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DUALISM IN LDC MANUFACTURING: A CASE STUDY

Mary Ann Baily

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INTRODUCTION

The phenomenon of dualism is frequently observed in the manufacturing sectors of developing countries. In many industries, there is a "modern" sector using sophisticated, capital-intensive technology similar to that used in developed countries, and a "craft" or "traditional" sector using old-fashioned, labor-intensive techniques. The causes of this dualism and its significance for the development process have been considered important by many development economists.

One interpretation can be called the diffusion model. According to this interpretation, the development of the manufacturing sector takes place by the expansion of the modern sector and the contraction and eventual disappearance of the craft sector as superior modern technology diffuses throughout each industry, much as newly invented technology diffuses in a developed country. Existing firms do not instantly adopt the modern technology especially if (as is usually the case) it is embodied in capital goods. Instead, the technology diffuses at a rate determined by the rate of spread of the new information and the rate at which it becomes profitable to replace existing equipment. In a developing country, one might expect diffusion to proceed much more slowly, explaining the bigger spread in the technology observed in place. Information, which comes from more technologically sophisticated countries, is likely to spread more slowly. Managers in LDCs tend to be less effective as profit-maximizers and therefore, slower to recognize the value of new technology. If there are imperfections in input or output markets, the cost advantage of the superior modern technology might be weakened and thus the traditional technology could survive longer, in spite of its lower productivity.

A particularly explicit discussion of this diffusion approach to dualism in manufacturing, developed with reference to Colombia, is that of Richard Nelson.[1]

Nelson assumes differential productivity between the two parts of each industry: there are two distinct production functions. Scale economies are more important in the modern sector production function. The efficiency difference between the two production functions varies with the capital-labor ratio, so that modern technology has a greater advantage at higher capital-labor ratios. Factor markets are imperfect; modern sector firms pay higher wages and have lower capital costs than craft sector firms.

The industry is not in equilibrium but is moving toward it. Since the modern sector technology has a cost advantage over the craft sector, even given factor market imperfections, and the relative rate of expansion of each sector is determined by unit profits (or losses), the modern sector is expanding faster than the craft sector.

Together, all of these assumptions imply that the dualism is a disequilibrium phenomenon. There is a final equilibrium in which all firms are modern, large and capital-intensive; the craft sector with its traditional, small, labor-intensive firms is entirely eliminated.

The policy implications depend to some extent on the causes of market imperfections. But in general, the model tends to support the "modern is better" attitude found in many developing countries. It suggests that factor market imperfections allow obsolete techniques to survive rather than encourage premature adoption of socially inefficient techniques. It portrays the traditional sector as composed of people not smart enough to see that they are obsolete. Speeding up the process by which the craft sector is eliminated and the modern sector grows is a good thing. Efforts to provide assistance to small and medium size firms are suspect on efficiency grounds. Any efforts to provide technology information should focus on spreading information about the superior modern technology, not on spreading information about craft technology, or looking for more productive forms of craft technology.

The model is plausible, it fits with casual observation, and it is consistent with aggregate industry statistics. However, casual observation has often proved misleading in the past and industrial statistics can be difficult to interpret. For example, Nelson argues that Colombian statistics show that the size composition of industry is changing over time in the direction of larger firms. However, the statistics are not very suitable for examining the composition of industry by size over time, and are likely to contain a built-in bias toward showing that result. The industrial statistics in Colombia (and in nearly all LDC's) include all of the largest and the great majority of middle-size firms but only a small fraction of the small firms. Very little information is available about the number of firms in the smaller size classes of any industry, so it is hard to know just what fraction is included in any given year. Firms generally grow over time. Some firms go out of business, and it is reasonable to think that turnover is greater among smaller firms. For both these reasons, the average size of firm in a sample will automatically grow over time unless adjustments are made for entry and exit. But it is hard to make the correct adjustment. The larger firms entering will tend to be included, but given the lack of information about small firms, it is very unlikely that small firms will be added to the sample in the right proportions to maintain a sample which accurately reflects the real size distribution of firms in the industry.

Thus, it is useful to look at a specific industry at the micro-level in the context of the diffusion model. The Colombian clay brick industry is a perfect example of a dualistic industry. The technology in operation in the industry ranges from a modern, large, capital-intensive factory to tiny artisan establishments using centuries-old techniques. In this paper, the questions asked are, To what extent does this industry fulfill the assumptions in the diffusion model, and does it seem to be evolving toward the equilibrium described by the model?

This paper is complementary to another paper by this author on the brick industry[2] which examines an alternative hypothesis:

that industry structure (size distribution and technology choice) represents a long-run equilibrium generated by entrepreneurs maximizing profits subject to a particular set of factor market imperfections.

It is argued there that the empirical evidence is consistent with a model in which there is one industry production function, not two. A higher scale of production, higher capital-labor ratio and a higher ex post wage rental ratio are all associated but small-scale, labor-intensive firms coexist with large-scale, capital-intensive firms indefinitely.

In this paper, we show that the empirical evidence is not consistent with the diffusion model.

A BRIEF HISTORY OF BRICK TECHNOLOGY

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.

Until the nineteenth century, production was characterized by hand-digging, natural weathering, hand-making , outdoor drying, and batch-firing in primitive kilns, either temporary structures ("open clamps") or simple permanent structures.

In the nineteenth century, molds were developed which made as many as 15 bricks at once. The process (the "soft mud" process) was mechanized, using animal and then steam power. By the end of the century, a new alternative, the extrusion process, had been developed and was well-established. In the extrusion process, instead of being molded, the bricks were extruded as a column of clay which was then cut with a wirecutting machine.

Heated floors were first used to speed up drying. Then chamber dryers were used, in which hot air was circulated around the formed bricks. In 1845, a continuous process dryer (the tunnel dryer), was invented, although it did not become a practical alternative to the hot floor and chamber dryer until the end of the century. In the tunnel dryer, bricks moved on cars through a tunnel as warm air was passed over them.

In kilns, the important innovation was the Hoffmann kiln, invented in 1858. This kiln transformed the firing process into a continuous process. It was composed of a series of individual chambers into which bricks were loaded and unloaded. The fire was moved from chamber to chamber as the bricks in each chamber were fired.

With the twentieth century came mechanization of the excavation step, with power shovels, bulldozers, etc. There was a shift toward more elaborate preparation of the clay and the development of stone separation, crushing and mixing machinery. De-airing was introduced into the extrusion process. This is the removal of air from the clay as it is being extruded in order to produce a denser, stronger product.

The tunnel kiln had been invented in 1840 but was not adapted for brickmaking until the twentieth century. It, like the Hoffmann kiln, involved a continuous firing process, but in the case of the tunnel kiln, the fire was stationary and the product moved through the kiln on cars.

Finally, mechanical methods of handling the bricks within and between processes were developed.

To summarize, there has been a substantial increase in the minimum scale of plant with the development of new technological alternatives, particularly in the case of kilns. Generally, the newer the technique, the less labor is used relative to capital in each process, and some substitution of skilled for unskilled labor has occurred. Also, for efficient operation, the tunnel kiln and tunnel dryer require skilled management of temperature controls.

THE STRUCTURE OF THE COLOMBIAN BRICK INDUSTRY

The characterization of technology is a difficult problem, particularly the measurement of the capital input. Book value is a poor measure because depreciation relates much more to tax law then to the economic value of capital. Measures of electrical energy consumed and rated horsepower measure economists' desperation, not capital. Replacement cost is perhaps the best alternative, but most firms have no idea what replacement cost is or even what the original cost of their capital was.

Moreover, firms are suspicious of surveys and reluctant to waste their time gathering information. Therefore, we sought a method that would capture the main alternatives but would be feasible.

After preliminary factory visits and discussion with local industry experts, the Colombian industry was divided into eight major categories of technology choice,[3] based on the major alternatives 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)

Table 1 shows the combinations of choices represented by the categories. The division between modern and craft sector can be roughly considered to fall between categories 4 and 5, although as the table shows, the structure of the industry is more complicated than just a two way division.[4]

A tentative specification of a representative plant was prepared for each category based on information from a small number of cooperative firms. These were used in designing the survey instrument. Brief questions on key points of the production process were included in the survey to determine what category each firm was in. The results of the survey were used to modify the original categories and plant designs. Then a single composite capital-labor ratio was computed for each of categories 2 to 8 from the modified plant designs. The capital figure was the approximate cost in Colombian pesos of purchasing plant and equipment new in 1975 plus the costs of construction in 1975 for kilns, drying sheds, and simple factory structures.[5] Labor was the number of full-time production workers employed per month.[6]

A capital-labor ratio could not be computed for category 1. This category consists of a single, very large scale firm using a sophisticated capital-intensive process. Since the firm refused to cooperate it is 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.

It is obvious that the capital-labor ratios are very approximate. We know that there is variation within categories but we do not have the quantitative data to say how large the

Table 1: Categories of Technology Choice

	"Modern" Sector				"Craft" Sector			
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 Colombian 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	Hoffman Kiln	Inter-mittent Kiln	Inter-mittent Kiln	Inter-mittent Kiln	Inter-mittent Kiln
Composite Capital/Labor Ratio	Unavailable	872.1	512.9	410.3	77.3	45.1	25.8	7.4

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[*] Only the single firm in category 1 dries all of its output artificially

variation is. Little significance can be attached to the numerical values; however, we feel that the ordering is robust. In this paper, capital-intensity is used mainly as an ordinal ranking of the categories.

The table, combined with the history of the development of the technology, shows that, as the diffusion model assumes, capital-intensity and "modernity" of the technology generally give the same ordering of categories. There is one partial exception. Category 6 uses a Colombian adaption of imported technology. This is a case where an "obsolete" type of foreign machinery has been reduced in size and copied for local manufacture. This adaptation began in the very early 1970's. More will be said about the significance of this later.

Size of firm was not used in the determination of the categories. However, in the sample, size of firm proved to be strongly correlated with category and therefore with capital-intensity and modernity, as the diffusion model assumes. Two measures of size were used: total employment and value of capacity output.[7] Quantitative information was available for 47 firms in categories 2 to 8. The correlation between size and capital-intensity as measured by category is given below.

Category	Kendall Correlation Coefficient	Significance Level
vs. size measured by employment	-0.5087	.001
vs. size measured by value of capacity output	-0.5944	.001

The correlation coefficient is negative since capital-intensity is measured ordinally from 2 to 8, from most to least capital-intensive. The factory in category 1 is known to be the largest brick factory in Colombia; therefore, its inclusion would strengthen the result.

FACTOR MARKET STRUCTURE

The Nelson model assumes that modern firms have a higher wage/rental ratio than traditional firms. With respect to wages, aggregate data show that the average wage increases with size of firm. Nelson assumes that this represents different wages for the same type of labor and that it results from a market imperfection tied to the type of technology chosen by the firm. He argues that the cause of the market imperfection is labor legislation which applies unevenly across firms. Similarly the rental rate is tied to the choice of technology.

Baily ("Factory Market Structure and Technology Choice in the Colombian Brick Industry") gives a detailed discussion of the structure of Colombian factor markets, in general and in the brick industry specifically. Quantitative evidence from the brick survey is presented to show that wages vary positively with size of firm even after allowing for education, experience, and stability of the labor force, firm location, and technology choice (as measured by technology category). It is argued that labor legislation is probably a major factor in this result but that its impact varies with size of firm (measured by capacity output) rather than with choice of technology.

It was difficult to obtain direct quantitative data on capital costs for individual firms. However, a study of the lending policies of the major sources of industrial credit leads to the conclusion that capital access does differ across firms. An elaborate system of capital market controls gives wide scope for the use of noneconomic factors in credit allocation. It is argued that capital access depends to some extent on the nature of a project,[8] but much more on characteristics of the borrower such as family background, social position and educational background. The survey showed that the larger, more capital-intensive firms had entrepreneurs with the characteristics associated with better capital access.

To summarize, our evidence indicates that there is the predicted association between size, modernity and capital-intensity, and a higher wage/rental ratio, although the association is not directly related to the type of technology chosen by the firm, but to other characteristics of the firm and its owners.

RELATIVE PRODUCTIVITY BY CATEGORY

The diffusion model assumes that modern technology dominates craft technology, i.e. is more efficient in the use of both capital and labor. This assumption has been much debated in the development literature. The debate is complicated by the fact that the production function is usually presented in terms of two homogeneous factors of production, labor and capital, while it is recognized that modern technology often requires a different labor skill mix as well as a different kind of entrepreneur. In the brick industry, there are also differences in the kind and amount of fuel per unit of output.

One approach would be to compare the different techniques directly, valuing inputs and output characteristics at the prices faced by the firms and at appropriate shadow prices. This must be done using not only the technical data on machine capacities, staffing ratios, etc. but data on the actual operations of Colombian firms; machines and people may operate differently than expected under everyday conditions in a developing country.[9]

One aspect of this is the quantity and quality of the managerial input, which is hard to measure but very important.[10] Nelson argues that the high profit rates which Colombian accountants believe characterize large modern firms are evidence for the greater productivity of the modern technology but they may actually represent rents to scarce entrepreneurial skills and/or rents to the entrepreneurial characteristics which give favorable access to investment funds.

We had originally hoped to get micro data of sufficient quality to enable us to tackle the problem directly, but this goes to the heart of the most sensitive issue to the businessman, his profitability, and we were unsuccessful. We did get enough evidence to convince us that the validity of Nelson's assumption is by no means obvious.

Some of this evidence is summarized in Figure 1. The value of output less the value of fuel (at actual domestic prices) was computed by category from the plant designs and used as a rough measure of output. The figure shows production labor and fixed capital per unit of output for categories 2 to 8; this gives an approximation of a unit isoquant (at the scale of operation assumed for the representative plant in that category, i.e. incorporating any economies of scale that may exist.) The plant designs incorporate a host of approximating assumptions, since there were substantial variations in the efficiency of firms within categories in their use of the same basic technique: variations from firm to firm, and for the same firm over time. (The notes to the figure contain further discussion of some of the more important aspects of this) Thus the figure is far from conclusive but it suggests that neigher the craft nor the modern technology clearly dominates.

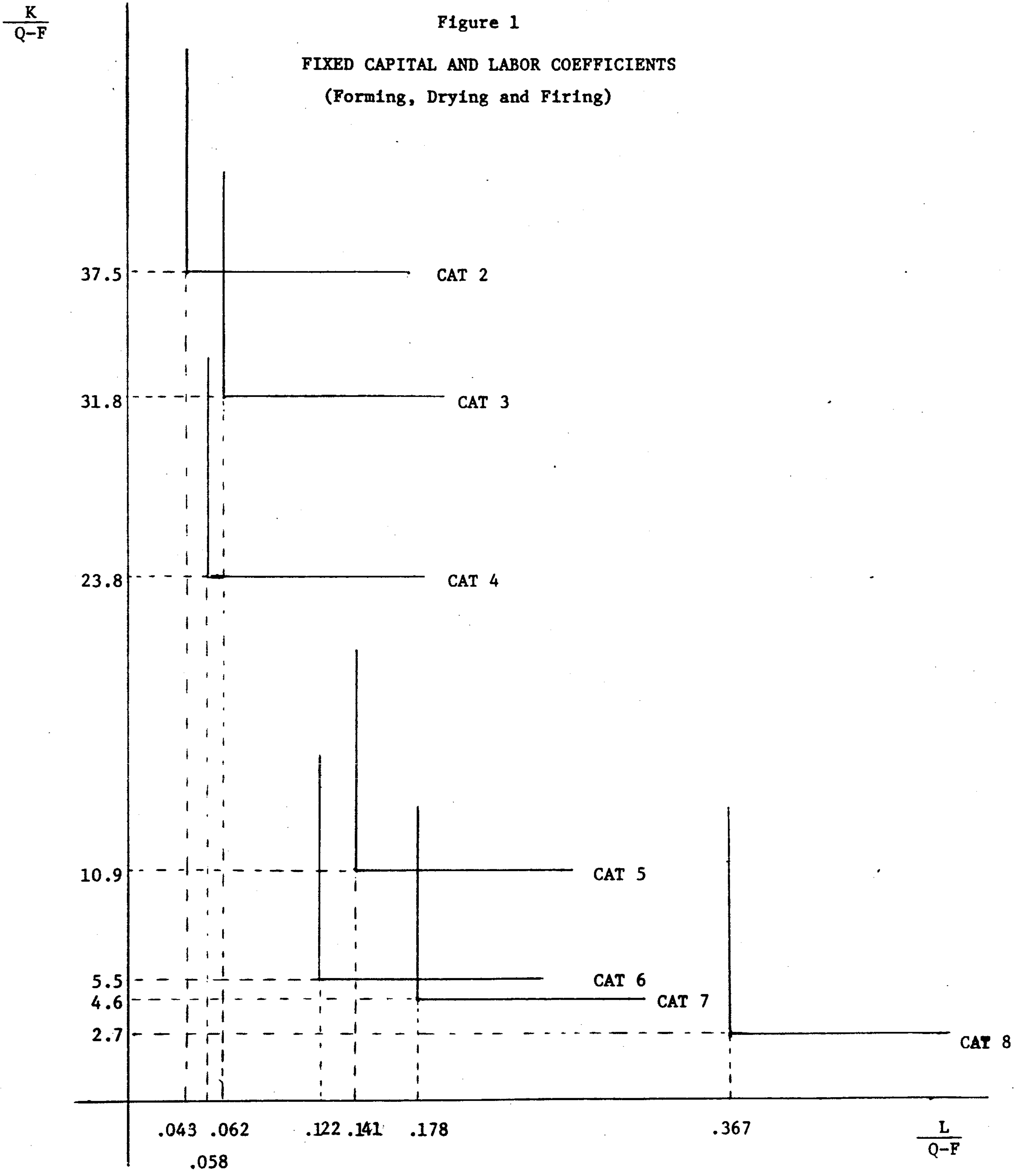
EVOLUTION OF THE INDUSTRY OVER TIME

Although we cannot resolve the relative productivity question, we can see if the industry is evolving over time as the diffusion model predicts.

If the new technology dominates the old, new firms should be large, modern and capital-intensive; old firms should gradually become so as expected profits from the change dominate the costs. (A possible exception: some new small scale firms may be set up with cheap secondhand capital goods

Figure 1

FIXED CAPITAL AND LABOR COEFFICIENTS
(Forming, Drying and Firing)



Notes to Figure 1

Some important reasons why the isoquants shown are very approximate:

1. As noted earlier, the pattern of shiftwork did not differ across firms within categories, but there was variation in the number of firings of the kilns per unit of time and the intensity of machinery use within a shift, across firms as well as across categories. Also, utilization rates varied for the same firm at different points in time.

2. There were variations in fuel efficiency, across firms within the same category, and in the same firm at different points in time. Fuel use varies with:

   the content of sand and other substances in the clay;

   the moisture content of the product at the end of the drying process;

   (This means that fuel use varies with the weather, since both artificial and natural drying are less efficient in wet weather; in the wet seasons, the kiln does some of the drying. Also, minor variations in construction of the drying sheds can affect drying efficiency.)

   the altitude;

   the design of the kiln, within a particular kiln type;

   (Minor variations in the structure of the air vents, etcetera, can have major effects on fuel efficiency.)

3. Not all inputs were included. For example, the labor coefficient includes only production labor, not managerial labor. Land is not included, either land for the factory or the land which comprises

Notes to Figure 1 (continued)

the clay reserves. It is virtually impossible to value the land in a consistent meaningful way, because typically the brick factories (of various sizes and categories, side-by-side) are located on land on the outskirts of the major cities--land which is unsuitable for agriculture and whose value is expected to increase as the city grows. In many cases, removal of the clay makes the land more suitable for eventual development.

Some specific points on a comparison of categories 3 and 4, and categories 5 and 6:

Category 3 is dominated by Category 4, given the coefficients shown. The difference between these two categories is in the use of artificial drying. Category 3 uses more fixed capital (in the form of the cost of the artificial dryer) and more fuel, but it uses less land and less working capital, since the drying time is shortened. The change in the value of work in progress between the two categories is at most, about 5% of the difference in fixed capital cost between the two categories, which is a negligible addition to the capital cost. The difference in land per thousands of pesos of Q-F (value of output less value of fuel) is substantial: 5.7 mt^2. However, to balance the Col. $8000 difference in fixed capital investment, the land would have to cost about Col. $1400 per mt^2, or Col. $14,000,000 per hectare, which is a very substantial sum indeed, (over $400,000 U.S. per acre) especially when it is considered that the land will appreciate in value while the dryer will depreciate. Thus the difference in land and working capital costs is unlikely to be sufficient to justify the increased fixed capital investment.

Notes to Figure 1 (continued)

Category 5 seems to be dominated by category 6. The main difference between these two categories is in the use of a simple domestic machine in preparation and forming in Cat. 6 compared to larger and more expensive imported machinery in Cat. 5. The utilization rate has been assumed to be rather low in category 5 (about 60%) on the grounds that this is representative, while the utilization rate in category F has been assumed to be 100%. To make a rough correction for this, if it is assumed that factors can be adjusted proportionally to give 100% utilization in both categories, then the capital coefficient is very close to that in category 6. (The capital coefficient in preparation and forming is still somewhat higher in 5 than in 6, but this is offset by the lower coefficient in firing). Thus it seems that an important aspect of the Colombian capital is the fact that it enables firms to produce at lower scales of production without having underutilized capacity.

discarded by the modernizing firms, since if there is any market in secondhand capital goods, their prices must adjust until the old capital is competitive with the new. But this is merely a transitional phenomenon.)

Although historical information was difficult to obtain, the survey provided data on the age of the firm, the size of the labor force at the end of the first year of operation and the ages of the major items of capital equipment, as well as whether they were bought new or secondhand.

Table 2 shows that the more modern, larger firms tend to be older, not younger, although the correlations are not strong. More direct evidence is provided by looking at changes in category and size of individual firms over time. The data were sufficient to identify an initial category for 37 of the 48 firms (The remaining eleven were the oldest firms; all date from 1957 or earlier). 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 of 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, with that exception, Table 2 shows that the general picture is not one of firms changing categories to become more modern. Of course, for 11 firms, nearly one-fourth of the sample, we do not know the initial category. But 8 of the 11 are now in categories 5 to 8, the "craft" sector, so would not change the overall picture.

Table 2

Current category	Kendall correlation coefficient	Significance Level
vs. Age of Firm	-0.2167	.024
vs. Employment at end of first year	-0.3550	.002

Age of Firm	Pearson correlation coefficient	Significance Level
vs. Current Size Measured by Employment	0.3082	.018
vs. Current Size Measured by Capacity	0.1791	.114

Changes in Category

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

*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 acquired their dryers after the start of the firm and at about the same time (the early 70s), so all moved from category 4 to 3.

**Both started in category 4.

One-half of the sample consists of firms 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 which 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, contrary to the prediction that only modern firms would be set up.

The survey showed 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 a severe slump in demand at the time of the survey and also because the capital-labor ratio and the output-labor ratio are likely to increase with size. Nevertheless employment had increased for 36 of the firms and decreased for only 7 (unknown for five). Capital equipment had generally been added over time. However, Table 2 suggests that growth comes primarily within the same category or with a movement to the next category only.

The age of the firm can be ambiguous. Many firms had changed their form of legal organization and their shareholders over time and it was not always clear what date to take for the founding of the company. Thus it is useful to look at the major items of capital equipment to see if there is a pattern of introduction of technology over time. If the age of the equipment is uniformly older, the higher the category number, then one could argue that coexistence of the categories represents the transitional phenomenon mentioned. Modernizing firms are selling off their outmoded equipment to other firms but the category will disappear when this equipment wears out.

Table 3 gives data on the machinery used in the preparation and forming processes in those firms which use machinery. The table shows that the importance of secondhand machinery does increase as the modernity of the category decreases. However, the introduction in category 6 of the Colombian adaptation of the type of machinery used in Category 5 suggests that the technology represented by the secondhand machinery is not obsolete. Although the average age of machinery in Category 7 is high, the standard deviations are large and there is some relatively new machinery used in the category.

Table 4 shows the average age of the kilns in the sample. The kilns vary widely in age and there does not seem to be any clear pattern between age and modernity of kiln type.

CONCLUSIONS

The evidence does not support the hypothesis that the brick industry is tending to an equilibrium in which all firms are modern, large and capital-intensive. Although the direct evidence on relative productivity of the categories is inadequate, the indirect evidence indicates that it is worthwhile to set up new firms with craft technology. It is interesting that in the construction boom of the early 70's, the industry seemed to expand

Table 3: Preparation and Forming Machinery

Type of Machinery	Tech Cat	# of Firms In Cat. With This Type Machine	Total # of Machines	# Machines Bought Second-hand	Age of Machines			
					Mean	Standard Deviation	Minimum	Maximum
Preparation Machinery	1	NA						
	2	1	5	0	21.0	0	21	21
	3	4	23	0	9.4	7.9	4	30
	4	7	20	10	15.5	7.8	4	28
	5	6	17	5	9.5	9.3	2	26
	6	3	4	4	18.0	4.0	12	20
	7	3	6	2	21.3	18.9	4	48
	8	4	4	3	15.0	7.8	4	21
Extruder Without De-airing Chamber	1	NA						
	2	0						
	3	0						
	4	0						
	5	0						
	6	0						
	7	9	11	10	21.9	20.3	1	51
	8	0						
Extruder With De-airing Chamber	1	NA						
	2	1	1	0	21.0	0	21	21
	3	4	7	0	13.9	10.3	4	30
	4	7	7	2	13.7	5.3	5	21
	5	9	10	2	9.3	7.2	4	26
	6	5	5	3	13.4	5.5	6	21
	7	0						
	8	0						
Manual Cutters	1	NA						
	2	0						
	3	1	1	1	29.0	0	29	29
	4	0						
	5	1	1	0	6.0	0	6	6
	6	4	4	1	9.5	3.0	6	12
	7	8	10	9	20.6	18.5	3	51
	8	0						
Automatic Cutter	1	NA						
	2	1	1	0	21.0	0	21	21
	3	4	7	0	8.1	6.0	4	20
	4	7	7	2	12.4	4.9	5	21
	5	9	9	2	7.9	4.4	4	16
	6	0						
	7	0						
	8	0						

NA = Not Available

Table 4: Kilns

Type of Kiln	Age of Kilns[1]					Capacity in Common Brick Volume Equivalents[2]				
	Total #	Mean	Standard Deviation	Minimum	Maximum	Total #	Mean	Standard Deviation	Minimum	Maximum
Intermittent (Vertical Flame)	102	11.8	11.1	0	46	101	40,925	21,339	6,000	86,100
Intermittent (Inverted Flame)	26	26.7	15.6	1	49	18	47,797	22,506	20,000	84,060
Hoffmann	16	18.7	13.1	5	56	14	286,106	127,881	147,600	508,096
Tunnel[3]	1	19	0	19	19	1	1,300,000	0	1,300,000	1,300,000

[1] Based on data for 148 kilns

[2] Based on data for 137 kilns

[3] Quantitative data available only for kiln in category 2. Tunnel kiln in category 1 is known to be newer and larger.

across the board. The largest, most technologically sophisticated brick factory in the country (in Category 1) was built. Category 3 was created, with the introduction of artificial chamber dryers for the first time in Colombia. But this was also the period of introduction of an adaptation of imported technology, the Colombian-produced de-airing extruder, which enabled firms to be smaller in scale, and less capital-intensive. In addition, there was a great expansion in the number of tiny artisan firms which use technology even simpler than the simplest craft technology discussed here.

The diffusion model is not a good description of this industry. The structure to this author looks more like the long-term coexistence of a set of representative firms with no tendency to converge on one type.

In another paper, we have argued that the structure of capital and labor markets in Colombia, a structure which is highly imperfect and whose imperfections can to a great extent be traced to government policies, creates an environment in which profit-maximizing entrepreneurs face different constraints and therefore choose to build firms in the different categories.

The input market imperfections have existed for a long time and show no great tendency to change (although the whole wage structure is moving upward over time). Thus the industry is likely to continue to develop with a structure of parallel lines of entrepreneurs who never meet. The individual categories may change over time, but the coexistence of different categories is not tending to be eliminated.

The evidence presented is for only one industry, but we think it can be generalized. The coexistence of widely different techniques of production is characteristic of other industries. The input market imperfections are not unique to the brick industry, but operate throughout the economy. Therefore we think it is quite likely that the results would be duplicated in other industries.

The analysis suggests that modern may not be better. Although it is hard to measure productivity directly, what data we have suggests that the craft technology is not necessarily dominated, and we know that in addition to capital, unskilled labor and fuel, (which are incorporated in Figure 1) modern technology does tend to use more of other factors that are in short supply such as managerial labor. Since the market imperfections are such that the wage/rental ratio that produces the large capital-intensive modern-style firm is farther from the social opportunity cost wage/rental ratios than for the smaller firms, perhaps the "right" industry structure would eliminate the large firms rather than the small firms.

FOOTNOTES

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[1] R. Nelson, T. P. Schultz, R. L. Slighton, Structural Change in a Developing Economy, (Princeton, N.J.: Princeton University Press, 1971), Chapter IV.

[2] M.A. Baily, "Factor Market Structure and Technology Choice in the Colombian Brick Industry," Journal of Development Economics, forthcoming.

[3] There was an additional category of tiny artisan establishments using temporary kilns (open clamp kilns) which we have not included in the study because it was impossible to get any survey data on them.

[4] Also, 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 whose characteristics are related to variations in choice of technology. However the products are much closer substitutes

than in broader industry classifications and no technology category produces a product which has no close substitute produced by some other category.

[5] Since the 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 peso prices would not change the order of the categories and would increase the dispersion of the capital-intensities.

[6] The pattern of shiftwork did not differ across firms within categories. There was variation in the number of firings of the kilns per unit of time and the intensity of machinery use within a shift, across firms and across categories. The composite capital-labor ratio for the category was adjusted in a rough way to reflect the pattern of utilization that was representative of the category operating at capacity as defined in footnote 7. In other words, since the capital figure is a stock figure and the labor figure is number of full-time workers per month (hours per month per full-time worker did not vary across firms) the composite ratio implicitly incorporates the choice of capital utilization rates as well as size of capital stock.

Further details of the data and the representative plant designs can be obtained in M.A. Baily, "Technology Choice in the Brick and Men's Leather Shoe Industries in Colombia," Final Report to Agency for International Development, Contract No. AID/otr C-1326, 1977, or by request to author.

[7] 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.

[8] Formal credit lines generally require the security of a machine or building and thus to some extent encourage the use of capital relative to labor. 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 gives him an interest in the profitability of the project.

[9] For example, we found evidence of significant variation in the productivity of technology as used in Colombia compared to the original models in foreign countries, particularly in the more sophisticated categories. Minor differences in construction and operation techniques led to lower efficiency

in the Hoffmann and tunnel kilns. None of the chamber dryers in the sample worked as well as they had been expected to, and several did not function at all.

[10] The quantitative data on labor force composition showed that while production workers hardly differed at all in skill level (being all relatively unskilled), the managerial staff tended to be better educated in the more modern categories. There was qualitative evidence that the more modern the firm in technology, the more sophisticated the entrepreneurs.