Measuring the Income Generating Potential of Land in Rural Mexico

by

Frederico Finan, Alain de Janvry, and Elisabeth Sadoulet

American Agricultural Economics Association
2002 Annual Meeting, July 28-31, 2002, Long Beach, California
Selected Paper

Measuring the Income Generating Potential of Land in Rural Mexico

Frederico Finan, Alain de Janvry, and Elisabeth Sadoulet
University of California at Berkeley

April 2002

Abstract

This paper measures the potential of land to generate income and establishes the contexts under which access to land can reduce poverty. Household data gathered in 1997 from the Mexican poverty alleviation program (PROGRESA) suggest that the marginal welfare value of land depends on both the complementary assets and contextual settings of the poor. Using non-parametric regression methods to estimate and graphically explore the relationship between land and welfare, we find that for small farmers, an additional hectare of land will increase welfare by as much as 1000 monthly pesos. Our results suggest that in areas with good infrastructure, land can be an important element of a poverty reducing strategy.

The comments and suggestions of Ethan Ligon, Xiangyi Meng, Armando Gonzalez, and Jeff Lafrance, greatly improved an earlier version of paper. The authors would also like to thank Caridad Araujo and Karen Macours for their help and comments.

Addresses: Frederico Finan, Giannini Hall 207, University of California, Berkeley, California 94720. Tel: 510-643-5418. Fax: 510-643-8911. E-mail: Finan@are.berkeley.edu.
Alain de Janvry, Giannini Hall 207, University of California, Berkeley, California 94720. Tel: 510-642-3348. Fax: 510-643-8911. E-mail: Alain@are.berkeley.edu.
Elisabeth Sadoulet, Giannini Hall 207, University of California, Berkeley, California 94720. Tel: 510-642-7225. Fax: 510-643-8911. E-mail: Sadoulet@are.berkeley.edu.

I. Introduction

Rural poverty reduction strategies have traditionally emphasized land reform and integrated rural development programs as means of increasing the assets of the poor (de Janvry and Sadoulet 2001). These approaches assume that chronic poverty is a direct consequence of land tenure arrangements, which limit the access of poor to land. Land reform programs however, have met with limited success, and recent literature calls into question the importance of land as a poverty-reducing instrument (López and Valdés 2000). Yet, there is an absence of convincing empirical evidence that measures the potential of land to generate income, particularly when we consider differences in other productive assets.

Several empirical studies have documented a positive association between land and incomes (see Scott (2000) for Chile; Gunning et. al (2000) for Zimbabwe; Grootaert, Kanbur and Oh (1997) for Cote d'Ivoire; Bouis and Haddad (1990) for Philippines; Carter and May (1999) for South Africa). However in many cases, this positive association actually translates into small welfare gains. McCulloch and Baulch (2000) simulate the impact of a policy giving two hectares of land to households in rural Pakistan with less than this amount to find that it has virtually no effect on income poverty. López and Valdés (2000) find in a recent series of case studies in Latin America that the income generating potential of land is also quite small. They estimate income to land elasticities that suggest that landholdings in rural areas of Colombia would have to quadruple in order for the poorest 40% of the farm households to reach just the poverty line.

Although the results will vary by case study, in general the empirical literature has ignored three important methodological considerations when measuring the marginal value of land. First, previous studies often assume a linear specification for the estimation of the income equation. This assumption can be overly restrictive when constraints on a household's ability to effectively utilize its assets induce a nonlinear relationship between land endowments and welfare. We use nonparametric techniques to graphically explore this possibility. Second, incomes from agricultural activities tend to be very noisy and a poor measure of household welfare. We compare an alternative measure of welfare that captures the multidimensionality of poverty. Finally, differences across households in both their asset positions and exposure to market imperfections demonstrate that the return to land is significantly affected by limits on the effective utilization of land and other assets. In measuring the return to land, it is important to account for the high degree of heterogeneity in income generating strategies across poor rural households.

Household data gathered in 1997 from the Mexican poverty alleviation program (PROGRESA) suggest that the marginal welfare value of land depends on both the complementary assets and contextual settings of the poor. Ethnicity is an important social asset as the marginal value of land for non-indigenous households is on average twice as high as is for indigenous households. In general, land has a high but decreasing marginal return for endowments of less than three hectares and a constant return for land sizes larger than three hectares. In effect, the marginal value of land for households with less than one hectare is almost 8 times higher than that for households possessing more than three hectares of land. These results are consistent with the theory that small landowners with low opportunity costs of labor exhibit a higher reservation price for land (see Carter and May (1999) and Carter and Mesbah (1993)).

This paper also contributes to the broader debate on the role of land as a valuable poverty-reducing instrument. For land to be an effective instrument, it must be part of an integrated policy that focuses on not only access to land, but on improving the complementary assets of the poor, such as education. In addition, such a policy must seek to reduce deficits in public goods investments, institutional gaps, and policy distortions that limit a household's effective utilization of these assets. In rural Mexico where labor opportunities are few and education levels low, we find that the marginal value of land is highest for households with more education and better access to markets. It is important to recognize that with rural households pursuing a multitude of economic activities, gained access to just a small amount of land can have a large welfare effect. We find that for small farmers, an additional hectare of land will increase welfare substantially.

The rest of the paper is outlined as follows. Section 2 of the paper derives our estimative income equation and explores a microeconomic household model for conditions that imply a nonlinear relationship between welfare and land. In section 3, we explain the semiparametric estimation of the income equation. The data are described in section 4, including a discussion on our welfare measure and the structure of landholdings in Mexico. The empirical results follow in section 5, and we conclude the paper in section 6.

II. Theoretical Framework: Derivation of the income equation

In this section we derive the specification of our income equation from the maximization of standard agrarian household production model. We present a model with multiple market imperfections to investigate how these distortions affect the economic return to land.

Our theoretical framework borrows from the work of Carter and Mesbah (1993) and it assumes three important frictions: 1) Land arrangements are ignored and land is treated as exogenous 2) Households face the possibility of off-farm unemployment 3) Access to credit increases with land size.

Under these assumptions, consider a household that generates income by cultivating agricultural land, in addition to possibly supplying labor at an exogenously determined market wage, *w*. The household is endowed with *T* hectares of land, and $\bar{L}$ hours of labor per year that are employed in on-farm agricultural work (L_f), and/or off-farm activities (L_s). The household cultivates a single crop using *X* kilograms of inputs per hectare, purchased at a per unit market price of *q*. The crop can be sold at an exogenous market price *p*. Let $F(L_f, X, T; z)$ represent a constant return to scale production function, where *z* represents the set of household and village characteristics that affect the return on productive assets; such as human and social capital or access to markets. Let $\Omega(L_s)$ denote the number of days employed as a function of labor supplied, L_s, where $\Omega' > 0, \Omega'' \leq 0$. Let $\Gamma(T)$ denote the amount of working capital available to a household, at an interest rate *i* and with land endowment, *T*. The cost of production, qX, must be financed by the sum of initial wealth *K*, wage income $w\Omega(L_s)$, and available capital $\Gamma(T)$.

Formally, the household chooses time allocation and purchased inputs to maximize its income:

$$
\begin{aligned}
&\underset{L_s, L_f, X}{\text{Max}} \; pF(L_f, X, T; z) - qX + w\Omega(L_s) - i\Gamma(T) \\
&s.t. \\
&L_s + L_f \le \overline{L} \\
&wL_h + qX \le K + w\Omega(L_s) + \Gamma(T) \\
&L_s \ge 0, L_f \ge 0.
\end{aligned}
\qquad \textbf{(1)}
$$

If (*) denotes solution values of the choice variables that maximize the program above, then the income equation associated with profit maximizing behavior can be specified as follows,

$$
Y = pF(L_f^*, X^*, T; z) - qX^* + w\Omega(L_s^*) - i\Gamma(T) = \Lambda(p, q, i, w, K, T, z). \qquad \textbf{(2)}
$$

The income equation is a function of prices, household's endowment of productive assets, and any characteristic that affects the return to these assets. We can differentiate equation (2) to see how an increase in landholdings changes household income,

$$
\frac{dY}{dT} = pF_T + (w\Omega' - pF_L)\frac{dL_s^*}{dT} + (pF_X - q)\frac{dX^*}{dT} - i\Gamma'. \qquad \textbf{(3)}
$$

If households face the same opportunity costs of labor and inputs, and capital markets are perfect, then the terms in the parentheses are identically zero and the marginal value of land is simply equal to the value of its marginal product, i.e. $\frac{dY}{dT} = pF_T$. Moreover, if we assume constant returns to scale, then the marginal return to land is constant for all land endowments.

Conversely, with imperfections in labor and input markets, an increase in landholdings has both a direct and an indirect effect on income. In addition to directly increasing production, more land decreases the allocation distortions of the production inputs by increasing their productivity. For instance, in poor rural areas characterized by thin labor markets, an increase in household land will increase the marginal product value of its labor and reduce the difference between its shadow wage and the market wage. If as Eswaran and Kotwal (1986) suggest, larger farms have better access to credit, then an increase in landholdings will increase the use of variable inputs and reduce the distortion in the input markets as well. With market distortions, we expect the marginal value of land to vary with land endowments, and quite possibly in a nonlinear manner.

For better insight into how imperfections in land, labor and credit market affect land's potential to generate income, we simulate the model above with specific functional forms and a rough parameterization, given our data.[1]

[1] See the appendix for the exact specification of the model.

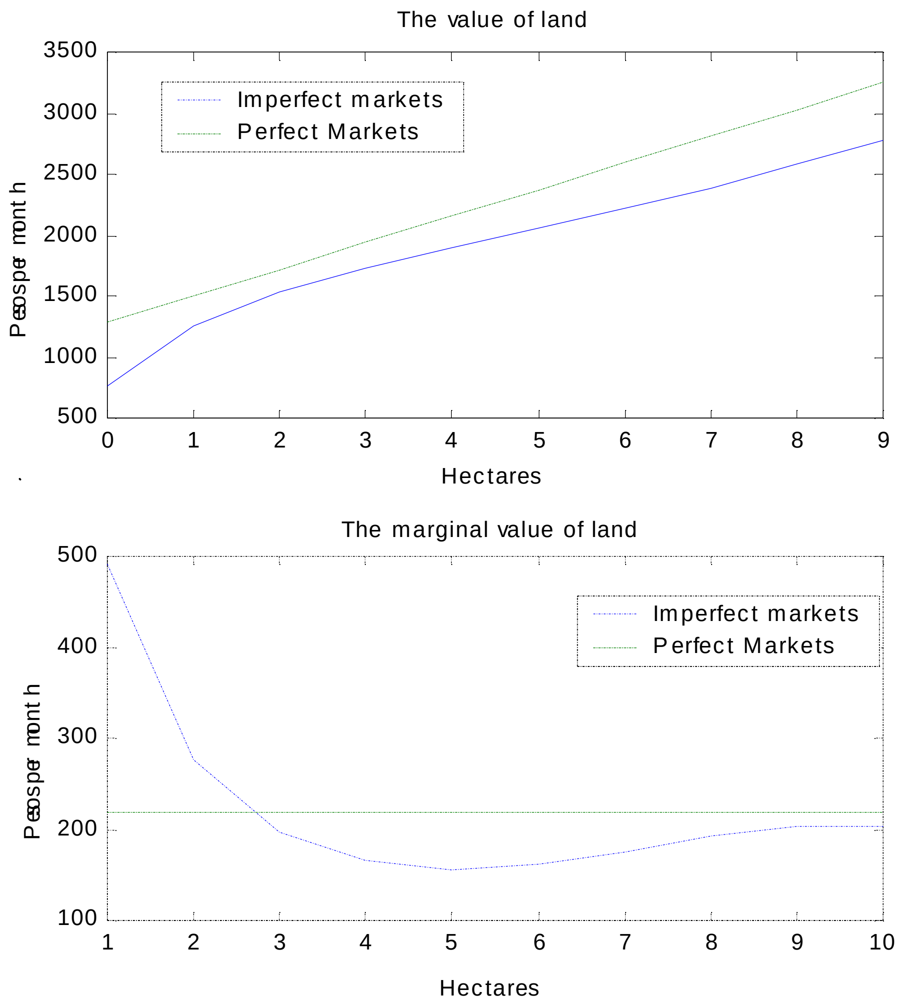


Figure 1

The results of the simulation are presented in Figure 1. The top panel displays the relationship between income and land for both perfect and imperfect markets. When markets are perfect, landless households must work entirely off-farm and earn a monthly income of 1280 pesos. With access to a hectare of land, household income will increase by the marginal value of land, 228 pesos, as the household adjusts its labor allocation between working its land and off-farm employment. In the presence of market imperfections, the mapping of land to income shifts downward and is no longer linear. The curve intercepts the y-axis at 768 pesos: the expected wage rate when faced with possible unemployment. With distortions in the labor market, the marginal value of land is high for small farmers since another plot of land will also increase their shadow wage. As land endowments increase and the household can allocate its labor more effectively, the marginal return to land declines. Around four hectares, as access to credit improves, the marginal value of land begins to increase. A household's inability to generate sufficient economic livelihood depends not only on its land endowments but also on its ability to effectively utilize the amount of land it does possess.

To estimate the marginal value of land, as depicted in Figure 1, a linear approximation to the income equation can be an overly restrictive assumption. Without knowing the underlying frictions of our environment and hence the relationship between land and income, we relax the functional form for land completely and explore the mapping with nonparametric estimation techniques.

III. Econometric specification of the income equation

This section outlines the semiparametric procedure for estimating the relationship between income and land endowments. Our production model implies that any characteristic that affects the return to the productive assets of the household should influence the household's income. This list includes household demographics, constraints on factor use, as well as regional and village factors that capture employment opportunities and market integration. Although a fully nonparametric specification of the income equation would best capture its underlying shape, with several possible covariates the computation cost of this technique is prohibitively high.[2] A semiparametric

[2] With *k* explanatory variables and a sample size of *N* observations, to evaluate the density on a k-dimensional grid of *G* points, requires NG^k evaluations (Deaton 1997). Even with the semiparametric approach, the income equation took over 8 hours to estimate.

procedure allows us to relax the functional form on land and still control for the other factors that determine household income. Following Robinson (1988), we estimate a model of the following form,

$$y = a + xb + g(z) + e \tag{4}$$

where *x* of dimension *n x k* is the set of controls and *z* of dimension *n x 1* is the land endowment of the household. The variable *y* represents some measure of household welfare. The constant term is denoted by a and b is a *kx1* vector of our parameters of interest. The error term, e , is distributed normally. We assume that the functional form of $g(\cdot)$ is unknown and $E(e \mid x, z) = 0$. Taking expectations of equation (4) conditional on *z*, we get

$$E(y \mid z) = a + E(x \mid z)b + g(z). \tag{5}$$

Subtracting (5) from (4) yields

$$y - E(y \mid z) = [x - E(x \mid z)]b + e. \tag{6}$$

With nonparametric estimates of $E(y \mid z)$ and $E(x \mid z)$, we can then estimate (6) by ordinary least squares to get a $\hat{b}$, that is $\sqrt{n}$ -consistent, asymptotically normal, and robust to any unknown form of $g(z)$.[3] The estimator for $g(z)$ is simply

---

[3] Both $E(y \mid z)$ and $E(x \mid z)$ are estimated using Cleveland (1979) robust locally weighed regression (LOWESS) technique. LOWESS estimates are calculated using weighted least squares within a defined neighborhood around the independent variable *z*. Computationally, the estimates are calculated as follows. The data is ordered so that $z_{i-1} \le z_i$ for $i = 1,\ldots, N-1$. Each observation $j \in [i_-, i_+]$, where $i_- = \max\left(1, i - \lfloor (N \cdot bandwidth)/2 \rfloor\right)$ and $i_+ = \max\left(i + \lfloor (N \cdot bandwidth)/2 \rfloor, N\right)$, is weighted with $w_j = \left\{1 - \left(\frac{|z_j - z_i|}{\Delta}\right)^3\right\}^3$ for $\Delta > 0$ and 1 otherwise and $\Delta = 1.0001 \max(z_+ - z_i, z_i - z_-)$.

$$\hat{g}(z) = E(y \mid z) - (a + E(x \mid z)\hat{b}) . \quad \textbf{(7)}$$

There are two important features to note about this procedure. First, since $\hat{b}$ converges at a rate of $\sqrt{n}$ and $\hat{g}(z)$ converges at a slower rate of $\sqrt{nh}$ (where h is the bandwidth size), the estimation of b does not affect the asymptotic distribution of $\hat{g}(X)$. Second, a constant term cannot be identified independently of $\hat{g}(z)$.

IV. Data

In this section we describe the data underlying the analysis and briefly characterize the landowners in our sample. Land and welfare are positively correlated. Larger farmers, on average, have higher monthly household income, consume more, and have a lower incidence of poverty. We also describe the welfare index that we construct and use in the analysis to follow.

The data for this study come from the 1997-1998 surveys conducted for the Mexican rural poverty alleviation program, PROGRESA. The program covers approximately 25,000 households over 500 localities and 7 states. A stratified randomization procedure selected the localities and every household within each locality was included in the sample. The data are available at the individual, household and locality levels, with detailed information on schooling, consumption and employment patterns of the household.

Land Endowments

Since the PROGRESA program targets marginalized rural communities 52% of households in our sample are classified as poor. Consequently, only 54% of the sample

---

The smooth value of the dependent variable is the weighted regression prediction (STATA 1999). This possesses land, and the average farm size is less than 2.7 hectares. Of the 97% that are used for agriculture, 90% of the land cultivates corn.

The rental market is very inactive with less than 4% of land rented-in (see Table 1). Unfortunately, the data is unclear as to the proportion of farmers who rent-out but we suspect this percentage is also small. An *ejido* community exists in 60% of the localities in our sample. This may explain some of the inactivity in the land rental market since until recently land transactions were prohibited in all *ejido* sectors. With few data on land transactions, we consider only household property and make the important assumption that land is exogenous.[4]

With data on both rainfed and irrigated types of land, we convert plot size into hectares of rainfed corn equivalence (RFE). The average yield of corn for both irrigated and rainfed land is calculated for each locality and normalized by the sample average yield of rainfed corn.[5] A household's endowment of land in hectares of rainfed corn equivalence is then the weighted sum of its rainfed and irrigated landholdings, where the normalized averages are used as the appropriate weights (de Janvry, Gordillo, Sadoulet 1997). By normalizing farm size by it yield, this adjustment incorporates an imperfect measure of land quality, a variable that is typically hard to observe.

---

procedure is computed at every value of z using a bandwidth of 0.8.

[4] We test this assumption in our estimation of the income equation.

[5] Since the data do not provide the percentage of the land used for corn production, the yield was averaged over only the households that produced strictly corn. In averaging by locality, if the number of observations was less than 30, we then averaged at the municipality level. Also these averages did not include crop failures, which for rainfed is a yield of less than .2 and irrigated a yield of less than .8.

Table 1: Average farm sizes by land and ownership type						
	All	<1	1-2	2-5	>5	Distribution of tenure type (%)
Distribution of farms (%)	100	30	28	28	14	
Farm size (ha RFE)	3.09	.70	1.40	3.09	11.09	
	(5.55)	(.24)	(.32)	(.83)	(11.27)	
Rainfed (ha)	2.81	.47	1.37	3.6	11.5	100
	(4.6)	(.14)	(.46)	(.80)	(10.0)	
Owned	3.00	0.46	1.38	3.6	11.4	89
	(4.7)	(.15)	(.47)	(.80)	(9.70)	
Rented	1.42	.48	1.19	3.39	16.15	3
	(2.68)	(.12)	(.38)	(.75)	(14.38)	
Borrowed	1.67	.46	1.28	3.48	15.96	6
	(3.83)	(.13)	(.43)	(.72)	(17.52)	
Sharecropped	2.27	.47	1.46	3.37	7.29	2
	(1.80)	(.14)	(.49)	(.71)	(2.10)	
Irrigated (ha)	2.34	.47	1.40	(3.50)	11.56	100
	(3.83)	(.18)	(.47)	(.72)	(10.22)	
Owned	2.40	.47	1.42	3.48	11.60	90
	(3.89)	(.17)	(.48)	(.71)	(10.31)	
Rented	2.13	.55*	NA*	3.67*	10*	1
	(2.73)	(.11)		(1.15)	(NA)	
Borrowed	1.40	.51	1.30	4*	NA*	5
	(1.05)	(.19)	(.46)	(.71)		
Sharecropped	1.68	.4*	1.33	3.35*	6*	4
	(1.27)	(.19)	(.43)	(.85)	(NA)	

* Denotes less than 10 observations. Standard deviations are in parentheses.

Table 2 characterizes the households in our sample by farm size measured in RFE hectares. On average, off-farm income (agricultural wages, nonagricultural wages, and other labor wages) accounts for over 61% of total household income. For households with at most one RFE hectare, off-farm income represents over 68% of their total income. This percentage decreases to 52% for larger farmers, although income due to nonagricultural wages increases. An important difference in income between the largest farmers and households with less than a RFE hectare is the amount of non-labor transfers, which on average is almost twice as much for the former. Patterns in the income data are consistent with occupational choice. As farm sizes increase, households substitute off-farm agricultural employment for working their own farm. Consumption expenditure also follows a similar pattern as income.

Household size and the age of the household head are positively correlated with larger landholdings. While the education of the household head is not associated with land size, average education in the household does increase with farm size, which may suggest that families with more land are better suited to invest in the human capital of their children. Indigenous households tend to own less land.

Table 2. Household characteristics by farm size

Farm size in rain-fed equivalent hectares	≤ 1	1-2	2-5	≥ 5	All
Number of households	4,311	4,108	4,013	3,273	15,705
Total income in pesos	1083.39	1115.95	1281.75	1489.83	1208.37
Total labor income	883.74	897.36	986.38	1115.22	950.69
Agricultural wages	521.89	500.66	466.29	445.38	489.09
Nonagricultural wages	220.87	225.61	265.73	329.61	250.92
Self-employment	100.31	116.87	149.63	172.03	129.35
Family-related business	35.98	47.54	94.34	149.89	72.45
Other labor wages	3.29	5.20	7.77	11.95	6.36
Non-labor transfers	199.65	218.58	295.37	374.61	257.68
Total monthly expenditure in pesos	640.64	700.20	817.66	903.18	744.82
Food expenditures	467.0	499.58	565.70	612.21	524.74
Nonfood expenditures	173.64	200.62	251.96	290.97	220.08
Number of workers per household					
Agricultural workers	0.91	0.89	0.78	0.72	0.84
Nonagricultural workers	0.22	0.21	0.24	0.23	0.22
Seller	0.24	0.28	0.27	0.27	0.26
Family-related business	0.34	0.43	0.61	0.73	0.50
Household characteristics					
Household size	5.63	6.06	6.17	6.13	5.97
Number of adult equivalent persons	5.12	5.55	5.75	5.76	5.51
Number of children	1.56	1.70	1.72	1.67	1.66
Maximum education in household	5.46	5.95	6.27	6.62	6.00
Mean level of education in household	2.57	2.80	3.07	3.32	2.88
Head of household characteristics					
Education	2.46	2.48	2.49	2.48	2.48
Age	46.85	47.62	50.59	52.85	49.00
Male	0.91	0.92	0.92	0.93	0.91
Indigenous	0.51	0.45	0.32	0.28	0.41

Figure 2 provides more evidence on the correlation between land and welfare. The association between land and the poverty indicator is quite striking. Among those households with less than one RFE hectare, 62% are poor. This proportion drops to only 38% when we consider farmers with more than 8 hectares of land.

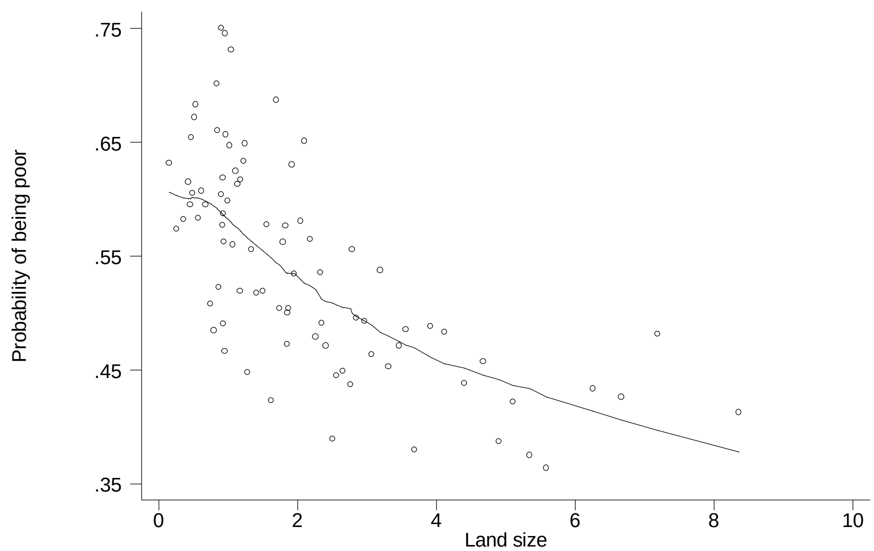


Figure 2: Poverty and land[6]

Welfare index

What is the best measure of welfare is a topic of much debate. Income, which is sensitive to volatile shocks, can be a poor indicator of long-term welfare for households predominately involved in agricultural and self-employed labor activities. With the possibility of households smoothing their consumption across time by borrowing, saving, and mutual insurance, consumption measures are considered much more reliable and more theoretically sound (Deaton 1997). Yet, both of these monetary-based measures fail to capture the multidimensionality of poverty, and in effect neglect important indicators of welfare, such as, access to sanitation, access to water, and adequate shelter.

With these concerns, we construct a welfare index consisting of various dwelling characteristics (running water, electricity, has a bathroom, number of rooms, and dirt

[6] Each point represents 137 observations.

floors), household durables (ownership of a blender, refrigerator, television, truck), in addition to the short-term measures of consumption expenditure and labor income. We aggregate these various indicators of poverty using principal component techniques.

Figure 3 plots the joint density of the welfare index and landholdings measured in RFE.[7] The welfare index appears normally distributed with a mean at 0.05 welfare units. The figure also illustrates that the mass of the land distribution is predominately located below 5 RFE hectares. Without having controlled for the other determinants of welfare, the figure however, does not depict a clear correlation between land and welfare.

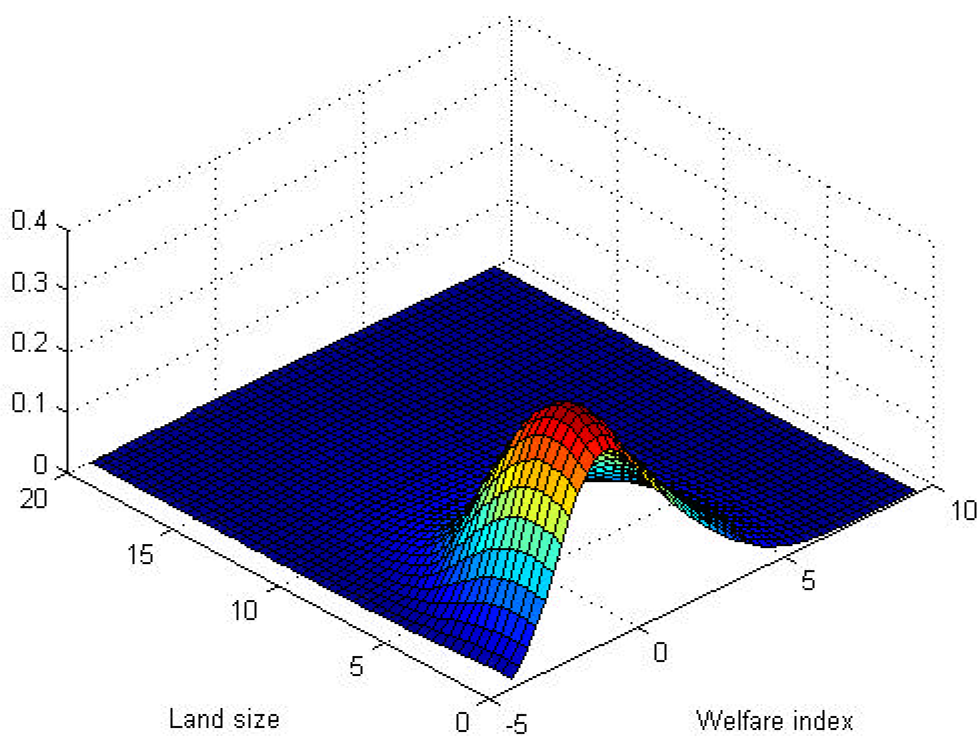


Figure 3: Joint distribution of welfare and land

[7] The joint density is computed using a bivariate Epanechnikov kernel with a bandwidth of 1.

For a better sense of this welfare index, Table 3 displays the average of various household characteristics by its quintiles. There is a consistent positive relationship between assets (land, farm animals, household education level), income, consumption and welfare. Households in the highest quintile earn approximately 2.2 times as much as the households in the lowest quintile, measured in monthly pesos. Non-labor transfers are 2.7 times higher for the highest quintile. Similar to Table 2, off-farm earnings are an important source of income, especially for those in the lowest quintile where 68% of their total income is derived from off-farm activities.

The difference in land assets between the highest and lowest quintile is only 2.2 RFE hectares, which is not entirely surprising given our sample of poor households. The average education level of the household in the highest quintile is almost two full years higher than the lowest quintile. Members of the highest quintile also tend to migrant more. Poverty is strongly associated with ethnicity, as fifty percent of households in the lowest quintile are indigenous compared to only 25% in the highest. Also while the number of agricultural workers per household varies little across the quintiles, households in the highest quintile have almost three times the number of nonagricultural workers as the lowest quintile.

Table 3. Mean characteristics of the poor across welfare levels

Quintiles of the welfare index	1	2	3	4	5	Total
Number of households	2,740	2,740	2,740	2,740	2,740	13,700
Quintile mean	-2.20	-1.23	-0.28	0.94	3.04	0.05
Quintile minimum	-4.22	-1.67	-0.79	0.27	1.72	-4.22
Quintile maximum	-1.67	-0.79	0.27	1.72	9.46	9.46
Occupation type within the household						
Agricultural workers	0.88	0.94	0.91	0.82	0.63	0.84
Nonagricultural workers	0.10	0.14	0.20	0.29	0.39	0.22
Seller	0.20	0.25	0.26	0.27	0.32	0.26
Family-related business	0.38	0.42	0.45	0.56	0.70	0.50
Total household monthly income in pesos						
Total	799.30	933.34	1125.75	1343.16	1847.73	1209.86
Labor wages	643.97	747.95	887.91	1047.93	1424.83	950.52
Agricultural wages	464.72	487.44	503.99	509.95	482.21	489.66
Non-agricultural wages	78.11	125.06	206.00	305.18	536.29	250.13
Self-employment	68.24	92.54	111.93	142.40	230.91	129.20
Family-related business	29.39	37.97	58.95	80.30	156.78	72.68
Other labor related wages	2.58	4.26	3.27	7.42	14.00	6.31
Non-labor transfers	155.33	185.39	237.84	295.23	422.90	259.34
Total household monthly expenditure in pesos						
Total	532.34	616.00	703.97	807.59	1101.22	752.22
Food expenditures	418.38	464.10	502.10	555.79	711.88	503.45
Non-food expenditures	113.96	151.90	201.88	251.80	389.33	221.78
Land assets in hectares						
Total rainfed	2.28	2.28	2.52	2.74	3.78	2.72
Total irrigated	0.06	0.08	0.12	0.18	0.32	0.15
Total in rainfed equivalence	2.46	2.53	2.87	3.21	4.63	3.14
Farm animals						
Horses	0.21	0.31	0.50	0.65	0.80	0.50
Mules	0.33	0.43	0.48	0.55	0.60	0.48
Oxen	0.07	0.12	0.15	0.18	0.23	0.15
Goats	1.15	1.77	1.65	1.99	2.84	1.88
Cattle	0.56	0.73	1.21	1.64	3.05	1.44
Pigs	1.01	1.27	1.49	1.47	1.58	1.36
Household characteristics						
Household size	5.43	5.92	6.16	6.33	6.29	6.03
Number of adult equivalent persons	4.84	5.38	5.72	5.93	5.96	5.56
Number of children	1.51	1.75	1.90	1.87	1.69	1.74
Number of migrants (by village)	6.64	7.95	8.62	8.66	9.01	8.18
Maximum education in household	4.39	5.38	6.05	6.58	7.56	5.99
Mean level of education in household	1.96	2.45	2.86	3.25	3.89	2.88
Head of household variables						
Education	1.91	2.31	2.46	2.64	3.04	2.47
Age	46.99	48.10	48.68	49.52	51.75	49.01
Male-head	0.89	0.92	0.93	0.92	0.91	0.91
Indigenous head	0.59	0.56	0.42	0.28	0.17	0.40

Thus far the descriptive analysis suggests a strong positive correlation between land and welfare. In the following section, we explore this relationship further with hopes of quantifying the economic value of land.

V. Estimation Results: Welfare generating potential of land

In this section, we estimate a household welfare equation to explore the relationship between land and welfare. There are three main findings. First, compared to the semiparametric approach a linear specification estimates a much lower marginal value of land. Second, there is a considerable difference in the return to land when using a consumption measure versus our welfare index. Finally, the marginal value of land differs according to a household's complementary assets and contextual settings.

Our final sample is restricted to the 12,034 landowners with complete household and village level data. Excluding the landless reduces the possibility of selection bias and ensures that the estimation is across a sample of households that do not pursue wildly different livelihood strategies. The final specification of the welfare equation consists of land, household characteristics, social and institutional assets, village characteristics, and states dummies. We also include the number of working-aged adults in the household by their education level. Since members of households with smaller farms may tend to migrate more, we incorporate into our definition of the number of working-aged adults, all the household members that have migrated within the last five years. This will help to mitigate any potential bias in household labor force due to endogenous migration strategies.

Regression (A) in Table 4 assumes a linear specification and uses monthly consumption expenditures as the measure of household welfare. The second and third columns report the OLS estimates with their corresponding t-statistics. Although significant, the estimated return to land is quite small. An increase of one RFE hectare will increase monthly consumption by 11.5 pesos, which is only 1.5% of the average monthly consumption of the sample. This result is an order of magnitude that is similar to those reported in López and Valdés (2000). This estimate also serves as a useful benchmark since it is based on a regression specification that is typically used in this literature.[8]

Interestingly, education also contributes little to current consumption. An additional year of education for the household head will improve monthly consumption by only 11 pesos. Even among male adults, there is no statistical difference between the return to an additional uneducated male and a male adult with a secondary education. Fortunately, for female adults the return to education is much steeper. Women with just a primary education contribute 3 times more to consumption than uneducated females, and those with more than a secondary education contribute almost 4 times as much.

Several contextual variables are important determinants of household welfare. Access to a federal road increases monthly consumption by 12%. Proximity to an urban center and presence of a village church are also positively associated with consumption.

Psacharopoulos and Patrinos (1993) document that 80% of the indigenous population in Mexico lives in poverty and in our sample 65% of the indigenous households are in fact classified as poor. With much of rural poverty associated with the indigenous population, it is perhaps not too surprising that indigenous households on average consume 11 percent less relative non-indigenous households.

---

[8] Several studies also use a log-linear specification. With this specification, we estimate a land to income elasticity of .105.

When we consider a different measure of welfare, our results are quite different (see regression (C) in Table 4). With our dependent variable measured in welfare units, we divide each of the estimated coefficients by the monetary transfer coefficient, .00015, to obtain results that are easier to interpret.[9] This calculation is reported in the eighth column along with its standard error. The marginal welfare value of land is 0.03 and highly significant. This suggests that increasing landholdings by one RFE hectare will increase welfare by 201 monthly pesos, which is 17 times the estimated return to land measured in consumption. For a better sense of the order of magnitude, the average monthly wage of an agricultural worker is 700 pesos, and the price of a metric ton of corn, in 1998, was on average 1460 pesos. If two months are required to cultivate a one-hectare plot of corn and the average yield for rainfed corn is 0.8 then 222 pesos is a sensible amount.

Measured with our welfare index, human assets are associated with large welfare effects. A marginal increase in the education level of the household head will raise welfare by 608 monthly pesos, an amount which is 3 times the return to land. While the addition of an adult male with a primary education increases welfare by a significant amount of 1504 pesos, the return of an adult male with more than a secondary education is 4557 pesos; a differential gain of 203%. Uneducated adults do not contribute to household welfare at the margin, and children and elderly members of the household are negatively associated with household welfare. There is still a high cost associated with ethnicity as being indigenous reduces welfare by 5073 monthly pesos.

[9] Monetary transfers are the monthly amount of pesos a household receives from non-labor sources. This includes government transfer from PROCAMPO and other scholarships.

Migration assets outside of Mexico contribute 282 more monthly pesos to welfare than migration assets within the country but outside of the respective state. Contained in only 14% of the villages, the presence of a health center increases welfare quite substantially by 1587 monthly pesos. Access to state and federal roads, which helps to reduce transaction costs, contribute greatly to welfare, as does proximity to an urban center. After controlling for differential asset positions and village characteristics, state effects remain significant. Relative to Guerrero only Michoacán is poorer.

Before proceeding with the semiparametric analysis, we explore the robustness of our results and consider the possibility of endogeneity bias. Despite the dearth of data on land market activities, our assumption to treat land as exogenous depends on the absence of intergenerational transmission of unobserved characteristics that determine land endowments as well as household welfare. Given our cross-sectional data, it is difficult to imagine a meaningful household level variable that is correlated with land endowments but does not affect welfare. Consequently, we use as instruments variables that are statistically valid, but admittedly ad hoc and imperfect. For our consumption regression, we instrument land with average village farm size, age of the household head, and gender of the household head. Similarly, for the welfare index regression we use average village farm size, the number of uneducated males, and the number of uneducated females. In both cases, the first-stage regressions (not shown) indicate that the instruments are strong predictors of household landholdings.[10] The overidentification tests fail to reject the null that the instruments are statistically valid (Davidson and MacKinnon 1993). The IV estimations of the welfare equation for both consumption and the welfare index produced

[10] The joint test of significance of the instruments in the first stage regression yield an F-statistic of 70.6 and 64.6 for consumption and the welfare index, respectively.

estimates that were not statistically different from the OLS estimations (see Appendix).[11] In terms of monthly consumption, the marginal value of land increased slightly to 15.26 pesos. And when measured with the welfare index, the marginal value of land also increased to 275.47 monthly pesos.

For another check of robustness, we estimate a village fixed-effects model to test whether any unobserved village-level variable affects the estimated return to land. The fixed-effects estimates (see Appendix) increase slightly but are also not significantly different from the OLS regression (*F-statistic* is 0.08). The estimated marginal value of land is 216 pesos compared to the 201 pesos reported in Table 4. As long as land quality remains constant within villages, it appears that adjusting land area by its yield has done a reasonable job of controlling for land quality differences across villages. Finally, we estimate a log linear specification of landholdings to discover that, evaluated at the average land size in the sample, the marginal welfare value of land more than triples to 611 monthly pesos. This result suggests that the specification does matter and that a semiparametric approach to the data is warranted.

[11] In an extended Hausman test, the F-statistics for the consumption and welfare index regression are 1.55 and 1.15, respectively.

Table 4. Parametric and semiparametric estimation of the welfare equation

		Household consumption				Household w		
		Parametric		Semiparametric		Parametric		
		(A)		(B)		(C)		
	$\bar{x}$	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat	Peso value
Land assets (RFE Hectares)	3.14	11.49	7.2			0.03	8.36	201.05 (52.06)
Monetary transfers (*1000)	123.99	0.03	2.9	0.02	2.56	0.15	4.52	1
Head of household characteristics								
Gender (dummy)	0.92	26.23	1.38	22.44	1.13	0.29	4.68	1969.15 (601.82)
Age (years)	49.20	0.45	0.9	0.12	0.24	0.02	9.23	99.23 (24.55)
Education level	2.49	11.00	3.72	10.41	4.18	0.09	11.10	608.22 (145.03)
Labor force (number of individuals)								
Male adults with $education == 0$	0.19	63.79	4.12	60.11	4.52	-0.04	-1.01	-262.99 (267.06)
Male adults with $0 < education < 6$	0.47	43.47	4.78	41.35	4.61	0.06	2.24	407.28 (201.70)
Male adults with $education == 6$	0.31	61.23	6.63	59.02	6.66	0.23	7.84	1503.95 (386.12)
Male adults with $6 < education \leq 9$	0.16	68.15	4.87	61.68	5.44	0.47	12.52	3139.64 (737.25)
Male adults with $education > 9$	0.05	114.08	5.71	106.76	5.38	0.68	9.47	4556.76 (1124.08)
Female adults with $education == 0$	0.32	39.28	3.55	37.63	3.52	0.03	0.77	166.00 (217.53)

Female adults with $0 < education < 6$	0.44	44.42	4.41	42.54	4.47	0.30	10.03	2017.23 (488.81)
Female adults with $education == 6$	0.28	92.98	8.42	90.70	9.49	0.54	17.77	3611.89 (826.10)
Female adults with $6 < education \leq 9$	0.12	117.97	6.8	116.35	9.35	0.66	15.65	4383.89 (1011.85)
Female adults with $education > 9$	0.03	157.66	5.67	152.06	6.55	1.05	11.12	7004.26 (1688.03)
Children (under 17 years old)	2.59	30.17	11.52	29.03	11.33	-0.01	-1.02	-53.81 (53.50)
Males, at least 55 years old	0.35	26.45	1.65	21.80	1.45	-0.12	-2.38	-785.92 (371.19)
Females, at least 55 years old	0.31	39.69	3.07	36.76	3.08	0.24	6.16	1580.38 (434.60)
Social and institutional assets								
Indigenous household (dummy)	0.40	-89.26	-6.85	-78.59	-6.35	-0.76	-19.7	-5072.80 (1162.12)
Access to agricultural cooperative (dummy)	0.04	-33.42	-1.6	-43.87	-1.75	0.01	0.17	88.40 (509.5)
Access to credit cooperative (dummy)	0.01	-113.90	-2.61	-110.7	-1.81	-0.41	-2.34	-2754.02 (1333.44)
Church present (dummy)	0.40	30.20	2.81	28.71	2.80	0.02	0.56	119.68 (217.68)
Migration Assets (number of individuals in the village)								
Out of the state	3.28	-8.76	-5.52	-8.29	-4.74	0.01	2.91	95.84 (38.57)
Out of Mexico	1.21	16.00	6.85	16.27	8.39	0.06	7.36	378.17 (96.72)
Locality Characteristics								
State Road (dummy)	0.17	34.18	2.34	37.59	2.68	0.22	4.93	1465.21 (438.46)
Federal Road (dummy)	0.26	88.47	6.58	93.06	7.80	0.22	5.74	1488.07 (416)
Health center (dummy)	0.14	2.39	0.13	-4.38	-0.29	0.24	4.85	1586.71

								(485.17)
DICONSA shop (dummy)	0.30	31.97	2.75	38.08	3.44	-0.08	-2.20	-500.20
								(257.33)
Min. distance to an urban center (km)	107.37	-1.21	-6.85	-1.17	-6.08	-0.01	-7.45	-29.69
								(7.71)
Min. distance to the state capital (km)	154.86	0.08	0.73	0.07	0.56	-0.00	-3.79	-10.42
								(3.57)
Male agricultural wage (daily)	32.56	1.27	2.59	1.08	2.35	0.02	12.96	129.35
								(30.29)
Male non-agricultural wage (daily)	3.82	0.80	1.95	0.85	2.12	-0.00	-1.09	-10.33
								(9.77)
Male self-employed wage (daily)	1.69	0.00	0	0.18	0.29	0.01	2.54	34.21
								(15.65)
Female agricultural wage (daily)	13.02	0.06	0.2	0.00	-0.02	0.00	4.34	29.67
								(9.42)
Female non-agricultural wage (daily)	1.14	-1.66	-2.22	-1.57	-1.88	0.01	2.56	48.05
								(21.15)
Female self-employed wage (daily)	1.14	1.03	1.36	0.91	1.14	0.00	-0.07	-1.23
								(17.3)
Population	393.12	-0.02	-1.19	-0.03	-1.44	0.00	5.40	2.31
								(0.68)
				State dummies				
Hidalgo	0.17	218.05	9.49	218.21	10.78	-0.22	-3.50	-1474.54
								(527.27)
Michoacan	0.12	84.59	2.96	60.72	2.37	-1.56	-18.37	-10419.37
								(2352.24)
Puebla	0.15	122.35	4.91	120.67	5.40	-0.45	-6.54	-2982.35
								(795.62)
Queretaro	0.04	-14.47	-0.42	-32.56	-1.02	-1.19	-10.6	-7926.20
								(1879.62)
San Luis Potsi	0.15	22.48	0.9	-3.69	-0.16	-0.50	-6.85	-3324.70
								(860.33)
Veracruz	0.28	34.44	1.44	23.23	1.01	-0.60	-8.36	-4015.28
								(1001.99)

Intercept	1	393.46	9	-	-	-1.34	-9.71	-
Endogenous variable (mean welfare)	.08	749.67						
Number of observations	12034							
F(33, 12124)		49.88		42.85		132		
R^2		0.15		0.13		0.32		

* Standard errors were computed with the delta method and are displayed in parentheses. The t-statistics are based on Eicker-Wh

Semiparametric Estimation

The regressions (B) and (D) displayed in Table 4 correspond to the second step of the semiparametric procedure: estimation of equation (6) above. Interestingly, the semiparametric procedure does not estimate coefficients significantly different from the estimates of the OLS regression. The resulting semiparametric estimate of the welfare value of land, $g(X)$, is shown in Figure 4, where welfare appears as an increasing concave function of land.[12] The vertical axis refers to welfare units and includes the constant term. While the shape of the welfare value of land becomes increasing linear as landholdings increase, it does suggest that a linear specification may in fact provide a poor approximation.

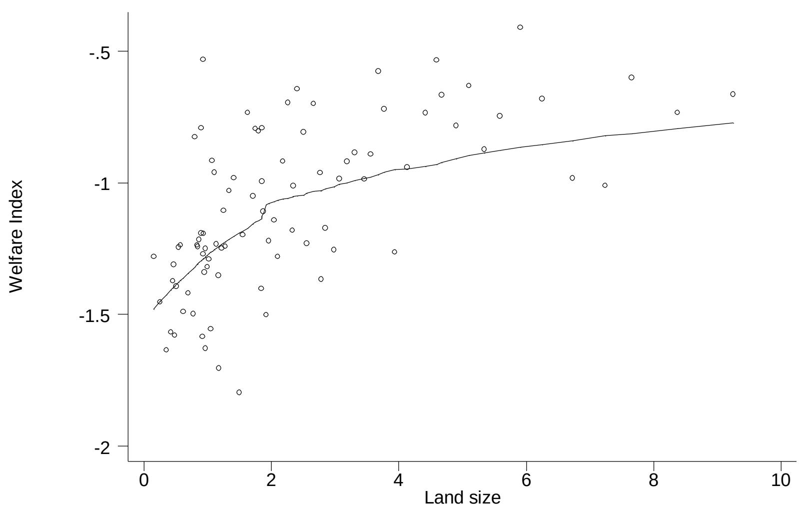


Figure 4: Welfare value of land[13]

[12] The graph corresponding to the consumption measure is very similar in appearance.
[13] Each point represents 120 households.

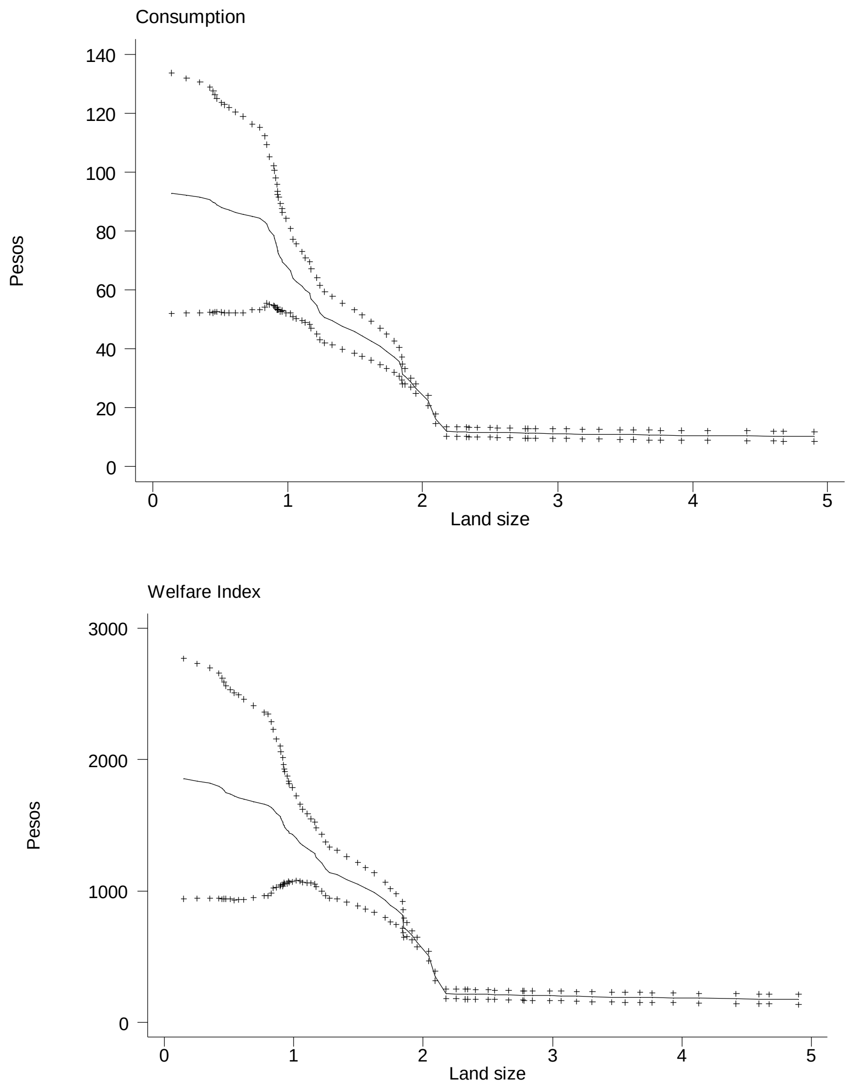


Figure 5: Marginal value of land

Figure 5 displays the marginal value of land for both consumption and the welfare index along with their 95% point-wise confidence intervals.[14] The bottom figure corresponds to Figure 4 above, except that the y-axis has been normalized to the appropriate pesos value. Regardless of the measure of welfare, the shape of the two

[14] It should be noted that pointwise confidence intervals do not suggest that all the estimated values jointly fall within these bounds. Cleveland and Devlin (1988) have proposed an F-test to compare a parametric specification against a non-parametric specification, and this will be incorporated in the next version of the paper.

marginal value of land curves are quite similar. An additional hectare of land for farmers with at most one hectare is associated with an increase in their monthly consumption of 82 pesos (see Table 5). This represents an increase of 14% over the average consumption among these households. Measured in terms of our welfare index, for these same farmers, an additional plot of land translates into a 1636 pesos increase in their welfare. With both measures, the curves appear to asymptote at an estimated value that is comparable to the parametric fit, suggesting that a linear specification can grossly underestimate the marginal value of land. A simple average of the return to land measure in monthly expenditure is 43 pesos, which is almost four times the benchmark case of 11.5 pesos.

Table 5. Marginal value of land in monthly pesos

Farm size in RFE hectares	Number of households	Consumption Average marginal value of land	Welfare Index Average marginal value of land
≤1	3557	81.9	1636.3
1-3	5180	37.0	810.9
<3	3452	10.1	172.8

Recalling Figure 1, the shape of Figure 5 is remarkably similar to our theoretical predictions of the impact of a labor market constraint on the return to land. Figure 5 appears to capture the fact that for small farmers additional land garners a return that is higher than the simple production value of the extra plot of land. Additional land will increase the marginal product value of household labor and other productive assets thus reducing the impact of any distortions that may exist. The shape suggests that a lack of rural employment opportunities is a possible constraint that these household face.

Heterogeneity in the marginal value of land

An important component of this measurement exercise is to account for the large variation in income generating strategies pursued by the rural poor. The high degree of heterogeneity in both asset positions and exposure to market imperfections suggests that the marginal value of land should not be constant across poor rural households. While our previous parametric and semiparametric specifications permit for the demographic and contextual characteristics of the household to shift the welfare equation, we still restrict the coefficient to be the same across a very diverse sample.

The pooling of data across different subgroups may also cause spurious curvature in the semiparametric estimation of land (Bhalotra and Attfield 1998). Suppose, for example, that the relationship between welfare and land is actually linear, but that indigenous land is systematically smaller and produces a higher return. The marginal value of land for non-indigenous households will be lower and lie predominantly to the right of the indigenous sample. While the relationship is in fact linear, the combination of these data will result in a nonlinear presentation.

Table 7 compares the return to land across different subgroups of the population using parametric and semiparametric estimation of the welfare index. With a linear specification, the return to land falls short of the 5% significance level only within a few subgroups (community population size, Gulf, access to health). However, when comparing the difference between the subgroups only the indigenous and non-indigenous split recorded a significant difference in the return to land. *A priori*, this is a curious result since one would expect that access to a road or a higher average household education level would affect the marginal value of land. Yet this presumes, incorrectly, that a linear specification is a good approximation. When we relax the functional specification, the marginal value of land, as displayed in Figure 6, does vary across these subgroups.

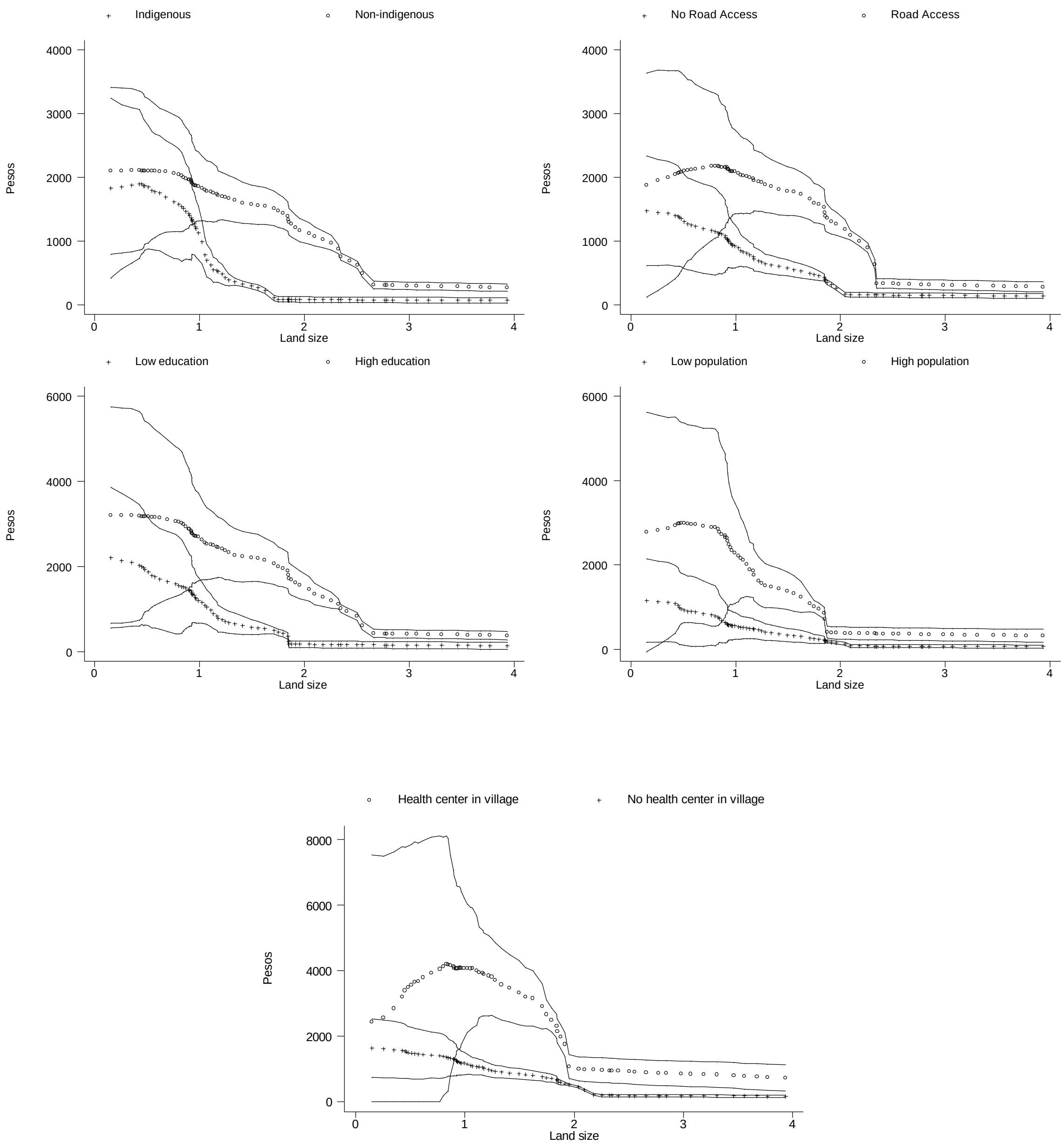
The income generating potential of indigenous land is three times lower than non-indigenous land for landholdings greater than 3 hectares. Households residing in a village with a road and a health center garner a higher return to land. Access to a paved road is important for reducing transaction costs on product and factor markets, which will increase the return to land. While it may appear strange that access to a health center should affect the income generating potential of land, this variable is most likely a proxy for market integration and the degree of urbanization. Households with a higher average adult education level also achieve a higher return to their land.

In all the plots, the general curvature of the land function remained consistent. This provides some evidence that the curvature is not spurious.

Table 7. Marginal welfare value of land in monthly pesos						
	Land Size	Sample Size	Parametric	Semiparametric Farm size		
				<1	1-3	>3
Household Assets						
Indigenous	2.52	4800	94	1585	375	70
			(39)	[1778]	[2090]	[932]
Non-indigenous	3.55	7234	283**	2013	1233	251
			(89)	[1729]	[3021]	[2484]
Average education (<2.1)	2.61	3908	176	1647	516	131
			(79)	[1390]	[1645]	[873]
Average education (>3.5)	3.79	4055	342	2989	1727	355
			(165)	[958]	[1671]	[1426]
Village characteristics						
No access to a road	3.09	6875	136	1170	499	131
			(40)	[2044]	[2983]	[1848]
Access to a road	3.21	5159	281	2107	1308	269
			(114)	[1463]	[2128]	[1568]
Lowest population quintile	3.34	2418	62	796	259	57
(192)			(34)	[727]	[901]	[630]
Highest population quintile	2.56	2364	310	2734	1156	305
(556)			(196)	[782]	[1161]	[559]
No access to health center	3.24	10400	172	1379	665	151
			(48)	[2998]	[4386]	[3016]
Access to health center	2.46	1634	714	3773	2538	668
			(524)	[509]	[725]	[400]
Agro-ecological regions						
Central Region (Hidalgo,	2.90	5719	268	1648	1083	275
Michoacan, Puebla,			(103)	[1849]	[2329]	[1541]
Queretaro)						
South Pacific (Guerrero)	1.60	1137	258	-151	355	309
			(208)	[451]	[561]	[125]
Gulf (Veracruz)	3.05	3346	323	6824	2893	401
			(289)	[832]	[1585]	[929]
North (San Luis Potsi)	5.01	1832	113	928	464	123
			(46)	[375]	[636]	[821]

*The standard errors displayed in parentheses are computed by using the delta method. The numbers in the brackets are number of households with the corresponding amount of land. All these regressions include the same covariates displayed in Table 3. (**) denotes difference within subgroup is significant at <.05. The t-statistic is based on Eicker-White corrected standard errors.

Figure 6: Marginal value of land across subgroups



Heterogeneity in the level of welfare

To better understand the value of land access in reducing poverty, we investigate how differences in asset positions and contextual settings translate to differences in welfare levels. In order to decompose these differences, we re-estimate our welfare equation using a spline function for land. In this situation, a flexible parametric specification is needed because the nonparametric approach came at the expense of not being able to identify the constant term. However, the nonparametric exploration of the land to welfare contour does guide us in our choice of the number and location of the knot points, which in a spline regression can be fairly arbitrary.

In the spirit of Oaxaca's (1973) wage-gap decomposition, we explore the welfare differential between subgroups. The welfare gap, $\overline{W}_A - \overline{W}_B$, between group A and group B can be decomposed as,

$$\overline{W}_A - \overline{W}_B = g_A(Z) - g_B(Z) + \overline{X}_A(b_A - b_B) + (\overline{X}_A - \overline{X}_B)b_B \tag{7}$$

where $g_A(Z), g_B(Z)$ denote household landholdings, and $\overline{X}_A, \overline{X}_B$ are the average endowments of the determinants of household welfare. The first term in equation (7) represents, at a given farm size, the difference in the return to land between the two groups. The second term captures differences in the estimated return to the determinants of welfare due to omitted factors. The last term is the portion of the welfare gap attributed to differences in endowments.

The decomposition of the difference in predicted welfare levels between households with a low and high average education level is depicted by landholdings in Figure 7. Here, we see that access to land does little to alleviate poverty among households with low education levels.[15] Differences in endowments explain on average 57% of the welfare gap. While highly educated households would still experience higher welfare levels even after controlling for endowment differences, only those low-educated households with less than 2 hectares of land would be below poverty. This graph emphasizes the importance of an integrated poverty alleviation strategy. A single approach, such as land access will do little for households with few complementary assets.

Figure 8 shows the decomposition between indigenous and non-indigenous households. In this case, eliminating the endowment differential between indigenous and non-indigenous households would be insufficient to raise the indigenous households with less than 15 hectares of land out of poverty. Non-indigenous households receive an unexplained premium that is on average 55% of the welfare differential. If indigenous households were to receive the same return to their assets as non-indigenous households, indigenous households would only require access to three hectares of land to reach the poverty line.

Figure 9 plots the difference in welfare between those households with access to a road and those households without road access. With access to a paved road, households only need less than 1 hectare of land to reach the poverty line, compared to household without road access who need 9 hectares. Again, we see that if there were no differences in either endowments or in this case, the return to land, only households with less than 3 hectares of land would remain in poverty.

[15] The poverty line was determined by estimating the poverty indicator on our welfare index. The threshold value maximizes the number of correctly classified households.

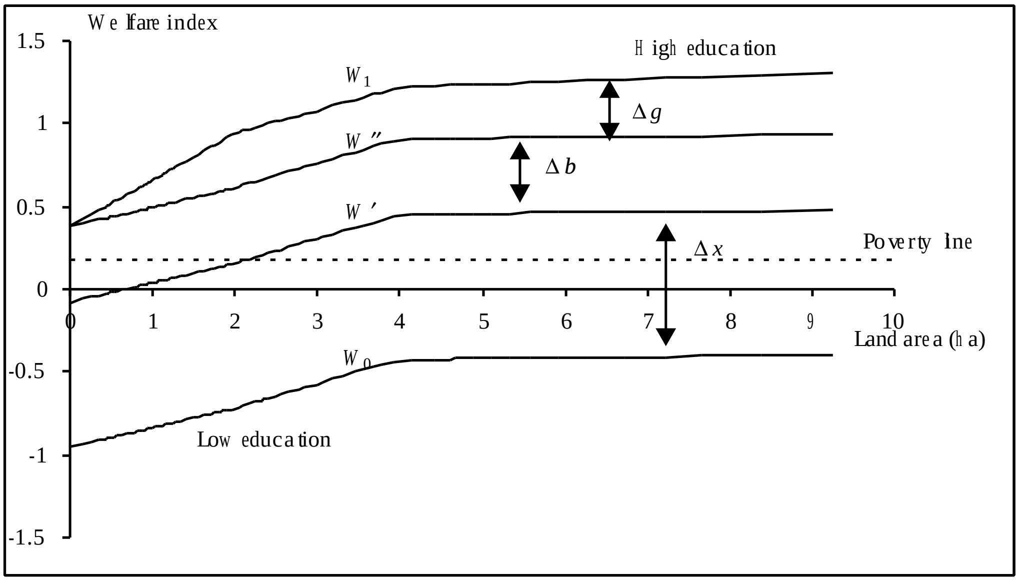


Figure 7: Welfare as a function of land assets:
The role of asset complementarity

$$W_0 = g_0(\text{land}) + b_0'\bar{x}_0 \quad \text{Welfare of group 0}$$
$$W' = g_0(\text{land}) + b_0'\bar{x}_1 \quad + \text{ non-land assets of group1}$$
$$W'' = g_0(\text{land}) + b_1'\bar{x}_1 \quad + \text{ return to assets of group1}$$
$$W_1 = g_1(\text{land}) + b_1'\bar{x}_1 \quad + \text{ return to land of group1}$$
$$= \text{ Welfare of group 1}$$

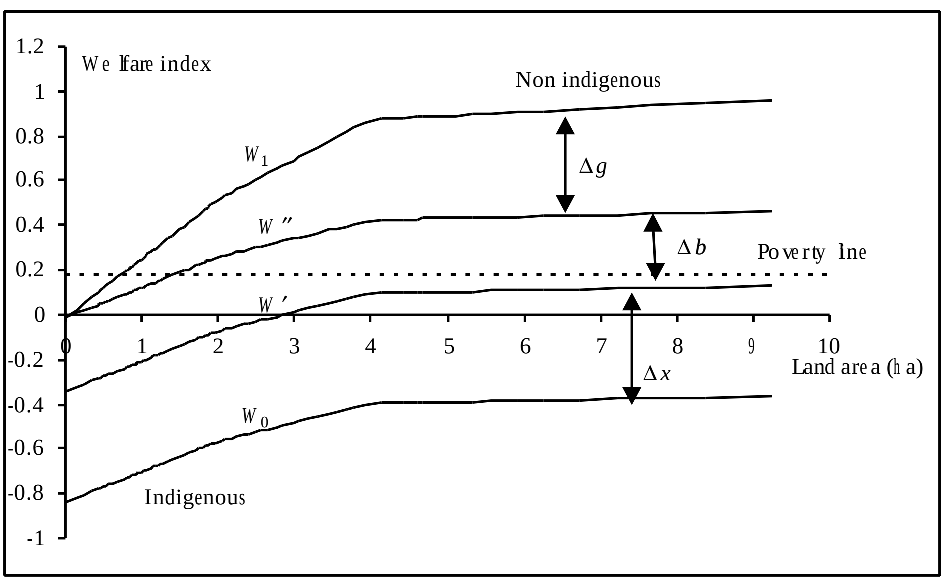


Figure 8: Welfare as a function of land assets:
The role of household characteristics

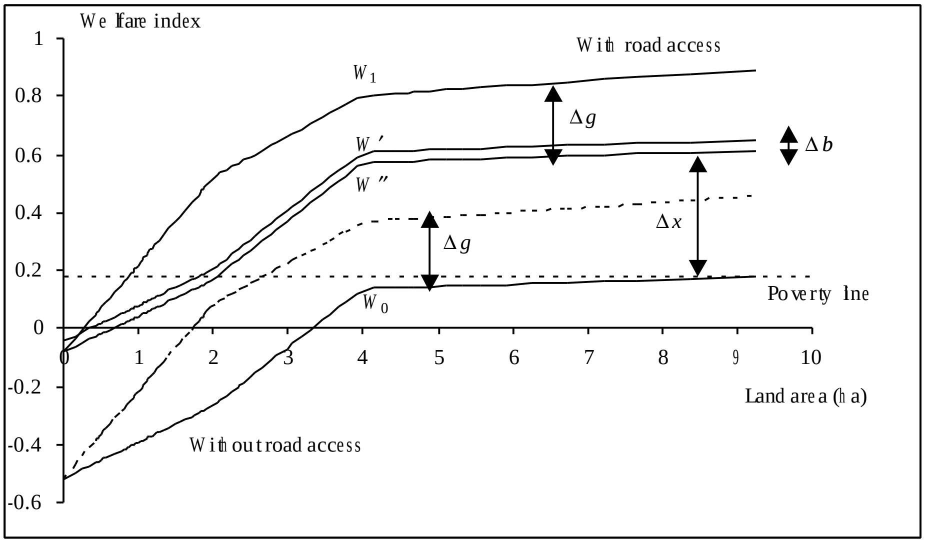


Figure 9: Welfare as a function of land assets:
The role of the context

VI. Conclusion

There has been much controversy about the value of access to land in reducing poverty. Lopéz and Valdés (2000), in particular, have argued that land contributes little to income and that consequently, it is better to look at other instruments if poverty is a concern. Yet, we consider that the methodology they used has several deficiencies, which we proceed to correct in this paper. In addition, we believe that this overall statement needs to be qualified to recognize the considerable heterogeneity of conditions under which land is used; in particular, the role of household characteristics, complementary assets, and the context where land is used. To do this, we measure the potential of land to generate income in rural Mexico in an effort to provide more accurate measurements and to identify the contexts under which land access can help to reduce poverty. In general, we find that the marginal welfare value of land is quite high for households with less than 2 hectares of rainfed corn equivalence. For these farmers, an additional plot of land will increase welfare by as much as 1000 monthly pesos. This represents 1.4 times the average monthly income of an agricultural worker in our sample. The high return to land captures the increase in the value of the marginal product of other household assets due to market failures, in addition to the increase in the direct production value of the land. We find that the shape of the mapping between land and welfare is consistent with a theory of labor rationing in off-farm employment.

Given the variation in livelihood strategies resulting from differences in asset positions and market exposure across households, we investigate the role heterogeneity plays in land's ability to generate economic livelihood. We observe that complementary and contextual assets of the household greatly influence land's income generating potential. Social assets such as ethnicity lower the marginal value of land, whereas households with more human capital receive a higher return to land. Households that face lower transaction costs as measured by access to roads and access to a health center, garner a return to land that is twice as high. Moreover, access to only one hectare of land is sufficient for households with access to a paved road to escape poverty.

These findings suggest that in particular contexts land can be an important element of a poverty reducing strategy. Besides better access to land, it is also important to improve complementary assets such as education and to reduce the market imperfections that limit the effective utilization of these assets. Promoting rural development to increase off-farm employment will greatly benefit those households with limited access to land. Policies that recommend massive land redistribution, while politically difficult, may not be necessary, as better access to even minimal amounts of land can translate into significant welfare gains if this is done under conditions that allow effective use of the land.

References

Blundell, Richard, Alan Duncan and Krishna Pendakur. 1998. “Semiparametric Estimation and Consumer Demand.” *Journal of Applied Econometrics*, Volume 13, pp. 435-461.

Carter, Michael R. “Agrarian Class Formation and Structural Evolution in Imperfect Market Environments: Theory and Analysis of the Agricultural Decollectivization in Latin America.” Mimeo 1990.

Carter, Michael R. and Julian May. “Poverty, Livelihood and Class in Rural South Africa.” *World Development*, Volume 27, Number 7, pp. 1-20, 1999.

Carter, Michael R. and Dina Mesbah. “Can Land Market Reform Mitigate the Exclusionary Aspects of Rapid Agro-Export Growth?” *World Development*, Volume 21, Number 7, pp.1085-1100, 1993.

Cleveland, W.S. 1979. “Robust Locally Weighted Regression and Smoothing Scatterplots.” Journal of the American Statistical Association. 74: 829-836.

Cleveland, W.S. and Susan Devlin. 1988. “Locally weighted regression and smoothing scatterplots.” *Journal of American Statistical Association*. 83:596-610.

Davidson, R. and J. MacKinnon. 1993. *Estimation and Inference in Econometrics*. NewYork: Oxford University Press.

de Janvry, Alain, Gustavo Gordillo and Elisabeth Sadoulet. “*Mexico’s Second Agrarian Reform*.” Center for U.S.-Mexican Studies at the University of California, San Diego. 1997.

de Janvry, Alain and Elisabeth Sadoulet. “Income Strategies Among Rural Households in Mexico: The Role of Off-farm Activities.” *World Development*, Volume 29, Number 3, pp. 467-480, 2001.

Deaton, Angus. 1997. *The analysis of household surveys: A microeconometric approach to development policy*. Baltimore, M.D. The World Bank. The Johns Hopkins University Press.

López, Ramon and Alberto Valdés. “Fighting Rural Poverty in Latin America: New Evidence of the Effects of Education, Demographics, and Access to Land”. *Economic and Development and Cultural Change*, Volume 49, Number 1, October 2000, pp. 197-211.

Oaxaca, R.L. 1973. “Male-female Wage Differentials in Urban Labor Markets.” *International Economic Review.* Volume 14. 693-709.

Psacharopoulos, George and Harry A. Patrinos. 1993. *Indigenous People and Poverty in Latin America: An Empirical Analysis.* Report No. 30. World Bank, Latin American and the Caribbean Technical Department, Regional Studies Program, Washington D.C.

Ravallion Martin. 1996. "Issues in Measuring and Modeling Poverty." *Economic Journal*, 106 (September).

Robinson, P.M. "Root-N-Consistent Semiparametric Regression." *Econometrica*, Volume 56, Issue 4, July 1988, pp. 931-954.

Sen, A.K. *Poverty and Famines: An Essay on Entitlement and Deprivation*. Clarendon Press, Oxford, 1981.

Singh, I, L. Squire and J. Strauss (eds.) *Agricultural Household Models*. Baltimore, MD. The John Hopkins University Press. 1986.

Appendix A: A stylized agricultural household model

Three important assumptions are made in this model:

1) Land is exogenous.
2) There exists a probability of unemployment.
3) Access to credit increases with land size.

The household's decision problem is to maximize

$$\begin{aligned}
&\underset{L_s, L_f, X}{\text{Max}} \; pF(L_f, X, T) - qX + w\Omega(L_s) - i\Gamma(T) \\
&s.t. \\
&L_s + L_f \leq \bar{L} \\
&wL_h + qX \leq K + w\Omega(L_s) + \Gamma(T) \\
&L_s \geq 0, L_f \geq 0.
\end{aligned}$$

- The production function is Cobb-Douglas with $F(\cdot) = L_f^{1/3} X^{1/3} T^{1/3}$
- The possibility of unemployment is characterized by $\Omega(L_s) = L_s - .4 * L_s^2$
- The availability of credit is defined as $\Gamma(T) = 1300 * \Phi\left(\frac{T-10}{3}\right)$.
- The price of a metric ton of corn, *p*, is 1500 pesos.
- The average wage for a nonagricultural worker, *w*, is 1280 pesos per month.
- The average per unit cost of corn production, *q*, is 460 pesos per month.
- The interest rate, *i*, is .05.

The solution to this problem can be characterized by the Kuhn-Tucker conditions for constrained maximization.

Appendix B: IV estimation of welfare index

Instrumental variables (2SLS) regression

Source	SS	df	MS
Model	13957.1794	41	340.41901
Residual	29481.883	11992	2.45846256
Total	43439.0624	12033	3.60999438

Number of obs	= 12034
F(41, 11992)	= 136.30
Prob > F	= 0.0000
R-squared	= 0.3213
Adj R-squared	= 0.3190
Root MSE	= 1.5679

welfare	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
land_rfe	.0395575	.0075156	5.26	0.000	.0248258	.0542892
hohmale	.2788248	.0598936	4.66	0.000	.1614237	.3962259
hohage	.0147325	.0015964	9.23	0.000	.0116033	.0178617
hohedu	.092898	.0067641	13.73	0.000	.0796392	.1061568
hohindig	-.7548928	.0379816	-19.88	0.000	-.8293428	-.6804429
n_outstate	.0143705	.0054364	2.64	0.008	.0037143	.0250267
n_country	.0572624	.0060037	9.54	0.000	.0454942	.0690306
ag_coop	.0081641	.0773921	0.11	0.916	-.1435369	.1598651
credit_coop	-.4068156	.1895311	-2.15	0.032	-.7783273	-.0353039
church	.0154047	.0318284	0.48	0.628	-.046984	.0777935
est	.221462	.0434762	5.09	0.000	.1362416	.3066825
fed	.2271161	.0370429	6.13	0.000	.154506	.2997261
health	.2378403	.0468043	5.08	0.000	.1460964	.3295842
diconsa	-.0716731	.034358	-2.09	0.037	-.1390203	-.0043259
min_dist	-.0043764	.0006011	-7.28	0.000	-.0055547	-.0031981
dist_cap	-.0015609	.000395	-3.95	0.000	-.0023351	-.0007867
wm_jor	.0191097	.0014347	13.32	0.000	.0162976	.0219219
wm_obr	-.0013965	.0012478	-1.12	0.263	-.0038424	.0010493
wm_emp	.0052212	.0018958	2.75	0.006	.0015052	.0089372
ww_jor	.0044603	.0009222	4.84	0.000	.0026526	.0062681
ww_obr	.0071439	.0025902	2.76	0.006	.0020667	.0122212
ww_emp	-.0002518	.0024837	-0.10	0.919	-.0051203	.0046167
state2	-.2264458	.0625597	-3.62	0.000	-.3490729	-.1038187
state3	-1.56974	.0787793	-19.93	0.000	-1.72416	-1.41532
state4	-.4461384	.068946	-6.47	0.000	-.5812838	-.3109931
state5	-1.198849	.0997399	-12.02	0.000	-1.394355	-1.003342
state6	-.5243572	.0706293	-7.42	0.000	-.662802	-.3859123
state7	-.6109551	.0709643	-8.61	0.000	-.7500565	-.4718536
pop	.0003494	.0000674	5.18	0.000	.0002173	.0004815
lprimary_m	.0715371	.0258231	2.77	0.006	.0209195	.1221546
primary_m	.2273151	.0272466	8.34	0.000	.1739073	.2807229
secondary_m	.4692215	.0350698	13.38	0.000	.4004791	.537964
msec_m	.6745278	.0616612	10.94	0.000	.5536618	.7953938
lprimary_f	.2923964	.0273094	10.71	0.000	.2388656	.3459272
primary_f	.5356178	.029178	18.36	0.000	.4784241	.5928114
secondary_f	.6520432	.0386009	16.89	0.000	.5763792	.7277071
msec_f	1.040923	.0721579	14.43	0.000	.8994818	1.182364
child16	-.0074693	.0078512	-0.95	0.341	-.022859	.0079204
m55p	-.1086002	.0451427	-2.41	0.016	-.1970872	-.0201133
f55p	.233022	.03609	6.46	0.000	.1622797	.3037643
transfer	.0001436	.0000277	5.18	0.000	.0000892	.0001979
_cons	-1.34414	.1346617	-9.98	0.000	-1.608099	-1.080181

Instrumented: land_rfe

Instruments: hohmale hohage hohedu hohindig n_outstate n_country ag_coop credit_coop church est fed health diconsa min_dist dist_cap wm_jor wm_obr wm_emp ww_jor ww_obr ww_emp state2 state3 state4 state5 state6 state7 pop lprimary_m primary_m secondary_m msec_m lprimary_f primary_f secondary_f msec_f child16 m55p f55p transfer mvland noedu_m noedu_f

Test of overidentifying restrictions: 1.363844 Chi-sq(2) P-value = .5056

Appendix C: IV estimation of consumption

Instrumental variables (2SLS) regression

Source	SS	df	MS
Model	570044113	41	13903515.0
Residual	3.1551e+09	11992	263096.617
Total	3.7251e+09	12033	309573.568

Number of obs =	12034
F(41, 11992) =	49.94
Prob > F =	0.0000
R-squared =	0.1530
Adj R-squared =	0.1501
Root MSE =	512.93

consumo	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
land_rfe	15.26886	2.450065	6.23	0.000	10.46633	20.07138
hohedu	10.79402	2.295196	4.70	0.000	6.295066	15.29298
hohindig	-87.8887	12.52606	-7.02	0.000	-112.4418	-63.33559
n_outstate	-8.783285	1.776308	-4.94	0.000	-12.26514	-5.301435
n_country	16.25642	1.96315	8.28	0.000	12.40833	20.10451
ag_coop	-35.54149	25.31496	-1.40	0.160	-85.16291	14.07994
credit_coop	-113.6722	62.00514	-1.83	0.067	-235.2123	7.867889
church	29.11359	10.40721	2.80	0.005	8.713778	49.51339
est	35.2873	14.22167	2.48	0.013	7.410528	63.16407
fed	89.82468	12.11314	7.42	0.000	66.08097	113.5684
health	3.01789	15.30874	0.20	0.844	-26.98973	33.02551
diconsa	33.45773	11.24018	2.98	0.003	11.42516	55.4903
min_dist	-1.174792	.1967881	-5.97	0.000	-1.560528	-.7890553
dist_cap	.0811784	.1292673	0.63	0.530	-.1722064	.3345631
wm_jor	1.152106	.4694295	2.45	0.014	.231948	2.072264
wm_obr	.8562415	.4079604	2.10	0.036	.0565731	1.65591
wm_emp	.0387808	.620256	0.06	0.950	-1.177021	1.254583
ww_jor	.0712315	.3018506	0.24	0.813	-.5204445	.6629074
ww_obr	-1.688923	.8471361	-1.99	0.046	-3.349447	-.028399
ww_emp	.9963238	.812617	1.23	0.220	-.596537	2.589185
state2	216.5909	20.55124	10.54	0.000	176.3071	256.8746
state3	83.18642	25.9106	3.21	0.001	32.39745	133.9754
state4	123.3626	22.64524	5.45	0.000	78.97426	167.751
state5	-18.66814	32.6633	-0.57	0.568	-82.69349	45.35721
state6	14.34688	23.31932	0.62	0.538	-31.36276	60.05652
state7	32.43271	23.31679	1.39	0.164	-13.27197	78.13739
pop	-.0229281	.0220364	-1.04	0.298	-.066123	.0202668
noedu_m	65.74082	13.06808	5.03	0.000	40.12527	91.35636
lprimary_m	45.5401	8.870244	5.13	0.000	28.15298	62.92721
primary_m	61.4094	8.948385	6.86	0.000	43.86912	78.94968
secondary_m	67.81863	11.4469	5.92	0.000	45.38084	90.25641
msec_m	112.3139	20.12876	5.58	0.000	72.85823	151.7695
noedu_f	38.11331	10.80643	3.53	0.000	16.93096	59.29566
lprimary_f	43.03384	9.669038	4.45	0.000	24.08096	61.98672
primary_f	91.57665	9.685673	9.45	0.000	72.59117	110.5621
secondary_f	116.4902	12.65273	9.21	0.000	91.68877	141.2916
msec_f	154.8838	23.61277	6.56	0.000	108.599	201.1687
child16	30.35625	2.567021	11.83	0.000	25.32447	35.38802
m55p	36.90152	11.77339	3.13	0.002	13.82376	59.97927
f55p	38.46339	11.37419	3.38	0.001	16.16813	60.75865
transfer	.0236005	.0090724	2.60	0.009	.0058172	.0413838
_cons	425.1326	33.49564	12.69	0.000	359.4757	490.7894

Instrumented: land_rfe

Instruments: hohedu hohindig n_outstate n_country ag_coop credit_coop church est fed health diconsa min_dist dist_cap wm_jor wm_obr wm_emp ww_jor ww_obr ww_emp state2 state3 state4 state5 state6 state7 pop noedu_m lprimary_m primary_m secondary_m msec_m noedu_f lprimary_f primary_f secondary_f msec_f child16 m55p f55p transfer mvland hohage hohmale

Test of overidentifying restrictions: 1.814439 Chi-sq(2) P-value = .4036

Appendix D: Fixed-effects model

```
Fixed-effects (within) regression               Number of obs      =     12034
Group variable (i) : locality                   Number of groups   =       489

R-sq:  within  = 0.1458                         Obs per group: min =         1
       between = 0.3564                                        avg =      24.6
       overall = 0.2059                                        max =       146

                                                F(19,11526)        =    103.57
corr(u_i, Xb)  = 0.2172                         Prob > F           =    0.0000
```

welfare	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
land_rfe	.0233751	.0024808	9.42	0.000	.0185122	.028238
hohmale	.2029607	.0544846	3.73	0.000	.0961617	.3097597
hohage	.01022	.0014302	7.15	0.000	.0074166	.0130234
hohedu	.0728743	.0070151	10.39	0.000	.0591235	.086625
hohindig	-.2126327	.0625184	-3.40	0.001	-.3351794	-.0900859
noedu_m	.0031361	.0367802	0.09	0.932	-.0689594	.0752316
lprimary_m	.114797	.0248538	4.62	0.000	.0660794	.1635146
primary_m	.2007368	.0244568	8.21	0.000	.1527972	.2486763
secondary_m	.4051641	.0312988	12.95	0.000	.3438131	.4665151
msec_m	.6404119	.0549464	11.66	0.000	.5327076	.7481162
noedu_f	.1073251	.0298646	3.59	0.000	.0487854	.1658648
lprimary_f	.274125	.0263139	10.42	0.000	.2225453	.3257047
primary_f	.4041092	.0265331	15.23	0.000	.3520998	.4561186
secondary_f	.5143274	.0343624	14.97	0.000	.4469713	.5816835
msec_f	.9275207	.0637595	14.55	0.000	.8025413	1.0525
child16	.0083645	.0071116	1.18	0.240	-.0055755	.0223045
m55p	-.0764831	.0411816	-1.86	0.063	-.157206	.0042399
f55p	.2190012	.0326534	6.71	0.000	.1549949	.2830074
transfer	.000108	.0000243	4.44	0.000	.0000603	.0001556
_cons	-1.428215	.0997004	-14.33	0.000	-1.623644	-1.232785
sigma_u	1.1959506					
sigma_e	1.3530587					
rho	.43859828	(fraction of variance due to u_i)				

```
F test that all u_i=0:     F(488, 11526) =    12.91          Prob > F = 0.0000
```

Appendix E: Log linear specification

Regression with robust standard errors

Number of obs =	12034
F(43, 11990) =	139.13
Prob > F =	0.0000
R-squared =	0.3300
Root MSE =	1.558

welfare	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnland	.2643416	.0168204	15.72	0.000	.2313708	.2973124
hohmale	.2795143	.0629829	4.44	0.000	.1560577	.402971
hohage	.0135303	.0016037	8.44	0.000	.0103868	.0166738
hohedu	.0891497	.0081613	10.92	0.000	.0731522	.1051472
hohindig	-.7177157	.0384394	-18.67	0.000	-.7930632	-.6423682
n_outstate	.0161118	.0048928	3.29	0.001	.0065212	.0257024
n_country	.0568002	.0075449	7.53	0.000	.0420109	.0715895
ag_coop	-.0293716	.0759464	-0.39	0.699	-.1782388	.1194956
credit_coop	-.4299746	.1743237	-2.47	0.014	-.7716773	-.0882719
church	.0106976	.0320157	0.33	0.738	-.0520584	.0734535
est	.2318223	.0441428	5.25	0.000	.1452954	.3183493
fed	.2422355	.0386035	6.27	0.000	.1665663	.3179047
health	.2146993	.0485491	4.42	0.000	.1195352	.3098633
diconsa	-.0492493	.0340345	-1.45	0.148	-.1159625	.0174639
min_dist	-.004317	.0005916	-7.30	0.000	-.0054767	-.0031573
dist_cap	-.0016174	.0004076	-3.97	0.000	-.0024163	-.0008185
wm_jor	.0184417	.0014889	12.39	0.000	.0155232	.0213601
wm_obr	-.0013798	.0014169	-0.97	0.330	-.0041573	.0013976
wm_emp	.0053482	.0020486	2.61	0.009	.0013325	.0093639
ww_jor	.0041728	.0010202	4.09	0.000	.0021732	.0061725
ww_obr	.0075212	.0028401	2.65	0.008	.0019541	.0130882
ww_emp	-.0004179	.0026306	-0.16	0.874	-.0055743	.0047384
state2	-.2151774	.0626281	-3.44	0.001	-.3379385	-.0924162
state3	-1.639926	.0849079	-19.31	0.000	-1.806359	-1.473493
state4	-.4566485	.0677968	-6.74	0.000	-.5895413	-.3237558
state5	-1.238269	.1115501	-11.10	0.000	-1.456925	-1.019612
state6	-.5925511	.0725991	-8.16	0.000	-.7348571	-.4502451
state7	-.6433101	.0716825	-8.97	0.000	-.7838193	-.5028008
pop	.0003203	.0000637	5.03	0.000	.0001956	.0004451
noedu_m	-.0548639	.0387558	-1.42	0.157	-.1308316	.0211037
lprimary_m	.0510007	.0271891	1.88	0.061	-.0022942	.1042957
primary_m	.2152189	.0285273	7.54	0.000	.1593007	.2711371
secondary_m	.4475293	.0374614	11.95	0.000	.3740989	.5209597
msec_m	.6552171	.0708858	9.24	0.000	.5162695	.7941647
noedu_f	.0162013	.0320307	0.51	0.613	-.046584	.0789866
lprimary_f	.2925996	.0299117	9.78	0.000	.2339678	.3512315
primary_f	.5317261	.0303584	17.51	0.000	.4722187	.5912334
secondary_f	.6431403	.0414814	15.50	0.000	.5618301	.7244505
msec_f	1.031823	.0920198	11.21	0.000	.8514497	1.212197
child16	-.0111343	.0078394	-1.42	0.156	-.0265007	.0042322
m55p	-.1283126	.0492658	-2.60	0.009	-.2248816	-.0317437
f55p	.2257019	.0382197	5.91	0.000	.1507852	.3006187
transfer	.0001378	.0000319	4.32	0.000	.0000752	.0002003
_cons	-1.223682	.1369491	-8.94	0.000	-1.492124	-.9552394