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The Amenity Value of Agricultural Landscape and Rural-Urban Land Allocation

by

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The Amenity Value of Agricultural Landscape and Rural-Urban Land Allocation

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Abstract: We analyze rural-urban land allocation in light of the increasing environmental role of agricultural landscape. The amenity value of farmland varies across crops and as a result affects the optimal crop mix in addition to its effect on rural-urban land allocation. Investigating the effects of population and income growth processes, we find that, contrary to market outcomes, the socially optimal allocation may call for more farmland preservation under both processes. In an empirical application to a region in Israel we find that the extent of market undersupply of farmland is substantial and that population growth calls for more farmland preservation at the expense of urban land.

JEL classification: Q10,Q24,Q50

Keywords: rural-urban, land allocation, landscape amenities, willingness to pay

1. Introduction

The increasing role of farmland as a provider of environmental amenities, in addition to its traditional role as a primary input of agricultural production, has long been recognized in developed countries. Rising living standards, population growth and added leisure all operate to increase the demand for environmental amenities, including agricultural landscape. At the same time, these processes also increase the demand for urban land. The balance between these competing trends underlies rural-urban land allocation. The public good nature of agricultural landscape renders land market allocations suboptimal – an argument often used to justify some of the agricultural support policies in developed countries (Brunstad et al., 1999 ; OECD, 2003).

In this article we analyze the role of agricultural landscape in rural-urban land allocation, allowing for the amenity value of farmland to vary across crops. For example, highly profitable cash crops grown in greenhouses typically elicit low landscape value while extensively cultivated field crops generate a more desirable landscape. This feature implies that, in addition to land allocation between farming and housing, environmental considerations should also affect land allocation within the agricultural sector (between crops) and this feature bears upon farm policies. Investigating the effects of population and income growth processes, we find that, contrary to market outcomes, the socially optimal farmland allocation may call for more farmland preservation under either process. Indeed, in our empirical study, the socially optimal farmland allocation increases with population.

It should be noted that the agricultural sector entails a variety of external effects in addition to landscape. Some are positive (e.g., heritage preservation, maintenance of food production capability, groundwater recharge enhancement) and some are negative (e.g., pollution due to fertilizers and pesticides, soil erosion). In this work we focus on the positive externality of agricultural landscape.

Our work is related to the large body of literature that deals with the positive external effects of agricultural landscape (see, e.g., OECD, 2000; Peterson, et al., 2002).). Noticeable examples in the context of urban-rural land allocation include McConnell (1989), Lopez et al. (1994) and Brunstad et al. (1999). Rural landscape values have been estimated in a number of countries, including Austria (Hackl and Pruckner, 1997), USA (Bergstrom et al., 1985; Beasley et al., 1986; Halstead, 1984; Ready et al, 1997), UK (Hanley et al., 1998), Canada (Bowker and Didychuk, 1994) and Israel (Fleischer and Tsur, 2003). However, in these works, as in McConnell (1989) and Lopez et al. (1994), the amenity value of farmland does not vary across crops. Drake (1992), Schlapfer et al. (2004) and Brunstad et al. (1999) differentiate the amenity value between agricultural activities (they considered tilled land, pasture and woodland) but ignore the rural-urban land allocation issue. The present contribution analyzes rural-urban land allocation under heterogeneous amenity values of farmland across crops within a unified framework.

The next section describes the regional land economy. Section 3 characterizes the market and socially optimal land allocations. An empirical analysis applied to Northern Israel is presented in Section 4 and the final section concludes with a few policy remarks.

2. The regional land economy

The urban sector: The regional urban sector consists of N households, each deriving utility from the consumption of private goods and a public good in the form of environmental quality. The latter depends on a variety of factors, such as availability of parks and beaches, air and water pollution, and aesthetic landscape.

Here we concentrate on environmental benefits generated by agricultural landscape, allowing for heterogeneity with respect to different agricultural crops. Accordingly, the representative household's utility depends on the consumption of a composite private good z, housing characteristics ℓ_H (size, quality of nearby schools, access to shopping and service centers) and environmental amenity generated by agricultural land allocated among K crop groups L_k, $k = 1,2,\ldots,K$, and a non-agricultural open space (e.g., parks), denoted L_0, in a region of area M. In this work we focus on one house characteristic, namely, the lot size, so ℓ_H measures the lot size (ha).

The household's utility is assumed to be additively separable with respect to the private goods (z,ℓ_H) and agricultural land allocation $\mathbf{L} = (L_0,L_1,L_2,\ldots,L_K)$:

$$u(z,\ell_H,\mathbf{L}) = u_p(z,\ell_H) + u_e(\mathbf{L}). \tag{1}$$

The utility u_p, derived from housing per se, depends on the housing characteristics index ℓ_H but not on the surrounding environment. The latter effect enters through the u_e term. This assumption means that households do not view the landscape from their own home but have to go out to open spaces that exist in their area. This is the situation in most urban centers in Israel. While entailing some loss of generality, this assumption will prove useful in the empirical analysis. Maximizing utility with respect to z and ℓ_H subject to the budget constraint $p_z z + r_H\ell_H = y$ gives the demands $z(r_H,y)$ and $\ell_H(r_H,y)$, where y is household's income and r_H is urban land rental rate (the price of z, p_z, is assumed constant and is therefore suppressed as an argument for convenience). Inverting $\ell_H(\cdot)$ gives $D_H(\cdot)$: at a land rental rate r_H, a household's housing land demand satisfies $D_H(\ell_H,y) = r_H$. In terms of aggregate urban land, $L_H = N\ell_H$, this relation is expressed as

$$D_H(L_H / N, y) = r_H \,. \tag{2}$$

Define the indirect utility

$$v(y\,,\mathbf{L}) = u_p(z(r_H,y),\ell_H(r_H,y)) + u_e(\mathbf{L}), \tag{3}$$

where r_H is assumed constant, hence suppressed as an argument. Let $wtp(y,\mathbf{L})$ represent the income required to compensate for the loss of $\mathbf{L}$, (see, e.g., Hanemann 1991, Freeman 2003):

$$v(y{+}wtp(y,\mathbf{L})\,,\mathbf{0}) = v(y\,,\mathbf{L}) \tag{4}$$

The WTP to preserve crop k area L_k conditional on land allocation for all other crops given at $\mathbf{L}_{\,k}{=}(L_1,L_2,\ldots L_{k-1},L_{k+1},\ldots,L_K)$ is defined by

$$wtp_k(y, L_k, \mathbf{L}_{-k}) = \int_0^{L_k} [\partial wtp(y, s, \mathbf{L}_{-k}) / \partial s] ds,\; k = 0,1,2,...,K \,. \tag{5}$$

Notice that the demand for crop k landscape, conditional on other crops land allocation given at $\mathbf{L}_{-k}$, is the marginal WTP $\partial wtp(y,s,\mathbf{L}_{-k})/\partial s$. Equation (5), thus, express the conditional WTP for crop k landscape as the area underneath this demand to the left of L_k. We shall use these conditional WTPs in the empirical analysis. This assumption allows, for example, that a larger area of field crops implies a smaller willingness to pay for an additional hectare of orchards.

The agricultural sector: The agricultural sector in the region consists of identical farmers growing K crops. In the interest of simplicity (and without loss of generality), we assume a single representative farmer. Let $F_k(X_k,L_k)$ represent crop k's production function, using land input L_k and other inputs X_k, assumed for ease of notation to be a single dimension index.[1] Let L_A represent total agricultural land in the region. For a given cropland allocation L_k, $k = 1,2,\ldots,K$, satisfying $\Sigma_k L_k \leq L_A$, The input vector X_k, k

[1] The consideration of many single-crop production functions rather than a general multi-crop production function facilitates the empirical analysis.

= 1,2,…,K, is chosen in order to maximize $\sum_{k=1}^{K}\{p_k F_k(X_k, L_k) - p_x X_k\}$, taking as given the output prices p_k, k = 1,2,…,K, and the price of X, p_x. Necessary conditions for this problem are $\partial F_k(X_k,L_k)/\partial X_k = p_x/p_k$, k = 1,2,…,K. These conditions define the optimal choice of X_k as a function of L_k, p_k and p_x, denoted $X_k(L_k)$, k = 1,2,…,K. Substituting $X_k(L_k)$ in crop k's profit gives crop k's returns to land function

$$\pi_k(L_k) = p_k F_k(X_k(L_k),L_k) - p_x X_k(L_k),\ k = 1,2,\ldots,K. \tag{6}$$

The agricultural output and input prices p_x and p_k, k = 1,2,…,K, are assumed exogenous to the region under consideration (e.g., are world prices) and are therefore suppressed as arguments.

The inverse derived demand for crop k's land is given by the marginal profit of land in crop k production $\pi_k'(L_k)$. When $F_k(X_k,L_k)$ exhibits decreasing returns to scale (e.g., due to the fixed quantity of the farmer's own labor and managerial skills) and $\pi_k(L_k)$ is strictly concave, $\pi_k'(L_k)$ is decreasing and can be inverted to give $\pi_k'^{-1}(r)$. At a land rental rate r, the demand for crop k's land is $\pi_k'^{-1}(r)$ (or 0 if $\pi_k'(0) \le r$). $\pi_k'(L_k)$ is therefore the inverse derived demands for crop k land, k = 1,2,…,K.

The regional derived demand for agricultural land is obtained by horizontally summing the aggregate crop demands $\pi_k'(L_k)$ and is denoted $\Pi'(L)$. When land rental rate equals r, crop k's land demand is the L_k satisfying

$$\pi_k'(L_k) = r,\ k = 1,2,\ldots,K, \tag{7}$$

which we denote $L_k(r)$, and the aggregate agricultural land demand is $L(r) = \Sigma_k L_k(r)$.

When $F_k(X,L)$, k = 1,2,…,K, exhibit constant returns to scale (CRS), the individual crop profit functions $\pi_k(L_k)$ are linear and the marginal profits $\pi_k'(L_k)$, k = 1,2,…,K, are constants, independent of the L_k values. In the absence of additional constraints, the farmer will grow only the crop with the highest π_k'. In actual practice farmland is not homogenous and each crop has its own sensitivity to land quality. The crop with the highest marginal profit will be grown first until it hits its land grade constraint, then the second highest crop, and so on.

3. Rural – urban land allocation

Focusing attention on agricultural-urban land allocation, we take the non-agricultural open area L_0 (parks) as given. The agricultural land available for allocation among the K crops is $\overline{L} = M - L_0$ such that

$$L_H + \sum_{k=1}^{K} L_k \leq \overline{L} . \tag{8}$$

Market allocation: Ignoring distributional aspects, the particular structure of land ownership in the economy is immaterial for welfare evaluation so long as it can support land market transactions. When land rental rate is the same for housing and for crop production, we obtain from (2) and (7),

$$D_H(L_H / N, y) = \pi_k'(L_k), k = 1,2,...,K . \tag{9}$$

Equations (8) and (9) provide K+1 relations to solve for the K+1 market allocations L_H^M and L_k^M, k = 1,2,…,K. The total agricultural area under market allocation is $L_A^M = \sum_{k=1}^{K} L_k^M$.

Social allocation: A feasible land allocation L_H, L_1,L_2,…,L_K (that satisfies constraint 8) generates the surplus $\int_0^{L_H/N} D_H(\ell, y)d\ell + wtp(y, \mathbf{L})$ to the representative household and the agricultural profit $\sum_{k=1}^{K} \pi_k(L_k)$, where $\mathbf{L}$=(L_0,L_1,…,L_K). The allocation thus generates the social welfare

$$W(L_H, \mathbf{L}) = N\left[\int_0^{L_H/N} D_H(\ell, y)d\ell + wtp(y, \mathbf{L})\right] + \sum_{k=1}^{K} \pi_k(L_k) . \tag{10}$$

The socially optimal land allocation maximizes (10) subject to the feasibility constraint (8). Defining the Lagrangean $\Im = W + \mu[\overline{L} - L_H - \sum_{k=1}^{K} L_k]$, the necessary conditions for optimum include:

$$D_H(L_H / N, y) = \mu \,, \tag{11a}$$

where it is recalled that $L_H/N = \ell_H$, and

$$N \frac{\partial wtp(y, \mathbf{L})}{\partial L_k} + \pi_k{}'(L_K) = \mu, k = 1,2,...,K \,. \tag{11b}$$

Conditions (11a-b) imply

$$D_H(L_H / N, y) = N \frac{\partial wtp(y, \mathbf{L})}{\partial L_k} + \pi_k{}'(L_K), \; k = 1,2,...,K \,. \tag{12}$$

The K+1 relations (8) and (12) solve for the K+1 social land allocations L_H^S and L_k^S, $k = 1,2,\ldots,K$. They differ from the market allocation rule (9) due to the marginal WTP for agricultural landscape.[2]

The regional demand for agricultural land is obtained as follows. Let $L_A = \sum_{k=1}^{K} L_k$ denote total (regional) agricultural land and $D_A(L_A,y)$ represent the social (farmers and households) demand for L_A. Let $r_m = Max_k\{N\partial wtp(y,0)/\partial L_k + \pi_k{}'(0)\}$ be the social demand (households and farmers) for the first hectare of agricultural land and define $D_A(0,y) = r_m$. For any $r \in [0,r_m]$, let $L_k(r,y)$, $k = 1,2,\ldots,K$, be the cropland allocations that solve (11b) with $\mu = r$. Then, $L_A(r, y) = \sum_{k=1}^{K} L_k(r, y)$ and $D_A(L_A,y)$ is defined as the inverse of $L_A(r,y)$, i.e., it satisfies

$$D_A(L_A(r, y), y) = r \,. \tag{13}$$

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[2] Notice that the household's WTP is multiplied by N since in its environmental role agricultural land is a public good and Samuelson's (1954) formula applies.

In view of (11b) and (13)

$$D_A(L_A(r,y),y) = N\frac{\partial wtp(y,\mathbf{L})}{\partial L_k} + \pi_k'(L_K(r,y)),\ k = 1,2,...,K\ ,$$

and using (12) we find that the socially optimal agricultural land allocation L_A^S satisfies

$$D_A(L_A^S, y) = D_H((\overline{L} - L_A^S)/N, y)\ . \tag{14}$$

In (14) it is assumed that constraint (8) is binding so that $L_H^S = \overline{L} - L_A^S$. The social land rental rate is

$$r^S = D_A(L_A^S, y) = D_H(L_H^S/N, y) \tag{15}$$

and the social cropland allocations are $L_k^S = L_k(r^S, y), k = 1,2,...,K$. By construction, $L_A^S = \sum_{k=1}^K L_k^S$.

Population and income effects: We investigate the effects of population and income on the social agricultural land allocation L_A^S, assuming for simplicity a single agricultural crop (*K* = 1). With *K* = 1 the crop index *k* is dropped and condition (12) reduces to

$$D_H((\overline{L} - L_A^S)/N, y) = N \times wtp_L(y, L_A^S) + \pi'(L_A^S)$$

where $wtp_L(y,L) = \partial wtp(y,L)/\partial L$ is the representative household's marginal WTP for agricultural land. Differentiating with respect to *N* and rearranging gives

$$L_A^S{}'(N) = \frac{\left(N \times wtp_L(y, L_A^S) - D_H(\ell_H^S, y)/\eta_H(\ell_H^S, y)\right)/N}{-D_H'(\ell_H^S, y)/N - N \times wtp_{LL}(y, L_A^S) - \pi''(L_A^S)} \tag{16}$$

where $D_H' = \partial D_H(\ell_H, y)/\partial \ell_H$, $wtp_{LL} = \partial^2 wtp(y,L)/\partial L^2$, $\eta_H = -(1/D_H')(D_H/\ell_H)$ is the (representative household's) demand elasticity for urban land (recall that $\ell_H = L_H/N$), and the superscript *s* indicates evaluation at the socially optimal land allocation. The denominator on the right-hand side of (16) is positive (the household's demands for urban and agricultural land and the marginal WTP are downward sloping and π is concave), hence the sign of $L_A^S{}'(N)$ is the same as the sign of $N{\cdot}wtp_L - D_H/\eta_H$.

If $(D_H/\eta_H)/N$ decreases with N, there exists a critical urban population above which $L_A^S{}'(N)$ is positive. For example, when $D_H(\ell_H, y) = y/\sqrt{\ell_H}$, the elasticity $\eta_H = 2$, $D_H/\eta_H = y/(2\sqrt{L_H/N})$ and $(D_H/\eta_H)/N = (y/(2\sqrt{L_H})/\sqrt{N}$. As N increases, D_H/η_H diminishes with N and eventually must fall below the representative household's marginal WTP for agricultural land (which, if anything, should increase with N). In this case, for large enough N, the public-good nature of agricultural landscape outweighs the scarcity cost of land, and the social allocation of farmland increases with the urban population. Indeed, this states-of-affair turns out to prevail in our case study (see Section 4).

The income effect on agricultural land allocation is similarly calculated to yield

$$L_A^S{}'(y) = \frac{N\partial wtp/\partial y - \partial D_H/\partial y}{-D_H{}'/N - Nwtp_{LL} - \pi''}. \tag{17}$$

We see that the sign of $L_A^S{}'(y)$ depends on the balance between the income effects of aggregate urban marginal WTP for the amenity ($N{\cdot}\partial wtp/\partial y$) and the income effect of the individual household's urban land demand ($\partial D_H/\partial y$). As in the previous case, it is possible that the income effect on agricultural land will be positive for a large enough urban population.

It is straightforward to verify that both $L_A^M{}'(N)$ and $L_A^M{}'(y)$ are always negative. Thus, land markets will decrease agricultural land allocation in response to either population or income growth, which may contradict the socially desirable outcome.

4. Application

The densely populated, northern half of Israel (the area above the thick line in the map – Figure 1) has been undergoing massive rural-to-urban land relocation, particularly near urban centers where the amenity value of open space in general and farmland in particular is large (Fleischer and Tsur, 2003). Table 1 compares population densities in a number of countries. Figure 1 presents a map and table 2 gives cropland pattern for northern Israel.

Table 1

Figure 1 (Map)

Table 2

We will evaluate the market and social land allocations and the associated welfare measures for a particular sub-region (number 421 in Figure 1), representing non-metropolitan regions in Israel's densely populated costal strip. The region's size is 10,190 ha, of which L_0 = 200 ha are reserved for parks, leaving $\bar{L} = 9{,}990$ ha for allocation between crop production and housing. The number of households in the region is currently around 70,000.

Applying the theory requires: (i) the demand for farmland; (ii) the housing land demand; (iii) the willingness-to-pay for different types of agricultural landscape by urban households; and (iv) combining these three demand components to solve for the market and social allocation of farmland under different assumptions regarding population density. In subsection 4.1 we obtain the derived demand for farmland by calculating the per-hectare quasi profit for each crop, based on revenue, actual crop-land allocation and input cost data.

In section 4.2 we estimate the urban land demand. Because the land market in Israel is highly regulated, we cannot use a standard demand-supply framework. Instead we use an instrumental variable approach with a free parameter that is calibrated based on actual land allocation (to represent the administrative regulation).

In section 4.3 we estimate willingness to pay (WTP) for six crops. We first arrange the six crops in three crop groups, based on a preliminary focus-group analysis, such that crops in the same group have the same landscape value. The WTP functions are specified to allow for cross-group (interaction) effects. The maximum likelihood estimates of the WTP parameters are calculated using survey data collected via double-bounded-dichotomous-choice elicitation method.

In 4.4 we combine the three demand components (farmland, urban and agricultural landscape) to determine the market and social allocation of farmland and in subsection 4.5 we simulate land allocation under an a population increase scenario.

4.1 Farmers' land demand: Aggregate production data are available on area planted, revenues and input costs for six major crops. The data exclude land cost, which is determined endogenously by the model, but include interest payment on capital investment. The six crops are (in descending order of per-hectare profit): (1) flowers grown in greenhouses; (2) orchards (not including citrus); (3) vegetables; (4) citrus groves; (5) irrigated field crops; and (6) unirrigated field crops. Table 2 presents returns per hectare (profits) excluding land costs. It also lists the reserved open area (L_0) that, although cannot be reallocated, will play a role in the derivation of the WTP for agricultural landscape below.

CRS production technology is assumed for each crop, under which the marginal profits are calculated as the return per hectare (revenue minus cost), excluding land rental cost (Table 2). As discussed in Section 2, without exogenous constraints, farmers will grow only the highest value crop – flowers in the present case. But exogenous constraints, such as different soil types and grades, restrict planting area. Consequently, we let the actual planting areas represent these implicit restrictions and obtain the region's inverse derived demand for agricultural land depicted in Figure 2.

Figure 2

4.2 Urban land demand: About 95% of Israel's land is owned by the state and managed by Israel's Land Authority (ILA). An effective farmland protection policy made the development of rural land very difficult in the past, but this policy has been loosening up recently (Feitelson, 1999). Rural land developers pay the ILA a fee determined by land appraisers based on existing plots sold in the market in the same location. We use these data as a proxy for prices of rural land designated for development.

Regarding the quantity variable in the urban land demand equation, we use the average housing area (ha) per household in each of the 34 regional councils of the northern half of Israel. Averaging the price data for each of the regional councils gives 34 price-quantity observations. Data are also available on various soci-economic characteristics of each regional council and an index that ranks them based on eight demographic, education and standard-of-living variables. Table 3 presents summary statistics of the urban demand data.

Table 3

A log-log specification is assumed for the urban demand equation (other forms were tested without improving the fit):

$$\log(p_{Hi}) = \beta_H \log(\ell_{Hi}) + [\alpha_{H0} + \alpha_{Hd} \log(distance_i) + \alpha_{HR} \log(Rank_i)] + \varepsilon_i, \quad (18)$$

where p_{Hi} is the average land price in region *i*. To test for exogeneity of ℓ_h, we use Davidson and MacKinnon's variant of Hausman's (1978) test (see, e.g., Davidson and MacKinnon, 1993) with the intercept, *distance*, *rank*, *permatriculation*, *area*, *age* and *motorate* as instruments (see table 3 for variable descriptions). The test does not reject the hypothesis that log ℓ_H is uncorrelated with ε, justifying the use of OLS. The OLS estimates of the urban demand equation are reported in table 4.

Table 4

The coefficient of log ℓ_h is negative, as expected. Also expected are the positive estimate of the coefficient of *rank* and the negative estimate of the coefficient of *distance* (housing prices are higher in localities that have higher levels of socio-economic characteristics and that are closer to metropolitan centers).

The urban land prices include infrastructure cost such as sewerage, roads, electricity and communication. To put them on a par with marginal values of farmland and landscape WTP, the infrastructure cost should be accounted for and the annual (rental) equivalent should be calculated. With q denoting the interest rate and ρ the part of the urban land price due to infrastructure cost, the rental rate of urban land net of the infrastructure costs is $r_H = q(1-\rho)p_k$, which in view of (18) is given by $r_H = e^{\alpha_h} \ell_H^{\beta_h}$, where $\alpha_h=\alpha_{h0}+\alpha_{hd}\log(distance)+\alpha_{hR}\log(Rank)+\log(q(1-\rho))$.

We use the OLS estimate $\hat{\beta}_h$ = -0.712 (table 4) for β_h, and calibrate α_h so that the *market* allocation of urban land in the region under consideration is larger than the *observed* allocation. In doing so, we account for existing administrative restrictions that mitigate land-markets operation. Amongst them is the Planning and Building law which identifies protection of agricultural land as a statutory objective of the different planning authorities (Israel has a centralized land planning system). Likewise, any change of land use from agriculture to non-agriculture must be approved by various planning and regulation authorities at the regional and national levels (Alterman, 1997;Feitelson, 1999; Israel 2020, 1995). In particular we assume, based on Feitelson(1999), that the market allocation of urban land is about a third larger than the observed allocation of 4,100 ha and set it at 5,500 ha. The corresponding agricultural land market allocation is 9,990–5,500 = 4,490 ha, which falls at the irrigated field-crop area (see Figure 2). We thus calibrate α_h such that the urban land demand at L_H=5,500 ha equals $268 per ha – the marginal profit of land at irrigated field crop production (see Table 2 and Figure 2). The calibrated $\hat{\alpha}_h$, thus, satisfies $268 = e^{\hat{\alpha}_h}\left(\frac{L_H}{N}\right)^{-0.712} = e^{\hat{\alpha}_h}\left(\frac{5500}{70000}\right)^{-0.712}$, giving $\hat{\alpha}_h$= 3.78. We thus obtain the following inverse demand for urban land:

$$r_h = e^{3.78}\left(\frac{L_H}{N}\right)^{-0.712}. \qquad (19)$$

4.3 WTP estimation: In 4.3.1 we describe the data collection and explain how the crop groups were determined. In subsection 4.3.2 we depict the specification of the WTP functions and 4.3.3 specifies the likelihood function and presents the maximum likelihood estimates.

4.3.1 WTP data and crop-group classification: Data on WTP for agricultural landscape were collected using a double-bounded-dichotomous-choice elicitation method (also called take-it-or-leave-it-with-a-follow-up by Mitchell and Carson (1989); see also Hanemann et al. (1991) and Bateman et al. (2002)) with six random levels of annual tax bids. The WTP data were collected from Israel's urban population during the autumn of 2002. The questionnaire was designed based on three focus groups that served to establish crop groups (if households are indifferent between landscape of 2 or more crops, these crops are lumped to form a crop group), to assess the bid range, and to test different scenarios of landscape transformation (further details can be found in Shemesh-Adani, 2003).

Individuals in the focus groups received over 30 cards with photos of crop landscapes in the Hula Valley, located at the northeast tip of Israel[3], and were asked to classify the landscapes according to their aesthetic value. This led to the classification of agricultural landscapes into three crop groups: group 1 includes orchards and citrus; group 2 includes field crops (irrigated and unirrigated), vegetables and natural open spaces; and group 3 consists of flowers grown in greenhouses. Respondents were indifferent between crop landscapes within each group and ranked group 1 (orchards and citrus) as having the highest landscape value, followed by group 2 (field crops, vegetables and open spaces) and group 3 (greenhouses). We thus had six crops (K = 6) and three crop groups (J = 3). The crop-group classification is summarized in table 5.

Table 5

Based on the focus groups the annual bids for agricultural landscape were set between \$2.5 and \$55. I addition a preliminary questionnaire was created and pre-tested in a pilot of 47 respondents, after which the final questionnaire was designed.

A face-to-face survey was conducted among a representative sample of the urban population (cities above 50,000 inhabitants) to obtain WTP for each landscape type. The sample was designed as follows: the relevant cities were divided into small (50,000 – 100,000 inhabitants), medium (100,000 – 200,000 inhabitants) and large (above 200,000 inhabitants). From each of the 4 large and 9 medium cities, a sample size proportional to the city's population was randomly drawn. Regarding the small

[3] For practical reasons it is hard to provide respondents with landscape pictures taken from their own regions and the Hula Valley served to illustrate the landscape types (see Shuttleworth, 1980 and Dunn, 1976 for the use of photos as surrogates for on-site visual assessment).

cities, 9 were selected at random and a random sample was drawn from each. Altogether, the sample contained 350 respondents.

Each respondent received pictures of the three landscape types and was confronted with the scenario under which the agricultural landscape would be developed (transformed into urban land). Preserving the agricultural landscape requires imposing a tax (at the bid level) and respondents were asked if they were willing to pay it[4]. Those that answered "yes" were given a higher tax level (bid) and those that refused to pay were given a lower tax bid. This procedure was repeated for each of the three landscape types (crop groups). In this way, the upper and lower bounds for the WTP range of each respondent for each landscape type were set.

Finally, we need to obtain the landscape allocation between the three crop groups for each respondent's locality. To that end, we use land allocation data for 43 "natural" sub-regions, determined by Israel's Central Bureau of Statistics (see Figure 1). For each of these sub-regions, data are available on population density (number of inhabitants per square kilometer) and cropland areas for the three crop groups. By identifying the sub-region of residence, we can associate these data with each respondent. Table 6 presents summary statistics of various socio-economic and demographic variables for the 43 sub-regions.

Table 6

4.3.2 WTP specification: A quadratic WTP function has been adopted

[4] To minimize anchoring effects, the value of the first bid was based on the focus groups and the pretest preceding the survey. Following Green et al. (1998) suggestion, an open-ended follow up was used in the pretest to the first bid according to which the final first bid values in the questionnaire were chosen.

$$wtp_i = \sum_{j=1}^{3}(\alpha_{ij}\mathbf{L}_{ij} + \tfrac{1}{2}\beta_j\mathbf{L}_{ij}^2) + \gamma_{12}\mathbf{L}_{i1}\mathbf{L}_{i2} + \gamma_{13}\mathbf{L}_{i1}\mathbf{L}_{i3} + \gamma_{23}\mathbf{L}_{i2}\mathbf{L}_{i3}, \tag{20}$$

where $\mathbf{L}_{ij}$ is crop group j's land allocation in respondent i's locality (sub- region), $\alpha_{ij} = \alpha_j + \alpha_{jy}y_i + \alpha_{jA}Age_i$, j=1,2,3, and y_i and Age_i represent respondent i's income and age, respectively. In view of equation (5) the conditional WTP functions for crops in group 1 landscape (orchards and citrus), 2 (vegetables, field crops and parks) and 3 (greenhouses) are specified, respectively, as:

$$\begin{cases} wtp_{1i} = (\alpha_1 + \alpha_{1y}y_i + \alpha_{1A}Age_i)\mathbf{L}_{i1} + (\gamma_{12}\mathbf{L}_{i2} + \gamma_{13}\mathbf{L}_{i3})\mathbf{L}_{i1} + 0.5\beta_1\mathbf{L}_{i1}^2 \\ wtp_{2i} = (\alpha_2 + \alpha_{2y}y_i + \alpha_{2A}Age_i)\mathbf{L}_{i2} + (\gamma_{12}\mathbf{L}_{i1} + \gamma_{23}\mathbf{L}_{i3})\mathbf{L}_{i2} + 0.5\beta_2\mathbf{L}_{i2}^2 \\ wtp_{3i} = (\alpha_3 + \alpha_{3y}y_i + \alpha_{3A}Age_i)\mathbf{L}_{i3} + (\gamma_{13}\mathbf{L}_{i1} + \gamma_{23}\mathbf{L}_{i2})\mathbf{L}_{i3} + 0.5\beta_3\mathbf{L}_{i3}^2 \end{cases} \tag{21}$$

4.3.3 *Estimation*: Our observations entail the conditional WTPs, specified in (21), rather than the unconditional WTP of (20). Adopting Hanemann et al.'s (1991) logistic specification, the likelihood of crop group j's conditional WTP of household (respondent) i is specified as:

$$\Im_{ij} = \begin{cases} 1-[1+\exp(\frac{1}{\sigma_j}wtp_{ij} - \frac{1}{\sigma_j}BU_{ij})]^{-1} & if\ yy \\ [1+\exp(\frac{1}{\sigma_j}wtp_{ij} - \frac{1}{\sigma_j}BU_{ij})]^{-1} - [1+\exp(\frac{1}{\sigma_j}wtp_{ij} - \frac{1}{\sigma_j}B_{ij})]^{-1} & if\ yn \\ [1+\exp(\frac{1}{\sigma_j}wtp_{ij} - \frac{1}{\sigma_j}B_{ij})]^{-1} - [1+\exp(\frac{1}{\sigma_j}wtp_{ij} - \frac{1}{\sigma_j}BL_{ij})]^{-1} & if\ ny \\ [1+\exp(\frac{1}{\sigma_j}wtp_{ij} - \frac{1}{\sigma_j}BL_{ij})]^{-1} & if\ nn \end{cases} \tag{22}$$

where BL_{ij}, B_{ij} and BU_{ij} represent, respectively, the lower bid, the initial bid and the upper bid of the double-bounded dichotomous-choice procedure, *yy* means a "*yes*" response to the initial bid and a "*yes*" response to the following (upper) bid, *yn* indicates a "*yes*" followed by "*no*" and so on. Assuming independence of the conditional WTPs across crop groups, the likelihood of the i'th respondent is given by $\Im_i = \Im_{i1} \times \Im_{i2} \times \Im_{i3}$. The maximum likelihood estimates are presented in table 7.

Table 7

As expected, the own-effect parameters (β_1, β_2 and β_3) are negative, verifying the diminishing marginal WTP for agricultural landscape: the larger the crop group area, the smaller the WTP for an additional land of the same crop group. The cross-effects parameters, γ_{ij}, can be of either sign, depending on the interaction between crop groups. For example, a negative γ_{12} implies that the marginal WTP for group 2 landscape decreases with group 1 area, in which case we say that the two crop groups are substitutable. A positive γ_{12} value indicates that crop groups 1 and 2 are complementary.

Figure (3) reveals that the market allocation occurs at the irrigated field crops area, where the areas of greenhouses (L_1 = $\mathbf{L}_3$), orchards and citrus (L_2+L_4=$\mathbf{L}_1$), vegetables (L_3) and parks (L_0) are fixed. Observing equation (12), the social allocation requires marginal WTP for field crops area, i.e., $\partial wtp/\partial \mathbf{L}_2$, which, in view of (20), is given by

$$\partial wtp/\partial \mathbf{L}_2 = (\alpha_2 + \alpha_{2y}y + \alpha_{2A}Age + \gamma_{12}\mathbf{L}_1 + \gamma_{23}\mathbf{L}_3) + \beta_2\mathbf{L}_2. \qquad (23)$$

Evaluating (23) at the parameter estimates, using the region's levels of y_i and Age_i, and setting greenhouses (L_1 = $\mathbf{L}_3$=190 ha), orchards and citrus ($\mathbf{L}_1$=L_2+L_4 =2,110 ha), vegetables (L_3 = 2080) and parks (L_0= 200) at their observed levels, we obtain

$$\frac{\partial wtp}{\partial \mathbf{L}_2} = \begin{cases} 0.003316 - 1.51245 \times 10^{-7}(200 + 2080 + L_5 + L_6) & if\ \ 0 \le L_5 + L_6 \le 670 + 840 \\ 0.003316 - 1.51245 \times 10^{-7}(200 + 2080 + 670 + 840) & otherwise \end{cases} \qquad (24)$$

4.4. We now use the farmland demand, urban housing demand and agricultural landscape demand to determine the market (subsection 4.4.1) and social (subsection 4.4.2) land allocation.

4.4.1 Market allocation: In Figure 3, farmland is measured (on the horizontal axis) from left to right and urban land from right to left. The private (farmers') derived demand for farmland and the urban land demand (equation 19) are denoted D_A^M and D_H, respectively. The market allocation occurs at the intersection of the two demand curves, giving L_A^M = 4,490 ha and L_H^M = 9,990 – 4,490 = 5,500 ha, which is larger than the observed urban land allocation of 4,100 ha by about 33 % (see discussion above equation 19).

Figure 3

We see (Figure 3) that the market allocation occurs over the irrigated field crops area, with the 4,490 ha of farmland allocated as follows: L_1 = 190 ha (flowers), L_2 = 440 ha (orchards), L_3 = 2080 ha (vegetables), L_4 = 1,670 ha (citrus) and L_5=110 ha (irrigated field crops). We know that the social allocation can only increase the agricultural area. Given the farmers' land demand depicted in Figure 2, an increase in farmland (above the market allocation) implies an increase in land allocated to irrigated field crops (L_5) and possibly to unirrigated field crops (L_6). This property facilitates the evaluation of the social land allocation, to which we now turn.

4.4.2 *Socially optimal allocation*: The social demand for farmland is the sum of marginal value of land from crop production and the marginal WTP for the crop groups multiplied by the number of households, (c.f. the right-hand side of equation 12). Due to the interaction effects, the marginal WTP for each crop group depends on land allocated to the other crop groups as well. In general, the land allocation must be determined simultaneously for all crops (according to equations 8 and 12). In the present case, the CRS assumption and the WTP estimates simplify matters, allowing to consider only field crops allocation while taking the other crops land allocations at their observed levels. Thus, in equation (24) the intercept (0.003316) already accounts for the interaction effects of irrigated and unirrigated field crops (crop group 2) WTP with that of flowers, orchards and citrus, and vegetables, which are assumed given at their observed areas (see equation 23).

In Figure 4, we add the marginal WTP for field crops, specified in equation (24), to the private (farmers') demand and obtain the social demand for farmland. In doing so we exploit the CRS with restrictions and the WTP pattern under which the land allocations of the higher-valued crops (flowers, orchards, vegetables and citrus) remain unchanged. The social allocation is obtained at the intersection of the social demand for agricultural land and the urban land demand, giving: L_A^S = 5,061 ha and L_H^S = 4,929 ha.

Accounting for the amenity value of farmland reduces urban land allocation from 5,500 ha to 4,929 ha (a decrease of about 10 %) and increases farmland allocation by about 13 % -- from 4,490 ha to 5,061 ha (see Table 8). Evaluating equation (20) at the parameter estimates, we can calculate the WTP for an average household at the market and social farmland allocation. Multiplying by the number of households in the region gives the aggregate WTPs of \$3.478 million and \$3.595 million for the market and social allocations, respectively (see Table 8). As shares of farming profits, these WTPs are 15.5 % and 16 % under the market and social allocations, respectively.

Figure 4

4.5 Population effect: The above allocations are calculated at the current population level. At the prevailing growth rate (2.5%), Israel's population will double in less than 30 years. We thus repeat the calculations under regional population of 140,000 households. The land allocation results are reported in Table 8 and shown in Figure 5. Indeed, in the present case a growing population calls for more farmland preservation rather than less (the agricultural land increases from 4,380 ha to 5,234 ha while the urban land decreases from 5,610 ha under the market allocation to 4,756 ha under the social allocation). The aggregate WTPs under the market and social allocations are, respectively, \$6.9 million and \$7.26 million, which amount to 31.6% and 33.5% of the farmers' profits.

This result of increase in farmland allocation with increase in population was alluded to in the theoretical part where we show analytically that for large enough N social allocation can result in an increase in farmland with increase in population. The intuition behind it stems from the fact that increase in population entails two counteractive forces. One, is increase in demand for urban land and thus to a decrease in farmland. The second is increase in demand for landscape which leads to increase of farmland. In our case apparently due to the strong preference of population to landscape the second force is stronger and the end result is more farmland supplying landscape service than urban land supplying housing service.

Table 8

Figure 5

The above calculation considers the pure effect of population growth. In actual practice, many other circumstances are likely to change over time, which should be accounted by land allocation policies.

5. Concluding comments

Disappearing farmlands due to urban sprawls are commonplace in developed and densely populated regions. This is indeed the inevitable outcome of the invisible-hand's response to population and income pressures. We show that the amenity value of agricultural landscape should mitigate these trends and may even reverse them – as is the case in our empirical study. In our framework the optimal farmland allocation depends not only on the amenity value of agricultural landscape in general but also on its distribution across agricultural crops. Crop areas differ in their return to farming and in the amenity value they generate. The amenity value of farmland, thus, bears both on the overall rural-urban land allocation and on the allocation of farmland between the different crops. These observations should be considered in any agricultural policy intervention.

The failure of land markets to account for the amenity value of farmland can be addressed by a variety of policy interventions (Hodge, 2000). Examples include strict regulation such as zoning (Alterman, 1997), market-based mechanisms such as rural tourism infrastructure aimed at internalizing the landscape externality (Fleischer and Felsenstein, 2000), and incentive-based approaches such as agricultural landscape subsidies (Feather and Barnard, 2003). If the current farm programs in developed countries are to be justified by this market failure, they should pay close attention to the heterogeneity of the amenity value of farmland across crops.

The analysis presented here can be extended in a number of ways. First, the agricultural production technology, giving rise to farmland demand, can be specified as a multi-crop technology with cross-crops (e.g., land rotation) restrictions and generalized to allow for decreasing (or increasing) returns to scale. Second, the separability of utility with respect to the private and environmental goods can be done away with. Finally, a dynamic framework that considers the region's evolution over time can be formulated. Each of these extensions will enable addressing a broader range of issues and policies, and will require appropriate data for an empirical investigation.

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Shuttleworth, S. (1980). The use of photographs as an environmental presentation medium in landscape studies. *Journal of Environmental Management*, 11:61-76.

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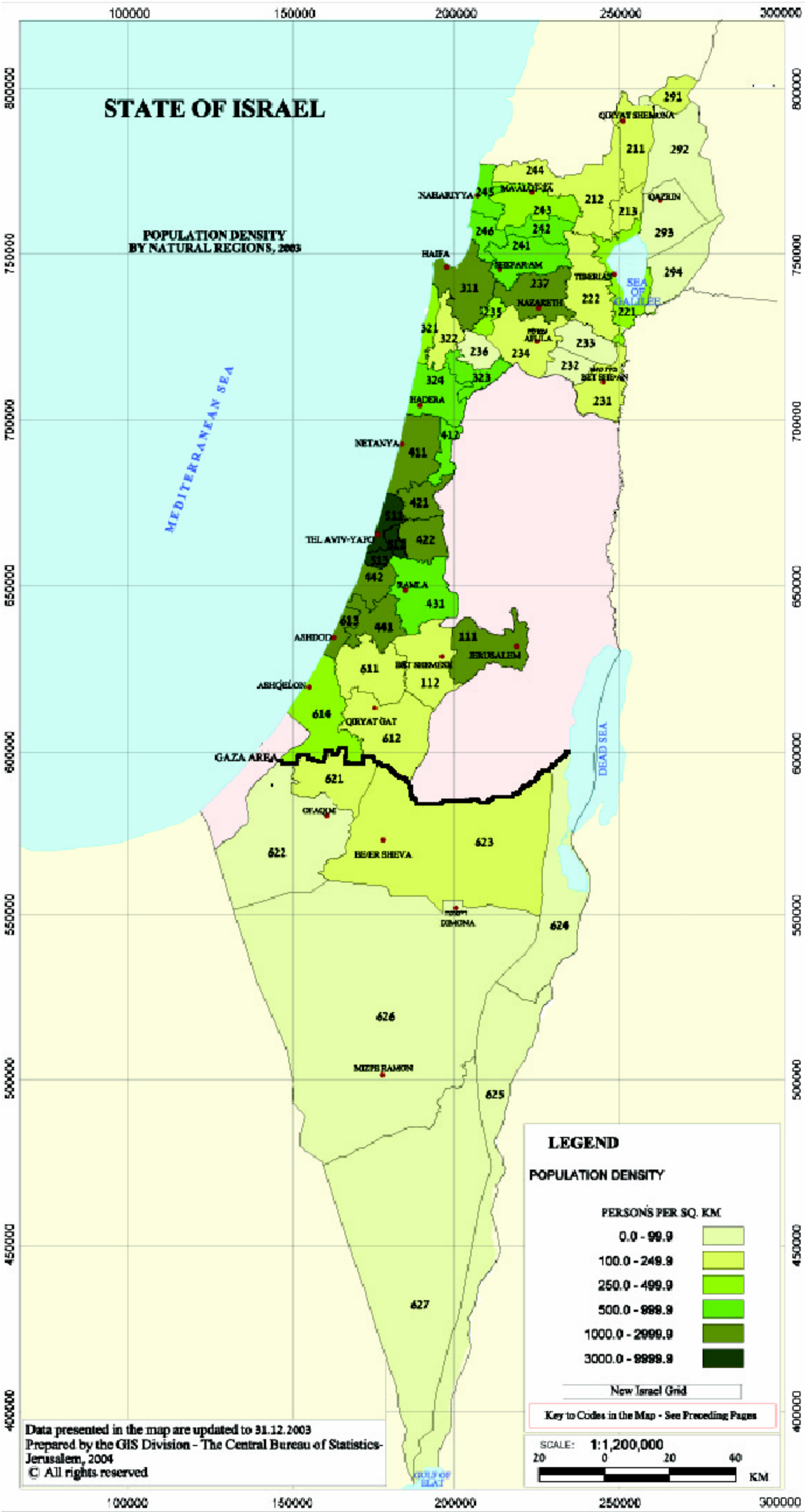
STATE OF ISRAEL
POPULATION DENSITY
BY NATURAL REGIONS, 2003
MEDITERRANEAN SEA
SEA OF GALILEE
DEAD SEA
GAZA AREA
QIRYAT SHEMONA
NAHARIYYA
QAZRIN
HAIFA
TIBERIAS
NAZARETH
HADERA
NETANYA
TEL AVIV-YAFO
RAMLA
ASHDOD
JERUSALEM
BET SHEMESH
ASHQELON
QIRYAT GAT
OFAQIM
BE'ER SHEVA
DIMONA
MIZPE RAMON
GULF OF ELAT
LEGEND
POPULATION DENSITY
PERSONS PER SQ. KM
0.0 - 99.9
100.0 - 249.9
250.0 - 499.9
500.0 - 999.9
1000.0 - 2999.9
3000.0 - 9999.9
New Israel Grid
Key to Codes in the Map - See Preceding Pages
SCALE: 1:1,200,000
20 0 20 40
KM
Data presented in the map are updated to 31.12.2003
Prepared by the GIS Division - The Central Bureau of Statistics-Jerusalem, 2004
© All rights reserved

Figure 2: Farmers' derived demand for Land.

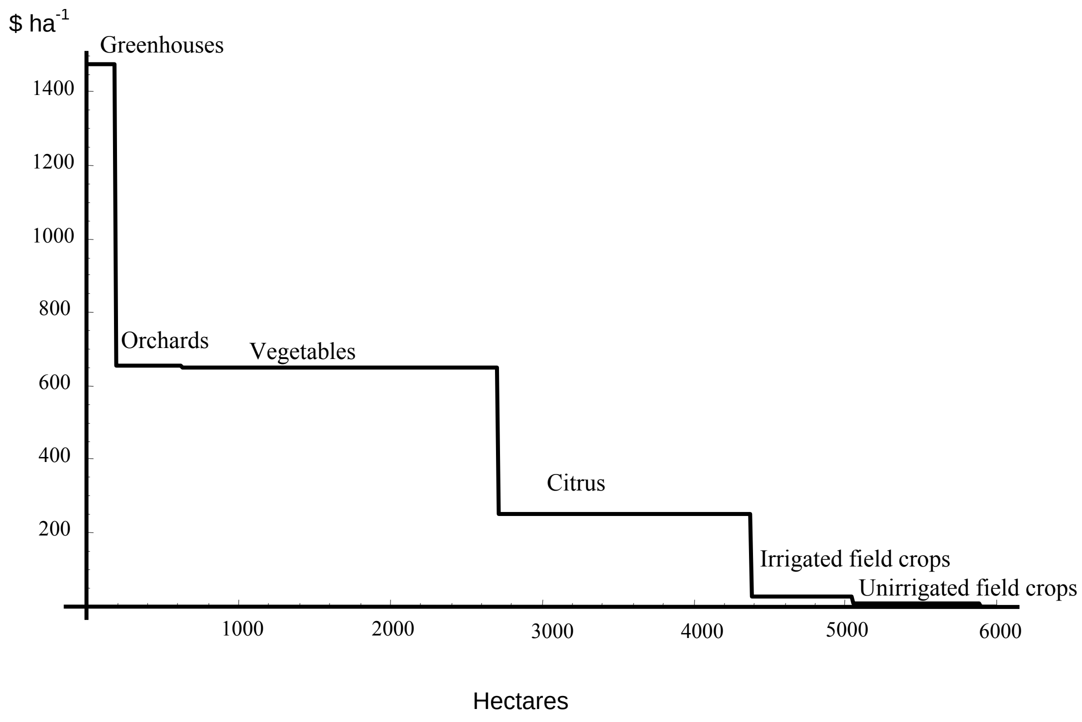

Figure 3: Market allocation of farmland

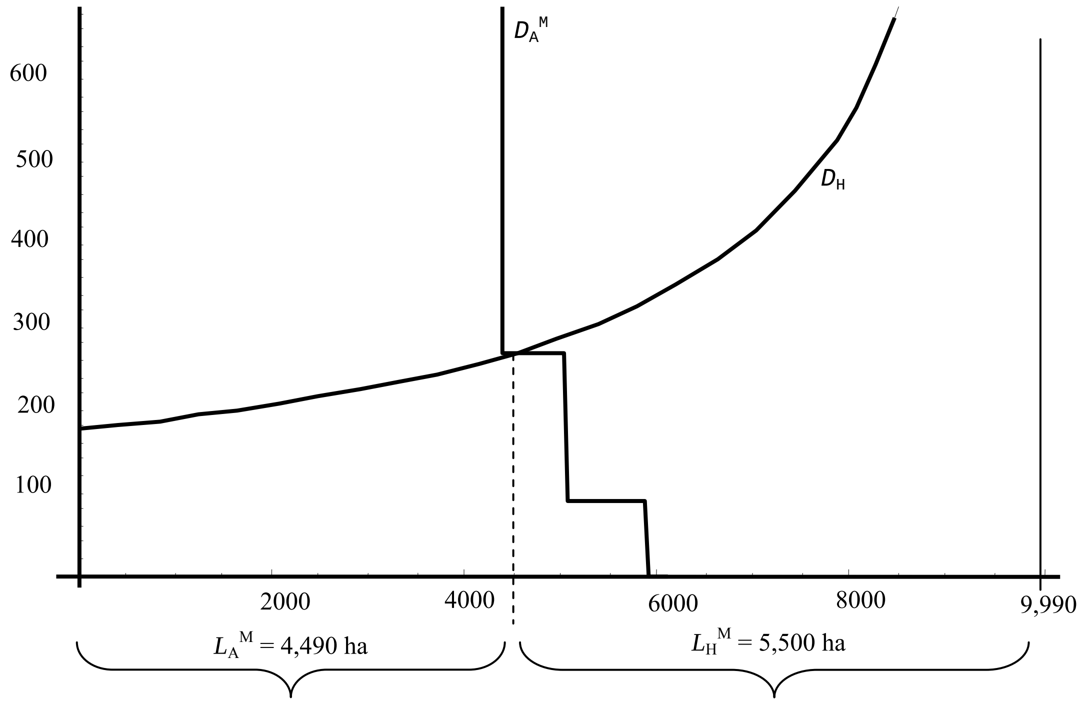

Figure 4: Social allocation of farmland

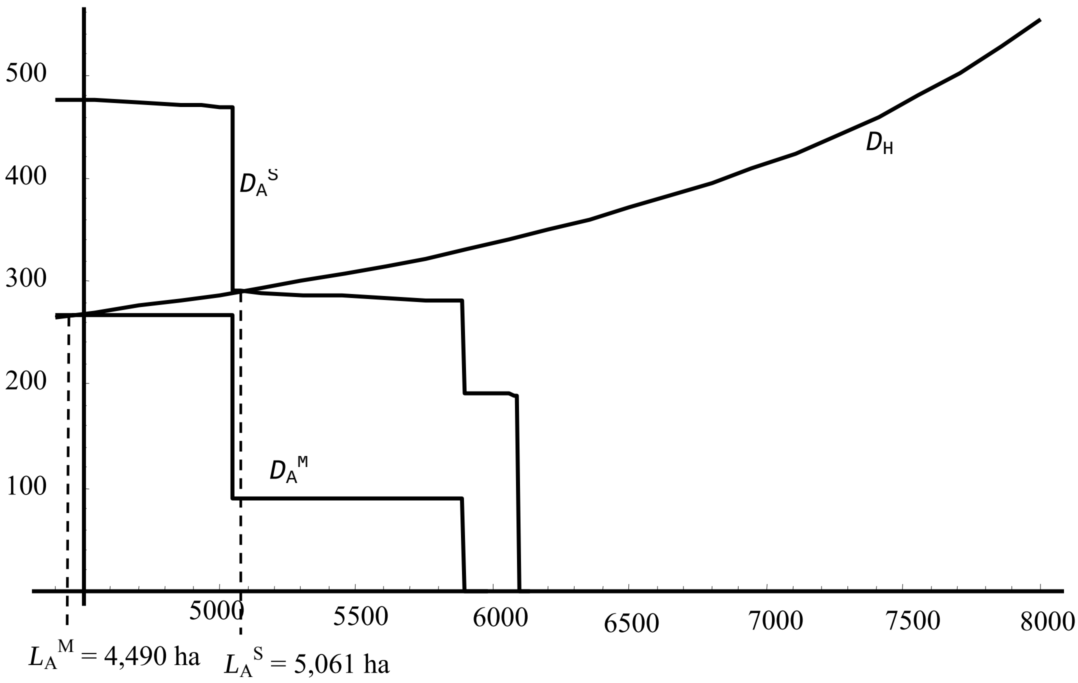

Figure 5: The Effect of Doubling the Population on Market and Social Allocation

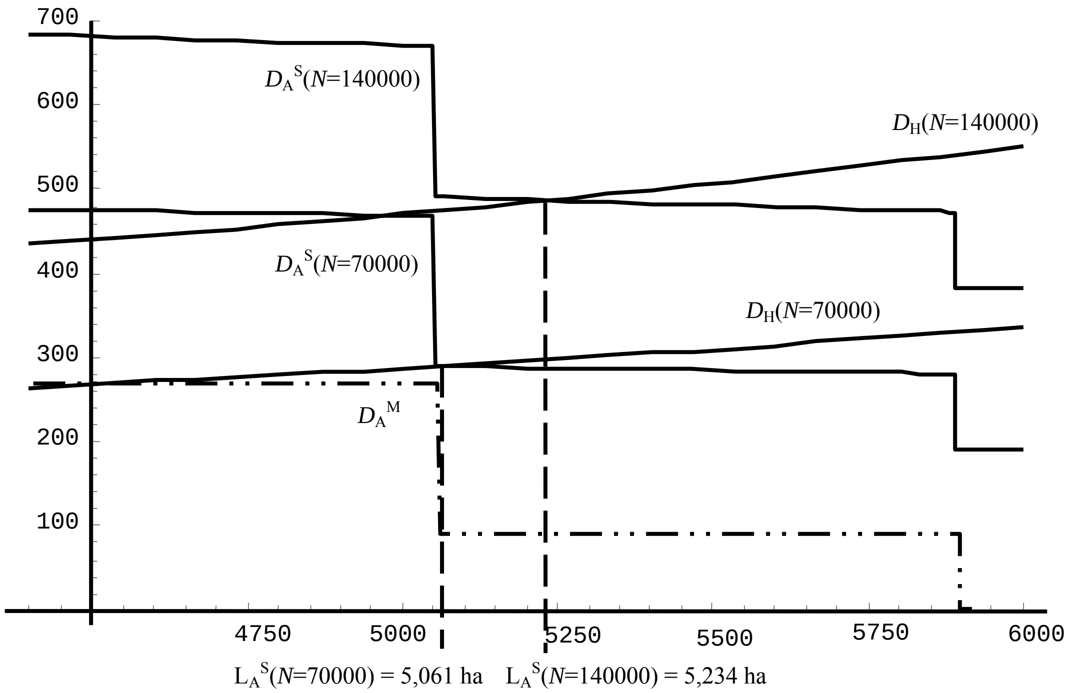

Table 1: Some Population Density Data (inhabitants per km^2).

	1961[1]	**2000**[2]
USA	20	29
France	84	107
UK	218	241
Netherlands	345	381
Israel (north-central region)	180 (270)	291 (691)

Sources:
1) World Bank (2000)
2) Israel Central Bureau of Statistics (2002)

Table 2: Agricultural Data and Land Use Distribution of the Study Region.

	Land use [1,3] **(ha)**	**Revenue**[2] **($/ha)**	**Cost**[2] **($/ha)**	**Profit= revenue-cost ($/ha)** [2]
Flowers (greenhouses)	190	98,358	83,596	14,762
Other orchards	440	20,780	14,224	6,554
Vegetables	2,080	53,587	47,078	6,509
Citrus groves	1670	10,173	7,669	2,504
Irrigated field crops	670	2,224	1,956	268
Unirrigated field crops	840	740	651	89
Natural open space	200	-	-	-
Housing	4,100	-	-	-

Sources: (1) Israeli Ministry of Agriculture and Rural Development (2002); (2) Hadas (2003); (3) Frenkel (2001)

Table 3: Descriptive Statistics of the Regional Councils' Data

Variables	**Description**	**Mean**	**SD**
p_h	Payment to the ILA ($ per ha) (1)	758,357	828,568
ℓ_h	Developed land per household (ha) (2)	0.12	0.07
distance	Measured in distance rings from metropolitan center(3)	2.4	2.0
rank	Socio-economic ranking of local authority (4)	31.5	14.9
age	The median age in the Regional Council(4)	26.7	3.7
permatriculation	Percent of high-school graduates receiving matriculation certificate as a share of the age group 18-19(4)	52.9	12.2
area	Total area of Regional Council in km^2 (2)	285.1	186.2
motorate	Percent of car owners (4)	26.6	8.7

Sources: (1) ILA: http://www.mmi.gov.il/Envelope/index.asp
(2) Israel Central Bureau of Statistics (2002)
(3) The rings are measured in 16 km increments from the center of the nearest metropolitan. Local authority located less than 16 km from the center receives the value 1, local authority located between 16 and 32 km receives the value 2 and so forth.
(4) Israel Central Bureau of Statistics: http://www.cbs.gov.il/hodaot2004/13_04_22.htm#tabsgraphs

Table 4: OLS Estimates of The Urban Land Demand Coefficients

Variable	**Coefficient**	**SE**
α_{h0}	10.65**	1.63
$\log(\ell_h)$	-0.712***	0.44
log(distance)	-1.36**	0.31
log(rank)	0.56*	0.31
R^2	0.60	
N	33	

** and * denote significance at the 5% and 10% levels, respectively

*** significant at 6% against the alternative that the parameter is nonnegative.

Table 5: Classification of Crops and Crop Groups

Crops			**Crop groups**		
Index *k*	**Description**	**Area symbol**	**Index *j***	**Description**	**Area symbol**
1	Flowers (greenhouses)	L_1	**1**	Orchards and citurs (k=2, 4)	$\boldsymbol{L}_1=L_2+L_4$
2	Orchards	L_2	**2**	Field crops, vegetables and open space (k = 3, 5, 6, 0)	$\boldsymbol{L}_2 = L_3 + L_5 + L_6 + \mathrm{L}_0$
3	Vegetables	L_3	**3**	Flowers (k=1)	$\boldsymbol{L}_3=L_1$
4	Citrus	L_4			
5	Irrigated field crops	L_5			
6	Unirrigated field crops	L_6			
0	Reserved open space	L_0			

Table 6: Summary Statistics of Explanatory Variables in WTP Equations

Variables	**Description**	**Mean**	**SD**
Age	Years, head of household	43.2	16.9
Income	Monthly income after tax ($)	1,674	788
$\mathbf{L}_1$ (1)	Area of crop group 1 (citrus and other orchards)	2,124	1,184
$\mathbf{L}_2$ (1)	Area of crop group 2 (field crops, vegetables, open space)	4,804	5,279
$\mathbf{L}_3$ (1)	Area of crop group 3 (greenhouses)	123	187

Source: (1) Israel Central Bureau of Statistics (2002)

Table 7: Maximum Likelihood Estimates of WTP Parameters

Group1 (orchards and citrus)	**Coefficient**	**Std. Err.**
β_1/σ_1 (own effect) **	-5.4×10^{-7}	1.86×10^{-7}
γ_{13}/σ_1 (interaction with greenhouse) **	7.41×10^{-7}	3.9×10^{-7}
γ_{12}/σ_1 (interaction with field crops)	-2.2×10^{-8}	1.99×10^{-8}
α_1/σ_1 **	0.00127	0.00044
α_{1y}/σ_1 (income) *	4.28×10^{-8}	2.28×10^{-8}
α_{1A}/σ_1 (age)**	-1.19×10^{-5}	5×10^{-6}
$1/\sigma_1$ **	0.057	0.0053
Group 2 (vegetables, field crops and open areas)		
β_2/σ_2 (own effect)	-8.65×10^{-9}	9.6×10^{-9}
γ_{23}/σ_2 (interaction with greenhouses)	1.42×10^{-7}	2.02×10^{-7}
α_2/σ_2 **	2.81×10^{-4}	1.43×10^{-4}
α_{2y}/σ_2 (income)	6.83×10^{-9}	7.97×10^{-9}
α_{2A}/σ_2 (age) **	-4.57×10^{-6}	1.67×10^{-6}
$1/\sigma_2$ **	0.057	0.0068
Group 3 (greenhouses)		
β_3/σ_3 (own effect)**	-1.5×10^{-5}	6.89×10^{-6}
α_3/σ_3	0.00545	0.00468
α_{3y}/σ_3 (income)	-1.17×10^{-7}	2.97×10^{-7}
α_{3a}/σ_3 (age)	-7×10^{-7}	7.8×10^{-7}
$1/\sigma_3$ **	0.069	0.0066

** and * denote significance at the 5% and 10%, respectively.

Table 8: Land allocation and WTP for agricultural landscape.

	Total area: 10,190 ha **Reserved open space: 200 ha** **Area for allocation between crop production and housing: 9,990 ha**			
	N= 70,000 households		**N = 140,000 households**	
	Market	Social	Market	Social
L_A (ha)	4,490 ha	5,061 ha	4,380 ha	5,234 ha
L_H (ha)	5,500 ha	4,929 ha	5,610 ha	4,756 ha
Aggregate WTP ($)	3,478,350	3,594,780	6,910,000	7,260,000
WTP as a share of return from farming (%)	15.5	16	31.6	33.5

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