relates to the openness of their agricultural systems. In Israel some 26 percent of the agricultural production was exported in 1971 (the year for which data have been available for this study). Exports consisted mainly of fruits and vegetables and directed mostly to the European Common Market. In the United States some 12.5 percent of the agricultural production were exported in 1969 (the year for which data were analyzed in the U.S. study), consisting mainly of wheat and corn, and directed generally to Asia, Africa and the Soviet Union.

While the Israeli percentage of exports was as much as twice the American rate, a few reservations have to be made concerning these figures. The impact of exports in the American agricultural economy is higher than the "real" exports. This is mainly because almost all exports originate in one region, the Midwest, and concentrate in two crops, namely wheat and corn. Being a leading sector in the agricultural economy, changes in the rates or prices of exports may cause fluctuations in the prices of other crops as well. This is amplified by the fact that both crops serve as interim goods in the production of livestock products (eggs, milk, meat) and baked goods (bread , cakes etc.). Although the Iseaeli system is more export-oriented, still the vast majority of agricultural production in 1971 was for local consumption.

This opennes of advanced agricultural systems serves, of course, as a distorting factor when aThunian macro-model is defined by the territorial boundaries of a studied country. The question still remains whether this might cause, together with regional specialization, a sharp decline of the explanatory power of a Thünian macro-model. In the United States this decline has been found to exist and the following case-study will test Israeli data to see whether the macro-Thünian model holds in a small country or not.

THE TEST MODEL AND PROCEDURES

The major hypothesis to be tested here was that the Israeli rent-surface shows the same trend as the American in that the Thünian rent factors of urban markets are of less importance and that regional specialization might have more explanatory power regarding variations in rent values. As in the test of the American system, the rent surface has been referred to here as the spatial expression of the combined rent curve, rather than a collection of crop-specific rent curves (Kellerman, 1977). Here, however, the differentiation among levels of the urban markets had to be altered. For the rather extensive American urban system, three levels have been suggested: The macro-scale or the impact on rent of Megalopolis, the meso-scale or the aggregate power of metropolitan areas on rents, and the micro-scale or the aggregate impact of small urban areas on rents. Here, due to the small scale of the country, the two first urban-market elements have been unified to study the spatial field of influence of major urban areas.

Data from the Israeli Census of Agriculture, 1971 (1975) have been used for the construction of the dependent variable. These data permit a comparison with the U.S. study in which data for 1969 were analyzed. The data provide information on value of agricultural production and farmers' expenses for labor and water. Since no data were collected on other production expenses, no index of net income could be constructed following Muller (1973), who defined net income per unit of land as the average market value of all agricultural products sold, minus all production expenses (Muller, 1973). Lozano (1968) discussed also the problem of transportation costs . He showed that transportation costs are included and, therefore, reflected by the market price since, under circumstances of modern, rapid and efficient transportation networks, the weight of transportation costs among other costs is much lower than in Thünen's times. Muller, who adopted Lozano's arguments and tests, pointed to difficulties one encounters if willing to separate transportation costs. In the Israeli case, not only is there a modern transportation network, but

the small size of the country makes this factor even less important than in the U.S.

However, since water and labor are two of the major production factors in the Israeli-agricultural system, it was assumed that the following index of income from agricultural land could serve as a good approximation of net income.

$$\bar{Y}_i = V_i - \frac{(W_i\ c_1) + (L_i\ c_2)}{A_i} \qquad (1)$$

where,

$\bar{Y}_i$ = average income from agriculture per unit of agricultural land in natural region i;
V_i = production value in natural region i;
W_i = water consumption (in thousands of cubic meters) in natural region i;
c_1 = cost of one cubic meter of water (equal nationwide)
L_i = labor input in days in natural region i;
c_2 = average daily wage of an agricultural worker;
A_i = agricultural area in natural region i (in dunams)

The income per unit of land per natural region is equal, therefore, to production value per unit of land less expenses on labor and water. This index was computed for all 38 Israeli natural regions (which comprise the finest statistical division of the country for these data).

This index serves this study as a rent-surrogate. Von Thünen defined rent as "that portion of the farm revenue that is left after deduction of the interest on the value of the buildings, timber, fences and all other valuable objects *separable from the land,* that portion which pertains to the land itself". (Von Thünen, 1966). In Modern research rent has been usually referred to as "net return above costs" (Dunn, 1954). The index of income used here does not assume deduction of all production expenses, but since labor and water are the major expenditure items in the Israeli agricultural production, it is assumed that it can be used to give an idea of inter-regional differences in returns from agricultural production.

The index of average income per unit of land was regressed against two urban factors:

1. A metropolitan factor, counting for both macro-and meso-urban markets. This factor was defined by the population potential per natural region in 1971. This is derived from the summation of the population of every natural region divided by the distance of the center of one natural region to its counter-part, so that

(2)

$$_iV = \sum_{j=1}^{38} \frac{P_j}{r_{ij}}$$

where

i, j = indices to denote natural regions;
$_iV$ = potential value at natural region *i;*

P_j = population of natural region *j;*
$_ir_j$ = shortest straight-line distance from the center of natural region *i* to the center of each and every natural region *j*, from 1 to 38.

The potential value of each natural region reflected, therefore, its distance from the major population concentrations.

2. **The local factor,** defined by the population per natural region in 1971. Since 90 percent of the Israeli population is urban, this variable represented the local demand for agricultural products. The data for the two urban factors were the official 1971 population estimates per natural regoin (Statistical Yearbook, 1972).

FINDINGS AND ANALYSIS

The results of the regression analysis are similar to the equivalent findings in the American study (Table I).

Table 1: Multiple Regression of Urban Factors Against the Index of Income from Agriculture

Variable	Multiple R	R^2	R^2 Change	r	b
ISRAEL					
Metropolitan Effects	0.337	0.113	0.113	0.337	2.044
Local Effects	0.433	0.188	0.074	0.289	−1.728
Constant: 339.802					
U.S.A.	0.301	0.091	0.091	0.301	11.946
Megalopolitan Effects	0.327	0.106	0.015	0.286	0.183
Metropolitan Effects	0.400	0.160	0.053	0.266	0.000
Local Effects					
Constant: —29.446					

The metropolitan factor "explains" some 11.4 percent of the variation among index values, while in the American case, the Megalopolitan factor alone explained some 9.1 percent of the variation, and the multiple regression coefficient reached 10.6 percent when the metropolitan effects were added to the equation. The same trend is true for the local effects which contributed here 7.4 percent and in the equivalent American study added 5.3 percent. Due to the small size of Israel and to the concentration of urban population in the three major metropolitan areas, however, the two independent variables (metropolitan and local effects), were highly intercorrelated ($r = 0.987$).

Our conclusion at this stage is, therefore, that the Thünian theory does not explain much of the variation of income from agricultural land in Israel. The comparison with the American findings is interesting in some aspects. In both countries which enjoy advanced agricultural technology and modern agricultural transportation facilities, the impact of urban markets and distances from them to farms is not an important factor, *regardless of the areal size of the country and its population,* so that rent-variations have to be explained by some other factors.

The American-Israeli comparison has another aspect, namely the relatively small differences between the impact of large urban areas and small ones. This might be related to two factors. The first is the geographical variation in the costs and structure of marketing (which in the U.S. is handled by private companies and in Israel by companies owned by the national farmers' organization). Another factor is the impact of urban growth pressures on agricultural production in cities of different sizes. This question has already been dealt with (Kellerman, 1978), but needs empirical tests under various conditions of urban size and growth.

Further Analysis

The discussion of the Israeli agriculture presented earlier in this paper suggested that the Thünian model may be distorted by regional variations, reflecting the Ricardian view of rents (Ricardo, 1817). When exports and subsidies are considered, regional variation becomes even more important, especially in the Israeli context, since optimal production of specialized crops using favorable physical conditions is being sought. In the American macro-study, data on livestock, poultry and dairy sales were available and they added altogether some 10 percent to variation explained. Winsberg (1980) showed an increased trend of regional crop-specialization in the U.S. between 1939 and 1978.

In this study data on income and expenses were available for all crops, but due to limitations of the data on area devoted to each crop per natural region, only two crops could be added to the regression model. The two crops are citrus and all other plantations such as apples, peaches etc. Both are major crops in Israeli agricultural production and account for much of the country's agricultural exports. Using equation (1), the index of income was computed for the two crops and then added to the regression analysis (Table 2).

The stepwise multiple regression analysis was performed in such a manner that independent variables are added to the regression equation according to their r coefficients with the dependent variable in order of decreasing values. Plantations proved to be the first variable "explaining" some 14 percent of income variations. Citrus was found to add very little to the equation though its correlation with income is $r = 0.149$. This result is partially explained by the intercorrelation between plantations and citrus of $r = 0.469$, and partially by

Table 2: Multiple Regression of Urban and Crop Factors Against the Index of Income from Agriculture

Variable	Multiple R	R^2	R^2 Change	r	b
Plantations	0.374	0.140	0.140	0.374	0..486
Metropolitan Effects	0.484	0.234	0.094	0.337	3.139
Local Effects	0.643	0.413	0.178	0.289	-2.87
Citrus	0.644	0.415	0.001	0.149	0.64
constant: —114.783					

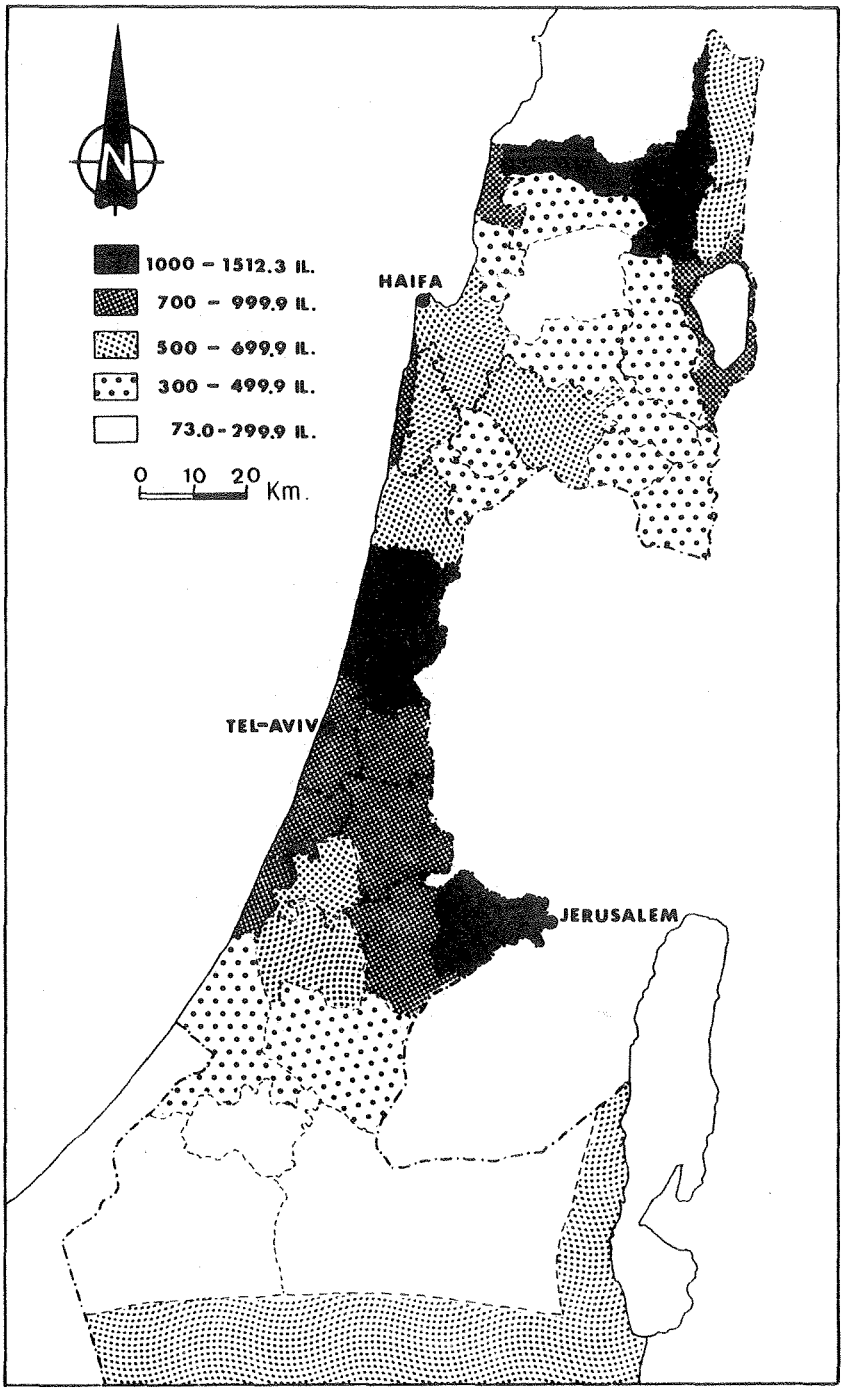

Fig. 1: Average income from agriculture per dunam of land in farms for Israel by natural regions, 1971

the spread of citrus even in areas which were once considered as unsuited to citrus fruits. The two urban factors together seem to explain more than before, some 27.2 percent compared to 18.8 percent in the former regression analysis. This rate is misleading, however, since the r 0.987 intercorrelation rate between the two urban factors caused the increase here in the regression coefficient of local effects from 7.4 percent in the former run to 17.8 percent here. This is also why the total "explanation" of 41.5 percent should be reduced by at least ten points.

Since plantations are not significantly correlated with the two urban factors, metropolitan and local effects (r 0.081, r 0.135 respectively), their net explanation of 14 percent is quite high as one variable among many. Thus, crop specialization may add to the explanation of rent variation even more than urban factors.

Map Analysis

With the results of the statistical analysis in mind it is interesting to look at the map of average income from agriculture per unit of land in farms for Israel by natural regions, 1971 (Figure I). The map strengthens the impression that regional specialization plays a larger role in rent determination than large urban areas, though there is some spatial coincidence between the two factors.

The three areas of highest rates of income per dunam are: Jerusalem, the extreme north (the Upper Galilee) and the central area (the Sharon). While Jerusalem and the central area are adjacent to two major metropolitan areas, they also specialize in poultry and citrus respectively. Upper Galilee is an area of poor agriculture but since it specializes in poultry the income per unit of land is high.

The next group of income rates exhibits quite high rates in regions just beyond the metropolitan areas of all three major cities, and although some agricultural specialization exists in these regions as well, the high rates may be related to the proximity to large urban markets.

The pattern of the other regions, while exhibiting decline of income with distance from the center to the north and south, represents also the relatively poorer agricultural conditions in the mountainous north and in the southern desert (the Negev). The medium rates in the extreme south reflect the high values achieved in the settlements along the Arava valley where the desert sun conditions together with pumped ground water make it possible to grow out-of-season fruits and vegetables.

CONCLUSION AND DIRECTIONS FOR FURTHER RESEARCH

The findings of this research make the macro-Thünian model more doubtful for the study of rent factors in countries of advanced agriculture. While it is hoped that further empirical studies of this model in European countries will improve our understanding of the model, it might well be that the focus of our willingness to understand rent-factors in a nation-wide context should be directed to other possible avenues of explanation. The suggestion, made earlier in this paper, to study more carefully regional crop specialization is

repeated here. Other rent-factors which might well be major ones are the spatial structure of government subsidies and major regions of exports. These last two rent-factors should be studied in terms of their interrelationships with crop regional specialization.

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