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EMPLOYMENT EFFECTS OF RESIDENTIAL CONSTRUCTION AT DIFFERENT LEVELS OF DEVELOPMENT

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Choice of the character or volume of a housing program can be affected by the number of jobs created. Policy makers need a simple but reasonable method for estimating the employment consequences at the time designs, sites, and scale are first discussed. Employment estimates that come months or years after buildings are complete have less practical value. Relative wages and prices, construction techniques, and designs will have changed so that new projects could need a different number of workers per dollar, peso, or rupee invested. The aim here is to develop a simple employment estimating method that can give fast yet reasonable answers.

The constraint of speed must limit us to estimating gross onsite employment. Net employment changes depend on the extent to which a project uses workers that would otherwise be without jobs. Determining that takes detailed knowledge of other construction projects and other economic sectors, knowledge that cannot be developed quickly. Nor could it be incorporated in a simple formula. Offsite and indirect employment also vary too much from contractor to contractor and from country to country for general treatment. Employment in the contractor's office does not change directly with the scale and characteristics of any one project being built. Much of it is a fixed cost spread over as many projects as happen to be under way.

Indirect employment makes and transports materials and tools, as well as the inputs into those activities, ad infinitum. Generalizations

about indirect employment are impossible because materials or components may come from inventory, may use idle productive capacity, or be imported to an extent that varies from year to year and from country to country. Each of these contingencies greatly changes employment effects. Moreover, such studies are applications of input-output analysis that I have not seen completed in less than two years. As a rule, offsite and indirect employment will be less than onsite employment--about two-thirds as much in countries that make their own construction supplies.

A Formula

The simplest way of estimating onsite employment generation is to divide the wages share of the cost by the average wage. If the wage bill of a $10 million project is a quarter, and if the average worker gets $5 daily, then 500,000 workdays will be generated.

C = Cost of the project
r = Share of wages in the cost (percent)
w = Average daily wage
N = Employment measured in days

Then,

$$N = \frac{r}{w} C \qquad (1)$$

That formula would be very nice if r and w were both readily available. But different projects and different components of projects, such as plumbing or roofing, will take a different mix of skilled and unskilled labor. Since skilled workers are paid more, changing the mix changes the average wage for a project. The national average wage in construction is therefore irrelevant.

In the poorest countries unskilled construction workers seem to be an inexhaustible legion who earn half as much as skilled workers. In some

activities they can supplement and substitute for the skilled workers; in others not. On the average, three may be employed per skilled worker. As migration slows and eduction spreads, the differential paid for skills will fall below 30 percent, and no more than one common laborer will be employed for every three skilled workers. The pace of substitution will vary from process to process in accordance with technical options. Moreover, both types of onsite labor can be replaced by construction equipment and more easily installable materials. As a result, r, the share of wages in total costs may change.

If data were available, we should wish to estimate the elasticities of simultaneously substituting non-labor inputs, skilled labor, and unskilled labor for one another as their costs change while producing a single dwelling type. But this task is too complex. The data that we can get refer to input prices and volumes for dwellings, workers, and materials that are not comparable. We can only observe single points on different production functions. In the light of this difficulty, we shall usually treat the overall share of wages and fringe benefits separately from the mix of skills and the pay differential among them. Above all, the aim is to find a term, an "employment generator," that is independent of monetary units. Such a term allows international and intertemporal comparisons in a way that is unaffected by inflationary changes or exchange rate adjustments.

Derivation

The employment generator, $\emptyset$, will be expressed in terms of three ratios, r, p, and q. These are defined as follows:

$r = W/C$,	the wage bill, W, in total costs, C.
$p = w_s/w_u$,	the ratio of skilled to unskilled wages.
$q = N_u/N_s$,	the number of unskilled workers employed for every skilled worker.

The wage bill, W, is equal to the daily wage rate, including fringes, w, times the number of workdays, N, of each type of worker--skilled, s, and unskilled, u.

$$W = w_s N_s + w_u N_u \tag{2}$$

Using the second two ratios above, we can simplify matters by expressing everything in terms of the wages of unskilled workers, w_u, and the number of skilled workers, N_s, since $w_s = w_u p$ and $N_u = N_s q$.

$$W = w_u N_s (p + q) \tag{3}$$

We now have the employment of skilled workers for a given wage bill.

$$N_s = \frac{W}{w_u(p + q)} \tag{4}$$

Using the ratio, r, or W = rC, skilled employment can be related to the cost of the project,

$$N_s = \frac{rC}{w_u(p + q)} \tag{5}$$

Since the number of unskilled workers is equal to qN_s, total employment, $N = N_s(1 + q)$, or

$$N = \frac{r(1 + q)}{(p + q)} \cdot \frac{1}{w_u} \cdot C \quad \text{and} \quad \emptyset = \frac{r(1 + q)}{(p + q)} \tag{6}$$

$$N = \emptyset \cdot \frac{1}{w_u} \cdot C \tag{7}$$

The first term of (6) relates the three ratios to one another and is the generator, $\emptyset$. The second term is the reciprocal of the unskilled wage rate. Together these two constitute a multiplier that relates the total cost of a project, C, to the employment, N, that is generated. Because of the possibility of inflation, the term with the ratios, $\emptyset$, is likely to be more stable than the other two. But r and q may vary with the type of project, i, and should actually be expressed as r_i and q_i.

As an example, how much employment will be created by a $10 million project if one fourth is spent on wages with skilled workers making up a third of the labor force and earning twice as much as unskilled workers, who earn $5 daily?

In this case, $\emptyset = \frac{\frac{1}{4}(1 + 2)}{(2 + 2)} = .1875$

$$N = .1875\ (1/\$5)\ (\$10{,}000{,}000)$$
$$= 375{,}000 \text{ workdays.}$$

The Employment Generator in Three Countries

To determine the range of the employment generator, members of a Housing in Development Unit at Michigan State University during the summer of 1979 carried out detailed surveys in Colombia, Kenya, Pakistan, Sri Lanka, Tunisia, and Zambia. Skilled and unskilled labor needed to build a standard 25.9 M^2 expandable dwelling on a 72 M^2 lot were determined for different volumes to be built by building firms of different sizes. In addition, labor needed to build alternative designs was estimated. Combined with total costs and wage rates, employment generators can therefore be found not only for each dwelling but in a disaggregated way for its components. All that will be reported later.

Here we shall offer a preliminary morsel to suggest that the range of the employment generator is not great, that it may vary only 6 percent up or down from 0.2 for dwellings as a whole. Consider the figures in Table 1. Common building laborers earn 17 times as much daily in unionized United States cities as in a Latin American capital and 83 times as much as in a semirural Asian town. But the share of labor earnings remains close to one quarter, and the employment generator goes only from .212 (Anuradhnapura) to .188 (Mexico City) and then back to .201 (United States).

What has changed conspicuously is the premium paid for skills--67 percent, Anuradhnapura; 39 percent, Mexico City; and only 27 percent, United States. As both cause and effect of this trend, the 3:1 ratio of unskilled to skilled workers drops to a 1:3 ratio. If both dwelling and worker categories had been homogeneous--which is far from the case--we could reckon that the elasticity of substitution between skilled and unskilled labor is very high, close to 5, meaning that a 1 percent change in the wage ratio causes a 5 percent change in the skill ratio.

The presence of skilled workers reduces employment by just about one-fifth at all levels of development. The possibility of substituting better capital and materials inputs seems to limit the labor share to a one-quarter "wages fund." Changing the skill-mix does not much change employment because one either has very few skilled workers who get a high premium or many with a low premium to an extent that just exhausts the wages fund without additional hiring. If this is true, as an empirical regularity, rather than a logical necessity, then the employment formula becomes

$$N = \frac{.8r}{w_u} C$$

Table 1

EMPLOYMENT GENERATION IN SINGLE STORY HOUSING IN SRI LANKA, MEXICO, AND THE UNITED STATES

Place	6 Workdays per $1,000,000	1 Wage Bill in Total Costs r	2 Ratio of Skilled to Unskilled Wages p	3 Number of Unskilled Workers per Skilled Worker q	4 Employment Generator Ø	5 Unskilled Daily Earnings (US$) 1979
1. Anuradhnapura, Sri Lanka	212,000	.25	1.67	2.75	.212	1
2. Mexico City	37,600	.23	1.39	.765	.188	5
3. United States	2,400	.24	1.27	.35	.201	83

SOURCES: (1) Field interviews by the writer at Anuradhnapura, July 1979. Dwellings had a floorspace of 40 M^2, plastered loadbearing brickwalls, and asbestos sheet roofs. Water came from wells and each dwelling had a septic tank. Dwellings were sold for 40,500 rupees or $2,700 (US).

(2) Mexican data comes from Christian Araud and Santiago Rincón Gallardo, "Direct and Indirect Employment Effects of Eight Representative Types of Housing in Mexico," in G. Araud, G. Boon, V. Urquidi, and W. P. Strassmann, Studies on Employment in the Mexican Housing Industry (Paris: OECD, 1973), pp. 45-113. The 47.3 M^2 dwelling estimated has the average specifications of seven low-cost dwellings that were actually being constructed around 1970 in Mexico City. The 1970 cost without land was 12,940 pesos or $1,169 (US), according to a best-practice cost manual by Alfredo Plazola Cisneros, Normas y Costos de Construcción, 2d. ed. (Mexico: Editorial Limusa-Wiley, 1965). The legal minimum wage due to unskilled construction workers in 1970 was 32 pesos daily or $2.56 (US), but a survey by G. Treviño of 150 workers found that the actual average was only 25 pesos or $2.00 (US). G. Treviño, "Los peones en la industria de la construcción," thesis, National Autonomous University of Mexico, 1970, cited by Dimitrios Germidis, The Construction Industry of Mexico (Paris: OECD, 1972). For 1979 the dollar amounts should be doubled.

Table 1: SOURCES (Cont'd.)

(3) United States figures come from Building Construction Cost Data: 1979 (Duxbury, Mass.: R. S. Means, 1978) and Bureau of Labor Statistics, Labor and Material Requirements for Construction of Private Single-Family Houses, Bulletin 1755 (Washington, D.C.: 1972), pp. 11-15. In 1969 the average three-bedroom house had 130.5 M^2, cost $22,083, and required 1,215 hours of onsite labor. Average hourly earnings were $3.94. By early 1979 union wage rates in the 30 largest cities were: common building laborers $10.40, bricklayers $13.45, painters $12.30, plumbers $14.70, carpenters $13.20, electricians $14.85, plasterers $12.80, roofers, $12.60, tile layers $12.70. Standard crew compositions for different operations are given in the Means volume, pp. v-xii.

or when r = .25,

$$N = \frac{.2}{w_u} C \tag{8}$$

If one could build exclusively with unskilled workers, employment effects could be estimated with a formula like that of equation (1) above, $N = \frac{r}{w_u} C$. Equation (8) is even simpler. But is it stable?

Range of the Employment Generator

Possible variations in the employment generator can be explored by assuming plausible combinations of p, q, and r. Since the telling interaction is between p and q, we shall keep r at a constant .25. One way to approach the task is to assume a value for Ø and either p or q. In this case, one solves equation (6) in the form of either equation (9) or (10).

$$p = \frac{r(1 + q)}{\emptyset} - q \tag{9}$$

$$q = \frac{\frac{p\emptyset}{r} - 1}{1 - \frac{\emptyset}{r}} \tag{10}$$

For example, Table 2 begins with a "Typical Set" of p-q combinations that leave Ø at a .2 level. If the skill premium is 100 percent (p = 2), three unskilled workers are used with each skilled one. Unskilled labor disappears when the skill premium falls to 20 percent. This set resembles that of Table 1.

If that ratio of unskilled to skilled is deemed too high, one can bring it far down and develop a second set of employment generators that remains at .1875. Or one can bring the skill premium far down and have a set of Ø's

Table 2

HYPOTHETICAL VALUES OF THE EMPLOYMENT GENERATOR, Ø, WITH ALTERNATIVE LEVELS OF THE SKILL RATIO, q, AND THE WAGE RATIO, p

Case	p	q	Ø
1. Typical Set	2.00	3.00	.200
	1.63	1.50	.200
	1.50	1.00	.200
	1.38	.50	.200
	1.20	0	.200
2. Relatively Low Unskilled Ratio	2.00	2.00	.1875
	1.67	1.00	.1875
	1.50	.50	.1875
	1.33	0	.1875
3. Relatively Low Wage Ratio	1.500	3.00	.2222
	1.312	1.50	.2222
	1.250	1.00	.2222
	1.188	.50	.2222
	1.125	0	.2222
4. Extreme Combinations			
Low Ø	2.500	1.00	.1429
High Ø	1.200	3.00	.2381

NOTE: r is assumed to be .25.

at .2222. (See the second and third sets in Table 2.) Unskilled workers now disappear with a 33 percent premium, which is higher than that of the United States or with a mere 12.5 percent premium which seems low.

Since p and q will move in opposite directions, one has to make rather extreme assumptions to find a $\emptyset$ outside of the .18-.22 range. To bring $\emptyset$ down to 0.14 one has to assume than an enormous 150 percent skill premium does not lead to more employment of unskilled than skilled workers. The skill ratio is only unity. To bring $\emptyset$ up to .24 one has to assume that even with a mere 20 percent skill premium, skilled workers will be only a quarter of the labor force.

As a generalization we can say tentatively that although $1.2 < p < 3.0$ and $0 < q < 3.0$, the $\emptyset$ range is $.18 < \emptyset < .22$. We can also observe that $\emptyset$ is much more sensitive to the wage differential for skills than to the employment mix. Suppose p=1.5, q=1.0, and $\emptyset$=.2 as in the third line of Table 2. A look at the seventh and eighth lines of the table shows that p has to rise much less than q would have to fall if $\emptyset$ is to fall to .1875. With the other constant, p would have to rise by only 11.3 percent to 1.67, while q must fall by 50 percent from 1.0 to .5. To bring $\emptyset$ up from .2 to .2222, p would have to fall only a sixth from 1.5 to 1.25; but q would have to triple and rise from 1.0 to 3.0. Since q appears in both the numerator and denominator of equation (5), its variations have less of an effect than those of p, which is only in the denominator. Moreover any given change in either p or q will have less of an effect on $\emptyset$ if the level of the other term (q or p) is high than if it is low.

If $\emptyset$ is held constant through the offsetting variations in p and q, as in the top three sets of Table 2, then elasticities of substitution

between skilled and unskilled labor may be estimated. They will typically be around 5.0, but higher when p and q are low, and lower when they are high.

The underlying cause is intuitively obvious. When skilled wages rise, average wages rise, and out of a given one-quarter wages fund, fewer workers of both types can be hired. On the other hand, if the proportion of skilled workers is to rise, average wages will rise, too; but most of the unskilled workers laid off are replaced by newly hired skilled workers. One could achieve that result in two steps. First, lay off enough unskilled workers to reach the new lower q. Then use the funds thereby released to rehire both skilled and unskilled workers in the new proportion.

Employment Projections with Changing Wage Differentials

Economic development consists of rising productivity, hence rising incomes. A corollary of rising productivity, however, is that given changes in output will generate less and less employment. In times of labor scarcity, the need for less labor is a blessing; but in the presence of unemployment, the need to accelerate output growth for constant employment effects may cause problems.

In the case of onsite construction employment, loss of jobs is due to two causes: (1) the substitution of equipment and more processed materials for any type of labor, and (2) the substitution of skilled for unskilled workers. Since the second effect occurs only as education spreads and demographic trends slow down, generating work with construction projects grows more difficult as countries develop. The aim here is to illustrate that pattern with a hypothetical example using a few plausible growth rates and ratios.

During the initial period, wages of skilled workers are assumed 50 percent above the unskilled, and therefore 50 percent more unskilled than skilled workers are employed. If the wage bill is one-quarter of costs, and if unskilled workers earn $50 monthly, equation (6) suggests that 4,166 months of work will be created by a $1,000,000 project.

For the first ten years, unskilled wages fail to rise since such workers appear to be in "unlimited" supply. Wages of skilled workers rise at an annual 3 percent and go from 50 percent to 102 percent above unskilled wages. Unskilled employment tends to rise as such workers are substituted for the skilled in accordance with the elasticity of substitution. We have assumed a low elasticity (σ) of 0.8 in order to differ further from Table 2. If $\sigma = 0.8$, as the skilled-unskilled wage ratio rises by 100 percent, the unskilled-skilled employment ratio rises by only 80 percent. A change in the ratio does not, however, imply much of a change in employment by itself.

Indeed, any employment generation is more than offset by the fact that the rising wages of skilled workers have led to enough substitution of offsite factors for all labor that the share of wages in total costs remains one-quarter. The labor share is half of the value of materials which, in turn, are half of total costs. Altogether, as may be seen in the simulation results of Table 3, in the first ten years 460 jobs are lost as employment falls from 4,166 to 3,706. Four hundred skilled workers have been displaced, but only sixty unskilled. If all these workers were to be absorbed through a rising volume of construction, the annual growth rate of that would have to be 1.2 percent--a modest amount.

For the period from the tenth through the thirtieth year, we have assumed a transition during which unskilled wages begin to rise although

replace this in MS, P. 13

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Table 3

SIMULATION OF GROWTH IN WAGES FOR SKILLED AND UNSKILLED WORKERS AND EMPLOYMENT GENERATION BY A GIVEN VOLUME OF CONSTRUCTION

Year	Monthly Wages Unskilled (Dollars)	Monthly Wages Skilled (Dollars)	p Ratio of Skilled to Unskilled Wages	q Ratio of Unskilled to Skilled Employment	Ø Employment Generator	Employment Months Generated by a $1,000,000 Project
0	50	75	1.50	1.50	.2083	4166
5	50	87	1.74	2.02	.2008	4016
10	50	101	2.02	2.72	.1962	3924
15	55	117	2.13	3.03	.1952	3904
20	61	135	2.21	3.26	.1947	3192
25	67	157	2.34	3.65	.1941	2897
30	74	182	2.46	4.03	.1938	2619
35	95	211	2.22	3.29	.1946	2048
40	121	245	2.02	2.72	.1962	1621
45	154	284	1.84	2.26	.1987	1290
50	197	329	1.67	1.86	.2025	1028

NOTE: Assumptions are the following: (1) Skilled wages rise at a steady 3 percent annual rate. (2) Unskilled wages do not rise for 10 years, then rise at an annual 2 percent for 20 years, followed by an acceleration to 5 percent annually. (3) The elasticity of substitution between skilled and unskilled labor is 2.0. (4) Although the efficiency parameter of the underlying CES production function rises, the function is homothetic and keeps its shape with a substitution parameter of -0.5 and a distribution parameter of 0.5505. (5) The elasticity of substitution between all types of labor and non-labor inputs is 1.0. The share of all labor inputs therefore remains at 25 percent of costs.

not as much as skilled wages. Several countries that are still classified as "developing" have already reached that stage. For illustrative purposes, skilled wages are still rising at 3 percent annually, but unskilled wages are now growing at an annual 2 percent. In the thirtieth year the differential between the two reaches a peak of 146 percent, and for every skilled worker 2.27 unskilled are employed. Meanwhile the combined effect of rising labor costs will have led to the displacement of 1,371 additional workers; 555 skilled and 816 unskilled. To offset these losses, construction would have to grow at an annual 2.3 percent.

Finally, we reach a period when the wage rates for jobs classified as unskilled begin to catch up with other wages, growing at an annual 5 percent, compared with the continuing 3 percent for skilled wages. After 20 years of this pattern, in the 50th year, the ratio of skilled to unskilled wages has fallen from 2.46 back to 1.67, and the ratio of unskilled to skilled workers is back to 1.64. Enough substitution of offsite factors will have occurred (by assumption) to keep the wages share at one quarter, so that we now find that the $1,000,000 project requires only 1,012 workers. A further 1,323 jobs have been lost: 325 skilled jobs and 998 unskilled jobs (man months).

Note that in the first stage, many more skilled than unskilled jobs were lost, while in the last stage the pattern was reversed. A naive analysis might look for specific techniques that came in during the first stage to be used by the unskilled to displace the skilled. During the last stage the new techniques to be identified would use relatively more skilled operators to displace unskilled workers. Such techniques would indeed be found. But they are not themselves the sole causes of the employment

patterns. They are not likely to have appeared and been adopted in reverse sequence, first the unskilled-displacing, then the skilled-displacing. The story would be incomplete without noting the differential availability and wage rates of skilled and unskilled workers as causal factors.

During the final twenty years, the volume of construction would have to grow at an annual 4.3 percent to avoid a loss of employment. The average compound rate for the entire 50 years has to be 2.9 percent. Output or productivity of this labor force will have more than quadrupled--just as their wages will have quadrupled. In the last year the unskilled will get $197 monthly and the skilled $328 monthly, 3.9 and 4.4 times the initial amounts, respectively.

In the course of this process, the employment generator necessarily behaved as might be expected. It began around 0.2, fell, and recovered to a 0.2 level. Its course may be observed in the fifth column of Table 3. From the twentieth to the thirty-fifth year, $\emptyset$ went below the limit of .18 that was set forth in the previous section. The low substitution elasticity of 0.8 and the high skill premium of 146 percent that was allowed to develop caused the unusual drop. Yet a $\emptyset$ of .1728, its lowest point, was still not an enormous deviation. If employment estimators had continued to use $\emptyset$=0.2, their reckonings would have been only 13.6 percent too high in the worst year, which is not too bad as such forecasts go.

At this point it may be wise to unsettle any budding confidence in $\emptyset$=0.2 by noting its great diversity among the different processes that make up the components of a building.

A Mexican Example

Some years ago, as already cited above, costs of Mexican residential construction were analyzed carefully by Christian Araud and Santiago Rincón Gallardo, and their data can be adapted to our framework. In the case of a low-cost 47.3 M^2 house, we estimated the employment generator Ø as .188. The implication is that with a monthly wage of $100 for unskilled workers, one million dollars spent on such housing would generate 1,800 months of work or 157 onsite work years.

Table 4 gives a breakdown of onsite costs into ten categories--clearing and levelling the site, excavation and trenching, foundations, walls, roofing, flooring, painting, plumbing, electrical work, and carpentry or metalwork. Each of these generates a different amount of employment in accordance with its labor intensity and overall weight. Installation of plumbing and related fixtures is the most costly component and accounts for 27.5 percent of onsite costs. Its onsite employment generator, however, is the lowest (Ø = .09) because labor is a low percent of costs (r=.12) and because only one unskilled worker is hired for every two skilled workers (q=.46). The plumbing wage bill is concentrated on trained plumbers.

At the other extreme are the earthmoving activities at the beginning of the construction process, clearing, levelling, excavation, and trenching. These involve no materials at all, and for every skilled worker several unskilled are hired. The employment generator is high (Ø = .7), but this activity comes to only two percent of onsite costs.

In building the foundations, walls, and the roof--the basic shell--skilled and unskilled workers are used in almost equal numbers. Typically

Table 4

ONSITE COSTS OF A 47.3 M^2 LOW-COST HOUSE, MEXICO 1965-70

	Onsite Costs $	%	Materials	r	Labor $	Unskilled Labor $	Skilled Labor $	l (6/7)	q	ø
1. Clearing, Levelling Site 71 M^2	13.55	1.5	--	.750	13.55	9.17	4.38	2.09	2.91	.68
2. Excavation & Trenching, 7.6 M^3	4.76	.5	--	.750	4.76	4.02	.74	5.43	7.55	.72
3. Building the Foundation, 6.9 M^3	56.58	6.5	38.16	.244	18.42	7.79	10.63	.73	1.02	.20
4. Walls, 95.5 M^2	79.75	9.1	34.38	.427	45.37	18.94	26.43	.72	1.00	.36
5. Roof, 54.8 M^2, vaulted	187.59	21.4	141.63	.184	45.96	19.62	26.34	.74	1.03	.15
6. Flooring, 47.3 M^2 (7% glazed tiles, 88% other tiles, 5% cement)	75.77	8.6	47.35	.281	28.42	8.63	19.79	.44	.61	.23
7. Painting (whitewash), 191 M^2	28.72	3.3	11.31	.455	17.41	3.51	13.90	.25	.35	.35
8. Plumbing & Fixtures										
Faucets			10.10							
Toilet			19.52							
Shower			9.37							
Sink			22.48							
Wash Basin			14.39							
Water Tank			48.24							
Others (pipes, etc.)			78.26							
TOTAL, Plumbing	240.98	27.5	202.36	.120	38.62	9.53	29.09	.33	.46	.09
9. Electrical	129.80	14.8	83.13	.360	46.67	11.67	35.00	.33	.46	.28
10. Carpentry & Metalwork										
Doors			15.57							
Latches			1.47							
Windows & Glass			32.01							
TOTAL, Carpentry & Metalwork	59.01	6.7	49.05	.127	9.96	2.99	6.97	.43	.60	.10
TOTAL	876.51	100.0	607.37	.230	269.14	95.87	173.27	.55	.765	.188

SOURCE: See text

NOTE: Costs are given in dollars. US $1 = 12.50 pesos. The skilled-unskilled wage-ratio, p = 1.391. Offsite costs equal one-third of onsite costs.

each skilled worker has a helper. The ratio of labor to materials is highest in building the walls, however, yielding a Ø of .36 and lowest for the roof, Ø = .15. After plumbing, the roof is the most expensive component with a cost of 21.4 percent of the total. Although the surface of the roof, 54.5 M^2 is only 57 percent as large as that of the walls, building it takes about as much labor, and material costs are four times as much. According to experts a roof that falls in causes resentment, so one cannot be too careful.

In all the final stages of construction, categories 6-10, about one unskilled worker is used for every two skilled workers, who install relatively expensive materials. Hence the employment generators tend to be low. Flooring, painting, carpentry, metalwork, and electrical fixtures come to one-third of onsite costs or one-fourth of structural costs without the site. By leaving tiling, painting, and the installation of some fixtures to the occupant, perhaps half of these final costs can be saved, reducing the price of housing by about ten percent. Employment is not lost but merely shifted to others.

The physical dimensions assumed by Araud and Rincón Gallardo are an average of seven dwelling types built in the vicintiy of Mexico City around 1970. Their floorspace ranged from 38 M^2 to 61 M^2 and averaged 47.3 M^2 as previously mentioned. Most other averages are shown in Table 4. In addition, bathrooms averaged 2.15 M^2, the kitchen 2.53 M^2, and the area of windows was 4.96 M^2. From these dimensions, the cost of materials and the labor needed for installation were derived. Much reliance was placed on Alfredo Plazola Cisneros, Normas y Costos de Construcción, 2d. ed. (Mexico: Editorial Limusa-Wiley, 1965). This handbook gives reasonable coefficients per M^2 etc. at representative work sites in the Federal District of Mexico. Although

Plazola distinguishes among a variety of occupations, Araud and Rincón Gallardo combined them into skilled and unskilled.

Offsite costs were not analyzed by Plazola, but Araud et. al. found the following, summarizing everything;

Table 5

WORKYEARS GENERATED BY A LOW-COST 47.3 M^2
MEXICAN HOUSE, 1965-70

Dwelling	Workyears	
Onsite Skilled	.175	
Onsite Unskilled	.134	
Total, onsite	.31	
Offsite	.05	
Indirect, Materials	.15	
Total, Dwelling		.51
Infrastructure		
Construction	.06	
Indirect, Materials	.02	
Total, Infrastructure		.08
TOTAL EMPLOYMENT		.59

Employment Generation in Infrastructure

In the Mexican project, using our analytical framework, employment generation by the infrastructure was of the same order of magnitude as employment generation by the dwelling itself, that is, the relation of workyears to cost. The following relations obtained:

$$p = 1.391$$
$$q = .825$$
$$r = .252$$

Hence,

$$\emptyset = .208.$$

The employment generator, $\emptyset$, is about 10.6 percent larger than that for the structure of low-cost single family dwellings ($\emptyset = .188$). Of course, these generators refer only to on-site employment. Building infrastructure is more labor-intensive, partly because the wage bill is higher, raising r, and also because more unskilled workers can be used, raising q from .765 to .825. This tendency is somewhat offset by the lower labor intensity of materials used for roads, ditches, sewers, and water pipes. For every three onsite infrastructure jobs, only one was created in the materials; while the ratio in low-cost dwelling construction was two-to-one, according to the Mexcian data.

Cost components and employment from infrastructure are best estimated for an <u>area</u> that is to be serviced rather than on a per <u>dwelling</u> basis. Through use of the average lot size, infrastructure and dwelling effects can then be related to one another. For the sake of comparability, effects outside of an area should be omitted, meaning the connection of drainage

or sewerage systems to distant collectors, the expansion of electric generating capacity elsewhere, and the like. Soils should be assumed to have an average degree of flatness and rockiness.

A common way of estimating infrastructure costs is "per saleable M^2 of land." Thus if 14 lots of 71 M^2 are to be sold, there are 994 M^2, roughly 1,000 M^2 of saleable land. Infrastructure for 47.3 M^2 low-cost Mexican housing at such a density cost the following in 1970:

Table 6

1970 INFRASTRUCTURE COSTS FOR LOW-COST MEXICAN HOUSING PER 1,000 M^2 OF SALEABLE LAND (U.S. DOLLARS)

Earthwork	$494	
Excavation		$ 54
Hauling		98
Other		342
Sewer System & Drainage	$448	
Excavation		$ 37
Cement Pipes		202
Drains		31
Compacting		16
Rainwater Lines		111
Well		37
Collectors		14
Drinking Water	$338	
Excavation		$ 23
Cement Pipes		188
Individual Connections		60
Valves		8
Compacting		9
Special Pieces		50
Roads	$276	
Curbs		$131
Sidewalks		97
Pavement		48
Electricity	$197	
Street Lighting	$ 37	
Street Signs	$ 6	
TOTAL	$1,796	

Per dwelling costs were $128 for the infrastructure. Of this amount, 25.2 percent went for labor on the site or $32. In physical terms it was 0.72 workmonths--0.33 for unskilled labor and 0.39 for skilled labor. These observations should be treated with some reserve because they came from the records of a single enterprise.

To sum up, the cost breakdown of this prototype dwelling, built according to the best-practice methods of 1965-70, was:

71 M^2 site without infrastructure @ $4/$M^2$	$ 284
Infrastructure	128
Offsite costs, dwelling	292
Onsite costs, dwelling	877
TOTAL	$1,581

The onsite employment generated by the infrastructure and the dwelling was 0.37 workyears. That is 8.6 percent less than the 0.405 workyears that would have been estimated by the rough formula (8) suggested earlier in this paper.

$$N = \frac{.2}{w_u} C$$

$$= \frac{.2}{\$640} \$1297$$

$$= .405.$$

In 1970 the minimum unskilled daily wage in Mexico City was 32 pesos or $2.56. Assuming 250 workdays in a year, we have an annual unskilled wage of $640. Of course, all the figures except the workyears have to be about doubled to maked them comparable with others expressed in 1979 dollars. But since the monetary corrections multiply the numerator and denominator equally, they make no difference to employment.

Summary

A simplified way of estimating employment in construction must confine itself to that onsite. One should focus on the labor share in costs, the skill composition, and the pay differential for skills. The employment generator that was derived in these terms, $\emptyset = r(1 + q)/(p + q)$, varied surprisingly little from 0.2 for dwellings as a whole under different assumptions and in different settings. One set of assumptions changed the skill composition and the pay differential from one extreme to another. Employment generation was found to be more sensitive to the pay differential than to the skill composition.

A simulation model showed what happens to employment if unskilled wages lag behind the skilled in early development and then catch up. The employment generator declined somewhat from 0.2 and then recovered. But since the generator must be deflated by the unskilled wage rate, $\emptyset/w_u$, and since that rate lags, construction employment will be higher and fall less in early development.

Although not conclusive, a comparison of an Asian rural town, a Latin American capital, and the United States, bore out that the employment generator is close to 0.2 under different conditions and that it dips slightly at the (Mexican) middle-income level. Data from an earlier Mexican study could be used to show that the 0.19 level of the employment generator in that country was the weighted average of widely diverse generators from excavation, masonry, roofing, plumbing, etc. They ranged from .09 to .72. To learn more about the reliability of the employment generator, especially with respect to housing for the poor built by small enterprises, fieldwork has been carried out in Colombia, Kenya, Pakistan, Sri Lanka, Tunisia, and Zambia.