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THE CONSUMPTION BENEFITS OF INVESTMENT IN URBAN INFRASTRUCTURE: THE EVALUATION OF SITES AND SERVICES PROGRAMS IN UNDERDEVELOPED COUNTRIES

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THE CONSUMPTION BENEFITS OF INVESTMENT IN URBAN INFRASTRUCTURE: THE EVALUATION OF SITES AND SERVICES PROGRAMS IN UNDERDEVELOPED COUNTRIES*

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Abstract

The justifications for housing subsidy programs in developing countries often rely upon substantial indirect benefits accruing to program participants (in the form of health, earning capacity or employment, or non-market activity). The empirical analysis in this paper suggests that such programs may often be justified soley on the basis of direct impacts.

The paper presents a methodology for deriving rigoriously the direct Hicksian benefits of housing subsidy programs such as "sites and services" and "slum upgrading" projects in developing countries. The methodology is used to evaluate the net benefits of a sites and services project typical of recent "urban shelter" programs sponsored by the World Bank. The results suggest that the direct benefits of such programs may be substantial. In the particular case analyzed the rate of return approaches forty percent.

I. Introduction

It has long been recognized that conventional subsidized housing projects in developing countries have fallen far short of achieving national goals or those of international donor agencies.1/ For example, the overdesign and expense of conventional projects has meant that few programs are able to provide for the needs of lower income groups in any meaningful way.2/

In this context, "slum upgrading" and "sites and services" projects may provide attractive alternatives to conventional housing programs. Such projects are inexpensive per household served or per dwelling unit produced. Sites-and-services projects involve the provision of serviced land, including roads, water supply, sanitation, drainage, electricity, construction loans for housing, and social services. Slum-upgrading projects have extended water supply, sanitation, raodways, footpaths, drainage, and electricity into dense urban settlements.3/ In many countries, the dwellings provided or upgraded under these programs would not have passed the minimum standards for new housing units legislated nationally (but seldom enforced). In contrast to the legislated minimum standard, however, "slum-upgraded" or "sites-and-services" dwellings are designed to be affordable by the poor.4/ When

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1/ See, for example, Nevitt (1967), The World Bank (1972).

2/ For example, Grimes' study (1976) of housing in underdeveloped countries concluded that, even with subsidized construction, sixty percent of the population of developing countries were simply too poor to afford the cheapest unit of public ally assisted housing.

3/ The nature of these projects is reviewed in some detail in The World Bank (1982).

4/ In contrast, in many cities, it is estimated that less than half the households can afford the cheapest existing dwellings meeting minimum code standards. For example, at a 15% interest rate, it is estimated that only the richest third of Mexico City households can afford the cheapest "standard dwelling"; in Nairobi, only the richest quartile of the income distribution can afford the cheapest legal unit. Almost 80% of the households in Madras are too poor to afford the legislated minimum standard dwelling. See The World Bank (1975).

sponsored by international agencies, moreover, such projects can be designed to be replicable by recipient governments; that is, programs may be structured so that local authorities can extend the project and recover all, or most, of the costs by levying user fees affordable by program participants.

The past decade has seen increasing emphasis upon slum upgrading and sites-and-services programs, especially by international agencies. For example, the World Bank[5/] has approved more than $2 billion in lending for "urban shelter" programs -- 62 sites-and-services and slum upgrading projects in twenty developing countries.

If shelter is provided under these programs at less than market value, then it is routine to conclude that the programs involve some deadweight loss. This need not, however, imply that these programs providing substantial in-kind benefits are less efficient than a redistribution of the investment in cash. Consider, for example, a slum upgrading project in a dense urban area. Simply by internalizing the externalities associated with divided ownership of contiguous parcels of land, a program to upgrade housing could increase efficiency in the housing market so that the consumption value of the housing provided to recipients exceeded the investment cost of the program. This is, of course, the classic rationale for urban "renewal." (See Davis, 1960). In underdeveloped countries, where markets may work less efficiently, such programs may generate substantial efficiency gains which can be used to redistribute in-kind resources in desired ways. These programs may provide a particularly attractive rationale

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5/ The World Bank includes the International Bank for Reconstruction and Development, the International Development Association, and the International Finance Corporation.

for intervention in the labor and housing markets, where, it is alledged, the competitive market operates less efficiently than in the developed world.[6/]

By emphasizing "progressive development", sites and services projects can be designed to overcome such impediments in the local capital and labor markets. Under this concept (Keare and Parris, 1982), initial infrastructure -- water, sewage, streets, etc. -- is provided by a contractor. Unfinished structures are built by a process of self-help, or mutual help, in which households may work independently or in supervised groups. Each participating household then finishes its individual dwelling at its own pace, as time and resources permit. This self-help aspect reduces the financial cost of the program, making the program affordable to households further down in the income distribution. Moreover, depending upon local labor market conditions, participating households may be able to "purchase" their own labor at less than the market price.

Note, however, that the presumption of efficient markets may work to the disadvantage of slum upgrading or sites and services programs. The presumption implies that the value of in-kind benefits is less than program costs, suggesting that if such investment is to be justified as socially "profitable", there must be substantial indirect benefits accruing to the participants. Thus, to rationalize such programs on benefit-cost grounds, it becomes necessary to assert that better housing has important effects on the health of residents, on the earning capacities of participants, or on their non-market

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6/ Obviously, it would be possible to intervene to improve the efficiency of markets and to use the gains generated to provide cash, rather than in-kind, transfers to deserving individuals. This may be infeasible, especially in developing countries where a large fraction of the population would be eligible on "needs" criteria for any conceivable program of cash redistribution. The horizontal inequities and deadweight losses implicit in in-kind transfers to a small group of recipients may be the only feasible method of allocating the efficiency gains from better functioning markets.

behavior. Such assertions are virtually impossible to verify.[7/] In contrast, the quantitative analysis presented in this paper suggests that urban shelter programs may generate substantial net private benefits even in the absence of any indirect benefits.

This paper derives rigorous measures of the benefits of investments in urban housing projects when viewed from the perspective of program participants. It then applies this methodology to estimate the direct benefits of a representative World Bank-sponsored project providing sites and services benefits to poor urban households. The empirical results (based upon the rich body of longitudinal data gathered in program monitoring) illustrate concretely the substantial and direct economic effects of one fairly inexpensive urban investment. Section II describes salient project characteristics typical of applications of the sites and services concept. Section III presents an overview of the methodology and derives (Hicksian) measures of willingness to pay for program benefits by poor households, and Section IV presents the empirical results. Section V combines the theoretical and empirical aspects of program evaluation.

7/ Indeed, despite dozens of papers on the topic, there seems to be no convincing evidence that better housing per se is causaly related to physical or mental health, employment of life "satisfaction" in any respect. See Burns and Grebler (1976) and Renaud (1980) for a discussion of these issues. Compare with Strassman's (1976) discussion of the labor intensity of residential construction.

II. THE SITES AND SERVICES PROJECT IN SANTA ANA

The empirical analysis reported in this paper is based upon the World Bank-sponsored 'Sites and Services' project in Santa Ana, the second largest city in El Salvador (population 130,000). During the decade of the sixties, it was estimated that more than 10,000 new urban households were formed annually in El Salvador.[8/] During the same period, public and private housing programs produced an average of about 2,600 new units per year. It was estimated in 1972 that 147,000 units, or 55 percent of the nation's urban housing stock, needed improvement or replacement. New housing was not only numerically insufficient, but it was largely directed to families in the upper forty percent of the income distribution. Virtually no formal housing was provided for the poorer segments of the urban population; most of those in the lower half of the income distribution resided in dwellings provided through the informal or illegal market.

The informal housing market is largely outside the bounds of government regulation; in general, dwellings in the informal market are provided little or no public services, and tenure arrangements are insecure. The three main types of informal housing in urban areas are:

(i) squatter settlements (tugurios), shantytowns built in areas not usable for other construction, including ravines, steep hillsides, and railroad rights of way. The level of public services provided is generally very low in these communities, but their location is often near employment centers;

8/ Some of the material in this section is discussed in more detail in Bamberger, et al., "Evaluation of Sites and Services Projects: The Evidence from El Salvador", World Bank Staff Working Paper No. 549, 1982.

(ii) tenements (mesones), generally consisting of 5-50 rooms clustered around a central patio. In most cases, a family rents a single room and shares water and sanitary services. These tenements are usually locted in the industrial center of the city. In most mesones, residents have access to water and electricity, often for only a few hours a day; and

(iii) extralegal subdivisions (colonias ilegales), land subdivided for sale as housing without the installation of basic services. These extralegal subdivisions are often rented under contract-purchase agreements. Lot size and construction materials vary widely within the colonias ilegales. Most of the homes were built by their present residents, and most extralegal units lack any public utilities. They are typically located in the periphery of the city.

Against this background of inadequate housing conditions faced by the urban poor, the first El Salvador Sites and Services project was initiated in 1974 through a $15.5 million investment financed in part through a World Bank loan. The project itself was implemented through the Fundacion Salvadorena de Desarrollo y Vivienda Minima (FSDVM), a non-profit agency. The project included the provision of some 7,000 lots serviced with water, sewerage, streets and electricity, the provision of some 7,000 core units (basic dwellings with sanitary facilities), and the provision of financing for the self-help of program participants in extending their core units.

To encourage development of regional centers, project sites were distributed between the capital and secondary cities in roughly a 4:3 ratio -- about 4,100 lots were developed in five different sites in metropolitan San Salvador; the remaining 2,900 lots were distributed among the four largest secondary cities (950 in Santa Ana, 1,000 in San Miguel, 550 in Sonsonate, and 400 in Usulutan).

Program participants in the Santa Ana site were selected from applicants to the FSDVM in July 1976. At the same time that participants were selected, the monitoring and evaluation aspect of the program collected detailed information about the socio-economic composition and the initial housing consumption for a sample of these participants and also for a control group of eligible households not selected as program participants.

Participating households were required to supply 52.5 days (420 hours) of labor by the household head during the period 1976-77. This time was spent in mutual help on consecutive weekends under the direction of the FSDVM. The construction of shell structures served by water and sanitary facilities, of roadways and infrastructure was accomplished largely (but not exclusively) through mutual help, using materials purchased with loan proceeds. The mutual help phase was completed by July 1978, after which participating households were free to move into their new dwellings.

Program participants were required to assume a 20-year level-payment mortgage at the time they moved into their dwellings. The monthly payments were sufficient to amortize public investment in the project at a six percent interest rate. Participating households were also eligible to apply for market rate loans from FSVDM to purchase materials or to hire labor to extend or to finish their dwellings.

In 1979, shortly after households had moved into their new dwellings, detailed socio-economic and dwelling unit information was obtained from the same sample of participants and from the control group (consisting of the residents of the dwellings occupied by non-participants sampled in 1976). Finally, in late 1980, data on the same households and dwellings were assembled again.

By any comparative standard, the housing conditions of program participants improved substantially after they moved into their completed units. For example, participating households moved from dwellings containing an average 1.27 rooms and 41 square meters of space to dwellings containing 2.10 rooms and 50 square meters. Access to running water, electricity and sanitary services was similarly improved for those households selected for participation..

III. Evaluation Methods

The housing services consumed by households in an urban area consist of a complex bundle of diverse attributes, but the prices of individual attributes of dwellings are not directly observed. Only market rents, in the units of price-times-quantity, are observed. Individual attributes are jointly priced in a potentially complex way.

Nevertheless, the total expenditure on housing services by any household can be readily associated with the particular dwelling unit emitting services and with the particular household paying for them. Observations on available dwelling units, their characteristics, and the expenditures they command, permit households to evaluate the attributes of the housing bundle which may be consumed at different levels of expenditure. Consumers choose a particular bundle of services and a rental payment so that the marginal rate of substitution between any two housing attributes equals the ratio of their implicit marginal prices. Regardless of the conditions affecting housing supplies, if demanders are competitive all consumers with the same endowments will be equally well-off in equilibrium. Thus, if we observe identical households spending different amounts on housing, they must be compensated in terms of housing services consumed.

At any moment, observations in the market provide information on the vector of attributes h, which describe the services provided by each dwelling, and the level of expenditures R, which each dwelling commands. From observations on the dwellings and their associated housing attributes in a single competitive market,

(1) $R = p(h)$

describes the relationship between the characteristics of housing services and market rents. This "hedonic" price function, presumably non-linear, indicates the total cost of each collection of attributes, and by differentiation the marginal price for any attribute, $\partial P(h)/\partial h$, is inferred.

If housing attributes were not jointly purchased in bundles, or if bundles could be re-packaged costlessly, arbitrage by middlemen would ensure that the hedonic function was linear in housing characteristics (Rosen, 1974). Since arbitrage is generally impossible and since housing attributes are only available in bundles, there are few restrictions which can be imposed on the non-linear form of the hedonic relationship, at least not without making further assumptions. The "correct" form of hedonic relationship is largely an empirical issue.

The relationship between this non-linear market price function and consumer preferences may, however, be illustrated easily. Without loss of generality, assume that there are two housing attributes, h_1 and h_2, which are jointly priced, $p[(h_1, h_2)]$. Consumers have well defined preferences over housing attributes and other goods x, at a price of 1. According to this notation, if we observe a household of income y^o consuming housing attributes h_1^o and h_2^o, then the maximum amount B, that can be bid for other amounts of housing h_1 and h_2 leaving the household equally well off is:

$$(2) \quad U(y^o - P[h_1^o, h_2^o], h_1^o, h_2^o) = U(y^o - B, h_1, h_2)$$

Equation 2 defines the implicit relationship between the bid-rent B, expressed in terms of the numeraire, and housing attributes h_1 and h_2 yielding the same well being. With standard utility functions, $U_h > 0$, $U_{hh} < 0$, the bid for any housing attribute is increasing at a decreasing rate, $B_h > 0$, $B_{hh} < 0$. Of course, in equilibrium the bid for a marginal unit of h in terms of the numeraire x is the marginal rate of substitution of h for x. Thus,

$$(3) \quad \begin{aligned} \frac{\partial B}{\partial h_1} &= \frac{\partial U/\partial h_1}{\partial U/\partial x} = \frac{\partial P}{\partial h_1} \\ \frac{\partial B}{\partial h_2} &= \frac{\partial U/\partial h_2}{\partial U/\partial x} = \frac{\partial P}{\partial h_2} \end{aligned}$$

Equation (3) is the compensated demand curve for h_1 and h_2 -- that is, it represents the demand price in dollars for additional units of h_1 or h_2 at a constant level of utility (Rosen, 1974).

This analysis indicates that the compensated demand curves of consumers can be identified and estimated empirically by the following procedure.

Estimate (1) from observations on the vector of housing attributes h associated with a sample of dwellings and their market rents. Presumably (1) is estimated according to some "best fit" statistical criterion.

Then impose some theoretically plausible functional form on consumers' utility functions and estimate the set of equations represented by (3). (See also, Brown and Rosen, 1982.)

For a concrete example of this approach, assume that there are n components of the vector of housing attributes and that consumers' utility functions are GCES (see Murray, 1975), i.e.,

$$(4) \qquad U(h_1, h_2, \ldots, h_n, x) = \left(\sum_{i=1}^{n} a_i h_i^{\beta_i} + x^{\varepsilon}\right)^{\phi}$$

where the α's, β's and ε are parameters, and ϕ is arbitrary. Substitution into (3) yields the system of equations:

$$(5) \qquad \begin{aligned} \log \partial P/\partial h_1 &= \log \frac{\alpha_1 \beta_2}{\varepsilon} + (\beta_1 - 1) \log h_1 - (\varepsilon - 1) \log x \\ &\vdots \\ \log \partial P/\partial h_n &= \log \frac{\alpha_1 \beta_1}{\varepsilon} + (\beta_n - 1) \log h_n - (\varepsilon - 1) \log x \end{aligned}$$

Statistical estimation of these n equations, subject to one cross-equation constraint, yields 2n + 1 parameters which can be solved for the α's, β's and the value of ε. These parameters, in turn define the curvature of preference functions and permit Hicksian welfare comparisons to be made.

Consider a household of income y initially observed consuming housing attributes $h_1^o, \ldots, h_n^o$ at price p^o, which accepts a housing program, and receives $\tilde{h}_1, \ldots, \tilde{h}_n$ at price $\tilde{p}$. The equivalent variation of the program, the amount of income Δ which could be given to the household instead of the program, is clearly:

$$(6a) \qquad \Delta = [\sum_{i=1}^{n} \alpha_i (\tilde{h}_i^{\beta_i} - h_i^{o\,\beta_i}) + (y - \tilde{P})^{\varepsilon}]^{1/\varepsilon} + (y - p^o)$$

and the compensating variation, the amount of income δ which could be taxed to leave the household as well off as it had been initially, is

$$(6b) \qquad \delta = -[\sum_{i=1}^{n} \alpha_i (h_i^{o\,\beta_i} - \tilde{h}_i^{\beta_i}) + (y - p^o)^{\varepsilon}]^{1/\varepsilon} + (y - \tilde{p})$$

These measures are alternative representations of the household's willingness to pay for the housing program and its benefits to them.

IV. Empirical Analysis

Three steps are required to apply this methodology to evaluate the Santa Ana sites and services program on a willingness to pay criterion. First, the marketwide hedonic price function (equation 1) is estimated by suitable means. Second, given this price function, the compensated demand curves of housing attributes (equation 3) are estimated. Third, to compute the value of program benefits, the private costs imposed on program participants must be estimated. In addition to mortgage repayment and loan amortization, these costs include the value of time expended by the household head in mutual help construction and by all household members in extending and finishing individual dwellings.

In this section, we use the samples of program participants and the control group to conduct these three empirical analyses.

A. The Market Price Function for Housing Services

Table 1 presents summary information on a cross-section of 291 dwelling units in the private Santa Ana housing market in 1980. Included are a number of measures of the quantitative and qualitative attributes of the dwellings. Five related measures of the size of dwellings are reported: the number of rooms; the amount of floor space and the area per room for each dwelling; the parcel area and the yard space associated with each rental dwelling. The table also indicates that about two-thirds of these units are served by electricity. About a third of the sampled dwellings are in _mesones_ (multi-family tenements) and another third are in _tugurios_ (low quality private rental accomodations). The remaining dwelling units are located in _colonias ilegales_ (squatter settlements).

Table 1

Means and Standard Deviation of Housing Variables

291 Observations on Private
Housing Market

Variable	Mean	Standard Deviation	Minimum	Maximum
Rooms	1.718	1.117	1.00	7.00
Lot size (meters ^{2})	146.470	174.45	11.00	1200.00
Area per room	28.506	11.399	7.500	75.000
Yard space (meters ^{2})	99.230	162.360	0	1146.00
Floor space (meters ^{2})	48.361	39.022	9.00	304.00
Electricity (1=yes)	0.660	-	0	1.00
Water Service	1.605	1.228	0	3.00
Sanitary Service	5.681	2.730	0	10.00
Aggregate Quality Index	6.811	2.341	3.00	9.00
Tugurio	0.337	-	0	1.00
Meson	0.343	-	0	1.00
Rent (colones per month) a/	52.684	58.786	10.00	300.00

a/ Monthly rental payments for renter households; estimates of monthly rent for owner occupants. (US$1 = 4 colones in 1980). See Jimenez (1982) for a recent comparison of these measures.

The table also reports three indices of the quality of selected aspects of the individual dwellings; water, sanitary services, and a structural quality index. Each of these indices was created from raw data describing the detailed characteristics of dwelling units.[9/] The functional form appropriate to the hedonic relationship is inferred using the method suggested by Box and Cox (1964).

Define the following family of transformations of the dependent variable rent, R:

$$(7)\quad \begin{aligned} R^{(\lambda)} &= (R^{\lambda} - 1)/\lambda \qquad && \text{for } \lambda \neq o \\ R^{(\lambda)} &= \log R && \text{for } \lambda = o \end{aligned}$$

9/ For example, the basic information describing water service consists of five binary and four continuous variables. The binary variables describe the basic types of service: private piped water; public piped water; water purchased from vendors; water carried from stream or wells; well water. Three continuous variables measure the number of hours per day water is available for the first three types. A variable also measures the distance water must be carried. Analogously, the information underlying the index of sanitary services consists of four binary variables and two continuous measures. Three indexes measuring the quality of roofs, floors, and walls are based upon binary variables describing the materials and construction. The structural quality index is the simple sum of these three indices. Although the computation of these indices is somewhat complex, they are not arbitrary aggregations of the underlying data. Specifically, for a given functional form for the hedonic relations, the restrictions imposed by the index definition were tested by comparing regression results using these indices and using the raw descriptive data. The appropriate F tests indicated in each case that the hypothesis that water service (or sanitary service, or the other aspects of quality) is measured appropriately by a single index cannot be rejected.

This family of transformations is well defined for all $R > 0$; moreover because it is generated by λ, standard parametric methods of inference are appropriate. If it is assumed that for the regression equation,

$$(8) \quad R^{(\lambda)} = b_o + \Sigma\, b_i\, h_i + u$$

the u´s are normally distributed (or truncated normal: see Olsen) with zero mean and variance σ, we may estimate b, λ and σ by standard maximum likelihood techniques. Since the dependent variable, rent, is truncated at zero, some departure from normality in u is indicated.

Table 2 reports the coefficients of the hedonic price regression, estimated by the Olsen technique, at the maximum likelihood estimates of λ. The model includes dummy variables for electricity and <u>mesones</u>, and quality indices for water and sanitary services as well as overall structural quality. The model also includes the number of rooms, the total floor space and the yard area associated with each unit.

The three size variables are highly significant as are two of the three quality measures. The variable measuring structural quality is significantly different from zero at about the .06 level. The dummy variable for dwelling units served by electricity is highly significant as is the dummy variable for <u>mesones</u>.

Table 2

Hedonic Regressions Computed from Box-Cox Transformation of Dependent Variable: $(rent - 1)^{\lambda}/\lambda$ and the Marginal Prices of Housing Attributes

Variable	Coefficient	Mean Marginal Price a/
Number of rooms	0.126 (5.36) b/	12.986 (16.96) c/
Yard area (meters^2 x 1000)	0.233 (2.04)	0.213 (0.28)
Floor space (meters^2 x 1000)	0.207 (3.26)	0.024 (0.03)
Electricity (1 = yes)	0.206 (3.01)	21.300 d/ (27.82)
Meson (1 = yes)	-0.187 (3.27)	-19.319 d/ (25.24)
Water Service	0.081 (3.15)	8.324 (10.87)
Aggregate Quality	0.032 (1.92)	3.326 (4.34)
Sanitary Service	0.020 (2.51)	2.020 (2.64)
Intercept	1.839 (14.02)	
R^2	0.726	
SEE/Mean	0.100	
R^2 in original space	0.485	
λ	-0.150	

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a/ Average marginal price, computed at the mean of the other housing attributes.

b/ T-ratios in parentheses.

c/ Standard deviation in parentheses.

d/ Average additional cost of attribute at the mean of the other attributes.

The model explains 73 percent of the variance of the (transformed) dependent variable, or about half the variance in the monthly rents of dwelling units in Santa Ana. In sum, the model performs well. The maximum likelihood value of λ is significantly different from zero $(\chi^2 = 8.2)$ and from one $(\chi^2 = 31.9)$.

Estimates of the coefficients and the functional form of the hedonic relation permit the marginal prices of each housing attribute to be computed for each dwelling unit in the sample. Table 2 also summarizes these implicit prices; column two presents the mean value as well as the standard deviation of the marginal price of each housing attribute in the sample of private dwellings. According to the model, the average price of an additional room is 13 colones per month; an additional 10 meters of floor space costs about 2 colones. An additional unit of water service costs about 8.5 colones per month; additional sanitary service about 2 colones; and additional structural quality about 3 colones. Finally, it should be noted that there is considerable variation in the marginal prices of the housing attributes across dwellings in the sample, indicating that the households occupying these units have chosen very different marginal prices.

B. The Parameters of Utility Functions

We now exploit the non-linearity of the hedonic price function to infer the utility functions of consumers. We assume that households have preferences over space per person, over structural and quality attributes, and other goods. We further assume that the form of the utility function is GCES in its arguments, i.e.,

$$(9) \quad U = \left[\sum_{i=1}^{3} \alpha_i (h_i/\text{person})^{\beta_i} + \sum_{i=4}^{6} \alpha_i h_i^{\beta_i} + \sum_{i=7}^{8} \alpha_i h_i + x^{\varepsilon}\right]^{\phi}$$

where,

h_1 = number of rooms

h_2 = yard area

h_3 = total floor area

h_4 = water service

h_5 = aggregate quality

h_6 = sanitary service

h_7 = electricity

h_8 = meson

x = other goods

The assumed GCES form of the utility function is quite general and includes most of the more common forms as special cases. For example, if $\beta_i = \beta_j = \varepsilon = 1/\phi$, then the function is CES; as β_i, β_j, ε approach zero, the function approaches Cobb-Douglas.

Maximizing (9) subject to the budget constraint yields six equalities of the form of equation (5) as well as two inequalities.

The system of six equations, including 13 unknown parameters, is estimated jointly, subject to one common cross-equation constraint. In the constrained regression, the dependent variables are the logarithms of the relevant marginal prices.

Table 3 presents the results of this estimation. The table presents regression results for the GCES as well as the more familiar CES utility function. The F-ratio indicates that the CES function can be rejected in favor of the GCES function by a wide margin. The equations as a whole explain about 85 percent of the variance in marginal prices. The implied estimates of the exponents appear plausible:

$$(11)\quad U = [0.632\ (\text{rooms/person})^{1.708} + 0.0004\ (\text{yard area/person})^{1.247} + 0.001\ (\text{floor area/person})^{1.717} + 0.084\ (\text{water service})^{1.878} + 0.011\ (\text{quality})^{1.833} + 0.005\ (\text{sanitary service})^{2.333} + (\text{other goods})^{0.627} + z]^{\phi}$$

Table 3

Estimates of Utility Function Parameters a/

Coefficient	GCES	CES
$\log \frac{\alpha_1 \beta_1}{\varepsilon}$	0.344 (2.72)	2.757 (16.02)
$\log \frac{\alpha_2 \beta_2}{\varepsilon}$	-7.035 (35.41)	-3.901 (37.19)
$\log \frac{\alpha_3 \beta_3}{\varepsilon}$	-5.903 (24.41)	-1.725 (16.64)
$\log \frac{\alpha_4 \beta_4}{\varepsilon}$	-1.38 (7.25)	2.108 (16.02)
$\log \frac{\alpha_5 \beta_5}{\varepsilon}$	-3.451 (11.36)	0.691 (6.04)
$\log \frac{\alpha_6 \beta_6}{\varepsilon}$	-4.040 (14.14)	1.063 (9.61)
$(\beta_1 - 1)$	0.708 (9.62)	
$(\beta_2 - 1)$	0.247 (7.80)	
$(\beta_3 - 1)$	0.717 (10.66)	
$(\beta_4 - 1)$	0.878 (9.72)	
$(\beta_5 - 1)$	0.833 (5.84)	
$(\beta_6 - 1)$	1.333 (10.19)	
$(\beta - 1)$		0.114 (4.87)
$-(\varepsilon - 1)$	0.373 (12.09)	
F-ratio b/	116.11	
R^2	0.881	0.831

a/ t-ratios in parentheses
b/ Test of the hypothesis that $\beta_i = \beta_j = \varepsilon$.

Note: Data consist of 236 observations on each of 6 first order conditions.

The estimated utility functions include all those parameters associated with the marginal equivalences implied by household utility maximization. They do not, however, include the two discrete elements of the housing bundle, electricity and structure type. These parameters are estimated using the methodology described in Quigley (1982). Those results indicate that:

(12) $Z = -3.464\ (\text{meson}) + 3.523\ (\text{electricity})$

C. Housing Costs of Participants in the Sites and Services Program

As noted previously, program participation required that heads of households spend 52.5 days of labor in constructing shell houses in common. Subsequently, many households obtained loans from program authorities to finish their dwellings or to add amenities to the structures. They purchased materials (and sometimes hired labor) and devoted their own labor to improving their dwellings. Finally, participating households were required to amortize public investment by repaying a 20-year mortgage at a six percent rate of interest.

In contrast, the expenditures on housing previously made by program participants are readily observable. All participants had been renters in the private economy, paying monthly fees for housing services.

The monthly equivalent $\tilde{P}$ of the costs borne by program recipients is:

(13) $\tilde{P} = A\ \delta_A + B\ \delta_I + [(420 + T_h)\ w_h + T_s w_s + T_o w_o]\ \delta_I$

where,

A = the monthly payment made to amortize the 20-year mortgage

B = purchased materials and hired labor

$T_{h,s,o}$ = hours of labor in construction and finishing supplied by the head (h), spouse (s), and other household members (o), respectively

$w_{h,s,o}$ = hourly value of labor supplied respectively by head, spouse, and other household members

$\delta_{A,I}$ = discount factors required to convert twenty-year contractual payments (A) or initial payments (I) to comparable rental payments.

Out-of-pocket expenditures A,B, and time commitments $T_{h,s,o}$ are observed from the sample survey, and the appropriate discount factors $\delta_{A,I}$ can be computed easily. The value of labor supplied by household members cannot be stipulated, however, unless additional assumptions are made. If labor markets were fully competitive and if we observed all workers selling some labor services, then the observed marginal wage rate would measure appropriately the income foregone or the value of leisure foregone by households in constructing their dwellings.

In a labor market with significant unemployment and underemployment, however, it is not at all clear that the marginal wage reflects the valuation of time spent in non-market activity.

For empirical purposes, we follow three approaches to valuing labor inputs and hence to calculating the monthly equivalent prices charged for participation in the sites and services program, two according rules and one more sophisticated economic calculation:

(i) valuing labor by the estimates used in planning the program itself.

By using this method, all the elements in equation (13) are available as data, and the costs of participation can be computed straightforwardly. The biases introduced by adopting the planning values are unknown.

(ii) valuing labor by the amount of earned income foregone by household members.

Survey responses indicate the amount of money income actually foregone by each member of the household during the construction and finishing of the dwellings. If the labor market were competitive, then the foregone income would be equal in value to the foregone leisure for those in the labor force. For those not in the labor force, the (zero) foregone income would certainly understate the value of leisure exchanged for house construction activities. By using this method, all the elements in equation (13) are also available as data.

(iii) valuing labor by the standardized earning capacity of household members.

According to standard labor supply theory, the observed wage of an individual may be viewed as a rental payment to his stock of human capital, and the rental value of the stock should be the same in market and non-market activities. For individuals who are not employed or who are not in the labor force, we do not observe the rental value of the stock. We conclude only that the unobserved reservation wage of the individual is greater than the unobserved wage offer made to the individual. However, consistent estimates of the human capital parameters (and hence time valuation) of workers can be obtained by exploiting observations on the labor force participation decisions of workers. For example, assuming joint normality of the disturbance terms (u,v), Heckman (1976) has shown that the human capital rental equation can be estimated consistently in a two-step process:

$$(14) \quad \rho = f(X_1) + u$$

$$(15) \quad w = g(X_2) + \beta \frac{1}{M(\rho)} + v$$

where,

ρ is the probability of labor force participation;

w is the observed wage for employed workers;

$M(\rho)$ is the Mills ratio or hazard rate associated with the probability that an individual is observed in the labor force (i.e., $1/M(\rho) = f(\rho)/[1 - F(\rho)]$ where f is the s.d.f. and F is the c.d.f.);

β is an estimated coefficient ($\beta > o$);

and X_1 and X_2 are the observable personal characteristics governing labor force participation and wage determination, respectively.

Estimates obtained for equations (14) and (15) provide a method for valuing labor supplied to market or non-market activities for individuals, whether employed or not, assuming a fully competitive labor market.

We implement this strategy separately for household heads and for spouses in the following way. We estimate (14) the probability of labor force participation using a probit specification. Using the predicted value of ρ, we compute the Mills ratio for each employed individual, and we enter its inverse in the regression estimate (15), the wage equation for those in the labor force.

Table 4 presents probit estimates of the labor force participation equation, estimated separately for household heads and spouses. For household heads, measures of age and sex are highly significant. The probability of labor force participation is quadratic in age and is higher for males than for females. When other factors are controlled, there is no evidence that those with more education are more likely to be employed, and the labor force participation decision for household heads appears to be unrelated to the demographic composition of the household.

For spouses, age and sex are also important determinants of labor force participation. In contrast to the results for heads, the formal education of the spouse is highly significant. Somewhat surprisingly, at least in comparison with developed countries, where the extended family is less prevalent, there is little evidence that the demographic composition of the household affects spouse labor force participation. It does appear, however, that in households where the head's income is greater, spouses are more likely to specialize in "home production".

Table 5 presents estimates of the wage equations, estimated separately for household heads and spouses. The table also compares the results with and without the inclusion of the Mills ratio among the regressors.

Table 4

Probit Estimates of Labor Force Participation
for Household Heads and Spouses a/

	Household Head	Spouse	
Years of Education	0.018 (0.66)	0.079 (2.71)	0.082 (2.80)
Age	0.061 (2.06)	0.137 (3.93)	0.136 (3.89)
Age squared x 10^3	-8.841 (2.90)	-1.515 (3.84)	-1.502 (3.81)
Sex (1=male)	1.137 (7.43)	1.737 (5.48)	1.738 (5.47)
Number of children	-0.059 (1.03)	0.054 (0.88)	
Number of other adults			0.042 (0.37)
Number of children under 6			0.116 (1.28)
Head's income x 10^3		0.661 (1.75)	0.659 (1.76)
Constant	-0.506 (0.68)	-3.103 (4.04)	-3.302 (3.67)
Log likelihood	-188.52	-192.79	-192.35
Percent correctly predicted	85.12	67.35	67.65
Number of observations	510	340	340

a/ Asymptotic t-ratios in parentheses.

Table 5

Estimates of Hourly Wage Regressions
for Household Heads and Spouses a/

	Household Head			Spouse	
Experience	0.008 (0.90)	0.083 (0.72)	0.005 (0.28)	-0.016 b/ (0.54)	-0.021 (0.73)
Experience squared x 10^3	-0.204 (1.78)	-0.214 (1.13)	-0.165 (0.67)	-0.109 (0.27)	0.176 (0.47)
Years of education	0.040 (3.59)	0.040 (3.57)	0.046 (2.18)	0.024 (0.74)	0.019 (0.62)
Sex (1=male)	0.420 (6.46)	0.436 (1.66)	0.476 (3.88)	0.089 (0.20)	0.001 (0.00)
Inverse of Mills ratio		-0.076 (0.06)		1.088 (0.91)	1.347 (1.18)
Constant	-0.044 (0.25)	0.049 (0.03)	-0.245 (0.68)	-1.034 (1.09)	-1.223 (1.36)
R^2	.216	.216	.152	.156	.159
Number of Observations	418			175	

a/ T-ratios in parentheses
b/ Calculating the Mills ratio using the coefficients in Table 4, Column 2.
c/ Calculating the Mills ratio using the coefficients in Table 4, Column 3.

When the Mills ratio is not included, the results for heads indicate that experience (age minus years of education minus six), education, and sex are important determinants of market wages. For spouses, education and sex are important determinants of market wages. When the Mills ratio is included, with one exception the coefficients are insignificantly different from zero. Importantly, the coefficients on the Mills ratio itself are insignificantly different from zero. This implies that for the household heads and spouses we cannot reject the hypothesis that sample censoring for the wage functions is an empirically unimportant phenomenon, at least for these particular samples of workers.

Table 6 summarizes the out-of-pocket costs and the time costs borne by program participants. Out-of-pocket costs consist of purchases of materials and labor and the present value of the 20-year mortgage obligations. Purchases of materials and labor are directly observed; the present value of mortgage obligations were calculated from observations on monthly payments using a 12 percent rate of interest.[10/] Table 6 also presents the monthly equivalent of these capital costs using 12 percent rate of interest.[11/] These out-of-pocket costs sum to an equivalent monthly payment of about 31 colones.

10/ i.e., $PV = A \left[\frac{i + (1 + r/12)^{12n}}{r/12} \right]$

where PV is the present value, A is the monthly payment, r is 12 percent, and n is 20 years.

11/ $X = PV/(r/12)$, where X is the monthly payment, PV is the present value, and r is 12 percent per annum.

Table 6

Mean Costs of Participation for Sites and Services Beneficiaries
(Standard Deviations in Parentheses)

	Present Value	Monthly Equivalent
(a) Out-of-Pocket Costs		
Amortization of Principal	2549.80	25.50
	(340.66)	(3.41)
Materials Purchased	208.30	2.08
	(120.80)	(1.21)
Hired labor - skilled	332.28	3.32
	(452.97)	(4.53)
unskilled	6.41	0.06
	(42.09)	(0.42)
Total Colones	3096.79	30.97
(b) Time Costs		
Variant I		
time of head	559.80	5.60
	(189.32)	(1.89)
time of spouse	11.52	0.12
	(58.32)	(0.58)
time of other members	42.42	0.42
	(140.98)	(1.41)
Total Colones	613.74	6.14
Variant II		
time of head	63.28	0.63
	(183.06)	(1.83)
time of spouse	5.41	0.05
	(35.43)	(0.35)
time of other members	48.01	0.48
	(292.67)	(2.92)
Total Colones	116.70	1.17
Variant III		
time of head	886.68	8.87
	(608.39)	(6.08)
time of spouse	17.98	0.18
	(97.11)	(0.97)
time of other members	6.14	0.06
	(20.40)	(0.20)
Total Colones	910.80	9.11

Notes: Variant I, the value of time using program planning figures, values time inputs of all household members at 1 colon/hr.

Variant II, the foregone income associated with time inputs, is taken from survey responses for each household member.

Variant III, the value of time at the market wage, is computed using the average hourly wage for each household member in the labor force and the estimated hourly wage, presented in Table 5, for household members who are not in the labor force.

The table also presents estimates of the average values of time inputs used by household members in constructing and extending their dwellings. Variant I, which values time inputs by the planning figures of one colon per hour, indicates that household heads averaged 560 hours of work (including 420 hours of mutual help, or construction activity in common). Spouses supplied only about 12 hours of labor, and other household members supplied 42 hours. These labor inputs sum to over 600 hours of labor, or a monthly cost of 6.14 colones using the valuation of one colon per hour and a 12 percent rate of interest.

Under Variant II, summary data are presented on the income actually foregone by households in constructing and extending their dwellings. These self-reported income losses are about 117 colones; they are about one-sixth as large as the planning estimates. Clearly, these figures underestimate the value of time inputs -- since they value foregone income but do not value the leisure foregone by program participants.

Variant III presents similar valuation information using the implicit rental value of human capital. Assuming that household members are free to vary their working hours in a competitive market, the marginal value of leisure and the marginal value of work are equivalent and âre equal to the average wage rate. Thus, for employed household members, estimates of the value of time inputs are obtained by multiplying hours worked by observed wage rates. For those not in the labor force, the rental value of human capital is estimated using the results presented in Table 5. This procedure yields and average estimate of time expenditures of 887 colones for household heads, 18 colones for spouses, and 6 colones for other members. The monthly estimates of time valuation by this method are 9.11 colones, or about 50 percent higher than the planning estimates.

Taken together, the results suggest that the average monthly equivalent of the costs of housing for program participants is 32.14 colones, 37.11 colones, or 40.08 colones, depending upon the valuation of time inputs.

V. Program Evaluation and Conclusion

The three empirical analysis are now combined to estimate net benefits generated by the sites and services program in the Santa Ana housing market.

Results reported elsewhere (Quigley [1982]) indicate that the operation of the sites and services program was not of a sufficiently large scale to affect the housing prices paid by non-participants in the program. This, in turn, implies that all the program benefits accrue to participants (and that no non-participants, especially landlords, suffer losses due to the program). Thus, the total benefits of the program consist of the equivalent variation or the compensating variation of the sites and services program summed across all participants.

The survey data gathered permits two kinds of comparisons to be made:

(a) A comparison of utilities between households who are program participants and "otherwise identical" households in the private unsubsidized economy.

(b) A comparison of the utility levels of individual program participants with their levels of utility before the program was undertaken.

The first comparison utilizes the 1980 cross section of participant and control households, for which the data are of high quality, especially when compared with the data gathered in 1976 and 1979. This approach does, however, compare levels of utility across different individual households (though of the same income and family size).

The latter approach makes no interpersonal comparisons of utility levels (i.e., each household is compared only with itself), but does compare individual households at different points in time. In addition, unfortunately, the data on housing consumption gathered in 1976 is somewhat less detailed and less reliable than the cross section gathered in 1980. In particular, the error rates appear to be higher and several attributes of the services provided by each dwelling unit are described in less detail.

For the cross-sectional analysis, benefit estimates are computed in a straightforward manner. To estimate the equivalent variation of the program, we compute levels of utility for control households separately for 30 income-family size classifications. For program participants, we then ask: By how much could income be reduced to leave each of these households as well off as the average of identical households (i.e., those with the same income and family size) in the control group? That is, by solving equation (6b) we calculate for each participating household the maximum amount which could be taxed away to leave them as well off as non-participants.

To estimate the compensating variation of the program, we compute levels of utility for participating households separately for each of the same income-family size classifications. For non-participant households, we then ask: By how much would the income of each of these households have to be increased to make it as well off as the average of identical households who are program participants? By solving equation (6a) for non-participants, we calculate the amount of income which could be given to each household in lieu of the sites and services program and which would make them as well off as program participants.

Table 7 summarizes the comparisons between control households in the private economy and program participants. The mean value and the standard deviation of the two measures of program benefits are presented separately for each of three different estimates of the value of household labor supplied in the construction and house finishing phase of the project.

When household labor is valued at the planning figures of 1 colon per hour, the estimated net benefits of the urban project are 11 to 14 colones per household per month. When household labor is valued only by the income actually foregone by workers, program benefits are somewhat higher -- on average between 15-18 colones per month. Finally, under Variant III, benefits are estimated when labor is valued by its opportunity costs assuming a competitive labor market and that workers are free to vary their number of hours worked. Even under this assumption, which values the time inputs of all household members by the rental values of their human capital stocks, estimated benefits are positive, ranging between 7 and 10 colones per month.

For the comparison of changes in the utility levels of program participants, equations (6a) and (6b) are similarly solved for measures of program benefits for each household. Based on the family size and income of each household in 1976, we compute the amount of money which could be given to

Table 7

Average Sites and Services Program Benefits
Per Household in Santa Ana
1980 colones per month
(Standard Deviations in Parentheses)

(a) Cross Sectional Comparison of Program Participants and Control Households in 1980

	Equivalent Variation a/	Compensating Variation b/
Variant I	10.812 (65.75)	14.026 (47.13)
Variant II	15.270 (65.77)	18.346 (47.31)
Variant III	7.901 (65.61)	10.277 (46.77)

(b) Comparisons of Program Participants in 1976 and 1980

	Equivalent Variation c/	Compensating Variation c/
Variant I	16.054 (63.17)	17.151 (46.15)
Variant II	17.206 (54.03)	21.065 (40.27)
Variant III	8.612 (69.82)	11.299 (48.13)

a/ Averages for 144 participating households.
b/ Averages for sample of 249 control households.
c/ Averages for 141 participating households with good data in 1976 and 1980.

each household instead of the program (compensating variation) and the amount by which they could be taxed in 1980 to leave them as well off as they were observed to be in 1976 (equivalent variation). For both these comparisons, we express 1976 housing payments in 1980 prices.[12/]

The bottom part of Table 7 also presents summary information on program benefits by computing the average compensating and equivalent variations of the program for participating households observed in 1976 and 1980. The general pattern of results is similar, but the magnitudes of benefits are uniformly larger. Using planning figures, per household benefits are estimated to be 14-17 colones; using foregone money income, benefits are estimated to be 17-21 colones. Using the strong assumptions of competitive labor markets, the level of benefits is still estimated to be 8-11 colones per month.

These results provide strong evidence that 'progressive development' shelter assistance programs -- or at least the specific 'sites and services' program undertaken in Santa Ana -- generate considerable net benefits as measured by the willingness to pay of project beneficiaries. These estimates, moreover, include only direct housing consumption benefits themselves, and ignore any indirect benefits which may arise from home ownership and land tenure or from improved sanitation or other aspects of the program. The precise estimates depend upon the specific assumptions employed about the valuation of household labor. Net benefits range from about 7 colones per month (making extremely strong assumptions about competitive labor markets) to

12/ A few differences in the quality and detail of data on dwelling attributes gathered in the 1976 and 1980 surveys makes this comparison less credible. In particular, in 1976 the availability of water was identified by a single dummy variable, and the sanitary services of dwellings were represented by a more crude set of measurements.

about 21 colones per month, using assumptions that are consistent with large amounts of underemployment or involuntary unemployment in the economy.

Capitalized at 12 percent, these monthly benefits are roughly 700 to 2,100 colones in net benefits per recipient household; that is, the willingness of poor to pay for the program exceeds program costs by 700-2,100 colones. At this discount rate, between US$277,000 and US$831,000 in benefits is generated by the investment in 950 serviced lots in Santa Ana. If other urban households in Bank-sponsored sites and services programs value benefits in a similar manner, the empirical results suggest that the private rate of return is quite large. In this particular program, it approaches forty percent.

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