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by

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

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Abstract

We study the effect of the amenity benefits of agricultural landscape on rural-urban land allocation. The amenity benefits vary with agricultural activities (crops), and thus also affect crop-land allocation within the agricultural sector. Land markets ignore the amenity benefits and as a result lead to undersupply agricultural land. Moreover, contrary to land market allocations, increased population and households’ income may call for more farmland preservation. An application to an Israeli case reveals that the extent of market undersupply of farmland and the associated welfare loss are substantial. Some corrective policies are discussed.

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Introduction

The increasing role of farmland as a provider of environmental amenities – in addition to its traditional role as an 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 outdoor recreation which requires rural amenities. At the same time, these processes increase the demand for urban land, which competes with agriculture for land resources. The balance of these conflicting trends – the increased demand for the environmental amenities provided by farmland on the one hand and the increased urban land demand on the other – underlies rural-urban land allocation. The public good nature of the amenities provided by agricultural landscape renders land markets a suboptimal allocation mechanism and calls for policy intervention.

In this paper we study agricultural-urban land allocation in light of the rising amenity value of agricultural landscape. A given land area is to be allocated between a number of agricultural activities (crops) and urban use. Each activity (crop) area generates private benefits (profit from agricultural produce) and amenity benefits (open space, aesthetic landscape, hiking trails). Land allocated for housing provides only private benefits. Land markets overlook the social (environmental) role of agricultural land and as a result lead to undersupply of farmland. In an empirical study of an Israeli case, we find the undersupply of farmland and the associated deadweight loss to be substantial.

Our framework is related to the large body of literature dealing with external effects in agriculture (see, e.g., OECD, 2000; Peterson, Boisvert and de Gorter, 2002 and references therein) and focuses on the positive externalities generated by agricultural landscape. Earlier works in this vein include McConnell (1989), Lopez et

The present effort analyzes rural-urban land allocation when the environmental benefits of farmland vary across agricultural activities (crops). Empirical evidence (Shemesh-Adani, 2003) suggests that different crop groups, such as field crops, orchards and greenhouses, have different amenity benefits. 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).

We also study effects of population and income growth on rural-urban land allocation. Contrary to market allocation outcomes, we find that an increase in either population or income may call for more farmland preservation. Some policy measures to correct land market failures are discussed.

The next section describes the economic environment and specifies demands for agricultural land and for urban land. The following section characterizes the market and socially optimal land allocations and the associated welfare measures. An empirical analysis to the Israeli case reveals a substantial welfare loss due to marker allocation. Possible corrective policies are discussed.

The Economy

*Households:* There are $N$ identical households in the economy, each deriving utility from the consumption of private goods and public goods (environmental
quality). The latter depends on a variety of factors, such as availability of urban and national parks, beaches, air and water pollution, and aesthetic landscape (Fleischer and Tsur, 2003). Here we concentrate on environmental benefits due to 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 (denoted $z$), the consumption of housing or housing land $\ell_H$, and the consumption of environmental quality as represented by agricultural land allocation among $K$ crops, $L_k$, $k=1,2,\ldots,K$. We assume that the utility is additively separable with respect to the private $(z,\ell_H)$ and environmental $(L_1,L_2,\ldots,L_K)$ commodities and that the environmental subutility is additively separable with respect to the $L_k$'s:

$$u(z,\ell_H,L_1,L_2,\ldots,L_K) = u_0(z,\ell_H) + \sum_{k=1}^{K} u_k(L_k).$$

The choice of $z$ and $\ell_H$ that maximizes $u$ 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 hence suppressed as an argument for convenience). Inverting $\ell_H(r_H,y)$ gives the inverse demand for urban land $D_H(\ell_H,y)$. At a land rental rate $r_H$, the representative household's land demand satisfies $D_H(\ell_H,y) = r_H$, or in terms of the aggregate urban land $L_H = N\ell_H$

$$D_H(L_H / N, y) = r_H. \tag{1}$$

To specify the household's demand for crop $k$'s planting area $L_k$, $k=1,2,\ldots,K$, we use the indirect utility (see, e.g., Freeman 2003)

$$v(r_H, y, L_1, L_2,\ldots,L_K) = u_0(z(r_H,y), \ell_H(r_H,y)) + \sum_{k=1}^{K} u_k(L_k).$$
The utility compensating change in income associated with a small change in $L_k$ satisfies $(\partial v / \partial y) dy + (\partial v / \partial L_k) dL_k = 0$, from which we obtain

$$\frac{dy}{dL_k} = -\frac{\partial u_k / \partial L_k}{\partial v / \partial y} \equiv D_k(L_k, y), \quad k = 1, 2, \ldots, K. \tag{2}$$

$D_k(L_k, y)$ stands for the representative household's marginal willingness to pay for crop $k$'s land: the household's willingness to pay for an increase in crop $k$'s land from $L_{k}^a$ to $L_{k}^b$ is

$$\int_{L_{k}^a}^{L_{k}^b} D_k(L, y) dL.$$

**Farmers:** The agricultural sector consists of $N_A$ identical farmers growing $K$ crops. Let $F_k(x_k, l_k)$ represent crop $k$'s production function for the representative farm, using land input $l_k$ and an $m$-dimensional vector of other inputs $x_k$. Let $\ell_A$ denote farm size, so that total agricultural land equals $N_A \ell_A$. For a given crop-land assignment $\ell_k$, $k = 1, 2, \ldots, K$, satisfying $\Sigma_k \ell_k \leq \ell_A$, the representative farmer chooses $x_k$, $k = 1, 2, \ldots, K$, in order to maximize

$$\sum_{k=1}^{K} \left\{ p_k F_k(x_k, l_k) - p_x x_k \right\},$$

taking as given the crop prices $p_k$, $k = 1, 2, \ldots, K$, and the vector of $x$ prices $p_x$. Necessary conditions for this problem are

$$\partial F_k(x_k, l_k) / \partial x_k = p_k / p_x, \quad k = 1, 2, \ldots, K,$

where $\partial F_k(x_k, l_k) / \partial x_k$ is the gradient vector of partial derivatives of $F_k$ with respect to the elements of $x_k$. These conditions define the optimal choice of $x_k$ as a function of $\ell_k$, $p_k$ and $p_x$, denoted $x_k(\ell_k)$, $k = 1, 2, \ldots, K$.

Substituting $x_k(\ell_k)$ in crop $k$'s profit gives crop $k$'s returns to land function

$$\pi_k(\ell_k) = p_k F_k(x_k(\ell_k), l_k) - p_x x_k(\ell_k), \quad k = 1, 2, \ldots, K.$$

The agricultural output and input prices $p_x$ and $p_k$, $k = 1, 2, \ldots, K$, are exogenous to the individual farmers' decisions and are therefore suppressed as arguments.

The representative farm's inverse derived demand for crop $k$'s land is given by the value of marginal product (VMP) of land in crop $k$ production $\pi_k'(\ell_k)$. When
F_{k}(x,\ell) exhibits decreasing returns to scale (e.g., due to the fixed quantity of the farmer's own labor and managerial skills) and \(\pi_{k}(\ell_{k})\) is strictly concave, \(\pi_{k}'(\ell_{k})\) is decreasing and can be inverted to give the derived demand function \(\pi_{k}^{-1}(r)\). At land rental rate \(r\) the demand for crop \(k\)'s land is \(\pi_{k}^{-1}(r)\) if \(\pi_{k}'(0) \geq r\) and zero otherwise. The aggregate land allocation for crop \(k\) is \(L_{k} = N_{A}\ell_{k}\) and the inverse derived demands can be expressed in terms of \(L_{k}\) as \(\pi_{k}'(L_{k}/N_{A})\), \(k = 1,2,\ldots,K\).

The aggregate inverse derived demand for agricultural land is obtained by horizontally summing the aggregate crop demands \(\pi_{k}'(L_{k}/N_{A})\) and is denoted \(\Pi'(L/N_{A})\) (see Figure 1). When land rental rate equals \(r\), the crop land demands \(L_{k}(r)\) are the \(L_{k}\)'s satisfying

\[
\pi_{k}'(L_{k}/N_{A}) = r, \quad k = 1,2,\ldots,K, \tag{3}
\]

and aggregate agricultural land demand is obtained from \(\Pi'(L/N_{A}) = r\), provided \(\Pi'^{-1}(r) \leq \ell_{A}\).

Figure 1

When \(F_{k}(x,\ell), k = 1,2,\ldots,K\), exhibit constant returns to scale (CRS), the individual crops return-to-land functions \(\pi_{k}(\ell_{k})\) are linear and the VMP of land in crop \(k\) production, \(\pi_{k}', k = 1,2,\ldots,K\), are constants, independent of the \(L_{k}\)'s. In the absence of additional constraints, the farmer will grow only the crop with the highest VMP (i.e., the crop with the highest \(\pi_{k}'\)). With additional constraints (e.g., marketing quotas), the crop with the highest VMP will be grown first until it hits its constraint, then the second highest value crop will be grown, and so on. Suppose the exogenous constraints are in the form of upper bounds \(\ell_{k}\) on crop \(k\)'s land allocation, \(k = 1,2,\ldots,K\). Ordering the crops in a descending VMP order, \(\pi_{1}' > \pi_{2}' > \cdots > \pi_{K}'\), the farm derived demand for land is the step function shown in Figure 2.
The step-function form obtained under CRS production technology and exogenous crop land constraints is convenient for empirical analysis and will be used in the application below.

**Agriculture – Urban Land Allocation**

*Market Allocation:* The particular structure of land ownership in the economy is immaterial for aggregate welfare evaluations 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 (1) and (3),

$$D_H(L_H / N, y) = \pi_k^*(L_k / N_A), k = 1, 2, ..., K.$$  \hspace{1cm} (4)

Let $\bar{L}$ denote the total land area suitable for cultivation and housing, so that

$$L_H + \sum_{k=1}^{K} L_K \leq \bar{L}.$$ \hspace{1cm} (5)

Equations (4) and (5) provide $K+1$ relations to solve for the $K+1$ market allocations $L_H^M$ and $L_k^M$, $k = 1, 2, ..., K$. The agricultural area under market allocation is

$$L_A^M = \sum_{k=1}^{K} L_k^M,$$ as Figure 3 illustrates.

**Socially Optimal Allocation:** A feasible land allocation $L_H$ and $L_k$, $k=1,2,...,K$, (by feasible we mean an allocation that satisfies (5)) generates the surplus

$$\int_0^{L_H} D_H(\ell, y) d\ell + \sum_{k=1}^{K} \left\{ \int_0^{L_k^M} D_L(L, y) dL \right\}$$ to the representative household and the profit

$$\sum_{k=1}^{K} \pi_k(L_k^M / N_A)$$ to the representative farm. Accordingly, the welfare function is specified as
The socially optimal land allocation is obtained by maximizing (6) with respect to \(L_H\) and \(L_k, k = 1,2,\ldots,K\), subject to the feasibility constraint (5). Defining the Lagrangian \(\mathfrak{S} = W + \mu[L - L_H - \sum_{k=1}^{K} L_k]\), the necessary conditions for optimum include:

\[
D_H(L_H / N,y) - \mu = 0 \tag{7a}
\]

and

\[
ND_k(L_k,y) + \pi_k'(L_K / N_A) - \mu = 0, \quad k = 1,2,\ldots,K. \tag{7b}
\]

Conditions (7a-b) give

\[
D_H(L_H / N,y) = ND_k(L_k,y) + \pi_k'(L_K / N_A), \quad k = 1,2,\ldots,K. \tag{8}
\]

The \(K+1\) relations (5) and (8) solve for the \(K+1\) social land allocations \(L_H^s\) and \(L_k^s, k = 1,2,\ldots,K\). The difference from the market allocation rule (4) is due to the environmental demands \(ND_k, k=1,2,\ldots,K\).

The social demand for agricultural land (by farmers and households) is obtained by horizontally summing the \(K\) crop-land demands

\[
ND_k(L_k,y) + \pi_k'(L_K / N_A), \quad k=1,2,\ldots,K. \tag{9}
\]

We denote this total demand by \(D_A(L,y)\) (see Figure 3) and note that \(D_A\) satisfies

\[
N \sum_{k=1}^{K} \left[ \int_0^{L_k} D_k(L,y)dL \right] + N_A \sum_{k=1}^{K} \pi_k(L_K / N_A) = \int_0^{L_A} D_A(L,y)dL \tag{9}
\]

where the upper limit on the right-hand integral is the total farmland \(L_A = \sum_{k=1}^{K} L_k\).

Notice that \(D_A\) depends also on \(N\) and \(N_A\).
The social agriculture-urban land allocation is found as follows. If total land demand at zero rental rate exceeds $\bar{L}$, condition (4) holds as equality and $D_H((\bar{L} - L) / N, y)$ and $D_A(L, y)$ intersect at some $L < \bar{L}$. The agricultural land allocation at the intersection point corresponds to the socially optimal allocation $L_A^S$ satisfying (Figure 3)

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

(10a)

The corresponding urban-land allocation is $L_U^S = \bar{L} - L_A^S$; the social land rental rate is

$$\mu = D_A(L_A^S, y) = D_H(L_U^S / N, y)$$

(10b)

and the $K$ crops' land allocations are determined from

$$ND_k(L_k^S, y) + \pi_k'(L_k^S / N_A) = \mu, \ k = 1,2,...,K.$$  

(10c)

By construction, $\sum_{k=1}^K L_k^S = L_A^S$.

When total land demand at zero rental rate falls short of $\bar{L}$, land is not scarce and its social rental rate vanishes. The ensuing agricultural and urban land allocations are then determined from $D_A(L_A^S, y) = D_H(L_U^S / N, y) = 0$ and the crop land allocations are determined from $ND_k(L_k^S, y) + \pi_k'(L_k^S / N_A) = 0, k = 1,2,...,K$.

**A Welfare measure of agricultural land:** Using (9) and $L_U = \bar{L} - L_A$, we rewrite (6) as

$$W = N \int_0^{(\bar{L} - L) / N} D_H(\ell, y) d\ell + \int_0^{L_A} D_A(L, y) dL$$

and differentiate with respect to $L_A$ to obtain

$$\partial W / \partial L_A \equiv W'(L_A) = -D_H((\bar{L} - L_A) / N, y) + D_A(L_A, y).$$

(11)

The welfare generated by the total agricultural land $L_A$ is defined as

$$W^A(L_A) = L_A \int_0^{L_A} W'(L) dL = \int_0^{L_A} [D_A(L, y) - D_H((\bar{L} - L) / N, y)] dL.$$  

(12)
\( W^A(L_A) \) is given by the area between \( D_A \) and \( D_H \) to the left of \( L_A \) (see Figure 3).

**Population and Income Effects:** The positive externality of agricultural landscape leads to undersupply of agricultural land by land markets, as can be seen by comparing \( L_A^H \) and \( L_A^S \) in Figure 3. The magnitude of the distortion depends on households' marginal willingness to pay for the environmental amenities, \( N D_k \), \( k=1,2,\ldots,K \), and is expected to increase over time as urban population (\( N \)) and income (\( y \)) rise. We investigate the effect of population and income on agricultural land allocation, assuming, for simplicity, a single agricultural crop (\( K = 1 \)) and a constant number of farmers \( N_A \). When \( K = 1 \), the crop subscript \( k \) is dropped and (8) reduces to

\[
D_H((L - L_A^S) / N, y) = ND(L_A^S, y) + \pi' / \pi_A^S
\]

(\( D \) is the household's demand for agricultural land). Differentiating with respect to \( N \) and rearranging gives

\[
L_A^S(N) = \left( ND - D_H / \eta_H \right) / N - D_H' / N - ND' - \pi'' / \pi_A^S,
\]

where \( D_H' = \partial D_H / \partial (L_H / N) \), \( D' = \partial D / \partial L_A \), and \( \eta_H = -1 / (D_H') (D_H / (L_H / N)) \) is the demand elasticity of urban land. The denominator on the right-hand side is clearly positive (\( D_H' \) and \( D' \) are both negative and \( \pi'' \leq 0 \)), hence the sign of \( L_A^S(N) \) is the same as the sign of \( ND - D_H / \eta_H \. \) It will be positive at large enough \( N \) or elastic enough urban land demand. In such cases, the positive externality of agricultural landscape outweighs the scarcity cost of land, and agricultural land should increase with urban population.

The income effect is similarly calculated to yield

\[
L_A^S(y) = \left( ND / \partial y - \partial D_H / \partial y \right) - D_H' / N - ND' - \pi'' / \pi_A^S.
\]
We see that the sign of \( L^S_a(y) \) depends on the balance between the income effects of total urban marginal willingness to pay for environmental quality \((N\partial D/\partial y)\) and the income effect of the individual household's urban land demand \( (\partial D/H/\partial y) \). As in the previous case, a large enough urban population yields a positive income effect on agricultural land allocation.

It is straightforward to verify that both \( L^M_a(N) \) and \( L^M_a(y) \) are always negative. Thus, land markets will lead to decreasing agricultural land in response to either population or income growth, which may run contrary to the socially desirable trend.

**Application**

We apply the above model to the densely populated northern half of Israel. The population density in Israel ranks high among developed countries (Table 1). As a result, demand for urban land is high and competes with agricultural use, particularly near urban centers where the amenity value of open space in general and farmland in particular is large (Fleischer and Tsur, 2003). Urban sprawl is causing the green open areas of farmland between urban centers to disappear, resulting in what might turn out to be a substantial welfare loss. We use the above model to assess the socially optimal and market agriculture-urban land allocations and to evaluate the welfare loss associated with the latter. Policy measures to mitigate the perils of land market allocation are discussed in the next section.

**Table 1**

*Demand for Agricultural Land:* We obtained aggregate data (Table 2) on area planted, input costs (excluding land cost but including interest payment on capital investment) and revenue for five crop groups: citrus orchards, other orchards, flowers, irrigated field crops (including vegetables, potatoes and melons), and unirrigated field
crops (Israeli Ministry of Agriculture and Rural Development (2002), and Hadas (2003)).

Table 2

CRS production technology is assumed for each crop. Under CRS, the marginal value of land productivity for each crop is given by the return per hectare reported in the fourth column of Table 2, calculated as the revenue per hectare minus the cost per hectare of all production inputs (including capital) other than land. As discussed in the previous section, without exogenous constraints, farmers will grow only the highest value – the highest $\pi_k$ – crop (flowers in the present case). But exogenous constraints, such as marketing restrictions and water quotas, restrict planting area. Consequently, we let the actual planting areas represent these implicit restrictions and obtain the inverse derived demand for agricultural land depicted in Figure 4.

Figure 4

**Environmental Demand for Agricultural Land:** The amenity value of agricultural landscape has been estimated in a number of countries, e.g., Austria (Hackl and Pruckner, 1997), Sweden (Drake, 1992) and Israel (Fleischer and Tsur, 2000). In all cases, agriculture landscape was taken as a homogenous environmental commodity (single crop). Here we differentiate between types of landscape, using the work of Shemesh-Adani (2003) which provides (i) a classification into crop groups as perceived by the urban population, and (ii) willingness to pay (WTP) for each different crop group's landscape.

Three focus groups received cards with photos of crop landscapes and were asked to classify them according to their aesthetic value. Types of agricultural landscape were classified into orchards, open fields, pastures and greenhouses
(respondents did not distinguish between landscape types within each group). They were also asked to rank these types of agricultural landscape by level of aesthetic value, from high to low. Orchards were ranked highest, followed by pastures, open fields and greenhouses.

Once the four distinct landscape types were established by the focus groups, 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. Each of the 350 respondents received pictures of the four landscape types in a particular agricultural region and was confronted with a possible scenario under which the entire region would be developed, leading to the elimination of all agricultural landscape. To preserve the farmland requires imposing a tax and the respondents were asked if the tax level given in the questionnaire was fair and if they would be willing to pay it. This was repeated for each of the landscape types (crop group). In this way, WTP measures were obtained for each type of landscape.

The chosen elicitation method consisted of take-it-or-leave-it with a followup (Carson et al., 1986), with six random levels of (annual) tax bids ranging from $2.50 to $55. The average of the tax bids (over all respondents) provides estimates of the representative household's WTP to preserve each of the four crop groups. Assuming constant marginal WTP for each crop group, the marginal WTP is the same as the average (per hectare) WTP and is obtained by dividing the household's WTP by the area under study (for each crop group). To obtain the aggregate marginal WTP we multiply by the number of urban households (N). Adding the aggregate marginal WTP of urban households to the private (farmers') demand for agricultural land gives the social demand for farmland (the dashed line in Figure 4). Notice that each crop
has a different amenity value, as represented by the aggregate marginal WTP and measured by the vertical distance between the dashed and solid lines of Figure 4.

**Demand for Urban Land:** The inhabited northern half of Israel was divided into six iso-distance belts from the metropolitan centers of Tel Aviv, Jerusalem and Haifa. For each belt, the average prices of urban land and of total agricultural and urban land were assembled. Plotting urban land prices, \( P_H \), against accumulated urban land, \( L_H \), suggests a log-linear relation. Consequently, the inverse demand for urban land is specified as \( \log P_H = \alpha - \beta L_H \) and the estimation results are

\[
\log P_H = 0.6 - 0.000024 L_H ,
\]

(t-stat) (5.3) (-7.8) \( R^2 = 0.94 \). (13)

A 5 percent interest rate was used to translate land prices to land rental rates \( r_H = 0.05 p_H \).

The market and socially optimal land allocations are depicted in Figure 4. We obtained the following results: markets will allocate \( L^M_A = 116,000 \) ha of farmland at a rental rate of \( r^M = \$267 \) per ha per year (at a 5% percent interest rate is equivalent to a peripheral land price of \$5,333 per ha). The socially optimal land allocation is

\( L^S_A = 214,000 \) ha at a rental rate of \( r^S = \$3,780 \) per ha per year (at a 5% interest rate is equivalent to a peripheral land price of \$75,600 per ha). The welfare loss due to market allocation (the area ABC in Figure 4) is \$250 million per annum. Administrative restrictions on land transactions in Israel mitigate the market allocation and give rise to an actual agricultural land of 170,000 ha, reducing the potential welfare loss to about \$71 million per year.

**Policy Intervention**

The market and social allocations are indicated by points \( M \) and \( S \) in Figure 5. The welfare generated by farmland at the socially optimal allocation (defined by
$W^A(L^S_A)$ in equation 12 is the area ASC ($1,347$ million in the case studied above) at 214,000 ha. The corresponding welfare under the market allocation is the area AEMC ($1,097$ million) at 116,000 ha. The welfare difference—the deadweight loss—is the area ESM ($250$ million), which is 18% of the total agricultural surplus.

Figure 5

The difference between social and market allocations of farmland is 98,000 ha, which is 84% of the market allocation of farmland. We discuss three policy interventions to correct (some of) the land market failures.

*Land Use (Zoning) Restrictions:* A straightforward policy entails imposing administrative restrictions on urban land development or on farmland preservation. Such a policy, however, is vulnerable to pressure from political and special interest groups (see discussion in Alterman, 1997) and often conflicts with other rights endowed to land owners (see Innes, 1995, on the related issue of takings). It is therefore rarely used in actual practice, except in places where some or most of the land is publicly owned, so the second obstacle (landowners' rights) does not exist. Such is the case, for example, in Israel, where most of the land is owned by the state. Indeed, in Israel, centrally planned zoning is the main policy used for the preservation of farmland and open space (Alterman, 1997).

A policy that restricts farmland to not falling below $L^S_A$ forms a wedge between land rental rates for farming and for urban use. Farmers pay $r^Z$ while urban dwellers pay the higher rent $r^S$ (Figure 5). Farmers enjoy the added profit (compare to the market solution) given by the area $r^M M Z r^Z$. Land owners lose from the lower farmland rents but gain from the higher urban rents. Urban households lose from the higher rental rates but gain from the increased amenity provided by the added farmland.
Land Subsidies: If farmers are paid an area subsidy ($/ha by crop) based on the amenity services they provide, i.e., the marginal WTP for agricultural landscape, their land demand changes to the social demand ($D_A$ in Figure 5) and the resulting land allocation will be the social allocation (point $S$ in Figure 5). This policy amounts to internalizing the external effects of agricultural landscape. Indeed, both Lopez et al. (1994) and Brunsatd et al. (1999) point out that such an argument can be used to justify (some of) the agricultural subsidies in Europe and North America. Such a crop-dependent, land subsidy scheme was recently proposed in Israel (alas, not in recognition of the environmental role of farmland but as countervail for rising irrigation water rates) but not implemented.

Rural Tourism: Rural tourism has become an important income source for farmers in developed countries. Wine trails, bed & breakfasts, agricultural festivals, and pick-your-own-fruits (or vegetables) farms are becoming popular activities among tourists (Fleischer and Pizam, 1997). The visitors pay for some of the benefits they derive from agricultural landscape to those that provide these services—the farmers. Thus, rural tourism internalizes some of the external effects of agricultural landscape. The role of farmland in attracting tourists will show up in farmers' demand for land. This suggests that different schemes to support rural tourism can serve to mitigate the failure of land markets. Indeed, subsidies earmarked to agro-tourism activities are pervasive in Europe and Israel (Fleischer and Felsenstein, 2000).

Concluding Comments

The role of farmland in supplying environmental amenities has been increasing with economic and population growth. In some developed countries, the amenity value of farmland has surpassed its traditional value as an input of agricultural production (Drake, 1992; Fleischer and Tsur, 2000; Hackl and Pruckner,
Moreover, different crops generate different amenity values. These observations have profound implications for land allocation between agricultural production and other uses and within the agricultural sector (between different crops). We offer a land allocation model that accounts for these effects and discuss several policy measures to implement the optimal land allocation.

Population growth increases the demand for urban land, which competes with agriculture for the available land resources, while at the same time increases the demand for the environmental services of farmland. We find that due to the public good nature of agricultural landscape, the latter effect may well outweigh the former, giving rise to a positive population effect on farmland (i.e., an increase in population calls for an increase in farmland). For the same reason, a positive relation between household income and household demand for farmland can occur. Land markets, however, ignore the external effects of farmland and will always give negative effects of population and income on farmland allocation, leading to an undersupply of farmland.

An empirical application to Israel reveals that the extent of the market undersupply of farmland and the associated welfare loss are substantial. Different policy measures are discussed, including zoning, farmland subsidy and rural tourism subsidy. The first policy may conflict with land owners' property rights. The second policy is vulnerable to political pressure from farmers and urban groups. The third policy (rural tourism) requires minimal intervention and operates by generating economic incentives for farmland preservation.
References


World Bank (2000). World Development Indicators, CD-ROM.
Figure 1: Farm-level derived demand for land for each crop is given by the value of marginal product of land $\pi'_k$. The whole farm's demand for land is the horizontal summation of the individual crop demands. When land rental rate is $r$, crop $k$ land allocation is $\pi'_k r^{-1}(r)$ and the whole farmland allocation is given by $Min\{\Pi'^{-1}(r), \ell_A\}$.
Figure 2: Derived demand for farmland when the crop production functions exhibit constant returns to scale and crop land allocations are restricted.
Figure 3: Private and social demands for agricultural land (measured from left to right). \( \Pi' \) is private demand for farmland; \( D_A \) is social (farmers and households) demand for farmland; \( D_H \) is household demand for urban land (urban land is measured from right to left). The shaded area is the welfare generated by farmland level \( L_A \).
Figure 4: Demands for agricultural and urban land in the northern half of Israel.
Figure 5: Market and social farmland allocations and associated welfare measures.
Table 1: Some population density data (inhabitants per square kilometer).

<table>
<thead>
<tr>
<th>Country</th>
<th>1961</th>
<th>1996-97</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>20</td>
<td>29</td>
</tr>
<tr>
<td>France</td>
<td>84</td>
<td>106</td>
</tr>
<tr>
<td>UK</td>
<td>218</td>
<td>243</td>
</tr>
<tr>
<td>Netherlands</td>
<td>345</td>
<td>457</td>
</tr>
<tr>
<td>Israel (north-central region)</td>
<td>108 (270)</td>
<td>273 (630)</td>
</tr>
</tbody>
</table>

Table 2: Agricultural production data and amenity values for 6 major crops in Israel.

<table>
<thead>
<tr>
<th></th>
<th>Area (ha)</th>
<th>Revenue ($/ha)</th>
<th>Cost(^1) ($/ha)</th>
<th>Profit= Rev-cost ($/ha)</th>
<th>Amenity value(^2) ($/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flowers</td>
<td>3,512.9</td>
<td>98,358</td>
<td>83,596</td>
<td>14,762</td>
<td>2,671</td>
</tr>
<tr>
<td>Other orchards</td>
<td>57,216.6</td>
<td>20,780</td>
<td>14,224</td>
<td>6,554</td>
<td>3,953</td>
</tr>
<tr>
<td>Vegetables</td>
<td>29,774.2</td>
<td>53,587</td>
<td>47,078</td>
<td>6,509</td>
<td>3,611</td>
</tr>
<tr>
<td>Citrus orchards</td>
<td>17,421.2</td>
<td>10,173</td>
<td>7,669</td>
<td>2,504</td>
<td>3,953</td>
</tr>
<tr>
<td>Field crops</td>
<td>116,020.9</td>
<td>2,224</td>
<td>1,956</td>
<td>268</td>
<td>3,611</td>
</tr>
<tr>
<td>Unirrigated field crops(^3)</td>
<td>180,479.4</td>
<td>740</td>
<td>651</td>
<td>89</td>
<td>3,611</td>
</tr>
</tbody>
</table>

\(^1\) Including variable costs, water costs and imputed capital cost.
\(^2\) Orchards and citrus are in the same group of amenity values and so are vegetables and field crops.
\(^3\) Unirrigated fields contain all residual crops.
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