AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523
BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY
Batch 77 ARDA

1. SUBJECT CLASSIFICATION

A. PRIMARY
Development and economics — DM00-0000-G518

B. SECONDARY
Industries and industrialization--Colombia

2. TITLE AND SUBTITLE
Technology choice in the brick and men's leather shoe industries in Colombia

3. AUTHOR(S)
Baily, M.A.

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1977	~~271p.~~ 555p.	ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
Yale

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*

9. ABSTRACT

This paper reports on a project on technology choice in the brick and men's leather shoe industries in Colombia. The project is based on secondary data and on the results of a micro-level field survey of firms in the two industries.

It was found that each industry exhibits a very broad range of different choices of technology actually in use, representing wide variations across firms in the use of major inputs such as capital and labor. The most important factors in causing the patterns observed were imperfections in the capital markets, particularly in the capital market.

Channels of technology information were also examined. Colombian firms were found to obtain technology information through international channels which are costly, restricted in access and reliability, and dependent on historical accidents for their existence. The most important aspect is the limited diffusion of information about variations in technology whose significance is not readily visible (i.e. not appreciated without detailed engineering information) such as major variations in kilns and drying chambers, which affect fuel and drying efficiency, in the brick industry, factory organization and cost accounting systems in the shoe industry.

10. CONTROL NUMBER
PN-AAF-182

11. PRICE OF DOCUMENT

12. DESCRIPTORS
Colombia
Brick industry
Diffusion
Efficiency
Manpower
Profits
Shoe industry
Small scale industries
Technological change

13. PROJECT NUMBER

14. CONTRACT NUMBER
AID/otr-C-1326 Res.

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

Technology Choice and Employment in Developing Countries

Contract No. AID/otr C-1326

July 1, 1974 - August 31, 1977

Principal Investigators: Gustav Ranis
John C. H. Fei
Lucy A. Cardwell
Mary Ann Baily

Economic Growth Center

Yale University

Box 1987, Yale Station
New Haven, Connecticut

TECHNOLOGY CHOICE IN THE BRICK AND MEN'S LEATHER SHOE INDUSTRIES IN COLOMBIA

Mary Ann Baily

August, 1977

ACKNOWLEDGMENTS

To Gustav Ranis, John Fei, Lucy Cardwell, and Martin Baily of Yale University; to Luis Delfín Borrero, Felicia Cruz, Roberto DiBella, Rosa Amaya, Leon Teicher, Carlos Jaramillo, Pedro Veloza, Luis Vallejo, and other personnel of FICITEC; to Dr. Antonio Paredes, brick industry consultant, and the personnel of Rapida Industrial, shoe industry consultants; to Eleanor Sylvan, Christine Kiley and Leonardo Hakim for research assistance; to the secretarial staff of the Economic Growth Center; to the manufacturers in the brick and shoe industries; and to many others who contributed to this study.

ABSTRACT

This paper reports on a project on technology choice in the brick and men's leather shoe industries in Colombia. The project is based on secondary data and on the results of a micro-level field survey of firms in the two industries.

It was found that each industry exhibited a very broad range of different choices of technology actually in use, representing wide variations across firms in the use of major inputs such as capital and labor. The most important factors in causing the patterns observed were imperfections in the input markets, particularly in the capital market.

Channels of technology information were also examined. Colombian firms were found to obtain technology information through international channels which are costly, restricted in access and reliability, and dependent on historical accident for their existence. The most important aspect is the limited diffusion of information about variations in technology whose significance is not readily visible (i.e. not appreciated without detailed cost accounting information) such as: minor variations in kilns and drying sheds, which affect fuel and drying efficiency, in the brick industry; factory organization and cost accounting systems in the shoe industry.

INTRODUCTION

This paper reports on a research project on technology choice in Colombia in the brick and men's leather shoe industries.

The research project was carried out in collaboration with the Foundation for the Development of Scientific and Technological Research (Fundacion para el Fomento de la Investigacion Cientifica y Technologica -- FICITEC) of Bogotá, Colombia.

Section One discusses the conceptual issues in technology choice that are relevant to the study. Section Two describes the methodology of the field work. Sections Three & Four discuss the results of the project for each industry. Section Five summarizes the conclusions of the study and gives policy recommendations.

SECTION ONE: ASPECTS OF TECHNOLOGY CHOICE

I. THE PRODUCTION SET

The technology available to a firm can be represented by a production set of vectors $(y_1, \ldots, y_m; x_1, \ldots, x_n)$, where each vector represents a possible production point and gives the amounts of each input x_i required and each output y_i produced. The outputs and the inputs can be disaggregated as finely as desired to allow for different quality levels of output, different types of labor or capital inputs. Frequently it is convenient to assume that there are only two inputs and one output.

The next step is often to assume a preliminary optimization procedure, defining a production function by discarding those points which are dominated by other points, i.e., such that there exists another point which produces the same output with fewer inputs. In the one output, two input case, this procedure gives the familiar isoquant

diagram.

One issue that arises with respect to this production model is: For a given amount of output, is there only one technically efficient combination of inputs that can be used to produce it or more than one? In other words, when the preliminary optimization is performed, is there more than one point which is not dominated? This is an engineering question; for the industries chosen for this project, the answer is yes.

A second issue is: Are techniques of production "embodied" in particular capital goods? For example, is it true that the possibilities of adjusting output and labor input with a given type of machine are very limited, although it would be possible to change the capital and labor input coefficients substantially if it were possible to use different types of machines? This is the well-known putty-clay model; capital is putty before the investment decision is made but clay afterwards. At the micro level, this distinction is not important if firms rent perfectly divisible machinery.

But assume that instead the firm owns some of the factors of production which are not used up in the production process. If the future is known perfectly and is the same as the present, then the firm would have no need to adjust. But the world is not static and the firm must take into account the possibility of incurring adjustment costs, including capital losses on its machines These adjustment costs can be very large, especially given the fact that second-hand markets tend to be imperfect.

The model of production for this project is one of a production set of points with extensive ex ante substitutability and some substi-

tutability ex post, but much more limited.

A third issue is the relevance of the assumption of preliminary optimization. It is often argued that developing country firms are hardly ever on their production functions. There are a number of ways of looking at this type of "inefficiency."

It may result from a lack of interest in cost-minimizing. It has been argued that LDC managers are more interested in other goals. For example, they feel a social responsibility to have a large labor force, or they enjoy owning technologically sophisticated machinery. This is possible, but it raises certain questions with respect to market organization which will be discussed further below.

It may result from the use of crude input indices which can obscure important quality differences. This is particularly true in the case of labor. There may be differences in the inputs of managerial ability, supervision, cost accounting, so that a machine operates below its rated capacity per hour because of the quality and quantity of these other inputs. It seems better to look at this as a separate production point; it is possible to produce the same output with the same machine, but with various combinations of different types of labor.

The firm may not know what its production function is. The simple model assumes that the production set is perfectly known by all. In a well-organized industry with good sources of information in an industrialized country, this may be close to the truth. In LDC's, looking across firm size classes, industries, countries, it may be more realistic to assume that entrepreneurs know only a part of the production set, and can acquire further information only at a cost of resources. At any

instant of time, different producers may have different production sets, although the entire production set could be known by any individual if he spent enough resources on information acquisition.

Closely related to the situation of a given set with existing techniques that an entrepreneur doesn't know about, is the situation of a set which could be enlarged by adding newly discovered techniques which nobody knows about. In both cases it is a question of spending resources to acquire information about a new way of doing something.

An important feature of both situations is uncertainty. One could build models with incomplete information but no uncertainty. The entrepreneur does not know every technique in the production set, but knows how worthwhile the knowledge would be and how much it would cost to acquire the knowledge, or in the case of innovation, knows how much it will cost to produce a new technique with certain characteristics. But of course, this assumes away a crucial feature. The problem with information is usually that one doesn't know the value of the information until one has it.

In this paper it will generally be assumed that the production set is given although it may be incompletely known by any individual producer. (The problem of innovation and adaptation will not be addressed.) We will return to the question of the cost of information below.

II. THE CHOICE OF TECHNIQUE

Next, it is necessary to introduce the prices of inputs and outputs and a behavioral assumption to determine which production point an entrepreneur will choose.

To start with the simplest model, assume that all factors are perfectly adjustable instantaneously. Assume there is one homogeneous ouput. Assume firms can buy as much as they want of all factors in quantities per unit of time at constant prices. Assume that firms minimize the cost of producing any given output. In other words, consider the firm's long run cost curve. For any given set of input prices $(w_1,\ldots,w_n)$ and any given amount of output y, the production point chosen $(y,x_1,\ldots,x_n)$ and the total cost $c(y) = w_1x_1 + \ldots + w_nx_n$ are determined by solving the minimization problem. The two factor case yields the familiar isocost curve, isoquant diagram.

In simple models, it is usually assumed that all firms have the same production set and face the same factor prices and therefore have the same cost curve. Given the cost curve, the next step is to determine the number and size of firms in the long-run equilibrium of the industry.

The two simple models of market organization are the polar cases of monopoly and perfect competition. In both cases, the procedure is to introduce the firm's demand function, and assume that the firm maximizes profits. In the monopoly case, the firm faces the total industry demand curve. In the perfect competition case, the firm is small enough relative to the total demand to sell all it wants at the existing market price.

In the U-shaped cost curve case, firms enter or leave the industry when there are positive or negative profits (in the sense of profits which are over and above the return on investment in the rest of the economy); this adjustment process implies that the long-run market equilibrium price and size of firm are determined at the point of minimum long run average costs. (In the constant returns to scale case, with a horizontal long run average cost curve, price and industry output are determined, but the size of the individual firm is indeterminate.) The models of other forms of imperfect competition are legion. Those comparative statics models that are in the spirit of these two cases make the same assumption of profit maximization. The problem is in the specification of the demand curve that is relevant to the individual firm's output and price decision since it must incorporate the impact of other firms' decisions on this firm's market position. In general, the long-run equilibrium of the industry (in terms of aggregate output and aggregate profits) will lie between the monopoly and perfect competition results.

Note that with perfect knowledge, properly specified inputs, and perfect competition, it is not so much that all firms do cost-minimize automatically but that if they don't, the force of competition drives them out of business. If there are any entrepreneurs who minimize cost, they will tend to be successful and to drive the others out. Of course, perfect competition is rare in LDCs. The usual problem is the small size of the market combined with transport costs and restrictions on international trade.

The simple models do not predict a variation across firms in size

of output and in input coefficients within an industry. However, many people have observed very large variations. Looking across firms in an LDC industry, one frequently observes a wide range of techniques in use, a range that is usually much greater than the range of techniques observed in highly industrialized countries. One also observes a large variation in size of firm within the industry, usually correlated to some extent with type of technology.

The two industries chosen for this study, bricks and men's leather shoes, exhibit this pattern as will be seen in Sections Three and Four.

There are many ways of complicating the simple comparative statics models discussed above to provide partial or complete explanations of the pattern observed. Here we discuss some that are important for this study.

A. Product Definition

The difference in choice of techniques within an industry may be the result of the aggregation of very different products with different production sets in industry statistics. Even though products have been specified rather narrowly to make the study of the technology manageable, there is still considerable product differentiation of this type within the two industries.

Given product differentiation, the question is, what determines the composition of output, as well as the choice of technique to produce any individual product?

This could be analized using the theory of joint production. The firm faces a set of demand functions. It will adjust the composition of

its output until the rate of tradeoff in revenue between any two products is exactly equal to the rate of tradeoff in costs.

Typically, differences in product that also represent substantial differences in the type of technology used are observed between firms. Each firm tends to produce one product or a set of very closely related products using very similar techniques of production. The "industry" consists of a set of related markets for products that are close substitutes for each other. If the markets were perfectly competitive, then the markets would adjust so that in long run equilibrium, the equilibrium price ratio between any two of the products was equated to both the rate of tradeoff in consumer satisfaction between the two products and the rate at which one product could be transformed into the other in production, by transferring of resources from the production of one to the other. This relative price adjustment would also mean that only normal profits would be made in the production of any of the goods. If greater than normal profits were being made in one product line, firms would switch into that product line.

If this is the explanation, then there is no obvious reason to object to the result. It represents the outcome of underlying demand and production conditions.

However, this conclusion may be modified by:

1) Market Imperfections: Because of these, prices may not reflect real scarcities and consumers may not be paying the true opportunity cost to the economy of indulging their preferences.

2) Maldistribution of Income: Demand curves, of course, include the distribution of income, and if the distribution of income isn't optimal, then neither is the composition of demand.

B. Capital Vintages

Technical progress is continually enlarging the production set and the new techniques are embodied in the new capital goods. As the new techniques are invented and are cheaper to use at existing factor prices, firms adjust by adopting the new technology but only gradually, as the expected profits from the change dominate the adjustment costs. Assuming perfect information, new firms will tend to adopt the new technology. There will be gradual diffusion among the old ones, the speed of which will depend on such things as the age of the old machinery. At any moment of time, a wide range of vintages will be observed in use, although if technical progress stopped, and the system went to long run equilibrium, all firms would be using the same production methods.

C. Factor Markets

If all firms had the same information about technology but operated in different factor markets, then, of course, their technology choices would be different. In a simple comparative statics long run model, there is no obvious reason why factor markets should differ, which is why the problem is assumed away. In the long run, factors can migrate; even in the case of complete factor immobility, the movement of goods would tend to equalize factor prices. Moreover, in Section Three it will be clear that it would require substantial differences to explain the pattern observed.

However, there is evidence that factor market conditions are considerably

different for different firms in Colombia. First, of course, factor prices differ over time; in a dynamic world, changes in prices are occurring all the time, and even if the production set is fixed, the optimal choice of technique will change with the changes in prices. Given ex post rigidity and adjustment costs, it is clear that one will observe at any instant of time a set of choices that have been under different conditions. Again, if prices stopped changing, and the system went to long run equilibrium, all firms would be doing the same thing.

But in Colombia factor prices also differ across firms at any moment in time. Appendix 1 discusses general features of the structure of the labor and capital markets in Colombia. Section Three and Four discuss the role that these markets play in technology choice in the two industries.

Imperfections in input markets affect both the choice of technique given the product, and the choice of product. For example, a very high cost of credit will bias manufacturers toward labor-intensive techniques in producing a given product and also toward the type of product that can be produced in a labor-intensive manner.

D. Technology Information

If entrepreneurs do not have perfect information about the production set, then profit-maximization may lead to different choices, even when factor prices are the same for all firms.

If one considers the information available to an individual entrepreneur to be the outcome of a process of diffusion of information throughout the industry, then the pattern observed is a snapshot of this dynamic

process. It will be similar to the discussion above, under capital vintages, in that the system will be evolving toward a long run equilibrium in which all firms do the same thing.

It will be argued below that it is more realistic to consider the acquisition of technology information itself to be a process which requires firms to evaluate the costs and benefits of different information-seeking activities. These costs and benefits may differ across firms, and may produce a permanent pattern of varying choices.

E. Different Behavioral Assumptions

It is possible that firms do not profit-maximize. Since the patterns observed are clearly not random, it is not plausible to assume simple irrationality. There are two other possibilities.

1) They are not profit-maximizing, but are systematically trying to to do something else. Then of course some other plausible behavioral rule must be assumed which will predict the observed patterns.

2) They are trying, roughly, to profit-maximize but in a context of great uncertainty, change, and complexity, and therefore they are not necessarily succeeding very well. In this case, models which assume profit-maximization will tend to give results that are roughly correct, or will at least indicate the direction of the firm's efforts.

In the following sub-section, we discuss in more detail the role of information in technology choice.

III. INFORMATION

The problem of imperfect information and its effect on economic models has received increasing attention in recent years. For example there has been extensive work on market models in which buyers and sellers must search for information about price.[1]

Kenneth Arrow discusses information acquisition in a more general context in The Limits of Organization.[2] He begins with the assumption that an economic agent starts out with incomplete information and that the acquisition of additional information costs resources. Arrow points out three key characteristics of the cost of information.

1. The individual himself is an input, in the sense that in order for the information to be used in making decisions, it must be actually processed by the decision-maker at the appropriate time. Even with the aid of computers there are limits to the individual's ability to do this. In other words, the possible "span of control" is limited.

Of course, individuals can specialize in different types of information. Even rather small firms tend to have specialists--one partner will handle the business side and one the technical side, for example. But then there arises the problem of communication within the firm. Specialization is only worthwhile if it is possible for the specialist to screen information and transmit it to the decision-maker in condensed form. (Arrow compares this to the theory of sufficient statistics, which is an example of the reduction of information without loss of value.)

2. The opening of an information channel may involve capital

costs. For example, to receive information signals in French, one has to invest the time in learning the language. To receive information about technology, one must invest in learning at least the basic technical vocabulary.

The capital cost of opening an information channel may be irreversible. For example, once a person learns French, he knows it. The investment cannot be sold to anyone, although like ordinary investments it may depreciate over time. This irreversibility means that once an information channel has been opened it may be cheaper to keep on using it than to open up a new channel, even if the initial choice was wrong. This means that there may be an important historical element in the reasons for existing information structures.

3. The costs of information are not the same in all directions. The cost of opening or using an already opened channel of information will depend on the individual's personal attributes that may put him in a favorable position vis-a-vis certain channels; for example, education, language ability, previous business experience, ethnic group.

An important attribute of information is its reliability. For a given cost, some channels provide information of a higher quality in the sense that it is more reliable. For example, for a given level of technical education, information that comes from a trusted friend is more reliable than information from a stranger.

Using as a base these general ideas, we can discuss more specifically the problem of incomplete information about the production set and its impact on the choice of technique.

Let the set of production points be a set of vectors Z of inputs

and outputs where $Z = (y_1, \ldots, y_m; x_1, \ldots, x_n)$. Assume that there is a set of conditions in input and output markets, and whatever they are, all firms face the same ones. Firms profit maximize. They all, therefore, can compute what profits would be given any Z (by profits is meant present discounted value of the firm). For the time being we ignore uncertainty with respect to profits; the relationship between a production point and profits is certain.

One way of incorporating imperfect information is to assume that firms have different endowments of information about the production set. They maximize profits over their individual production sets, and therefore choose a production point.

Then even though firms face the same market conditions, they choose different points. The firms with "better technology information" will earn a rent to their information. (This obviously has the flavor of the classic Ricardian rent model.) If there is no information flow at all, then the long run equilibrium of the industry will involve a set of firms having different production points and there will be no tendency for the production points to become the same over time.

Now, instead of an endowment of information, think about information as something the firm acquires. There is an extensive literature on the spread of information by a process of diffusion. "Diffusion" suggests what happens to a drop of ink in a glass of water; it spreads until the whole glass of water has changed color. The process is automatic; it is only a matter of time until the color has diffused throughout. The use of this process as a model tends to de-emphasize the mechanisms whereby the information spreads, and the role of the economic agents

whose behavior changes as a result of the information in actually seeking it.

In many cases it may be a reasonable model. Consider, for example; the diffusion of certain attitudes or behavior characteristic of "modernization" in the extensive sociological literature on that subject.[3] The implicit assumption is frequently that information spreads through social channels that exist for other purposes. People acquire the information and modify their behavior as a byproduct of their normal activities. They do not actively seek the information and it costs them nothing to acquire it.

In the case of technology information, it is possible that some information spreads in this costless almost accidental way, but it seems more realistic to think of the acquisition of information about technology as a purposive act, particularly when it is a question of the actual production point, rather than just a vague notion of "trends in shoe machinery." The passive acquisition of information can be included in this more complex context.

To specify in general the mechanism of information acquisition, assume that the entrepreneur knows his profit function but not the production points. Assume that there are channels of information about the production points. To operate a channel costs resources; when the channel is operated, it produces a set of Z's from which the entrepreneur chooses the profit maximizing point by substituting the points into his profit function.

To give some examples of potential channels of technology information:

1. Movement of personnel from one firm to another
   a. The manager of a firm may have experience in another firm in the industry, local or foreign
   b. Workers with technical information gained in another firm, local or foreign, may be hired.
2. Direct contacts among managers of firms, local and foreign
3. Contacts with sellers of capital goods (since technology is usually embodied in capital goods)
   a. Personal - Machinery distributors, local and foreign
      Industrial fairs, local and foreign
      Builders of kilns and dryers (in brick industry)
   b. Written - Catalogs
4. Contacts with technical assistance organizations
   a. Government, local or international
   b. Private non-profit, local or foreign
   c. Private consultants, local and foreign
5. Foreign investor in joint enterprise
6. Partner in subcontracting arrangements

If there were only one channel, and all firms had the same profit function, they would all choose the same point, and the cost of operating the channel would be a fixed cost of entry into the industry. (Note: we include the cost of calculating the maximum in the cost of operating the channel.)

If there are different channels, with different costs of operation (assume for the time being that the costs of operation are the same for every firm, but different for different channels), the production set is divided up into subsets, which may or may not be overlapping, associated with different information channels. There is a profit maximum on each subset, of course, but a particular subset may or may not contain the global profit maximum. One goes to a trade fair in Germany, which tends to have mostly German machines. One talks to a Pfaff machinery salesman, who of course says nothing about the latest United Shoe Machinery line. One hires a Japanese consultant. One makes a joint investment with a U.S. based multi-national corporation.

The entrepreneur then decides which channel to operate, based on the costs and benefits expected from each channel. Note that even if there is perfect certainty, in the sense that the entrepreneur knows exactly which channel would yield the global profit-maximizing production point and even what that profit would be, he will not necessarily use that channel. The difference in maximum profit between two channels does not necessarily outweigh the difference in the cost of using them. And note that since the cost of calculating the actual profit maximum among a set of points is part of the cost of using the channel, a channel which would give all the possible production points could be less desirable than one which only gave a selection, even though it was known that the selection did not include the global maximum.

It is important to include this aspect of the cost of operating an information channel. For example, consider acquiring technology

information by purchasing a consultant's time. Often the technology information which is unknown to the entrepreneur, and which would be useful, is foreign information. Leaving aside the problems of language, culture, etc. which make communication difficult, and the problem of knowing whether or not the consultant is actually competent, there is still a fundamental problem left. The entrepreneur, let us assume, knows all about his own environment in terms of relevant prices and qualities of inputs, demand conditions for outputs, climate, etc.--i.e. he knows his profit function. The expert knows all about the technology. To make the optimal choice, the information must be combined and the relative desirability of all the various options considered. But the information is very complex. In fact, probably only a few points will be looked at carefully and if the entrepreneur knows little about technology and the expert knows little about Colombia, these points may be very far from the optimal one.

Thus, continuing to assume that all firms are identical, all firms choose the same point, but it may be "sub-optimal" in the sense that there are points which would give higher profits, ignoring information costs. Of course, since the information costs are real, it is the optimal choice from the firm's point of view.

And of course, if there are potential economies in the cost of operating the channels--for example, the case of an international channel which could be operated once and then the information acquired spread more cheaply to domestic firms through a domestic channel--there may be a divergence between private and social cost and an argument for collective

action. Or, there may be a role for private information intermediation, as a profit-making enterprise. We will return to this aspect later.

Even without introducing any uncertainty or any differences among firms within a country, the above discussion could be used as an explanation for differences across countries, over and above factor prices. In particular, it can explain the choice of "inefficient points," which differences in factor prices cannot do. The firms may know that more efficient points exist but it is not worth the resources to find out about them. This is similar, in effect, to international trade models which assume that different countries have different production functions, but the focus is different in that it contains an explanation for why differences may persist and suggests a direction to look for policy conclusions, namely toward the nature of the information channels: where they come from, how they change over time and how they can be changed.

It is more realistic to assume that the entrepreneur does not know which channel would yield the global optimum, if operated. He does know something about the channels. He cannot know which Z's he will get because that is the essence of his problem, but he does have an idea of roughly the "type" of technology information one is likely to get from a given channel, in terms of how profitable the production points are likely to be under Colombian conditions. To make this more specific, we assume that he has an ex ante distribution of the maximum profit point that the operation of a particular channel would yield. This distribution will, of course, depend on the conditions in the input and

output market that go into the profit function (including conditions like special characteristics of the labor force, the climate, etc.), as well as characteristics of the channel itself.

The expected value of operating a channel is: $E(\pi(Z_i)) - C_i$ where $\pi(Z_i)$ is the random variable which represents the maximum profit point over the set of points covered by the information channel, and C_i is the cost of operating the channel.

If a firm maximizes expected profits, then it will operate the channel for which this expression is the largest. The result of this trial will be an actual maximum profit point $\pi(\overline{Z})$. The firm will then operate the next best channel if and only if $E(\pi(Z_j)) - C_j > \pi(\overline{Z})$ and similarly, until it draws a profit point which makes the next step not worthwhile.

If the firm has an initial endowment of information, then it compares the maximum profit point over the set of points in the initial endowment with the expected net value of operating an information channel.

If entrepreneurs are not risk-neutral then the expression above must be restated in expected utility terms. If they are risk-averters, then the greater the variability in the possible outcomes, the greater will have to be the profit premium over the cost of operating the channel to make the use of the channel worthwhile.

Note also that it is total expected profits that matter, not profits per unit, since the information cost is a fixed cost, not a variable cost. Therefore, if the maximum profit production point represents small scale

operation, the information costs will loom larger in the firm's decision.

As before, if all firms are alike, they will all make the same decisions and choose the same point. As before, they may make a "sub-optimal choice" in the sense that it is not the global maximum, because of the cost of operating the channel, or, now because their ex ante probability distributions do not reflect reality. E.g. they may all have the idea that Italian shoe machinery is particularly suitable to Colombian conditions but in fact this is not true; the channel which has the highest value of $\pi(Z)$ is some other channel. All the firms then make a sub-optimal choice by choosing the Italian channel; note that there is no mechanism in what we have said so far for revealing the "error."

Now let us make an important modification. We continue to assume that all firms have the same profit function, but we assume that the cost of using a particular information channel differs across firms. Entrepreneurs who have pre-existing contacts abroad or know foreign languages can use international channels more cheaply. Entrepreneurs with technical education can use technical sources cheaply. Here, we are incorporating the type of variable which relates to the firms' "contacts," "social interactions," etc. They come in as influences on the cost of a particular information acquisition decision. Then the firms will not all make the same choices. It may be quite easy to find a firm which could increase profits by changing to the production point of another firm, but it does not. The firm may know that other firms do things differently but it does not know the details, i.e. exactly what the difference is, and whether it would increase or decrease profits to change.

It would cost resources to actually find out the production point. For example, an entrepreneur may know that another firm has just bought a new machine, but he does not know how much it cost, what its inputs and outputs are, what its effect on profit would be. He may even know that the firm associates are showing signs of affluence, with flashy new cars, etc. and therefore suspect that the new machine is profitable, but he does not know. In this context, it is particularly important to remember that the differences between production points are not necessarily readily visible. Some very important changes may be in organizational inputs, e.g. a system of cost accounting. Even when there is a highly profitable production point characterized by a particular machine, the machine is likely to require adjustments in the type of raw materials, changes in the skill level of operators, or the necessary level of supervision, changes in maintenance inputs, compared to the production point that it would replace. And if these adjustments are not made, adopting the machine may actually lower profits. This may be particularly true of production points that have never been used before in Colombia.

The discussion above is to some extent an application of Arrow's discussion of information but it differs in one important respect in taking the channels as given, and considering the firm's decision to be whether or not to use them. Given the putty-clay nature of technology, the decision on a production point is often a discrete decision, infrequently made. In the discussion above, we are thinking about the initial decision made by the entrepreneur upon entering the industry. The discussion can also apply to infrequent major changes in production point with the provisos that:

1. The previous decisions will obviously condition the current decision; ownership of a large quantity of a particular type of machinery, or a reputation as a producer of a product with particular characteristics, will affect the expected profitability of new information about production points; 2. Previous experience with a particular information channel may affect the entrepreneur's assessment of the profit distribution.

To the extent that an industry is such that entrepreneurs tend to make a practically continuous series of small decisions about technology, the model must be expanded in the direction of opening and frequent monitoring of channels.

So far, in order to highlight the information channel aspect, we have been assuming that all firms have the same profit function. In the Colombian case, as we stated before, there is evidence that conditions in input markets, e.g. capital and labor markets, differ across firms. This, as we pointed out, is another possible explanation for different choices of production point in itself. There is a distinction that it is important to make here:

1. The conditions in the input and output markets that affect profits may be associated with the production point or they may be associated with the firm.

Examples of the first: Appendix 1 discusses provisions in the Colombian labor code which affect the cost of labor by number of workers employed. The effective cost of a particular machine may be lower because of favorable credit arrangements with that supplier.

Examples of the second: An entrepreneur with very good banking connections or with extensive property that can be used for collateral

may be able to borrow at a lower interest rate than another entrepreneur without such advantages.

In the case of the first, the profit functions are the same for all firms, in the sense that given a particular Z, any firm which chose it would get the same profit, but if firms chose different points one would still observe variations across firms in actual input prices paid.

If the cost of operating an information channel was the same for all firms and if the profit functions were the same, in the above sense, then firms would only choose different production points if the global maximum was not unique. (This, of course, is not impossible, given the possibility of variations in market conditions according to the production point chosen.)

It is the case of the second type of thing that we mean when we say that profit functions differ across firms.

The discussion above is in comparative static terms. Channels exist at an instant of time; the production set exists and is fixed. The profit function includes all relevant future input and output conditions fixed and known with certainty. The cost of using the channel will be spread over the lifetime of the firm. This means that practically speaking information costs would have to be quite large to be significant.

When we add real world changing conditions, the firm's problem becomes much more complex. It is no longer simply a problem of making a single information decision and then a decision on the optimal production point; it is a problem of choosing the optimal strategies for seeking information and for altering the production point over time, given a profit function and a production function that are changing under conditions

of uncertainty. It would, of course, be very complex to model this. One thing that is clear, however, is that the value of technology information will tend to be lessened by frequent and unpredictable changes in the environment. This will not only affect the firm's information strategy; it will also tend to affect the nature of the information channels available. If all firms have the same profit function, then it might be easy and profitable to find out the optimum production point for them by operating, say, an expensive international channel, and then sell them the information at relatively low cost. But the information intermediary will then have an investment in the information. If economic conditions, and/or the underlying production set, change rapidly, the return to this investment will naturally tend to decrease. Similarly, if firms have very different profit functions, the potential information economies are then much smaller. Given this, it is interesting to note the degree to which information channels are either non-profit social agencies, or a side-line to other activities which generate information as a by-product.

For example:

1. Machinery Producers: These are usually an important source of information, since they are of course familiar already with their own equipment's characteristics and since the provision of information may improve their market position. Of course, this implies an obvious bias in the nature of their information as well.

2. Trading companies: In Japan the great trading companies played an important role in providing technology information to firms, and even

organized entire industrial projects on contract. This was a natural joint product, given the international market contacts necessitated by their main import export business.

In the Japanese case, the formidable language barriers greatly increased the cost to an individual firm of seeking foreign technological information (this is probably less true now, when many more Japanese learn languages as a matter of course during their early education).

3. Multinational Corporations: A firm which for one reason or another has valuable technology information - perhaps because it has generated it itself through internal R & D - could sell the information to its competitors, but it would then lose potential rents on the information. Thus, one sees the very familiar arrangement by which the MNC sells the information to LDC firms, through joint ventures, royalty arrangements, etc. with a prohibition against exports to markets served by the parent firm.

4. Sub-contracting arrangements: There are of course many aspects to the economic desirability or undesirability of sub-contracting. In this context, we can mention that the provision of technological information can be a very valuable part of a sub-contracting deal for a small firm, while being very cheap for the large firm to provide.

It is also worth noting that the above discussion suggests that a competitive industry will tend not to have collective information institutions. An oligopolistic industry might, since with explicit collusion they can arrange to share out the costs and benefits of the information activities.

SECTION ONE--NOTES

[1]See, for example, the articles by Stigler, Rothschild, Ozga given in the references.

[2]W.W. Norton & Company, New York, 1974. See also J. Marschak, "The Economics of Enquiring, Communicating, Deciding," American Economic Review, Papers & Proceedings, 58 (May) 1-18.

[3]One example of this sort of model that can be found in the economics literature is S. A. Ozga, "Imperfect Markets Through Lack of Knowledge," Quarterly Journal of Economics, 54 (February, 1960), 29-52. The basic idea of his model is that information about market conditions for consumer products diffuses through social contacts and advertising; the focus is on information that is not deliberately sought.

SECTION TWO: FIELD RESEARCH

The study is based on secondary data and on primary micro data collected at the firm level from a sample of firms in the men's leather shoe and brick industries.

In a study of this type, there is a serious data problem. It is very difficult to get quantitative data from individual firms. They are afraid that the information will be used in a way that will be damaging to their interests; they are reluctant to spend time gathering information together, and frequently they simply do not have even basic accounting information.

Capital data is particularly difficult. The problem is not only the theoretical existence or non-existence of a suitable unit for measuring capital. One could agree that current replacement cost was a suitable unit, but many firms do not have any idea what this number is or even what they originally paid for the capital. Book value is not a good measure, since depreciation relates much more to tax law than to the economic value of the capital. The other common measures of electrical energy consumed and rated horsepower are more measures of economists' desperation than of capital. Therefore we looked for a method of characterizing a firm's technology choice that would enable us to capture the main alternatives in the industry but which would be feasible.

We decided to use a two stage approach to the data collection. The idea was to begin by finding natural partitionings of the production set and then to find a simple set of questions or factory observations which would place the firm's choice in a particular region of the set. With the assistance of local consultants with technical knowledge as

well as extensive knowledge of the Colombian industries, a set of categories of technology choice was developed for each industry. FICITEC agreed to prepare a specification of a representative plant for each category, based on information from a small number of typical firms (located on the advice of the consultants) which were willing to provide information.

The tentative plant designs were used as a part of the basis for a survey. Questions on key points of the production process were included in the survey to determine what category the firm was in. Then the results of the survey were used to suggest modifications in the original categories and plant designs. The final categorization of technology choice in each industry is described in Sections Three and Four. The representative plant designs are given in Appendices 2 and 3.

The survey questionnaire also asked for information relevant to determining the firm's position in capital and labor markets and its use of information sources.

SELECTION OF THE SAMPLE:

As is common in studies of this type, a major difficulty was the absence of a satisfactory list of the population of firms to be sampled. The base was the list of the government statistical agency DANE (Departamento Administrativo Nacional de Estadistica). The list was very incomplete, especially for the smaller firms. It was supplemented with a list prepared for a study by the local association of construction-related firms, for the brick industry and with a list prepared for a FICTEC-PROEXPO report, for men's leather shoes. However, we still had almost no information

about firms with less than 10 employees.

The sample was stratified by size of firm measured by employment size class in both industries. Four size classes were used. The artisan class was originally defined as less than 10 employees. The category "small" comprised firms with 10 to 49 workers, "medium" comprised firms with 50 to 99 workers, and "large" comprised firms with 100 or more workers.[2]

Forty firms were selected from the lists by simple random sampling without replacement within the three strata denoted as small, medium and large. Ten artisan firms were selected in each industry, using a simple type of area sampling. In each of the large cities of Colombia there are usually geographical clusterings of small brick and shoe factories. The interviewers were to go to these areas, and select arbitrarily a certain number of firms to be part of the sample. The number of firms chosen in each city was to be proportional to estimates of the share of that city in the total number of such firms in all the cities to be sampled.

In addition to this sample of 50 firms, we chose a sample of 30 firms, and designed a slightly longer questionnaire which included questions designed to provide more cross country comparative detail on machinery. The method of selection of the supplementary sample was the same as that for the sample of 50 firms.

When the interviewers went to interview the selected firms, they found that it was frequently impossible to interview the chosen firm. In the shoe industry, the reasons were, in order of importance:

a) the firm had changed its line of production
   e.g. to women's or children's shoes

b) it had gone bankrupt

c) it had stopped producing shoes and become a distributor only. In the brick industry, the major problem was bankruptcy, since the industry was in a state of upheaval as a result of a construction slump produced by the government's shift away from its earlier policy of promoting residential construction. In addition, of course, some

firms refused to cooperate. An additional 10% of firms had been selected in each size category to serve as alternates but these were quickly used, and generated the same problems. In order to fill out the sample, the interviewers selected firms arbitrarily by using the telephone directory and by asking the firms that they visited for the names of other firms that produce men's leather shoes or bricks. They tried to maintain the same size distribution of firms in this process to the extent possible. Of course, biases have undoubtedly been introduced into the sample by this approach, but given the problems of conducting micro level surveys in LDC's there was no feasible alternative.

Using these methods, at least some information was obtained from 73 firms in the men's leather shoe industry. In bricks, the final sample size was 50.

SECTION TWO--NOTES

[1]PROEXPO is the Export Promotion Fund (Fondo de Promocion de Exportaciones), a government agency.

[2]In the actual analysis of the data, we re-grouped the firms into slightly different size groups (described in Section Three) since for the chosen industries, these groups were more homogeneous than the original groups. Definitions of size categories vary in different studies. For example, Robert Slighton uses the definition given here for the smallest sector, which he calls the craft sector, in The Craft Sector in Colombian Manufacturing, Rand, February, 1968. But Albert Berry defines the smallest sector (which he calls the "cottage shop" sector) to be firms with less than five employees, in "The Relevance and Prospects of Small Scale Industry in Colombia," Economic Growth Center Discussion Paper No. 142, April 25, 1972.

SECTION THREE: THE BRICK INDUSTRY

I. INTRODUCTION: THE TECHNOLOGY OF THE PRODUCTION OF CLAY BRICKS[1]

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.

For the purposes of this study, the main features of the development of the technology over time are the following.

There has been a substantial increase in the minimum scale of plant with the development of the new technological alternatives, particularly in the case of kilns.

In general, the newer the technique, the less labor is used relative to capital, in each process. In addition, the nature of the work has changed. The conditions under which the laborer must work are less

unpleasant; for example, the temperature conditions are less harsh in the case of the tunnel kiln compared to other types of kilns. Moreover, some substitution of skilled for unskilled labor has occurred in the newer techniques. For efficient operation, the tunnel kiln and tunnel dryer require careful technical management with respect to temperature controls.

Efficiency of fuel use is an important factor. Obviously, artificial drying uses more fuel than natural drying. The hot floor is less efficient than the chamber and tunnel dryers; the latter two vary depending upon the specific design and operation, but are potentially equally efficient. Kilns also vary in fuel efficiency depending on specific design (so that there can be overlap) but in general, the more recent the vintage of kiln type, the greater the efficiency. However the tunnel kiln, although it tends to be the most efficient in fuel use, is least versatile. It is most suitable for use with oil or gas while the other types can use any fuel.

II. THE BRICK INDUSTRY IN COLOMBIA

A. Overview

1. Categories of technology choice

The range of technological alternatives in use in Colombia spans the history of the industry. We have divided the industry into ten categories, as shown in Table 3.1. They are ordered by technological sophistication.[2] The main characteristics determining a firm's classification were the following:

a) Forming: semi-dry press process
extrusion with de-airing
without de-airing
manual molding

b) Drying: artificial drying - tunnel dryer
chamber dryer
natural drying

c) Firing: continuous kiln - tunnel kiln
Hoffmann kiln
intermittent kiln - vertical or inverted flame
open clamp

Appendix 2 gives a more detailed description of a representative firm in each category.

The information on Categories S, D and I is more limited than that for the other categories. Category S consists of a single large factory producing a unique type of brick by a modern process, and owned by a very large brick firm. Since this firm has an important position in the market, we were eager to include it in the study. However, we were unable to obtain its cooperation. Therefore, we have been restricted to using information which could be obtained from indirect sources. Category I, the unmechanized chircales, consists of very small artisan family firms typical of the Bogotá region. These firms were sampled and visited but it was impossible to obtain their cooperation in filling out a formal questionnaire. Thus Categories S and I are not included in the tabulations of survey results in most cases.

Table 3.2
BRICK INDUSTRY

DISTRIBUTION OF OUTPUT BY CATEGORY AND PRODUCT IN SAMPLE

	CAT. S		CAT. A		CAT. B		CAT. C		CAT. D		CAT. E		CAT. F		CAT. G		CAT. H		CAT. I	
	Number Produced	% of Output in Value terms	Number Produced	% of Output in Value terms	Number Produced	% of Output in Value terms	Number Produced	% of Output in Value terms	Number Produced	% of Output in Value terms	Number Produced	% of Output in Value terms	Number Produced	% of Output in Value terms	Number Produced	% of Output in Value terms	Number Produced	% of Output in Value terms	Number Produced	% of Output in Value terms
Common Brick			493,393	63.7	185,470	11.9	322,993	7.5	410,020	61.9			240,000	14.6	1,232,886	96.1	1,087,000	100.0	N.A.	100%
Repressed Brick							40,000	1.0	25,000	5.0					32,130	2.5				
Pressed Brick	N.A.	100%																		
Hollow Brick											46,930	2.8								
Block #4					178,220	22.2	686,837	36.9	60,000	22.5	818,050	65.1	202,700	33.7						
Block #5					400,690	63.1	836,579	53.2	20,000	10.6	325,400	26.2	66,300	11.9						
Block #6			156,085	36.3	14,420	2.8	19,500	1.5			5,000	.8								
Blocks #2 & 3											13,490	1.1	205,000	39.9	18,000	1.4				
Blocks #7 & 9											39,069	4.1								
Total Value		N.A.		764,105		1,524,635		3967,632		452,795		2,481,052		2,481,052		1,283,016		916,700		N.A.

N.A. = Not available

Category D consists of only three firms which would not fit into the other categories but which are quite different from each other; in terms of technological sophistication, they fall in between Categories C and E but do not in fact form a real category themselves, and therefore no representative plant has been prepared for them.

2. Products

Table 3.1 indicates the types of products produced by each category by name and Table 3.2 shows the distribution of output by category and by product in the sample. There is a surprising amount of product differentiation in the industry and product characteristics are related to technology choice. Below are the principal types of products produced in Colombia.

a) Common Brick (Tolete común). A solid parallelopiped with dimensions of approximately 25x12x6.5cms. It is produced in all categories except the first in factories representing a wide range of technological sophistication by methods ranging from extrusion and wirecutting to forming in simple wooden molds. Its external appearance varies according to the method of production, becoming more regular in shape and homogeneous in color as the level of mechanization increases. The strength and durability also increase somewhat with the level of mechanization.

b) Repressed Brick (Tolete Reprensado). Similar to a common brick. The first part of the production process is the same as that for the common brick, but when the brick is partially dry it is pressed in a press (usually human-powered) to improve its appearance. Repressed bricks are generally produced in partially mechanized artisan factories.

BRICK INDUSTRY

TABLE 3.1

Category	Special	A	B	C	D	
Products	Pressed Brick	Common Brick Block #6	Common Brick Block #4,5,6	Common Brick Block #4,5,6 Repressed brick	Common Brick Repressed Brick Block #4,5	Common Br Hollow Br Block #4,
Excavation	Mechanized with own equipment	Mechanized: Subcontracted	Mechanized: majority with own equipment	Mechanized with own equipment	Mechanized, with own equipment	Majority with own Minority with
Preparation	Feeder Box Clay Crushers Hammer Mill Pre-drying for semi-dry process Mixer for dry ground process	Feeder box Clay crusher Stone screening Rolls Wet Pan Mills Roll Mills Mixer	Some or all of: Dose Measurer Mill hopper Clay Crushers (or crushing rolls) Stone-Screening rolls Roll Mill Mixer	Similar to B	Some type of preparation machine: Grinder Double roll mill Rolling Press Mixer	Box Feed Double r Mixer
Forming	Rotary table in semi-dry process	Extruder with de-airing chamber and automatic wire cutter	Extruder with de-airing chamber and automatic wire-cutter	Extruder and de-airing chamber and automatic wirecutter	Two firms have extruders with de-airing chamber and automatic wire cutter One firm has extruder without de-airing chamber and manual cutting	Extruder airing ch automatic
Drying	Tunnel dryer	Combination of tunnel drying & covered natural drying	Combination of chamber drying & covered natural drying	Covered natural Drying	2: Covered natural Drying 1: Chamber Dryer	Covered Drying
Firing	Tunnel Kiln	Tunnel Kiln	Hoffman kiln	Hoffman Kiln	2: Hoffman Kiln 1: Intermittent Kiln	Intermitt Kilns

TABLE 3.1

D	E	F	G	H	I
ck Brick	Common Brick Hollow Brick Block #4,5,6,7,9	Common Brick Block #2,3,4,5	Common Brick Repressed Brick	Common Brick	Common Brick
, with ent	Majority mechanized, with own equipment Minority mechanized with rented equipment	Majority mechanized; rented equipment is common	Occassionally mechanized, or machinery rented. Usually manual or animal power-material excavated daily	Manual	Manual
of machine: ll mill ress	Box Feeder, Double roll mill, Mixer	Limited machinery; no more than two of: Mill Hoppers Crushing Rolls Double Cylinder Roll Mills Mixer	Limited machinery; a few firms have either Stone Mill or Rolling Press, Machinery used is connected to mixer and extruder	Wooden mills operated by horse power, or horses or young oxen walking on clay--no machines; some firms use simple mixers	Wooden Mills operated by horse power
ave extruders ing chamber ic wire cutter s extruder airing manual	Extruder with de-airing chamber and automatic cutter	Extruder with de-airing chamber (Colombian adaptation) and manual wirecutter	Extruder without de-airing chamber and manual wire-cutter	Manual-Bricks are formed using simple wooden molds	Manual-use sample wooden molds
natural Dryer	Covered Natural Drying	Covered natural Drying	Covered or uncovered natural drying	Covered or uncovered natural drying	Uncovered natural drying
kiln ttent	Intermittent Kilns	Intermittent Kilns	Intermittent kilns, one example of open clamp kiln	Intermittent kilns	Open clamp Kiln

c) Hollow Brick (Tolete Hueco). Similar in size and appearance to the common brick, but containing holes of 2 cms. in diameter. It is produced by the extrusion process. It is new on the market and is produced by only a few factories.

d) Pressed Brick (Tolete Prensado). Similar in size and shape to the above products but significantly more uniform in shape, color and texture, and not as strong or durable. The pressed brick is produced by the single factory in Category S using a process which includes artifically drying the clay before it is formed into a brick.

e) Block (Bloque). A hollow block made by the extrusion process. Blocks are made in various sizes and with varying numbers of holes depending on the matrix used in the extruder. The most common sizes are:

No. 4 approximately 33x23x9cms.

No. 5 approximately 33x23x12cms.

No. 6 approximately 33x23x15 cms.

Other sizes appearing in the market in much smaller volume are:

Nos. 2 & 3 Blocks No. 4 and No. 6 divided in half.

No. 7 approximately 12x25x6cm.

No. 9 approximately 12x25x12cm.

Blocks are produced only by factories in categories A to F. They cannot be produced by purely manual methods; the factory must have an extruder with a de-airing chamber.

The products described are not perfect substitutes. Blocks are especially suitable for multi-story buildings. They are used for the interior structural components and then covered over with a facade of

some other material. Since this use requires a combination of strength and light weight, products a) through d) are not suitable.

Pressed bricks are used almost entirely for facades of buildings, since their uniform shape and color gives a pleasing appearance, while their lack of strength makes them unsuitable for structural purposes. Although they have become the major choice for building facades in the years since they came on the market, there is actually some question about their suitability, since they are somewhat porous and become more fragile when wet; thus they are not weather-resistant.

The common brick has too rough an appearance to compete readily with the pressed brick in urban construction for facades. The repressed brick, while not as homogeneous as the pressed brick, does have a good appearance, and has the advantage of being stronger and more durable. It was the major choice for facades before the introduction of the pressed brick. Now it is less used, and is usually produced on special order.

The common brick is used for structural purposes in one story buildings and for other general purpose construction use where the special characteristics of the other products are not needed. For these purposes, uniformity in size and shape is still of some importance since the more uniform the product, the less mortar and plaster or other covering material the construction firm has to use to fill in the spaces caused by irregularities in the brick product.

3. The relationship between category and size of firm

The categories were defined by type of technology and not by size of firm. Thus it is interesting to consider the relationship between size and category. Table 3,3 gives a contingency table relating

category to employment size group.[3] The high value of chi-square shows that size group is positively correlated with technology category and the Gamma and Cramer's V statistics suggest that the relationship is a fairly strong one. Table 3.4 is a scattergram of employment against technology category; Kendall's tau shows that employment is positively correlated with sophistication of technique. However, the correlation is not as strong as it is for the shoe industry. We suspected that one problem was the inadequacy of employment as a measure of size.

This was of particular importance during 1975, the year of the survey. The brick industry was in a state of some disarray, because changes in government policy relating to residential construction had caused a slump in the construction industry, and many brick firms were operating much below normal capacity with smaller than usual labor forces. Therefore we computed a second set of tables (Tables 3.5 and 3.6) using size as measured by capacity output.[4]

These figures show a closer correlation between size and category. Chi-square, Cramer's V, Gamma and Kendall's tau are all greater in absolute value.[5]

The conclusion is: the choice of greater sophistication in technology is correlated with the choice of a larger volume of production.

4. The Market for Bricks

a) Market Structure

The structure of the market is somewhat complicated, because of product differentiation, and because the existence of transport costs causes the market to be segmented into regional markets. The five important regional markets are:

Table 3.3

Brick Industry

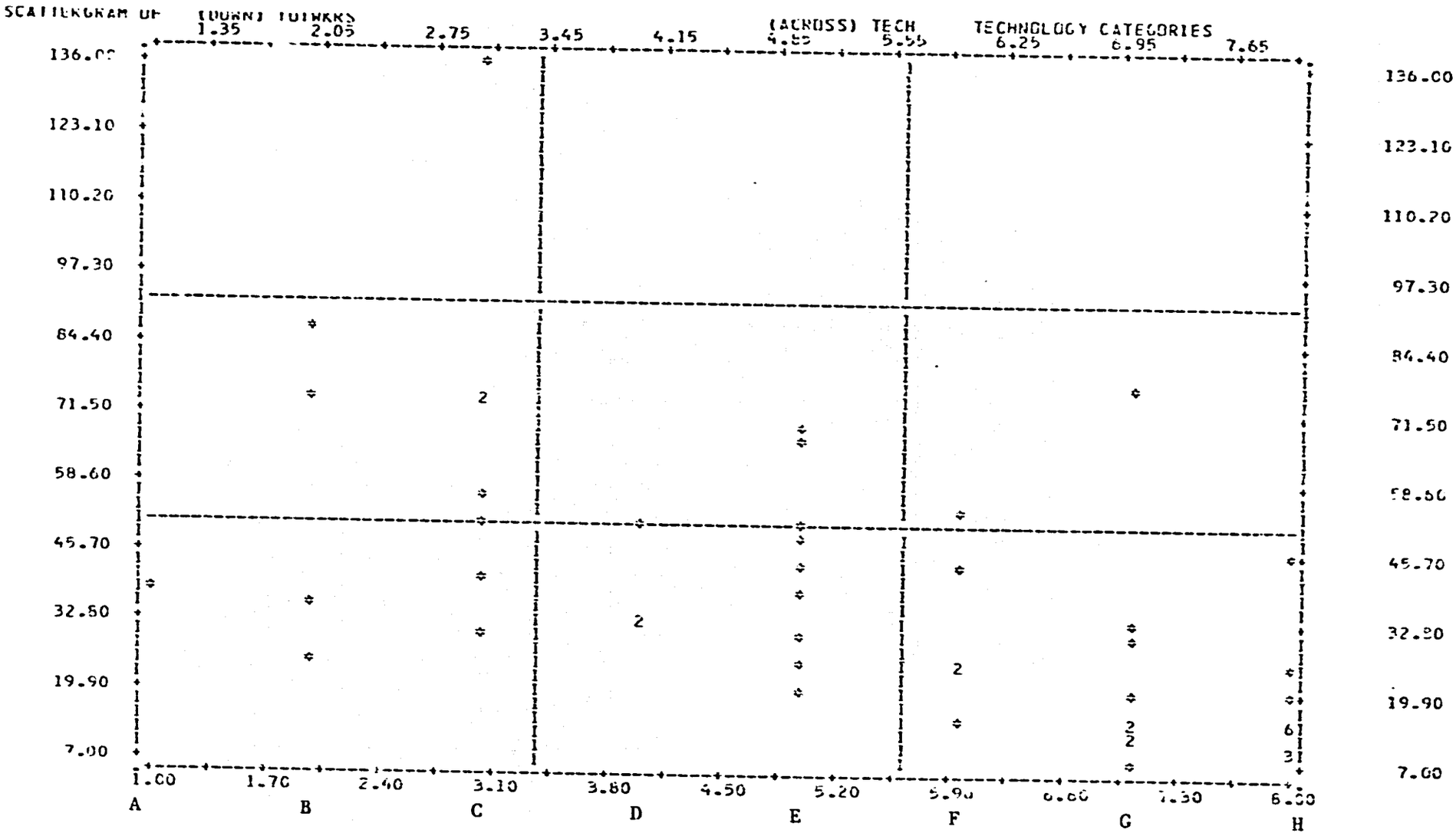
* *

EMPLOYMT EMPLOYMENT GROUPS BY TECH TECHNOLOGY CATEGORIES

EMPLOYMT	COUNT / ROW PCT / COL PCT / TOT PCT	CAT A (0)	CAT B (1)	CAT C (2)	CAT D (3)	CAT E (4)	CAT F (5)	CAT G (6)	CAT H (7)	CAT I (8)	ROW TOTAL
<16 WORKERS (1)		0	1	0	0	0	0	1	7	0	9
		0.0	11.1	0.0	0.0	0.0	0.0	11.1	77.8	0.0	11.1
		0.0	50.0	0.0	0.0	0.0	0.0	50.0	41.2	0.0	
		0.0	0.9	0.0	0.0	0.0	0.0	0.9	6.4	0.0	
16-50 WORKERS (2)		0	1	2	2	2	7	2	11	0	27
		0.0	3.7	7.4	7.4	7.4	25.9	7.4	40.7	0.0	24.8
		0.0	100.0	50.0	28.6	28.6	77.8	50.0	64.7	0.0	
		0.0	0.9	1.8	1.8	1.8	6.4	1.8	10.1	0.0	
51-100 WORKERS (3)		0	0	2	4	3	1	1	1	0	12
		0.0	0.0	16.7	33.3	25.0	8.3	8.3	8.3	0.0	11.0
		0.0	0.0	50.0	57.1	42.9	11.1	50.0	5.9	0.0	
		0.0	0.0	1.8	3.7	2.8	0.9	0.9	0.9	0.0	
>100 WORKERS (4)		1	0	0	1	0	0	0	0	1	3
		33.3	0.0	0.0	33.3	0.0	0.0	0.0	0.0	33.3	2.8
		100.0	0.0	0.0	14.3	0.0	0.0	0.0	0.0	100.0	
		0.9	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.9	
COLUMN TOTAL		1	2	4	7	5	8	4	17	1	51
		2.0	3.9	7.8	13.7	9.8	15.7	7.8	33.3	2.0	46.8

RAW CHI SQUARE = 53.46276 WITH 24 DEGREES OF FREEDOM. SIGNIFICANCE = 0.0005
CRAMER'S V = 0.51196
GAMMA = -0.70055

Table 3.4 Brick Industry



KENDALL CORRELATION COEFFICIENTS

VARIABLE PAIR	VARIABLE PAIR	VARIABLE PAIR	VARIABLE PAIR	VARIABLE PAIR	VARIABLE PAIR
TOTWKRS WITH TECH -0.5157 N(50) SIG .001					

Table 3.5 Brick Industry

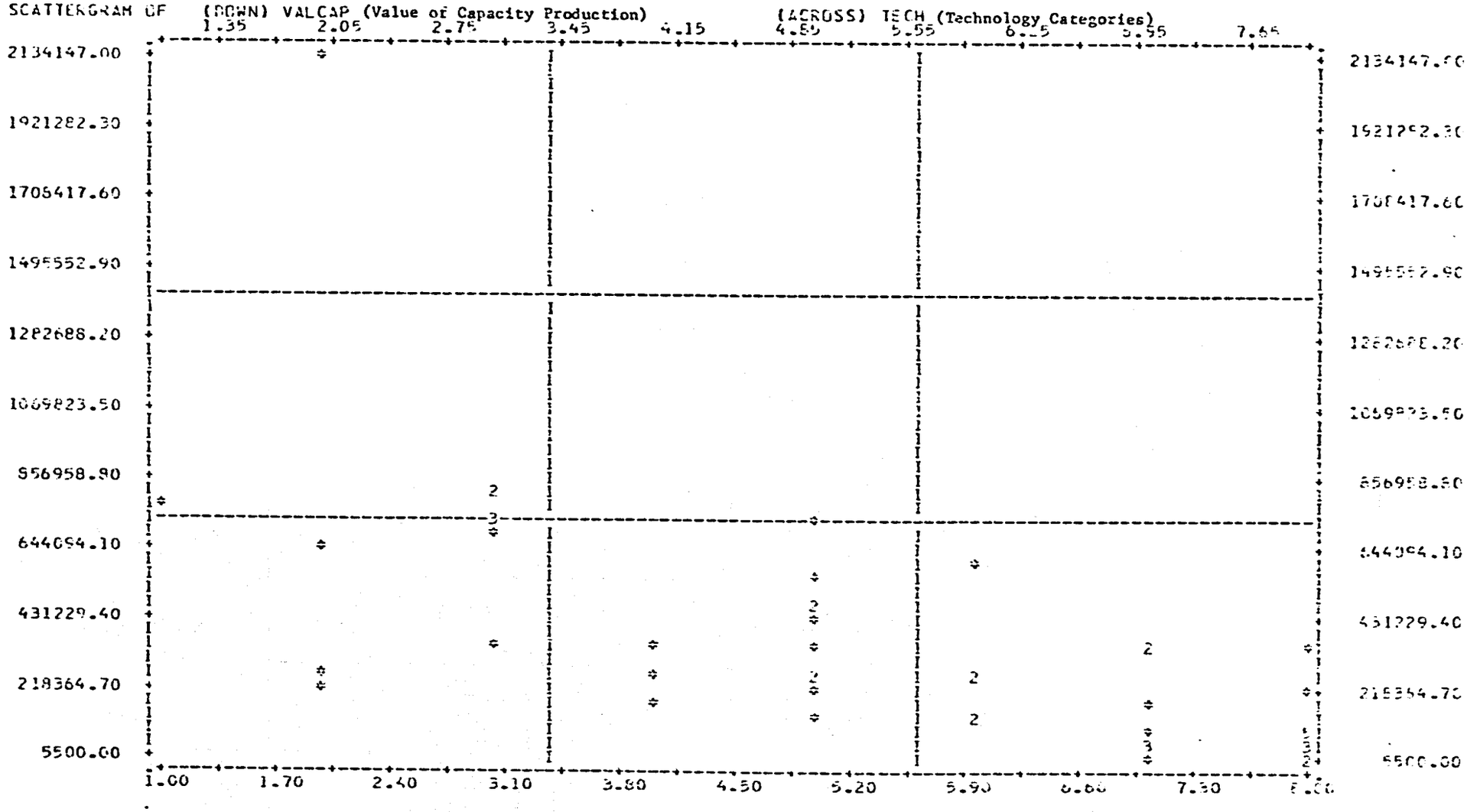
HCAT

CAPACITY CAPACITY GROUPS — CROSSTABULATION OF — BY TECH — TECHNOLOGY CATEGORIES

APACITY	COUNT / ROW PCT / COL PCT / TOT PCT	TECH 0	CAT A 1	CAT B 2	CAT C 3	CAT D 4	CAT E 5	CAT F 6	CAT G 7	CAT H	ROW TOTAL
<100000	1	0 0.0 0.0 0.0	0 0.0 0.0 0.0	0 0.0 0.0 0.0	0 0.0 0.0 0.0	0 0.0 0.0 0.0	0 0.0 0.0 0.0	0 0.0 0.0 0.0	5 33.3 35.7 9.8	10 66.7 83.3 19.6	15 29.4
100000-300000	2	0 0.0 0.0 0.0	0 0.0 0.0 0.0	2 14.3 50.0 3.9	0 0.0 0.0 0.0	2 14.3 66.7 3.9	4 28.6 44.4 7.8	4 28.6 80.0 7.8	1 7.1 11.1 2.0	1 7.1 8.3 2.0	14 27.5
300000-600000	3	0 0.0 0.0 0.0	0 0.0 0.0 0.0	0 0.0 0.0 0.0	1 9.1 14.3 2.0	1 9.1 33.3 2.0	4 36.4 44.4 7.8	1 9.1 20.0 2.0	3 27.3 33.3 5.9	1 9.1 8.3 2.0	11 21.6
>600000	4	1 9.1 100.0 2.0	1 9.1 100.0 2.0	2 18.2 50.0 3.9	6 54.5 85.7 11.8	0 0.0 0.0 0.0	1 9.1 11.1 2.0	0 0.0 0.0 0.0	0 0.0 0.0 0.0	0 0.0 0.0 0.0	11 21.6
	COLUMN TOTAL	1 2.0	1 2.0	4 7.8	7 13.7	3 5.9	9 17.6	5 9.8	9 17.6	12 23.5	51 100.0

AW CHI SQUARE = 68.78783 WITH 24 DEGREES OF FREEDOM. SIGNIFICANCE = 0.0000
RAMER'S V = 0.67052
AMMA = -0.76271

Table 3.6 Brick Industry



KENDALL CORRELATION COEFFICIENTS

VARIABLE PAIR	VARIABLE PAIR	VARIABLE PAIR	VARIABLE PAIR	VARIABLE PAIR	VARIABLE PAIR
VALCAP WITH TECH -0.5957 N(50) SIG .001					

Table 3.7 Brick Industry

```
* * * * * * * * * * * * * * * * * * * *   C R O S S T A B U L A T I O N   O F   * * * * * * * * * * * * * * * * * * * *
    EMPLOYMT  EMPLOYMENT GROUPS                                                  BY  CAPACITY  CAPACITY GROUPS
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  PAGE  1 C
```

EMPLOYMT	CAPACITY COUNT ROW PCT COL PCT TOT PCT	<100000 1	100000-300000 2	300000-600000 3	>600000 4	ROW TOTAL
<16 WORKERS	1	11 91.7 73.3 21.6	1 8.3 7.1 2.0	0 0.0 0.0 0.0	0 0.0 0.0 0.0	12 23.5
16-50 WORKERS	2	4 15.4 26.7 7.8	12 46.2 85.7 23.5	8 30.8 72.7 15.7	2 7.7 18.2 3.9	26 51.0
51-100 WORKERS	3	0 0.0 0.0 0.0	1 9.1 7.1 2.0	3 27.3 27.3 5.9	7 63.6 63.6 13.7	11 21.6
>100 WORKERS	4	0 0.0 0.0 0.0	0 0.0 0.0 0.0	0 0.0 0.0 0.0	2 100.0 18.2 3.9	2 3.9
	COLUMN TOTAL	15 29.4	14 27.5	11 21.6	11 21.6	51 100.0

RAW CHI SQUARE = 52.03096 WITH 9 DEGREES OF FREEDOM. SIGNIFICANCE = 0.0000
CRAMER'S V = 0.58316
GAMMA = 0.94310

Table 3.8

Geographical Distribution of Brick Industry
by Employment Size Group

Region	SIZE GROUP <10 Workers	10-49 Workers	50-99 Workers	>100 Workers	Total
Bogotá	367	64	14	2	447
Medellín	50	59	8	-	117
Cúcuta	100	8	2	1	111
Bucaramanga	30	5	3	-	38
Costa Atlantica	N.A.*	4	1	1	6
Valle Del Cauca	52	33	3	1	89
Popayan Y Pasto	N.A.	6	-	-	6
PMAC (Pereira, Manizales, Armenia, Cartago	78	26	-	-	104
Total	677	205	31	5	918

Source: CAMACOL (Colombian Association of Construction Related Industries)

Source: DANE (Department of National Statistics)

*Seasonal Production only

Table 3.9 Brick Industry Geographical Distribution of Sample - Number of Firms by Departamento

TABLE 3.10

BRICK INDUSTRY

GEOGRAPHICAL DISTRIBUTION OF SAMPLE

Antioquia

	Cat C	Cat D	Cat E	Cat F
Employ 2			4	2
Employ 3		1	2	1
Employ 4	1			

Risaralda

	Cat H
Employ 1	1

Cundimarca

	Cat B	Cat C	Cat D	Cat G
Employ 1				3
Employ 2	2	2	2	
Employ 3	2	4		

Quindio

	Cat G	Cat H
Employ 1	1	3

Valle

	Cat A	Cat E	Cat F	Cat G	Cat H
Employ 1					3
Employ 2	1	2	1	3	5
Employ 3				1	

Caldas

	Cat F
Employ 1	1

Norte De Santander

	Cat E	Cat G
Employ 1		1
Employ 2	1	

Bogotá

Medellín

Cali

PMAC (Pereira, Manizales, Armenia, Cartago)

Cúcuta

Of these, the largest are the first three. The geographical distribution of the industry by employment size group, as far as it is known, is shown in Table 3.8, and the geographical distribution of the sample in Tables 3.9 and 3.10.

Within each regional market, the block market is oligopolistic. We will argue below that the structure of the capital market in conjunction with the fixed investment required to produce these products creates a limit on entry. There are a small number of medium and large-sized firms which set the prices for blocks. These firms can and do get together explicitly to fix prices. (This is not illegal in Colombia.) The smaller firms producing blocks are price-takers.

The market for bricks (common and repressed) is competitive. The minimum fixed investment to produce these products is low and entry and exit occurs easily.

In the Bogotá market, the Santa Fe brick company holds a somewhat special position. Formerly, the medium and large factories (including Santa Fe) had an oligopolistic arrangement of the type above. Then Santa Fe expanded. They have the factory described in Category S which produces pressed bricks on a very large scale. They also have plants with the technology of Category B producing blocks and ordinary brick. Their volume of production makes them the price leaders in

the market. The other firms producing blocks, up to Category F, are price-following oligopolists, and Categories F through I are price-takers.

It is important to note that while market size sets a limit on scale, in the larger markets there is still a very wide range of sizes of firms. The size of the market may preclude a very large firm, for the smaller markets, but in the large markets there are still many small firms. Moreover, the explanation is not some intra-regional transport cost element, since typically the various sizes of firms will be located in exactly the same place. The small firms surround a large firm in the good clay regions outside a major city.

Table 3.10 shows rough average prices for the major products in the major regions in December, 1975. These are approximate, since product characteristics and prices do vary somewhat from firm to firm. Also, prices have fluctuated in the last few years with fluctuations in construction activity.

Table 3.11 shows the main distribution outlets by category and size group. The figures show the importance of sales to construction firms. Column 6 shows the percentage of sales to the largest buyer; a single large buyer (in terms of percentage of firm's sales) seems to be less characteristic of the largest and the smallest firms compared to those in between, although there is considerable variation across firms. Some firms have direct links to construction companies, which are then their largest buyers. (Sante Fe, Category S, is part of the industrial group which includes two of the largest construction firms in the country) Such an arrangement has both advantages and disadvantages. It can

Table 3.10

Brick Industry

City:	Type of Product	Average Price in Pesos Per Thousand
Bogotá	Block #4	2,075
	Block #5	2,411
	Block #6	2,900
	Common Brick	653
	Repressed Brick	795
	Pressed Brick	897
Medellín	102030(4)*	1,800
	152030(6)*	2,800
Cali	102030(4)*	2,000
	132030(6)*	2,300
	Common Brick	800
PMAC (Pereira, Manizales, Armenia, Cartago)	Common Brick	780
Cúcuta	Common Brick	1,590
	Block #5	2,430
	Block #6	3,180
	Block #7	1,158

*These are blocks corresponding to #4 and #6 but a slightly different size.

Table 3.11 Brick Sales Distribution Outlets by Size Group and Category

% of Sales to:

	Small amts. at factory to individuals	Construction Firms	Retailers	Middlemen with trucks	Others	% sales to largest buyer
Employ 1 (12)[1]	59.9[2] (36.0)[3] 3.3-100.[4]	25.7 (30.) 0-70	8.6 (25.8) 0-90	5.7 (17.2) 0-60	0	19.6 (23.3) 0-60
Employ 2 (26)	39.4 (31.0) 0-100	37.7 (32.3) 0-90	8.8 (19.6) 0-90	6.7 (20.8) 0-95	7.5 (26.5) 0-100	35.3 (32.6) 0-95
Employ 3 (11)	45.5 (36.7) 0-90	47.3 (39.5) 0-100	5.9 (8.3) 0-25	.5 (1.5) 0-5	.9 (3.0) 0-10	11.2 (15.5) 0-50
Employ 4 (1	15	50	0	35	0	15
CAPAC 1 (15)	62.3 (34.2) 0-100	25.7 (28.5) 0-70	6.7 (23.2) 0-90	4 (15.5) 0-60	1.3 (3.5) 0-10	18.9 (23.4) 0-60
CAPAC 2 (14)	33.2 (31.6) 0-90	31.8 (32.1) 0-80	16.1 (25.4) 0-90	11.8 (27.7) 0-95	7.1 (26.7) 0-100	26.8 (30.2) 0-90 (13)
CAPAC 3 (11)	20.5 (21.5) 0-70	68.2 (31.2) 0-100	1.4 (3.2) 0-10	.5 (1.5) 0-5	9.5 (28.5) 0-95	45.9 (35.1) 0-95
CAPAC 4 (10)	62.5 (27.2) 10-90	27.5 (26.4) 0-90	5 (5.8) 0-15	4. (11.) 0-35	1. (3.2) 0-10	11.8 (10.7) 0-30
CAT A (1)	70.	30.	0	0	0	30.
CAT B (4)	42.5 (44.3) 0-90	27.5 (42.7) 0-90	5. (5.8) 0-10	0	24. (00.) 0-100	27.5 (42.7) 0-90
CAT C (7)	65. (22.5) 15-80	23.6 (15.5) 0-50	5.7 (6.1) 0-15	5.7 (13.0) 0-35	0	14. (10.3) 0-30
CAT D (3)	30 (26.5) 10-60	56.7 (35.) 20-90	6.7 (11.5) 0-20	6.7 (11.5) 0-20	0	9. (12.7) 0-18
CAT E (9)	27.8 (33.8) 0-90	45.6 (42.5) 0-100	18.3 (31.2) 0-90	6.1 (16.5) 0-50	2.2 (4.4) 0-10	25. (31.4) 0-90
CAT F (5)	31.0 (33.6) 0-80	41.0 (34.4) 0-75	9.0 (10.2) 0-25	19.0 (42.5) 0-95	0	22.0 (24.9) 0-60
CAT G (9)	33.9 (28.0) 5-100	47.8 (34.9) 0-80	0	6.7 (20.0) 0-60	11.7 (31.4) 0-95	46.3 (34.5) 0-95
CAT H (12)	63.2 (34.8) 3.3-100	28.2 (31.) 0-80	8.3 (25.9) 0-90	.3 (1.0) 0-3.3	0	22.7 (27.2) 0-60

[1] # of firms included

[2] Mean

[3] Standard deviation

[4] Minimum and maximum

lessen the firm's marketing problems by guaranteeing it a regular outlet for its products, but if the construction company experiences a slump, then the brick factory is in a difficult position.

b) Recent Trends in Demand

The demand for the industry's products has been subject to exceptionally sharp fluctuations in the last few years.

Early in the 70's, the government made the promotion of the construction industry a corner stone of its development policy. A key policy instrument was the creation of an indexed savings asset, earmarked for construction, which had a greater return than alternative assets. This led to a tremendous boom in construction, especially residential construction, and to very strong demand for construction inputs. However, with the change in government in 1974, the focus of government policy shifted away from construction. Moreover, there was a slowdown in the economy, which affected industrial activities generally. The construction sector was plunged into a slump and the input industries suffered accordingly. In 1976, construction activity picked up again, although it is not likely to be as strong as during the boom.

B. Further Discussion of the Categories

1. Relationship between categories and capital-intensity

We used the expression "sophistication of technology" in defining the categories in order not to prejudge the question of whether the categories are ordered by capital-intensity. In the brick industry, the categories did prove to be ordered by capital-intensity (as they were by size) except for category I which was close to category H

but slightly more capital-intensive. Table 3.12 gives a rough measure of the capital-intensity of each category: the total initial investment cost per worker[6] for a representative plant in each category. The figures are shown with and without the capital and labor in the excavation process because of the variation in the use of the rental option in excavation (see discussion below). The capital figure is the approximate cost of purchasing plant and equipment new in 1975 plus the cost of construction in 1975 (kilns, drying sheds and simple factory shelters).[7]

The cost of land is not included. The two parts of this cost are the cost of the clay reserves and the cost of the land required for the factory.

The factories in the survey are located on the outskirts of cities, on land that (because of its heavy clay content) is unsuitable for agriculture. As the city expands, the land will gradually be developed for urban construction uses. Obviously the value of the land varies tremendously with location and is gradually appreciating in value. The removal of clay from the land actually adds to its value, since the levelling of the ground and removal of the clay leaves it in a better state for this future use.

The clay itself does not vary systematically in quality across categories, since different sizes and types of firms are usually clustered in the same general areas. Firms in the categories from A to I do at most only the simplest periodic analysis of the clay and many have never done any at all. (Table 3.13) The assessment of clay quality and characteristics is very rough and ready.

Table 3.12

Brick Industry

INITIAL INVESTMENT IN FIXED CAPITAL/WORKER

	Excluding Excavation	Including Excavation
	K in thousands of pesos/ # of workers	K in thousands of pesos/ # of workers
CAT A	871.9	778.4
CAT B	406.2	371.4
CAT C	302.9	277.0
CAT E	70.4	
Excavation		
Own Equipment		77.6
Rented Equipment		65.1
CAT F	45.1	
Excavation-Rented Equipment		40.3
Excavation-Hand Equipment		33.3
CAT G	25.6	
Excavation-Rented Equipment		22.9
Excavation-Hand Equipment		18.9
CAT H	7.2	6.6
CAT I	10.3*	9.2

*3 firings/year assumed

Table 3.13

BRICK INDUSTRY

	Number of Firms Which Have Done a Chemical Analysis of Clay
EMPLOY 1(12)*	2
EMPLOY 2 (26)	8
EMPLOY 3 (11)	6
EMPLOY 4 (1)	1
CAPAC 1 (15)	2
CAPAC 2 (15)	2
CAPAC 3 (10)	6
CAPAC 4 (10)	7
CAT A (1)	1
CAT B (4)	2
CAT C (7)	5
CAT D (3)	1
CAT E (9)	3
CAT F (5)	2
CAT G (9)	2
CAT H (12)	1

*Total # of firms included.

In category I, the chircales, the factory site and the access to the clay are usually rented from people who are holding the land as an investment. In the rest of the categories, the firms usually own their own land and their own clay reserves. The larger and newer the factory , the more clay reserves it will tend to have, but we found that firms often have only a vague idea of how much clay they have. They know the area of the land but do not know how deep the clay goes. Therefore we have not attempted to give an estimate of the size of the clay reserves by category.

Given the capital gain element in the cost of land and the uncertainties with respect to quantity and quality of clay reserves, we have not attempted to value the land or the clay. Obviously, it is an element of fixed investment in the cost of setting up the factory except in the case of the chircales. However, if the same time horizon is taken for all factories and the factory is assumed to want reserves to last for its time horizon, this cost will not tend to alter the rankings of the categories by capital/labor ratios. One exception to this is in the drying process, where there is a difference in land use between the natural and artificial drying alternatives. This point is discussed further below.

The fact that workers are generally rotated through the various processes (all of which require no particular skill) made it impossible to obtain reliable estimates of labor by process and therefore to consider capital-labor ratios by process. Instead, Table 3.14 shows capital/output ratios by process to give some idea how capital-intensity varies by process within and across categories.

Table 3.14

Brick Industry

INITIAL INVESTMENT IN FIXED CAPITAL/VALUE OF OUTPUT

	CATEGORY							
	A	B	C	E	F	G	H	I
Excavation								
Owned		5.6	5.6	1.5				
Rented or Hand	0				0	0	0	0
Preparation & Forming	5.3	7.1	7.1	6.7	2.8	1.7	.40	.57
Drying	9.4	5.7	.47	.33	.35	.42	.43	0
Firing	13.5	8.3	8.3	.73	1.04	1.4	1.2	2.5
Total:								
Exc. Owned		26.7	21.5	9.3				
Rented or Hand	28.2				4.2		2.0	3.1

3. Discussion of the Individual Processes

Appendix 2 discusses each category. Here we draw out some important features of the individual processes, based on the representative plants and on the survey data.

a) Excavation

This process was not used as a classifying element in designing the categories. Generally, the more sophisticated the category, the more capital-intensive the methods used. However, there is some variation across categories in the degree to which firms own their own capital for this process. The one firm in category A subcontracts this process, although the subcontractor uses a relatively capital-intensive method to do it.[9] The firms in categories B through D all use bulldozers in the excavation process and the overwhelming majority (12 of 14) own their own equipment; the others rent. In category E, all but one firm uses bulldozers for excavation but a larger fraction rents the equipment. In categories F and G, no firm owns a bulldozer; a few firms rent them and the rest do the excavation manually. In category H, no firms use bulldozers and all but one do the excavation completely manually.

b) Preparation and Forming

Table 3.15 gives information on the machinery used in preparation and forming. In categories A,B,C,E, and F, all firms have extruders with de-airing chambers, which means that they can produce hollow blocks. In category G, firms use extruders without de-airing chambers, while in category H, the entire process is manual with only a few firms using simple mechanical mixers.

Table 3.15
BRICK INDUSTRY

	CAT.	# of firms	total # of machines	# of machines by country of origin: Colombia	Spain	West Germany	Italy	England	U.S.A.	Switzerland	Brazil	# of machines bought: new	second hand
Preparation Machinery	A	1	5			5						1	
	B	4	23		9	3	2		22		7	[illegible]	
	C	7	20		3	5	10		2			11	9
	D	3	6	3			3					2	3
	E	6	17	1	4	1	4				7	12	5
	F	3	4	3			1						4
	G	3	6	3				2				4	2
	H	4	4	4								1	3
Extruders with De-airing	A	1	1			1						1	
	B	4	7		1	1	1		2		2	7	
	C	8	8		1	4	2		1			2	2
	D	1	1						1				1
	E	9	10		6	1	2				1	8	2
	F	5	5	4	1							2	3
	G												
	H												
Extruders without De-airing	A												
	B												
	C												
	D	2	2	1			1					1	1
	E												
	F												
	G	9	11	5		1	1	4	1			1	10
	H												
Manual Cutters	A	1	1			1							
	B												1
	C												
	D	2	2	1			1					1	1
	E	1	1								1	1	
	F	4	4	4								3	1
	G	8	10	5		1		3	1			1	9
	H												
Automatic Cutters	A	1	1			1						1	
	B	3	3				1				2	3	
	C	3	3			5	2			1		6	2
	D	1	1		1								1
	E	9	9	1	3	3	1				1	7	2
	F												
	G												
	H												

The national origin of the machinery shows an interesting pattern. Colombian machinery is nonexistent in categories A to C, except for occasional simple motors and conveyor belts, but begins to become an important factor in categories D through G. The Colombian made machinery is generally a simple extruder without a de-airing chamber, or with a simple adaptation of a de-airing chamber and a manual cutter.

The Colombian machinery comes from several types of sources. Some is made in workshops to the specification of the client. A manual wirecutter is a relatively simple piece of equipment that can be made by many Colombian workshops. Extruders are more likely to be made by a few workshops which specialize in brick machinery and repair. They may also come from a single large factory whose major product line is agricultural machinery, but which used to make brick machinery some fifteen years ago. A few years ago, during the construction boom, this firm developed a simple de-airing chamber which could be added as a modification to some brick machines they had in storage, made before they dropped the line. The modified extruders sold well; a similar model is now being sold by the other small workshops which specialize in brick machinery.[10]

The table shows the truth of the hypothesis that the less sophisticated technology categories are more likely to use domestic capital inputs.

With respect to other countries, England is the source only for very old machinery of manual type used in Category H. Brazil has only recently become a source of brick machinery and there is no Brazilian machinery that is more than six years old. The Brazilian machinery comes from a new subsidiary of an Italian firm (Morando) that has been important

in the Colombian market for some years. The remaining machinery comes from Spain, West Germany, Italy, the U.S. and Switzerland (1 firm only).

Firms generally prefer to have the preparation and extrusion machinery of the same origin, since this facilitiates combining them. The cutter is less important and is sometimes of a different make than the rest.

With respect to secondhand machinery, there is also a clear pattern. It is almost nonexistent in categories A,B, and C, but it then becomes increasingly important as a fraction of total machinery in the remaining categories.

There is no organized market in secondhand machinery. The machinery is sold by firms which are changing their machinery or which have gone bankrupt, on a purely individual basis. Used brick machinery is not imported.

c) Drying

The major alternatives in Colombia are uncovered or covered natural drying, chamber drying and tunnel drying. All of the firms in the sample that have artificial drying also do some natural drying as well, in covered sheds.

The elements affecting technology choice in drying are land, labor, capital, fuel and drying time. Table 3.16 shows how the alternatives rank in their use of these inputs. Since artificial drying speeds up the production process, the factory has a smaller stock of work in progress, and production is less affected by the weather. The table expresses approximate rankings.

Table 3.16 BRICK INDUSTRY

ELEMENTS AFFECTING TECHNOLOGY CHOICE IN DRYING PROCESS

The 4 alternatives:
1. Natural - Uncovered
2. Natural - Covered
3. Artificial - Chamber
4. Artificial - Tunnel

The 4 alternatives ranked from highest to lowest in their use of each input:

Land	Labor	Initial Fixed Capital Cost	Fuel	Time
1	1,2,3	4	4 & 3	1
2	4	3	2 & 1	2
3 & 4		2		3
		1		4

Within each alternative, there will be considerable variation across firms, according to the weather and according to the layout of the drying area or the design of the artificial dryer.

Artificial drying is relatively rare in Colombia. There is only one tunnel dryer in the sample (and only a few in the entire country) and there are very few chamber dryers. All of the artificial dryers are either domestic designs or domestic adaptations of foreign designs. The tunnel dryers use oil while the chamber dryers can be used with other fuels, and are generally operated, in Colombia, with coal.

d) Kilns

Category A is characterized by the tunnel kiln. Categories B and C are characterized by Hoffman kilns. Categories E through H have intermittent kilns, usually of the vertical flame type. Category I uses a simpler type of intermittent kiln, the open clamp.

The figures on average capacity of individual kilns show a close association between capacity and type of kiln. (Table 3.17) The trend in brick technology has been toward changes in technology which increase the minimum scale of plant. In Colombia kiln capacity increases across open clamp, vertical flame, inverted flame, Hoffman and tunnel kilns.

The construction cost of kilns of a particular type varies depending on the expertise of the builder. In addition, there are scale economies in construction. However, in spite of the scale economies, most firms in categories E through H which have intermittent kilns have more than one. With more than one, it is possible to have a smoother flow of production for the labor force and the other capital in the factory,

Table 3.17

BRICK INDUSTRY

Type of Kiln	Age of Kilns[1]			Capacity of Kilns[2] (in common brick volume equivalents)		
Open Clamp Kilns	51.[3]	51-51[5]	(0)[4]	30,000	25,000-35,000	(5,000)
	# of kilns: (3)					# of kilns: (3)
Vertical Flame Kilns	11.8	0-46	(11.1)	40,925	6,000-86,100	(21,339)
			(102)			(101)
Inverted Flame Kilns	26.7	1-49	(15.6)	47,797	20,000-84,060	(22,506)
			(26)			(18)
All Hoffman Kilns	18.7	5-56	(13.1)	286,106	147,600-508,096	(127,881)
			(16)			(14)
Tunnel Kilns	19.	19-19	(0)	1,300,000	1,300,000-1,300,000	(0)
			(1)			(1)

Footnotes:

[1] Based on 148 kilns

[2] Based on 137 kilns

[3] Mean

[4] Standard deviation

[5] Minimum and maximum

given the batch process nature of production. In category I, production is a small-scale family operation; there is only one kiln which is only fired one to three times a year, and all the processes are done sequentially, for a single batch of output. This is the reason for the higher capital-labor ratio for this category, compared to category H, in which the kiln is more expensive but is fired much more often.

A critical element in technology choice in firing is fuel use. There is a significant difference across types of kilns in the versatility in types of fuel that can be used, and in the efficiency of the firing. As noted in the introduction, the tunnel kiln is most suitable for use with oil or gas since it requires a fuel which can be easily controlled and which does not yield strong soot emission. (The kiln can only be cleaned and inspected for maintenance when it is stopped and cooled). Thus, it is not suitable for use with coal. Hoffman kilns can be used with oil, gas or coal. The intermittent kilns are the most versatile; they can be used with virtually any fuel. In Colombia, the tunnel kilns use oil.[11] Coal is the usual fuel for the other types, although wood and a material called cisco de café are also used. Cisco is the waste produced from the coffee bean; it is used in intermittent kilns in the coffee-growing regions, during those peiods of the year when it is available. (The material is very bulky and highly flammable and thus cannot be stored; in fact, it is usually delivered on a <u>daily</u> basis).

Fuel efficiency varies systematically with the type of kiln. Table 3.18 shows approximate figures for fuel use by category from the representative plants: tons of coal per thousand pesos of output for

Table 3.18

Brick Industry

FUEL EFFICIENCY BY CATEGORY

	Tons of Coal/ Output in Col $1000	Value of Fuel/ Output in Col $1000
CAT A	--	.250
CAT B	.507	.177
CAT C	.346	.121
CAT E	.662	.232
CAT F	.675	.236
CAT G	.663	.232
CAT H	.674	.236
CAT I	.962	.335

all categories from A to I. Moving from Hoffman kilns to open clamp kilns, fuel efficiency falls as the capital cost of the kiln falls.

The data in the representative plant designs for Categories B and C is for the standard and most usual type of Hoffman kiln: the covered Hoffmann. There are three other sub-types of Hoffman kilns: the buried Hoffmann, (dug into the earth, with the earth forming part of the walls), the zig-zag kiln (with the firing chambers arranged in a zig-zag, instead of in a rectangle), and the uncovered Hoffman (a kiln with no roof; the bricks are covered with ashes for firing). Among these four types, there is also a tradeoff between capital cost and fuel efficiency. The uncovered type, for example, is the cheapest to build but uses the most fuel.

The tunnel kiln and dryer are integrated (the dryer uses heat from the kiln for drying) so the fuel efficiency cannot be directly compared without taking this into account. (The table shows total fuel use for drying and firing in each category) However, comparing that alternative to the alternative of Hoffman kiln and chamber dryer in category B, it can be seen that the tunnel kiln and dryer are surprisingly inefficient. It was expected that the latter alternative would be more fuel-efficient especially since the two are compared in value terms and the price of oil is well below the world price while the price of coal is closer to the world price. However, the explanation is the fact that the tunnel kiln and dryer in category A are not constructed well, and in addition, the factory does not make the frequent adjustments in temperature settings and feeding of fuel which are

necessary for optimum efficiency.

The figures given can only be rough approximations, since in addition to variations with type of kiln, there are substantial variations in fuel efficiency across individual firms, and in the same firm from month to month. Fuel use varies with the content of sand and other substances in the clay. More sand means less fuel is needed (although too much sand makes the product fragile and inclined to break during drying). Fuel use varies with the moisture content of the product at the end of the drying process. The product is dried by artificial dryers which vary in efficiency, or more commonly by natural methods, which means that the moisture content of the brick varies with the weather. In the wet seasons, the kiln in fact does some of the drying. In wetter regions, more fuel will be used on average than in dryer regions. Fuel use varies with altitude; Bogotá, for example, is 8,000 feet in altitude, and there is less oxygen in the air. Finally, fuel use varies with the design of the kiln, within a particular type. Minor variations in the structure of the air vents, etcetera can have major effects on fuel efficiency.

4. Comparison of Input Coefficients Across Categories

Table 3.19 shows data on capital, labor and fuel use. The value of output less the value of fuel has been computed by category and fixed capital and labor coefficients computed using the difference as a measure of output. Figures 3.1 and 3.2 show a graph of these coefficients, computed with and without the excavation process.

Category B is dominated by category C, given the coefficients shown. The difference between these two categories is in the use of artificial

Table 3.19

Brick Industry

FIXED CAPITAL AND LABOR COEFFICIENTS BY CATEGORY

	Including Excavation		Excluding Excavation	
	$\frac{L}{Q-F}$	$\frac{K}{Q-F}$	$\frac{L}{Q-F}$	$\frac{K}{Q-F}$
CAT A	.043	37.5	.043	37.5
CAT B	.068	32.2	.062	31.8
CAT C	.064	23.8	.058	23.8
CAT E	.152	10.9	.141	10.9
CAT F	.152	5.5	.122	5.5
CAT G	.222	4.5	.178	4.6
CAT H	.400	2.6	.367	2.7
CAT I	.503	4.6	.446	4.6

L = number of full-time workers/month

K = initial fixed capital investment in thousands of pesos

Q = output in thousands of pesos

F = fuel in thousands of pesos

Figure 3.1

Brick Industry

FIXED CAPITAL AND LABOR COEFFICIENTS
INCLUDING EXCAVATION

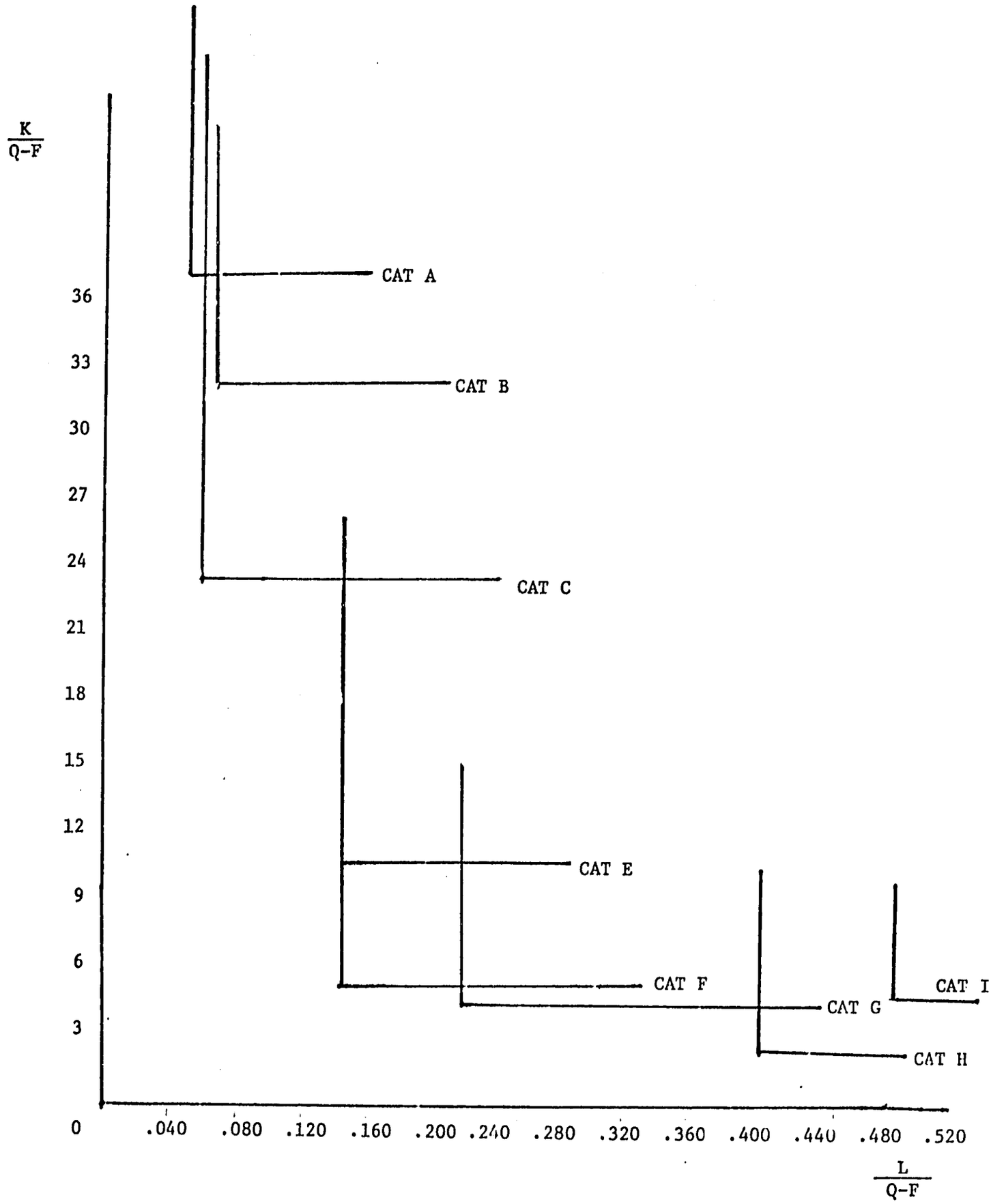
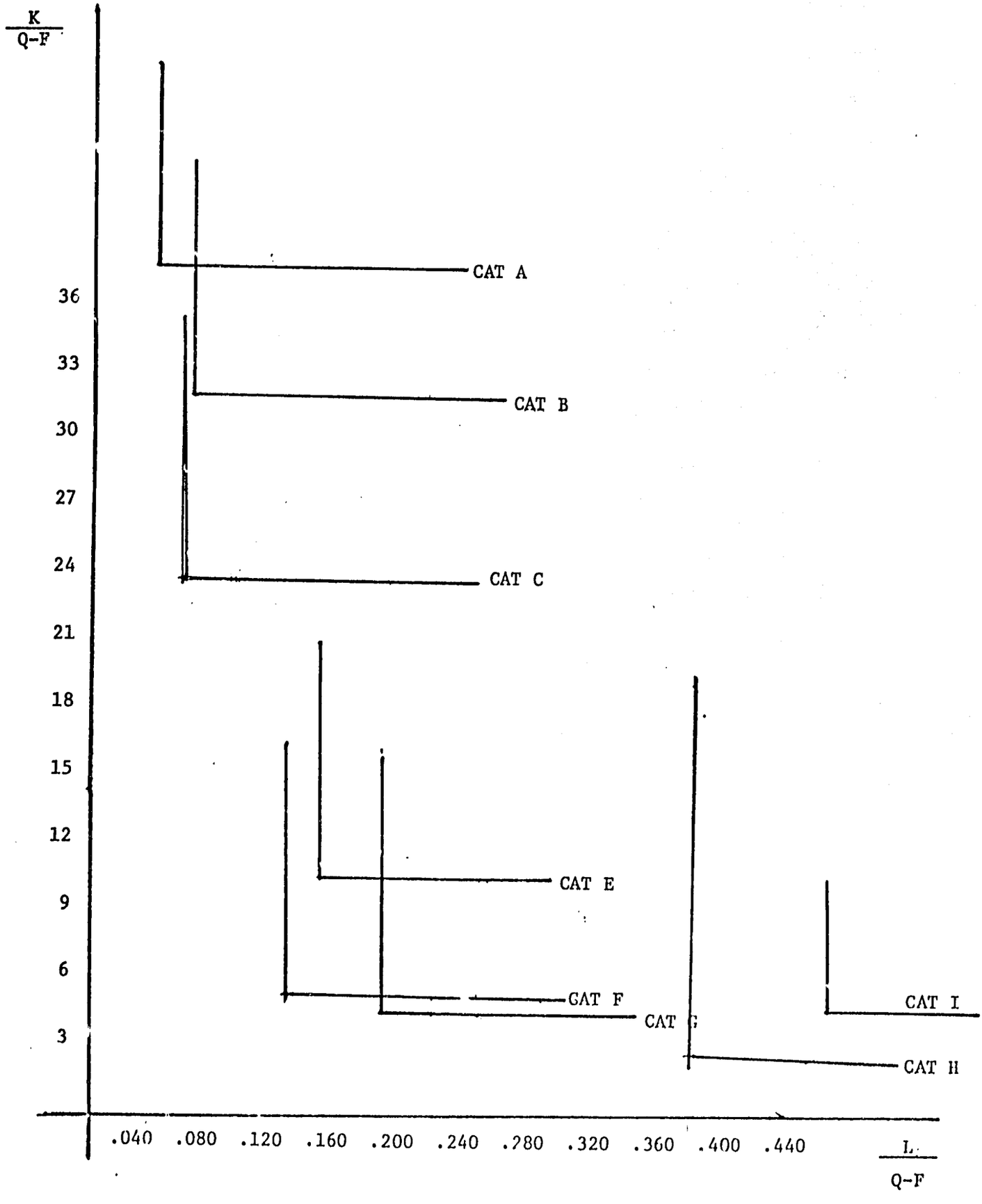


Figure 3.2

Brick Industry

FIXED CAPITAL AND LABOR COEFFICIENTS
EXCLUDING EXCAVATION



drying . Category B 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 $1400 per mt^2, or $14,000,000 per hectare, which is a very substantial sum indeed, especially when it is considered that the land will appreciate in value while the dryer will depreciate.[12]

Category E seems to be dominated by category F. The main difference between these two categories is in the use of a simple domestic machine in preparation and forming in Cat. F compared to larger and more expensive imported machinery in Cat. E. The utilization rate has been assumed to be rather low in category E (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 F. (The capital coefficient in preparation and forming is still somewhat higher in E than in F, 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 hollow blocks at lower scales of production without having underutilized capacity.[13]

Category I seems to be dominated by categories G and H. However, the figures are somewhat misleading. The "chircaleros" in Category I sometimes rent the kiln along with the land. When they do not rent it, they build it themselves with family labor. Very little in the way of materials is required; the major input is hand labor. The simple wooden molds and the well can also be made by family labor. Thus a large fraction of the initial investment in this category requires no cash outlay, and uses inputs which have a low private and social opportunity cost.

III. AGE OF FIRM AND RELATIONSHIP TO TECHNOLOGY CHOICE

The discussion in Section One about changes in the production set, changes in relative factor prices, and imperfections in the capital market suggests explanations for the pattern of technology choice which are based on the evolution of the industry over time.

These can be summarized in the following three "stories":

1. The production set has been changing over time. The new techniques added to the set are more capital-intensive and exhibit strong scale economies; they dominate the old techniques. As stated in Section One, firms do not instantly adopt the new technology because it is embodied in new capital goods. However, new firms being set up in the industry will adopt the new technology; they will be large and modern. Old firms will gradually become modern as expected profits from changing to the new technology dominate adjustment costs. New firms will not be set up with old technology and on a small scale, unless it is with very cheap,

secondhand capital goods discarded by the modernizing firms, and this is a transitional phenomenon. (To the extent there is a secondhand market in capital goods, prices, will, of course, have to adjust until the old capital is competitive with the new technique).

In the case of the brick industry, the technology in use in Colombia has been known for a long time. However, the above description can be interpreted as referring to the changing local knowledge of the world production set.

This analysis predicts that all new firms will be large and capital-intensive. There will be a positive correlation between size and technological sophistication (which we have observed in the sample), but a negative correlation between age and technological sophistication and between age and size. Of course, the correlation will not be perfect since large, technologically sophisticated firms may also be modernized old firms.

2. For a <u>given</u> production set, changes in the local conditions determining private profitability, specifically factor prices and the size of the market, have occurred over time. The current profit-maximizing choice is large-scale, capital-intensive technology.

The predictions are the same as those for 1.

3. A third story adds a type of capital market imperfection to the above analysis. The most profitable type of firm is large and capital-intensive, for some combination of the reasons in 1 and 2. However, capital market imperfections prevent firms from starting out at that scale. They must start small and grow via reinvested profits. Thus the coexistence of large and small firms with varying degrees of technological

sophistication occurs because the firms are at different stages in their development history.

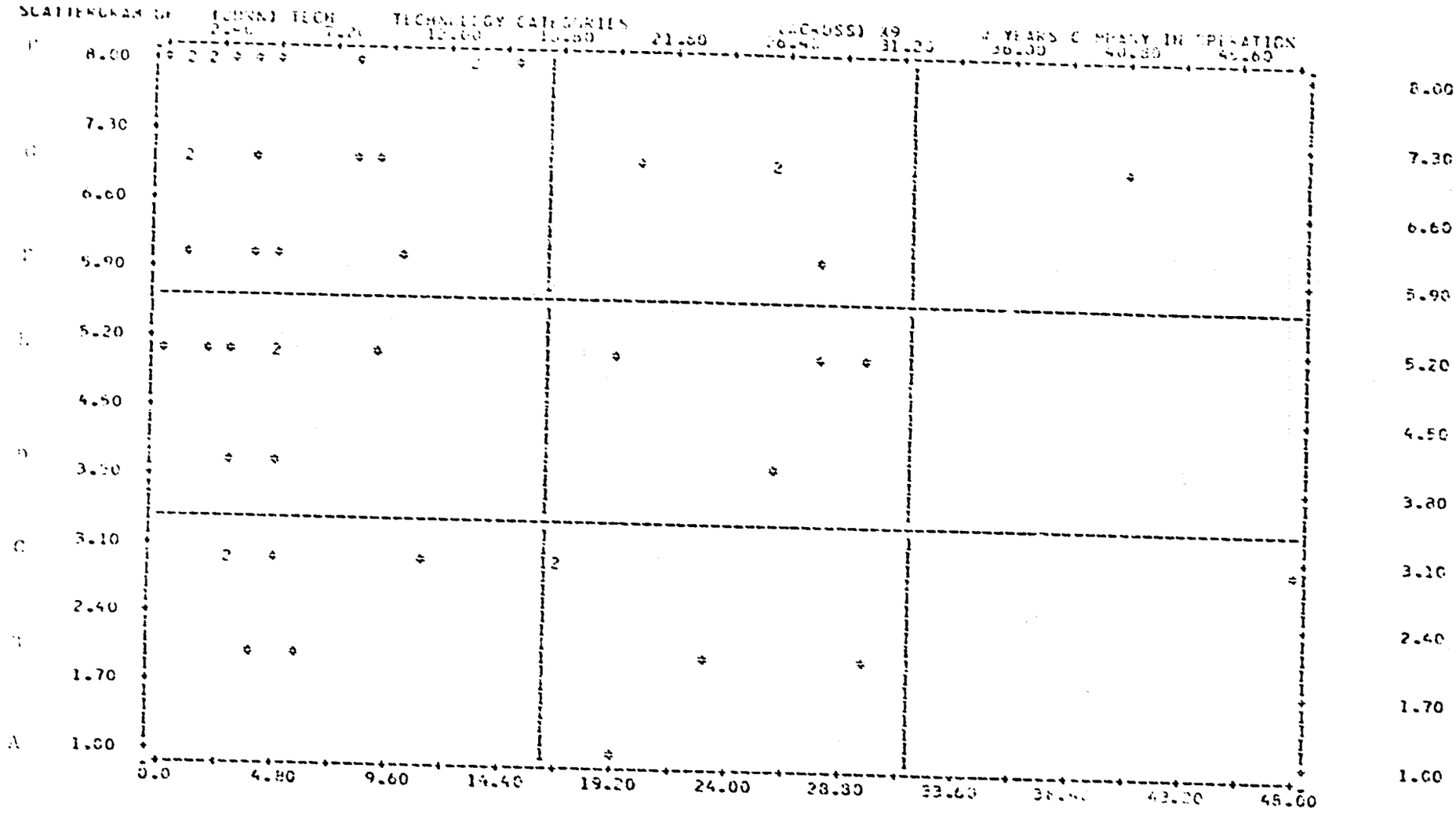
This predicts that all new firms will be small. The older the firm, the farther along in its growth pattern it will be, and therefore the closer to a large, technologically sophisticated firm. Thus there will be a positive correlation between age, and size and technological sophistication.

It was not possible to obtain much information about the past but we did ask a few very simple questions in the survey: specifically, the number of years the company had been in operation and its original size (in terms of total employment at end of first year of operation). We also obtained some information on the age of installed capital.

This information has been used to consider the empirical validity of the above predictions.

The evidence does not tend to support any of the stories strongly. Table 3.20 gives a scattergram of technology category against age. Kendall's tau is negative and small in absolute value. To the extent that there is a relationship, it suggests that the older the firm, the more sophisticated the technology but the relationship is weak. A second scattergram (Table 3.21) giving age against size of firm measured by total employment gives a relatively low R^2. Given the defects in employment as a measure of size in the industry, we also measured size by value of capacity output. The scattergram of this against age (Table 3.22) gives an even lower R^2. The scattergrams do not include the smallest and least mechanized category, the chircales of the Bogotá

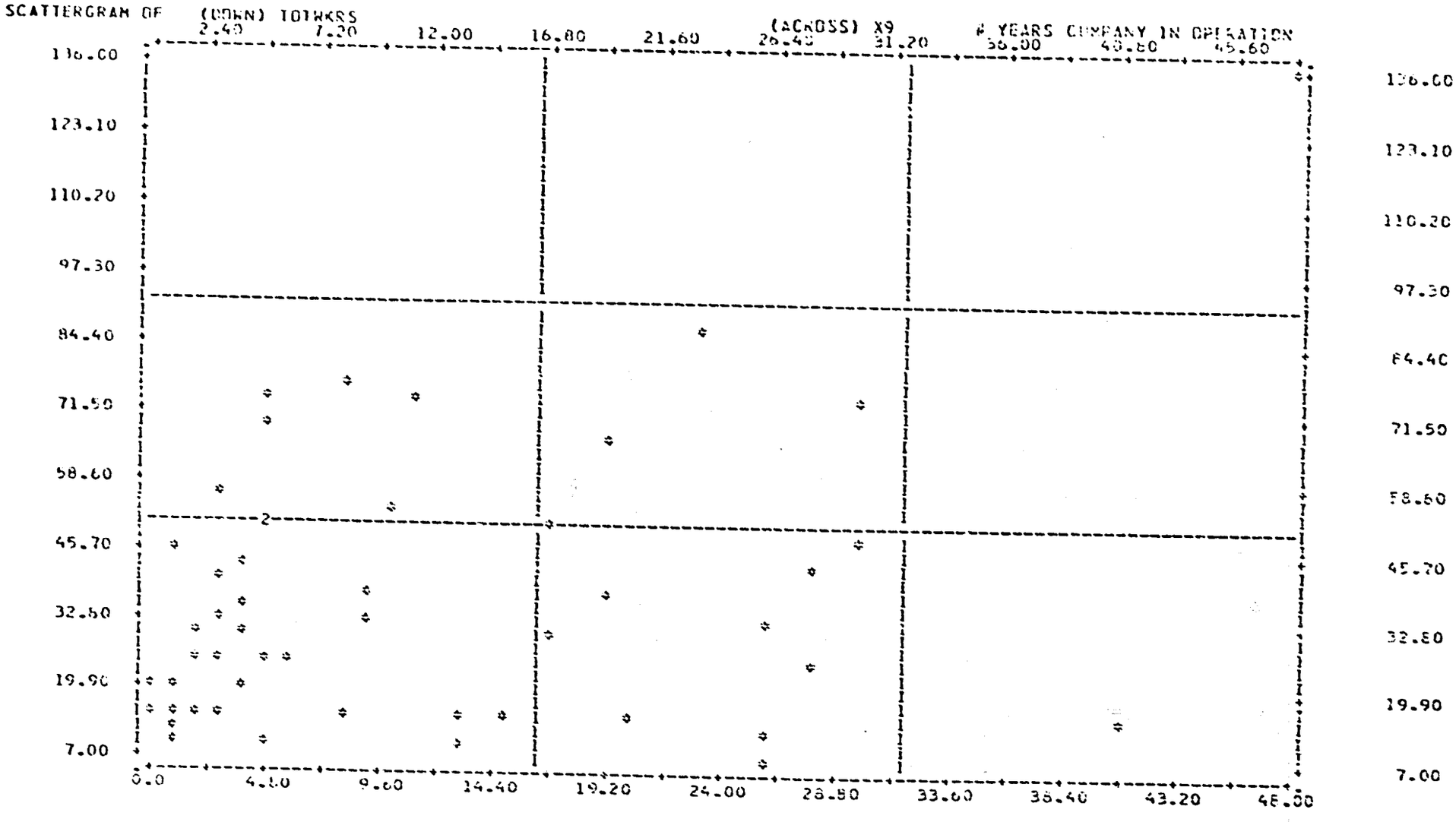
Table 3.20 Brick Industry



- - - - - - - - - - - - - - K E N D A L L C O R R E L A T I O N C O E F F I C I E N T S - - - - - - - - - - - - - -

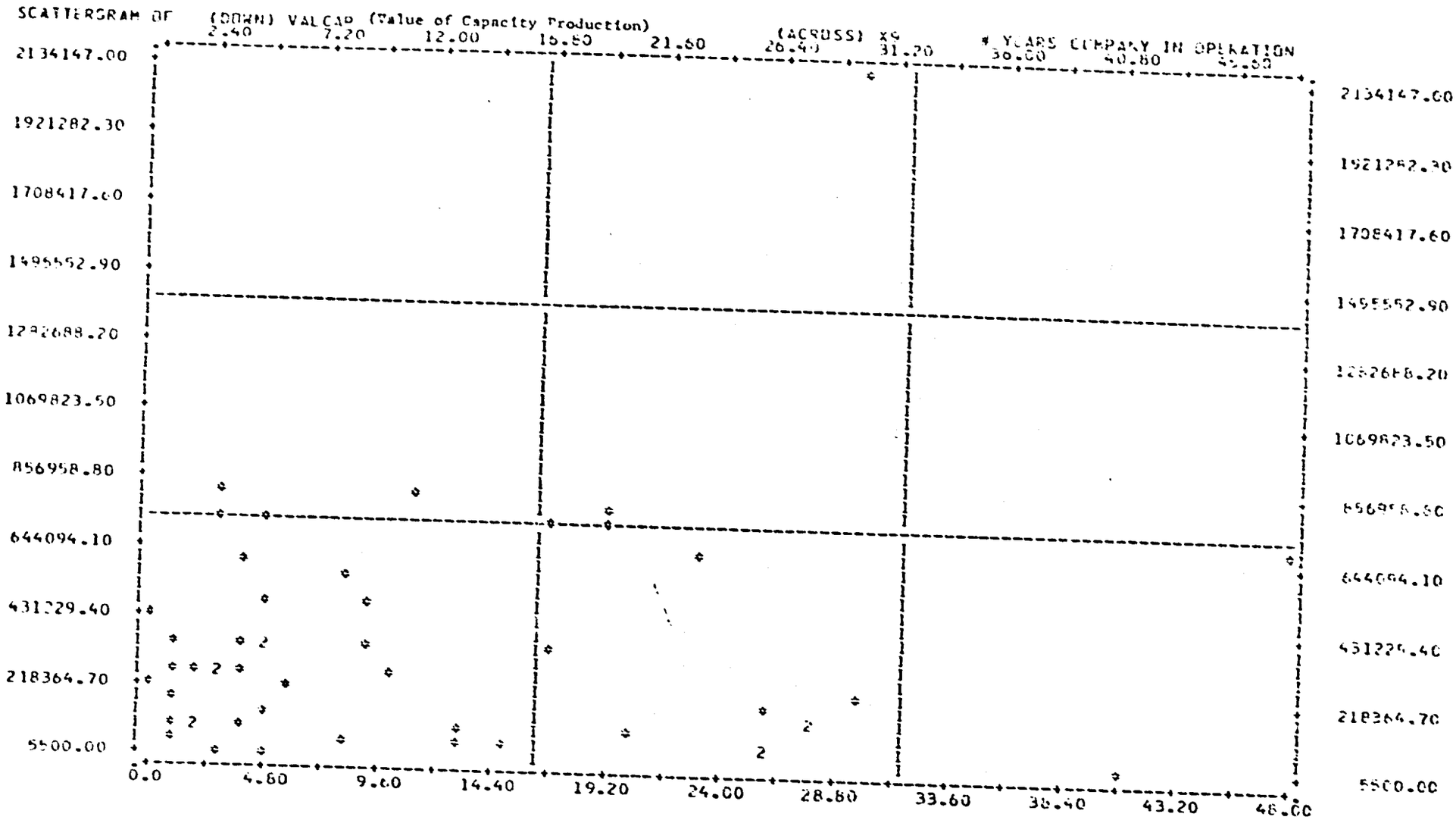
VARIABLE PAIR	VARIABLE PAIR	VARIABLE PAIR	VARIABLE PAIR	VARIABLE PAIR	VARIABLE PAIR
TECH WITH	-0.2134 N(60)				

Table 3.21 Brick Industry



STATISTICS..

CORRELATION (R)-	0.34697	R SQUARED -	0.12039	SIGNIFICANCE -	0.01356
PLOTTED VALUES -	50	EXCLUDED VALUES-	0	MISSING VALUES -	0



STATISTICS..

CORRELATION (R)-	0.18453	R SQUARED -	0.03405	SIGNIFICANCE -	0.19934
PLOTTED VALUES -	50	EXCLUDED VALUES-	0	MISSING VALUES -	0

Table 3.23

Brick Industry

	Number of Firms	Average Age in years
Firms which grew smaller	8	-
Firms for which data is missing	6	-
Size group stayed the same	16	8.3[1] (8.5)[2] 1-26[3]
Size group changed (to larger)	20	15.8 (13.0) 1-48
Artisan to Small	9	15.1 (13.2) 1-30
Artisan to Medium	2	17.5 (17.7) 5-30
Artisan to Large	0	-
Small to Medium	8	12.0 (7.03) 3-23
Small to Large	1	48(0) 48-48
Medium to Large	-	-
All Firms by Employment Size Group		
Size 1 Artisan	12	13.2 (12.8) 1-41
Size 2 Small	26	8.8 (9.7) 0-30
Size 3 Medium	11	12.4 (8.8) 3-30
Size 4 Large	1	48 (0) 48-48

[1] Mean

[2] Standard deviation

[3] Minimum and maximum

region. However, the qualitative evidence we collected indicates that these firms do not show any pattern by age, and in particular, many new chircales were set up during the construction boom of the early 70's.

Looking at the original size of the firm and its current size, measured by employment (which is all we have) we find that of the 44 firms for which we have data, 36 grew and 8 shrank. Of the 36, 16 remained in the same size group and 20 moved to a larger one. As Table 3.23 shows, the average age of the firms which changed size groups is greater than that of firms which remained in the same size group, but the variation in age within each set of firms is large and the standard errors are larger than the difference between the two.

The age of the firm can be somewhat ambiguous, since in this industry, many firms have 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 also at the age of the machinery, the dryers and the kilns to see if there is a pattern of introduction of technology over time.

Tables 3.15 and 3.24 give data on the machinery used in the preparation and forming processes in those firms which use machinery. As noted earlier, the importance of secondhand machinery does increase as the technological sophistication of the category decreases, (Table 3.15) but there is no particular pattern with respect to age of machinery by category. The success of the Colombian adaptation in Category F suggests that technology is not obsolete. The average age of machinery in category G is high which by itself would tend to support the theory that

Table 3.24

Brick Industry

Age of Forming Machines

	Extruders with de-airing chamber	Extruders without de-airing chamber	Manual Cutters	Automatic Cutters	Preparation Machinery
CAT A (1)[1]	21.0 (1)			21.0 (1)	21.0 (5)
CAT B (4)	13.9[2] (10.3)[3] 4-30[4] (7)[5]		29.0 (1)	8.1 (6.0) 4-20 (7)	9.4 (7.9) 4-30 (23)
CAT C (7)	12.8 (5.9) 5-21 (8)			10.5 (3.9) 5-16 (8)	15.5 (7.8) 4-28 (20)
CAT D (3)	12.0 (1)		29.0 (28.3) 9-49 (2)	8.0 (1)	28.2 (22.9) 4-49 (16)
CAT E (9)	9.3 (7.2) 4-26 (10)		6.0 (1)	7.9 (4.4) 4-16 (9)	9.5 (9.3) 2-26 (17)
CAT F (5)	13.4 (5.5) 6-21 (5)		9.5 (3) 6-12 (4)		18 (4) 12-20 (4)
CAT G (9)		21.9 (20.3) 1-51 (11)	20.6 (18.5) 3-51 (10)		21.3 (18.9) 4-48 (4)
CAT H (12)					15 (7.8) 4-21 (4)

[1] # of firms

[2] Mean

[3] Standard deviation

[4] Minimum & maximum

these firms represent old technology which will remain in use only until the old secondhand capital wears out. However the standard deviations are large and there is relatively new machinery used in the category. Moreover, the age of the machinery in category A is nearly as great as the average age of machinery in category G.

In drying, there is only one tunnel dryer in the sample (and only a few in the entire country) and very few chamber dryers. The tunnel dryer is 13 years old while the chamber dryers are very new. The oldest one is six years old and the rest are no more than two years old.

Table 3.17 shows the average age of the kilns in the sample. The kilns vary widely in age and there does not seem to be a pattern between age and sophistication of kiln type. There is only one firm which has open clamp kilns in the sample since this kiln is typical of Category I, the chircales, for which we have no survey data. However, we know from the interviews that many relatively new chircales exist, and in fact, the open clamp kiln of the type described in the plant design for Category I must be rebuilt after each six years of regular use.

We conclude that the coexistence of firms of different sizes and different categories of technology choice is not explained by any of the stories above.

IV. INPUT MARKETS AND THEIR RELATIONSHIP TO TECHNOLOGY CHOICE

In this section we discuss the impact of conditions in factor markets on the firm's technology choice. In the brick industry, the three major inputs are labor, capital and fuel.

A. The Labor Market

1. Characteristics of the Labor Force in the Sample, By Category and Size Group

The accompanying tables give information about the structure of the labor force. Tables 3.25 to 3.27 show the percentage of workers who are not paid direct salaries. The percentage importance of these workers is highest for the artisan firms (by size group) and for categories C & H (by category). These family members are, on the average, less well-educated in the smaller size groups and a fairly high percentage of all of the family members and associates have more than five years experience in the industry.

The breakdown of workers by general function is shown in tables 3.28 to 3.30. The fraction of the labor force that is production workers (as opposed to administration and non-production services such as sales personnel) does not differ very much by size of firm, while the fraction that is administration is greater the smaller the size group.

Turning to experience, it is clear that on average the firm's production labor force is not very experienced. (Experience refers to

TABLE 3.25
BRICK INDUSTRY

ASSOCIATES OR FAMILY MEMBERS

	NUMBER OF WORKERS[1]	% OF LABOR FORCE[2]	% IN EACH EXPERIENCE LEVEL[3] 1	2	3	MISSING	% IN EACH EDUCATION LEVEL[4] 1	2	3	4	5	MISSING
EMPLOY 1	1.9	14.0	7.8	8.3	83.9	0.0	34.7	8.3	35.8	21.1	0.0	0.0
	(1.2)	(7.8)	(19.0)	(28.9)	(32.5)	(0.0)	(45.2)	(28.9)	(46.2)	(38.3)	(0.0)	(0.0)
(12.OF12.)[5]	1.- 5.	7.- 33.	0.- 60.	0.-100.	0.-100.	0.- 0.	0.-100.	0.-100.	0.-100.	0.-100.	0.- 0.	0.- 0.
EMPLOY 2	2.1	4.6	3.1	14.6	82.3	0.0	9.4	27.1	25.0	33.3	3.1	2.1
	(1.1)	(4.3)	(12.5)	(34.4)	(35.2)	(0.0)	(27.2)	(40.3)	(36.5)	(43.5)	(12.5)	(8.3)
(16.OF26.)	1.- 5.	0.- 20.	0.- 50.	0.-100.	0.-100.	0.- 0.	0.-100.	0.-100.	0.-100.	0.-100.	0.- 50.	0.- 33.
EMPLOY 3	3.4	3.7	4.2	9.2	86.7	0.0	0.0	8.3	36.2	46.4	2.8	6.3
	(2.7)	(3.6)	(11.8)	(17.1)	(25.7)	(0.0)	(0.0)	(23.6)	(44.1)	(44.0)	(7.9)	(17.7)
(8.OF11.)	1.- 9.	0.- 12.	0.- 33.	0.- 40.	33.-100.	0.- 0.	0.- 0.	0.- 67.	0.-100.	0.-100.	0.- 22.	0.- 50.
EMPLOY 4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
(0.OF 1.)	0.- 0.	0.- 0.	0.- 0.	0.- 0.	0.- 0.	0.- 0.	0.- 0.	0.- 0.	0.- 0.	0.- 0.	0.- 0.	0.- 0.

1. Average number of associates or family members for firms which employ this type of worker.
2. Average % of labor force represented by associates or family members. Average is taken over all firms in each group providing labor force information, including those which do not employ associates or family members.
3. Experience levels: 1). < 1 year, 2). 1-5 years, 3). > 5 years, 4). missing---firm employs associates or family members but does not report all experience information. % based on those firms which employ associates or family members.
4. Education levels: 1). < secondary, 2). secondary but < technical degree, 3). technical degree but < university, 4). university---gereral degree, 5). university---engineering degree, 6). missing---firm employs associates or family members but does not report all education information. % based on those firms employing associates or family members.
5. Number of firms that employ associates or family members out of the total number of firms in this group (i.e. "3 of 5": three of a possible five firms employ associates or family members).

Table 3.2b
Brick Industry

ASSOCIATES OR FAMILY MEMBERS

	NUMBER OF WORKERS	% OF LABOR FORCE	% IN EACH EXPERIENCE LEVEL 1	2	3	MISSING	% IN EACH EDUCATION LEVEL 1	2	3	4	5	MISSING
CAPAC 1	1.9	13.7	6.2	6.7	87.1	0.0	24.4	13.3	32.0	30.2	0.0	0.0
	(1.4)	(7.5)	(17.2)	(25.8)	(29.5)	(0.0)	(38.2)	(35.2)	(43.1)	(44.6)	(0.0)	(0.0)
(15.OF15.)	1.- 5.	5.- 33.	0.- 60.	0.-100.	0.-100.	0.- 0.	0.-100.	0.-100.	0.-100.	0.-100.	0.- 0.	0.- 0.
CAPAC 2	2.0	3.6	7.1	28.6	64.3	0.0	28.6	35.7	14.3	14.3	7.1	0.0
	(0.8)	(1.7)	(18.9)	(48.8)	(47.6)	(0.0)	(48.8)	(47.6)	(24.4)	(24.4)	(18.9)	(0.0)
(7.OF14.)	1.- 3.	0.- 10.	0.- 50.	0.-100.	0.-100.	0.- 0.	0.-100.	0.-100.	0.- 50.	0.- 50.	0.- 50.	0.- 0.
CAPAC 3	2.1	3.6	0.0	4.2	95.8	0.0	0.0	10.4	62.5	16.7	0.0	10.4
	(1.0)	(2.7)	(0.0)	(11.8)	(11.8)	(0.0)	(0.0)	(19.8)	(44.3)	(35.6)	(0.0)	(19.8)
(8.OF11.)	1.- 4.	0.- 10.	0.- 0.	0.- 33.	67.-100.	0.- 0.	0.- 0.	0.- 50.	0.-100.	0.-100.	0.- 0.	0.- 50.
CAPAC 4	3.5	3.3	5.6	12.2	82.2	0.0	0.0	11.1	6.7	78.5	3.7	0.0
	(3.1)	(4.0)	(13.6)	(19.1)	(28.8)	(0.0)	(0.0)	(27.2)	(16.3)	(27.5)	(9.1)	(0.0)
(8.OF10.)	1.- 9.	0.- 12.	0.- 33.	0.- 40.	33.-100.	0.- 0.	0.- 0.	0.- 67.	0.- 40.	33.-100.	0.- 22.	0.- 0.

Table 3.27 Brick Industry

ASSOCIATES OR FAMILY MEMBERS

	NUMBER OF WORKERS	% OF LABOR FORCE	% IN EACH EXPERIENCE LEVEL 1	2	3	MISSING	% IN EACH EDUCATION LEVEL 1	2	3	4	5	MISSING
CAT A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
(0.OF 1.)	0.- 0.	0.- 0.	0.- 0.	0.- 0.	0.- 0.	0.- 0.	0.- 0.	0.- 0.	0.- 0.	0.- 0.	0.- 0.	0.- 0.
CAT B	1.5	2.3	25.0	0.0	75.0	0.0	0.0	25.0	25.0	50.0	0.0	0.0
	(0.7)	(4.8)	(35.4)	(0.0)	(35.4)	(0.0)	(0.0)	(35.4)	(35.4)	(70.7)	(0.0)	(0.0)
(2.OF 4.)	1.- 2.	0.- 6.	0.- 50.	0.- 0.	50.-100.	0.- 0.	0.- 0.	0.- 50.	0.- 50.	0.-100.	0.- 0.	0.- 0.
CAT C	3.6	5.9	5.6	17.8	76.7	0.0	0.0	16.7	6.7	67.4	3.7	5.6
	(2.9)	(3.8)	(13.6)	(19.6)	(27.9)	(0.0)	(0.0)	(27.9)	(16.3)	(30.4)	(9.1)	(13.6)
(6.OF 7.)	1.- 9.	0.- 12.	0.- 33.	0.- 40.	33.-100.	0.- 0.	0.- 0.	0.- 67.	0.- 40.	33.-100.	0.- 22.	0.- 33.
CAT D	2.0	3.4	0.0	0.0	100.0	0.0	0.0	0.0	50.0	25.0	0.0	25.0
	(0.0)	(1.6)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(35.4)	(0.0)	(35.4)
(2.OF 3.)	2.- 2.	0.- 6.	0.- 0.	0.- 0.	100.-100.	0.- 0.	0.- 0.	0.- 0.	50.- 50.	0.- 50.	0.- 0.	0.- 50.
CAT E	2.8	4.0	0.0	20.0	80.0	0.0	20.0	30.0	30.0	10.0	10.0	0.0
	(0.5)	(2.0)	(0.0)	(44.7)	(44.7)	(0.0)	(44.7)	(44.7)	(44.7)	(22.4)	(22.4)	(0.0)
(5.OF 9.)	2.- 4.	0.- 10.	0.- 0.	0.-100.	0.-100.	0.- 0.	0.-100.	0.-100.	0.-100.	0.- 50.	0.- 50.	0.- 0.
CAT F	1.0	1.9	0.0	0.0	100.0	0.0	50.0	0.0	50.0	0.0	0.0	0.0
	(0.0)	(3.4)	(0.0)	(0.0)	(0.0)	(0.0)	(70.7)	(0.0)	(70.7)	(0.0)	(0.0)	(0.0)
(2.OF 5.)	1.- 1.	0.- 7.	0.- 0.	0.- 0.	100.-100.	0.- 0.	0.-100.	0.- 0.	0.-100.	0.- 0.	0.- 0.	0.- 0.
CAT G	2.3	13.0	11.7	12.5	75.8	0.0	20.8	12.5	47.5	19.2	0.0	0.0
	(1.3)	(10.3)	(22.7)	(35.4)	(37.9)	(0.0)	(39.6)	(35.4)	(51.2)	(35.0)	(0.0)	(0.0)
(8.OF 9.)	1.- 5.	0.- 33.	0.- 60.	0.-100.	0.-100.	0.- 0.	0.-100.	0.-100.	0.-100.	0.-100.	0.- 0.	0.- 0.
CAT H	1.5	8.7	0.0	9.1	90.9	0.0	18.2	18.2	27.3	36.4	0.0	0.0
	(1.2)	(4.8)	(0.0)	(30.2)	(30.2)	(0.0)	(33.7)	(40.5)	(41.0)	(50.5)	(0.0)	(0.0)
(11.OF12.)	1.- 5.	0.- 20.	0.- 0.	0.-100.	0.-100.	0.- 0.	0.-100.	0.-100.	0.-100.	0.-100.	0.- 0.	0.- 0.

Table 4.2 a
Brick Industry

ADMINISTRATION WORKERS

	NUMBER OF WORKERS[1]	% OF LABOR FORCE[2]	% IN EACH EXPERIENCE LEVEL[3] 1	2	3	MISSING	% IN EACH EDUCATION LEVEL[4] 1	2	3	4	5	MISSING
EMPLOY 1	2.3	13.9	11.1	4.2	84.7	0.0	47.2	8.3	23.6	20.8	0.0	0.0
	(1.3)	(7.3)	(20.5)	(14.4)	(23.0)	(0.0)	(32.4)	(19.5)	(29.7)	(31.9)	(0.0)	(0.0)
(12.OF12.)[5]	1.- 5.	10.- 40.	0.- 50.	0.- 50.	50.-100.	0.- 0.	0.-100.	0.- 50.	0.- 67.	0.-100.	0.- 0.	0.- 0.
EMPLOY 2	4.2	10.9	6.5	17.6	72.6	3.2	20.3	19.9	24.9	25.8	2.7	6.4
	(1.1)	(3.7)	(12.4)	(33.9)	(33.5)	(9.2)	(27.2)	(26.6)	(28.5)	(28.8)	(10.4)	(12.1)
(26.OF26.)	1.- 5.	5.- 19.	0.- 33.	0.-100.	0.-100.	0.- 33.	0.-100.	0.- 75.	0.-100.	0.-100.	0.- 50.	0.- 33.
EMPLOY 3	5.1	8.5	4.3	20.4	73.0	1.8	5.1	25.5	25.8	32.0	2.0	5.7
	(1.9)	(2.9)	(13.3)	(27.9)	(30.1)	(6.0)	(20.2)	(37.8)	(31.7)	(31.6)	(6.7)	(15.2)
(11.OF11.)	1.- 9.	3.- 12.	0.- 50.	0.- 83.	17.-100.	0.- 20.	0.- 50.	0.-100.	0.-100.	0.- 78.	0.- 22.	0.- 50.
EMPLOY 4	2.0	8.0	0.0	0.0	100.0	0.0	0.0	33.3	44.4	11.1	11.1	0.0
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
(1.OF 1.)	2.- 2.	7.- 7.	0.- 0.	0.- 0.	100.-100.	0.- 0.	0.- 0.	33.- 33.	44.- 44.	11.- 11.	11.- 11.	0.- 0.

1. Average absolute number of this type of worker (e.g., in the above table, administrative workers) for firms which have this type.
2. Average % of labor force represented by this type of worker. Average is taken over all firms in each group providing labor force information, including those which do not employ this type of worker.
3. Experience levels: 1). < 1 year, 2). 1-5 years, 3). > 5 years, 4). missing---firm employs this type of worker but does not report all experience information. % based on those firms which employ this type of worker.
4. Education levels: 1). < secondary, 2). secondary but < technical degree, 3). technical degree but < university, 4). university---general degree, 5). university---engineering degree, 6). missing---firm has this type of worker but does not report all education information. % based on those firms employing type of worker specified in heading.
5. Number of firms that employ this type of worker out of the total number of firms in this group (i.e. "3. of 5.": three of a possible five firms have this type of worker).

Table 3.28b Brick Industry

PRODUCTION WORKERS

	NUMBER OF WORKERS	% OF LABOR FORCE	% IN EACH EXPERIENCE LEVEL 1	2	3	MISSING	% IN EACH EDUCATION LEVEL 1	2	3	4	5	MISSING
EXPLEV 1	5.3	74.5	25.5	35.1	24.5	14.6	82.6	0.0	0.0	0.0	0.0	17.4
	(1.7)	(0.4)	(26.9)	(24.8)	(23.1)	(34.5)	(35.7)	(0.0)	(0.0)	(0.0)	(0.0)	(38.7)
(12.0-12.)	0.- 12.	60.- 90.	0.- 83.	0.- 88.	0.- 70.	0.-100.	0.-100.	0.- 0.	0.- 0.	0.- 0.	0.- 0.	0.-100.
EXPLEV 2	24.9	81.2	21.1	42.8	33.0	3.1	83.6	4.0	0.6	0.0	0.0	11.9
	(8.4)	(9.3)	(16.4)	(16.3)	(20.7)	(5.1)	(32.2)	(19.6)	(2.2)	(0.0)	(0.0)	(27.7)
(26.0-26.)	12.- 42.	81.- 93.	0.- 50.	8.- 82.	8.- 71.	0.- 44.	0.-100.	0.-100.	0.- 11.	0.- 0.	0.- 0.	0.-100.
EXPLEV 3	91.4	77.7	12.9	36.1	47.3	3.7	88.8	0.7	1.2	0.0	0.0	9.3
	(12.6)	(12.6)	(14.2)	(23.3)	(26.5)	(5.0)	(18.7)	(1.7)	(2.8)	(0.0)	(0.0)	(19.2)
(11.0-11.)	30.- 93.	51.- 97.	0.- 40.	6.- 74.	11.- 94.	0.- 29.	41.-100.	0.- 5.	0.- 8.	0.- 0.	0.- 0.	0.- 59.
EXPLEV 4	1.2	82.4	23.2	58.9	13.4	4.5	65.6	0.9	0.0	0.0	0.0	29.5
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
(1.0- 1.)	112.-112.	82.- 82.	23.- 23.	59.- 59.	13.- 13.	4.- 4.	70.- 70.	1.- 1.	0.- 0.	0.- 0.	0.- 0.	29.- 29.

Table 3.28c Brick Industry

OTHER WORKERS

	NUMBER OF WORKERS	% OF LABOR FORCE	% IN EACH EXPERIENCE LEVEL 1	2	3	MISSING	% IN EACH EDUCATION LEVEL 1	2	3	4	5	MISSING
EMPLOY 1	1.7	2.9	0.0	50.0	50.0	0.0	50.0	0.0	50.0	0.0	0.0	0.0
	(0.6)	(3.9)	(0.0)	(50.0)	(50.0)	(0.0)	(50.0)	(0.0)	(50.0)	(0.0)	(0.0)	(0.0)
(3.OF12.)	1.- 2.	0.- 14.	0.- 0.	0.-100.	0.-100.	0.- 0.	0.-100.	0.- 0.	0.-100.	0.- 0.	0.- 0.	0.- 0.
EMPLOY 2	4.1	7.9	28.0	45.4	21.0	5.6	51.0	17.8	15.7	0.0	0.0	15.4
	(4.2)	(8.9)	(38.3)	(36.7)	(31.1)	(23.6)	(40.8)	(24.3)	(33.6)	(0.0)	(0.0)	(35.7)
(18.OF26.)	1.- 15.	0.- 32.	0.-100.	0.-100.	0.-100.	0.-100.	0.-100.	0.- 67.	0.-100.	0.- 0.	0.- 0.	0.-100.
EMPLOY 3	11.6	14.1	14.4	34.4	39.7	11.5	71.7	3.6	9.0	1.4	0.0	14.3
	(7.7)	(10.0)	(19.1)	(26.0)	(32.4)	(33.2)	(27.7)	(7.4)	(15.3)	(4.2)	(0.0)	(24.2)
(9.OF11.)	5.- 28.	0.- 38.	0.- 50.	0.- 80.	0.- 83.	0.-100.	13.-100.	0.- 20.	0.- 42.	0.- 13.	0.- 0.	0.- 75.
EMPLOY 4	15.0	11.0	0.0	86.7	13.3	0.0	66.7	33.3	0.0	0.0	0.0	0.0
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
(1.OF 1.)	15.- 15.	11.- 11.	0.- 0.	87.- 87.	13.- 13.	0.- 0.	67.- 67.	33.- 33.	0.- 0.	0.- 0.	0.- 0.	0.- 0.