EMPLOYMENT IN CONSTRUCTION: MULTI-COUNTRY ESTIMATES OF COSTS AND SUBSTITUTION ELASTICITIES FOR SMALL DWELLINGS

By

W. P. Strassmann

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Foreword

This paper is one of a series of reports produced by Michigan State University's Off-Farm Employment Project. The project, which is funded by the Office of Multi-Sectoral Development, Bureau of Science and Technology, U.S. Agency for International Development, has the basic purpose of enhancing the ability of AID missions and host country institutions to identify and implement programs and policies that generate off-farm employment and income opportunities benefiting the rural poor. One of the major components of the project is the generation of new knowledge relating to off-farm activities. In collaboration with host country institutions and AID missions, detailed field surveys of small-scale enterprises have been conducted in such countries as Egypt, Jamaica, Honduras, and Thailand; the results of these studies will be published in this series. A second component of the project involves the marshalling and dissemination of existing knowledge of off-farm activities. A state-of-knowledge paper has already been produced; in addition, special studies relating to off-farm activities will continue to appear in this series. Previously completed studies in this area currently available through the Off-Farm Employment Project include:

1. Carl Liedholm, "Research on Employment in the Rural Non-Farm Sector in Africa," African Rural Economy Paper No. 5, 1973.
2. Carl Liedholm and Enyinna Chuta, "The Economics of Rural and Urban Small-Scale Industries in Sierra Leone," African Rural Economy Paper No. 14, 1974.

3. Enyinna Chuta, "The Economics of the Gara (Tie-Dye) Cloth Industry in Sierra Leone," African Rural Economy Working Paper No. 25, 1978.

4. Adwale Maoowonku, "An Economic Evaluation of Apprenticeship Training in Western Nigerian Small-Scale Industry," African Rural Economy Paper No. 17, 1979.

5. Steve Haggblade, J. Defay and Bob Pitman, "Small Manufacturing and Repair Enterprises in Haiti: Survey Results," Michigan State University Rural Development Working Paper No. 4, 1979.

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9. Middleton Wilson, "Some Problems in Operating a Loan Program for Craft and Emerging Small-Scale Non-Farm Enterprises in Jamaica," Michigan State University Rural Development Working Paper No. 15, 1981.

10. Yacob Fisseha and Omar Davies, "The Small-Scale Manufacturing Enterprises in Jamaica: Socioeconomic Characteristics and Constraints," Michigan State Univeristy Rural Development Working Paper No. 16, 1981.

11. Enyinna Chuta, Carl Liedholm, Ola Roberts and Joseph Tommy, "Employment Growth and Change in Sierra Leone Small Scale Industry: 1974-1980," African Rural Economy Working Paper No. 37, 1981.

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14. W. P. Strassmann, "Employment in Construction: Multi-Country Estimates of Costs and Substitution Elasticities for Small Dwellings," Michigan State University International Development Working Paper No. 3, 1982.

15. Donald C. Mead, "Subcontracting in Rural Areas of Thailand," Michigan State University International Development Working Paper No. 4., 1982.

Copies of these papers can be obtained free of charge by writing:

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Introduction

As a trustworthy progenitor of jobs, the construction sector has been in and out of favor among economists. Some decades ago many agreed with Adam Smith that "No species of skilled labor . . . seems more easy to learn than that of masons or bricklayers."[1] As an extra advantage, the complementarity of such work with other inputs, except for materials, was thought to be low. Thus Arthur Lewis wrote in the 1950's that "buildings can be created by human labor with hardly any capital to speak of,"[2] and Nurkse found construction a splendid outlet for "surplus labor,"[3] the ideal entry chamber for rural-urban migrants. "On the whole," wrote W. B. Reddaway, "this is an industry which has relatively little in the way of 'supply difficulties.' "[4]

With experience, however, came doubts about the ease of substituting unskilled labor for other factors of production in making buildings. Summarizing World Bank experience, Albert Waterston noted unexpectedly high costs, long delays, "the use of defective or other improper materials, poor workmanship," and so forth resulting in "works or facilities which either cannot perform as expected or soon deteriorate."[5] After a detailed analysis of Kenyan residential building, Gordon Hughes stated that "housing projects cannot be considered a particularly good way of generating employment for unskilled workers unless . . . the requisite supply of skilled labor is assured. This would be difficult at the present time in Kenya, and the position would seem to be the same in many other African countries."[6] A group of experts convened in 1976 by the United Nations Center for Human settlements, however, concluded:

> . . . it is generally agreed that it is relatively easy to train skilled labor through, for example 9 to 12 month training programs at a government training center. The main difficulties are found in training middle level, or project level supervisors and technicians. There is also a need for the training of small contractors.[7]

But employment generation through construction does not only depend on the sheer quantity of skilled labor and supervisors and the ease or difficulty of training more of them. If the quantity is low and the difficulty of training is great, relatively high skilled wages will be an inducement to use more unskilled workers or more equipment. In other words, little can be said about employment possibilities without first measuring substitution elasticities.

The elasticities of substituting skilled for unskilled workers and labor in general for capital and other non-labor inputs is hard to measure in construction because of the heterogeneity of its output. Buildings generally sit on foundations, use lumber and nonmetallic mineral products, need weatherproofing, and so on; but beyond that, their functions, size, complexity, numbers at a site, and relations to urban facilities vary greatly. A widespread but unreliable rule of thumb is that onsite labor costs half as much as materials and equals offsite costs and profits (25 percent). If true at different levels of development, substitution elasticities would be unity. Then, whenever wages rise 10 percent compared with other input prices, employment falls by 10 percent, and the labor share in costs remains unchanged.

Unitary elasticities were, in fact, measured by Gerard Boon in specific Mexican processes: in manual versus mechanical excavating -- 1.09; shovels versus portable cement mixers -- 1.03; and manual winches versus cranes -- 0.97. If a power winch was compared with the crane or manual winching, the elasticities were 1.15 and 1.20, respectively (Boon, unpublished estimates made in connection with Boon, 1973).[8] For a cross-section of 16 countries in 1965, Boon also found an elasticity of 0.97. With pooled data for 1960-1970 for 15 countries, I found a somewhat lower elasticity of 0.86.[9] Using 1950-67 Mexican time series data, I found elasticities of 0.88 between labor and capital if depreciation is included as a cost and 0.92 if it is not.[10] Of course, in these cases apparent labor-non-labor substitution may not be due to differences in wage levels but show instead that at different times and places different sorts of buildings were constructed. Moreover, measured elasticities will be biased toward 1.0 if labor quality, output prices, and the efficiency parameter of production functions are not held constant.[11,12] Nor can Boon's process-specific substitution elasticities be aggregated easily into an assessment of general trends.

For more reliable substitution elasticities, one must hold the quality and the volume of output constant while factor prices vary. In this paper, such an attempt is reported. From seventy-seven builders in seven countries we tried to obtain estimates of employment and costs, component by component, for a 24.9 m^2 minimal dwelling with given specifications. The builders ranged from small to large, the volumes from one-off to thousands, and the unskilled wage levels from the equivalent of one to five dollars daily. The next two sections describe the dwelling (actually built in Tunisia) and the research procedures in more detail. After that comes a section with the general results and one that shows the experience with alternate designs in other countries. Finally comes a section with statistical tests. For both labor and non-labor inputs, as well as for skilled and unskilled workers, substitution elasticities appear to be between 0.7 and 0.9. The significance is appraised in the conclusion.

The Standard Plan

The standard plan, for which we obtained cost and employment estimates in seven countries, was a small, single-story, flat-roofed, rectangular dwelling covering an area of 24.9 m^2. Walls are made of concrete blocks between six reinforced concrete posts that are bound with a collar beam. There is a 14.2 m^2 all-purpose room, a 7.3 m^2 kitchen, a 1.2 m^2 entrance, and a 2.2 m^2 Turkish toilet connected to a septic tank. Each room has a window, and the kitchen has running water at a sink (see Figures 1 and 2). The specifications are summarized in Table 1, using the English measures that were still in wide use among builders in former British territories of Asia and Africa. In Tunisia and Latin America, specifications were metric and given in French and Spanish.

The floor plan was designed by the Société Nationale Immobilière de la Tunisie (SNIT), the Tunisian government housing agency, and called logement evolutif, "expandable house." It was part of the Fifth Development Plan, 1977-1981. Occupants were expected to add rooms on the standard 77 m^2 lot or on the flat roof of this dwelling and to set up a shower above the toilet. In fact, most built the shower elsewhere or continued using public baths.

About 1,400 such units were completed during 1980 at Tunis, Monastir, Mahdia, Gabes, and other locations. At each site between 40 and 200 units were built within about 18 months. For 500 units at Sousse, SNIT provided a 9 m^2 second room, but

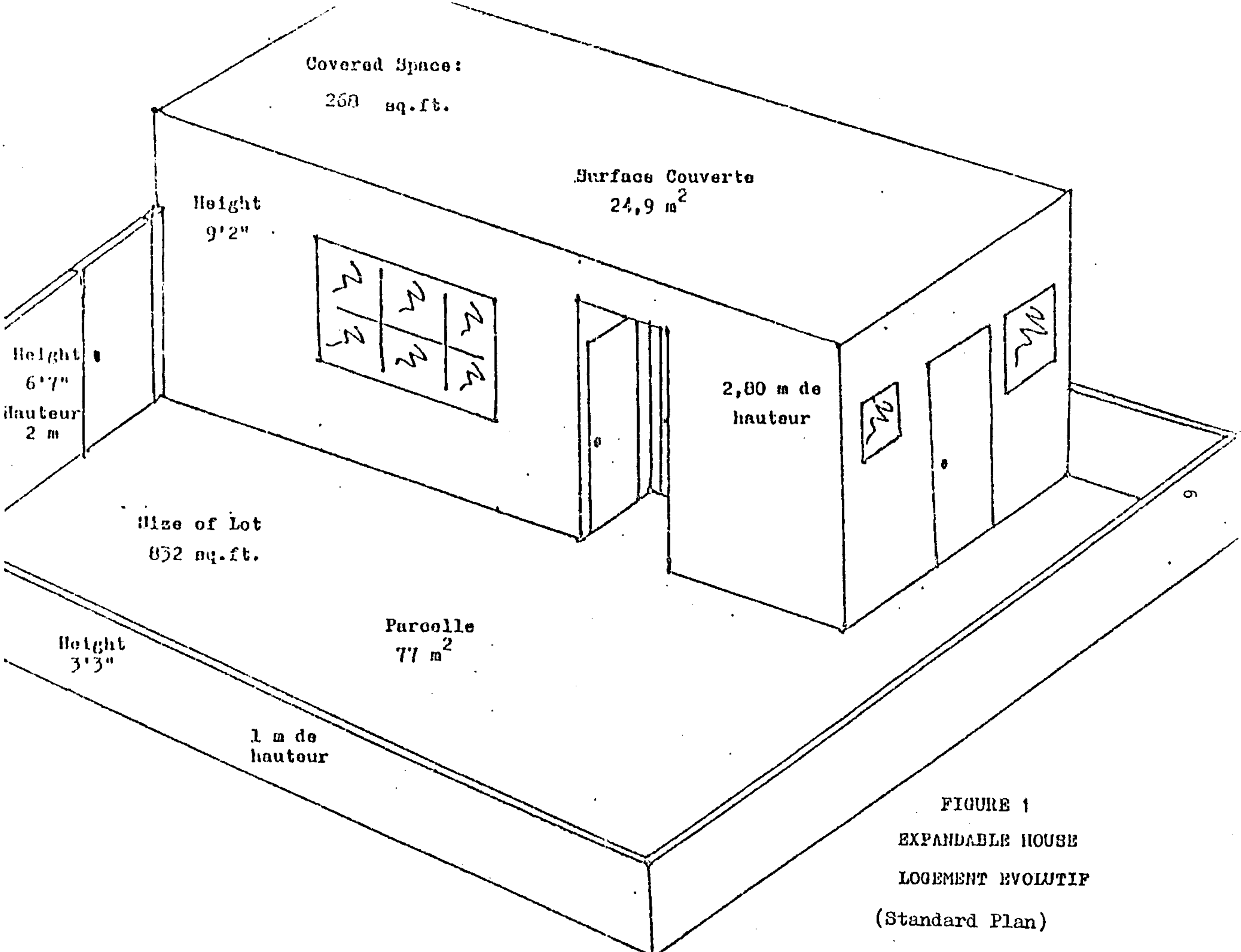


FIGURE 1
EXPANDABLE HOUSE
LOGEMENT EVOLUTIF
(Standard Plan)

FIGURE 2.

STANDARD PLAN
EXPANDABLE CORE HOUSE

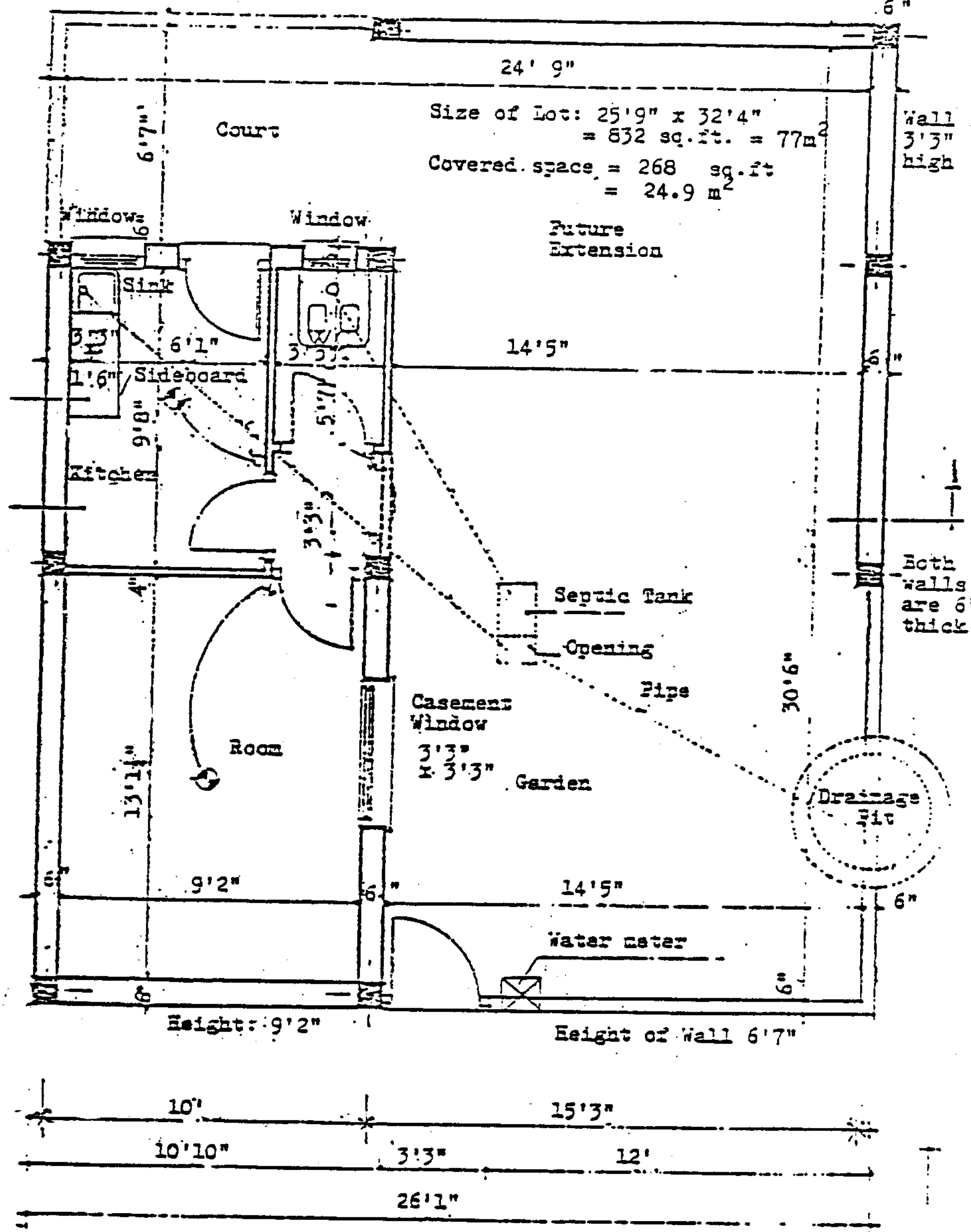


Table 1 EXPANDABLE HOUSE: SPECIFICATIONS

Component	Unit	Quantity
1. Site Preparation		
2. Excavation, Trenching		
a. Holes 5' deep for six posts 20" x 20"	cu. ft.	83.3
b. Trenches for the walls of fence and house	cu. ft.	78.0
3. The Shell: Walls, Ceiling, Floors		
a. Reinforced concrete collar beams and posts 6" x 6"	cu. ft.	70.6
b. Roof panels	sq. ft.	226.0
c. Standard concrete, 15 pounds per cubic foot	cu. ft.	88.3
d. Lightweight concrete, 10 pounds per cubic foot	cu. ft.	144.8
e. Bricks or blocks with holes for the housewalls, 9'2" high, 50'4" long	sq. ft.	462.9
f. Concrete block fence 6" x 3'3" front 6" x 6'7"	sq. ft.	193.8
g. Partitions, hollow blocks	sq. ft.	215.3
h. Cement floor 4 1/2", base 2"	sq. ft.	226.0
i. Plastering: Ceilings 205 sq. ft.; walls--all interior and only the facade outside, 195 sq. ft. Bathroom excluded.	sq. ft.	1,120.0
4. Carpentry		
a. Formwork, shuttering, frames, window sills		
b. Frames for windows, openings, and doors		8.0
c. Casement window 3'3" high, 3'3" wide		1.0
d. Window panes	sq. ft.	16.1
e. Garden door 35 1/2" x 79"	sq. ft.	19.5
f. Four interior doors	sq. ft.	75.5
5. Painting		
a. Oil paint on doors, windows	sq. ft.	237.0
b. Whitewash	sq. ft.	1,119.5
6. Plumbing		
a. Sink, sideboard, faucet and drain		1.0
b. Turkish toilet, tank, and drain 20 liters		1.0
c. Galvanized pipes	ft.	34.5

was average-to-large, as defined locally. With detailed

worksheets these firms estimated costs and employment for each

7. Electrical		
a. Lights, wiring, switches, plugs		

this was not really necessary since probably every owner-occupant would have added on with self-help as they did in the other cities. In April 1981 I saw as many as three rooms added, including two rooms on the second story of some units at Ouardia and Sidi Fatallah near Tunis. A few owners had changed the position of doors, windows, and plumbing. Construction of these dwellings had been supported by a US$5 million loan under the Housing Investment Guarantee program of the U.S. Agency for International Development. As such, they had to be within the means of households below the median income level. Later SNIT resumed financing somewhat larger expandable dwellings with a floor space of 35-45 m^2 for cities, and the 24.9 m^2 type was limited to rural areas.

SNIT gave contracts only to small and medium-sized builders with a capital of at least US$12,500 and a minimal monthly productive capacity of US$15,000. The maximum size was ten times these amounts. Thus they had an annual capacity for building at least 20 of the 24.9 m^2 dwellings but not more than 145 units. SNIT helped small contractors by suggesting work plans with schedules for hiring workers and ordering materials. They assisted with the layout of the site and sent technicians to interpret blueprints and specifications. Material suppliers were pressured to give better price and credit terms to the small builders. If unforeseen problems or expenses delayed construction, SNIT often did not charge the penalties specified in the contract but gave cash advances so that work might continue. As a result of using the small and medium-sized builders, costs were probably lower and employment was certainly higher.

The Sample

Tunis and Sfax, Tunisia, were two of the cities selected for our 1979 housing surveys. The others were Colombo, Sri Lanka; Rawalpindi, Pakistan; Lusaka, Zambia; Nairobi, Kenya; and Medellín, Colombia. A year later we added Lima, Peru. The choice of countries and cities was partly determined by the requirements of a broader research project about employment, small enterprises, and housing conditions in developing countries. Given the time available, the sample size of the building firm survey was left to the discretion of the local directors of research, primarily present or former economics Ph.D. candidates of Michigan State University. The numbers ranged from three firms in Lima to twenty in Rawalpindi. In each country highly detailed estimates had to be obtained from one very small builder, one medium-small, and another that was average-to-large, as defined locally. With detailed worksheets these firms estimated costs and employment for each step in building one, ten or one hundred of the standard units. They also made estimates 1) for building the standard plan with load-bearing blocks instead of reinforced concrete posts, 2) for modifying the standard plan in ways that made it more suitable for local conditions, and 3) for a local expandable core house that was actually in use. If additional firms were surveyed, they were asked to make estimates for sets of ten standard dwellings in terms of major components -- foundations, walls, roof, etc. -- without going into minute detail. One aim of these extra interviews was to serve as a check on the detailed three. The extent to which these extra interviews were complete and could be used in statistical analysis varied. In each country forty construction workers were also interviewed to check on wage rates paid and on the combination of skilled and unskilled workers in specific tasks.

General Results of the Survey

The pattern of costs, wage levels, and employment for building the 24.9 m^2 *logement evolutif* can be seen in Table 2. Cost averaged US$3,650, somewhat above the $3,500 actually experienced in Tunisia in 1980. In Lima, Peru, it would have cost 22 percent less, and in Lusaka, Zambia, 40 percent more. Daily pay of unskilled workers, including fringe benefits, ranged from about one dollar in Sri Lanka to over four dollars in Peru, Tunisia, and Colombia, according to builders. In general, builders claimed to pay about a fourth more in daily wages and benefits than workers said they received. This difference is partly due to uncertainty among workers about the daily cost of various benefits and partly due to a pretended adherence to minimum wage legislation among builders. The extreme case was Lima where the high legal minimum of $7.21 daily was evaded in a variety of ways but where unskilled workers said they received only $4.35 daily. For example, they said they would get paid for only three days but be expected to work five. Peruvian census figures show that construction

Table 2 COST OF CONSTRUCTION AND EMPLOYMENT GENERATION FOR A STANDARD 24.9 M^2 DWELLING BUILT WITH REINFORCED CONCRETE POSTS IN SIX COUNTRIES, SUMMER 1979 (LIMA = SUMMER 1980)

Volume: 1-10 Units

	Colombo, Sri Lanka	Rawalpindi, Pakistan	Lusaka, Zambia	Medellín, Colombia	Tunis, Tunisia	Lima, Peru	Average Six Countries
1. Cost of construction, c, US$ (Exchange Rate)	$3,117 (15.67)	$3,482 (9.84)	$5,107 (.79)	$3,794 (42.0)	$3,550 (.40)	$2,852 (285)	$3,650
2. Ratio of labor costs to total costs, r	.150	.185	.198	.205	.297	.265	.217
3. Daily pay, w, of unskilled workers, according to:							
a. Workers	$ .94	$ 1.92	$ 3.05	$ 3.30	$ 4.17	$ 4.35	$ 2.96
b. Builders	1.02	2.00	3.80	4.24	4.93	7.21	3.87
4. Daily pay, weighted average of all workers							
a. Workers	$ 1.21	$ 2.50	$ 4.15	$ 5.70	$ 5.53	$ 4.92	$ 4.00
b. Builders	1.52	3.03	5.25	6.93	6.08	7.50	5.05
5. Ratio of skilled to unskilled wages, p, according to:							
a. Workers	1.713	1.818	1.898	2.786	1.808	1.356	1.897
b. Builders	2.125	2.300	2.000	2.975	1.654	1.070	2.021
6. Unskilled workers employed per skilled worker, q, according to:							
a. Workers	1.50	1.73	1.50	1.46	.48	1.70	1.40
b. Builders	1.31	1.53	1.62	2.11	1.80	.74	1.52
7. Workdays for the dwelling according to:							
a. Workers	388	258	244	137	164	154	224
b. Builders	309	210	192	112	173	101	183

Source: Surveys, Summer 1979, except Lima, Summer 1980. Conversion to U.S. dollars is at official exchange rates at the time of the survey when, due to recent devaluations, they happened to be mainly realistic.

Note: Tunisian and Zambian estimates omit site preparation and should have costs raised by about $50 and employment by about 10 workdays. Lines 3a and 3b were used to determine the order cities in the columns from left to right.

employment in the formal sector is much higher than could be deduced by adding up workers officially reported on payrolls.

Skilled workers generally get twice as much as the unskilled (Table 2, lines 5a and 5b). In Lima builders claimed to pay only 7 percent more for skill, but workers said it was 35.6 percent more (on the basis of the much lower unskilled wage level). These differentials partly determine the relative use of skilled and unskilled workers, the average proportion being fifteen unskilled for ten skilled workers (Table 2, lines 6a and 6b). In U.S. residential building, ten skilled workers worked with only four semiskilled or unskilled helpers, and the skill premium was often below thirty percent.[13]

Labor costs ranged from 15 percent of the total in Sri Lanka to nearly 30 percent in Tunisia and averaged 21.7 percent. According to workers it took 224 workdays to build the house, and according to builders 183 workdays. Apart from the incentive to overstate wages, builders are often uncertain about the numbers of skilled and unskilled workers that actually show up whenever work is subcontracted on a piece rate basis. With either set of figures, one finds that Sri Lankan wages were 70 percent below the average, and Sri Lankan employment 70 percent above the average.

Table 3 shows the cost breakdown by major dwelling component for the six countries. Noteworthy is that in Sri Lanka and Zambia the share of the building shell is relatively low

Table 3 PERCENTAGE DISTRIBUTION OF COSTS BY COMPONENT FOR A STANDARD 24.9 M^2 DWELLING BUILT WITH REINFORCED CONCRETE POSTS IN SIX COUNTRIES, SUMMER 1979 (LIMA, SUMMER 1980)

Component	Colombo, Sri Lanka	Rawalpindi, Pakistan	Lusaka, Zambia	Medellín, Colombia	Tunis, Tunisia[a]	Lima, Peru	Average, Six Countries
1. Site preparation	0.7	1.3	-	2.9	-	0.7	0.9
2. Excavation and trenching	0.1	0.2	0.4	2.8	.7	1.2	0.9
3. The shell: reinforced posts and non-load-bearing blocks	40.9	68.6	58.7	62.9	67.4	39.7	56.0
4. Carpentry	26.8	17.8	14.3	15.0	18.6	42.3	22.5
5. Painting	2.3	1.6	6.6	3.4	2.3	2.6	3.1
6. Plumbing	25.9	6.7	17.6	9.0	8.7	8.7	12.8
7. Electrical	3.3	3.8	2.5	4.0	-	7.4	4.2
8. Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[a]For Tunisia, carpentry includes electrical work. Tunisia and Zambia omit site preparation.

and the share of the plumbing relatively high. In fact, carpentry and plumbing combined add up to over 50 percent in Sri Lanka, double that of the other countries. In the case of Sri Lankan carpentry, the high cost is due to the lack of prefabricated doors, window frames, and the like, which may be employment generating on the site but is otherwise inefficient. Plumbing installation in Colombo, by contrast, does not take more workdays than are needed in Rawalpindi or Lusaka; but the components, often imported are relatively expensive. The share of labor costs in plumbing installation are 8.9 percent in Colombo and average 20.4 percent in the other five cities, more than twice as much.

The estimates so far have assumed a low volume of building: one to ten units. At higher volumes, offsite and capital costs can be spread over a greater number of units, and larger firms become interested. Table 4 shows the effect in Tunisia for three sizes of firm and four levels of volume. The share of labor costs falls with size, but for a given firm it will be higher at the larger volume. Small firms producing a single unit are most employment-generating, but without special assistance (as SNIT eventually provided), their costs are 52 percent above those of a medium-sized firm producing at a low volume. The medium-sized firms have the lowest share of labor costs, use the fewest workdays per unit, and have lowest costs for this type of work. They therefore create more jobs and units for a given expenditure (Column 2) than do large firms. Note that these firms are intermediate in the use of unskilled

Table 4 EMPLOYMENT EFFECTS OF SIZE OF FIRM AND VOLUME FOR BUILDING A 24.9 M^2 DWELLING IN 1979, TUNISIA

Size of Firm	Units in Contract (1)	Cost per Unit (2)	Share of Labor in Costs (3)	Daily Unskilled Earnings (4)	Ratio of Skilled to Unskilled Earnings (5)	Unskilled Workers per Skilled Worker (6)	Workdays per Dwelling (7)	Workdays per $1,000,000 (8)
Small	1	5,407	.379	$4.70	2.00	2.00	327	60,500
Medium	10	3,550	.297	4.93	1.65	1.80	173	48,700
Medium	100	3,283	.317	4.93	1.65	1.80	171	52,100
Large	100	4,450	.310	5.50	1.47	.91	201	45,200
Large	1,000	3,650	.342	5.50	1.47	.91	182	49,900

Note: Managers of the three firms were asked to make detailed cost and employment estimates for an identical unit. Its 24.9 m^2 are divided among a kitchen, room, and water closet with a connection to a septic tank. Interviews with other firms suggest that the results are typical though not necessarily the arithmetic mean. Infrastructure and sitework are not included.

Altogether nine firms were surveyed in Tunisia. Small firms averaged 16 employees, none offsite, and could build 23 small dwellings per year. Medium-sized firms averaged 101 workers onsite and 14 offsite and could build 200 units annually. Large firms averaged 775 workers onsite, 89 offsite, and could build 750 small units annually. The survey was carried out by Dr. Ridha Ferchiou, University of Tunis, in collaboration with Michigan State University.

per skilled worker, the unskilled wage level, and the skill premium. Similar economies of scale have been found for residential building in the United States by Maisel,[14] Cassimates,[15] Stevens,[16] McConnaughey,[17] and the Bureau of Labor Statistics. All these refer to the number of units in a project. With respect to size of firm, however, Fleming found that in Northern Ireland, as in Tunisia, medium-sized builders (79-120 workers) priced dwellings (11.5 percent) less than the prices of either smaller or larger builders.[18]

Alternate Designs

Alternate designs tended to change quality in the sense of different roofing materials and type of bathroom. The alternatives also reduce costs, and lower employment, especially the relative use of unskilled workers. The most obvious possibility is to use load-bearing cement blocks instead of reinforced concrete posts for the walls. In Nairobi according to builders, this substitution would have lowered costs by 12.5 percent, and in Medellín, Colombia, by 8.0 percent (Table 5, column 1). It was also a change recommended to Tunisia by a group of foreign consultants, who estimated that a $222 saving -- or 6.2 percent would result from the substitution. In our sample of nine Tunisian firms, however, only three said that savings could result (1.5, 4.0, and 4.5 percent). Two said it would be more expensive; two claimed no cost difference; and two said they had never built with load-bearing blocks and had no idea. To resolve the confusion, we engaged a highly respected consulting engineer, Mr. Slaheddine Gribaa, who reported that cheaper

Table 5 COST AND EMPLOYMENT WITH ALTERNATIVE PLANS AND VOLUMES IN MEDELLIN, COLOMBIA

Design and Volume	Cost, C (1)	Share of Onsite Labor in Cost, r (2)	Ratio of Unskilled to Skilled Workers, q (3)	Workdays of Employment, N (4)	Share of the shell and excavation in (5)
A. Standard plan 24.9 m^2					
1. V = 1	3,794	.205	2.11	112	65.8
2. V = 100	3,107	.227	1.71	97	66.0
B. Standard plan with load-bearing blocks instead of posts					
1. V = 1	3,494	.206	1.88	99	64.8
2. V = 100	2,851	.227	1.50	85	64.9
C. Modified plan, 19.5 m^2					
1. V = 1	2,700	.248	1.48	84	58.9
2. V = 100	2,241	.267	1.07	69	59.1
D. Actual plan, Altos de Niquía, 19.2 m^2					
1. V = 10	1,780	.193	1.38	24	63.2
2. V = 3,001	1,377	.254	1.38	24	62.9

Source: Detailed estimates by two building firms for A, B, and C obtained by Norma L. Botero in the summer of 1979. At that time, construction of 3,001 units at Altos de Niquía was actually under way by the Instituto de Crédito Territorial, who provided data to Professor Botero. They stated that a smaller volume might raise material and offsite costs per unit but not employment.

Note: The Modified Plan C and the Actual Plan D both use asbestos sheet roofs and have load-bearing concrete block walls. Neither are plastered or painted. In Plan D one wall and some plumbing pipes are shared with a contiguous other dwelling. Plan C also has four instead of two windows, an extra door, an extra wash basin, and a water tank for the toilet. Plan D is designed for an incredibly steep site, north of Medellín.

building with load-bearing concrete blocks remained a merely theoretical possibility in Tunisia in 1979. Sufficiently cheap blocks of load-bearing quality were not yet being produced. For the types of soil where low-cost Tunisian housing development were actually located, prevailing construction techniques made 40 cm wide trenches, instead of 20 cm widths, mandatory. Consequently 13.5 m^3 of standard concrete, instead of 6.9 m^3 as with the standard plan, would be needed. This item raised costs by $265 and left a net increase of $195 or 4.3 percent. The share of labor cost and employment proportions were not affected. The point is that simple substitutions may be complex in practice.

For Tunisia we had no other modification of the standard plan, and this plan was the one actually in use. Other countries used floor plans more suited to local tastes and opportunities. They lowered costs with asbestos sheet roofs, had less covered space, left walls unpainted and unplastered, used communal standpipes and pit latrines; or they raised cost by insisting on a standard toilet, shower, and extra wash basins.

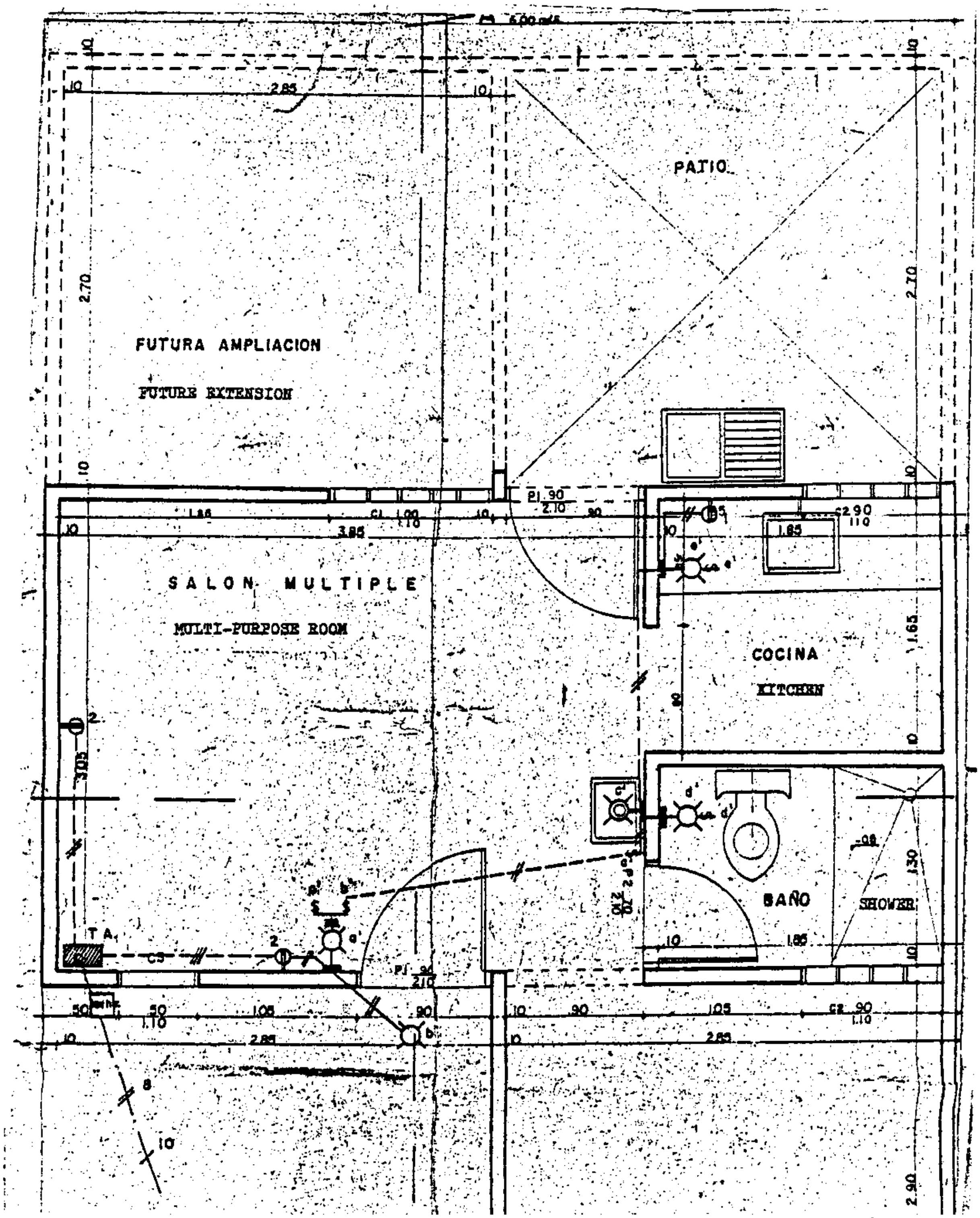
In the Chawama district of Lusaka, Zambia, for example, households were provided with two- and three-room concrete block dwellings with asbestos sheet roofs and a floorspace of 20 to 30 square meters for an average price of $353. Occupants had to use pit latrines and get water from standpipes that served twenty-five households. Ninety-three percent of households in these expandable or "half-finished" dwellings had already made improvements worth an average of $466.[19]

In Kenya expandable dwellings of 42 m^2 were sponsored by the U.S. Agency for International Development at Umoja and cost $3,743 without the site. The World Bank financed a plan with a variety of options at Dandora. A 3.8 m^2 "wetcore" consisted of a shower, toilet, and storage room and cost $638. To this, for an additional cost of $699, one could add an 8.7 m^2 kitchen that might double as sleeping quarters. Total cost: $1,337. Sales price: $1,800. Initially these units were built of lightweight cement "cheecolite" panels, but eventually concrete blocks again proved to be more reliable and economical. A further 10.8 m^2 room could bring floorspace to 23.3 m^2 and total cost to $1,975, still much below the cost of the Tunisian design. As usual, infrastructure and the site are not included. Within two years most of the occupants had added at least three rooms to their original allotment, and most were subletting part or all of their premises to pay for the expansion.

The local plan actually used in Pakistan cost $4,017, an increase of $535 compared with the standard plan due to $616 spent additionally on a larger shell and $81 saved on all other components combined. The locally used plan of Sri Lanka cost $1,349 or $1,750 less than the standard plan. Savings were mainly $467 on the shell and $1,209 on carpentry and plumbing.

An overview of what modifications of the standard design do to costs and employment at alternative volumes may be seen in Table 5 from Medellín, Colombia. We have already noted that substitution of blocks for reinforced posts would bring costs down by 8 percent but do little to the share of labor costs and somewhat lower the share of unskilled workers (lines B-1 and B-2). A modified 19.5 m^2 plan would lower costs by 29 percent for a single unit and by 28 percent for a set of one hundred due to an asbestos sheet roof, less space, less finish, but more plumbing (see Figure 3). As the share of the shell in total costs falls, the share of labor cost rises, but the rising proportion of skilled workers nevertheless lowers employment by a fourth or more compared with the standard plan.

That costs could fall to less than half of those for the standard plan, and even to two-thirds of the modified plan, is shown by 3,001 units actually built on the hillsides of Niquía in Bello, a suburb of Medellín, a half-hour bus ride north of the central business district. Units of 19.2 m^2 were built on the edge of 72 m^2 lots so that one wall could be shared with the neighboring dwelling (see Figure 4). Walls consist of 20x20x40 cm concrete blocks, and roofs are 12 asbestos cement sheets. There are two doors, only one window, a wash basin, shower, and a toilet with only a tap, not a tank. Nothing comes plastered or painted. The project was designed by the Medellín branch of the Instituto de Crédito Territorial (ICT), the Colombian public housing agency, and built by private contractors after public bidding. ICT officials said that such competition assured the use of low-cost, labor-intensive conventional technology. Cost of the



Niquía, the share in costs of the shell and foundations was 4 percent above that of the modified plan or 63 percent. The

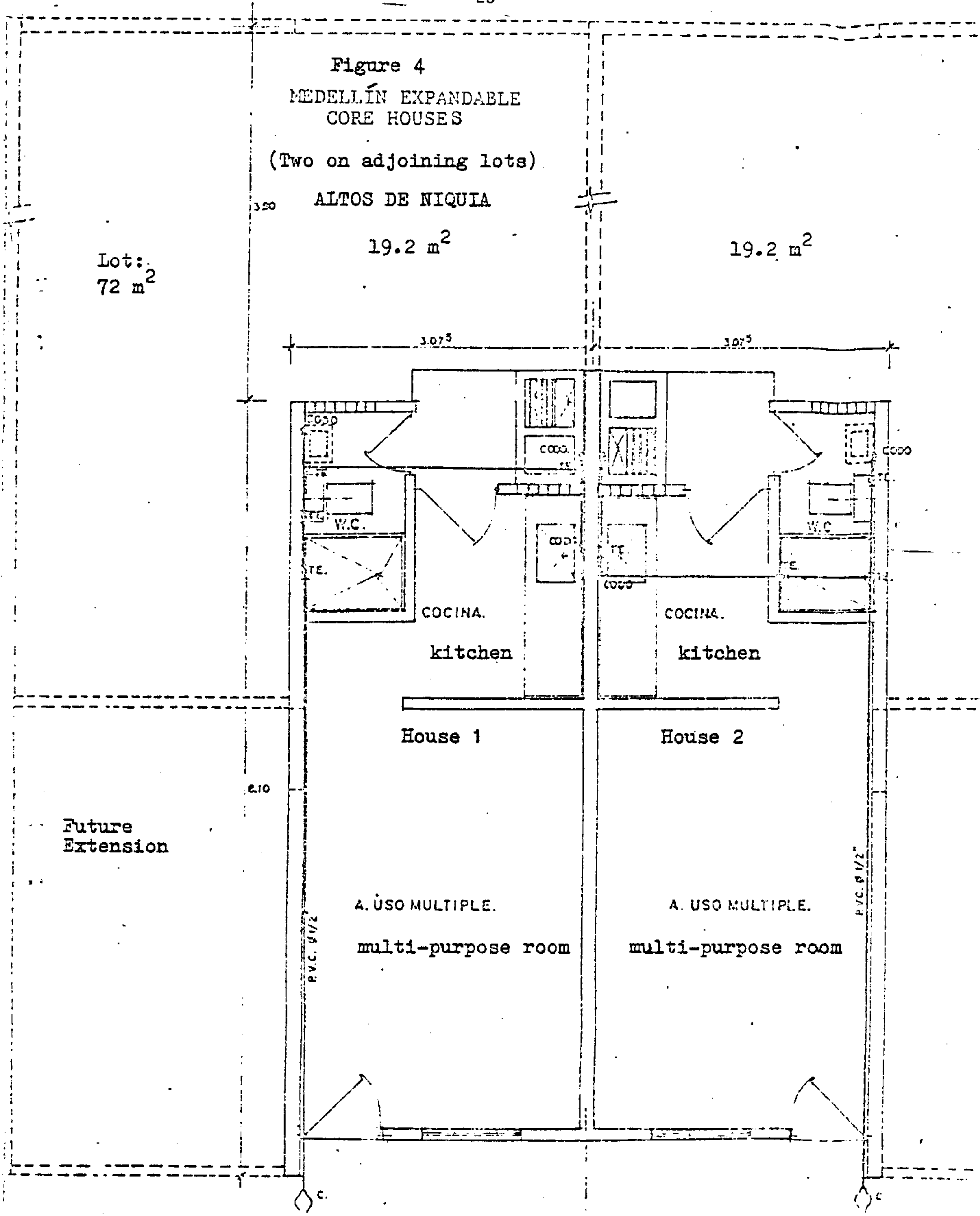


Figure 4
MEDELLÍN EXPANDABLE CORE HOUSES
(Two on adjoining lots)
ALTOS DE NIQUIA

infrastructure per lot was $482, not including utility trunk lines, primary roads, and bus stops. Sales price was $3,100, which compares with $1,800 for the 12.5 m^2 units at Dandora, Nairobi, and with $5,000 for the 24.9 m^2 standard dwelling in Tunisia.

Construction at Niquía began in July 1978 at the rate of 36 dwellings weekly, and in January 1979 the first occupants moved in. The work force consisted of 189 skilled and 261 unskilled laborers, working 48 weekly hours, plus 34 engineers, architects, social workers, and others offsite. By the time of the writer's visit in December 1980, about seventy percent of households had doubled the size of their dwellings and had added window grills, mosaics, flower boxes, and Christmas decorations. Many had reinforced the walls and substituted a flat roof for a second story. In the additions some had lodgers (illegally) and many had bakeries, pharmacies, key shops, and other stores. One typical occupant said that adding a room and substituting a flat roof for the original structure, which he had also subdivided, cost $875, including the services of one skilled and one unskilled worker. Finding such workers was no problem.

Since finishes and fixtures were reduced to a minimum at Niquía, the share in costs of the shell and foundations was 4 percent above that of the modified plan or 63 percent. The share of labor costs was close to the one-quarter of the familiar rule of thumb (Table 5, lines D-1 and D-2). But only 24 onsite workdays were needed per unit although construction techniques were conventional and the site was extraordinarily steep. At the larger volume only material and offsite costs were lower. This fact was carefully checked and may be attributed to superb organization and the work ethic for which the Colombian province of Antioquia is famous. Moreover, many of the dwellings were to be allocated to the construction workers themselves and were designed to be affordable by those who earned only the minimum legal wage.

One of the main points of this section is that specifications for a rudimentary minimal dwelling vary greatly from one country to another and thereby affect the share of labor in costs as well as the proportion of skilled and unskilled workers. To estimate substitution elasticities one has to use the same plan everywhere.

Substitution Elasticities

The way employment falls as wages rise, shown in the fourth section, implies that factor substitution is practical even without any change in design or materials. But since the percentage fall in employment is below the rise of relative wages, the elasticity appears to be below unity. For a more precise measure, one must assume a production function and estimate its coefficients.

A number of specifications were tried. The small sample and inadequate data on the price of non-labor inputs pointed in the direction of a CES specification using output per worker and the wage level as variables. The assumption of constant returns to scale of this specification does not bias the results since volume was held to ten or fewer units.[20] Since materials and work-in-progress are the primary non-labor input into construction, a case can be made for using gross output per worker (logs) as the dependent variable. The largest number of observations, 74 firms, could be used with this specification. Results were an elasticity of substitution of 0.95, as can be seen in Table 6, line A-1. For the largest country subsample, 20 Pakistani firms, the elasticity was only 0.80 (standard error = 0.41, $\overline{R}^2$ = .13). A lower elasticity would be consistent with the opinion that elasticities are lower in the short-run in a given place.[21]

Value added per worker (logs) is the usual dependent variable, but it could be used for only two-thirds as many firms, given the information provided. Nevertheless, the statistical fit improves, and $\overline{R}^2$ rises from .30 to .65. The overall elasticity of substitution falls to 0.86. For each major dwelling component, however, as can be seen in Table 6, the elasticity is lower with an average of .68. It is high (above 0.70) for site preparation and foundations, which also have a high labor content (two-thirds of cost or more) -- especially in the poorer countries, as one would expect. In these operations, unskilled workers can be replaced by machines. The elasticity is lowest for the highly skilled installation of plumbing pipes, sinks, and fixtures -- 0.57, and this component also has the lowest average share of labor in total costs, 0.185. These elasticities may be compared with those that McConnaughey found for the United States in 1972: Below

Table 6 LABOR-NON-LABOR AND SKILLED-UNSKILLED SUBSTITUTION ELASTICITIES: SEVEN DEVELOPING COUNTRIES, 1979-80

Dependent Variable	Independent Variable	Elasticity of Substitution (Slope Coefficient) (1)	Standard Error (2)	Constant (3)	$\bar{R}^2$ (4)	n= (5)
A. Gross Construction per Worker, Dwelling and Site (logs.)						
1. Sample of firms	Average daily earnings of labor including fringe benefits (logs)	.95	.17	1.04	.30	74
2. Sample of country averages	"	.67	.12	2.05	.89	6
B. Value Added per Worker, Sample of Firms (logs.)						
1. Dwelling and site	"	.86	.10	.83	.65	43
2. Infrastructure: unpaved road, drainage ditches, water and sewerage pipes	"	.71	.12	1.41	.45	43
3. Foundations	"	.74	.08	1.42	.65	51
4. Walls	"	.66	.09	1.43	.52	51
5. Roof	"	.67	.07	1.53	.62	51
6. Plumbing pipes, sinks, and fixtures	"	.57	.10	1.28	.38	51
7. Doors, windows, and other detailed finishes	"	.72	.07	1.48	.69	51
C. Ratio of Unskilled to Skilled Workers (logs.)	Ratio of daily earnings, skilled to unskilled workers (logs.)					
1. Sample of firms	"	.21	.44	.90	.00	35
2. Sample of country averages	"	.88	.29	-.02	.70	6

Source: Surveys of building firms, 1979 and 1980. For specifications of production functions see authors cited in the text.

Note: The sample of building firms includes 8 Kenyan firms, but the sample of countries (lines A-2 and C-2) omits Kenya since it is based on the highly detailed estimates, described in the text, which were not concluded for Kenya. The other countries are Colombia, Pakistan, Peru, Sri Lanka, Tunisia, and Zambia. Eight Tunisian firms are omitted from lines B-1 and B-2 since they did not report data for infrastructure. Except for line C-1, all slope coefficients are significant at the .01 level. Values were converted to US dollars for the estimates, as in Table 2.

unity for plumbing (.84) and special carpentry (.71), around unity for general residential contracting (1.05), and above for water and sewer lines (1.17).[22]

Since we have data on both employment and costs of skilled and unskilled labor, attempts were made to use three-factor production functions -- non-labor and two types of labor -- but without improvement in the statistical fit. Instead, we made the assumption of <u>separability</u>, that substitution between labor as a whole and non-labor factors or production -- capital, materials, and organization (K, M, O) does <u>not</u> affect substitution between skilled and unskilled workers (N_s, N_u). The formal expression is:

$$Y = [F(K,M,O)]^a[G(N_s,N_u)]^b.$$

Here <u>Y</u> is output and <u>a</u> and <u>b</u> are output elasticities for non-labor and labor factors respectively. The issue of separability and labor-labor substitution elasticities has not yet been studied at the level of laborers versus craftsmen within an industry. Often separability is assumed because non-labor inputs are poorly measured and may bias the relation between employment and wage rates among different types of labor.[23,24,25]

For our sample of firms, using the Kmenta[26,27] linear approximation of a CES production function, no significant statistical association between the skill premium and the relative use of skilled workers was found (Table 6, line C-1). However, if the regression is run for pooled observations for six countries, an elasticity of 0.88 is found with an $\bar{R}^2$ of .70. If the labor-non-labor elasticity of substitution is measured in this way, an elasticity of 0.67 is found with an $\bar{R}^2$ of .89.

Conclusion

Dwellings are the leading output of the construction sector if both formal and informal building activities are counted. Given income levels in developing countries, the vast majority of dwellings will be small ones, hence minimal units make a good starting point for studying employment generation through building. In this study we took a standard floor plan and asked seventy-seven firms about cost and employment characteristics. Other information was obtained from hundreds of households and construction workers. One should, of course, be cautious about considering seven cities as perfectly representative of all developing countries.

As wage levels rose from the poorest to the richest countries in the sample, the elasticity of substituting non-labor for labor in construction was found to be neither very high nor negligible. With four times the labor cost per day, employment fell to 40 percent, so an elasticity of 0.7 was implied for given volumes per firm. If the elasticity was measured for value-added, using individual firms as the units of observation instead of country averages, the elasticity was 0.86. The share of labor in total costs therefore had a tendency to rise from a seventh to about a quarter, but total cost stayed around $3,600 without much variation. Estimates among builders within a country varied less than differences among country averages. In Tunisia where this design was actually built, cost was $3,500. Medium-sized firms with a volume of around 100 appeared most efficient, but small firms could reach that level of efficiency with practical forms of assistance.

Valid substitution elasticities should be derived from a product of standard design. But since dwellings consist of components with varying labor intensities, rising wages will tend to change the component mix and lead to higher elasticities in practice. With data from Colombia, Kenya, Pakistan, Sri Lanka, Tunisia, and Zambia we showed the variety of ways that minimal facilities for security, sleeping, cooking, and sanitation were in fact provided by official housing programs. Reports from other countries could have been added. Apart from differences in factor costs, these design changes reflected variations in climate and the tastes of households and housing officials. Such features as Turkish toilets or shared walls with neighbors are accepted or rejected not only because of price.

In general, however, local variations tended to be cheaper and more labor-intensive than the Tunisian standard plan. Labor-intensity here means a higher share of labor in costs. This higher cost share nevertheless went with lower employment in terms of sheer numbers because a larger proportion of skilled workers was required. Depending on the trade and country, skilled workers generally received 70 to 130 percent more than the unskilled, with no particular trend among countries.

Three unskilled workers were generally used for every two craftsmen in the standard plan. The elasticity of substitution was 0.88. What raised the skilled share in the local substitute plans was the larger proportion of the skill-intensive components and the smaller share of the shell. Since the higher-wage countries were more inclined to leave the shell unplastered and unpainted, hired unskilled labor was eliminated there, while extra skilled workers were needed to install more elaborate plumbing facilities.

The overall conclusion is that in projecting employment one must be careful either about using standard plans or in accepting whatever mix of buildings is actually built at some income level. One should neither compare unlike combinations nor overgeneralize from a single design. Nevertheless, one can safely reject both the extravagant optimism among some economists about the employment potential of construction if wages are kept low and dismiss the pessimism about inelasticities that is common among technicians and planners.

The policy implication of substitution elasticities that are somewhat below unity is that one should be cautious about raising wages prematurely but not defeatist about keeping housing costs low in the long-run. In early development, construction workers tend to be in less militant unions or none and are subject to less vigilant social legislation than are manufacturing workers. No great effort should be made to change that situation because the lagging construction wages promote employment. Of course, labor productivity also lags because employers are not induced to spend on capital equipment and on more elaborate, easily installed materials. At this stage of development, higher wages for some workers would come at the expense of others.

But if labor is made more productive because of inexpensive training and better organization, unemployment is a less likely result because these increases in productivity can lead to lower costs and an expanded volume of building (in accordance with demand elasticities).

In the middle income phase of development, the need to build reaches a peak with accelerating migration, urbanization, and industrialization. Construction wages begin to rise faster than manufacturing wages and eventually surpass them on an hourly basis in many countries. The sector becomes partly unionized and socially regulated. Now builders have to reorganize with better equipment and different materials to raise productivity. They have to invest more, but costs will not rise much because substitution among inputs is not that difficult. The resulting higher productivity that goes with higher labor earnings is indeed the essence of development. If it does not happen prematurely, laid-off workers will be needed elsewhere, national output will not fall, and income distribution will not worsen just because of trends in building methods.

Footnotes

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