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## Factor Market Structure and Technology Choice in the Colombian Brick Industry

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IN THE COLOMBIAN BRICK INDUSTRY

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FACTOR MARKET STRUCTURE AND TECHNOLOGY CHOICE  
IN THE COLOMBIAN BRICK INDUSTRY

Mary Ann Bailly

Abstract

This paper examines the relationship between factor markets and a pattern of technology choice such that capital-intensity is correlated with size. Empirical evidence shows that wages vary positively with size of firm even after correcting for education, experience, turnover and firm location. Secondary source evidence suggests that capital access differs across entrepreneurs, according to characteristics relating to their positions in Colombian society. These assumptions are combined in a simple model which can generate the technology pattern observed.

This imperfect market model is compared to the hypothesis that capital access improves over a firm's lifetime, so that the pattern represents a growth path. The evidence does not tend to support this hypothesis.

## FACTOR MARKET STRUCTURE AND TECHNOLOGY CHOICE IN THE COLOMBIAN BRICK INDUSTRY

### INTRODUCTION

Casual observation and industry level data suggest that in many developing countries, industry structure exhibits a common pattern. There is great variation in size of firm. Large firms seem to be more capital-intensive, to pay higher average wages and to have more favorable access to investment funds than small firms.

Given the high unemployment in most developing countries, and the desire of governments to encourage investment with high employment-generating impact, this structure is of obvious policy significance. However, casual observation has often proved misleading in the past in developing countries, and industry level statistics can be difficult to interpret. The measures of output, capital and labor are generally weak, and the level of aggregation is high. Thus, it could be argued that the phenomenon does not really exist. Since heterogeneous products are being aggregated together in one industry, and the measure of labor does not allow for differences in skill level, it could be that the industry statistics are really aggregating together a series of different industries, with different production functions. There is a representative firm in each of the industries which uses a different combination of skilled labor, unskilled labor, and capital, and is of a different scale.

Thus one might ask, does the pattern described above really exist at the microeconomic level within a more narrowly specified industry. If

so, what is the relationship among size, capital-intensity and the structure of capital and labor markets, such that this pattern is produced.

In this paper, we present evidence from a micro-level study of one industry in one developing country: the clay brick industry in Colombia. The paper is based on survey data from an interview study of individual firms and on secondary sources on the structure of Colombian labor and capital markets. We find that there is great variation in technology choice across firms and capital-intensity is correlated with the size of firm. Evidence is presented on the existence of structural imperfections in the labor and capital markets. A simple analytical model is used to show that these imperfections are consistent with the patterns of technology choice observed.

#### CHARACTERIZATION OF TECHNOLOGY CHOICE

The main processes in the production of clay bricks are the excavation and preparation of the clay, the forming and drying of the raw bricks, and the firing of the bricks in kilns. For each process, there is a variety of alternatives available, from purely manual to highly mechanized.

After preliminary factory visits and discussion with local industry experts, the Colombian industry was divided into eight major categories of technology choice, based on the major alternative choices observed in the forming, drying and firing processes: (The choices are arranged here from most to least capital-intensive, within each process).

Forming: semi-dry press process

extrusion with de-airing--imported process

Colombian adaptation

without de-airing

manual molding

Drying: artificial drying - tunnel dryer  
chamber dryer

natural drying

Firing: continuous kiln - tunnel kiln

Hoffmann kiln

intermittent kiln - vertical flame (updraught) or inverted  
flame (downdraught)

A brief description of the alternatives:

The simplest method of forming bricks is by hand in simple wooden molds. In the extrusion process, the bricks are extruded by machine as a column of clay which is then cut with a wirecutting machine. A denser, stronger product can be made by removing some of the air from the bricks during extrusion, using a more complex machine. In the semi-dry process, much of the moisture in the clay is artifically removed first and the clay is then pressed by machine.

The most common drying method in Colombia is to store the bricks in sheds, which are open at the sides and covered on top, until the bricks dry naturally. In a chamber dryer, hot air is circulated around the formed bricks. The tunnel dryer is a continuous process dryer, in which bricks move on cars through a tunnel as warm air is passed over them.

Firing the bricks in intermittent kilns is a batch process. The bricks are placed in the kiln, fired, allowed to cool and then removed from the kiln. The Hoffmann kiln transforms the firing into a continuous process. It is composed of a series of individual chambers. The fire is moved from one chamber to the next and the bricks are continually loaded and unloaded in sequence as the fire moves and each chamber cools. The

tunnel kiln also involves a continuous firing process, but the fire is stationary and the product moves through the kiln on cars.

Table 1 shows the combinations of choices represented by the eight categories. We should note that by specifying the industry narrowly, product heterogeneity was greatly lessened but not eliminated. Within the clay brick industry, there are different products varying in characteristics which are related to variations in choice of technology. However the products are much closer substitutes than in broader industry classifications and no category produces a product which has no close substitute produced by some other category.

In the survey, each firm was classified into one of the eight categories. Then capital-labor ratios were computed for categories 2 to 8 from detailed data gathered from one or two representative plants in each category and from other industry sources such as capital goods importers. The capital figure was the approximate cost in Colombian pesos<sup>1</sup> of purchasing plant and equipment new in 1975 plus the costs of construction in 1975 (kilns, drying sheds, and simple factory shelters). Labor was the number of full-time production workers employed per month. In Table 1, the categories are numbered from most to least capital-intensive.

This procedure could not be used for category 1, which consists of a single firm using a sophisticated capital-intensive process and producing on an extremely large scale. This firm refused to cooperate with the study, and can therefore be incorporated in the analysis only to the extent that information about it is available from other sources. Although a capital-labor ratio could not be computed, there is no doubt that this category is the most capital-intensive.

Table 1: Categories of Technology Choice

Category Process	1	2	3	4	5	6	7	8
Forming	Semi-Dry Press Process	Extrusion with De-airing: Imported Process	Extrusion with De-airing: Imported Process	Extrusion with De-airing: Imported Process	Extrusion with De-airing: Imported Process	Extrusion with De-Airing: Columbian Adaptation	Extrusion without De-airing	Manual Molding
Drying	Tunnel Drying	Combination* of Tunnel and Natural Drying	Combination* of Chamber and Natural Drying	Natural Drying	Natural Drying	Natural Drying	Natural Drying	Natural Drying
Firing	Tunnel Kiln	Tunnel Kiln	Hoffman Kiln	Hoffmann Kiln	Inter-mittent Kiln	Inter-mittent Kiln	Inter-mittent Kiln	Inter-mittent Kiln

\*Only the single firm in Category 1 dries all of its output artificially



The procedure for determining capital-intensity is clearly an approximation. However, it is believed that this method gives a better approximation than could be obtained directly from the individual firms, since they did not have a very good idea of the value of their capital.

#### RELATIONSHIP BETWEEN SIZE AND CAPITAL-INTENSITY

Size was not used in the determination of the categories. However, size proved to be strongly correlated with capital-intensity of category. Two measures of size were used: total employment and value of capacity output.<sup>2</sup> Quantitative information was available for 47 firms in categories 2 to 8.<sup>3</sup> The correlation between size and capital-intensity as measured by category is

	Kendall correlation coefficient	Significance Levels
size measured by employment	-0.5261	.001
by value of capacity output	-0.6160	.001

The factory in category 1 is known to be the largest brick factory in Colombia; therefore, its inclusion would strengthen the result.

#### WAGE VARIATIONS ACROSS SIZE OF FIRM

As expected, average production wages were found to increase with size of firm. In this section, we discuss some of the possible reasons

for such variations and then test them empirically.

- 1) The money wage might vary because characteristics of the job vary with size of firm. In the brick industry, temperature conditions under which workers operate are usually less harsh in firms which have continuous kilns. Excavation by machine is less arduous than manual work. However, pleasantness of working conditions and size are both correlated with capital-intensity of technology, so this factor would tend to operate in the direction of lower wages for larger firms.
- 2) The productivity of workers may vary across firms because of a difference in turnover rates. The firm may have a choice among various combinations of turnover rates and wage rates, with a tradeoff between wages and marginal productivity caused by the effect of the turnover rates on the stability of the labor force. Large firms may have chosen the higher wage, lower turnover option to a greater extent than small firms.<sup>4</sup>
- 3) Large firms may be paying higher wages in order to obtain a more skilled labor force. According to local brick industry experts, there is little difference in skill level required for the different types of jobs in the factory, across categories or within an individual firm. Workers are usually rotated from one job to another within the factory. In the survey, most of the employers said that they were willing to hire inexperienced workers and to the extent that there was any variation by technology category and size of firm, it was the smaller, less capital-intensive firms that were unwilling.<sup>5</sup>
- 4) The labor market may be segmented into geographical regions by mobility costs, variations in minimum wage legislation or variations in the cost of

living. Firm size and location may be correlated in such a way that large firms tend to be located in higher wage areas.

In Colombia, there is a minimum wage, and it varies regionally. However, the variation is between rural and urban areas, and all of the firms in the sample were located in areas designated urban. (Typically, brick factories are clustered in areas with suitable clay deposits on the outskirts of the major cities.) Other locational factors are tested below.

5) Average wages may be higher in large firms because they are required by law to provide higher fringe benefits. Fringe benefits are a large fraction of total wage costs in Colombian firms. Government regulations require the payment of certain fringe benefits; the regulations vary somewhat by size of firm. Large firms (measured in terms of total capital) must pay higher annual bonuses. Firms with more than 10 workers or net worth of more than Col. \$50,000 must pay 6% of their payroll to the national apprenticeship program (SENA). All firms must pay 6% of their payroll to the social security program. Probably more important than these variations in laws across size of firm is the variation in the enforceability of the laws across size of firm. Small firms are more likely to evade laws relating to social security tax and fringe benefits.

6) Wages may vary across firms because of a differential impact of labor unions on large firms compared to small firms.<sup>6</sup> The government regulates the formation of unions, which are quite strong in Colombia. All the unions are enterprise unions, although they may also be members of broader associations; collective bargaining takes place on an individual factory basis. There is very strong legislation protecting the worker's job

security and the right to strike, which makes the strike a powerful union weapon.

According to law, there must be at least 25 people in a union before there can be a union in a particular factory. Thus by law there is a difference in the potential impact of unions by size of firm. This reinforces the usual labor economics arguments about why unions are likely to be more important in larger firms.

Detailed labor force data was available for 42 firms. To examine the influence of the above factors statistically, regressions were run relating the difference between a firm's average production wage and the average for the sample to variables measuring education, experience, turnover rate, degree of unionization and size of firm as well as variables for geographical region, all in logged and unlogged form. None of these variables was significant except size of firm. Education, experience and turnover frequently entered with the wrong sign. Size was generally significant and the magnitude of the effect was substantial. Size was measured by total employment, and by capacity output. When included together, employment became insignificant and the effect of size seemed to be measured best by capacity output.

The regressions were also run with dummy variables for the individual categories included in addition to size. These were not generally significant. Table 2 gives some of the final regressions.

Average production wage was computed including only those workers paid wages. Since the employment of family members, not subject to laws with respect to minimum wages and fringe benefits, is more important in

Table 2

## Wage Regression Results

Dependent Variable:

Average Hourly Wage of Production Workers by Firm--Average for All Sample Firms

Independent Variables:	Unlogged Form		Logged Form	
	Coefficient	t-Statistic	Coefficient	t-Statistic
Constant	7.994	11.86	1.669	10.02
Total Workers	0.011	0.78	0.009	0.11
Capacity in ten thousands	0.028	2.49	0.097	2.02
Dummy Cat 2	4.100	2.02	0.341	1.51
Dummy Cat 3	1.556	1.41	0.147	1.18
Dummy Cat 4	1.143	1.00	0.168	1.43
Dummy Cat 5	0.621	0.72	0.045	0.46
Dummy Cat 6	1.036	1.02	0.103	0.90
Dummy Cat 7	-0.971	-1.06	-0.107	-1.04

 $R^2 = 0.5498$  $R^2 = .5154$ 

Constant	8.205	13.36	1.676	11.17
Capacity in ten thousands	0.033	3.61	0.102	3.56
Dummy Cat 2	3.934	1.96	0.338	1.58
Dummy Cat 3	1.527	1.39	0.145	1.19
Dummy Cat 4	1.224	1.08	0.168	1.45
Dummy Cat 5	0.712	0.83	0.047	0.48
Dummy Cat 6	1.069	1.06	0.104	0.93
Dummy Cat 7	-0.926	-1.01	-0.106	-1.05

 $R^2 = 0.5414$  $R^2 = 0.5152$ 

Constant	7.997	11.32	1.944	9.46
Total Workers	0.004	0.18	-0.004	-0.05
Sales in hundred thousands	0.039	1.63	0.101	1.79
Dummy Cat 2	3.611	1.54	0.324	1.39
Dummy Cat 3	1.711	1.48	0.164	1.31
Dummy Cat 4	1.831	1.62	0.182	1.54
Dummy Cat 5	0.912	0.99	0.060	0.61
Dummy Cat 6	1.188	1.11	0.099	0.86
Dummy Cat 7	-0.793	-0.82	-0.101	-0.96

 $R^2 = .5055$  $R^2 = .5035$ 

Constant	8.034	12.04	1.935	20.91
Sales in hundred thousands	0.042	3.09	0.099	3.40
Dummy Cat 2	3.459	1.61	0.326	1.45
Dummy Cat 3	1.703	1.50	0.165	1.34
Dummy Cat 4	1.843	1.65	0.181	1.56
Dummy Cat 5	0.951	1.08	0.060	0.62
Dummy Cat 6	1.206	1.15	0.099	0.87
Dummy Cat 7	-0.772	-0.82	-0.102	-1.00

 $R^2 = .5050$  $R^2 = .5035$

the smaller firms, the actual average for those firms is lower. In addition, if there are biases in the data, firms paying very low wages would be more likely to overstate their true wages and fringe benefits in the survey to conceal the fact that they were paying less than legally required. Therefore, the sample data if anything understate the spread of wages across size of firm.

Since we did not have wage data for category 1, we could not include it in the regressions. What qualitative evidence we have suggests that this is a high wage firm. Thus wages for this category are likely to follow the same pattern, except that skill probably does have some effect on the wage in this firm. (See note 5)

We conclude that wage rates do increase with size of firm and the effect depends on the size of firm as measured by capacity output. The wage differential does not merely reflect a difference in the productivity of the workers, to the extent that we have succeeded in measuring potential differences in terms of education, experience and stability. It does not reflect a difference in the attractiveness of the job, since the dummy variables on category were insignificant, and in any case, that factor would tend to operate in the opposite direction.

Unionization was not significant in the regressions, but we think that it is more important in determining the outcome than this result suggests. Firms which are not unionized still have to worry about becoming unionized. According to qualitative statements in the interviews, firms frequently pay higher wages in order to avoid unionization. There are no union shops; workers are not required to belong to the union. The variable

measuring unionization is the percentage of workers who belong, and workers will be less likely to join if they are already satisfied with wages. The likelihood of unionization is greater for the larger firms, especially given the flat rule which sets a minimum number of members for the union.

The fact that wages increase with size of firm would, by itself, imply that the longrun cost curve for any prospective entrant would be such that larger output would be associated with greater capital-intensity. However, this does not explain the long term coexistence of large and small firms.

We turn now to variations in capital access across firms, and argue that the structure of the Colombian capital market is sufficient to explain this coexistence.

#### VARIATIONS IN CAPITAL ACCESS ACROSS SIZE OF FIRM

It is frequently argued that large firms have more favorable access to capital than small firms since they are better credit risks. One might say that the rental rate on capital paid by the firm is a decreasing function of output, just as the wage rate is an increasing function of output. From the point of view of model-building, the decision on the optimal scale of plant would involve balancing increasing unit cost of labor against decreasing unit cost of capital as output increased. There could be longrun coexistence of large firms and small firms with the same unit costs, and such that capital-intensity was positively correlated with size.

However the question of technology choice which is to be embodied in long-lived capital seems most natural in the context of a new entrant

into the industry. In this context, it seems odd to think that the bigger the plant the entrepreneur wants to build, the lower the interest rate he has to pay. We argue below that it is more natural to think of each prospective entrant as facing a horizontal or, more likely, upward-sloping supply curve of capital but one which varies systematically across entrepreneurs. Then variation in technology choice and size of firm is correlated with the characteristics of entrepreneurs which affect their access to capital.

It was much more difficult to obtain reliable quantitative information from firms on their capital access than on labor use. Therefore the discussion below is based on qualitative evidence from the interviews and on information about interest rates and lending policies from secondary sources, including publications of the financial institutions themselves.<sup>7</sup>

The capital market structure in Colombia is very imperfect. There is a major division in the market between the formal or institutional credit market, and the parallel or extrabank market. The formal market, composed of the usual financial intermediaries such as the commercial banks, savings and loan institutions, and development banks, is subject to extensive government control. There are portfolio requirements, which require that certain percentages of the reserves of financial institutions be held in the form of particular assets. Interest rates and terms of lending are controlled, at rates well below market-clearing rates. (Given the rate of inflation, at times the real interest rate has been negative). There is extensive rationing. Interest rate policy is used as an instrument to channel funds into particular sectors; the rates and lending terms differ for different borrowers and different loan purposes. The stock market is underdeveloped and relatively few companies are listed.



An elaborate structure of control has existed for a long period, at least two decades. As a result, an extensive parallel market has grown up, in which market forces set interest rates and the terms of lending. This market is not itself illegal, although some of the transactions in it are probably illegal, since they lend themselves to tax evasion. The market is well-organized; although it is called "extrabank" it does in fact make use of banking system instruments for collateral. The rates in the extrabank market are much higher than the controlled rates, and almost anyone can borrow at some interest rate. The higher rates reflect greater risk to some extent, but since overhead costs are low and the market is not illegal they primarily reflect market forces and the scarcity of capital in Colombia, which is obscured by the artificially controlled rates in the institutional market.

The structure described means that each entrepreneur (or set of associates) considering a project has a capital access function which can be quite complicated, given rationing and different interest rates for different uses. Capital access does depend to some extent on the nature of the project the entrepreneur has in mind. Formal credit lines generally require the security of a machine or building and thus to some extent discriminate in favor of capital-intensity. Credit terms tend to be better for imported machinery than for domestic machinery, since the former comes from large international companies with favorable access to capital themselves, and the latter is generally made in small Colombian workshops, which have poor access to capital. Of course any lender will be interested in the ability of the borrower to repay the loan, which means that he is interested in the profitability of the project.

However, while the nature of the project matters, the characteristics of the borrower are much more important. Colombian society is oligarchical. Those at the top of the oligarchy are related to others at the top. They can raise share capital through the issue of public shares or through family connections. They have the proper credentials to obtain large amounts of credit easily at favorable rates through the commercial banking system. The largest brick firm in the country which has the factory in category 1 is part of a large financial group which includes banking interests and two giant construction companies. The construction companies had extremely favorable access to capital during the period in which that factory was built, because of government policy favoring construction

Entrepreneurs of middle class origin have the educational background to obtain loans from special government credit lines for small and medium size industry, at concessional rates. These credit lines have the express purpose of increasing access to credit for those who are at a disadvantage in the normal sources. But the credit requires the firm to provide detailed accounting data. This adds a substantial cost element for the smaller firms, which are usually operated by people with little education and no accounting ability. Therefore, there is a bottom group of entrepreneurs whose only practical credit access is the extrabank market, at very high interest rates.

These entrepreneurs do, however, have an asset which has a low opportunity cost, namely their own and their family members' labor. To the extent that a project is such that they can transform their labor directly into capital, they can bypass the capital market. This is particularly important, in the brick industry, in the case of category 8, in which the

initial investment is low and a substantial fraction of it can be built with the entrepreneur's own labor.

The capital access function depends on characteristics of the entrepreneur for the above reasons, and also because the credit market's estimate of the profitability of the project will depend on characteristics of the entrepreneur. A higher level of education will be considered necessary for more complex projects. Equally important, given the extensive reliance in Colombia on quantity adjustments in markets and non-price allocation, the entrepreneur's "connections" will be important in determining the profitability of a project.

We hypothesize that this capital access schedule of each prospective industry entrant is a rising one, with the interest rate increasing with the amount of capital. This is not so much because individual credit sources raise their interest rates but because the entrepreneur reaches the limit of his ration for each source and has to turn to a higher cost source.

#### A SIMPLE MODEL

In this section we present a simple model of the relationship between the capital and labor market structure described above and technology choice.

Let the wage rate paid by the firm be

$$w = w(Q), \text{ with } w'(Q) > 0. \quad (1)$$

Let the marginal cost of capital to the firm,  $m$ , be a function of total capital  $K$  and a shift parameter  $s$ , which is a function of characteristics of the entrepreneur. The shift parameter is measured so that the larger is  $s$ , the better the entrepreneur's access to capital. (Figure 1)

$$m(K,s) \quad \frac{\partial m}{\partial K} > 0 \quad (2)$$

$$\frac{\partial m}{\partial s} \leq 0 \quad (3)$$

The function  $m(K,s)$  is a continuous approximation to a step-function, which represents the assumption that the firm is charged a constant interest rate by each source of funds but the total amount borrowed from that source is rationed. The cost function of a prospective entrant into the industry is derived by minimizing

$$C = w(Q) \cdot L + \int_0^K m(K,s) dK \quad (4)$$

subject to  $Q = F(K,L)$ , the production function.

The first order conditions are:

$$\frac{w(Q)}{m(K,s)} = \frac{F_L}{F_K} \quad (5)$$

$$\text{and } Q = F(K,L) \quad (6)$$

which define a family of cost functions

$$C(Q,s) = w(Q) \cdot L^*(Q,s) + \int_0^{K^*(Q,s)} m(K,s) dK \quad (7)$$

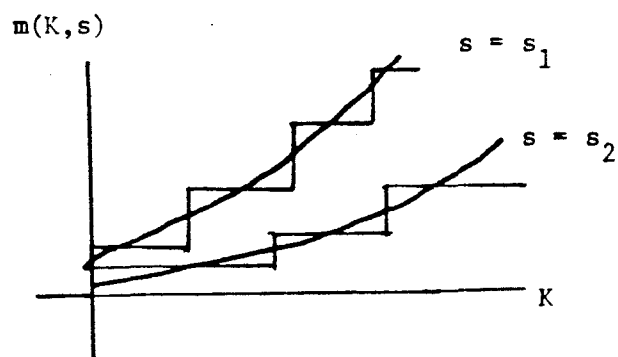


Figure 1

What do these cost functions look like?

In the case of a constant returns to scale production function, the average cost and marginal cost curves will still be upward-sloping for a given  $s$ , so that even with perfect competition, there will be an optimal size of firm. If there are increasing returns to scale, their effects will be blunted by the increase in per unit labor and capital costs at higher levels of output.

The assumptions made are not sufficient to imply that the capital-labor ratio will vary in a systematic way with the level of output for any given cost curve. Assume that the production function is homothetic (although it need not be constant returns to scale) so that there is no capital or labor-using bias in the production function itself as  $Q$  increases.

The first order conditions require that  $\frac{w(Q)}{m(K,s)} = \frac{F_L}{F_K}$ . Both  $w$  and  $m$

increase along the ray; depending on their relative rates of increase, the cost-minimizing capital labor ratio may increase, decrease, or remain the same. (Figure 2)

Consider what happens to the optimal size of firm and the degree of capital-intensity of the firm as capital access improves. The marginal cost function is:

$$MC = w(Q) \frac{\partial L^*}{\partial Q} + L^*(Q,s)w'(Q) + m[K^*(Q,s),s] \frac{\partial K^*}{\partial Q} \quad (8)$$

At the profit-maximizing point  $K_0, L_0, Q_0$ , whatever product market conditions are, costs are minimized; and  $\frac{w(Q_0)}{m(K_0,s_0)} = \frac{F_L}{F_K}$

(See Figure 3).

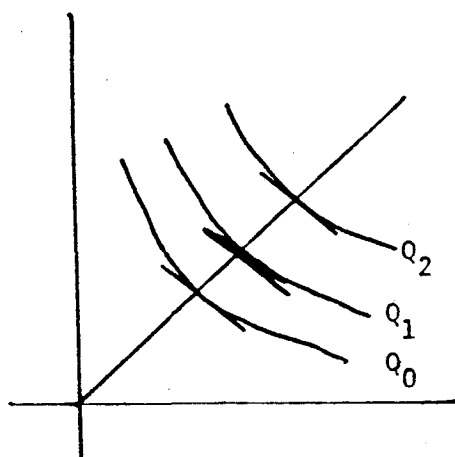


Figure 2

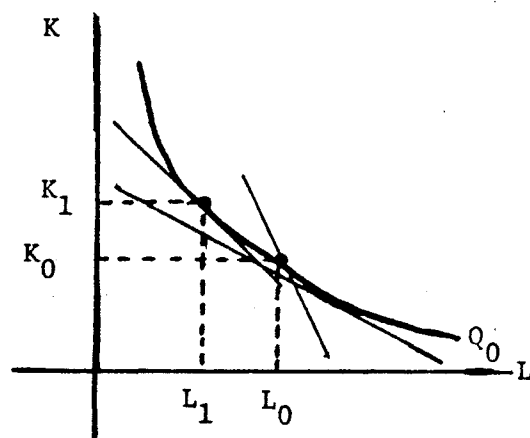


Figure 3



Raise  $s_0$  to  $s_1$ . The lefthand side increases, since  $\frac{\partial m}{\partial s} < 0$ . Keeping output constant and continuing to minimize cost implies increasing  $K$  and decreasing  $L$ , and moving to some new point  $K_1, L_1$ . Clearly  $\frac{w(Q_0)}{m(K_0, s_0)} < \frac{w(Q_0)}{m(K_1, s_1)}$  and the marginal cost of capital is lower at the new point.

The marginal cost of labor holding output constant is unchanged at  $w(Q_0)$ , and the effect on labor costs of increasing output, holding employment constant, is now smaller given the smaller labor force.

$$\text{i.e. } L_1 w'(Q_0) < L_0 w'(Q_0) \quad (9)$$

Therefore, marginal cost has unambiguously decreased, and output will be increased. The postulated shift in capital access does increase the optimal size of firm although the extent of the increase obviously depends on market conditions.

What happens to capital-intensity? Again, assume a homothetic production function. The above assumptions are not sufficient in themselves to guarantee that the capital-intensity of production will change, once the firm can adjust output as well as capital and labor. Let  $K_2, L_2, Q_1$  represent the new equilibrium. If the  $K/L$  ratio is unchanged or decreases, then it must be true that

$$\frac{w(Q_0)}{m(K_0, s_0)} \geq \frac{w(Q_1)}{m(K_2, s_1)} \quad (10)$$

or

$$\frac{m(K_2, s_1)}{m(K_0, s_0)} \geq \frac{w(Q_1)}{w(Q_0)} \quad (11)$$

(See Figure 4).

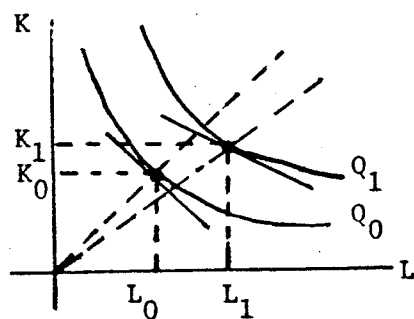


Figure 4

The marginal cost of capital must be higher in the new equilibrium, and the proportional change in the wage actually paid must be less than or equal to the proportional change in the marginal cost of capital actually faced. Although the capital market structure described above could generate this outcome, observation suggests the large capital-intensive firms do in fact have a lower marginal cost of capital than the smaller firms. The lender of last resort is the extrabank market. There is less use of this market by the firms in the more capital-intensive categories and the extrabank market offers more favorable interest rates to the type of entrepreneur that has a higher  $s$ .

Given this observation, the model predicts the pattern we observe: firms of varying sizes coexisting on a long term basis and such that size is positively correlated with capital-intensity.

#### VARIATIONS IN CAPITAL ACCESS OVER THE FIRM'S LIFETIME

Another way to model the assumption that large firms have better access to capital than small firms is to assume that all prospective entrants to the industry have the same initial capital access function but it shifts over the firm's lifetime. Once a firm is in existence, the availability of profits for reinvestment and the record of profitability established improve access to capital. Firms of different capital-intensities and sizes are observed because industry structure is a snapshot of a dynamic process. The entrepreneur entering the industry chooses an optimal growth path for the firm, not an optimal size. New firms are small and labor-intensive but they will grow up to be like the older, larger, capital-intensive firms.

To test this empirically, it would be useful to have information on the size and category of each sample firm when established. It was difficult to obtain good historical information from the firms, particularly the older ones. We were able to obtain the age of the firm, the size of the labor force at the end of the first year of operation (but not capacity output) and the ages of the major items of capital equipment. The data show that firms generally do grow over time. The change in the labor force is biased downward as an indicator of change in firm size, because of the slump in demand at the time of the survey; nevertheless, employment had increased for 36 of the firms and decreased for only 7 (unknown for 5 firms). Capital equipment had generally been added over time; for example, many firms had built additional kilns.

If the categories represent a growth path, then age of firm and current technology category (measured from most to least capital-intensive) should be negatively correlated. The correlation between (current) category and employment at the end of the first year of operation should be much weaker than the correlation between category and current employment.

The Kendall correlation coefficient between age of firm and category is  $-0.2240$ , with significance level  $.021$  (47 firms). The more capital-intensive firms do tend to be older, but the correlation is not very strong. The Kendall correlation coefficient between number of workers at the end of the first year and category is  $-0.3550$ , with significance level  $.001$  (for the 42 firms for which data was available). This is lower than the correlation between current employment and category ( $-0.5261$ ), but still substantial.

Table 3

<u>Category</u>	<u># of firms</u>	<u># of firms known to have started in same category</u>	<u># of firms for whom initial category unknown</u>	<u>Others</u>	<u># of firms set up in 70's and category</u>
1	1	0	0	1 started in cat 4	0
2	1	1	0	0	0
3	4	0	2	2 started in cat 4	2*
4	7	5	1	1 started in cat 5	3
5	9	6	3	0	5
6	4	3	1	0	3
7	10	6	4	0	3
8	<u>12</u>	<u>12</u>	<u>0</u>	<u>0</u>	<u>8</u>
Total	48	33	11	4	24

\*Both started in category 4

The more important question is: have the firms changed categories? Do the categories represent stages of growth or different types? The data were sufficient to identify an initial category for 37 of the 48 firms. (The eleven which could not be given an initial category were the oldest firms in the sample, as one might expect; all date from 1957 or earlier).

Table 3 summarizes the most important information.

Categories 3 and 4 are identical except that Category 3 firms have chamber dryers which may be used to dry part of the output. All the firms in this category acquired their dryers after the start of the firm and at about the same time (the early 70's), so all moved from Category 4 to 3 (and two firms may have moved from some other category since their initial category could not be determined). However, the general picture is not one of firms moving from the least capital intensive categories to the most capital-intensive categories. In the relatively capital-intensive categories (1 to 4), of the 13 firms, the majority, 6, started in the same category. Three started in the capital-intensive categories, the initial categories of 3 are unknown, and the single exception moved up only one category.

It is interesting to look at the subgroup of firms (24 firms; one-half of the sample) that were established during the construction boom in the early 70's. All of these firms are still in the same category they started in except the two firms that moved from category 4 to 3. The distribution of firms by category in this subgroup is not that different from the distribution of firms in the sample as a whole.

We conclude that while the data show that firms do grow over time, this is not likely to be the main explanation for the different technology choices represented by the categories.

Secondary source information on the capital market tends to corroborate this. The capital access function for an individual firm does depend on firm profitability and can be expected to shift downward over the firm's lifetime, to some extent. But the range of this shifting is rather small compared to the difference in the level of the functions across the types of entrepreneurs found in widely separated categories. The capital access function depends heavily on characteristics of the entrepreneur (social class, education, connections) which, given the hierarchical structure of Colombian society, are relatively permanent.

#### CONCLUSIONS

In this paper, we have shown that, in the Colombian brick industry there is a pattern of technology choice such that capital-intensity is correlated with size. It is argued that this pattern can be explained by the structure of capital and labor markets. In the labor market, wages vary positively with size of firm. Empirical evidence has been presented showing that this is true even after correcting for the influence of factors such as education, experience, stability of the labor force and geographical location of firm. In the capital market, it is argued that capital access differs across entrepreneurs, according to characteristics relating to their position in Colombian society. These two features are combined in a simple analytic model and it is shown that such a model can generate the pattern observed.

Then this imperfect market model is compared to the hypothesis that capital access improves over a firm's lifetime, and therefore that the technology categories represent a growth path. It is shown that while firms do grow and sometimes do change from one category to a closely related one, in general the evidence does not tend to support the growth path theory.

Since we have not discussed all the ways in which large capital intensive firms differ from small labor-intensive ones, discussion of policy implications must be tentative. However, there is a prima facie case for thinking that the smaller, less capital-intensive firms are more socially efficient, given the unemployment of labor and the scarcity of investment funds in Colombia. In other words, the input market conditions these entrepreneurs face more accurately reflect social opportunity cost.

The features of the input markets described are long term structural elements; therefore, there is every reason to think that the pattern of technology choice will persist, unless these structural elements change.

To a considerable extent, these elements are the result of government policies which should be changed. Capital market reform, in the form of the elimination of restrictions on interest rates and terms of lending, is particularly important. Even after such a reform, there would probably still be differences in capital access functions across prospective entrants into an industry, because of differential risk factors, but the difference would be narrower, and would more closely reflect real economic forces.



# Note

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<sup>1</sup> Since more capital-intensive categories tend to use more imported machinery, and historically, the Colombian exchange rate has generally been overvalued, the use of social opportunity cost prices instead of Colombian peso prices would not change the order of the categories and would increase the dispersion of the capital-intensities.

<sup>2</sup> Capacity output was defined as the value of output that the firm would be willing and able to produce, on a long term basis, with no more than a 5% additional expenditure on plant and equipment, and with as many additional workers as would be needed (assuming that they could be hired at the current wage rate, and that all output could be sold at current prices). Since the industry was experiencing an unanticipated slump, which was having uneven effects across the industry, it is felt that capacity output is the best measure of size of firm available.

<sup>3</sup> The data is for the year 1975 and was collected in an interview survey of a sample of brick firms conducted by FICITEC. Further details of the data are available upon request to author.

<sup>4</sup> In the Colombian context, there is an advantage as well as a disadvantage to a high turnover. Since it is difficult to lay off or fire workers, once they have become permanent employees (after three months of employment) the firm does not have as much flexibility to vary its labor force in response to changes in demand as neoclassical theory would suggest. If there is a high voluntary turnover, the firm can contract its labor force more easily in periods of slack demand. Smaller firms may be more subject to such shifts in demand and this could explain a differential choice on their part of the low wage, high turnover option.

<sup>5</sup> A potential exception is the case of the the firms in categories 1 and 2 which have tunnel kilns and tunnel dryers. These processes normally require skilled labor to monitor and adjust the temperature settings. Although we have no survey data for Category 1, we know that

this firm does have a more highly skilled labor force and a complex system of controls. The firm in category 2 has a production manager with an engineering degree, and is one of only a few such firms. However its production labor force is not any more skilled than that in the other categories, and the firm does not in fact adjust the kiln and dryer controls in the manner necessary for maximum technical efficiency. In other words, it seems to have chosen a lower level of technical efficiency and a lower level of skill of the labor force.

<sup>6</sup>For a discussion of labor unions in Colombia, see Urrutia (1969).

<sup>7</sup>The most important sources used are given in the references.

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