THE CHOICE OF TECHNIQUE IN THE BRICK MAKING INDUSTRY IN THE WESTERN CAPE: OPPORTUNITIES FOR ESTABLISHING WORKER CONTROLLED ENTERPRISES IN THIS SECTOR.

By Willem A. van der Westhuizen.

Submitted in partial fulfilment of the requirements for the degree of M. Phil in the Department of Economics, University of the Western Cape.

Promoter: Prof. L.J. Loots.

Date submitted: 20 March 1991

I declare that <u>THE CHOICE OF TECHNIQUE IN THE BRICK MAKING INDUSTRY IN THE WESTERN CAPE: OPPORTUNITIES FOR ESTABLISHING WORKER CONTROLLED ENTERPRISES IN THIS SECTOR</u> is my own work and that all the sources I have used or quoted have been indicated and acknowledged by means of complete references.

W.C. van Westhuizen [signature]   25 June 1993

ACKNOWLEDGEMENTS

Many people have contributed to the completion of this thesis. The members of the Department of Economics at the University of the Western Cape have provided the environment without which it would not have been possible. The members of the cooperatives at Launisma and Buthisiswe and the Unemployed Workers' Movement have shared their time and efforts with me, and have given me the opportunity to learn from their struggles.

The time set aside by the owners and managers of the various firms and other individuals that were interviewed made the research possible. With little prospects of any direct reward they shared with an outsider their knowledge and experience built up over a long period. It is appreciated.

Finally, the HSRC sponsored part of the cost of the research.

Thank you also to Debbi for all the support and encouragement.

ABSTRACT

The thesis focuses on the choice of technique as a key component in creating viable enterprises, including those controlled by their worker-members. A theoretical model of the choice of technique is presented, with its roots in the works of Pasinetti and others. Then a picture of the technological opportunities in the brick making industry is constructed through analyzing the actual technical choices made by a sample of firms in the industry. Implications for worker controlled enterprises are drawn throughout.

The choice of technique function is shown to be more complex than is usually assumed. In the presence of uncertainty an enterprise has to search for a viable operating space rather than an optimum position. The decision making criteria are firm specific decision rules built up over time. As such the enterprise can be viewed as 'embodied learning', with the power relations which characterise all social organisations. When making a choice, the enterprise has to reconcile the conflicting requirements of the technological system, the effective demand criteria and the institutional constraints. Furthermore, these must be adapted to the context in which the technique will operate. A key component of this context is the nature of the enterprise, the learning embodied in it, and the resources it possesses.

The specific conditions within a worker controlled enterprise require changes to the institutional framework in which they can be successful. These are directly related to the distribution of income and the nature of the organisation of production. The former affects the capacity of a worker controlled enterprise to acquire human and physical resources required to invest in new techniques. The latter relates to the establishment of efficient management structures.

The choice of technique in a sample of firms in the brick making industry in the Western Cape is investigated, and the technological opportunities and constraints analyzed. It is shown that smaller mechanised concrete masonry techniques seem to hold the most potential for a worker controlled enterprise under certain conditions. These conditions include particular state policies to foster the housing delivery systems geared towards small building contracts and squatter upgrading. These have to be supplemented with appropriate financing strategies and the provision of serviced land. The ability of worker controlled enterprises to attract efficient management skills will most probably depend on their capacity to integrate horizontally, and in so doing create economies of scale in the provision of managerial resources.

The viability of an enterprise will ultimately depend on whether it is able to adopt a technique which can deliver the products with appropriate characteristics, to a market segment which requires products of that nature at the cost required. In the Western Cape that growing market seems only to be possible in the sectors where housing is currently not affordable. Therefore, lack of effective demand places a limit on the viability of new enterprises until such time as state policies and the institutional context of land use and availability have been addressed.

CHAPTER I

INTRODUCTION

Worker controlled enterprises are productive social organisations in which the workers, as workers, control the basic decision making apparatuses. They are characterised by an institutional arrangement in which the productive relations found in capitalist firms have been altered. Instead of being based on or related to ownership, control over decision making now rests with the workers' collective. The term cooperative will refer to all the types of enterprises in which this change in productive relations has taken place[1].

Since worker controlled enterprises [coops] operate in competition with capitalist firms in a market environment, they face the same economic and technical conditions as firms with different institutional arrangements. The potential to establish worker controlled enterprises could thus be analyzed from two sides. On the one hand this study could focus on the technological opportunities and constraints. In this context, the pertinent questions are what these opportunities and constraints are and whether cooperative institutional arrangements will facilitate or hinder an enterprise in making efficient technical choices. On another level, questions could be asked about the viability of cooperative enterprises as economic social organisations per se. A large amount of literature and experience have been accumulated over the years with respect to the latter. This study, however, will not dwell on these latter issues. Instead, the key elements will be used in a simple model of cooperatives to serve as a basis from which the choice of technique options open to cooperative enterprises can be analyzed.

1. Details about the legal ownership structure and the means by which worker controlled enterprises are financed will not be taken into account.

The main purpose of this thesis is therefore to look at the technological opportunities and constraints in a particular industry at a given time, and identify the potential for establishing viable coops in the industry. In order to do this, the choice of technique in the industry is used as a focus.

The thesis is divided into two parts. The first develops a theoretical model that can be used to analyze the choice of technique by an enterprise. The model is extended to deal with the operation of worker controlled enterprises in a capitalist economy. In the second part the model is used to analyze the technological opportunities and constraints in the brick making industry in the Western Cape. It should be noted that the second part is an application of the model rather than a hypothesis testing exercise. It is not possible to do more than showing the model as useful, due to the unavailability of data to test both the choice of technique model and the underlying economic theory. Lack of data has also precluded a more comprehensive study on the choice of technique behaviour exhibited by worker controlled brick making firms in the Western Cape. As a result, the empirical work focuses on the 'conditions in which cooperatives will have to operate' with inferences drawn about their potential behaviour rather than on the 'behaviour of the cooperative enterprises themselves'. This is a definite limitation of the study. However, it might be a more realistic way to approach the subject of enterprise viability, in that it assumes that the collective action and learning potential of the people that make up an enterprise are at least as important as the 'objective' conditions that it faces. The very choice of technique is a discrete element that is also part of a continuous learning process that is at the heart of the viability of any enterprise. In small individually owned firms, this is part of what is usually referred to as entrepreneurship. In other words, this study is not about cooperative or collective entrepreneurship, but about the conditions under which a specific form of learning has to operate.

In the theoretical section, the choice of technique is developed as an analytical tool with which to analyze the interface between an enterprise and its environment. It is argued that the economic viability of any enterprise can be seen to depend on the technical choices made in the past, and the ability to make alternative choices. This involves being able to incorporate the economic conditions which the enterprise faces, the technical considerations and constraints under which it operates, and the institutional characteristics of the enterprise itself into an economically viable productive unit. The enterprise's institutional structure performs a mediating function, integrating the diverse technical, economic and institutional requirements. This integrating function is crucial, and follows from the nature of the enterprise as a social organisation, composed of human beings able to learn. In this context the enterprise can be viewed as an embodiment of the learning potential of the collective of people working there. This cumulative learning enables the enterprise to make choices, to change and to develop. But it simultaneously constrains the development potential and limits the technical choices open to the enterprise.

The theoretical model has at its base the human capacity to learn. The model therefore has to be able to deal with a dynamic process of considerable complexity. Within the dynamic and constantly changing environment generated by a learning process, techniques are chosen from time to time. The choice of technique itself takes place at a given time. It can be seen as a 'snapshot' within a bigger dynamic process of technological change. It is consequently essential that the theoretical foundation of the model be dynamic rather than static. There are a number of consequences for the study: Firstly, uncertainty in the Schumpeterian sense[2] has to be a crucial part of the model. Secondly, the centrality of learning and technical change has necessitated a theoretical framework based on an understanding of the structural dynamics of a growing production system. More specifically, the model presented by Pasinetti (1981) will be used. The static input-output coefficient type models such as that presented by Sraffa (1960) has been important as an alternative to marginalist economic theories, but still exhibit the problems of a static 'straight-jacket'. The value of the work by Pasinetti in this context lies in the analytical link created between the static model within which an analysis of the choice of techniques can be done and a truly dynamic analysis required to analyze technological change. Thirdly, the empirical analysis of the brick making industry will primarily be that of a 'snapshot', because data for a dynamic analysis of technical change are not available. While attempts will be made to extend the time horizon of the analysis forwards and backwards, the limitations in this regard should be borne in mind.

The centrality of human learning in the theoretical model has further consequences for the study. The most important is that of differential rates of economic growth in various industries as the flip-side of differential technological opportunities in various industries. This interrelation between technical and economic processes is a key aspect of the theoretical model. It leads to the analysis of economies of scale and heterogenous products and implies that the range of technical choices that are viable at any given time is determined not only by the effective demand conditions within the industry, but also by the economies of scope presented by different techniques. The former is determined by the distribution of income and the conditions of production in all the industries over the economy as a whole. The

2. See Schumpeter, J (1928:361-386)

latter is determined by the technological principles underlying the technique, resulting in different technical opportunities associated with each technique. Whereas the work of Pasinetti formed the basis for the economic model, the technological aspects of the learning process is borrowed largely from the work of Devendra Sahal (1981). In a fascinating way it starts from a series of technical premises but ends up with a theory of technical change mirroring that found by Pasinetti from an economic perspective.

A final aspect of the theoretical model deals with the integrating function of the institutional imperative. The ability to make technical and economic decisions depends on the experience and learning embodied within the enterprise, and the way in which the institutional nature of the enterprise facilitates such learning. At the same time, the institutional context outside the individual enterprise also plays a crucial role in the learning process[3]. The viability of cooperative enterprises (and other types of firms) is determined by the technical and learning opportunities within the industry, and by the ability of the organisational structure of the cooperative to enable the learning required to make use of those opportunities. A theoretical framework is presented as part of the model, drawing to some extent on the work done by Horvat (1982) and others for cooperatives, and Coombs et. al. (1987). However, it should be noted that this is an area that will require much more work since it is far more difficult to find definitive texts on the institutional imperative of worker controlled enterprises.

The second part of the study investigates the technical structure of the brick making industry in the Western Cape. The choice of technique in a sample of firms and the technological

3. See the arguments by Porter summarised for WESGRO by L Loots (1991)

opportunities and constraints in the industry are analyzed. The aim is twofold: to demonstrate that the approach to analyze the choice of technique functions developed in the first section is useful; and to draw specific conclusions about the technological structure of the brick making industry in the Western Cape and its consequences for the choice of technique by coops.

The first will be done by showing the existence of heterogenous products and its importance when technical choices are made in the context of uncertainty. The second will be done by analyzing the characteristic profiles of individual techniques within the industry as a whole. The crucial correlations between product characteristics, technical profiles, economic factors, and institutional characteristics will be shown.

Finally, the conclusion draws the findings of the study together, and develops a tentative framework that can be used to determine the potential of a worker controlled enterprise in the Western Cape. It is shown that smaller mechanised concrete masonry techniques seem to hold the most potential for a worker controlled enterprise under certain conditions. It is argued that the potential is constrained by the lack of effective demand for housing that is not affordable. Institutional changes will have to be effected, and they will have to be done in a specific way to create conditions favourable to the establishment of coops. These include an active housing policy based on individual home ownership and squatter upgrading focusing on small individual building projects rather than massive housing estates; provision of suitable land on a subsidised basis with individual tenure; and changes to the financial arrangements to facilitate the provision of smaller loans for upgrading and smaller building projects. Key organisational conditions within coops that need to be addressed are the access to skilled managerial resources, horizontal integration between different firms to create economies of scale in the provision of inputs of materials and management, and effective organisational structures to ensure that the productivity benefits due to increased motivation and reduced supervision requirements are realised.

CHAPTER II

THE CHOICE OF TECHNIQUE IN A COOPERATIVE FIRM.

The central argument of the choice of technique model can be stated as a series of propositions:

(1) The capacity of human beings to learn is at the heart of the analysis. An ongoing process of change creates a dynamic environment in which enterprises have to make choices. Techniques are chosen at intervals, when decisions about new investments or replacements of worn out equipment have to be made. The choices made create a rigidity enabling or constraining future learning possibilities.

(2) The framework within which choices are made is characterised by the prevalence of instability (Schumpeter. 1928), and the degree of technical change which the enterprise experiences. The former implies that the latter does not occur in an even and continuous manner. Moreover, the change of technique is both a social and a technical process. It requires learning which is governed by the social relations of production within the enterprise and exchange relations with the external world. Technical changes occur at an independent pace and frequency.

(3) The choice of technique can be analyzed from three viewpoints: the economic, technical and institutional imperatives. Each makes a separate but interdependent contribution to the technique.

(4) The economic imperative deals with two related matters: relative prices and effective demand. Both are dependent on the distribution of income at a given time. Relative prices reflect the conditions of production and productivity in

all the firms and industries that directly or indirectly contribute to the inputs of the firm.

The 'social use sector' is the unit of analysis for effective demand. This includes all the products and services that fulfil a specified function, or 'social use'. All these heterogenous commodities can be regarded as substitutes. The level of real wages together with consumer preferences (treated as exogenous but subject to learning itself) and interpersonal income distribution determine the consumption patterns of the society at a given time. As real wage levels increase, per capita consumption of a particular social use increases up to a certain level. Beyond this level, an increase in the real wage level leads to changes in the characteristics of the commodities making up the social use sector, but not the total quantity thereof, and allows for the establishment of new social uses.

Furthermore, more than one technique could be viable at any given time. This is due to uncertainty, the co-existence of demand for commodities with different characteristics, and different institutional arrangements within enterprises.

(5) The technical imperative can be approached from a systems viewpoint where a technique is evaluated in terms of its functional characteristics. These can be seen as the inverse of the input coefficients in the economic system. The technical system does have a (physically determined) dynamic of its own, which is encapsulated in the concept of 'technological guideposts'. Certain inherent characteristics of the technology determines the possibilities for changes in the technique, altering the performance characteristics in the environment in which it is to be

used. These give rise to differential technical innovation potentials for different technologies (in an engineering sense).

Learning is required not only to operate the technique, but also to change it[1]. It has a cumulative nature, building incrementally on previous experience. This learning and scaling[2] is object specific, and can only be transferred between different techniques with difficulty and cost. It is also largely enterprise specific in that many decisions are based on experience which people gain over time in a specific organisation. Firm or technologically specific competency is therefore not easily transferrable.

(6) The institutional sphere consists of all those social, organisational, environmental and political areas that regulate the decision making process on various levels. Learning is a social process that finds itself embodied in people, organisations, institutions and societies. The institutional framework in which decisions are made gives rise to power relations between different individuals and groups of people.

It deals with two aspects that are critical to the ability of an enterprise to make efficient technical choices: competency and power. Competency concerns the state of learning - the availability and acquisition of knowledge and sufficiently skilled and experienced people to make efficient choices. Power refers to the context in which these choices are made and controlled.

In the model, the organisational aspects related to the

1. This usually involves scaling (see note 1).

2. Changes in the scale of one or more of the components or sub-systems of the technique.

enterprise as a key institutional actor will be focused upon. Following the managerial conceptions of the firm, the enterprise is characterised as a bundle of physical and human resources, striving to different potentially conflicting goals. Firm specific decision rules govern decision making which can be seen as satisficing.

(7) Learning is a dynamic process in which the time dimension becomes crucial. Technical choices are made at a given time, and then the results of those choices live on into the future. Technical change is a slow (but relentless) process in which the effects of technical choices taken in succession add up to a constantly changing whole. This can be seen in differential rates of productivity growth in the various industries, and its technical counterpart of technical change through the joint processes of 'learning and scaling'. Institutional changes over time have to accompany technical and economic changes, at the same time mediating the diverse requirements of each imperative.

(8) The basis for the integration between the three imperatives therefore lies in the mediating role of the institutional imperative, and the learning and scaling processes embodied in it. In the technical imperative, the functional characteristics of a technique related to its technological principles translate into a set of inputs or commodities in the economic imperative. One result is the existence of economies of scale which can be seen as the result of the indivisibility of inputs, which is the (economic) inverse of the scaling properties of the technological principles of a technique. Matching the functional characteristics of the technique with the economic context in which it will be utilised is the basic task underlying scaling processes.

(9) In a cooperative a specific set of social relations of production is prevalent. This involves a change in the institutional but not necessarily in the economic and technical imperatives of the enterprise. At the at the heart of the institutional imperative lies the twin elements of competency and power. Depending on the situation, therefore, a cooperative's choice of technique function could be similar to or completely different from that of a capitalist firm. The experiences of cooperative enterprises elsewhere will be used to construct a simple behavioral model of the decision rules and organisational context in which these decisions could be taken effectively.

A. CAPITAL ACCUMULATION IN A DYNAMIC ECONOMY.

This thesis builds on those economic works that are compatible with the theory of value formalised by Piero Sraffa in THE PRODUCTION OF COMMODITIES BY MEANS OF COMMODITIES (1960). Especially important is the work of Luigi Pasinetti. In STRUCTURAL CHANGE AND ECONOMIC GROWTH he sets out to

> [develop] a theoretical model ... for an industrial economic system. ... As against the pure exchange model of marginal economics, the scheme itself may be called a pure production model. All commodities considered are produced, and can be made in practically whatever quantity may be wanted, provided that they are devoted that amount of effort they technically require. (1981:23-4)

The general principle underlying the model is represented by the learning process of human beings, in its twofold aspect of technical improvements and consumers' preference evolution (1981:23). Pasinetti does not consider the institutional arrangement of society explicitly, but looks at the "'primary and natural' features of a pure production system" (1981:25).

This analysis builds upon the Pasinetti foundation, sharing the general principle of cumulative human learning as a central part of the model. It also introduces uncertainty and product heterogeneity and makes explicit some of the technical and institutional features which remain external to Pasinetti's more general analysis.

1. Inter-industry coefficient analysis of price

In an industrial economic system commodities are being produced by commodities. As a result, a chain of costs (embodied inputs) is derived. If profits are to be made in the sale of commodity A, the price of A in terms of some common 'numeraire', must be more than that of commodity B which is a raw material input. The same holds for each industry. Therefore, in a hypothetical economy, with uniform[3] wage and profit rates, a set of relative prices can be determined given the technical coefficients and either the profit or the wage rate in terms of some numeraire common to all industries. This economy is viable if it produces sufficient of each commodity required as input in the next production period. The remaining surplus can be distributed between wages (to be consumed) and profits (to be reinvested).

As a point of departure, consider a stationary economy, with constant returns to scale. It is a well diversified industrial economy, with i commodities produced by j industries, $i;j=\{1,2,3,..,(n-1)\}$. In a stationary economy the quantity of a commodity produced by any industry and the quantity of that commodity required as inputs for the next round of production are the same. If all the capital goods are used up by the end of the period, a simple matrix[4] of equations representing the economy can be compiled. It contains a matrix of technical coefficients A, a column vector of outputs X, a row vector of prices p, and row vector of the labour inputs into each industry a_n:

Rows	*Col1*	*Col2*	*Col3*	...	*Col(n-1)*	*Outputs*
1	a_{11}	a_{12}	a_{13}	...	$a_{1(n-1)}$	X_1
2	a_{21}	a_{22}	a_{23}	...	$a_{2(n-1)}$	X_2
3	a_{31}	a_{32}	a_{33}	...	$a_{3(n-1)}$	X_3
...						
(n-1)	$a_{(n-1)1}$	$a_{(n-1)2}$	$a_{(n-1)3}$	...	$a_{(n-1)(n-1)}$	$X_{(n-1)}$
Labour	a_{n1}	a_{n2}	a_{n3}	...	$a_{n(n-1)}$	
Prices	p_1	p_2	p_3	...	$p_{(n-1)}$	

(II.1)

Each coefficient a_{ij} represents the amount of commodity i used by sector j. Each row (1 to n-1) represents the quantity of a particular commodity utilised as inputs by each industry. Each column denotes the input coefficients of each industry. Notice that a final row of inputs into each industry, the labour inputs, is included. But there is no column for labour, because labour-

3. Or varying according to a predetermined pattern.

4. It is comparable to but not the same as the Leontief input-output matrix.

power as a commodity is not produced by the economy.

Two related systems of equations can be deduced from the table:

i) The quantity system represents the demand for each commodity produced by the economic system. It simply adds the quantities of each commodity used by all industries. Because each coefficient in the same row represents the same commodity, it can be done without any loss of economic meaning. In the case of output X_1 it can be given as:

$$a_{11}+a_{12}+a_{13}+\ldots+a_{(n-1)}=X_1 \qquad \text{(II.2)}$$

ii) The price system. The quantities of input coefficients of different commodities along each column can only be added if they are expressed in terms of a common numeraire. In other words, when the relative values at which of commodities exchange rather than the quantities of commodities are expressed (Pasinetti. 1977:48-53). If the rate of profit is π and the wage rate, paid at the end of the period[5], is w, the price system would be given by a system of linear equations:

$$\begin{aligned}
(p_1a_{11}+p_2a_{21}+p_3a_{31}+\ldots+p_{(n-1)}a_{(n-1)1})(1+\pi)+a_nw&=p_1X_1\\
(p_1a_{12}+p_2a_{22}+p_3a_{32}+\ldots+p_{(n-1)}a_{(n-1)2})(1+\pi)+a_nw&=p_2X_2\\
(P_1a_{13}+p_2a_{23}+p_3a_{33}+\ldots+p_{(n-1)}a_{(n-1)3})(1+\pi)+a_nw&=p_3X_3\\
\ldots\qquad&=\ldots\\
(p_1a_{1(n-1)}+p_2a_{2(n-1)}+p_3a_{3(n-1)}+\ldots+p_{(n-1)}a_{(n-1)(n-1)})(1+\pi)\,a_{(n-1)}w&=p_{(n-1)}X_{(n-1)}
\end{aligned} \qquad \text{(II.3)}$$

These equations can be rewritten in matrix notation. The price system is given by

$$\mathbf{pA}(1+\pi)+\mathbf{a}_nw=\mathbf{pA} \qquad \text{(II.4)}$$

where $\mathbf{p}$ is a row vector of (n-1) relative prices, π the rate of profit, and w the wage rate for the uniform labour performed. The inter-industry (technical) coefficients are represented by square

5. Sraffa treats the wage as variable implying that the wage represents the workers' share in the surplus, rather than being fixed at the level of subsistence as done in the classical theory (Roncaglia, 1978:84). The post factum wage payment assumption rejects the classical view of wages as an advance from capital. But not making this assumption does not materially affect the price determination system (Steedman, 1981:103)

matrix $\mathbf{A}$ of order (n-1), and $\mathbf{a}_n$ a row vector of order (n-1) of direct labour coefficients. $[\mathbf{A},\mathbf{a}_n]'$, or the matrix with n rows and (n-1) columns represents what Pasinetti calls the 'technique of the system'. (Pasinetti. 1977:73).

The solution for the relative prices can be given as:

$$\mathbf{p} = \mathbf{a}_n[\mathbf{I}-(1+\pi)\mathbf{A}]^{-1}w \tag{II.5}$$

where $0 < \pi < R$; and R is the maximum possible rate of profit in the system. (Pasinetti. 1977:80)

The interpretation of (II.5) shows that, except under special circumstances, the level of relative prices change in an unpredictable way when the distribution of income between wages and profits changes[6]. Furthermore, the term $[\mathbf{I}-(1+\pi)\mathbf{A}]^{-1}$ "represents the quantities of commodities which are (conceptually) required in each 'round' of production in order to obtain each unit of the corresponding commodities as final commodities." (Pasinetti. 1977:90). Being pre-multiplied by the vector of direct labour coefficients in (II.5), suggests that (II.5) can be interpreted as the sum of labour requirements directly and indirectly required to produce each commodity, given the rate of profit[7].

This Sraffian model assumes a stationary economy, in which the composition of demand has been determined and is given[8]. It is

6. See Pasinetti 1977:82-84

7. See Pasinetti, 1977:91; Sraffa, 1960:35-38

8. Pasinetti (1977:71-2) outlines the specific assumptions underlying his theory of production - based on the Sraffian system:

1. Perfect stationary state: "Each 'year' the system produces exactly the same physical quantities of commodities."
2. The methods of production is such that each industry produces a single commodity by using up fixed quantities of commodities. These commodities are completely used up at the end of the production period, and have to be replaced entirely. Some of the output of the production process must therefore be devoted to replacement of the means of production, and what remains represents the nett national income or the nett product, which is available for consumption.
3. The value added in the economic system is equal to the value of the commodities remaining after provision for capital used up have been made. It is distributed at the end of the period in two forms: wages and profits. Wages are distributed in proportion to physical quantity of labour which has been contributed. Profits are distributed in proportion to the value of the means of production. It is assumed that labour is of uniform quality, and that both the wage rates and the rate of profits are equal throughout the system.

unable to deal with a dynamic economic system[9] in which equilibrium concepts become contradictory[10] (Pasinetti. 1981:47).

An inter-industry coefficient analysis of a stationary economy has difficulty in dealing with the demand and technology changes which characterise a dynamic economy. It focuses on the relations between industries, yielding information about the structure of the economy at a given time. But there is no simple way in which to link the analyses of various periods unambiguously. A vertically integrated analysis is required to deal with technical and demand changes. The importance of the work by Pasinetti (1981:114-117) lies precisely in the way that these two approaches are analytically linked.

2. Vertically integrated analysis.

Pasinetti[11] developed the 'vertically integrated unit of productive capacity' [VIU] as an analytical link between the inter-industry and vertically integrated analyses.

The inter-industry analysis above is expanded to include fixed and circulating capital. $\mathbf{A}^e$ is the matrix of initial stocks of capital goods actually used up during the year, assuming a constant proportion of fixed capital goods drops out of the production process each year. Each industry j is represented by a 'direct labour coefficient' and a "'unit of direct productive capacity' - a composite commodity defined by the jth column of

9. Attempts to move towards a dynamic analysis are confined to a system in dynamic equilibrium. Each industry is growing at the same rate and the structure of demand for the produced commodities remains the same, growing steadily at rate g. The technology remains the same over time and the system of relative prices is unaffected (Pasinetti (1977:197).

10. Decisions are by definition open ended, due to uncertainty. In an equilibrium model it is presumed that the outcome of such decisions have not only been determined, but that this outcome can be achieved by making a choice in the beginning.

11. In a paper published in 1973.

matrix **A**" (1980:19). In year t, (II.5) becomes

$$\mathbf{p}=\mathbf{a}_n w+\mathbf{p}\mathbf{A}^{0}+\mathbf{p}\mathbf{A}\pi \qquad \text{(II.6)}$$

The economy is classified according to the criterion of industry and all the magnitudes are directly observable.

Pasinetti then defines a new vector of the physical nett product of the system in which all the final commodity coefficients except the i^{th} one are zeros. All the economic processes that have to be activated in order to produce one unit of commodity i (i = 1,2,...m) as final product can then be seen in the form of an inter-industry analysis. In that way the economy is rearranged according to m sub-systems, each comprising all the economic activities that are associated with the production of a unit of one final commodity. The vector **v** and matrix **H** are defined to express in a consolidated way the quantity of labour v_i and the series of heterogenous physical quantities of commodities $\mathbf{h}_i$ (i=1,2,...,m) required as stocks in the whole economic system to obtain one physical unit of commodity i as a final good. "Scalar v_i and column vector $\mathbf{h}_i$, together, represent what we may call the <u>vertically integrated sector</u> for the production of commodity i as a final good" (1980:21).

$$\mathbf{v}=[v_i]=\mathbf{a}_n(\mathbf{I}-\mathbf{A}^{0})^{-1}$$
$$\mathbf{H}=[\mathbf{h}_i]=\mathbf{A}(\mathbf{I}-\mathbf{A}^{0})^{-1} \qquad \text{(II.7)}$$

(II.6) can be reorganised into (II.8)

$$\mathbf{p}=\mathbf{v}w+\mathbf{p}\mathbf{H}\pi$$
$$\mathbf{p}=\mathbf{v}(\mathbf{I}-\pi\mathbf{H})^{-1}w \qquad \text{(II.8)}$$

which explicitly shows that each price is ultimately made up of only two components: wages and profits. (Pasinetti. 1980:22) Furthermore, matrix **H** becomes an operator allowing transformation between the inter-industry and the vertically integrated analyses.

If the technical coefficients are no longer absolutely constant through time, as when technical progress occurs, the notion of a vertically integrated sector is not only unaffected but acquires a greater relevance. Because the notion of a physical unit of productive capacity is defined with reference to the commodity that is produced, it continues to make sense, as a physical unit, irrespective of its composition in terms of ordinary commodities. (Pasinetti. 1980:38) The implications of the notion of a vertical unit of productive capacity for dynamic analysis is immense:

> Even in the midst of a maze of physical and qualitative changes, we may indeed continue to say that replacement of used up capital goods has taken place if, at the end of each period, the economic system has recovered the same productive capacities as it had at the beginning." (Pasinetti. 1980:42)

Two important results follow: Firstly, all the magnitudes (including matrix **H**) must be dated. Technical choices are made at a given time t, and the choices made are relevant only for that period. In the next period, conditions will have changed and a different set of options and conditions will face the decision makers. This can be referred to as the 'snapshot' time frame in which decisions are made.

Secondly, if technical progress is embodied in new capital goods, older equipment will usually not be replaced by exactly the same equipment. Therefore, two sets of vertically integrated sectors should be distinguished. The <u>hypothetical</u> vertically integrated sectors denote the economy as if the latest techniques had been known in the past and implemented. This system is relevant for price formation. On the other hand, the actual economic system will be made up of a mixture of many techniques of different vintages. The <u>actual</u> vertically integrated sectors become relevant in representing the physical economic system. (Pasinetti. 1980:39)

Using the conceptual tools developed above, Pasinetti (1981) developed a theory of economic growth characterised by technological change and differential sectoral productivity growth, and changes in the structure of demand. The economy consists of a large number of 'vertically integrated sectors of productive capacity'. Each vertically integrated sector serves as a measure of capital in terms of an estimate of the amount of labour directly and indirectly used in the production of a given commodity. All macro-economic magnitudes should be seen as weighted aggregates of such vertically integrated sectors.

The dynamic growth of the economic system is characterised by two components: productivity growth and changes in demand patterns. These together lead to structurally unbalanced growth in an economy in which vertically integrated sectors have different productivity growth rates. Growth in productivity eventually means that a particular commodity is produced with less labour (direct or indirect). Some sectors will experience fast growth, while others will grow slower and eventually die away. At the same time increased overall productivity increases real wage rates, while profit rates remain fairly constant over the long term. Changes in per capita income is the major force behind changes in consumption patterns.

Consequently, the nature of consumption has to change in order to maintain effective utilisation of resources and full employment. Growth in productivity creates potential demand. If potential demand is not matched by effective (aggregate) demand, some of the productive capacity will stand idle, and some workers will be unemployed. (The opposite of what Pasinetti defines as equilibrium.) Aggregate demand must reflect aggregate productive capacity, but changes in sectoral productive capacity must also be matched with changes in consumption to reflect productive changes. These make up the demand conditions for 'dynamic equilibrium'. The capital accumulation conditions for 'dynamic equilibrium' require that at any one time there must be sufficient capital stocks to enable the labour flows to function at full capacity. (Pasinetti. 1981:85-93)6

3. Technical change and the choice of technique.

In the light of the discussion above it is now possible to look at the choice of technique in the context of a continually changing economy. The choice of technique takes place at the level of a given industry (firm) j at time t. All the prices of commodities directly or indirectly entering the production of j can be taken as given. And the choice of technique function could simply be evaluated as a rational choice situation of minimizing costs. However, the outcome of the choices made (and the others being made independently by other industries at the same time) is essentially unpredictable.

a. Choice of technique in the short run.

In a hypothetical static economy in equilibrium, technical changes associated with choices made by many firms can be taken as if they occur instantaneously. All the decision makers have sufficient information about the combined effect of all the technical choices by all firms throughout the economy. The choice of technique function for a basic commodity involving no joint products, and in which all the means of production are used up during the production process could then be constructed[12].

Assume that the choice criterion is minimum cost[13]. q is a basic commodity which can be produced by three alternative methods x;y;z. Vector **a**' of matrix **A** deals with the production of

12. Following Pasinetti, 1977:151-177

13. In the capitalist mode of production, this is the same as the maximisation of profits for a given wage rate. Thus, the choice of technique is not simply technological. The distribution of income plays a crucial role. (Pasinetti, 1977:152)

commodity q. With constant returns to scale, the coefficients of $\mathbf{A}$ can be expressed in the form a_{ij}/X_i, or the inputs per unit of output for each commodity. $\mathbf{p}'$ represents the row vector of the k prices of the basic commodities. $\mathbf{a}'$ represents the column vector of the k input levels of basic commodities used in the production of q. a" represent the labour input coefficient of the commodity q. The price of the commodity produced with each technique is therefore given by:

$$p_q = \mathbf{p}'\mathbf{a}'(1+\pi) + a''w \qquad (II.9)$$

For each technique $\mathbf{p}';\mathbf{a}'$ and a" will be different. $\mathbf{p}'$ is determined by the system of basic commodities for the technology currently used. $\mathbf{a}'$ and a" are given with the technique under consideration. w and π are assumed uniform for the system as a whole. If technique x is currently used, and $\mathbf{p}'_x$ is the row vector of k price coefficients produced under technique x actually in use, the alternative choices can be given by:

$$\begin{aligned} p_x &= \mathbf{p}'_x\mathbf{a}'_x(1+\pi) + a''_x w \\ p_y &= \mathbf{p}'_x\mathbf{a}'_y(1+\pi) + a''_y w \\ p_z &= \mathbf{p}'_x\mathbf{a}'_z(1+\pi) + a''_z w \end{aligned} \qquad (II.10)$$

The complications that arise with the choice of technique when a basic commodity is involved relates to the fact that a change in technique in only one industry affects the whole system of relative prices. There are in fact three different systems of relative prices related to the three techniques under consideration if they were chosen consecutively.

However, if a commodity produced in all three of the (hypothetical) systems is taken as numerãire, solving for the wage rate in terms of this commodity can be used to compare the wage-rate/profit-rate relationship in the three systems[14]. These polynomial equations can then be evaluated on the same set of

14. See Pasinetti, 1977:156-67 for an exposition of this analysis and a generalisation thereof.

axes[15]. The outermost 'border' of these curves taken together represents what Pasinetti calls "the technological frontier of income distribution possibilities". (1977:156) This frontier is strictly decreasing as the rate of profit increases. If at a certain rate of profit one technique is more profitable than another, it will yield prices in terms of the wage rate that are strictly lower than the less profitable technique. At certain points, the frontier curves for two techniques would 'switch'. Here, either method can be used to produce without any effect on the prices of any of the commodities.

The analysis so far suggests that productivity is given relative to the distribution of income, is primarily technologically driven, and the productivity in a single sector can only be assessed in conjunction with the productivity in all the sectors of the economy. The wage-rate/profit-rate comparisons can be seen as a complex measure of the potential (total factor) productivity in a particular industry. It is an important component of this choice of technique model.

b. Dynamic analysis and effective demand.

From a dynamic point of view the difference between the choice of technique and the change of technique becomes clear. The first deals with those specific moments at which, due to reinvestment or replacement, new techniques may be adopted. As soon as they are adopted, they become fairly fixed. Then changes of technique may take place as a process over time. "It involves a movement towards a <u>different</u> set of possible techniques and, therefore, towards a new problem of choice." (Pasinetti. 1981:189) Technical change emerges as a result of the interplay between the choice of technique and production functions[16] (1981:205). Innovations

---

15. See Figure II.2 on page 60.

16. Pasinetti defines a production function in terms of the actual vertically integrated production process at a given time.

have different effects on the choice of technique and production functions. The former simply become longer with more known techniques to choose from. The latter, on the vertically integrated level, result in productivity improvements over time.

The structural dynamics introduced by technical change follows from differential productivity growth by various sectors, relative to the sectoral growth in demand. When sectoral productivity growth is higher than demand growth, an imbalance will occur, and firms will have to adopt other strategies to achieve steady growth[17]. Therefore, "the efficient organisation of single units of production is not something which can be investigated in isolation from the structural dynamics of the economic system as a whole." (Pasinetti. 1981:225)

At a given time, the technical choice function can be seen as the way in which the economic conditions mentioned above are reconciled with the institutional and technical features of a particular enterprise. Contrary to the conventional theories, Pasinetti (1981:226) argues that the 'relevant decisions at the level of the single production units' are not wage and interest rates, but the technology and the demand. The most important factors are rate of profit[18]; the technical coefficients and their expected evolution over time[19]; the learning and scaling processes and potential in the particular technologies[20]; the composition of demand and its evolution over time[21]; and the institutional characteristics of the enterprise and its ability

17. 1. Diversify into new fields and produce new products
    2. Keep a reservoir of new products which can smooth out these difficulties.
    3. Try to manipulate consumers through advertising.
    4. Find new outlets or markets abroad.

18. See Pasinetti, 1981:191-197

19. I.e. learning processes in all the other industries.

20. Different technical methods of production may sometimes be preferred simply because its technology is improving very fast, even when its relative efficiency is not the optimum one at the time the choice is made.

21. The length of time before the productivity growth rate exceeds the demand growth rate; the possibilities for diversifying given the existing experience and productive capacity of the production unit; the possibilities for finding new markets etc.

to provide the framework in which learning can be accumulated[22].

This general analysis has to be specified more clearly in a number of areas. The first is of an economic nature. The effect of uncertainty, different types of labour employed, and heterogenous commodities on the evolution of relative prices and effective demand must be specified. Secondly, further attention must be given to the underlying technological phenomena, and their interrelation with productivity growth in the economic system. Finally, technical choice involves an institutional framework in which choices can be made, and which mediates the integration between the various aspects. The institutional framework consists of more than minimising costs, and includes the motivations of individual decision makers, the ways in which enterprises are organised and even the nature of the society as a whole.

22. The availability of resources and skills.

B. A THEORY OF TECHNOLOGY AND THE CHOICE OF TECHNIQUE

It has become necessary to define the concept 'technology'. Fransman suggests that in the economic literature the meaning has shifted from technology as the sum total of all known techniques to transforming inputs to outputs in a specific firm or industry (1986:584). In the 'engineering' literature, technology is used in at least two different ways. The first defines technology broadly, as the way in which knowledge is applied. The second is much more focused, and refers to a technology as a technical system with its own physical organizing principles.

Here, the term 'technique' refers to the way in which a particular production unit transforms a given vector of inputs into a given output at a given time. It is primarily an economic concept. A 'choice of technique' refers to the process whereby different techniques known are considered at a given time, and one technique is adopted by the production unit. On the other hand, a technical matter refers more to the physical 'engineering' rather than an economic issue. The two concepts 'technical' and 'technique' are closely related and describe the same phenomenon from engineering and economic angles respectively. A choice of technique is time specific. It depends on the conditions prevailing in a particular economic system at that time. It has its exogenous datum in a set of social relations and conditions. On the other hand, a technical choice has its exogenous datum in the physical operating principles, and the state of cumulative learning available to deal with those.

The term technology can therefore be defined more closely as the way in which the technical and economic features are combined through a process of human learning in a given institutional context. Human learning rather than the way in which inputs are transformed into outputs only is the central issue. It includes economic and technical data with their own imperatives within a definite institutional framework.

1. Economic imperative: Questions of effective demand.

The choice of technique model outlined above can now be expanded to incorporate uncertainty and product heterogeneity. Triplett (1985:283-307) and Alexander & Mitchell (1985:161-196) have attempted to develop more general theories of technical change incorporating heterogeneity amongst products and processes. Triplett (1985:283-307) attempts to extend the neoclassical production function concept to incorporate product characteristics[23]. The complications that arise when heterogenous goods are incorporated into the analysis is then shown. Not only are there many productive relations between inputs and outputs, but specifying the relations between them can be complicated. An example is 'production complementarities' that might exist between the 'quality' of inputs and of outputs[24]. The rest of the section will extend the model developed so far in section II.A.

a. Product heterogeneity and the social use sector.

Heterogenous products describe different products that are comparable in some crucial sense. If they are substitutes, this common factor is the function which they fulfil in a given society. A social use can then be defined as a particular function that is fulfilled by the consumption of one or more produced commodity. By definition, more than one commodity can serve the same social use. A social use sector is all those commodities that, at a given time in a given society, perform the

23. The production function $Q = f(K,L,M)$, "with inputs represented in the form of characteristics ... is: $Q = r(X_K,X_L,X_M)$, where X_K, X_L and X_M are vectors of capital, labour and materials characteristics, respectively. ... [O]utputs, as well as inputs are non-homogenous. We measure output as a vector of jointly produced characteristics (*output characteristics*), and the production relations become $s(X_Q,X_K,X_L,X_M) = 0$." (Triplett 1985:287-8). X_Q here represents the output in terms of characteristics.

24. The degree to which this is the case can differ from case to case. See Triplett (1985:288) for a description of the case of a bricklayer compared to an orchestra.

same function.

Suppose that after consideration two social uses are defined in the stationary economy of (II.1): Commodities i = 1 and i = 2 produced by industries j = 1 and j = 2 fulfil the same social use S_1, and are substitutes. All the other commodities fulfil social use S_2. The rows and columns are reorganised so that all the techniques associated with a given social use are adjacent in both the rows and the columns. Then the matrix and vectors are divided into component matrices and vectors, so that the number of rows and columns equal the number of social uses identified in the economy as in (II.11). Each element of **A** is a matrix of rank equal to the number of commodities that the social use sector is comprised of.

Rows	*Col1*	*Col2*	*Col3*	...	*Col(n-1)*	*Outputs*
1	a_{11}	a_{12}	a_{13}	...	$a_{1(n-1)}$	X_1
2	a_{21}	a_{22}	a_{23}	...	$a_{2(n-1)}$	X_2
--	--	--	--	--	--	
3	a_{31}	a_{32}	a_{33}	...	$a_{3(n-1)}$	X_3
...						
(n-1)	$a_{(n-1)1}$	$a_{(n-1)2}$	$a_{(n-1)3}$	...	$a_{(n-1)(n-1)}$	$X_{(n-1)}$
Labour	a_{n1}	a_{n2}	a_{n3}	...	$a_{n(n-1)}$	
Prices	p_1	p_2	p_3	...	$p_{(n-1)}$	

(II.11)

The economic meaning of (II.11) is straightforward. It is a transformation of a price system consisting of n-1 homogenous commodities into a price system with 2 composite heterogenous commodities. At time t, n-1 homogenous commodities were produced, and the relative prices determined, given consumer preferences. However, the exact composition of each 'composite commodity' can only be determined after the demand for the various commodities that make up the social use have been determined. Price formation is exactly the same as on the basis of homogenous commodities, without explicit reference to demand.

Two matters need further clarification. The first is a method to define a social use sector. The second is determination of effective demand in terms of the social use sector.

b. A characteristics approach to define the social use sector.

If different commodities fulfil the same function, then the various commodities comprising the social use sector must have some similar and some differing characteristics. Furthermore, users may assign different 'quality' valuations to each commodity. These valuations are complex, but can be regarded as being based on the characteristics of the various commodities themselves. This is similar to the concept of 'characteristics' and a consumption technology which Lancaster (1966, 1971) develops. He argues that the intrinsic properties of goods must be incorporated into an analysis of consumer theory (1966:341).

Using this approach, a social use sector can then be defined in terms of a unique vector of characteristics which are related to the fulfilment of a given social function. Different quality levels will be associated with different levels of one or more of these characteristics. The social use sector is therefore the collection of all industries producing commodities which, individually or in combination, yield at least a specific combination of characteristics.

c. Effective demand in the context of a dynamic analysis.

Effective demand for any commodity is determined by the income distribution and real wage rate[25], inter-personal distribution of income, and consumer preferences. In the static economic model, the quantity system identifies the effective demand conditions. They include three elements: demand for consumption

25. See the notes on the Engel curve later on.

goods; demand for new investments; and demand for replacing worn out capital goods (Pasinetti. 1981:46).

In a dynamic context, it can be argued that the evolution of demand for consumption goods with rises in per capita incomes will follow a distinct pattern. This is given by the generalisation of the Engel law: "The proportion of income spent on any type of good changes as per capita income increases" (Pasinetti. 1981:70). Thus, as technical change leads to rising per capita incomes, new social uses will be 'discovered'. Therefore, the dynamic analysis shows the usefulness of defining the social use sector in terms of final goods only.

Earlier it was shown that a 'vertically integrated unit of productive capacity' as a measure of capital is necessary for a dynamic analysis. In short, a VIU refers to all those economic processes that have to be activated to produce one unit of output of a final product alone (1980:39). The transformation of the VIU for homogenous final products into heterogenous commodities is straightforward. It is simply a reorganisation the vector of final goods in terms of which the VIU is defined. Each VIU then becomes all those economic processes that have to occur to produce a vector of final commodities, all serving the same social use. The only addition is the dated demand coefficients expressing the ratio of each homogenous commodity to the total number of commodities consumed in the social use sector. And to keep things simple, the total of all the elements of the final consumption vector could be made equal to one. Then it follows that the treatment of a homogenous commodity is simply the special case of the more general VIU for heterogenous commodities.

Since the commodities that make up the social use are substitutes, it follows that the demand pattern for the social use as a whole rather than the individual commodities will follow the pattern described by the Engel law. A rise in per capita income could cause the proportion of the total expenditure on a specific social use to drop. However, in the context of heterogenous commodities, the characteristics of commodities could also change, with more 'higher quality' commodities making up the sector[26].

In order to keep the analysis manageable, the set of consumer preferences at a given time will be taken as determined. This includes both the preferences for different social uses, and for different 'qualities' within each social use. While the process of learning and the distribution of income both affect the preference formation[27], the exact way in which that takes place is beyond the scope of this thesis.

These further effective demand conditions introduced into the price determination system in (II.11) requires that the relation between the characteristics and prices of the commodities within a social use sector be specified. A weak assumption that the rank order of the prices and 'qualities' of the commodities are the same will be sufficient. But there is no reason why more sophisticated models could not be used if required.

d. Heterogenous inputs.

The demand for investment goods due to replacement and new investment can be dealt with simultaneously. Most heterogenous products are also inputs. In the hypothetical static economy, all that happens is that firms can now choose between substitutes amongst their inputs as well. The model becomes much more compli-

26. This is important for a number of areas in economic analysis. Two that come to mind immediately are basic needs in welfare economics, and technological capacity in the context of technology transfers.

27. Social use sectors are ordered according to the level of the need that they fulfil. Suppose that ordering is strictly possible. Denote the social use sectors s_i, with i the level of that social use in the hierarchy. With a rise of real wages the quantity of each s_i consumed will increase up to a point. Then two possibilities arise. Either a new social use will be 'discovered' or the quality composition of each social use can change.

cated, and the definition of a basic commodity has to be adapted. In a vertically integrated analysis, things are much simpler. Because the inputs are resolved into either labour or capital stock inputs, heterogenous inputs are dealt with in the same way as technical change.

Labour-power is a unique commodity which is itself not produced[28], and is therefore dealt with separately. Steedman (1977:88-94) has relaxed the assumption of one single type of average labour power in the static economic model. He argues that when the labour force is segmented along skill or other lines, each type of labour-power is used not only to produce real wages for that group of workers, but for all the other groups of workers, as well as for profits (1977:90). He shows that under these conditions, the price system is determinate without having to reduce each type of labour to some sort of average. Furthermore, in the case of differential wage rates for different types of labour, an inverse linear relationship exists between the different wage rates if the rate of profit remains the same. Alternatively, if the technology remains the same, a rise in the wage rate for one type of labour could result in the decline of the wage rate for the other type of labour, or in the decline of the rate of profit, or both (1977:100).

This will have a bearing on the technical choice function. The occupational structure associated with each technique could affect the structure of personal incomes within the enterprise, and between the enterprise and the rest of the industry.

e. Implications for the choice of technique.

Product heterogeneity has introduced a number of significant issues into the choice of technique function:

---

28. See Hodgson, 1982:24

(a) More than one technique producing a given social use can co-exist at any given time. This requires the price-quality relations between the various techniques to be specified and analyzed.

(b) The choice of technique function becomes more complex, and operates within a dynamic environment. This increases the uncertainty within which techniques are chosen.

(c) A key area is the impact of heterogenous commodities on the composition of effective demand. Apart from the normal changes of demand for final goods with changes in income distribution as the Engel law suggests, changes in the characteristics composition of the social use sector can also follow. Changes in demand for investment goods are related to economies of scale and learning.

2. Technical imperative

The technical imperative presents a new set of exogenous determinants to the learning process. They are derived from the application of physical laws in the functioning of any technique.

a. Learning and Scaling

Technical change is central to productivity growth in an industrial society. Both 'learning' and 'scaling', are the two fundamental processes of technical change:

> "In its essence, there are two key determinants of technical progress. One is the process of learning or the acquisition of production skills. The other is the process of scaling or patterning of the system to perform certain desired tasks. The role of these two processes in technical progress turns out to be pivotal in a very interesting and somewhat surprising way." (Sahal. 1981:306).

Learning can be seen as technical progress in the time domain. It is commonly expressed by a learning curve showing the increased efficiency with which a given technique is operated over time. Sahal, maintains that the concept of learning also applies to the very process of technical innovation itself. "[L]earning is a central factor in the evolution of a technique in the first place. This type of learning occurs both in the design process (at the level of a single unit of physical equipment) and in the production activity (at the level of the plant)" (1981:307). Scaling can therefore be seen as technical progress in the space domain (1981:309).

The key proposition on which most of the work of Sahal depends, is that progressive flows of innovation are channelled by physical laws constraining what can be done, the internal logic of the learning process, and economic variables which retard and accelerate this process. The consequence is the emergence of what may be called technical systems. Each system has a set of underlying physical principles requiring specific 'specialised' knowledge. These provide the basis for the evolutionary development of a system, as well as the limits to that development. The knowledge acquired within the context of one technical system is tacit, and not readily transferrable to another system. Sahal (1981:309-313) has generalised these ideas into four general principles of technological innovation:

(1) Technological guideposts: Innovation leads to a certain pattern of machine design, which again sets boundaries for further innovations. Technical progress has its origin in bit-by-bit modifications of a given design. The emergence of a guidepost depends on the synthesis of proven concepts from the past. The more adaptable the technique is to its task environment, the more likely it is to become the vehicle for further advances[29].

(2) Creative symbiosis: There exist limits to the evolution of

29. The "characteristics of such a pattern are generalisable. First, the emergence of a technological guidepost often lies in the culmination of prior advances. It is seldom a matter of radical breakthrough. ... Second, it seems that the greater the variety of tasks to which a design is adaptable, the more likely it is to serve as a guide to the general direction of technical advances." (1981:36) See also Sahal, 1981:309

a technique, due to the "fixity of its form" and the "complexity of its structure". These limitations can be overcome by combining different technologies to simplify the overall structure of the system as a whole.

(3) Putty-clay principle of technical progress: Before a system is formed, there are many possible directions in which things could go. But as soon as the technical system is formed, a lot of the know-how becomes specific to that system. Advances in that know-how can leave other technical systems relatively unaffected.

(4) Technological insularity: Transferring the know-how between two technical systems is difficult and costly. While technology transfer does take place, it is by no means as easy as generally presumed.

These principles, and the concepts which underlie them, are crucial for the current analysis. They are present in concepts like technological opportunities and constraints[30], and the technological specificity of each plant[31]. Furthermore, as a dual to the pattern of dynamic development of the economy characterised by Pasinetti, they give a technical explanation for the phenomenon of differential productivity growth rates in various industries.

At the same time they present a basis from which the 'technical' imperative of the choice of technique function can be analyzed. The system forming nature of technological change has some important consequences for a proper understanding of the choice of technique. Firstly, the current production technology places constraints on the range of techniques that a particular firm at a given time can choose from. Secondly, different 'technologies' with different sets of technical principles could have significantly different characteristics. They could have

30. See Coombs, et. al. 1987:43

31. Rosegger, 1986:68

different levels of opportunity for further technological advances and learning potential. Enterprises might choose a technique because it is based on a set of technological principles which promises greater scope for advance in the future. Finally, the technical characteristics of a particular technique might not fit the conditions which the enterprise faces. These could be the nature of demand and consumer preferences for products with certain characteristics. Or it could be external conditions in the economy as well as the institutional situation internal to the enterprise.

Thus, given that technical opportunities exist, the outcome of technical choices is uncertain and strewn with pitfalls. But, these opportunities can only be realised if an enterprise consciously applies resources in order to make it work. The crucial enabling function of the enterprise amidst all the uncertainty appears to be the technical counterpart of economically viable enterprises.

b. A functional characteristics approach

In the basic economic model, products produced during the preceding production cycle are inputs in the current production processes. These goods or services can be considered as having particular functional characteristics[32]. In terms of this approach, any commodity, be it a physical product or an intangible service, can be described in terms of a set of properly weighted functional characteristics[33]. All the characteristics are presumed to add to the whole in some

32. The attempts to depict a product in terms of functions or characteristics is well documented in the literature. Triplett (1985) and Alexander and Mitchell (1985) have both given overviews of the different approaches.

33. The same general method was used to define the social use sector.

functional form[34]. Using this approach, it is theoretically possible to compile a general list of functional characteristics which will be sufficient to 'describe' all commodities in the economy.

The system of linear price equations can now be extended to incorporate a 'characteristics' analysis. The vertically integrated analysis will not be used, because the characteristics of each individual input commodity is required. As a result, all the parameters are dated. The price equation for each industry i can be given as:

$$p_i X_i = (p_1 a_{1j} + p_2 a_{2j} + \ldots + p_i a_{ij})(1+\pi) + a_{ni}(w) \qquad \text{(II.12)}$$

p_i = price for each commodity
a_{ij} = technical coefficient as input in each production process
X_i = output of each industry
a_{nj} = labour coefficient each production process.
k = n-1

Following Majer (1985:335-351), a distinction can be made between the functions and the characteristics. Each function is determined by a sum of m weighted characteristics c_m[35]. Each output coefficient is then represented by a sum of g weighted functions, f_g, and a scalar magnitude v_i indicating the number of commodity units. The bundle of functions f_g defines, amongst other things, the quality of the product. Thus

$$X_i = v_i f_g \qquad \text{(II.13)}$$

Each commodity is represented by three components: the price, quantity and characteristics. Each component is determined by quite different but interacting factors. Changes in the level of f_g, will most likely be accompanied by changes in p_i, and in changes in the production process itself. These changes can only be looked at in a dated sense, and it would be erroneous to imply

34. One functional form often used is a linear form. Other approaches see the characteristics not as contributing to a n-dimensional surface or hyperplane, but as clouds of points in n-dimensional characteristics-space. See for example Sahal for a formulation of a 'manifest technometric function' which determines not only a technometric index value which represents the observed features of the 'technology', but weights the various characteristics in terms of inherent technical parameters. (1985:12-22). Majer uses a functions approach to determine a quality index level for a particular group of products. A weighted series of functions, each consisting of a weighted series of characteristics, is used to compute an index level of quality (1985:336).

35. See Majer, 1985:339 for an example of such an approach.

any sort of equilibrating mechanism present in the equation.

Note that no assumptions about the scale returns have been made. Each quantity coefficient v_i contains information about the level of production in a particular production process at time t given a certain predetermined level of functional characteristics f_g. The specific relationship between short run deviations and long run price determination becomes important. The level of v reflects the capacity for which a plant has been designed, and the estimated level at which the plant expects to produce. Then, for the sake of simplicity, presume that only one plant operates in each industry, and that it operates at planned capacity.

Suppose that all the possible functions for all commodities can be listed. Then the g functions that would be the minimum necessary to indicate the functional capacity of any commodity could be selected. The same could be done for the characteristics to define each function. In principle a 'technical aggregation' parallel to the price equations, but transformed in terms of technical phenomena can therefore be performed. Each technical system, with its technical principles, can therefore be represented as a particular combination of different levels of a subset of functions and characteristics. Each weighted vector of functions, f_g would therefore represent a particular technical system, and will be represented by a particular set of weights for the subset of characteristics.

In general then, a commodity can be represented by a vector of functions. Each function is weighted according to it's contribution to the total functional capacity of the commodity by a coefficient α_k. Each function is expressed in terms of a vector of characteristics, $\mathbf{c}$, which are themselves weighted by a vector of coefficients, $\boldsymbol{\beta}_k$, denoting the importance of each characteristic c_m in determining the value of f_g. This fairly general additive approach is similar to that proposed by both Majer (1985:335-351) and Lancaster (1971).

Each commodity a_{ij} which represents the jth input of the ith industry can thus be described as a quantity plus a set of functional characteristics. The latter can be expressed in terms of a vector of functions, each of which is made up of a vector of characteristics.

$$p_i a_{ij} = p_i v_i \sum_{x=1}^{g} \alpha_x f_x = p_i v_i \sum_{x=1}^{g} \alpha_x \left(\sum_{y=1}^{m} \beta_{xy} C_y \right) \tag{II.14}$$

A number of aspects of this equation can be noted. Firstly, the same basic equation will hold for each of the input and output coefficients. Secondly, the vectors of functions and characteristics coefficients α and β will be sufficient to describe the scaling aspects of each commodity[36]. Finally, the additive functional form implies that different characteristics do not affect each other. One could imagine that certain characteristics of a commodity contribute proportionally less to the quality of the commodity as it increases. The opposite could also hold for other characteristics. However, for the sake of simplicity, the assumption of additivity of characteristics will be retained at this stage.

Furthermore, h categories of skills amongst the employees of the production unit could also be identified, each with wage rate w_h. For each total industry labour coefficient a_{ni}, and average wage rate w, the labour coefficients can similarly be described as

$$a_{ni} w = \sum_{x=1}^{g} l_x^{\alpha} \left(\sum_{y=1}^{h} l_{xy}^{\beta} w_y \right) \tag{II.15}$$

where l^{α} is the amount of labour-power utilised in conjunction

36. See Sahal, 1981, Ch9.

with each function. Each vector of 1^s indicates the proportion of the 1^e workers of each function falling in each skill category in the industry.

(II.14) and (II.15) therefore represent a transformation scheme in which input coefficients can be translated into either a set of functions, each represented by a vector of characteristics, or a set of labour skill inputs. Each commodity input is therefore described in terms of a set of functions and characteristics. Prices no longer represent the medium whereby different commodities are aggregated, but a system of weighted characteristics and functions in the production process.

The fundamental difference between the price system, and the characteristics system now becomes obvious. The price system can be regarded as integrative. It provides the basis for meaningfully comparing dissimilar commodities in terms of the labour equivalents that directly and indirectly enter into its production. The characteristics system on the other hand is insular. Whereas a general set of characteristics, functions and production steps can be postulated, each technique in a given technical system will have its own unique profile of coefficient vectors α and β. It is not even given that the same profile will be relevant in the different use contexts.

c. Economies of scale.

The discussion above presumes that the functional capacity of the inputs is fully utilised in each setting. Analogous to 'perfectly pliable' conceptions of capital, it is implicitly presumed that commodities can provide the exact levels of functional characteristics required in the production process. In the real world that is usually not the case. Input characteristics come 'packaged' in batches called commodities. A firm must purchase a batch of characteristics, even if it only requires a few of them. Therefore, the 'excess' functional capacity of a given commodity contributes nothing to the production process. It is a form of waste.

The effects of learning and the presence of indivisibilities amongst inputs are often discussed under the heading of economies of scale. It has been used in different contexts[37]. Different aspects have been identified[38], and different theoretical reasons for its existence have been postulated[39]. From the literature it also appears that scale factors are closely related to learning[40]. Sahal (1981:248) argues that while economies of scale are usually seen as indivisibility of inputs, the role of scale factors might be more encompassing than is usually recognised. Some of the indivisibilities might be industry-wide and even operate on a long term basis. Not all scale economies are of the reversible type, and scaling is itself primarily a matter of learning. The learning involved does not only occur in the production, but also in the utilisation of the technology.

It becomes clear that the phenomenon is in fact very pervasive, and is a central part of the functioning of any technique. It has technical, economic and institutional determinants and effects. Its effects stretch beyond the boundaries of firms and over time. We can therefore say that scale effects or scaling are concerned with how efficiently a particular technique fits into its use-context. Changes in scale is a fundamental feature of technological change, and generally has an evolutionary character. It is closely related to learning, and can be seen as

---

37. Rosegger (1986:67) argues that it was originally used in the context of efficiency gains with large scale operations. Later the emphasis moved to the effects on competition, resource use, the environment, safety risks, flexibility given uncertainty etc.

38. Rosegger (1986:68) identifies 'returns to scale' which is a technical concept and is fairly 'technologically specific'; 'economics of scale' which is a cost concept; and others like 'pecuniary economies'.

39. Rosegger (1986:69) supplies three: specialisation, dimensional effects and indivisibilities.

40. Enos and Park (1988:18) identifies 'learning-by-doing' as the increase in efficiency as the scale of output increases.

the outcome of a learning process. Said differently, adapting a technique to its use environment (scaling) is essentially a learning process.

At least three types of learning can be identified in this context: The first type consists in finding techniques with characteristics that are suitable to the context in which they are needed. This is the technical component of the choice of technique function. The second deals with the efficiency with which an industry as a whole is organised, including mechanisms which regulate the interaction between firms. Finally, innovations and technical change involve the changing of the characteristics levels required for particular techniques. Learning here is in the form of scaling[41].

The close and dynamic relation between learning and scaling is important. The former has to do with choices made and their effects[42]. The latter has to do with the creation of the technical opportunities to choose from.

d. The characteristics approach in a dynamic analysis.

So far, the characteristics approach have been developed with reference to the static price determination system. However, in a dynamic framework, learning and scaling continually introduce changes to some of the input coefficients as well as to the weighting coefficient vectors α and β.

---

41. Changing the "scale of technology is often accompanied by change in the division of labour amongst its components. ...[T]he evolution of a system generally involves three processes: (1) disproportionate growth of its subsystems; (2) change in the material of its construction; (3) increase in the complexity of its structure." (Sahal, 1981:67)

42. As an example, Enos and Park (1988:18-23) identifies at least seven different forms of learning from their case studies. All combine to produce an average rate at which direct costs decrease due to all forms of learning. The forms of learning that they have identified are as follows:
1. Static economies of scale in successively larger plants. The experience of a small pilot plant can be applied successfully to larger plants.
2. Savings on raw and processed materials.
3. Savings of energy.
4. Savings through the localisation of supply, especially of capital equipment.
5. Quality improvements.
6. Reduction of labour costs.
7. Ability to operate equipment in excess of design capacity, thereby reducing the average cost of capital.

The VIU[43] again provides a basis for transforming the static into a dynamic analysis. Technical change results in productivity growth. And the characteristics analysis now reveals two further results of technical change. Firstly, the level of characteristics given the direct and indirect labour inputs can increase. This is the characteristics equivalent of productivity growth. Alternatively, the characteristics level can increase together with the amount of labour inputs to produce better quality commodities.

Thus, an important addition to the analysis of the VIU must be made. Not only the composition of the vector of final commodities changes over time, but the characteristics composition of those commodities changes as well. Therefore, the level of characteristics of the output in the social use sector have to be specified with the final commodity in terms of which the VIU is defined. (See page 19) Using (II.13), an index of characteristics can be derived which can be incorporated in the vector of final commodities in terms of which the VIU is defined. Then, the VIU will be all those economic processes that have to be activated in the industry in order to provide a unit of output characteristics. With technical change, the industry can be regarded as having regained the same productive capacity if the same level of output characteristics can be produced. Productivity growth would have been achieved if less labour were used directly and indirectly to produce this level of characteristics.

e. Optimisation?

Earlier it was argued that physical laws constrained the degree to which the levels of characteristics in a technique could change. There are potentially great benefits for enterprises to

---

43. See paragraph A.2 page 17 for an explanation.

move closer to the technological frontier. But do firms attempt to go as close as possible to the 'frontier' when they are not sure where exactly the frontier lies? There might be great penalties involved with a slight movement over the frontier. For instance, introducing a new piece of equipment in one part of a production process, which in itself costs only a fraction of the total fixed investment, might promise substantial productivity improvements. However, this small step might introduce an unknown (at first) characteristic into the product, that might ruin the whole 'brand' of products. The costs of recapturing lost markets might be considerably more than the benefits potentially yielded by the equipment.

The emphasis should therefore be on the flexibility to reconcile different conflicting demands made on the production process. It could be argued that enterprises try and keep an acceptable distance above a certain critical level for each of the constraints that they face.

The nature of technical change reinforces this type of behaviour. The technological insularity principle suggests that information is not readily available to the enterprise, and what is available might not be applicable under the particular circumstances. Furthermore, technical change is often a bit-by-bit change in the scale of certain of the components. Its success depends on chance as much as focused effort. There is no way of telling exactly when the technological principles will present barriers to further advances.

The result is that the role of the institutional component of the enterprise as a depository of learning and experience performing a mediating function to reconcile these conflicting demands become more pronounced. Some evidence for the crucial role which the institutional mediation plays have been seen in case studies.

Fransman (1984:301-316) described how the machine producing firms in Hong Kong have adapted foreign machine technology to the local environment, producing "simpler machinery using lower-cost inputs and at times incorporating adaptations and modifications that increased suitability to the local environment" (1984:308).

This case study points to the close relations between the product characteristics, the production processes, and the institutional nature of the firm. The origins of the firms were usually humble, with the owner/entrepreneur learning the art while employed as a skilled worker somewhere else. Production starts with the production of simple equipment, usually manual machines. The owner entrepreneur usually performs the design function, with only some firms having design departments. The sources of the 'technology' was only indirectly foreign, and was limited to purchasing capital equipment, which was often acquired second hand. The division of labour was simple, with those involved in product design spending most of their time in routine production activities. Skills were not acquired through formal training, and the production processes tended to be relatively simple.

Another case study dealing with the interrelationship between social structure, production processes and product characteristics are given by Müller on the activities of traditional blacksmiths in Tanzania. The two social processes of colonisation and 'socialist transformation' both regarded the activities and production methods of the traditional blacksmiths as primitive and unsuitable. But despite all this pressure, they have remained, because they have the ability to produce and to maintain simple agricultural tools suitable to the agricultural conditions in a particular region (1984:378-9).

f. Implications for the choice of technique function.

The technical system has its own independent contribution to technical change. Not only does this result in the differential productivity growth rates in the various industries in the economic system. It is also a factor that has to be considered independently in the choice of technique function within a particular industry.

The characteristics approach has identified how productivity growth could be result of either quality improvements or reductions in the inputs for a given level of characteristics required.

Furthermore, the interrelations between the technical and economic imperatives have been shown to generate economies of scale. Learning in the technical sphere are guided constrained by the principles of change in technical systems. The characteristics of these systems do not fit the economic context in which they are applied perfectly, leading to the creation of economies of scale as well as the opportunities for further learning in the form of scaling.

Enterprises therefore have to make a choice and then build on what they have. The nature of the choice usually involves that various technical requirements have to be reconciled with one another and with the economic and institutional environment in which they operate. This often require adaptations to the technique through scaling. As a result the crucial mediating and enabling role of the institutional framework of each enterprise is reinforced.

In the final analysis, all choices of technique take place in the context of uncertainty. Knowing which technique has the greatest opportunity for further advance is usually only possible with hindsight, and some form of satisficing rather than optimisation as an operating principle should most probably be presumed.

3. Institutional imperative: Enabling technical choices under uncertainty.

Balcerowicz (1986:189) defines institutions as "all formal organisations and all legal rules", in order to deal with organisational adaptability in different economic systems. However, the 'social relations of production' concept used by Leys is wider than merely formal organisational rules and structures. It includes relations of ownership, classes and the corresponding form and character of the state. (Leys. 1984:176) The concept of institutions used here will not only include the formal structures and organisations, but also the social processes taking place on various levels. The role of institutions could be seen as the regulation, facilitation and coordination of human activities, motivations and conflicts.

How do these institutional factors relate to the choice of technique? Enos and Park have commented that even the little in the line of theory that is available is not very useful. The neoclassical micro-economic theory of the firm assumes that knowledge is acquired instantaneously and without cost. Knowledge is defined extremely broadly, and the local environment is represented in the theory simply by a different set of relative factor prices. The enterprise creating and adopting the new technology is seen as a monolithic body responding to a single-minded owner/manager, neglecting factors such as physical bottlenecks, government controls and regulations, conflicting objectives, unco-ordinated behaviour, risk and ignorance (1988:18).

a. Perspectives on the relation between institutional and techno-economic processes.

Most approaches to the study of organisations have emphasized one of two perspectives on organisations: Either they are technologically or structurally determined, or they are simply the product of human behaviour. The first is present in Weber's treatment of the bureaucracy, and implies that decision makers can do little to alter organisational functioning. Child has argued that at least two broad approaches can be discerned[44] (1986:8-12). Both suggest that technology ultimately determines the production process[45]. The second perspective is often associated with the human relations school. It argues that people can manipulate organisations to serve their ends rather than being dominated by them (Rushing, WA; Zald, MN. 1976:3).

Thompson has incorporated both perspectives into a model in which organisational technology constrains decision making, but

44. An input-output approach which focuses on the inputs and outputs that are involved in a production process. And the process approach focusing more on the production and especially the labour process itself.

45. This has been seen in at least two areas: The imperative to select 'best practice' technology; and the assumed neutral role that technology plays in society.

decision makers do have some scope to alter outcomes. In so doing, new conditions for decision making are created (Thompson JD. 1957:7-8).

Coombs et. al. (1987) have done the same, but in the context of technology. Technological innovation and technical change always take place in particular institutions. Furthermore, the coordination of individual economic activities in a capitalist society is carried out "by a mixture of institutions the most important of which are the firm, the market and the state, but with other institutions intervening as well" (1987:6-7).

(1) The enterprise: objectives and control structure.

The general economics literature contain a number of approaches to the firm[46]. Sawyer has identified three major ways in which firms have been conceptualised (1989:124-137). The 'black box' theorists concentrate on the inputs into and outputs from the firm with scant regard for what actually happens inside them. This firm[47] is usually seen to be profit maximising or cost minimising[48]. A second approach is to view firms as complex social organisations. The focus shifts to the inner workings of the firm as a social entity. The key question then becomes whether the firm has a single objective, and what it is. It is sometimes seen that the existence of a hierarchy of control 'imposes' objectives onto the firm, or that a firm is a collection of different interest groups, and that the objectives of the firm are the objectives of the different interest groups and the resolution of conflict between them[49]. This view is

46. It should be noted that it is not so easy to define what a firm is with any precision.

47. This is generally a privately owned firm in a market environment where there is at least some degree of competition between different firms.

48. The transactions costs view of the firm discussed by Williamson is an extension of this approach.

49. Cyert & March (1963) are closely associated with this view which identifies interest groups with their objectives.

associated with a rejection of maximisation[50] for a satisficing objective function. "[W]hen there are several interest groups within an organisation, if each group strives for a satisfactory level of whatever objective they pursue ... a reconciliation between the various groups is possible" (Sawyer. 1989:134). The third Marxian approach emphasises that privately owned capitalist firms operate in a capitalist environment. Thus the firms reflect the conditions of class struggle. But the workers are in an inferior position not controlling the means of production nor having access to finance capital. Non-capitalist types of firms (like cooperatives) might be forced into the same type of situation by the existence of the capitalist environment.

Coombs et. al. (1987) combines the view of the firm as a social organisation with elements of the Marxian approach. The firm with its four departments (R&D, Marketing, Production, Strategic Management) is seen as interacting with a range of external factors: Scientific and technical developments, market conditions, cost pressures and demand regularity, and survival growth and stability prospects (1987:11).

They develop a model based on the managerial theories, which don't reduce firms to epiphenomena of markets, starting with the analytical separation of ownership and control in large industrial companies first proposed by Berlé and Means (1932). They first review the theories on managerial motives and firm structure. Marris (1964) argued that managers will make the growth of the firm their most important objective, but this is subject to the constraints of being taken over by another company. Penrose (1980) argued that a firm is essentially a bundle of resources (physical and human), and its growth is conditioned by the managerial resources it possesses, and how they are utilised. Hay (1983) emphasised that empirical work has

50. In the absence of full information, an individual does not know what a maximising outcome would be. However, a satisfactory outcome can be foreseen. Sawyer (1989:134)

not given great support to these managerial theories of the firm, but that their intrinsic probabilities will continue to exert influence. The 'behavioral' approach stemming from the work of Cyert and March (1963) sees the firm as striving towards five potentially conflicting goals. The firm is therefore presented as a coalition of managers, that are satisficing, with incremental decisions being made according to firm specific 'decision rules'[51].

Coombs et. al. then develop their own synthesis in which firms are presented as managerial hierarchies, with considerable autonomy, internally differentiated, facing uncertainty, with growth as an objective. They will create rather than observe production functions, and create products and markets (Coombs et. al. 1987:32-39). They introduce technical change as an active component of firm behaviour, and conclude that structural features of the technical environment fundamentally constrain the direction of growth which a managerial firm can achieve (Coombs et. al. 1987:40-41). This hypothesis is methodologically close to the thesis of Thompson discussed above.

The firm can therefore be seen as 'embodied learning'. This involves not only managerial knowledge but the knowledge of all the employees of that firm. This provides a basis for further learning, but is constrained by technical and economic factors. The decision making process in the firm is seen as satisficing, rather than optimising. Firm specific decision rules provide the basis on which decisions are made in the face of a lack of information, and conflicts of interest. They can be regarded as the firm's institutional determinant in the choice of technique function. These decision rules are partly endogenous to the technical system under consideration, in that prior learning experiences contribute to their formation and implementation.

---

51. This aspect was also dealt with by Nelson and Winter (1977).

(2) Market structure and the ability of new firms to enter.

The relations between firms might be just as important as the situation within a given firm. These relations could be vertical or horizontal.

The existence of vertical integration has been ascribed to both economic and technical conditions. The transaction costs approach by Williamson (1975) sees firms as minimising costs of information and control by creating or abolishing hierarchical structures. Others have emphasised that technical determinants could in certain cases be more important, for instance in the case of hot steel coming off a blast furnace that should be rolled on the same site, requiring vertical integration (Coombs et. al. 1987:42).

The nature of the relationship between firms in a particular vertically integrated sector could lead to some economies of scale. 'Just in time' production systems seem to have done so under certain circumstances. But some of these benefits could be pecuniary[52].

Horizontal relations between firms are affected by the structure of the industry, and the barriers to entry for new firms. Barriers to entry were highlighted as important in the differential innovation potential between big and small firms by Dorfman (1987:223): "We have seen that innovation can occur under a variety of different market structures, and that the structure of the market can play an important role in determining the kind of firm - whether large or small, new or old - that innovates." These comments should be read in the context of the considerable debate whether the large monopolistic firms are more innovative

52. A dependency relationship between a big assembly plant and small component manufacturer can reasonably give rise to power differentials in favour of the bigger firm. For example, the reduction in inventories on the assembly line could simply mean that component suppliers have to hold more stocks.

than smaller firms[53]. Dorfman (1987:224) discusses the barriers to entry which confer competitive advantages to incumbents over potential entrants. These barriers are scale economies, absolute cost advantages[54], and advantages in differentiating products[55]. Smaller firms also have to contend with established firms that are potential entrants to new markets opened up by the smaller firms.

(3) The socio-economic environment

The environment in which firms operate is important for the analysis of technical choice as well. Apart from factors like state support for technical change, industrial, trade and monetary policy, the mechanisms which force firms to make technical choices are important. On a broader level, the discussion of whether a market environment is supportive of technical change is relevant here[56]. In a market framework, the existence of both a 'hard budget constraint' and Schumpeterian rents act like a carrot and stick to entice and force firms to make technical changes. In the context of satisficing firm behaviour they set upper and lower boundaries within which a firm has to operate.

Apart from the macro economic policy framework, it has also been argued that the interrelationship between institutional and techno-economic processes operates on a longer term basis as well. Coombs et. al. (1987:172) maintained that phases of accelerated or decelerated growth in a 'long wave', are related to imbalances between "technical changes and structural changes

53. See Scherer, 1984:59-64; Dorfman 1987:2-8

54. These could be capital cost barriers or restricted access to critical production techniques or resources. Dorfman describes how small firms in the electronics industry firms secured access to capital, and at the same time reduced their capital requirements by focusing on products at the low end of the spectrum. (1987:229)

55. "Small, new innovators in the computer industry avoided the formidable product differentiation barriers by targeting customers who were not served by the large established vendors. ... [They] created new markets, followed other firms into them, or carved out specialised market niches." (Dorfman, 1987:232)

56. See Hanson & Pavitt, 1986 for a discussion of the economics of research and development in Eastern and Western countries.

which have certain predictable dynamic behaviour patterns, and institutional changes which do not". In this context, structural changes refer to a sectoral analysis of the economy, in which the interaction between sectors is a crucial component[57].

b. Learning and the integrating role of the institutional imperative in choice of technique.

The dual role of the institutional imperative can now be specified more clearly. This duality is parallel to the view by Thompson discussed above. On the one hand the institutional structure provides the context in which a technique must be chosen. It presents possibilities, but also constraints to the choices that can be made on various levels.

On the other hand, the institutional imperative is the integrative component, mediating between the various diverse technical, economic and institutional requirements that have to be satisfied. The human learning which is embodied in institutions is the basis for this mediating function. It takes place on various levels, over time and in space changing the scale of the various components. In the context of an enterprise this usually leads to the establishment of various decision rules, guiding decision making. It also leads to scaling, or technical change based on changing the scale of operation of one or more of the components of a technique. Both are to some extent enterprise specific.

57. Blackburn et. al. (1985:59) have attempted to analyze, on a macro level, the changing patterns of mechanisation, which have historically been related with patterns of work organisation, and production and consumption technologies. Primary mechanisation, it is argued, consisted in the mechanisation of transformation processes. Secondary mechanisation consisted of mechanisation of transfer processes into product lines. Combined with Taylorist work organisation techniques and the expansion of mass consumer markets for certain goods, a pattern of productive organisation called Fordism emerged. Neo-Fordism, it is argued is busy emerging from the constraints of inflexibility etc. which limited the further expansion of Fordist production processes. The focus has shifted to the mechanisation of the control functions, and the changes in the work organisation accompanying that.

c. Uncertainty and the costly transfer of information

The enterprise specificity of much of the knowledge and experience results in two closely related conditions affecting the choice of techniques by any enterprise. The first is the difficulty with which information is transferred, and the second is the prevalence of uncertainty about the parameters or outcomes of technical choices.

The difficult transfer of knowledge constrains the choices which could be made. For instance, Steward (1977:3) argues that the technology available to LDC's is determined by the total number of techniques available world wide, and the extent to which the firms in the LDC know about them. But it also creates opportunities, especially for the 'first movers'[58] (Scherer. 1984:63). Once again, the key role which an enterprise's 'base of embodied learning' plays in enabling efficient technical choices can be seen.

A lack of 'complete' knowledge also concerns the 'outcome' or effects of particular choices made. With Schumpeterian theories of technological change, uncertainty is related to the injection of a set of technological unknowns into the economic system[59]. Pasinetti further argued that there is no automatic correction or 'equilibrating' mechanism in a non-stationary growing economy[60].

Choices of technique therefore take place under uncertain conditions. More importantly, 'uncertainty' in this sense always

---

58. Dorfman (1987:235-239) discusses some possible first mover advantages:
1. It takes time to develop an imitation of an innovation, which confers a temporary monopoly on the first mover. It also takes time to mobilise resources and arrange for production and marketing.
2. Specialised resources may be monopolised by a first mover.
3. Trade secrets and patents may also put further barriers on the transferral of technical know-how.
4. In the case of steep learning curves, the first mover may enjoy lower unit costs than followers.

59. Freeman (1982) argued that uncertainty consists of a technological component; a market component; and the broad economic climate. (Coombs et. al. 1987:75).

60. Pasinetti does list some factors working in the direction of some form of 'self-correction' that is possible but imperfect, and in principle not sufficient. (1982:228)

implies something that cannot be quantified to a single number or probability.

Consequently, enterprises have to develop ways of dealing with uncertainty, also when choosing techniques. It seems that the assumption that firms exhibit satisficing behaviour as a general assumption when choosing techniques seems plausible. Nelson and Winter (1974:891-3) formulated it as follows: "The basic behavioral premise is that a firm at any time operates largely according to a set of decision rules that link a domain of environmental stimuli to a range of responses on the part of firms." These decision rules are stable in the short run. In the longer run, processes of rule change are triggered by an economic selection mechanism. A prominent rule change process is goal orientated search or problem solving activities. To model these search processes, aspects such as the firm goals, the intensity, direction and strategy of the search process and the field of search have to be incorporated.

Even the trigger mechanism setting the search process in motion is firm specific. A simplified model could posit such a trigger mechanism when the rate of profit falls below a certain firm-specific minimum. It is possible that more long term movements in economic and environmental variables might play a role as well. This might include changes in demand patterns, state regulations, or even the activities of competitors or market leaders.

The enabling role of the institutional imperative turns out to be a crucial component of the viability of any enterprise. It merits much more attention that can be afforded in the limited space available in this study.

C. FORMALISING THE MODEL

Before analyzing the choice of technique in a cooperative firm, the choice of technique model developed so far can be formalised. Figure II.1 summarises it schematically.

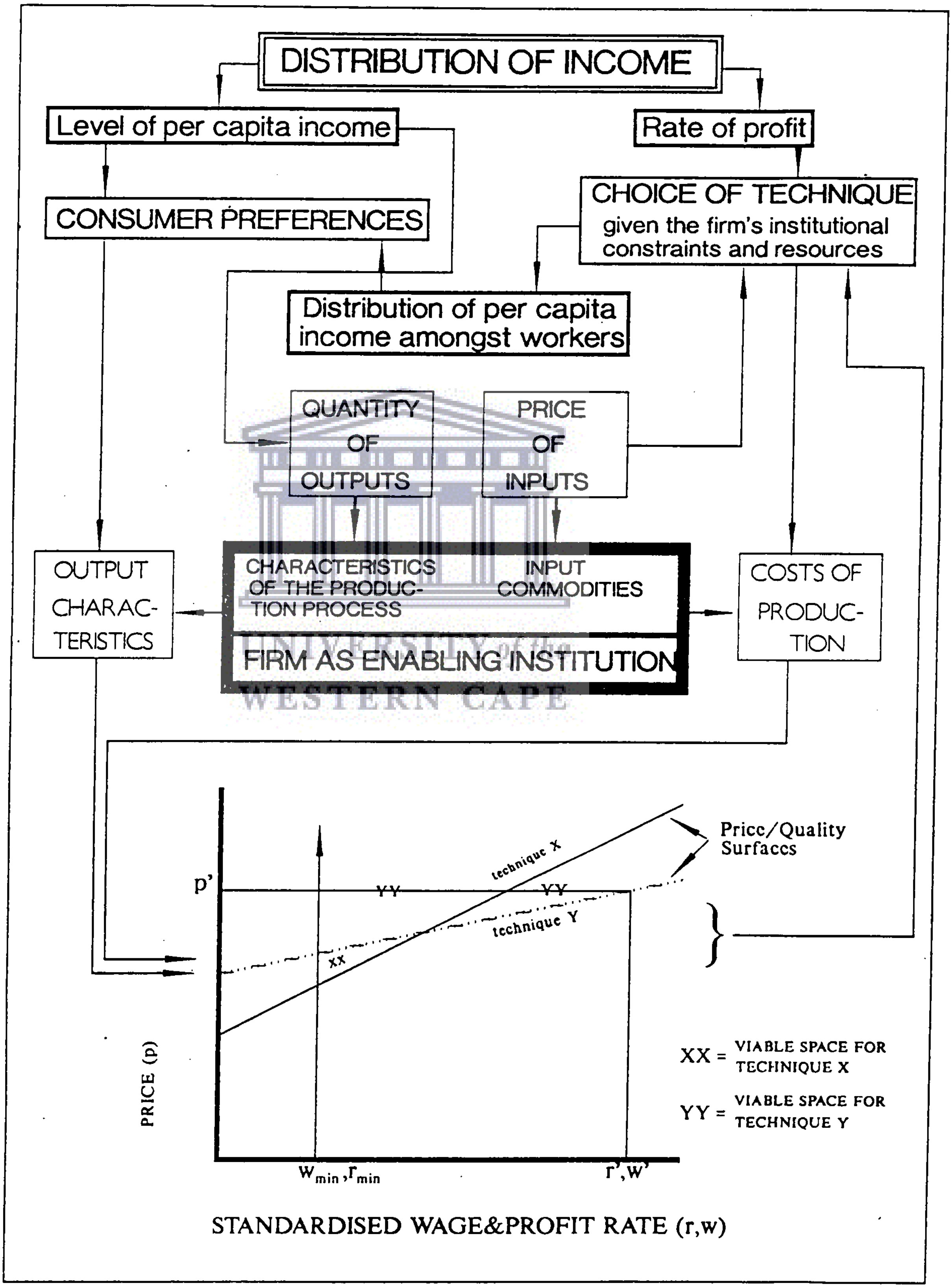


Figure II.1. The Choice of Technique Model.

The foundation was laid with the choice of technique model (section II.A.3.a page 21), of which equation (II.9) is the centrepiece. If the vector of prices and the wage rate for each of the three techniques are expressed in terms of a commodity that occurs in all three, the technique which yields the highest wage rate for a given rate of profit is the most productive[61]. These curves can then be plotted on the same set of axes. The frontier formed by the various segments of the techniques that are furthest from the origin is the optimal technique for each distribution of income.

However, the choice of technique function must be placed in a dynamic[62] and institutional context. In a dynamic world, with uncertainty, the interpretation of the model changes. Firstly, firms are bound by the decisions that they have made in the past. This is reflected in a reduced number of techniques that they can choose from. And even more important, firms usually make choices without knowing the outcome of those decisions. Consequently, optimisation criteria for technical choice models become less useful. As a substitute, firms develop rules of thumb which guide them when making choices. These decision rules are often the result of practical experience in the field (learning), as well as the way in which the more important and powerful interest groups in the firm affect the outcome of decisions and the creation of these decision rules. Furthermore, technical and economic constraints which the firm faces and the resources it possesses also influence decisions. These might increase the riskiness of a venture, or put it out of reach of a firm.

The technological frontier therefore becomes a hypothetical frontier. Firms would most likely retain the current technique while the rate of profit remains above a minimum level. If the

61. In essence, the comparison of the techniques yields a measure of the relative total factor productivity of each technique given the distribution of income.

62. See Enos and Park. (1988:10-12).

rate of profit it falls below that level a search process for a new technique is triggered. In the mean time the process of cumulative learning continues, creating the conditions allowing for the choice of new techniques. In other words, instead of a technological frontier, a technically viable space[63] within which a firm operates would be formed. It is bounded by the theoretical optimum technique, the minimum wage range, and the trigger level profit rate. Uncertainty is indicated by a space, within which a particular technique is viably operable. The size and shape of this space, and the position of the technique within this space are all important elements of the model to determine some form of 'optimality'. But production anywhere within that space is 'viable' at a given time. Firms have to identify viable positions within this space[64], and hope that the viability conditions remain stable or change roughly as they expect it to.

In the model with perfect knowledge, it was assumed that one optimal technique could be identified, except in the special case where a switching of techniques occurred. The current model shifts the focus from optimality to viability. In general more than one technique can co-exist in a particular industry. Therefore the term 'switching space' can be used to describe the area or space in which more than one technique can viably co-exist.

Thus, under the presumption of a certain set of decision rules which guide firms to make choices, a range of techniques all satisfying some minimum level of economic criteria is viable if they suit the technical and institutional considerations important to the firm. The specific choice depends on a set of factors, of which the nature and objectives of the firm, its learning experiences, barriers to entry etc. are all involved. In the model

63. It is obvious that more than one technique might satisfy the viability condition, i.e. producing at a rate or profit that exceeds the firm specific trigger level at the given wage rate w at time t.

64. This is equivalent to market niches and other decisions that have to be made by the enterprise.

these will be represented by the final list of techniques which the firm considers, and which enters into the choice function.

This can be shown on Figure II.2. Line AA' represents the trigger level of the rate of profit. Similarly, line BB' is the minimum wage rate that the workers in the firm would find acceptable. The hypothetical technological frontier then represents an outward boundary to the space in which the firms would be able to operate viably, using one of the techniques available to it. The current techniques used by the industry could be represented on the technical choice map, as well as estimates for new ones.

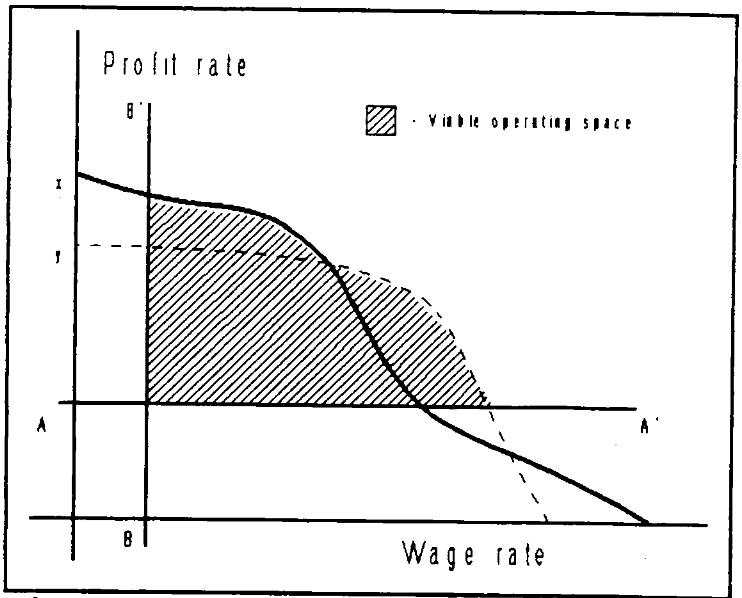


Figure II.2. Choice of technique in uncertain conditions.

However, the picture presented in Figure II.2 is not an equilibrium situation, but is dated. Looking back at the previous period it contains certain fixed parameters which cannot be changed momentarily. The most important are the distribution of income and the set of input prices which can be taken as fixed at time t. The options for the future are only guestimates on the map.

With the distribution of income relatively fixed, it becomes possible to disregard the potential technical choices at all distributions of income[65] other than the actual one. Figure II.2 can be stripped of data for all the distributions of income not currently relevant. Initially, the price level of each product

65. Technical choices themselves might have an impact on the distribution of income through productivity growth etc. But these generally take place gradually over time.

can be taken as comparable in some way. Then the actual productivity of the various techniques comprising the social use sector can be compared. There might be differences in the levels of wages and profits between firms in a single industry. It is therefore necessary to standardise the data from the various firms in order to make them comparable. This has been done in Figure II.3.

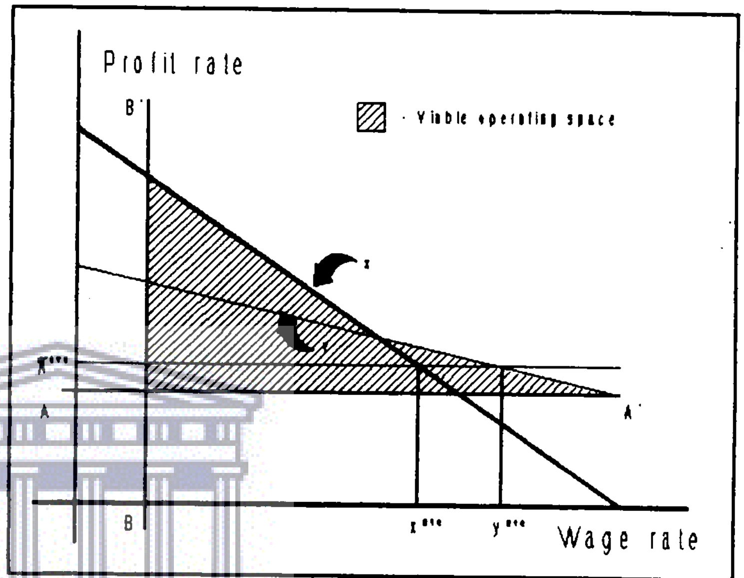


Figure II.3. Technical choice in a dynamic economy under uncertainty.

The magnitudes of AA' and BB' are determined by the decision rules of each firm. A space to the top right of these two lines is formed in which the firm could operate viably. The results of the choices which firms have made can be looked at on the set of axes. The actual performance level can then be standardised by taking the average rate of profit and adjusting wage rate or vice versa. In Figure II.3 the arrows indicate the actual positions of firms with technique x and y respectively. The lines represent these standardisation possibilities. If wage rates are standardised to the average rate of profit in the industry, π^{ave}, the productivity of the firms relative to the industry average can be compared. It can then be seen that technique y is more productive than technique x because wage rate y^{ave} that firm y would be able to pay at π^{ave} is higher than that of technique x at wage rate x^{ave}.

It is easy to show that the adjustment is determined by the degree of mechanisation[66]. If p is the price for the commodity

66. Capital/labour ratio (Pasinetti, 1980:181)

produced at volume V, π' is the actual rate of profit with which a firm is producing, w' is the actual wage rate paid by the firm, C is the cost of the inputs (capital) and L the number of workers employed by the firm, the standardisation can be given as:

$$\begin{aligned} pV &= C(1+\pi') + Lw' \\ pV &= C(1+\pi'') + Lw'' \\ \therefore w'' &= \frac{C}{L}(\pi' - \pi'') + w' \\ \therefore \pi'' &= \frac{L}{C}(w'' - w') + \pi' \end{aligned} \qquad \text{(II.16)}$$

w" is the standardised wage rate at the average profit rate $\pi'' = \pi^{ave}$ or vice versa. From (II.16) it follows that with uncertainty the degree of mechanisation might affect technical choices in an interesting way. The profit rate of highly mechanised techniques with a low L/C ratio is not as sensitive to changes in the wage rate as techniques with a high number of workers employed per unit of capital employed. It can therefore be that certain techniques have a lower flexibility in the light of specific types of changes than others.

As soon as heterogenous products are introduced, the number of equations representing different techniques will increase. A further determinant on the technical choice function, relating to the demand conditions, must therefore be introduced. If a one on one ordering of price levels and quality levels is performed, only those commodities which, at a given wage rate and profit rate have a lower price than all the commodities with a lower quality, will be viable.

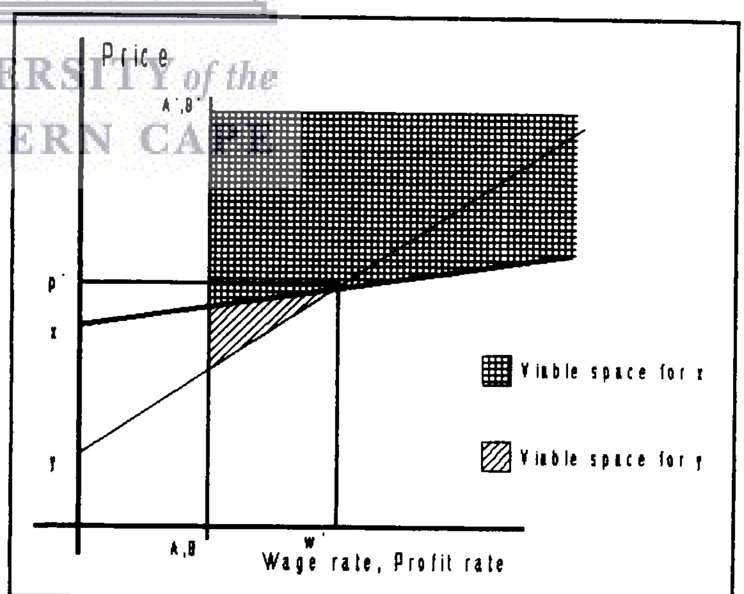


Figure II.4. Technical choice with uncertainty and heterogenous products at time t.

If all these 'viable' techniques were to be indicated on the wage profit frontier, a third axis - price - must be introduced. It is no longer possible to evaluate different techniques presuming that the prices of the products produced are comparable. The price axis therefore lies perpendicular to the wage-profit rate axes. To simplify matters, the standardised wage and profit rates could be used which would reduce the number of axes to two. This is the case in Figure II.4.

Figure II.4 shows that if prices were reduced, the level of wages and/or profits will have to be reduced as well. The slope of this curve is strictly positive, when producing with capital, and it can be shown that the capital intensity[67] together with the labour productivity of the technique determine this slope. This can be seen in (II.17).

$$\begin{aligned} & p'V = C\pi' + Lw' \\ & p''V = C\pi'' + Lw'' \\ & \therefore p'' = p + \frac{C}{V}(\pi'' - \pi') + \frac{L}{V}(w'' - w') \\ \text{let } & w'' = w' \\ & \therefore p'' = p + \frac{C}{V}(\pi'' - \pi') \end{aligned} \qquad \text{(II.17)}$$

The factors which limit the area in which firms can operate viably now become clear. By introducing the relation between prices of different quality products as a further equation in the set of price forming equations, it is possible that certain 'qualities' of products cannot be produced at certain profit rates. In that case, either some of the industries must fall away, or the profit rate structure must change so that these 'affected' industries operate with a lower rate of profit, in order to be able to lower prices adequately to reflect its position in the quality hierarchy. This can only happen if the rate of profit does not have to drop beyond the trigger level. Figure II.4 gives an interesting picture of such a situation. For the price level below p', the products from technique y are more

67. Capital output ratio according to Pasinetti (1981:181)

productive. If the quality of the product y is lower than that of product x, it means that the ability of the firm producing y to cope with uncertainty by reducing the wage and profit rates is constrained by AB-A'B'. However, the ability to raise their prices is constrained by the technique x. It can then be seen that the scope for movement of technique y is much less than that for technique x. Now, due to technical and institutional factors a firm might not be able to choose technique x. Consequently, technique y is the only one available to them, with the potentially adverse consequences that it holds.

The room for manoeuvre of technique x is therefore much larger than that of technique y. It does not necessarily mean that x is more viable than y. But the scope for a firm able to adopt y to increase their prices in the event of unplanned events occurring is bigger than for x. However, the nature of the demand for the various commodities with different characteristics might be such that it introduces new complexities into the situation. For example, technique x could represent a technique to make high quality hand crafted furniture. The furniture is sought after in specialised markets, where they can receive premium prices. The firm can only produce low volumes, and has to situate itself correctly in the market place. Technique y on the other hand produces mass furniture with mechanised production processes. It has to have high output volumes with low margins. But they are able to make cheaper furniture. Therefore, the firms being able to choose y would have to be big and have access to large amounts of capital. A small cooperative firm might not be able to choose y because of its institutional structure. On the other hand, the craft like technology involved in technique x will make it unattractive for a large firm, presenting less technical opportunities for control over the production process if they were to produce at the output levels required.

D. THE CHOICE OF TECHNIQUE IN A COOPERATIVE ENTERPRISE

In the light of the model developed above, the choice of technique in a cooperative enterprise can now be analyzed. The first section looks at the nature of the cooperative social relations, followed by an overview of the historical development of cooperatives under capitalism. Thereafter the economic requirements for efficient cooperative institutional arrangements as well as the productive relations in a cooperative enterprise are looked at. This is followed by a tentative behavioral model of the choice of technique in an enterprise with cooperative institutional arrangements.

1. Basic principles: income distribution and worker control

In a cooperative enterprise, different rules and conventions exist which govern the control over the means of production, and the claims to the product produced. Thus, on a micro level, some key elements of capitalist productive relations have been replaced by a different set of cooperative productive relations[68]. But on a macro level, a cooperative firm still operates within a society in which the capitalist social relations are dominant[69].

Under capitalist productive relations workers are separated from ownership and control of the means of production, which are privately owned by a capitalist class (Hodgson. 1982:24). However, there is no generally accepted definition of cooperative productive relations[70]. This analysis draws largely on Horvat's definition of "workers' self management", based on

68. The nature of these productive relations will be identified in the next section.

69. Two implicit assumptions are made. Firstly, cooperatives can survive in a capitalist market economy. Secondly, 'adjustments' to the capitalist market could be made sufficiently to enable the efficient functioning of a cooperative sector. This is similar to the views of those arguing for cooperatives as 'third sector' of a mixed economy, rather than viewpoints suggesting that coops can only survive if they can be isolated from the capitalist economy.

70. An overview of some of the approaches can be found in Wright (1979).

the Yugoslavian model. Productive resources are no longer owned or controlled privately by individual owners. Productive resources 'belong' to the society as a whole, while the control over the use of these resources resides in the workers' collectives. Thus the Roman-Dutch concept of property rights as absolute control over something, is replaced by 'social property' rights. Under social property, no specific class of owners of means of production exists, neither individually nor collectively. "Everyone is an owner, which means that no one in particular is an owner" (Horvat. 1982:237). Therefore, everybody has the same right to use the productive goods of society, and to benefit from the use of those goods.

Cooperative relations of production can therefore be characterised by three basic principles[71]

1. No control over the labour of another. Since production is a social process, this translates into full worker participation in the management and decision making within the enterprise. Every worker, and only workers in a particular productive unit, has an equal say in the decision making and control of the productive unit.
2. Appropriation of the product according to the labour inputs and not property ownership. In principle, all productive property is socially owned, and the society as a whole appropriates that part of the product 'contributed' by using accumulated capital. In essence it means that society as a whole rather than individual property owners determine the rate of accumulation.
3. Equal distribution of power and meaningful participation in decision making.

Cooperative productive relations therefore deal with workers' control of the productive unit, and distribution of the product

71. These principles are based on the theory of social property formulated by Horvat (1982).

according to work done, not according to property ownership[72].

2. History of cooperatives under capitalism

The definition above deals with two general areas: the production of a surplus; and the means of distributing that surplus. Both are necessary for a cooperative to be established efficiently under capitalism. Historically, the success of cooperatives has been associated with the way in which these two areas have been dealt with. These developments can be divided into three periods[73].

During the phase of competitive capitalism before 1880, cooperatives were strongly supported by the early (utopian) socialists[74] as a moral alternative to the misery caused by early capitalist development. Some liberal economic theories based largely on a Christian paternalist ethic also supported the idea of 'associations of labour' (Hardach; Karras. 1978:1-16). The development of cooperatives in the early period of competitive capitalism saw the emergence of idealistic views of cooperatives as answer to social problems. They concentrated on giving each worker a fair share - therefore looking at the way in which surplus is distributed. But their ideas failed in the long run, after initial successes, and they soon degenerated into joint stock companies (Oakeshott. 1978:54-59).

In the face of massive hardship during the phase of monopoly capitalist development between the 1880's and WWI, many workers set up successful producers' coops based on Rochdale type

72. Various schemes in which ownership of productive resources is dispersed more widely throughout society, but remains in the hands of individuals would not be included in such a definition. This would include various forms of cooperatives share-ownership schemes; ESOP's; collective ownership by groups where the coop is owned collectively by the members which collectively hold the rights of transfer of ownership rights; and certain instances where organisations like a particular community organisation or union owns the productive property.

73. See Horvat 1982:17 for a description of the periodisation.

74. In this period early socialist thinkers often envisaged 'cooperative' economies as an alternative to the misery experienced by the working class. But their analyses either focused on the question of competition, with cooperation seen as the alternative, or on a return to small scale agriculturalism. Some envisaged a change in property rights, either through nationalisation and state direction of an economy of cooperative producers (Blanc, Fourrier), or through more voluntary organisation of cooperatives in a market type of structure. (Hardach & Karras 1978: 1-16)

principles. It seemed that at last a viable type of cooperative had been developed. But the distributional aspects of these coops were similar to capitalist companies, and were the focus of socialist critiques by theorists favouring nationalisation and centralised political action[75]. Oakeshott describes the establishment of British producer coops between 1880 and WWII. He argues that during this time a more or less working model of a coop evolved through reduced goals of the earlier coops. The motives for forming them were low wages; strikes; ideological commitment to keep consumer coops and labour together; boycotts of consumers coops by manufacturers, etc. (1978:63). They were in fact fairly successful economically, but were based on individual share holding. They had fairly close links with either the consumers' coop movement or the local trade unions. Oakeshott's review of the debates reveals that they were essentially struggling with ways to change the nature of production to a more democratic form. Distributional matters were not really brought into the picture at this stage, and still took place largely through individual ownership of capital in the form of shares. This was a leading impetus towards the tendency to degenerate, and to fail[76].

Since WWII, coops received renewed attention. Mondragon and others have shown that it is possible to form coops that might even be more efficient than capitalist firms. At the same time, the Yugoslavian experiment in workers' self-management, although not without problems, has started developing towards a system in which both democratic production processes and socialist distributive mechanisms can prevail.

Cooperatives and other forms of workers' self government have

---

75. The opponents of cooperatives as a part of the strategy towards socialism concentrated on centralised political action, and nationalisation of the productive property. Oakeshott 1978:36

76. Some members acquired so great a share in the coop, that they effectively had a large say in the running of the coop. Alternately, as the share value increased with the increase in the value of the firm, the workers that held shares either took on non-members as wage labourers, because the workers were reluctant to share the accumulated surpluses with the new members, or sold the coop to a capitalist concern in order to realise the value of the coop. (Horvat 1982:128)

been recurring initiatives taken by workers' themselves, in the face of severe hardship or some temporary revolutionary successes. These practical experiences have led to the development of much better organisational structures and a better understanding of the nature of and needs for successful democratic production methods[77]. It would seem that more successful cooperatives like those in Mondragon have not only succeeded in developing efficient production and management structures, but have addressed the distributional matters as well. The distributional requirements involve two aspects: 1] The basis on which it is determined how much of the surplus must be reinvested, and what happens to the rest of the surplus after the proportion to be reinvested has been determined? 2] Who benefits from the reinvested surplus? (Burkitt. 1981:171)

The next section will deal with the distributional relations of the cooperative mode of production defined above, and the productive relations in the following one.

3. Economic efficiency of a cooperative institutional framework.

In the past, a number of criticisms on an economic level have been directed at cooperatives. Firstly, they would tend to restrict output with price increases if the coops are collectively owned and workers maximise dividends per worker. This leads to a self-extinction process in which first labour and then capital are reduced until only one member remains[78].

77. . The structure of older producers coops based on the Rochdale principles has been changed in at least two ways: 1. Some coops have emphasized the need that all and only the workers working in the coop should own shares. 2. In some coops the workers control and benefit because they are workers and not because they are owners of shares or capital in the coop. This has been the pattern of the ICOM coops in Britain. (Oakeshott 1987)

78. Basically they argue that markets will function less efficiently (Vanek 1977:18, Milenkovitch, D. 1984:74) because capital assets are indivisible in collectively owned units. With an increase in the price of a firms' product, a quasi-rent might be earned if output is restricted. The appropriation of the quasi-rent is by the members of the firm, based on their being members not based on the labour inputs that they have made. Consequently, the fewer members, the more rent can be appropriated per member. There would thus be an incentive to reduce membership. But by now, some capital would become idle, and the firm would reduce its capital base. Ultimately this will continue until only one member is left. Counter arguments have been proposed, focusing on the objective function and the behavioral premises of the 'Illyrian theorists'. Vanek (1977:20) argues that firms would not expel members in order to share the quasi rent between fewer members. Horvat has argued that labour managed firms will in fact maximise profits rather than dividends per worker. (Milenkovitch 1984)

Secondly, there would be a tendency to under-invest in firms where there are no vested claims. Thirdly, cooperative firms would sooner or later degenerate to ordinary capitalist firms.

Attempts to model the behaviour of labour managed firms have all involved implicit assumptions about the distribution of the value added. Using the Sraffian price determination system[79], these assumptions can be evaluated. The value added is distributed between the amount that is to be reinvested, and the amount that is to be consumed. The former takes the form of a proportion of the current capital used. The latter is distributed in proportion to the labour inputs provided.

Under capitalist relations of production a set of institutional arrangements has developed over time in which two distinct classes in society compete for their share[80]. The share going for accumulation (and a bit of consumption) is distributed according to the current capital ownership. The share going for consumption is by and large based on labour inputs made. From (II.4) the price equations per unit of output at time t can be derived. For an individual industry or firm, where A is the vector of inputs, a_n is the labour input coefficient per unit of output and v the value added:

$$\begin{aligned} &p=pA(1+\pi)+a_n w \\ &\therefore v=[\pi]pA+a_n w \\ &p=pA(1+[i+c+b])+a_n w \\ &\therefore v=[i+c+b]pA+a_n w \end{aligned} \qquad \text{(II.18)}$$

Profit rate π can be divided into at least three components: the amount to be reinvested, i, the amount consumed by capitalists c, and the profit share by workers, b. The distinction between c and b is important. cpA represents the income for consumption

---

79. See Pasinetti (1977:71-73) for a discussion on the assumptions. It turns out that the system of (n-1) linear equations contain (n+1) unknowns. Two unknowns must therefore be fixed to render the system determinate. An arbitrary commodity can be set to unity, and then it remains to fix the level of either π or w.

80. Obviously, the types of factors that contribute to these decisions are diverse, and could include interest rate movements, propensities to save by various income classes, bargaining power of the various classes, and the institutional structure in which they operate. (Burkitt, 1984:171-178)

purposes accruing to any person on the basis of individual property ownership rights in a particular firm. Traditionally this is exclusive capitalist domain. bpA on the other hand represents the workers' share of value added due to their power in the production process relative to the owners of the productive assets, rather than direct labour inputs delivered[81]. It also represents an 'incentive' or production bonus type of an element. Therefore, these terms represent the amount of property income appropriated by the owners and the workers (non-owners) respectively, as distinct from the labour incomes earned.

In the pure capitalist system, b will be 0 and c will tend not to affect the relation between accumulation and consumption because of competitive pressures to reinvest. Also, reinvestment is rewarded on the basis of individual ownership. The same is the case with c. Thus, in the distribution of income ipA and cpA is interchangeable from the point of view of the individual capitalist. They are both based on individual capital ownership.

According to the theory of the Illyrian firm, however, workers maximise the dividend per worker. But capital is not owned individually. Thus the wage rate w is effectively taken as 0, and the distribution mechanism[82] becomes bpA/a_n. When bpA is appropriated individually but owned collectively, the interchangeability between b and i falls away from the point of view of the individual. The reason is that the appropriation of bpA is no longer on the basis of ownership of a 'transferable' measure of capital pA. It is on the basis of the access of a_n individuals to that capital as a fixed unit. Whatever is obtained in revenue need not be evaluated in terms of the effort to produce it, but in terms of the access to the capital inputs. The equilibrating market mechanism therefore becomes getting access

81. Usually, it is income appropriated not by all workers, but certain groups of 'privileged' workers.

82. Ward in Milenkovitch 1984:73

to capital, which is organised in indivisible units. Consequently, capital is lumpy by design. It comes in indivisible inappropriable units. The Illyrian theory of price perversity therefore essentially argues that market mechanisms are more inefficient[83] under an 'Illyrian' type of cooperative institutional set-up.

However, under cooperative productive relations c=0 and b=0 by definition. In such an economy, there would be no appropriation of non-labour income. Therefore, the profit component can be seen as comprising only of a part that has to be reinvested. Whatever is consumed is appropriated on the basis of labour incomes. The price equation would therefore become

$$p=pA(1+[i])+a_n w \qquad \text{(II.19)}$$

Notice the mathematical symmetry with (II.4). Only the economic meaning of the elements of the equation has changed. This is brought about by the qualitative changes in the organisational structures of the cooperative enterprises.

a. Instability in the intermediate forms of productive organisation:

In the capitalist economy, relative prices are determined by distribution of income between profits (going to capitalists who seek to maximise profits) and wages going to workers seeking to retain the current level of living or budget-line. (Hodgson. 1982:53). The distribution between the rate of reinvestment and consumption by capitalists are exogenously determined.

However, when a firm moves closer to being a cooperative, three potential sources of instability are introduced. Firstly, the size of cpA/a_n relative to bpA/a_n will be determined by the

83. See Milenkovitch (1984) with a similar conclusion from a neoclassical framework.

relative power of worker shareholders relative to non-worker shareholders. Related to this is the relationship between bpA/a_n and w which is determined by the relative power of worker shareholders to workers not holding shares. This could be stabilised by ensuring a symmetry between wage payments and share holding[84]. A third potential source of instability is the determination of the size of ipA relative to the value added v (or the reinvestment ratio). If the workers do not behave as capitalists (maximising profits), as the Illyrian theorists believe[85], the determinants of i will become very complex as well, and might lead to degenerating tendencies.

It has been shown that a model of collectively owned cooperatives based on completely external loan funding in perpetuity would solve this problem[86]. In this case, the interest rate payable determined external to the firm would effectively determine i. On this basis two broad approaches to the establishment of cooperative enterprises can be identified. They have different instability features.

<u>Worker owned enterprises.</u> One approach has been to create coops based on individual claims, but with restrictions that only workers and all workers must be owners. Thus, if appropriation of bpA was on the basis of individual claims on pA, reducing a_n would automatically involve reducing bpA, and the capital rent can therefore not be appropriated by the remaining a_n members. Individual claims reduce the lumpiness of the capital. At the same time workers can withdraw the capital that they invested, so the under-investment tendency would not manifest itself.

But the distribution of income must be assessed. Each worker is

---

84. This would require new workers joining existing firms to buy large amounts of shares.

85. See the work of Nygind (1985)

86. See the work by Vanek 1970; 1972; 1975

also an owner. Thus, labour input is rewarded through w, and capital ownership through[87] (i+b)pA. The same worker must therefore now play a triple potentially contradictory role in the price determination process. First of all, the relation between current consumption and investment for future consumption must be determined. There is no longer a single class of people whose consumption is determined by the amount they invest. Secondly, the amount of consumption by individual members is determined by the relation between b and w, and the structure of ownership. In the special case where the structure of ownership and the structure of labour inputs are the same this potential conflict would disappear. But the potential for conflict within a coop between groups of workers with short or longer term objectives exists. Furthermore, a potential for conflict between those with more and those with less ownership would also exist. In fact, this conflict has often been mentioned as reason for coops of this type to degenerate into joint stock companies. This cooperative form based on individual 'worker-ownership' is unstable, and can only be maintained under exceptional circumstances.

<u>Worker controlled enterprises.</u> The first conclusion is therefore that for a cooperative to remain stable, b should either be 0, or be directly related to the wage structure of the enterprise (which amounts to the same thing). Then the determination of the relation between i and w becomes the only question. If it is determined within the firm, the instability reappears. And if the coop is owned collectively, and the value of ipA invested is lost to the individual worker members irrevocably, they might not invest at all and increase w relative to i. The second conclusion is therefore that the mechanism which determines the size of i relative to w should be external to the productive unit itself. This is similar to the case of the fully externally financed

87. There are now vested claims.

firm, proposed by Vanek. Off course, the rate of interest would be the mechanism whereby society would indicate its preferences for growth and accumulation relative to current consumption. But it need not be the only way. It could also be on the basis of a negotiated rate of return on capital borrowed from private sources.

Elsewhere[88] I have argued that as far as the distributional elements go the efficiency of cooperative firms depends on a number of institutional factors: The first is well functioning capital markets. This requires a well developed set of financial instruments (and a support structure) designed specifically to serve the worker managed sector (Vanek, J. 1977:23). Secondly, stable coops require efficient structures determining the rate of accumulation external to the firm, as well as the distribution of current consumption according to labour inputs and not capital ownership. Thirdly, these conditions can only be achieved if firms are financed in a manner which corresponds to perpetual debt financing, with a secondary market where different sources of financing can be exchanged. Fourthly, this should be done in such a manner that conditions for entry and exit of new firms, and new members are made as easy as possible to smooth further rapid adjustments in the face of changing conditions. Fifthly, any capital rents or quasi-rents due to sluggish adjustment should be removed so that they could not be appropriated by worker managers. Finally, the organisational forms which coops could take should be as diversified as possible to ensure efficient operation under different technical and social conditions.

4. The nature of decision making in a cooperative enterprise.

Under cooperative social relations worker-members control the

88. See Van der Westhuizen (1990).

decisions within the working collective. Two sets of questions emerge: Will such a set of productive relations lead to efficient management, and under which conditions? And what impact will workers' participation in decision making have on power relations within the firm.

a. Decision making structures and efficient management.

It appears as if some sort of consensus exists, or at least a strong case is made that in principle labour managed firms could be just as efficient as comparable capitalist firms. The argument usually rests on the increased motivation due to participation of workers in the decision making process (Mellor et. al. 1988:107). Added is the argument that a reduction in the class conflict brought about by the cooperative organisational form cannot be matched by capitalist firms (Mygind. 1981). Specific case studies of firms also tend to confirm this. Examples are Mondragon in Spain, Breman in Holland, various firms in Denmark etc. (Junge-Jensen. 1981; Levin. 1984)

The question is how to structure participation in order to ensure both technical efficiency and democracy. The experiences of cooperative firms throughout the world present a diversified picture. Compare for instance the organisational needs of collectives started by highly educated people, seeking a more humane and personalised working environment with that of the Hoedads reforestation coop[89]. The organisational form of the former is closely knit, with all members directly involved. (Gunn, C. 1984; Jackall. 1984). From a theoretical perspective this is to be expected, and one would suggest that a range of factors would affect the choice of efficient organisational structure: the environment and the technical conditions within which it operates; the age of the enterprise; the motives of those

89. The Hoedads is characterised by a need for the productive units to be fairly independent. The result is a much more fragmented coop, with representative democracy, almost similar to current agricultural supply coops, with more democratic subunits.

starting it etc..

Oakeshott (1978:25) argues that the difficulty about management is twofold: The separation between day-to-day management and ultimate control; and the vague belief that in a fully democratic enterprise, almost all the functions of management as they are known today should be dispensed with. The second is simply utopian, while the first could, according to Horvat, best be understood as a distinction between professional and political spheres of authority. In the Yugoslavian case, the basic unit of organisation is not the enterprise but the work group. Crucial or far reaching decisions are taken by the general assembly of workers. But the 'central legislative organ' is the workers' council made up of representatives from each work unit, and commission chairpeople elected by general vote[90]. The executive committee replaces the former management board. The workers council appoints a manager as chairperson of the executive committee. The general manager presents a development plan, and if this is accepted by the workers' council, the manager is appointed for a fixed period (four years), with the programme accepted becoming a sort of internal law (Horvat. 1982:245).

A number of principles to ensure the efficient structuring of a democratic firm can be deduced: (Horvat. 1975: 141)

1. The creation of sufficiently small and sufficiently homogenous work groups, which allow direct participation of all the members in making decisions and where decisions are sufficiently transparent.
2. The bodies or individuals that make decisions bear responsibility for them.
3. Execution of decisions is a matter of expertise and not democracy.
4. Separation of the value or interest sphere from the sphere

90. The commissions are technical committees advising the workers' council on specific issues.

of expertise; of political authority from professional authority; of decisions about policy from the field of administration[91].

b. Power relations and participation in decision making.

The evaluation of whether cooperative enterprises have in fact managed to establish participatory decision making practices depends to a large extend on the criteria used to judge with. Against an idealised perspective in which all workers are to participate in making all decisions, the prospects are dim. But against the view that democratisation is a process not an end state, the verdict is less pessimistic. (Lammers. 1989:356; Dunn; Obradivic. 1978:16)

What becomes more important is an understanding of how power relations within firms develop as a result of the way in which they have been organised. Dunn and Obradovic (1978:22-23) have argued that the ideal types of a self-managed organisation such as proposed by Horvat above, should be understood in the context of an 'intermediate association'[92]. The latter is contrasted with an 'enterprise' with a hierarchical non-participatory structure on the one hand, and with a 'total association' with complete participation on all issues on the other hand. Power relations tend to be fluid, and shows cyclical tendencies. They are associated with the periodic realignment of different sources of social power. Participation tends to be optimal rather than full.

---

91. In the value sphere each has one vote of equal weight. In the experience sphere weights depends on the particular expertise which is sought for the given work. (Horvat 1955:141)

92. As intermediary associations they have the following characteristics:
1. Structural duality: Multiple goals are pursued promoting complex interactions between representative and administrative structures.
2. Poly-functional. It seeks to satisfy more needs than in conventional bureaucratic organisations.
3. Compressed role structures. Due to interaction between representative and hierarchical structures.
4. Optimal rather than full participation in decision making. Due to constraints by the dual structure and goals of the intermediate association. Social power tends to be poly-archic in the representative structure and oligarchic within the hierarchical structure.
5. Environmental interdependence. Not showing the high degree of autonomy and collective egoism of enterprises or total associations in a competitive social system.
6. Different functional groups including professional managers etc. Fluid relationships appear at all organisational levels, and recurrent social conflicts occur between members of the hierarchical and representative structure. An unstable and dynamic equilibrium results in cyclical trends in workers' participation and influence. Organisational objectives are periodically realigned with different sources of social power.

The interrelation between enterprise structure and power relations has a crucial impact on the nature of participation in and control over decision making in an enterprise. A potentially instable equilibrium holding all the components together is important. It has to integrate the various objectives of different groups of social power within the enterprise, and marry that to the requirements for efficient decision making, and professional implementation of decision.

c. A simplified model of decision making in a worker controlled enterprise.

Any model of decision making therefore has to incorporate the various sources of power that can affect decisions, and the structures which guide the way in which they are implemented. The actual Yugoslavian experience can give some indication of where to go. In Yugoslavia, there is no enterprise in the traditional Western sense, but various associations of associated labour operating on different levels. At the lowest level workers create self-management in the basic organisation of associated labour [BOAL][93]. However, the market unit is formed on the basis of an efficient division of work. Thus BOAL's are required to be integrated into work organisations of associated labour [WOAL]. Legally, the WOAL is responsible for the performance of its BOAL's, and constitute its business unit. Higher levels of association may form on a voluntary basis. (Prasnikar; Svenjar. 1988:239).

Decision making is the result of a complex interplay between three institutions. Self-management decisions[94] concern basic business policy of the firm (annual plans & reports, income distribution, control of operational management, and

93. Legally a BOAL must be created whenever a technological unit exists, and the economic results of the unit is measurable.

94. This can be direct via a referendum or workers' council. Or indirect via a delegate system onto workers' councils; self-management interest groups; banks; local community.

responsibility for personnel management). These are made at the BOAL level. Operational management undertakes day to day management but not personnel activities. Business decisions are made at the level of the WOAL, supported by a professional service unit at that level. Thirdly, socio-political organisations influence decision making as well. Trade unions represent society in the decision making process and control all elections. The League of Communists have a strong indirect influence through the top management officials (Prasnikar; Svenjar. 1988:243-4)

Within this structural framework, the objectives of the various actors are important. Workers generally aim for growth in personal incomes; stable employment and income; and capital accumulation but not at the expense of growth in personal incomes. Managers stress personal income, career stability and status. This is related to goals which managers hold of the WOAL: growth in economic power and capital accumulation. Socio-political organisations should pursue desirable social objectives, while the sociopolitical community is interested in employment generation and taxes. Analytically, the objective function of the BOAL and WOAL is pluralistic, with economic objectives dominant (Prasnikar; Svenjar. 1988:247-9).

In the local situation[95], worker controlled firms operate in very much the same basic framework. The three elements (workers, some form of management and community interest) are also present in the making of decisions. But in the South African context, no general organisational structure has emerged. This has generally led to two sets of problems. Firstly, the relationship between workers and managers have been unclear and problematic. An attitude of 'no bosses' has led to managerial roles and authority being informal and ineffective. This has been complicated by marginality of cooperative ventures. Secondly, cooperatives then

95. This section is based on observation and involvement with cooperatives in the Western Cape during the past three years.

find themselves dependent on support from the outside as a result of their marginal position. This mostly takes the form of an outside service organisation, which supports cooperatives for ideological or developmental reasons. Furthermore, funding of these cooperative firms in the form of grants often accompany such a relationship. Service agencies are also not properly equipped to deal with the managerial and entrepreneurial demands made upon them. And at the same time, the relationship of authority and responsibility of the service agency with the cooperative is unclear, resulting in what can be called 'management by generally poor advice'.

But the essential components of a cooperative as an intermediate association similar to that described above are present locally as well. This requires that the relations between the cooperative and the outside community are clear. Furthermore, the relationship between self-management functions and operational management has been clarified in the context of the basic principles outlined above (section D.4.a page 77).

The objectives of the various actors are also quite similar to those discussed above. Workers generally want access to a job in the first place with an increase in a standard of living as well as a pleasant working environment following[96]. The objectives of those coop members playing a managerial role are more difficult to define. My own observations are that they are twofold: on the one hand, there are people with political motives. On the other hand, there are people with longer term economic motives. This often involve individuals who would not otherwise have access to finance to start up small businesses. Finally, the objectives of service agencies are even more difficult and varied. Some have definite development or welfare objectives, while others have political objectives seeing cooperatives as a way to expand their

96. Jaffee 1988: 52 and own experience.

own political programmes[97]. To this should be added the objective of those multiple sources of funds, from overseas welfare agencies to local big business 'social responsibility' programmes.

d. Technical choices in a cooperative firm - towards a behavioral model.

This section is very tentative, and is based to a large extent on my own observations and involvement with cooperative enterprises for the past 6 years, together with some of the experiences of cooperative enterprises in other countries[98].

A model of the choice of technique in a cooperative can be developed. The coop will be faced by a minimum rate of profit (rate of accumulation determined externally to the firm), and a minimum level of wage rates acceptable to the worker members. Grants from service agencies tend to lower the minimum performance level required affecting the choice of technique, which could inhibit the development of learning processes creating competitive advantages. The choice of technique will then be made according to the conditions within and facing the particular production unit.

The range of choices open to a cooperatively structured firm will be determined by the access it has to two basic resources: <u>financial and managerial</u>. Both are potentially problematic, as has been shown elsewhere. In fact, evidence from cooperatives all over the world suggest that effective coops often get by with relatively less of these resources than what could be expected. This applies especially to supervisory staff levels, and with

---

97. See Jaffee, 1988:2-14

98. Examples of these experiences can be found in Lindkvist & Westenholz et. a. (1987) for the experiences in the Nordic countries, Jackall & Levin et. al. (1984) for the experience in America, Bradley & Gelb (1981) for the Mondragon experience, Abell & Mahoney (no date) for an analysis of small scale producer cooperatives in developing countries, Chaplin & Cowe (1977) for an earlier British experience, Collins & Collins (1984) and Jaffee (1992) for a South African perspective, and finally Bellas (1975) for an earlier view of the Plywood cooperatives in Northwest United States.

lower levels of salaries for managerial staff. But there are two minimum conditions that could constrain development: The first is that some form of capital provision beyond the means of the individual members must be available using means other than collateral as security. Secondly, a minimum level of 'entrepreneurial skills' must be present in the enterprise in order to provide the leadership required to get access to other resources needed.

This would suggest that ways of forming new cooperatives are limited by these impediments: either they should start by bringing in some members with entrepreneurial skills, and start small. In this case they will find the same constraints as ordinary small businesses, but with potentially more problems in some areas and less in other areas. The increased collective focus and aims provide resources strengthening the small business making it more resilient than equivalent privately owned small businesses. It might also be more difficult to attract suitable 'entrepreneurial' resources - but not impossible. The availability of some agency specialising in providing finance to cooperative enterprises on a non-collateral basis would also be important. An alternative way to start cooperative firms would be by converting existing medium sized or larger firms from privately owned to member controlled firms through some form of worker buy-out or company initiated mechanism. In this case, a technical base will be existing, and the choice of technique will most probably be similar to that of a non-cooperative firm. Much will depend on whether the cooperative conversion takes place in a crisis situation or not. This type of experience has not been common in South Africa, with the exception of a number of attempts to use retrenchment packages to start up new cooperatives.

Cooperative enterprises will have to adapt the techniques in existence continually if they want to survive. The technique here is used in a broader sense than the narrow 'technical' aspect. Cooperative enterprises that possess sufficient managerial capacity seem to learn easier, possibly because members have more motivation to learn and a longer term interest to remain in the enterprise. In fact, cooperative enterprises seem to need and enable more sophisticated management techniques than privately owned firms of comparable size and technology. This could both be a drawback, and a strength.

There is sometimes a tendency for cooperative enterprises to be unbalanced in terms of the various aspects of productive behaviour. Production is logically the strongest focus, while marketing, product development and financial management are often the weak links. This ought to translate into advantages for cooperative enterprises in choosing techniques that present a lot of learning opportunities in the production sphere. In order to realise this potential, sufficient production management capacity should exist to create the capacity to learn. At the same time, there might be an incentive to choose techniques that easier to use and operate by workers. It is possible that less productive techniques are chosen because they are less strenuous or unpleasant rather than because they are potentially slightly less profitable.

The ability of a cooperative enterprise to adapt its institutional structure to the requirements of the techniques chosen and the economic conditions will influence to a large extent the viability of particular technical choices. Some of the more important aspects here are the willingness create the conditions for sufficient managerial authority, and find ways of dealing with conflicts and conflicting interests. It is difficult to model these required responses before hand. They often need intimate knowledge of the technical and economic aspects of a particular industry and technique.

Because of the limitations of capital and managerial resources, especially for a new firm, it might be difficult for cooperatives (apart from those started up through a worker buy-out) to operate with economies of large scale. They might have to restrict themselves to techniques that can operate more flexibly on a smaller scale with higher value added processes. The reality is often that cooperative enterprises find themselves in the sector that is relentlessly competitive with below average wage rates due to the labour intensity of these techniques. Cooperatives will either be able to use their institutional characteristics to generate flexibility and learning advantages over competitors, or will most probably be at a disadvantage.

Within these conditions, the options can be placed on a continuum between the following two poles:

The first can be called the 'appropriate technology' choice. A cooperative group operating at the fringes of the economy can find a niche where they can operate with their current knowledge and skill base. In practise this often means low quality products and cost cutting, often using cheaper capital goods and materials, little overheads etc.. In terms of the technical choice model this involves finding a technique with a small viable space. Thus, many of these techniques are only marginally viable. The experience in the Western Cape has been that cooperatives following this route tend to have a particular decision making structure. They are usually characterised by a strong leadership figure, without proper skills. These leaders are in strong control in an informal manner. The service organisations associated with them have very little part in the technical choices made, except for providing some information and often helping to arrange funding. But making and implementing these choices remain within the cooperative with their existing pool of skills. They also resist any attempts to bring in more skills, and are prepared to accept very low wages. Formally, everybody in the coop usually receives equal wages.

The second can be labelled the 'high value added' approach. The search for a technique is extended to one that promises higher value added, and usually a bigger viable operating space. This often involves changing the institutional situation of the cooperative, and a minimum requirement would be to bring in skills. This would increase the capacity of the coop to learn and assimilate new techniques. The institutional framework associated with this option often involves a support organisation with more entrepreneurial skills available. There is usually also differentiated wages, and an acceptance of the need for professional management.

The rest of the thesis will analyze the brick-making industry in the Western Cape, in order to analyze the technological opportunities and constraints that cooperative firms will face in order to start up.

CHAPTER III

TECHNOLOGY IN THE BRICK MAKING INDUSTRY IN THE WESTERN CAPE

This chapter analyzes the techniques actually in use in the industry. The aim is twofold: to demonstrate that the approach to analyze the choice of technique functions developed in Chapter II is useful; and to draw specific conclusions about the technological structure of the brick making industry in the Western Cape and its consequences for the choice of technique by cooperative enterprises.

A key part of the analysis presented in this section is based on the development of a technique with which to analyze the characteristic profiles of individual techniques within the industry as a whole. Following the theory of technology developed in the first section, in which it is argued that the scaling properties of techniques involve the efficient combination of a range of sub-system components into an efficient whole. The implication is that each technique will present a unique characteristics profile, and that within an industry a range of technical profiles will emerge as a result of the constraints laid by the underlying technological principles. The various components identified in the first section will be taken, and the crucial correlations between product characteristics, technical profiles, economic factors, and institutional characteristics will be shown.

A set of analytical and measurement tools with which to analyze the technological profiles is developed. They are based on the multivariate statistical analysis technique Correspondence Analysis, as well as a synthesis of various 'technology measurement' techniques. An appendix presents an overview of these techniques. The one drawback of most of these techniques are that they require a lot of data. However, it was felt that by analyzing the technological profiles of the various techniques actually in use, we might uncover correlations or clusters of associated characteristics associated with the institutional characteristics of particular firms. This might give us an understanding of the types of technical choices open to cooperative firms. This is also what was found, and some interesting profiles and correlations were made. In future more sophisticated measurement tools than those which were used here can be developed to apply the technique to other industries.

The first section will define the shelter social use sector, and the vertical building elements [VBE] components industry as a major input into that social use. The method of analysis will then be discussed. Thereafter, the efficiency and technical choice possibilities of various firms are analyzed using the model developed in the chapter II. This will be followed by the economic structure of the different firms. Then the product characteristics are analyzed, followed by the technical characteristics profiles of various techniques. Finally, the institutional characteristics of the firms within the industry, and of the industry itself will be analyzed.

A. DEFINITIONS AND BACKGROUND TO THE SHELTER SOCIAL USE SECTOR

This section will define the area of study, the 'shelter' social use sector, and note some of the analytical difficulties involved in making the definition operational. The vertical building elements [VBE] component will be identified as the focus area of the study.

1. Definition of the 'shelter' social use.

A social use sector is defined as a range of final commodity substitutes. The final good in this case, is the need for shelter for individuals and families. The need for shelter is one of the most basic human needs and has to be fulfilled before many others[1].

2. Some analytical problems caused by the definition.

There are three types of problems to deal with in order to make the definition operational: Firstly, a wide range of commodities go into the production of a shelter. It is beyond the scope of this study to look at all those components. It will concentrate on only one of the subsystems, the vertical building elements. Vertical building elements perform at least two structural functions: carry the roof structure, and enclose the sides of the shelter from the elements. The analysis will further be limited to the production of concrete and clay masonry vertical building elements [VBE] for use in the construction of residential units in the Western Cape only. This choice can be justified for a number of reasons, apart from the lack of space. In the sphere of low cost housing at least, most developments in housing construction methods have occurred in the area of walling (NBRI. 1987:G1). And concrete and clay masonry also make up by far the

1. Maslow's material safety needs. (Schein 1980:85)

biggest proportion of the VBE industry.

Secondly, the same products contribute to more than one social use. VBE are not only part of houses, but are also part of the production of industrial buildings, other public places etc.. Strictly speaking, bricks used in the production of industrial or commercial buildings and paving are not part of the shelter social use sector. They are inputs involved in the production of other goods or services, and are therefore not final commodities. However, in so far as VBE are concerned, it will be very difficult to isolate these from VBE used in the provision of shelter, mainly because of a lack of relevant data.

Finally, some firms contribute to more than one social use, aggravating the problem of data availability. However, housing represents at least 75% of the market for bricks[2]. Furthermore, most of the smaller firms are not really affected, and that the few bigger firms supply most of the masonry used for industrial buildings.

3. Broad overview of the shelter social use.

a. Economic factors.

(1) Housing demand, income distribution and affordability.

A house is a commodity of a special kind. It has to last for a long time, and has to provide its inhabitants with safe and pleasant conditions in which to live. One approach to the determination of demand for housing is premised on indifference curves[3]. Another approach regards housing as a basic need, which each family needs to be productive. Housing needs are then

2. Interview with H Voorma. (Nov. 1989)

3. See Hillebrandt (1985:Chapter 4) for a neoclassical treatment of the subject.

calculated by taking the population figures, assuming the average family size, and calculating the number of housing units required. This is compared with the estimated housing stock, to arrive at a figure for the 'housing shortage'. Usually, different assumptions are made for different 'population groups'. However, such calculations are often unsatisfactory due to poor data[4], and implausible assumptions made[5].

In practice, the need for shelter and the ability to pay for this housing of a given level of characteristics must both be incorporated into the determination of demand. Effective demand is affected by a number of factors, of which the level and distribution of income, prices of available housing and of other goods and services are but a few. People with a very low income have proportionately less money available for housing than people with higher incomes due to minimum nutritional and clothing requirements to stay alive. Demographic and cultural factors[6] play a role as well as the availability of money[7].

The NBRI (1987:B1) constructed a table utilising some of these assumptions[8] for the country as a whole. The results are summarised in Table 1. 55.11% of households cannot afford a house at all, while 21.47% could only afford a basic shack, or a very basic core house.

The Urban Foundation looks at the 'black housing market backlog' as consisting of 4 segments: 10% can afford 'conventional housing', which can be supplied by private builders without any

---

4. See Loots, 1985 for examples of such problems in the Western Cape.

5. NBRI, 1987:B1-3; Grimes, O.F. jr. 1976:62

6. See the approach by a development company, Goldstein Homes, which examines 'household size, employment type, interest in home ownership, and an income profile of the township. "We found striking differences in affordability levels and house design preferences in townships that are only a few kilometres apart." (HSA, Nov 1987:8) See also Grimes 1976:62

7. See an interview with D Norton, FM 7/7/1989; p57-8 and with D Ackerman in FM, 7/7/1989 p61-4.; NBRI, 1987:B1

8. They use 1985 data, and assume a household subsistence level of R342 per month. They also assume that all housing shortages occur amongst people earning below R900 per month, as well as an interest rate of 17% repayable over 25 years without any problems of access to loan finance. They also assume housing shortages distributed uniformly amongst the different income categories.

Table 1. Housing Affordability in South Africa.

INCOME	INCOME FOR ACCOMMODATION	AFFORDABLE LOAN	HOUSING SHORTAGE	% OF TOTAL
1- 99	-	0	133000	20.6
100-199	-	0	108000	16.7
200-299	-	0	114500	17.7
300-399	8	556	70000	10.8
400-499	108	7511	68500	10.6
500-599	208	14467	55500	8.6
600-699	308	21422	39000	6.0
700-799	408	28377	34000	5.2
800-899	508	35332	25000	3.8
TOTAL			645000	100.0

Source: NBRI

Note: 1985 data assuming a subsistence level of R342 per month. Interest rate of 17% pa. over 25 years.

difficulty. The 'starter homes' segment, 33% of the backlog, requires lower quality finishes and smaller sizes to bring the cost within the R15000 to R30000 range. Thirdly, 40% of the market is for 'incremental homes'. This means site and service schemes and upgrading projects which cost between R3500 to R15500. These are essentially 'non-habitable products' for which the occupant must devise their own means of shelter. Finally, "about 20% of people who can't even afford a R3500 product and must rent or be given government assistance..." (FM. 7/7/1989:73)

(2) Provision of housing and effective demand in the Western Cape.

Data to analyze the effective demand for housing in the Western Cape alone is not readily available. Consequently, various other sources had to be used as approximations. These are generally only available in racial category format. Therefore this superficial overview will follow suit.

Roughly half of the number and 64% of the value of the housing units completed in the country as a whole between January and May in 1988 belonged to people classified as 'white'[9]. During that year 8666 housing units were completed in the Cape Town area, of which roughly 4300 would then have been for whites. The average price for all 8666 units was R40326, If 60% of the value of houses completed were for 'whites', then the average cost per house would be R48762. This is considerably lower than the figures which the United Building Society presented as the prices of new houses during the third quarter of 1989: R103841 for a small, R145341 for a medium size and R180699 for a large new house[10]. Since data on income distribution and housing supply for whites in the Western Cape are not readily available, an estimate is that about 3000 housing units above the R50000 range are supplied to whites annually.

The Urban Foundation [UF] has produced two confidential reports for people classified 'coloured' and 'black' respectively. In 1986 they estimated the total housing need of 'coloured' people in the 01 statistical region as 229950 units. The actual supply was 134955 units, of which 42% belonged to the private sector. Apart from the backlog of 60000 to 70000, 5500 new housing units are required each year. Supply is about 2900 units, adding 2600 to the backlog annually. Of the 5500 units needed, only about one third (1700) could translate into real demand which can be met by the private sector. If the prices of these dwellings could be dropped to between R20000 and R30000, another 20% of the need (1000 units) could be supplied. That leaves 55% of the total need to be satisfied in some other way. Furthermore, it was only between 1978 and 1982 that housing provision exceeded demand.

For Africans the situation is even bleaker. Accurate data are almost non-existent. Presuming the total population to be roughly

---

9. Out of 14725 units completed between January and May 1988, 49.7% went to whites and 24.7% to Africans. Of the total expenditure on housing of R683m, 64,2% were for whites and 15.7% for Africans. For whites, average floor sizes remained fairly constant (±156m^2) between 1986 and 1987, with the cost per m^2 increased by 6.5% to R384.46/m^2. For Africans, the average size per unit decreased by 6.6m^2, to about 78.3m^2. The cost/m^2 increased 9.6% to R375.04. (HSA: August 1988:6)

10. The difference could be accounted for in that many of the cheaper houses built were not included with the UBS data. For instance, houses below R30000 and above R300000 were excluded. Self-help and other low income housing would not be adequately reflected either. Quarterly Housing Review, July-Sept 1989:9

700000, and a household size of 6.57, the UF estimates that 124282 housing units are required. The existing stock of housing is 21105 formal housing units, 42416 informal but permanent units, and about 700 hostel units. It appears as if the number of families that can afford anything more than a core/shell house is as low as 3%. That means about 97% of the African population need to be housed in units costing less than R25000. Furthermore, about 45% of the population can almost not afford any form of housing.

Table 2. Estimates of housing need in the Western Cape.

Population group	1990 population estimates	growth rate	family size	New housing required
African	700,000	4.08%	6.50	4,393
Coloured	1,300,000	2.8 %	4.60	7,913
White	670,000	1.9 %	3.80	3,350
TOTAL	2,670,000			15,656

Source: Own calculations and estimates. See text for the references used.

Note: The data are intended as an indication of the order of magnitude only.

Table 2 is a compilation of data extracted from various sources mentioned above, as well as those guestimates by Thomas (1990) and the Draft guide plan for the Cape Metropolitan Area (1984). It is by no means accurate, and intended to give some indications of the order of magnitude only.

Roughly one third of all new housing requirements could be of a conventional type. This usually means brick and mortar construction. For the rest, lower cost solutions will have to be found. These have traditionally been sought in two fields: technical and institutional.

b. Technical factors

Table 3. Summary of Affordable Housing estimates.

Population group	New housing required	Affordable housing					
		R0-20000		R20-35000		R35000+	
		%	no	%	no	%	no
African	4,393	45	1,977	45	1,977	10	439
Coloured	7,913	47	3,719	20	1,583	33	2,611
White	3,350	00	0	20	670	80	2,680
TOTAL	15,656		5,696		4,230		5,730

Source: Own calculations and estimates.

Note: The data are intended to give an indication of the order of magnitude only.

(1) Historical background.

A first glance suggests that the potential for radical technical change to drastically alter the nature of the sector's technology is limited.

> "Advances in home-building technology over the past 30 years have been minimal when compared to developments in other technological fields and they have scarcely had any impact on low-cost housing." (NBRI. 1987:G2)

However, the changes in industrial building systems that have occurred can be analyzed along a number of axes: The first is the *choice of materials*. A distinction can be made between 'light' and 'heavy' materials. Earlier, steel framed construction methods in the nineteenth century were replaced by reinforced concrete structures in the twentieth (Clarke. 1982:4). A second axis deals with the *way in which the materials are prepared and delivered to the site*. Traditionally, artisans on site used the most basic building elements. In time, these elements were adapted to various degrees. Clarke has identified four levels of specialisation: rationalised traditional; 'dimensionally coordinated' units in an open and flexible building system; closed systems; and complete prefabricated houses (1982:2-3). The third axis is related to the second, and specifies the *degree of production of these components in a factory situation*, to be assembled on site only. This normally coincides with reduction in skilled and unskilled labour used on site, and increases in semi-skilled and managerial labour in the prefabrication and planning process. (Clarke, 1982:15) Finally, the *degree of mechanical handling of materials on site* has increased as well.

In South Africa, the development of industrialised and innovative building systems has really only started in the last twenty to thirty years (Clarke, 1982:13). They seem to have had little impact. Evenwell estimated that about 1% of total construction in 1965 was of an industrialised nature, and that these would grow at about 3.8% p.a. (Clarke, 1982:14). However, in the mid 1980's, the trend seems to be reversing[11]. Many of these systems are industrialised systems, replacing labour with mechanisation and prefabrication, mostly in large schemes. And by far the largest number involved design modifications to hollow concrete blocks[12]. One of the reasons is that "successful application of industrial building in the low-cost housing market is dependent on ... large-volume production of relatively standardised designs within a reasonable distance of the production facility.". User preferences and cost factors also seem to favour those systems that are technologically closest to the conventional masonry: hollow concrete blocks laid in an innovative way. (NBRI, 1987:G2). Thus, with increased emphasis on low cost housing, 'ordinary' hollow concrete blocks have become more important as a building material rather than sophisticated alternative systems or alternative materials.

Another reason for the relatively poor performance of these alternative systems seems to be the lack of suitable skills to produce them, and the massive retraining which will have to take

11. Of the 75 'innovative building systems' which were registered at the Agrément Board since 1969, only about half were in use in by 1987. By the end of 1984, 60000 houses had been built by these systems. That represents an average of 9% of total housing supplied between 1970 to 1981, with a peak of 17% in 1981. This has declined to 5% in 1983.

12. Schlotfeldt has shown that in total 34350 houses were built with 'innovative methods' between 1980 and 1984. Of these more than 90% occurred in larger housing schemes, as opposed to single houses. And of the 31450 houses in schemes, 84.3% used 'hollow concrete blocks laid in an innovative manner' (against 0.4% in the single houses). Large precast concrete panels had 6.1% and 1% of the market share respectively, cast in situ concrete 3.7% and 3.6%; timber frame with various types of cladding 1.1% and 26.2%; steel frame 4.8% and 63.6% and small precast panels 0% and 5.3% respectively. (NBRI, 1987:G2)

place if such systems were to be implemented on a large scale[13].

The NBRI has argued that the drop in innovative building systems in 1983 was due to large manufacturers moving back to hollow concrete blocks used in a conventional way. Hollow concrete block technology seems to have "established itself as an extremely economical method of construction in mass housing schemes, where the contractor often establishes a block-making plant on site." (1987:G2) Reasons advanced are: cost (lower material costs and labour as well as lower skill requirements; no need for expensive equipment); Adaptability and flexibility (large and small scale operations; building designs and easily extendable using local materials) and consumer acceptance in the tradition of masonry construction. (NBRI, 1987:G2-G3)

In conclusion the move towards industrial building systems represents capital intensification in the case of shortages of skilled labour, or where time is of crucial importance. But the experience in other countries has shown that these effects are not uniform between construction projects in different sectors. And when these are viewed in the larger whole of services, maintenance etc. the picture is less sharp. What is clear is that direct labour costs are less, while capital depreciation and material costs are higher. (Clarke, 1982:23-25) Furthermore, in an analysis of 46 housing projects, the NBRI found that there was a clear trade-off between the rate of housing delivery and the number of jobs created per house[14].

Other developments include using more plastic products in plumbing, prefabricated trusses in roofs, and new roof sheeting profiles with better features in specific applications like low

13. In an evaluation of an experimental project in Belhar in 1986, the CSIR comments: "What has come out of the project is that most of the innovative technology can be applied only by skilled artisans, entrepreneurs, contractors or developers. ... The project has also shown that self-help and self-builder housing is only likely to succeed if the technique employed and the building materials used are relatively similar to conventional or traditional building systems with which people are generally familiar.". (Housing Research Review, No 9/1987)

14. Housing Research Review No 11 1988

slopes or longer spanning capabilities; in the sphere of 'self help' housing the increased use of local materials in 'low technology' or upgraded indigenous methods of home building in formal housing schemes. "In other respects a comparison of current low cost-housing construction methods and materials with those of the 1950's reveals remarkably little change. (NBRI, 1987:G3).

(2) Vertical building elements.

(a) Basic components.

The wall construction techniques can be analyzed in terms of three components: the materials used; the building systems (the way in which the materials are formed into a walling unit); and the supply systems (the way in which the whole building system is organised.)

The heavy weight *materials* used range between unburnt clayey soil[15]; a mixture of sandy soil and portland cement or lime; concrete; calcium silicate; burnt clay; gypsum[16]; natural stone. Then there is a range of lightweight board products like gypsum board, different types of wood board and insulation materials called 'sandwich panel wall'.

The *production systems* can be seen as basically two types: Preparing the materials in a modular format which is assembled in some way on site; and casting the raw materials in situ[17]. The latter requires the construction of mould systems, which differ in size from a small movable mould to large modular

15. Adobe, or hand 'moulded, unburnt, sun-dried building block made of soil containing a fair amount of clay. Pise-de-terre also uses clayey soil, but is rammed into a form on the wall itself.

16. Gypsum blocks are usually manufactured to high precision, and is only suitable for interior walling. It does not seem to be viable at the moment (Bornecrantz & Vissers, 1986:135).

17. Examples are the Pise-de-terre system; the Zenzele system, in which treated gum-poles are planted, covered by wire mesh, and filled with locally available materials or rubble. (NBRI 1987:G13-14). Another experimental method that has been used is a small 'travelling mould', in which sand-cement mixture is compacted by hand, the mould removed and assembled elsewhere on the wall (NBRI 1987:G11-12).

systems which require that almost the whole structure be included in the mould. The advantages of 'cast-in-situ walls' are that the materials are handled or processed only once, and the surface is often of high quality requiring little extra finishing. A variety of materials can be used.(NBRI, 1987:G10). On the other hand, some form of standardisation is generally a prerequisite, because the moulds should be used as many times as possible[18].

Pre-produced modular systems on the other hand differ not only in the materials that are used in the construction of the modules, but also in the design, size and shape of the modules, and the methods by which they are secured during assembly. The majority of housing construction taking place utilises this type of construction system, in which masonry bricks are assembled using a layer of mortar as a binding method. Later on different sizes and shapes of products have been developed, mostly using concrete as a material. One could see the range from ordinary bricks, through hollow blocks to different sizes and shapes of precast panels. These are mostly cast from concrete, but systems in which bricks are first cast into panels have also been developed. Then there are light weight panels which are assembled using a light weight frame of wood or metal[19].

The *supply systems* can range from supplying individual houses to larger scale systems in which more than one house is constructed at the same place and time, reaping some scale benefits. These could be of two types: It could involve a job rationalisation, in which jobs are fragmented so that one team performs the same function over a whole range of houses. Or it could involve standardisation of the design of the housing units, or some of their components which involves scale economies. This

18. For example the BRISC system, "amply demonstrated the feasibility of using labour-intensive techniques and a relatively large basic planning and construction module to realise some of the benefits available from the application of standardisation and mass production." (NBRI, 1987:G10)

19. "Whether this Utopian Meccano set will ever materialise at a price affordable by the masses remain to be seen" (NBRI, 1987:G12-13).

is generally a prerequisite for mechanising the building process to any great extent. It has the drawback that the more standardised the less flexible it becomes. It then becomes difficult to provide housing with an element of individual 'touch'[20]. In conclusion, we can note that the coordination requirements of both these integrated production systems increase considerably.

(b) Scale economies in the provision of housing.

From what has been said so far, it is clear that some scale economies can be generated by standardisation, and specifying larger projects. Whether this also implies that a few large firms handling large contracts are more efficient than a lot of smaller firms handling the same contract is not apparent, and is difficult to determine. Smaller firms have lower overhead costs, while larger firms could have a more efficiently organised production process[21]. At the same time, some of the benefits which large firms enjoy might be pecuniary[22].

The costs of housing are affected by the size, site, design and the specifications of the individual components of which the dwelling is made up of. The ability to be able to specify some of these subsystems would generally increase the cost of the house. But, there is not a direct relation between reduction in costs between the different components. The NBRI identifies three groups of components in so far as their costs change with a change in the surface area of the house. Elements like plumbing and electricity installation are almost not affected by changes in the floor space. The 'horizontal' elements (roof and flooring)

20. Some attention to detailed elements could remedy some of these constraints. An example is the experience of W.J. Levitt, who "created the residential version of the Model T, constructing as many as 150 houses per day. They were built with conventional materials, and all were basically the same conventional looking house. By varying colours, window placement, roof lines, and setbacks, Levitt made buyers feel that each house was somewhat unique." (Cvitanich; HSA, Oct 1987)

21. See NBRI, 1987:B6

22. Some small brick making firms have complained of the practice by large companies to gradually increase the repayment periods to small companies, especially in difficult periods.

are affected directly. But the vertical elements are affected to a lesser extent. A study performed showed that to increase the size of a house by 10% only increases the cost by 4.3%. In this study, the non-varying costs made up 44% of total costs, horizontal items 30% of total cost, and vertical items 26% (NBRI, 1987:B8-9)[23]. Because the price of housing units does not fall proportionately with its size, certain sub-elements have to absorb relatively more of the cost reductions. The potential for such reductions are given by the technology involved in supplying each sub-system.

Therefore, with a reduction in total cost of a house, the options are constrained in two ways: less flexibility due to greater standardisation to reap economies of scale or cheaper materials which might have to differ from the traditionally preferred masonry construction[24].

Another source of scale economies is associated with the design and layout of land-use systems. In essence, higher density of land use for private living would tend to be cheaper, but this must be counterbalanced with sociological factors brought about by these higher densities[25]. New computer based design processes can also cut the costs of designing township services[26] and houses. Other computerised systems include estimating and tendering systems[27].

23. "[T]he main expense of building a house is the plumbing and electrical wiring. This costs just as much whatever the size of the structure. And we cannot go on reducing the size of houses indefinitely." CT 11/1/89

24. See the work done by Dr. F Frescura in Port Elizabeth, where residents evaluated their shell-houses as "poorly built, poorly finished, poorly insulated, relatively expensive, too small and offering little securing either to themselves or their property." FM 7/7/89 p66. A longer term trend towards lower quality, cheaper finishes, unpainted houses and fewer extra's like built in cupboards is predicted. "Already there is some acceptance of cheaper products like concrete door and window frames, thinner glazing, [cheaper]... paints, cement slab flooring and concrete bricks and blocks that can be manufactured on site" ibid p66.

25. See NBRI, 1987 Section C

26. HSA, May 1988:p27 describes how technical advances have put programmes for the design of township services within reach of most developers, reducing the design time with more than 50%.

27. See the Xtend system installed by OVCON, developed by Brett Schachatt Construction company. HSA, Oct 1988:28

(3) Design characteristics which determine the 'quality' of a house.

Meyer (1982:1-9) has outlined the following minimum requirements to ensure that building systems fulfil their function. These are grouped under four headings: Health (including resistance to rain penetration; rodent attack; thermal performance and condensation, especially in the 'Southern Coastal Condensation Problem Area.). Secondly, safety in relation to fire and the structural strength and stability. Thirdly, habitability, including acoustic performance. Finally, the durability of the structure.

The most basic characteristics required become more pronounced when dealing with low cost housing. As the total costs increase, these technical constraints become less pronounced compared to aesthetic factors. The basic technical requirements which will limit the choice of materials and construction techniques can be seen as structural stability; thermal performance and rain penetration. Added to these are geological and climatic features specific to the region itself, and the basic design and layout and how this is related to the occupants' requirements (NBRI, 1987:F3).

c. Institutional factors.

(1) Standards.

Building standards are regulated by the National Building Regulations. In recent years calls have been made for the reduction of standards applicable to the construction of low cost houses[28]. But there has also been some opposition[29]. Whatever the case might be, a process has been set in motion which has seen

28. See for example Roelvert, in HSA, Jan/Feb 1988:p9 and Webb in HSA June 1988:p20

29. For example, the Western Cape Master Builders' Association called for the maintenance of standards. (HSA, June 1988:p5)

lowering of building standards under certain circumstances.

In the case of innovative or new construction methods, which are not yet contained in the building regulations, a separate system of regulation has been instituted. This involves the Agrément Board, which supplies Agrément certification[30]. "Such certification will provide a basis for the use of unconventional building methods in a manner that will ensure that proven and accepted health and safety standards are maintained for both the occupants of the buildings and the community in which they are situated." (Schlotfeldt, HSA Nov 1987:12).

MANTAG (Minimum Agrement Norms and Technical Advisory Guide), the 'second tier of the Agrément certification system, was initiated in July 1985. It was stimulated by the changes in government urbanisation policies, and is restricted to "simple, single storey detached dwellings constructed with the use of innovative building materials, components or methods, in areas designated by the local community or a regional authority as areas where site-and-service schemes, self-help schemes and simple shelters are acceptable." (Schlotfeldt, HSA Nov 1987:16). Based on a set of performance criteria meeting essential health and safety standards, it will give adequate shelter without becoming a danger or health hazard.

MANTAG[31] comprises two parts: A mandatory part, which specifies the essential criteria which have to be satisfied, and a technical advice part which provides technical advice on other (non-mandatory) aspects of the performance criteria that are not mandatory but should be kept in mind by prospective occupants.

---

30. This concept was introduced in 1969 to encourage the use of innovative building materials, methods, components and products. Performance criteria was related to the conventional construction methods. (Schlotfeldt, HSA Nov 1987:12)

31. The Agrément and MANTAG criteria represent a fundamental difference in approach. MANTAG requires no fire rating but only provisions made for safe exit to the exterior in the case of fire. Thermal performance is permitted to fall as low as the 'minimum winter outdoor temperature at the coldest time of day in the area where the dwelling is located, and the 40°C Standard Effective Temperature' the maximum. Water penetration of the walls is permitted if it will not go onto the floor, and will not weaken the structure. Finally, substances that are known to have a harmful effect on the occupants may not be used as materials (Schlotfeldt, HSA Nov 1987:16).

The essential criteria refer to behaviour in fire, structural strength and stability, termite resistance, thermal performance essential for health requirements, weathertightness, ventilation and natural lighting (Schlotfeldt, HSA Nov 1987:16).

(2) Institutional support for the provision of housing.

A number of institutions support the provision of housing in some way. *The National Housing Commission* supplies housing units to lower income people[32].

Three types of semi-private institutions are involved in the provision of housing: The Development Bank of Southern Africa [DBSA]; South African Housing Trust [SAHT]; and Utility Housing companies. The DBSA does not provide finance for housing as such. They support the private sector to finance and carry out the developments, while the DBSA loans itself "are mainly channelled into the provision of bulk and connector services to prepare the way for private involvement." (Roelvert, HSA March 1988:21) The SAHT was established in January 1987 as the first major joint housing initiative between the state and private enterprise. They aimed not only at 'improv[ing] the quality of life of lower income communities through the funding and initiation of mass housing', but seek to do this in a way that maximises job creation, opportunities for entrepreneurs and the application of own resources of individuals within the communities[33]. Utility Companies are formed with the express purpose of providing the housing needs for low income families. There are no shareholders, and dividends are channelled back for new projects[34].

Private developing companies, apart from mining companies, "were

32. Between 1950 and 1986, they supplied 849345 units. (Oosthuizen, HSA Oct 1987:35)

33. Roelvert, 1988:21

34. By 1982 there were only 2 large utility housing companies, but since then up to 1988 24 have been established that functions with some success. The Urban Foundation has established 6. (Roelvert, 1988:22)

slow and still are reluctant to become involved in low cost housing. They concentrated on the needs of the higher income communities which only form a small segment of not more than 5 percent of the total market." (Roelvert HSA March 1988:22)

A new strategy of government departments calling for the development of and entire town, like in Blue Downs in the Western Cape, stimulated private sector developers to do intensive research. Consortiums of private sector companies were formed to tackle large scale projects on a joint basis. A consequence is that owners now replace tenants, since 'the private sector simply cannot accept the risk of building for tenants on a rental basis. Individual contracts with the prospective owners are signed, the financing directed via a financial institution. This has meant that the occupants get a say in the choice of location, design, specifications and final cost of a unit. (Roelvert HSA March 1988:23)

But a number of matters need to be kept in mind when assessing the role of private companies. Firstly, most of the houses are dependent on some form of subsidy[35]. Most of the houses are in the same type of price range[36], and have the same type of floor surface area[37]. Finally, little attention is being paid to options in the market below the R30000.

(3) State housing and land use policies.

A fundamental shift occurred in state housing policy since 1983. The burden of providing housing was shifted to the private sector, and the states 'responsibility' was reduced to providing

35. HSA, Oct 1987:26

36. LTA Comiat provided houses in the 'middle income group' range in (R35000 - R60000) in Blue Downs. (HSA, Oct 1987:26)

37. e.g. Goldbel, a joint venture between Bellandia and Goldstein, built houses selling from R50000, to qualify for the first time home owners (GO709) subsidy. These houses have on average 74 m^2 floor space, on 330 m^2 plots. (HSA, Oct 1987:21)

plots and services; and to assist in special categories where people would not be able to obtain proper housing[38]. At the same time, the state slowly started to sell approximately 500000 state houses to present tenants[39]. Government subsidies only apply to the interest rate and the determination of the redemption period. Recipients whose income is too low to qualify for such a scheme must be helped by welfare agencies[40] (HSA, 8/1988:32-33). One of the consequences of the change in policy is that massive housing projects are no longer undertaken. Private sector companies have to build houses and sell them before being able to build more. Consequently, the demand for VBE has become much more volatile.

Urbanisation and land use policies changed when, with the abolition of influx control, certain forms of property rights for African people were introduced. The 1978 99 year leasehold scheme was 'improved' by adding perpetuity rights in 1981, and full ownership rights were implemented in 1986. (HSA, March 1988:22) This has highlighted the constraints on the availability of suitable land for the development of housing[41], especially in the Western Cape where land suitable for housing is particularly scarce[42].

The Group Areas Act, started by regulating the ownership and occupation of immovable property on a permanent basis among people classified as belonging to different races. In time this also became extended to temporary occupation, and included social and labour matters. (Oosthuizen, HSA, Oct 1987:p35). Apart from

---

38. Where it is not possible for them to get funding from private financial institutions; and in providing for the aged, pensioners and those with an income so low that no other form of relief is possible. (Roelvert, Jan/Feb 1988:p3).

39. In the Western Cape only 7.8% of 20041 allocated houses were sold by March 1988. (HSA, Mar 1988:p17)

40. The principle was that at R800 per month (1988 figures), a person could afford to pay 25% of income to housing, which amounted to a house valued at R30000. Below that, interest is subsidised on a sliding scale, because it cannot be taken that such a person can still spend 25% of income on accommodation. The values of houses incorporated into the scheme thus ranges from R10000 to R30000. (HSA, 8/1988:32-33)

41. Land costs constitute an important component in the cost of low-cost housing.

42. See Housing, March 1989 p 47.

the fact that people were moved against their will[43], insufficient land for housing people classified as 'Coloured' and 'Indian' was provided[44]. This and illegal means of circumventing the act, distorted prices significantly.

4. Implications for the brick making industry.

The higher income market segments are almost saturated and at the lower end of the spectrum lack of effective demand (concurrently with high levels of real social need) limit the provision of housing given the current circumstances.

It seems as if two types of approach would be needed: changes to increase access to affordable housing. This could include housing subsidies, measures to increase access to finance and channelling state resources into the housing sector[45]. Secondly, technical changes leading to a reduction in the quality and cost of building materials and methods used, coupled to the provision of subsidised land and services.

Table 3 gives an indication of the order of magnitude of demand. Three categories of effective demand for housing are distinguished. Firstly, those that can afford houses of up to R20000. While some of these will not be able to afford any housing at all, the rest will have to be satisfied with non-conventional means and other types of core housing that can be upgraded later on. Next, the demand for housing with scaled down characteristics follow[46]. The third category involves those households which can afford 'conventional' housing.

---

43. Between 1950 and 1984 126176 families were resettled, 69548 of them in the Cape Province. (HSA, Oct 1987:35)

44. The UF confidential report estimates that twice as much land are allocated to whites in the Western Cape, while the number of people classified 'white' are half those classified 'coloured'.

45. See the argument by T Adler in SA Builder March 1988:20

46. An example would be the Delft 'affordable housing' project.

This would impact on the brick making industry in various ways. In the conventional housing segment, the change in state policies is important. Because developers must now sign contracts with individual owners, a 'stop-start' pattern of housing construction is developing. This results in developers building smaller batches of homes which are sold before starting again[47]. This has a major impact on the brick making industry, in that it requires smaller batches of VBE's rather than large continuous flows. This implies that the production processes have to become much more flexible, and able to adapt to variations in demand levels.

In the 'starter homes' sector it is unlikely that smaller builders will be able to make any major impact because of scale factors under the current circumstances. That will leave their role in the more saturated and smaller conventional market, and importantly, in the upgrading market if they are able to adapt to those kinds of circumstances. The potentially large upgrading market of the 'self-help sector' will require cheap materials in small volumes easily accessible to the builders. This might itself be affected by institutional factors such as financing arrangements.

47. Interview with Mr. Low from Murray & Roberts, October 1989.

B. METHODOLOGY

The analysis of technology is data intensive. A key methodological task will therefore be to develop analysis and measurement techniques which can be used to compress large amounts of data, that are often not strictly comparable, into a manageable format. In this section, the data used will first be presented, and the measurement techniques introduced.

1. Sources of data.

The data are primarily interviews with a cross-section of firms operating in the industry, as well as with individuals[48] closely related to the industry. Further data were obtained from secondary sources such as technical and academic publications related to the brick making industry, and the Central Statistical Services.

Two sets of historical data from within the industry were obtained. They are not necessarily independent. One was gathered by an individual, Mr. Low, who has been involved in the industry for a long time. The second originates from the records kept by the Western Province Masonry Manufacturers' Association [WPMMA].

a. The Low data set in Table 4 covers the period 1983 to 1989. It only gives yearly sales figures for concrete and clay products in millions of brick equivalents. That would include both VBE and

Table 4. Yearly sales of VBE in millions of brick equivalents.

YEAR	CLAY	CONCRETE	TOTAL
1983	444.0	-	-
1984	446.0	71.5	517.5
1985	330.0	82.2	412.2
1986	297.0	92.8	389.8
1987	377.0	140.0	517.0
1988	386.0	172.0	558.0
1989	316.0	155.0	471.0

Source: R. Low

48. These include suppliers of equipment, local government officials, academic and research personnel involved in a support capacity, and individuals that were directly involved in the industry in the past.

pavers. The data were originally compiled from personal resources, up to 1986. From 1987 the WPMMA served as the basis for the data.

b. The WPMMA data series in Table 5 has been kept up since the beginning of 1987. The data are derived from voluntary monthly returns of sales and stock figures by member firms. These are collated by the WPMMA, and total figures are returned to the members as a whole. They use the data to determine their individual market share[49].

However, the data from both sources only cover the larger firms in the industry. The composition of the contributing firms also changed over time, with clay VBE producers supplying information more consistently than concrete VBE producers. The columns labelled 'FIRM' in Table 5 indicate the number of firms that contributed each month. The total sales were divided by the number of firms contributing data in the concrete and clay masonry sections respectively for a particular month. In this way an average production per firm figure for each month in both sections of the industry were derived[50]. Note that small firms are under-represented, and have a different product mix from large VBE producers. They might also experience different seasonal and even cyclical patterns. So the data should be approached with caution.

c. The survey of brick making firms. Interviews were conducted during the period October to December 1989 with 29 firms. Prior to that, a list of firms engaged in the brick making industry was compiled (Appendix B). References were obtained from the classified advertisements section of local newspapers, the Yellow Pages, other firms, and by generally attempting to collect as

49. This data are sensitive and it is not easy to obtain, and for that matter verify, the data given.

50. This off course assumes that the different firms have exactly the same product composition, and that the firms that submitted data erratically were of average output with an average output profile.

Table 5. Monthly Brick Production per Firm. (In 1000 brick equivalents)
Source: WPMMA.

	CLAY						CONCRETE							
	----FACE---		PLASTER	-------TOTAL-----			--------FACE--------			---PLASTER--		------TOTAL-------		
MONTH	PAVER	BRICK	BRICK	SALES	STOCK	FIRM	PAVER	BRICK	BLOCK	BRICK	BLOCK	SALES	STOCK	FIRM
Jan 87	279	604	1917	2521	7257	9	85	5	10	164	501	680	1478	7
Feb 87	429	794	2691	3485	7874	9	156	4	33	273	697	1008	1534	7
Mar 87	411	909	3151	4060	7846	9	164	5	26	293	761	1085	1470	8
Apr 87	537	874	2649	3522	8403	9	143	11	14	362	687	1074	1514	8
May 87	434	765	2349	3114	8943	9	136	8	20	275	681	983	1569	7
Jun 87	468	962	2630	3593	8399	9	115	11	23	274	779	1087	1565	8
Jul 87	437	1025	3294	4318	7323	9	134	7	18	332	868	1226	1478	7
Aug 87	355	895	3734	4628	5718	9	290	4	16	520	817	1357	1191	8
Sep 87	497	870	3707	4577	5754	9	185	11	8	439	918	1376	1508	8
Oct 87	509	1145	3810	4955	5450	8	187	10	10	308	1150	1478	1189	8
Nov 87	650	1189	3381	4571	4855	8	238	7	10	364	1076	1456	1039	7
Dec 87	395	799	2383	3182	6405	8	95	8	4	175	601	787	1055	7
Jan 88	422	756	4380	5136	6144	8	64	6	5	297	816	1124	1143	7
Feb 88	432	1196	3377	4573	6272	8	120	13	8	308	1110	1440	1205	7
Mar 88	559	1137	3619	4757	6585	5	163	4	18	145	1211	1378	1235	7
Apr 88	442	941	2794	3735	7242	5	190	20	21	285	1331	1657	1093	7
May 88	387	990	2988	3978	6457	5	144	12	15	310	1020	1357	1392	7
Jun 88	342	1099	3333	4433	5833	5	217	15	15	165	1318	1513	1677	7
Jul 88	426	1054	3265	4320	5140	5	229	14	12	164	1180	1369	1520	7
Aug 88	459	1216	3657	4873	4398	7	210	12	15	389	1201	1618	1751	7
Sep 88	559	1256	3277	4532	3691	7	256	17	14	546	1413	1990	1767	7
Oct 88	596	1155	3478	4633	4100	7	245	12	4	363	1082	1461	1887	7
Nov 88	751	1007	3522	4530	4660	7	273	15	7	316	1045	1383	2014	7
Dec 88	350	405	1485	1890	6166	7	164	8	5	175	391	579	1861	7
Jan 89	439	702	2167	2869	7575	7	111	12	5	256	695	967	1605	7
Feb 89	531	819	2496	3315	8510	7	156	44	17	345	887	1292	1620	7
Mar 89	603	929	2460	3390	9634	7	181	14	10	285	849	1158	1969	7
Apr 89	544	835	2308	3143	9884	7	177	19	11	372	978	1381	1960	7
May 89	419	801	2525	3327	10269	7	153	12	10	348	937	1306	1919	7
Jun 89	392	859	2686	3545	9304	9	169	12	24	285	1233	1555	2237	7
Jul 89	333	732	2109	2841	9459	8	107	10	16	281	853	1160	2163	7
Aug 89	432	722	2872	3594	8670	9	112	11	38	261	1039	1349	2295	7
Sep 89	400	715	3027	3742	7296	9	144	16	11	275	1090	1392	2267	7
Monthly Average	461	914	2955	3869	7016	7.6	167	12	14	302	946	1274	1611	7.2

much information as possible from various other sources. It was not possible to draw a sample from these firms on any authoritative basis. Instead, it was attempted to get a proper spread of firms geographically and as far as possible according to the techniques in use by various firms. The names of the firms visited will not be indicated for the sake of confidentiality.

Interviews lasting for between one and two hours were conducted with the managers, or in isolated cases production managers of firms. They included a guided tour of the plant and facilities. In most cases interviews included observation of the actual production process which was then discussed with the interviewees. On the whole, people were prepared to give considerable information and insight into the nature of their firms' operations. With the exception of two firms[51], it was possible to get information about the financial situation of the firms as well[52]. A 'managerial bias' could be present due the managers being the only source of information apart from our own observations.

The structured interviews were recorded on tape, and later transcribed. While a lot of quantitative information was obtained, extensive note was taken of qualitative information indicating elements of the firm's nature that would otherwise not be available.

2. General method of analysis.

The analysis will aim to uncover what can be called the technological profile of the industry. This includes linking the characteristics of the economic, technical and institutional imperatives of each technique. The institutional sphere, together with the uncertainty which accompanies it should be added. There are trade-offs between all these dimensions[53].

The analysis techniques used will emphasize data exploration and description. Firstly, various descriptive techniques will be used to present the survey data. Then multivariate analysis tech-

51. It is suspected that these firms were in some form of financial difficulty.

52. The information given was generally not exact, based on the knowledge of the interviewee rather than financial statements. For instance, most of the financial data were based on an estimate for an 'average September month. This caused a lot of problems in making the data comparable and reliable. Throughout, it was attempted to limit these errors by cross referencing to other sections of the interview and comparing the results. It is not possible to describe each instance in which data were altered without jeopardising the confidentiality agreement with firms.

53. "[I]nnovative activity shapes the nature of trade-offs between various characteristics of technology as much as it reflects it." (Sahal, 1985:12).

niques, in particular the technique known as 'Correspondence analysis' [CA], will be used to describe the profiles of characteristics and achieve a reduction in the number of dimensions in the data. CA is principally a method to display a multitude of data in one graphical display (Greenacre 1984:3). It is really a variant of principal components analysis applied to categorical rather than continuous data. (Greenacre & Hastie 1987:446). "Correspondence analysis is an exploratory multivariate technique that converts a data matrix into a particular type of graphical display in which the rows and columns of the matrix are depicted as points" (Greenacre & Hastie 1987:437).

A non-technical explanation of the type of interpretation which can be made using CA boils down to taking the row and column profiles of a data matrix, and projecting them onto a first and second or third principle axis. Usually, these are taken in a two-dimensional plane. Row points that have similar profiles are organised close together on each axis. The same is the case for the column profiles. CA provides an explanation of the interaction or dependence between the rows and columns of the matrix. The orientation of each principal axis gives an indication of the principal components underlying or best describing the row and column profiles. The contribution of each principal axis to the total is indicated by the 'principal inertia'. But the contribution of each row and column profile to the principal inertia can further be seen in the geometric interpretation, in that they largely determine the orientation of the axis.

3. The measurement of technology.

There are a multitude of approaches that are utilised by analysts to measure technology, but none is generally accepted. An overview has been presented in Appendix A. This analysis will attempt to develop a method using CA, with elements from techniques developed by others working in the field.

It could be seen as the combination of a heuristic approach to the selection of characteristics and functions, with the engineering approach's concept of characteristics as clouds of points in multidimensional space with a trade-off surface reflecting the choices made under given economic conditions[54]. Thus, technology will be portrayed by a multidimensional trade-off surface, and each technique as a unique profile of points in n-dimensional characteristics space. CA is a unique method with which to analyze these profiles, in that the number of dimensions are reduced, and similar profiles are geometrically presented in clusters. The components that contributed most to this orientation are identified. In the rest of the analysis, the technological profile of each technique is compared with the others in the sample, and techniques that are similar are identified. Through supplementary points, their relationship with other characteristics are explored.

Furthermore, the 'quality' of each commodity will be represented by a properly weighted set of characteristics and functions. The specific characteristics that should be incorporated in the calculation are specific to the industry under consideration. The danger of choosing insufficient characteristics which then become misleading should also be noted[55].

In order to determine the characteristics to be included, the nine cell matrix developed by Van Wyk (1988:322-340) was used and extended into a sixteen cell matrix. Van Wyk focuses on the

---

54. Notice that the concept of a state of the art as a maximum achievable amount irrespective of costs does not feature in the analysis. The implicit argument is exactly that firms do not seek to push technology to the limits. They seek to make sufficient profits. We would as a rule expect firms not to use techniques that operate close to the technical limits - except under special conditions.

55. See Alexander & Mitchell, 1985:162

analysis of artifacts in terms of the function which they perform (process, transport, and store) and the nature of the output that they deliver (matter, energy, and information.). To this the output of 'feedback', and the function of 'control' was added. Sixteen basic functions which can be used to characterise any 'artifact', or commodity were therefore specified.

TYPE OF FUNCTION

OUTPUT		PROCESS	TRANSPORT	STORE	CONTROL
	MATTER	xxxxxxxxx	xxxxxxxxx	xxxxxxxxx	
	ENERGY	xxxxxxxxx	xxxxxxxxx	xxxxxxxxx	
	INFORMATION	xxxxxxxxx	xxxxxxxxx	xxxxxxxxx	
	FEEDBACK				

xxx - Van Wyk's model.

Van Wyk further suggests a number of 'standard trends' which could be used to measure technical progress of each function. These trends include two structural variables (size and complexity) and four performance variables (efficiency, capacity, density, accuracy). The scheme proposed by Van Wyk is primarily geared to measure individual commodities or 'artifacts'. But when applied to a production process in which large numbers of commodities are combined, two further problems emerge. Firstly, the production process comprises various steps, in which different inputs are used and intermediate outputs produced. Therefore, the way in which the various commodities should be weighted in the production process as a whole should be added. This was done using a trial and error method.

Furthermore, the sheer volume of data required to do an analysis of the kind Van Wyk proposes will make it impossible in the context of analyzing production processes rather than 'artifacts'. Therefore a proxy for the characteristics measurements must be sought. These can not be used as quantitative measures of the level of technology, but as a means of analyzing the profile with which various functions are combined in a single production process. The measure used as a proxy in this case will be the degree of mechanisation of each separate function in terms of one of three levels. Manual only, manual with some mechanisation, and completely mechanised. An example might make this clear. A manual brick press would use no other energy than human effort to form bricks. Then one find machines in which human effort to compress the concrete is aided with an electrical vibrator. Finally, the completely mechanised machines form bricks without any human effort in the formation function itself. Human effort might still be used to operate controls of the machine. But that is a different function - feedback processing - or giving feedback to the matter processing function which deals with the formation of the bricks.

The classification produced will then be used with a correspondence analysis to uncover the technical trade-off profiles. The simplicity of the coding system should be noted. Obviously, more sophisticated systems would have been preferable. But by keeping things simple, and using the CA technique which seemed to work well with this type of data, the analysis was kept manageable. A lot of scope for more sophisticated models exits.

C. CHOICE OF TECHNIQUE

In this section the choice of technique function developed in the previous chapter is used to analyze the choices of technique by the firms included in the survey. Based on an analysis of all the inputs into the production process, the relation between the product price, quality and efficiency of the firms is analyzed. The analysis of the various techniques' efficiency will form the basis for the subsequent analysis. Efficiency here refers to the 'total factor productivity' of the firm as a social and economic unit throughout this section. It has been measured as a relationship between inputs and value added per unit of capital and per worker.

1. The range of techniques included in the study.

Result 1 Number of production lines per plant.

NO OF LINES	FREQ	PCT	CUM%
1	28	75.68%	75.68%
2	6	16.21%	91.89%
4	3	8.11%	100.00%
CASES	37		
MISSING	0		

An initial overview reveals a significant diversity of techniques used in the industry. Of the 29 firms included in the sample, 22 (75.9%) produce bricks[56], while 17 (58.6%) produce blocks. 10 firms produce both bricks and blocks. Furthermore, 8 (27.6%) firms produce clay masonry products, while 21 (72,4%) produce concrete masonry products[57]. Of the firms producing concrete masonry products, 9 (31.03%) use egg-layers and 14 (48.28%) use static brick presses. 2 firms use both. Of the clay masonry producers, 7 (24.14%) firms use clay extruders, and one (3.45%) a hand mould. Two of the firms produce facing bricks in tunnel kilns, one uses a simple

---

56. Solid or hollow product which is light enough to be handled by a worker with one hand. The popular sizes are imperial (220x105x73) and maxi bricks (220x90x115)

57. Including calcium silicate products.

form of chamber kiln for facing bricks, and clamp kilns for non facing bricks. 6 firms therefore use clamp kilns. Three of the firms producing clay bricks use tunnel dryers, and the rest dry in the sun.

Result 2. Firm size distribution according to employment by occupational category.

Blue collar employment:

Employees	Firms	Pct.	Cum%
0-10	6	20.7%	20.7%
10-20	6	20.7%	41.4%
20-30	4	13.8%	55.2%
30-40	4	13.8%	69.0%
40-50	2	6.9%	75.9%
50-100	3	10.4%	86.2%
100-150	1	3.5%	89.7%
150-200	2	6.9%	96.6%
200-250	1	3.5%	100.0%

White collar employment:

Employees	Firms	Pct.	Cum%
0- 2	16	55.2%	55.2%
2- 4	7	24.1%	79.3%
4-10	2	6.9%	86.2%
10-15	3	10.4%	96.6%
15-20	1	3.5%	100.0%

Note: Percentages do not add due to rounding error

In the survey, a distinction was made between firms, plants and production lines. Firms are legal entities, and most of the economic information as well as the institutional information in the study are given for firms rather than plants. Plants refer to a single production technique used. It is obvious that a single firm could operate more than one plant at one or more geographical locations. Most of the technical information are given for plants, rather than firms. A single plant may have more than one production line of the same type running in the plant. Whereas a plant is a technical unit, a production line is an organisational unit. The sample comprises of 29 firms which include 37 plants, and 52 production lines. The concrete masonry producers experience more organisational variation, with smaller technical units resulting in more production lines per plant and per firm[58]. The clay brick industry, however, seems to be using only one production line per

58. Of the 21 firms in the concrete masonry industry, 2 firms have 3 plants, mostly at the same geographical site. Of the 52 production lines, 43 were in the concrete masonry industry.

plant, and mostly one plant per firm[59].

The firms are generally small to medium in size, although some are part of larger groups of companies. According to monthly sales value, 14 (48.3%) firms were small (less than R100,000.00) 8 (27.6%) large (more than R200,000.00) while 7 (24.2%) firms were medium sized. Result 2 summarises some indicators of firm size based on employment. Nearly 70% have less than 40 employees. 79% of firms have 4 or less white collar employees[60]. No single firm is extremely large. The biggest has about 230 employees[61].

2. Capital Labour ratios per unit of output.

The relationship between the capital services and labour services per unit of output[62] is presented in Figure III.1. It appears as if fewer substitution possibilities exist in the clay compared to the concrete masonry industry. Figure III.1 suggests that product quality differences are an important aspect of the choice of technique. Certain firms seem to be using both more capital and labour per unit of output. But they might be able to sell their bricks at a higher price to cover their costs. The implication is that the choice of technique analysis should incorporate the existence of heterogenous products.

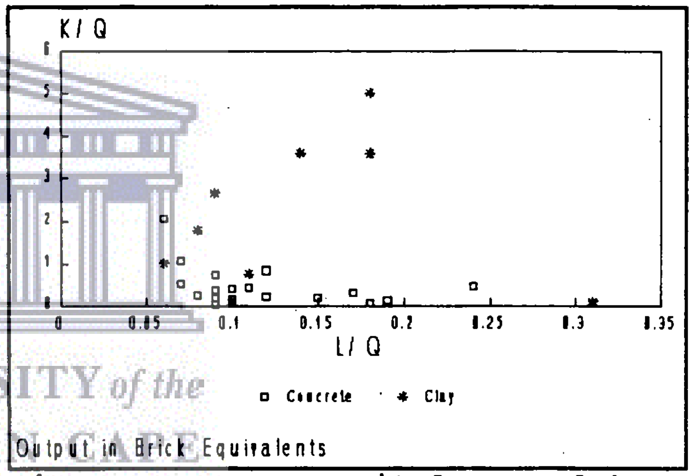


Figure III.1. Capital - labour substitutability.

59. The 8 firms in the clay brick industry have one plant each. One does have more than one plant associated with it. But it was only possible to include information about one plant in the analysis.

60. Including managers and clerical staff. Owner managers are treated as managers.

61. It should be noted that some sampling error is involved here. According to our information the biggest firm in the Western Cape has about 600 people employed directly and by direct subcontractors at three plants. Even this might be a low figure, since some of their other plants have been closed down.

62. Capital services were obtained by adjusting the capital stock at book value for capacity utilisation. For the sake of consistency, the value of land and delivery trucks were not included with the firms that had such investments. Labour services are the total number of labour hours by all employees in the firm.

3. Choice of technique in the context of heterogenous products.

The choice of technique function is closely related to an analysis of the relative efficiency of the various techniques. Efficiency is used here in the sense of total factor productivity, and not X-efficiency or similar usages. In order to make comparisons between firms, the wage rate, and the profit rate will be standardised in the way developed in Chapter II. Occupational and skill differentials will be taken into account as well. This leads to an analysis of the relationship between the prices and the quality of the output products.

a. Wage rate, profit rate and efficiency.

The wage rate was measured in two ways: as the average wage (the wages and labour bill divided by the number of employees) or the hourly wage rate. The latter, however, does not reflect the hours worked. In order to arrive at actual hourly wage rates, the hourly wage rates supplied by the firms were adjusted using the total labour costs of the firm. The proportion of the wage bill going to a particular occupational category[63] was divided by the number of labour hours expended[64] in order to arrive at the hourly wage rate for each occupational category.

The profit rate[65] refers to the ratio of the value of sales minus the capital costs, divided by the capital costs; not to the rate of return on assets. The capital costs comprise all inputs,

63. Four categories were used: unskilled, semi-skilled, skilled, white collar. See notes 72, 73, 74, 75 and 74 for more detail about the definitions.

64. Note that the number of hours overtime were included with the total number of hours. But no provision was made for the higher payment for overtime, and would be spread over the whole number of hours worked. A slight discrepancy might arise when differentiating between the wage rates for different skill levels.

65. Two firms were not prepared to give sufficient information in order to calculate the profit rates. Some figures could be constructed for firm [O], but should be treated with caution. Firm [D] was excluded.

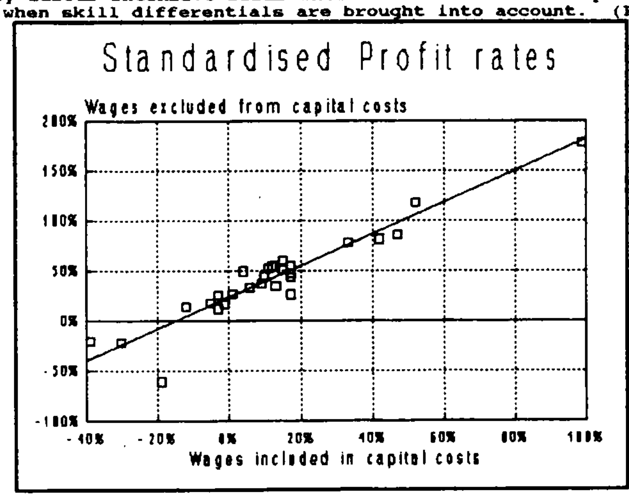
excluding labour costs[66]. Assets are represented as depreciation costs on a monthly basis. The return on assets for the firms in the sample were 43% on average if the firms were weighted equally[67] compared to 55.44% as defined above. This is the average profit rate that will be used as the basis for standardisation of the wage rates later on.

In Chapter II it was shown that the wage rate and the profit rate enable comparisons of the relative 'efficiency' of various techniques. At a given time, the distribution of income is given. Therefore the vector of relative prices is given as well. The value of the capital costs (inputs) can then be determined from (II.16). Thus, the value added (pV-C) and the way in which it is distributed between the workers and the owners of the capital[68] ($C\pi + Lw$) can be seen. Furthermore, more 'efficient' firms can be identified because they will be able to pay higher wage rates for comparable levels of π.

Figure III.2 presents the relationship between the wage rate and the profit rate for the firms included in the study. It exhibits the expected pattern (Figure II.3). But the existence of different skill and occupational levels have not been accounted

---

66. In order to make the calculations easier. It is assumed that wages are paid at the end of the period. Steedman (1977:105) has shown that it does not affect the results. We have looked at the different results if the profit rates are calculated using the various methods represented by the plot below. Distortion occurs in the case of very labour intensive firms where labour costs make up substantial part production costs. These are removed when skill differentials are brought into account. (R^2 = 89.14%)



67. If the profits and investments for all the firms in the industry are added, the collective return on assets drops to 10.5%, signifying that the smaller firms maintained a higher rate of return on assets.

68. See Pasinetti, 1980:22 for a generalised treatment of this matter.

for. Firms with more skilled labour, receiving higher wages will result in inflated average wage rates, and vice versa.

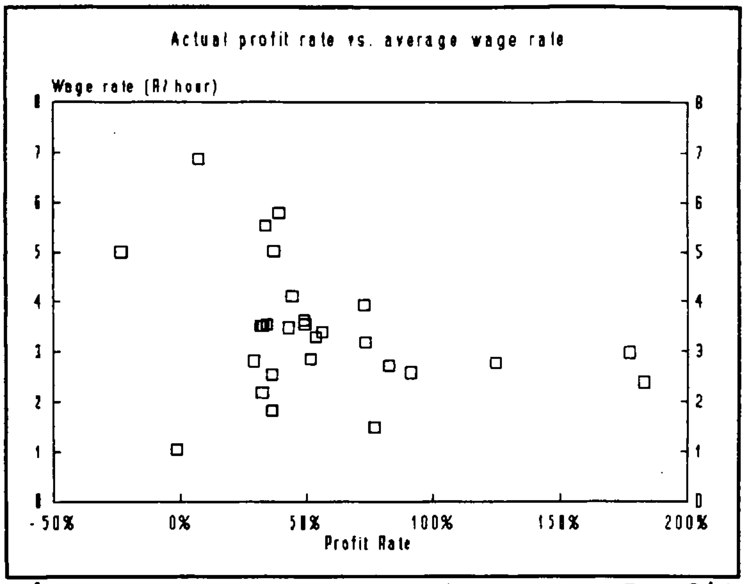


Figure III.2. Wage rates vs. Profit rates for 28 brick making firms.

Therefore, a number of standardisations were made. These transformations are based on the presumption that the cost of capital inputs and labour time are given with the given income distribution at a specific time. Similarly the volume of output is given. From (II.16) it follows that three parameters measure the relative efficiency of the firms: p, π and w. If the firm is very efficient, it would either have higher wage or profit rates than other firms, or would be able to reduce its price, p. Thus, the data for the various firms must be standardised in order to be comparable. Initially, the level of prices for each firm will be taken as given.

b. A standardised profit rate.

The average wage rate w' and profit rate π' for each of the firms[69] were calculated first, and then a standardised profit rate π^s using (II.16)[70]. π^s represents the profit rate that the firms would have received charging p for their products, but paying w' wages to their employees. The same was done to get a

69. Note that the firms contributed equally to the determination of the average wage rates, and the average profit rates where they were calculated. They were not weighted according to firm size or some other criterion. The calculations done were also based on hourly wage rates and employment levels.

70.

$$\pi^s = \pi + \frac{(w' - w)L}{C}$$

standardised wage rate[71] w^s, which is the average hourly wage rate which the firm would have been able to pay to its workers and still retain the average profit rate π' (55.4% in this case).

But when skill structures and wage rates for different occupations vary, an average wage rate introduces some distortion into the transformations. For instance, where a firm employs predominantly unskilled workers the average wage rate w^* for the firm might be lower than w'. But the firm might be paying higher wage rates per skill or occupational category than the average for the industry as a whole.

Table 6. Average profit and wage rates for 28 firms.

Profit rate (wages part of costs)		15.2%
Profit rate (wages excluded from costs)		55.4%
Monthly wage rate		R664.91
Hourly wage rates:		
Average (all occupations)	w	R 3.31
Unskilled	w_u	R 2.11
Semi-skilled	w_s	R 2.83
Skilled	w_a	R 9.57
Managerial	w_m	R 14.87

Therefore, skill adjusted standard profit rates, π^{sk}, were calculated. Data were collected on the number of employees that worked in each of 4 occupational categories: unskilled labourers l_u, semi-skilled machine operators[72] l_s, skilled artisans and supervisors[73] l_a, and finally, clerical and managerial employees l_m. Data on the number of ordinary and overtime hours which blue

71.

$$w^s = w + (\pi - \pi')\frac{C}{L}$$

72. The criteria used to distinguish between unskilled and semi-skilled employees were: The existence of wage differentials; The type of work performed (e.g. machine operators); The extent of training and experience needed to perform a job.

73. Skilled workers had some formal apprenticeship training. However, it was not always possible to separate skilled and supervisory staff. Apprentices often performed some kind of managerial function as well, especially the smaller firms. Consequently, the skilled artisans and supervisors were lumped together.

collar workers worked[74] per week were collected as well. Hourly wage rates w_u, w_s, w_a, w_m could therefore be computed. Average hourly wage rates for all the firms w_u', w_s', w_a', w_m' were calculated as well[75]. They are presented in Table 6.

Figure III.3 represents the results of this standardisation exercise. The firms were sorted according to the skill adjusted standard profit rate

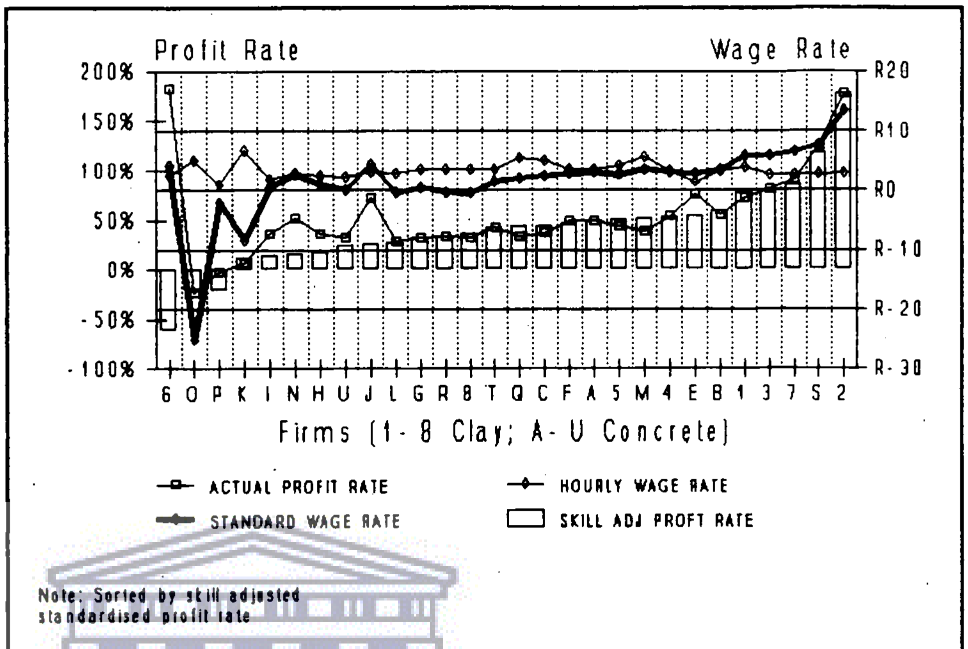


Figure III.3. Comparisons of the relative efficiency of 28 brick making firms.

π^{sk}. This can be interpreted as being from the least to the most efficient. Compared with the qualitative information gathered during the interviews, the ordering seem to make intuitive sense. Notice that a small clay brick firm [6], using no mechanical preparation equipment at all is least efficient. The most efficient firm [2] is a clay brick firm with a characteristic productivity bonus scheme whereby workers are paid progressively more for each unit of bricks completed. They also use some of the least expensive mechanised preparation plants, operate throughout the year, and have made a lot of their equipment themselves, indicating the presence of shopfloor based learning processes. A similar situation was found in firm [S], producing concrete

74. It was presumed that clerical and managerial employees worked 40 hour working weeks, with no overtime. This might be an underestimate for the smaller firms. Supervisors were presumed to work the same hours as skilled artisans.

75. It not possible to obtain data on the remuneration levels of managers, nor of the profits that went to owner managers. In order to at least leave the firms comparable a managerial salary was imputed to all managers where more detailed information was not available. See the section on the economic analysis for a more detailed discussion.

masonry.

The values for π^{sk} are given by the bars in Figure III.3. Notice the S shaped distribution. Furthermore, some indication of how the standardisations affect the data for the firms can be seen. The least efficient firm [6] has a very high actual profit rate while the actual wage rate is quite low. But the technique used is labour intensive, and wages make up the biggest part of the costs of the firm. Therefore, raising wages to the industry average levels results in the profit rate falling well below zero. The opposite is the case for firm [0] which is capital intensive, but operates inefficiently, with low profit rates to start with.

c. Efficiency, prices and quality.

It follows that the actual product price level[76] could influence the evaluation of efficiency substantially. If it was possible for a firm to maintain their prices sufficiently high relative to their productivity, then the presumption that price levels can be left out of the analysis is mistaken. Two possible reasons can be advanced why such price differentials exist: The market structure in the industry[77]; or the relation between the prices of the products and their qualities. Both would provide elements of monopoly power to the incumbents allowing them to increase prices relative to productivity.

Note that the measure of efficiency is based on the production costs of inputs (both labour and capital) plus mark-up. Heterogenous products do not affect the efficiency measures, in so far as producing different quality products entails different

---

76. The price measures are not derived from the list prices but from the financial data gathered from each firm. The sales figures were translated into volume units and the average price per volume was determined. In so far as it was possible, product diversity were taken into account when calculating the volume output.

77. Different levels of mark-up will have to be explained. In particular, a distinction should be made between temporary monopoly rents due to innovation, and monopoly rents due to power relations between firms. The former have something to do with efficiency, the latter not.

input costs. However, if heterogenous products enable differential mark-ups, the focus has to shift to the institutional arrangements which allow this to happen.

Figure III.4 shows the relationship between the efficiency (π^{sk}) and the average product price of each firm. No simple pattern can be seen. As the profit rates increase from left to right, the actual price varies almost in a random fashion. This is confirmed by an initial analysis of a scatter plot of the data in Figure III.10.

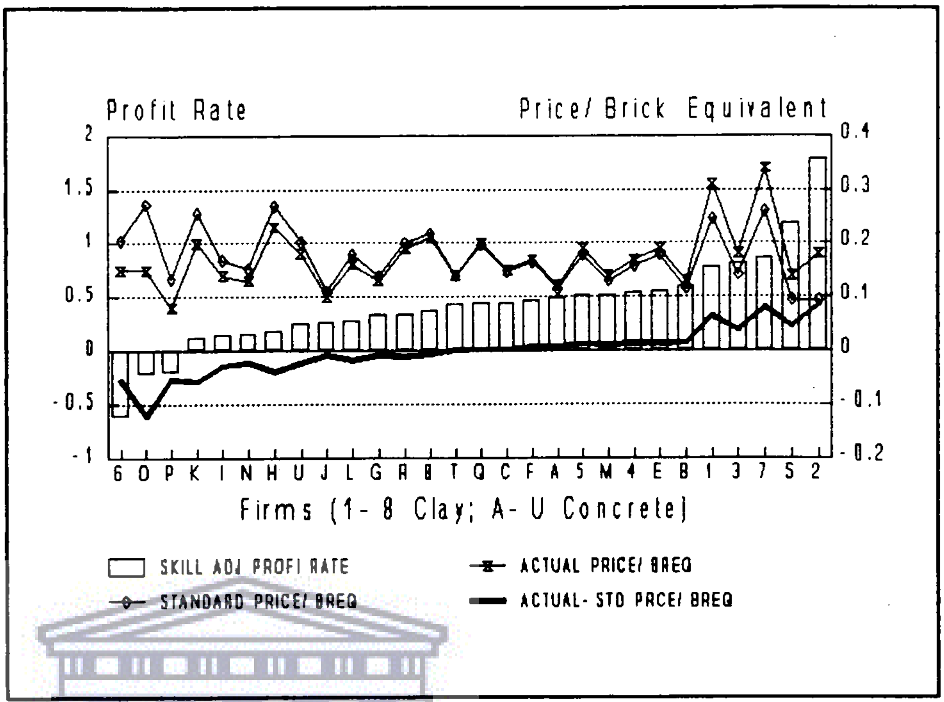


Figure III.4. Relationship between product price and firm efficiency.

Figure III.4 further shows the relationship between the actual price p, and the standardised price p'[78]. The latter is calculated[79] and shows the prices which the firms should have charged had they all paid the average wage rates, and received the average profit rate.

The difference between the standardised and actual price level follows the same pattern as the standard profit rates. This is

78. In Figure III.4 the prices are expressed per brick equivalent. Other measures of output such as the weight could also be used. But it will be shown later that output per ton is not a good measure except when looking at raw material usage.

79. π'' is the average standardised profit rate for the industry as a whole and π' for each firm. Standardised price p' is given by

$$p' = p + (\pi'' - \pi')\frac{C}{V}$$

to be expected in the light of the trade-off between p, w and π. Note however, that the absolute levels of both the actual and the standardised prices follow a similar pattern. But neither seems to show any simple relation with the profit rates. It suggests that the actual price level is determined by something other than the 'efficiency' of the firm only. Apart from quality differences and market structures, the perceived pattern might also be the result of the choice of output measures.

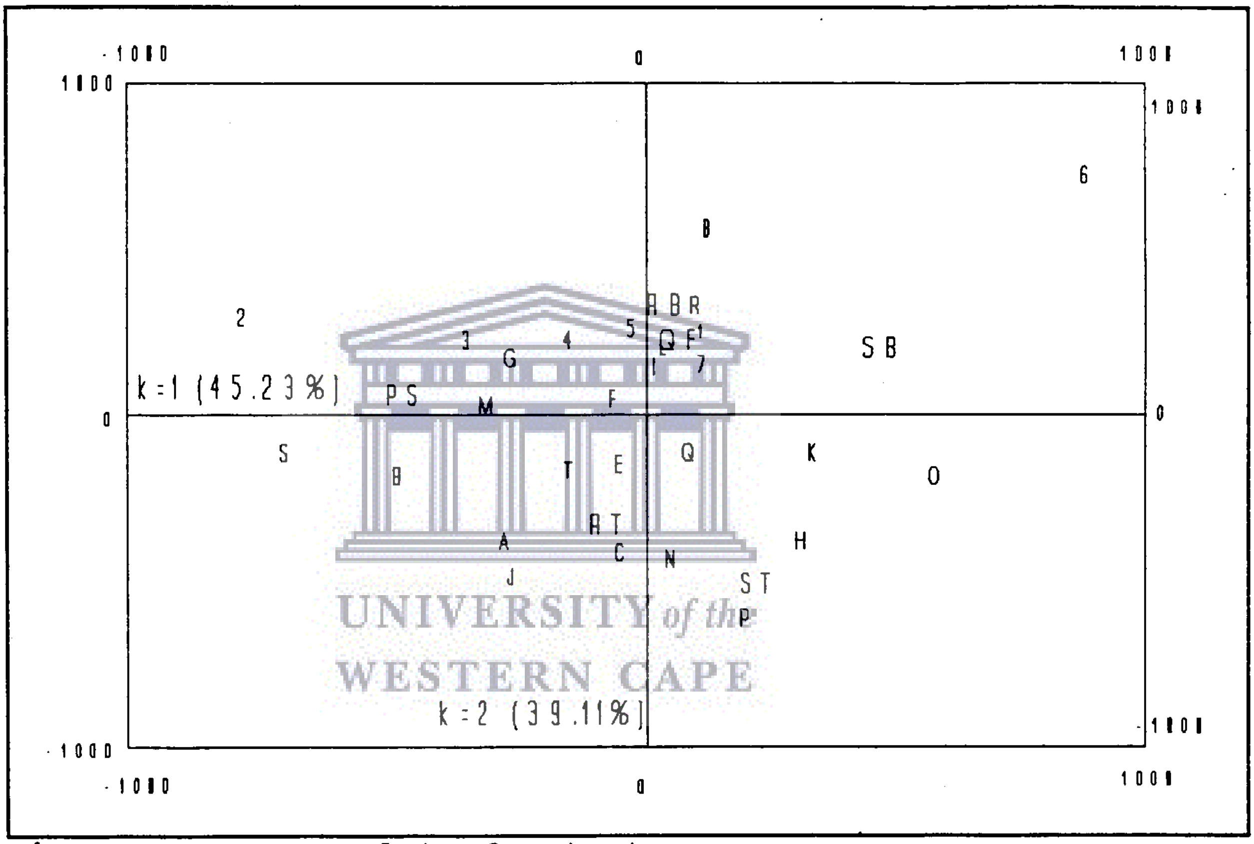


Figure III.5. CA plot of output measures.

An alternative output measure could be weight rather than volume. But Figure III.5 suggests that neither of the output measures has any correlation with the efficiency indicator. Figure III.5 is a CA plot, of which the column contributions were given by the standardised profit rate [PS], the price per brick equivalent [RB] and per ton [RT] as well as standardised prices[80] per brick equivalent [SB] and ton [ST]. Firms with above average efficiency levels would be expected to have below average prices. That is

80. A standardised price would be the price that a firm would have to charge if they wanted to have average wage and profit rates.

not the case for actual prices measured either in terms of volume [RB] or weight [RT]. These two points both lie at right angles with the horizontal axis, and [PS]. The orientation of the vertical axis is determined by the price per brick equivalent [RB] upwards, and the price per ton indicator [RT] as well as the standardised price per ton indicator [ST] downwards. The orientation of the firms show that those in the bottom half [P;N;H;C;A;J] (corresponding with above average price per ton values and below average price per brick equivalents values) produce hollow concrete blocks only. The firms in the top half produce solid bricks only. It is interesting that both clay and concrete brick producing firms find themselves here. Figure III.5 therefore confirms that product differentiation rather than choice of output measures are responsible for the absence of a correlation between absolute price levels and efficiency. In Figure III.5 the quality indicator [QF] lies adjacent to the price per brick equivalent indicator [RB], but to the opposite side of the price per ton indicator. This suggests that products with a high price per volume tends to be of above average quality and below average price per weight.

Furthermore, the price per brick equivalent indicator is more suitable as a measure of output than a weight based measure when it comes to quality measurements. A quality index based on a range of characteristics measurements was constructed[81]. It can be seen from Figure III.7 that a close relation between the price of a product as measured in brick

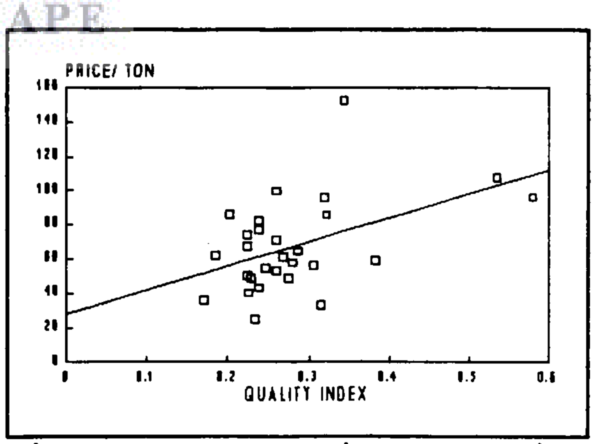


Figure III.6. Price - quality relationship (R^2=.225 with price dep.)

81. A full explanation of how this index was created will follow later.

equivalents, and the quality index number exists[82]. This relation is not so strong between the quality index and the price per tonne[83] in Figure III.6.

A further reason why the price per brick equivalent is a more suitable measure than a price per ton is that users of the bricks normally don't buy brick on a per tonne basis, but on a volume basis.

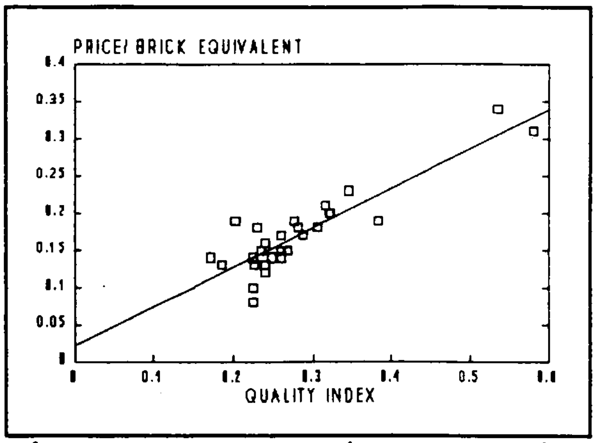


Figure III.7. Price - quality relationship. (R^2 = .772 with price dep.)

But the correlation between quality and actual price levels is not the only factor affecting the actual price levels. It appears as if firms producing certain qualities of products have been able to raise their prices relative to the efficiency with which they operate. In Figure III.5 no correlation between the price per brick equivalent [RB] and the standard profit rate [PS] (efficiency) is apparent. However, as soon as the price level is adjusted to where firms would pay average wage rates and receive average profits, a negative correlation develops between the standardised price [SB] and profit [PS] rates. But the relationship between the price [SB] and quality indicator [QF] becomes much weaker[84].

This suggests that actual price and quality of products are closely related, but different firms producing certain types of products were able to increase the actual price level relative to the industry average. Product differences might therefore also

82. The regression had a R^2 of .772, and the quality index had a coefficient of .53 at a significance level of 0.000 with the price per brick equivalent dependent. If the standardised price per brick equivalent is taken as dependent, the R^2 drops to .319

83. The regression had a R^2 of .225, and the quality index had a coefficient of 140.1 at a significance level of 0.009 with the price per ton dependent. If the standardised price per ton is taken as dependent, the R^2 drops to .057

84. See footnotes 82 and 83.

shape the inter-firm relations themselves.

The ratio between price and quality index is instructive in this regard. If firms passed on efficiency gains to their customers, it would mean that more efficient firms would have higher quality/price ratios than less efficient firms relative to the quality of the products they produce. That would entail that prices are determined on the basis of average production costs rather than some external price setting measure. However, if firms with certain techniques are able to produce at a higher margin, no direct relation between price and quality needs to be manifested.

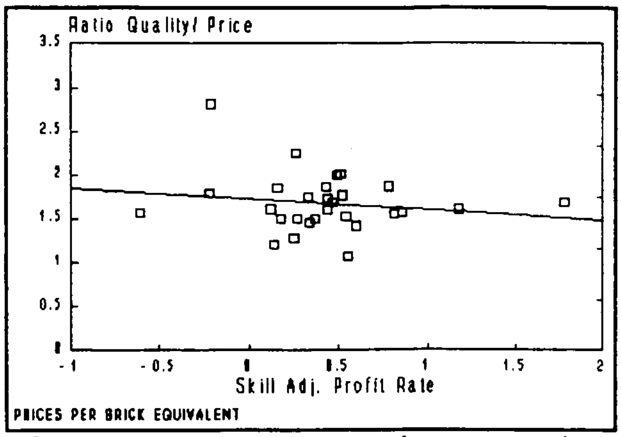


Figure III.8. Quality, price and firm efficiency. (R^2=.025 with standard profit rate dependent)

The latter seems to be true in this case. In Figure III.8 the quality/price ratio was plotted against π^{sk}. No linear relationship was found (R^2=.025 for π^{sk} dependent and the price per brick equivalent independent[85]). In Figure III.9 the quality/standard price relationship is plotted. Here a positively sloping relation (slope = .712) was found if the quality/standard price per brick equivalent measure is taken (R^2=.644 with the π^{sk} dependent[86]). This is similar to the hypothetical case in which all the effi-

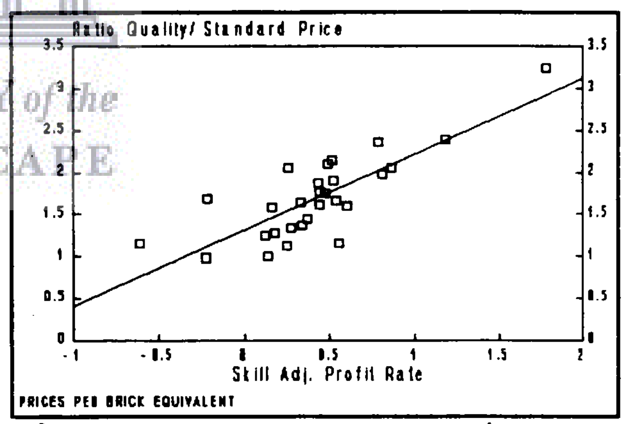


Figure III.9 Quality, standard price and firm efficiency. (R^2=.644 with standard profit rate dependent.)

85. If price per ton is used as independent variable, R^2=.033

86. If quality/price per ton is used as independent variable the relationship becomes much poorer with R^2=.233

ciency gains are given through to the users in the form of lower prices.

In conclusion, it appears that product quality differences combined with inter-firm power relations rather than measurement distortions underlie the observed price differentials. Furthermore, quality differences seem to be an integral part of the power relations between firms in the sector as well. This suggests that the structure of demand in a social use is a key component in determining the nature of inter-firm power relations. Identifying market niches created by consumer preferences for products with specific characteristics is a key aspect which has to enter the decision making of every firm. In certain circumstances the technical conditions in such a market structure could facilitate the formation of monopolistic conditions in which firms are able to raise their prices more than their level of efficiency would normally allow for. Matching the technical conditions of production with the structure of demand will be a key factor in the viability of cooperative firms.

d. Price, quality and efficiency: the position of individual firms.

The result so far, that a close relationship between the technical and demand issues in the form of the quality and price of outputs exists, was expected. The lack of a linear relationship between prices and efficiency given product heterogeneity was also suggested by the theoretical model. This relates back to Figure II.4 of the technical choice model developed in Chapter II. In Figure III.10 two sets of graphs were combined: The first depicting the relationship between the price/brick equivalent and the standard profit rate (π^{sk}); and the second between the quality index and the standard profit rate

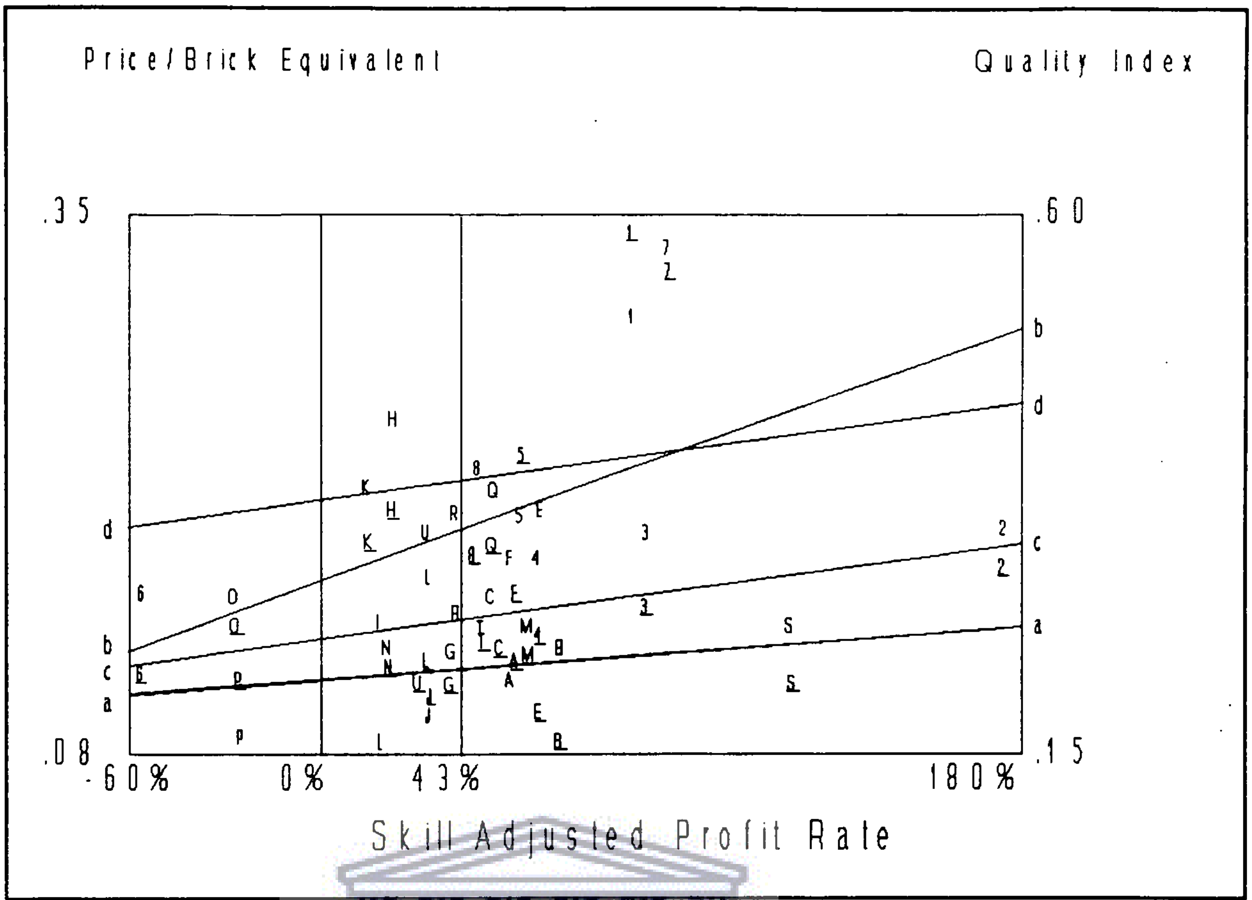


Figure III.10. Price, quality (underlined) and efficiency per firm.

(π^{sk}). The code for each firm is entered on the plot, and for the quality index data the firm code is underlined.

Notice firstly the close relation between the price and quality plots. But more interesting is the way in which the firms are grouped on the plot. The theoretical model suggests that each product associated with a particular quality will be able to function in a viable space. This space will be bounded by the minimum level of wages and profits acceptable, as well as the existence of another product with a higher quality which provides an upper boundary beyond which the price cannot move[87].

In Figure III.10 the firms can be divided into different areas based on the price that they charge per brick equivalent, taking into consideration the type of production technique and the nature of the product that they produce. The area below line aa

87. The specific relationship between quality and prices could be much more sophisticated if needed.

contains information for all those firms that produce hollow concrete block products with manual processes [A,B,J,P]. The average capital cost[88] to output ratio for these firms is .0737. Two firms, [E,I] do not fall in the same area even though they use the same processes. However, they produce bricks and not hollow blocks. The area between lines aa and bb contains information for those hollow block making firms that generally produce with some type of mechanical equipment, [C,F,G,M,N,T,S]. The average capital cost to output ratio for these firms is .0905.

The area above line bb contains those firms which produce high quality concrete blocks, generally with quite highly mechanised techniques, [K,O,Q][89]. The capital cost to labour ratio for these firms is on average .1741. Interspersed between the mechanical and manual block making plants are the (solid) brick makers, concrete and clay. The area in which they fall is bounded by lines cc and dd. Notice that the clay brick producers [2,3,4,5,8] seem to be more efficient than the concrete brick firms [E,I,L,R,U]. The concrete bricks also seem to be more expensive than the clay bricks. They are definitely more expensive than the hollow blocks, except those produced by the big firms with capital intensive production techniques. The average capital cost to output ratio here is .1100.

The clay face brick producers, using tunnel kilns, [1,7] are found above line dd. Notice that firm [5] also produces high quality products and some face bricks, but their prices are significantly below the relative quality of their products. The average capital cost to output ratio for these firms is .1634.

In this section therefore, the basic choice of technique

---

88. Notice that this is not the capital services to output ratio which would have been much lower. This is due to the cost of raw materials that are also included with the capital costs.

89. Firm [H] which falls into this segment is producing a specially designed block which is used without mortar, but produced with a less mechanised process. It is therefore something of a special case.

determinants were identified as the existence of heterogenous products in the context of uncertainty and a structure of demand that has to be related to the technical conditions in the industry. They are the same for each firm, cooperative or not. It was also shown that this is very close to what was expected given the theoretical analysis in chapter II. In the subsequent sections the economic, technical and institutional imperatives which both constrain and enable a cooperative firm to choose any of these techniques and to operate it efficiently, will be analyzed.

D. ECONOMIC STRUCTURE.

The economic structure can be seen as the outcome of the learning processes by each enterprise. These outcomes will be dealt with in two parts. Firstly, the way in which the firms interact with the external environment in which they operate will be analyzed. The second part analyzes the learning processes involved more directly with the economic aspects of each firm: capacity utilisation, investment and cost structures of firms and how these relate to product, technique and firm size characteristics.

1. Learning and the external environment.

a. Dealing with seasonal variations.

Seasonal fluctuations have a major impact on the production and demand profiles of firms. It seems that climatic conditions are a key source of seasonal fluctuations.

Each firm was asked how seasonal factors affected their firm. 76% experienced low sales in winter, with two major sources of decline: winter rain reduced building activity, and rain reduced the production capacity of clay firms using clamp kilns, and concrete firms using mainly egg-layers on an open slab without roof cover.

Table 7. Seasonal changes affecting the brick making industry.

a. Months during which highest and lowest sales were recorded:

Period	Highest	Lowest
Summer	15 (83%)	4 (21%)
Winter	3 (17%)	15 (79%)
Missing	12	11

b. Experience of Seasonal Changes in Demand for their Products.

Low in winter	(76%)	19
No clear pattern	(4%)	1
Peak in December	(4%)	1
Winter better	(12%)	3

Missing = 5

However, 3 firms reported better sales in winter than in summer[90]. They produce clay and concrete bricks (as opposed to hollow blocks) in winter[91]. Finally, one firm experiences a peak in December when the other firms close down. This is a small firm, using mainly hand-equipment to make concrete blocks. These are sold to owner builders during the holiday season.

In order to deal with these variations in production levels, firms pursue one of two strategies: some firms carry increased stocks while others lower production. This has significant implications for the need for firms to be flexible, and might affect areas like capacity utilisation etc. A priori it would seem likely that more mechanised firms would build up stocks, while less mechanised firms cut down on production. Two reasons can be advanced: the cost of machines relative to the raw materials and labour in the finished product is higher with more mechanised firms; and bigger mechanised plant with a process-type of technology might not be able to reduce the number of workers employed with decreases in production levels for technical reasons. It can then be expected that clay brick firms operate largely on full capacity, carrying stocks to deal with fluctuations. Big producers of concrete products also carry stocks to deal with fluctuations. But they are more flexible than clay producers. Smaller concrete masonry producers are much more flexible in so far as production volumes go.

The size of stocks relative to sales per firm for both clay and concrete products was traced for the period January 1987 to September 1989[92]. Figure III.11 suggests that concrete brick firms have lower levels of stock relative to sales, compared with clay brick firms. This result is strengthened by the curing time

90. Apart from the face brick factories, only two firms produce non-facing bricks in winter: one uses a dryer and a type of chamber kiln, and the other only a clamp kiln.

91. These tendencies could not be identified using the data by the WPMMA, because it is not sufficiently disaggregated.

92. Derived from the data supplied by the WPMMA. See the section on methodology.

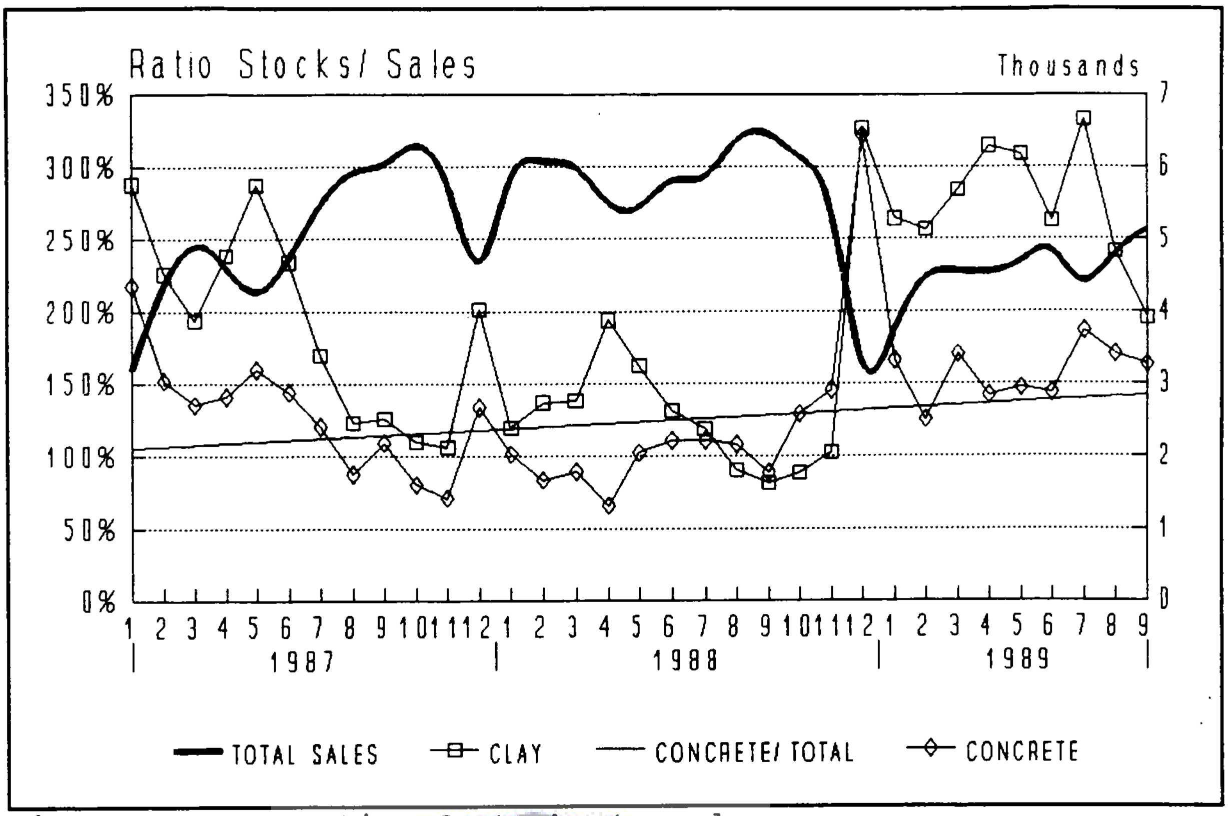


Figure III.11. Ratio of stocks to sales.

of up to three weeks after production required by concrete products. But the data above have a number of problems, the biggest of which is the bias against smaller firms.

Result 3. Independent Samples T-Test on the Stock/Sale ratio of three groups of firms.

<u>SMALL CONCRETE PRODUCERS.</u>

GROUP	N	MEAN	SD	
Small Concrete	16	0.617	0.501	
Big Concrete	5	2.910	1.682	
SEPARATE VARIANCES	T= 3.008	D.F.= 4.2		PROB = .040
POOLED VARIANCES	T= 5.027	D.F.= 19		PROB = .000

<u>BIG CLAY VS. BIG CONCRETE PRODUCERS.</u>

GROUP	N	MEAN	SD	
Big Clay	7	2.925	3.278	
Big Concrete	5	2.910	1.682	
SEPARATE VARIANCES	T= 0.010	D.F.= 9.3		PROB = .992
POOLED VARIANCES	T= 0.009	D.F.= 10		PROB = .993

The data collected during the interviews were then used and recoded into three groups: big[93] clay producers; big concrete producers; small concrete producers. The stock/sales ratio of each firm was calculated, and the groups compared. The results, presented in Result 3, were contrary to expectations in one respect. There seems to be no difference in the stock/sales ratio between the big clay and concrete brick producers. However, the smaller producers have stock holdings that are much smaller relative to sales than the big producers (61.7% compared to 291%)[94]. Clay brick firms have to operate at a much higher capacity to remain viable[95]. They therefore rely on stocks rather than idle capacity to deal with fluctuations[96]. The same seems to be the case with big concrete block making plants.

This is a finding which is relevant to the choice of technique by a cooperative. Smaller firms seem to absorb seasonal variations in reduced production rather than higher stockholding. Such variability of incomes can be quite problematic, especially in so far as fixed membership rather than casual workers are involved.

b. Cyclical factors and the choice of technique

Cyclical factors further affect the choice of technique in the industry. Many of the interviewees emphasised the peak-trough nature of the building industry in the Western Cape, and suggested that this impacted significantly on technical decisions[97]. The tendency has reportedly also been for the

---

93. Firms with a total investment in plant and equipment below and above R1m.

94. It should however be noted that the findings above are made on a single observation of data for each firm. Furthermore, there are two factors that might influence the conclusions above. Smaller concrete brick plants might be growing fast in new markets or increasing their market share. Both would tend to reduce stock levels relative to sales.

95. M. Ingram, August 1989.

96. One clay brick plant is preparing to deal with these variations in a new way. They have a relatively low machine cost component which is due to them rebuilding run-down second hand equipment. Consequently, they want to move away from building up large stocks during summer, and rather keep the level of production constant using chamber kilns and dryers.

97. It is suggested that these cyclical fluctuations will seriously inhibit large investments in plant, when there is uncertainty about the level of demand.

cycles to become shorter and more severe. Some years ago, Corobrick estimated the Western Cape masonry market at around 750 million brick equivalents per annum. The actual demand in 1989 was most probably only 500 million[98]. Actual data are difficult to obtain, but the data supplied by Low provide some idea of the development of the industry over time[99]. Figure III.12 shows the cyclical nature of the sales of especially clay masonry. In the concrete VBE industry, however, the cyclical changes have been less severe. This is most probably because of the high growth rate that the industry has achieved. A simple least squares regression of the sales levels on time gives some sort of indication of the trends. The results are to be found in Result 4. The indication is that concrete masonry sales grew by 21% per annum since 1984 with the projected curve explaining 78% of the variance. The clay masonry industry had a negative growth rate of -11,5% per annum. However, only 15% of the variance is explained by this regression.

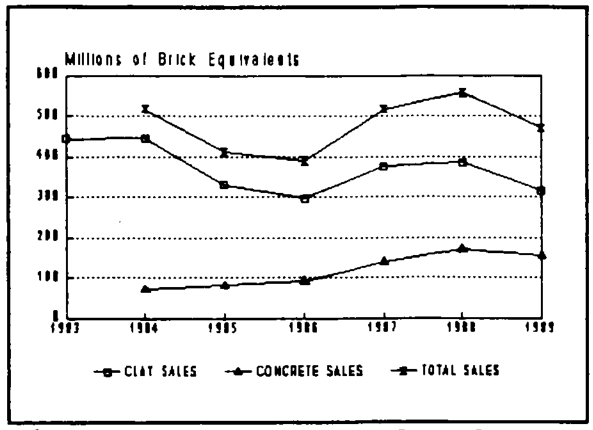


Figure III.12. Annual sales. Source: R. Low

The ability of firms to cope with these cyclical trends is affected by the cost structure of the firms, which is derived from the technique that the firm uses. Firms with high fixed/variable cost ratios are less able to operate at low capacity, and would be more vulnerable in the case of demand instability. The cost structure of the firms will be analyzed in the next paragraph. A preliminary conclusion is that larger clay brick firms[100] and some large and mechanised concrete firms are more vulnerable than smaller concrete firms with lower fixed

98. Interview with K. Ingram, August 1989.

99. The production of pavers is included in the data. For the period 1987 to 1989 pavers constituted approximately 10% of total sales.

100. Some of the larger clay brick manufacturers close down whole plants when the demand drops, and then restart them. (R. Low, November 1989).

Result 4 Least Squares Regression of Sales Data on Time.

TOTAL SALES =	(9.429) TIME	- (337.90)	
Significance:	(0.608)	(0.829)	
R^2	0.0717		
Adjusted R^2	-0.1602		
CLAY SALES =	(-11.485) TIME	+ (433.32)	
Significance:	(0.444)	(0.009)	
R^2	0.1523		
Adjusted R^2	-0.0595		
CONCRETE SALES =	(20.974) TIME	- (17.41)	
Significance:	(0.007)	(0.556)	
R^2	0.8705		
Adjusted R^2	0.8382		
Observations: 1984 - 1989 (yearly)			

costs. The limited access which cooperatives have to capital to carry large amounts of stocks, suggests that they would have difficulty in entering these industry segments.

In all, smaller less mechanised firms seem to be more flexible in the face of demand variations. But much of this is at the cost of jobs for casual unskilled workers. As with the seasonal variability, cooperatives with a relatively fixed membership might not perform as easily in the small scale sector unless a way is devised to deal with two matters: periodic slumps during which the production levels have to be curtailed; and boom periods in which production has to be expanded rapidly. Strategies such as diversification as well as appropriate marketing will have to be part of such a package.

c. Substitution of Concrete for Clay products

A further question is whether the higher growth rate of concrete block products relative to clay products represents a simple substitution, or the opening of new markets.

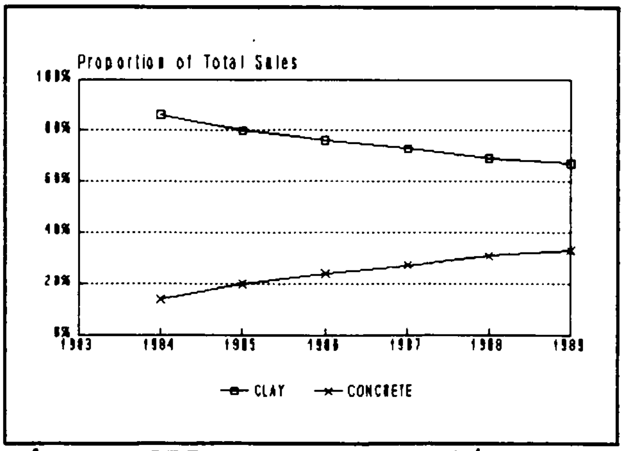


Figure III.13. Proportion of Total Sales.

Some of the interviewees suggested that the industry as a whole was declining, but that concrete products were growing and were making inroads into markets previously held by clay brick manufacturers. Some even suggested that this occurred at a rate of 5% pa. This is apparent when the sales of concrete and clay products relative to the total sales are compared. In Figure III.13 a fairly smooth rate of substitution emerges, tapering off at a 33% of total sales volume level.

But it is also possible that low cost housing projects have presented whole new markets, given the overall trends which Result 4 shows. This is confirmed by the large number of smaller firms producing concrete blocks that were established in the last 5 years[101].

The implications for establishing new cooperative firms are that the growth in concrete products sales seems to be tapering off (Figure III.12 and Figure III.13). If new firms were to be formed, their ability to orientate correctly in terms of new and growing markets will be crucial. This might well mean that the viability for establishing cooperative firms on any significant scale will depend on institutional factors such as finance

101. See the section on technical matters later on.

provision for housing and state housing policies.

d. Marketing and sales strategy.

The economic relation between the enterprise and the external environment ultimately concerns a correct reading of, and catering for effective demand. This has been identified as a key component in the choice of technique in Chapter II. How did the various firms structure the relationship with their customers? During the interviews, questions were asked about who the major customers of the firm are; where most of their sales went to; and what marketing strategy was used. The results are presented in Result 5.

The most important component in the marketing strategy seems to be a personal or informal relationship between brick maker and builder. 59% of firms reported this as the most important component in their marketing strategy. A second finding is that the security of receiving bricks on time, in the quantities required, is very important especially for the bigger construction firms. This seems to be the reason why big construction firms deal with big brick producers, and are even prepared to pay a premium for those products. Smaller firms, especially producing clay bricks, likewise tend to build up relations with smaller contractors.

One bigger concrete block manufacturer concentrates on the smaller clients when demand is high, because of the higher margins on the sales to smaller customers. In the difficult times, they concentrate on the bigger firms to get their products out, and because of the credit risk which smaller builders pose.

The market structure appears more clearly in a correspondence analysis on the recoded responses presented in Result 5. Notice

Result 5. Views on Each Firm's Relationship with the Market, their Market Profile and Strategy.

BARRIERS TO ENTRY AS IDENTIFIED BY EXISTING FIRMS

CODE	FREQ	PCT	LABEL
EA	9	42.86%	FINANCE
EB	10	47.62%	MARKET SHARE/STRUCTURE
EC	3	14.29%	TECHNICAL
ED	1	4.76%	EASY TO ENTER

CASES --> 28 MISSING --> 8

CUSTOMER PROFILES

CODE	FREQ	PCT	LABEL
EE	5	17.86%	OWNER BUILDERS
EF	7	25.00%	SMALL CONTRACTORS
EG	6	21.43%	MEDIUM SIZE AND A SPREAD
EH	10	35.71%	LARGE CONTRACTORS

CASES --> 28 MISSING --> 1

GEOGRAPHICAL AREA OF MAJOR SALES

CODE	FREQ	PCT	LABEL
EI	1	3.85%	SWELLENDAM
EJ	4	15.38%	BOLAND
EK	10	38.46%	TOWNSHIPS
EL	12	46.15%	GENERAL CAPE TOWN AREA

CASES --> 26 MISSING --> 3

MARKETING STRATEGY IDENTIFIED BY RESPONDENTS

CODE	FREQ	PCT	LABEL
EM	10	34.48%	ADVERTISE
EN	8	27.59%	SALES REP OR PERSONAL CONTACT
EO	9	31.03%	INFORMAL
EP	3	10.34%	LOCATION
EQ	4	13.79%	SERVICE AND QUALITY
ER	5	17.24%	MISC

CASES --> 29 MISSING --> 0

NOTE:
The totals and frequencies do not add up because firms could be recoded into more than one category.

FURTHER EXPLANATION OF CODES:

ET	IDC FUNDING	TA	CLAY PRODUCT PRODUCER
EU	BANK FINANCED	TB	CONCRETE PRODUCT PRODUCER
EV	EQUIPMENT SUPPLIER FINANCED	TC	BRICK PRODUCER
OA	LARGE FIRM	TD	HOLLOW BLOCK PRODUCER
OB	MEDIUM SIZE FIRM	TE	USING AN EGG-LAYER
OC	SMALL FIRM	TF	USING A STATIC PRESS
MX	MAXIMUM OUTPUT CAPACITY	TG	USING A PUG-MILL
MA	AVERAGE OUTPUT CAPACITY		
RF	RETURN ON INVESTMENT (FIRM EST. NOT CALCULATED)		

that the quality of the display is not high. The first three dimensions together only have an inertia of 44%. Figure III.14 and Figure III.15 show the relations between the first dimension

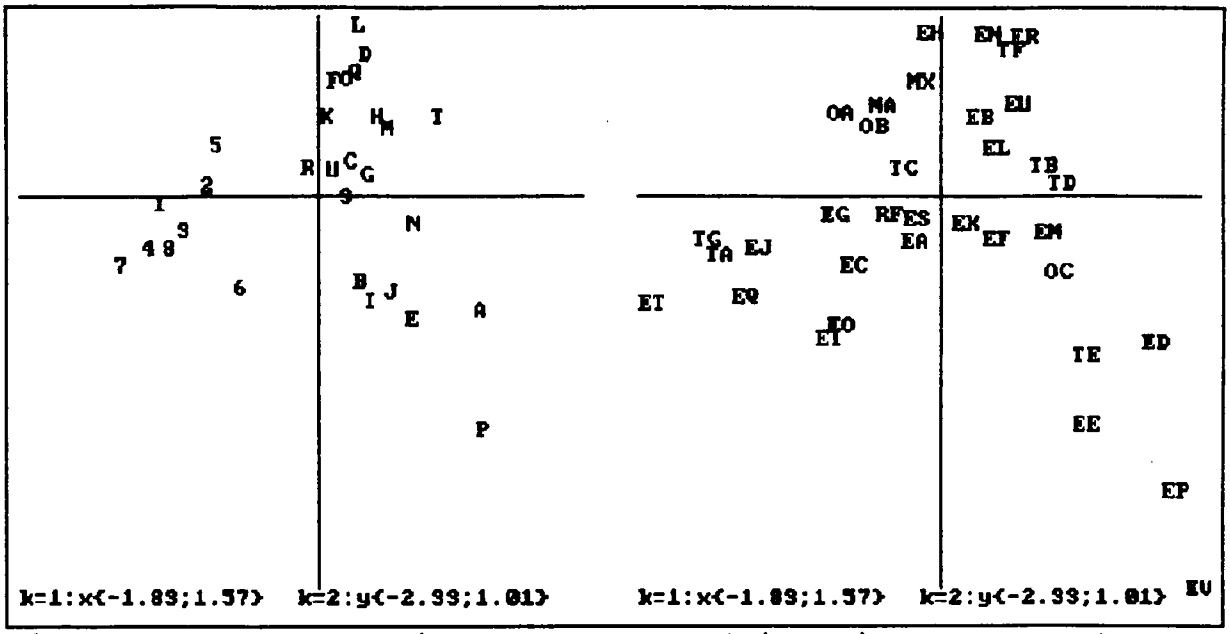


Figure III.14. Marketing strategy. (Dimensions 1 & 2). See Result 5 for description of the codes.

(19.85%) and the second (15.12%) and third (9.06%) dimensions respectively. The results are given in Result 6.

CA presents a type of principal components analysis with categorical data. The first principal component is the clay vs. concrete masonry differentiation, and is given along the first dimension: Clay producers [TA] to the left and concrete producers [TB] to the right determines the orientation of this display along the first dimension. The second dimension is largely determined by the customers: with sales to large contractors [EH] to the top and sales to owner builders [EE] to the bottom. The third dimension is largely determined by sales to small contractors [EF], to the bottom of the display.

Notice that the firm size indicators seem to lie diagonally across the display, with the small firms [OC] in the second and the medium [OB] and big [OA] firms together in the fourth quadrant.

The clay masonry industry seems to follow a marketing strategy based on quality and service [EQ], with sales to the medium sized construction firms and a spread of customers [EG]. They saw the technical barriers to entry [EC] as more important than the rest of the industry.

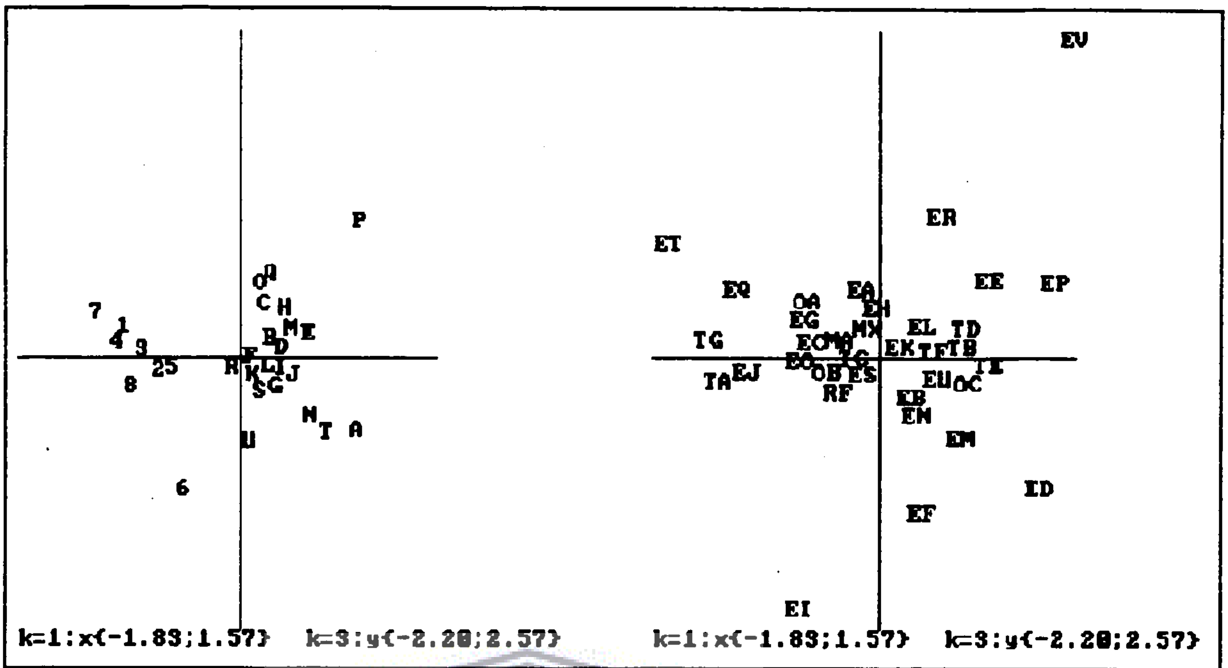


Figure III.15. Marketing strategy. (Dimensions 1 & 3). See Result 5 for description of the codes.

The analysis thus seems to support a differentiation between three market segments in the concrete masonry industry. These are visible largely within the second and third dimensions of the display. Firstly, some firms sell mostly to large contractors [EH]. These firms tend to have larger capacity [MA;MX], and use largely static brick presses [TF]. Furthermore, they tend to use informal contacts or representatives [EN] as marketing strategy. These firms also use other marketing strategies of which tendering is the most common.

The second marketing segment is found to the left of the display. Sales here go largely to owner-builders. These firms emphasise locational factors [EP] as important for their marketing, and largely use egg-layer technology [TE]. Furthermore, they find the barriers to entry as mostly financial [EA].

The third segment is a group of firms which sell to the smaller contractors [EF]. They tend to be the advertisers [EM]. These are

Result 6. Analysis results for Figure III.14 and Figure III.15.

Inertia and percentages of inertia:

k=1 0.369 (19.86%)

k=2 0.281 (15.12%)

k=3 0.169 (9.06%)

COL	QLT	MAS	INR	k=1	COR	CTR	k=2	COR	CTR	k=3	COR	CTR
EA	337	37	19	-196	40	4	-266	74	9	460	222	46
EB	454	41	18	209	54	5	470	270	32	-326	130	26
EC	112	12	29	-562	71	10	-408	37	7	117	3	1
ED	237	4	33	1292	112	19	-874	51	11	-1056	75	27
EE	649	15	38	859	161	31	-1363	406	101	613	82	34
EF	574	21	36	303	30	5	-259	22	5	-1268	522	205
EG	179	18	31	-677	144	23	-110	4	1	313	31	11
EH	613	31	30	-98	5	1	971	512	103	419	95	32
EI	228	3	47	-709	19	5	-849	27	9	-2197	182	95
EJ	327	13	32	-1162	303	48	-304	21	4	-124	3	1
EL	215	40	24	303	82	10	289	75	12	253	57	15
EM	468	30	29	621	209	31	-222	27	5	-654	232	75
EN	459	24	33	255	25	4	953	348	76	-475	87	32
EO	472	27	31	-644	193	30	-774	279	57	-27	0	0
EP	585	9	45	1419	216	48	-1758	331	98	595	38	19
EQ	388	12	36	-1231	269	49	-602	64	15	555	55	22
ER	441	15	43	472	41	9	937	161	46	1143	239	115
ET	235	3	34	-1832	171	29	-644	21	5	920	43	16
EU	316	32	29	438	115	17	545	178	34	-195	23	7
EV	519	3	48	1572	88	21	-2333	194	62	2574	237	126
TA	838	24	32	-1391	774	124	-348	49	10	-194	15	5
TB	905	62	14	598	833	60	154	55	5	87	18	3
TC	307	65	11	-262	221	12	163	86	6	-8	0	0
TD	706	50	20	678	616	63	112	17	2	234	73	16
TE	752	27	31	861	337	53	-953	413	86	-57	1	1
TF	794	41	25	402	141	18	859	646	109	91	7	2
TG	793	21	32	-1479	763	123	-251	22	5	144	7	3
OA	350	24	32	-651	168	27	494	97	21	461	85	30
OB	117	21	36	-442	61	11	413	54	13	-77	2	1
OC	631	41	26	695	415	54	-458	180	31	-206	36	10
RF	464	147	27	-353	359	49	-113	37	7	-154	69	21
MX	318	3	3	-158	15	0	679	271	5	232	32	1
MA	357	3	2	-384	118	1	528	223	3	141	16	0

Note: See Result 5 for description of the codes.

the smaller firms [OC], which tend to use their own finance [ES] to an extent, and medium sized firms [OB] which tend to rely on commercial bank finance [EU]. The smaller firms see easy entry into the market [ED], and the more medium sized firms suggest that tough market conditions and achieving a market share [EB] are the main barriers to entry.

Thus, the market segmentation is closely related to the technical choice function. Clay producers tend to have their own markets, often associated with close contacts with customers. Personal sales contacts, quality products and service are very important. The bigger concrete producers sell to the bigger construction companies, often at higher price levels. They tend to use static machine presses. Very small firms on the other hand, using mostly manual machines, sell directly to the owner builders. And in between a slightly less defined group of firms sells to the medium sized as well as the small builders. They are mostly advertisers.

This analysis therefore suggests that the potential for cooperatives in the clay and large scale concrete block sectors of the industry will likely be limited due to institutional constraints. The most notable are technical and financial barriers to entry. The medium sized market, where relatively low barriers to entry exist, is relatively saturated. That leaves the very small scale market for largely owner builders. Smaller scale cooperatives might be able to function here, with location and close contact with the end users as an important component of their marketing strategy. Supplying masonry to the larger construction firms would not be possible for the smaller firms because they require a more stable supply of products and spare productive capacity when they need it.

2. Learning and the interface between technical scale and economic efficiency.

The rest of the section will analyze the economic outcome of technical choices made in the brick making industry. This type of discussion often takes place under the heading of returns to scale, or economies of scale. The former can be seen as a physical and the latter as a cost effect of the size of a production unit, plant, or firm[102]. Here, the term economies of scale will be used in the sense of the interchange between technical characteristics and economic consequences of a technique. Scale factors are the outcome of technical change and innovation. Economies of scale is the economic outcome of these scale factors. Both are the result of learning.

a. Investment structure.

Rosegger (1980:69) suggests that there are three reasons for increasing returns to scale: specialisation, dimensional effects, and indivisibilities. Equipment and fixed assets represent some of the more important indivisible inputs into the production process. It can be argued that different techniques, representing different technical scale components would involve different investment structures. This would affect the choice of technique by a firm in that it might not be able to meet the investment or the scale requirements involved.

The investment structures of the various firms were disaggregated into equipment [EQ], fixed assets[103] [FA], and stocks [SK], each as a ratio of the total investment. The debt/equity ratio was used to see how these were financed.

Figure III.16 contains a CA plot in which the investment structures are analyzed. It appears that firms financed largely through loans tend to be using it for equipment rather than stock or fixed assets. These firms tend to be concrete block producers [TD].

The main determinant of the first dimension, with 47.5% of the inertia, is the type of financing. The portion of investment

---

102. See Rosegger 1980:67-68

103. Fixed assets include the buildings etc. but not the value of land which is excluded from the analysis.

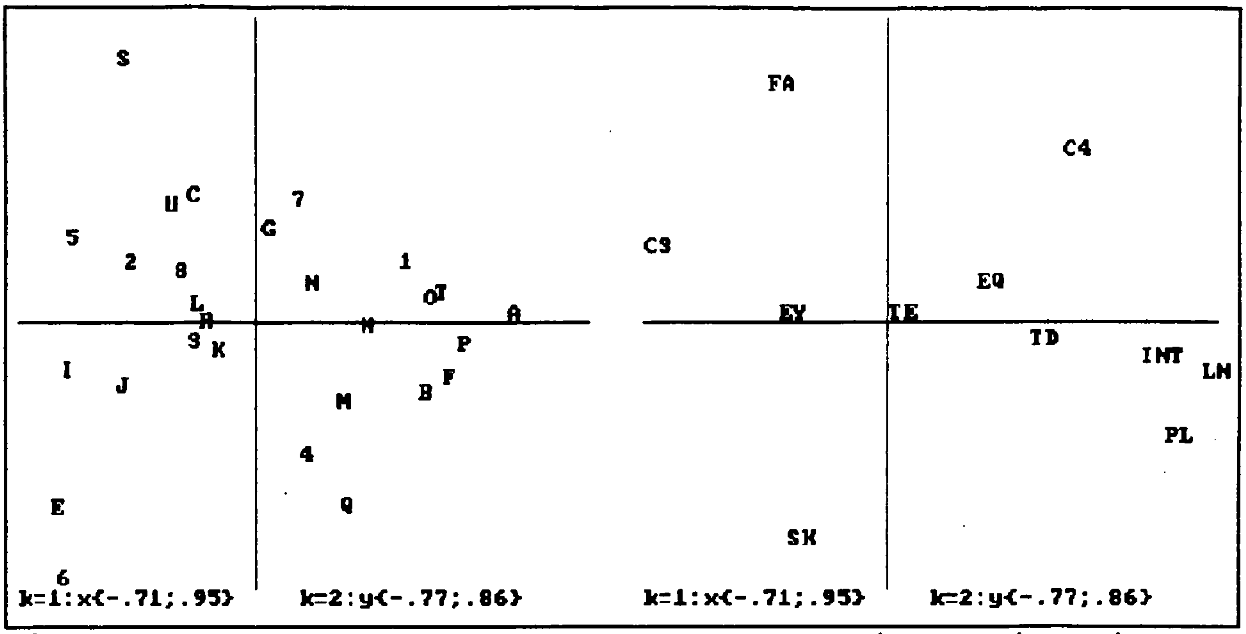


Figure III.16. Investment structure of 28 brick making firms.

funded by equity [EY] and by loans [LN] lie at opposite ends of the axis. The equipment indicator [EQ] has a high correlation (.461) with the first dimension, and is closely associated with above average loan frequency [LN]. The concrete block producers [TD] are also correlated with these two.

The orientation of the second dimension is largely determined by the stocks [SK] and fixed assets [FA] ratios. But both are to the negative side of the horizontal axis, suggesting that firms with below average debt-equity ratios tend to either have above average stocks or above average fixed assets ratios.

The third dimension has not been plotted, but suggests that firms using egg-layers have a specific investment structure. From Result 7 this axis is largely determined by fixed assets and loans in a negative direction. This suggests that firms using egg-layers have above average fixed asset ratios, and are financed by loans. This most probably relates to the nature of egg-layers: they need a big concrete slab on which to work, which is a big part of the investment in a egg-laying brick plant. The equipment is relatively inexpensive.

Result 7. Results of the CA plot in Figure III.16.

INERTIAS AND PERCENTAGES OF INERTIA

k=1 0.1653 (47.5%) k=2 0.0982 (28.2%) k=3 0.0708 (20.3%)

COLUMN CONTRIBUTIONS

NAME	QLT	MAS	INR	k=1	COR	CTR	k=2	COR	CTR	k=3	COR	CTR	DESCRIPTION
FA	981	76	214	-331	112	50	692	490	372	-609	379	399	FIXED ASSETS/INVESTMENT TOTAL
EQ	946	303	152	288	476	152	120	83	45	260	387	289	EQUIPMENT/INVESTMENT TOTAL
SK	968	142	208	-270	143	63	-622	759	559	-184	67	68	STOCKS/INVESTMENT TOTAL
EY	883	383	122	-300	813	209	33	10	4	81	60	36	EQUITY/INVESTMENT TOTAL
LN	981	96	304	953	823	526	-144	19	20	-392	139	208	LOANS/INVESTMENT TOTAL

SUPPLEMENTARY COLUMN CONTRIBUTIONS

NAME	QLT	MAS	INR	k=1	COR	CTR	k=2	COR	CTR	k=3	COR	CTR	DESCRIPTION
INT	552	11	38	767	492	40	-99	8	1	-250	52	10	INTEREST PAYMENTS
PL	286	20	181	837	222	84	-326	34	22	-310	30	27	LOAN PRINCIPAL REPAYMENTS
TD	357	3	7	442	242	4	-42	2	0	-301	112	4	CONCRETE BLOCK PRODUCERS
TE	209	2	10	25	0	0	35	1	0	-664	208	10	PRODUCERS USING EGG-LAYERS
C3	212	1	12	-707	87	2	222	9	0	814	116	7	CONCRETE BRICK PRODUCERS
C4	299	1	10	540	124	3	510	111	4	-391	65	3	SMALL TO MEDIUM SCALE CONCRETE BLOCK

Note: Supp. column indicators with low quality excluded.

Therefore, it seems that firms' access to different kinds of finance has a bearing on the technical choices which they make. The implication should be noted: A group of firms that were largely smaller, financed with loans, manufacturing concrete blocks could be identified. They tended to have below average stock/investment ratios. Access to different kinds of finance seems to be associated with different choices of techniques. It is also likely to influence the enterprises' responses to the seasonal fluctuations. The firms with predominantly debt financing tended to spend less of it on maintaining high stock levels. This suggests that they would let the equipment stand idle rather than having to build up large stocks.

The consequences for choice of technique by cooperative firms are that access to finance emerges as a key area. Given the problems which cooperative firms experience in obtaining finance, it can be expected that the area of capitalization with seasonal variability, are problem areas. These will limit the technical choices open to them to smaller scale concrete block manufacturing techniques. In fact, the only cooperative brick making firm included in the survey experienced both problems severely. The impact of seasonal variability were dealt with by keeping membership stable but having very low wage levels. The limited access to finance was dealt with by accepting credit from an equipment supplier at significantly increased interest rates, and keeping stock levels so low that production was affected - typical problems of under-capitalization.

b. Labour inputs and wages.

Table 8. Presumed management salaries.

Investment	Salary
R 20000	R1000
R 100000	R2000
R 200000	R2500
R 1000000	R3000
R 5000000	R3500
R10000000	R5000
R10000000+	R7500

Labour inputs into the production process are related to the size and technique of the production processes of a firm. It has been suggested that there are economies of scale in managerial inputs up to a certain point and dis-economies when further increases in scale increase the complexity of the organisation requiring more effort to manage (Rosegger, 1980:71).

Labour inputs are not homogenous either. Data on the skill and occupational structures of the workers in each firm[104] were collected. These were collated into 4 basic occupational categories: Unskilled workers [K1]; semi-skilled workers including machine operatives [K2]; skilled artisans including supervisors [K3]; and finally clerical and managerial workers[105] [K4]. These labour inputs were translated into labour hours, and

104. In the previous section C.3.a page 120 a detailed account of how the data were collected and collated was given.

105. See section C.3.a page 120.

the wage rates that they received were calculated[106]. Information on the salaries of managers were not available in most cases. In other cases owner managers did not take a regular salary. Therefore a presumed salary structure for the management of firms related to the size of the investment in the firm was used. The scales at which this has been done are represented in Table 8.

If economies of scale were present in labour inputs, especially managerial and possibly skilled labour inputs, it would limit the choice of technique by smaller cooperatives as well. To the extent that occupational and wage structures were technically determined, the scope for cooperatives to alter these would diminish, placing further constraints on their viable operation. On the other hand, the occupational structure also reflects the share in the distribution of income by cooperative members. The coops might not only function in the low skill segment, but consequently also in the low wage segment. That would potentially increase their viable space in that even relatively low wages in coop relative to the industry as a whole could be above average wages for the particular individuals.

In order to investigate the relation between occupational structure and wage rates, a CA plot was done. The actual labour hours were treated as supplementary, while the ratio of unskilled, semi-skilled, and skilled to total non-managerial labour inputs were active. The results are not displayed here. The major impression is that the wage structure seems to be

106. The hourly wage rates were calculated in a somewhat roundabout way. Two sources of information were used: the total labour bill of firms, and the hours of work and standard hourly wage rates for each skill or occupational category. Discrepancies arose between the two sources, and it was decided that the total wage bill was more accurate than the hourly wage rates specified. Furthermore, information about the average overtime worked was included, but the impression was created that this was overstated. Consequently, the hourly wage rate for each skill category was calculated in the following way:

$$\frac{\left(L\frac{W^{a}}{W^{tot}}\right)}{H^{a}}$$

where
L = total labour bill from financial data
W = wages calculated using hourly wage rates
a = occupational category
tot = all occupational categories together
H = total number of ordinary and overtime labour hours

almost independent from the occupational structure. A clear correlation between firm size and wage structure could not be shown either. The only case where some correspondence appear is for large automated concrete block firms where the skilled component of blue collar workers is above the average. These firms tend to have below average wage rates for skilled employees, but above average wage rates for unskilled and semi-skilled employees. Two possible explanations can be given for above average unskilled and semi-skilled wage rates. Firstly, with total wage payments a smaller proportion of total costs, these firms might be able to pay more. Secondly, these firms might require more responsible workers to operate expensive equipment, without disruptions. These factors obviously increase workers' bargaining position.

It suggests that for most firms, except those producing with expensive equipment in fairly automated plants, wage rates are not directly affected by the technical characteristics of the firms. Furthermore, the absence of any clear pattern suggests that institutional rather than technical arrangements[107] within firms are more important in the setting of wage rates. Therefore some scope for variation exists.

This is important in that it increases the scope for cooperatives to organise their operations in a way they prefer. This is obviously subject to the productivity constraints that they face along with other firms that may be paying much lower wage rates.

Because little correspondence between the wage and occupational structures were found, the occupational structure was analyzed independently. A much closer relationship between the occupational structure and the techniques chosen was found. The

107. This topic has been debated quite extensively in the literature between those proposing a close technical determination of labour processes, and empirical studies failing to find that. It has been proposed that this could be due to the level of analysis at the level of the firm, and not of the production unit, which for the current would affect this analysis to some extent as well. But, most of the firms in our study have only one production unit.

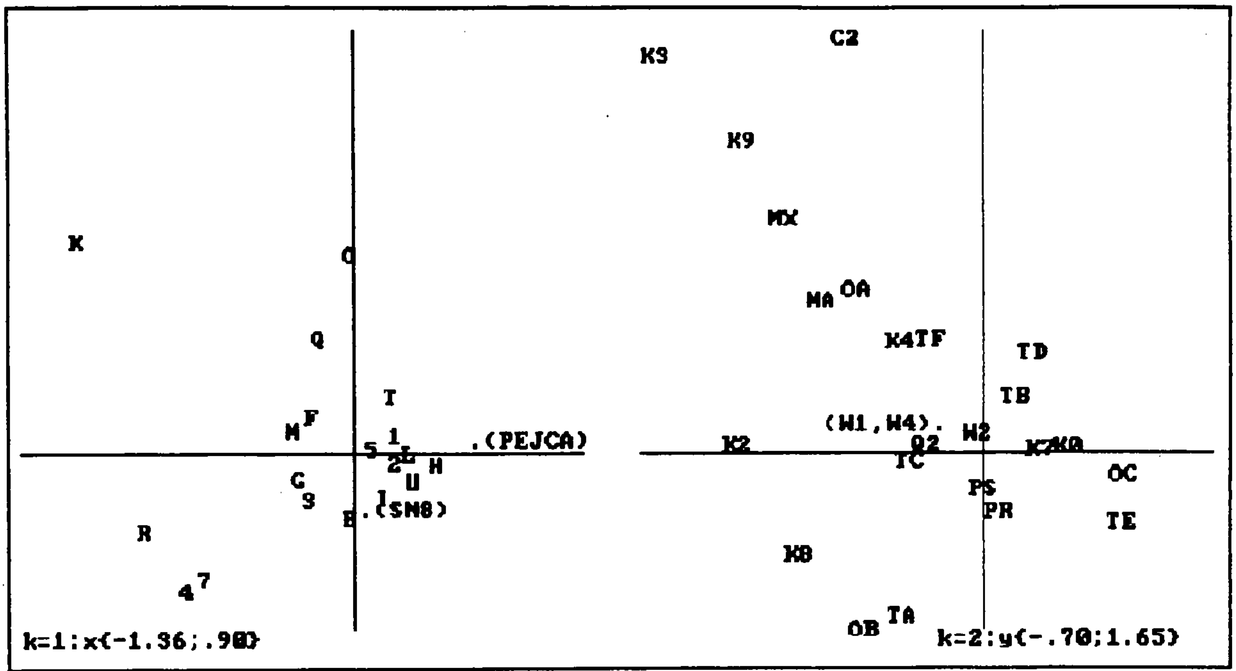


Figure III.17. Occupational structure of 27 brick making firms.

firms generally employed very few skilled workers. 44% of the firms have no skilled[108] production workers, and in 90% of firms, the ratio of skilled to total blue collar employees[109] was less than 10%.

Further, smaller firms have a higher ratio of white collar employees to total employment. Similarly, the smaller firms used less skilled labour, while the larger firms, using more sophisticated production processes tended to have more skilled labour as a proportion of the total production workers, and more semi skilled workers as proportion of the total number of production workers. These results can be found in Figure III.17 and Result 8. The horizontal dimension, with 61.4% of total inertia, shows a major orientation between firms with largely unskilled workers [K7], associated with above average managerial labour inputs [K0] on the right hand, and firms with largely semi-skilled workers [K8] associated with skilled labour [K9] to the left. It could be interpreted as the 'mechanisation divide' which technically corresponds with smaller firms [OC] using egg-

108. Which completed an apprenticeship. Here we have included supervisors.

109. Including supervisors.

layers [TE] on the right versus non egg-layers on the left.

Result 8. Occupational structure of 27 brick making firms. (Figure III.17)

INERTIAS AND PERCENTAGES OF INERTIA
1 0.178545 61.38% 2 0.094648 32.54% 3 0.017709 6.09%

COLUMN CONTRIBUTIONS

J	NAME	QLT	MAS	INR	k=1	COR	CTR	k=2	COR	CTR	k=3	COR	CTR	DESCRIPTION
1	K7	1000	755	119	211	966	188	15	5	2	36	28	56	Unskilled/Total Blue Collar empl.
2	K8	1000	165	430	-771	784	549	-404	216	285	-12	0	1	Semi-skilled/Tot Blue Collar empl
3	K9	1000	44	381	-998	391	243	1245	608	713	-11	0	0	Skilled/Total Blue Collar empl.
4	KO	1000	37	70	315	179	20	27	1	0	-674	819	942	White Collar/Total employment

COLUMN CONTRIBUTIONS

JS	NAME	QLT	MAS	INR	k=1	COR	CTR	k=2	COR	CTR	k=3	COR	CTR	DESCRIPTION
6	PR	208	716	659	40	6	6	-225	189	383	59	13	139	Profit Rate
7	PS	2371036		505	-25	4	4	-132	122	190	125	110	910	Standardised Profit Rate
10	Q2	265	191	202	-252	207	68	37	4	3	128	54	177	Quality index
11	MX	753	34	241	-830	329	129	939	421	312	73	3	10	Maximum production capacity
12	MA	523	34	183	-672	286	85	604	231	130	107	7	22	Average production
14	W1	2672046		892	-110	95	139	115	104	286	93	68	989	Unskilled wage rates
15	K2	546	6954594		-1024	5454083		33	1	8	-17	0	12	Unskilled labour hours
16	W2	2372727		582	-47	36	34	86	119	214	71	82	780	Semi-skilled wage rates
17	K3	768	4047947		-1361	3244194		1582	438	-	-192	6	841	Semi-skilled labour hours
19	K4	282	8713494		-362	113	641	444	1691817		16	0	13	Skilled labour hours
20	W4	432%	-	-	-149	1501817		122	1012311		163	180	-	Managerial labour hours
21	TA	254	2	25	-353	43	2	-645	142	11	448	69	28	Clay products
22	TB	223	7	8	107	33	0	224	146	4	-122	43	6	Concrete products
23	TC	555	7	9	-326	290	4	-29	2	0	310	263	39	Brick producer
24	TD	347	6	13	176	46	1	400	238	10	-207	63	14	Block producer
25	TE	231	3	22	538	147	5	-274	38	3	-297	45	16	Using Egg-layer
26	TF	246	5	17	-238	52	1	456	192	10	47	2	1	Using Static press
28	OA	327	3	24	-538	120	5	652	176	13	276	32	12	Large firm
29	OB	247	2	26	-515	74	3	-698	136	11	361	36	16	Medium size firm
30	OC	364	5	17	544	282	8	-81	6	0	-283	76	21	Small firm
32	C2	536	1	28	-574	57	3	1651	474	41	-165	5	2	Quality concrete blocks - automat

This does suggest some degree of increasing returns to scale on management labour inputs. The positive correlation between unskilled [K7] and managerial labour inputs [K0], and the small firm size indicator [OC] suggests that smaller firms tend to have above average managerial labour time input requirements. The firms involved [P,E,J,A,I] generally use manually operated egg-layers [TE] or smaller static machines in which most of the materials handling is still done manually [H,U,C]. But, if the assumption about higher managerial wage rates associated with bigger firms is correct, the impact on costs for the firm is unclear and could well mean higher managerial labour costs even though more managerial labour hours relative to the total number of labour hours are used.

Still, the impact on technical choices in a cooperative is significant. By choosing a small scale production process, the managerial inputs requirements are bigger relative to the number of worker members.

Furthermore, an interesting relation between the occupational structure and the technical characteristics of the firms is found. Smaller firms [OC] tend to use predominantly unskilled labour [K7] with egg-layers [TE]. Medium sized firms [OB] use more semi-skilled labour [K8]. These are largely clay brick producers [TA]. However, the big automated concrete block producers use more skilled, including supervisory, labour [K9].

This is an important finding, with significant impact on the choice of technique for a cooperative firm. Bigger firms, using more mechanised techniques require more skilled labour, and supervisors. Furthermore, smaller firms use less skilled labour. But from the interviews it became apparent that problems with supervision often mentioned by owners of small firms were actually problems of scale. Consequently, a variety of piecework and other managerial mechanisms were developed in order to compensate for the absence of supervision. Cooperatives, on the contrary, have been reported to need fewer supervisors compared to capitalist firms (Levin 1984:27). If this is the case, smaller scale cooperatives might be at an advantage.

Finally, notice that there is a tendency for increased skill usage with increasing mechanisation. This is a remarkable finding, which is directly opposite to the expectations of those suggesting that deskilling is associated with more mechanisation. In the light of the discussion in previous sections it even appears as if the more mechanised firms, and especially the larger firms with higher levels of mechanisation of the materials handling aspect of their operations, are less efficient (and profitable) as well. It is instructive that many of the techniques of the more efficient medium sized firms were developed, or partly developed locally with the expressed intention to make it adaptable for the local conditions. These invariably meant a shortage of skilled labour, large numbers of unskilled unemployed, and low levels of unskilled wage rates[110]. This can also be related to a comment made by a manager of a large clay face brick producer, which suggested that a few years ago it was general practice to look for labour replacing technologies. Now, with changes in the exchange rate, capital has become so expensive that a balance between labour and capital costs has been achieved[111]. Finally, the lack of properly skilled computer programmers was a key reason why some of the big clay brick factories did not automate certain stages in their production processes.

The implications for cooperatives are simple. To the extent that cooperatives comprise largely unskilled unemployed, the type of technique that they choose will have to take note of the technical constraints which they face. On the other hand, it appears that techniques which fit such a skill structure exist, and could even be more efficient in the light of supervisory constraints on such techniques operated by capitalist firms. However, the technical and quality constraints which they will face must be addressed. Access to adequate managerial skills is a major component, as is the demand for products with the characteristics that they can produce using these techniques.

c. Cost structures.

The input costs for each technique were divided into costs that could be regarded as fixed and costs that would vary with different output levels. The distinction between 'fixed' and 'variable' costs will therefore give an indication of the flexibility[112] of the firms under changes in demand.

110. Interview with designer of the Profile block making equipment during April 1989.

111. Interview with H Voorma, November 1989.

112. Not flexibility in product specifications in the sense that Kaplinsky (1990:1-5) uses the word.

Table 9. Cost structure of various types of production technique.

Technical class	Machine	Labour	Overheads	Materials
A. ACTUAL CAPACITY UTILISATION:				
Percentage of total production costs:				
Manual clay bricks	1.03%	63.48%	12.05%	23.44%
Manual concrete	1.80%	22.90%	6.82%	68.48%
Mech. concrete block	8.59%	26.12%	7.21%	58.08%
Clay bricks (Non face)	22.11%	22.29%	10.78%	44.82%
Concrete bricks	6.97%	19.30%	4.66%	69.06%
Auto. concrete block	18.58%	19.88%	4.94%	56.61%
Clay brick (face)	28.90%	22.16%	16.74%	32.20%
Per brick equivalent output:				
Manual clay bricks	R.002	R.092	R.018	R.034
Manual concrete	R.002	R.024	R.007	R.074
Mech. concrete block	R.011	R.033	R.009	R.073
Clay bricks (Non face)	R.033	R.032	R.014	R.066
Concrete bricks	R.011	R.030	R.007	R.107
Auto. concrete block	R.040	R.043	R.011	R.123
Clay brick (face)	R.066	R.051	R.039	R.074
Per ton output:				
Manual clay bricks	R.250	R15.367	R2.917	R5.675
Manual concrete	R1.041	R13.084	R4.054	R39.565
Mech. concrete block	R5.731	R17.050	R4.847	R36.328
Clay bricks (Non face)	R8.696	R8.910	R4.017	R17.888
Concrete bricks	R2.960	R7.859	R1.927	R28.387
Auto. concrete block	R17.987	R22.224	R5.018	R63.017
Clay brick (face)	R20.681	R16.090	R12.215	R23.161
B. HYPOTHETICAL 85% CAPACITY UTILISATION:				
Percentage of total production costs:				
Manual clay bricks	1.03%	63.48%	12.05%	23.44%
Manual concrete	1.40%	21.43%	4.12%	73.04%
Mech. concrete block	7.28%	24.68%	6.52%	61.51%
Clay bricks (Non face)	21.98%	22.18%	10.76%	45.09%
Concrete bricks	5.72%	17.90%	3.05%	73.33%
Auto. concrete block	14.61%	18.08%	3.24%	64.06%
Clay brick (face)	28.90%	22.16%	16.74%	32.20%
Per brick equivalent output:				
Manual clay bricks	R.002	R.092	R.018	R.034
Manual concrete	R.001	R.021	R.004	R.074
Mech. concrete block	R.009	R.029	R.008	R.073
Clay bricks (Non face)	R.032	R.031	R.014	R.066
Concrete bricks	R.008	R.026	R.004	R.107
Auto. concrete block	R.027	R.035	R.006	R.123
Clay brick (face)	R.066	R.051	R.039	R.074
Per ton output:				
Manual clay bricks	R.250	R15.367	R2.917	R5.675
Manual concrete	R.763	R11.512	R2.274	R39.588
Mech. concrete block	R4.315	R15.172	R4.176	R36.329
Clay bricks (Non face)	R8.579	R8.793	R3.995	R17.888
Concrete bricks	R2.254	R6.913	R1.168	R28.391
Auto. concrete block	R12.015	R18.377	R2.945	R63.056
Clay brick (face)	R20.681	R16.090	R12.215	R23.161

Four categories of costs were distinguished: Machinery [MC], overheads [OC], (raw) materials [RC], and labour costs [LC]. The machinery costs include depreciation costs[113] which are fixed, and maintenance[114], hiring of equipment[115] and other costs which are variable. Fixed overheads included administrative costs (excluding salaries)[116] and rent[117]. Variable overheads included marketing costs and Regional Services Council levies. Material costs included mining costs, fuel and electricity, coal, sand; cement and aggregates, and general running costs.

At the outset a trade-off between the machine and raw material cost components was expected, especially in the case of concrete masonry manufacturers. Bigger presses can supposedly compress and vibrate products more strongly, lessening the requirement for costly cement[118]. However, a set of complementarities rather than substitution between inputs was found. Increases in one cost component often meant that increases in other cost components per unit of output occurred as well. Furthermore, a significant difference between cost structures of clay and concrete masonry producers was found. Clay producers tend to have above average machine and overhead costs, while concrete producers tend to have above average raw material costs. Labour costs tend to be between 19% and 26% of total costs for all techniques except manual clay brick manufacture.

---

113. Very few firms were able to give a clear idea of depreciation costs. The value of machinery was depreciated by 20% per annum, except where the owners specifically mentioned a different period, usually shorter, for faster wearing equipment.

114. Maintenance costs are generally very high especially in the concrete brick industry, which work under very abrasive conditions. It is possible that firms did not report maintenance costs all that accurately, because the information was not at hand. Some dealers of equipment and firms which previously used egg-layers suggested that they are susceptible to much higher maintenance costs.

115. Hiring of equipment was not common.

116. Often firms would not specify these general running costs. In those cases a fee ranging between R500 and R1000 per month depending on the situation was added.

117. In cases where no rent was paid because the land was owned, rent was calculated as 10% of the value of the land and buildings. The value of the land and buildings was then not added to the investment costs. This was done in order to ensure comparability between different firms, some of which paid rent, and others which did not.

118. Firms were reluctant to specify the cost of cement that they used, because this could reveal information regarding their mixtures to competitors. But raw material costs, of which cement is roughly 50%, make up between 44% and 71% of the total production costs. The comparable range for clay brick factories is 23% to 49%. If the production levels of the firms are scaled up to 85%, the raw material costs for clay firms remain the same, but for concrete firms it rises to between 53% and 80%.

Table 9 contains the data on the cost structures for both the actual and a hypothetical 85% capacity utilisation level[119]. It is clear that the labour costs per brick equivalent of output increase with increases in the machine costs per unit of output. Raw material costs per ton of output also tend to increase with machine and labour costs. However, clay products have lower absolute raw material costs than concrete products. And the absolute raw material costs of manual concrete block plants are both high compared to other costs, and slightly higher than those for small mechanical concrete block producing techniques.

These findings are explained by technical factors, including the characteristics of the output. More mechanised production processes produce better quality products, using more expensive raw materials, and more labour costs per unit of output. The high labour costs per unit of output for automatic concrete block plants is most probably due to the higher level of skill required, resulting in higher wage rates and in significantly higher managerial salary costs at current relatively low volumes[120]. The only counter to the trend outlined above is that manual clay brick manufacturers have very low machine and raw material costs per unit of output, but very high labour costs.

A CA was performed with the 4 cost components as a ratio of the total costs as active columns. A set of technical indicators was added as supplementary points, shown in Figure III.18. The three firm size indicators [OA] indicating large firms, [OB] medium sized firms and [OC] small firms lie on a 'size axis'. But the quality of display of the medium sized firms is very poor, with the quality of the other two much better (Result 9). This mainly shows the above average machine cost component of large and below average machine cost component of smaller firms. More important

119. See the next paragraph. Firms operating on capacity levels above 85% would be the same in both tables.

120. Given their generally low levels of production volume, this might change if their output was increased closer to capacity.

is the product type which is being produced. Firms producing clay products [TA] and concrete products [TB] lie opposite each other, both with quite high quality displays. Clay producers tend to have above average overhead, machine and labour cost,

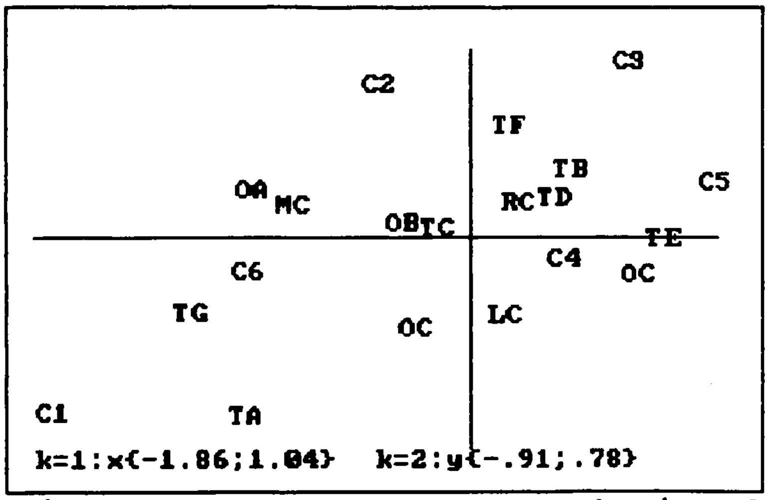


Figure III.18. Technical characteristics associated with the cost structure.

and low raw materials cost ratios. A different and more diversified picture is true for the concrete producers. Techniques using egg-layers [TE] are associated with low machine costs, while those using static machines [TF] are associated with above average raw material costs, and below average labour costs. This does suggest that some form of substitution between labour and other input costs were taking place. However, in absolute terms all cost components per unit of output was higher for the more mechanised concrete block plants.

Result 9. Supplementary column results for Figure III.18.

PERCENTAGES OF INERTIA:
k=1 58.23% k=2 30.67% k=3 11.10%

COLUMN CONTRIBUTIONS

NAME	QLT	MAS	INR	k=1	COR	CTR	k=2	COR	CTR	k=3	COR	CTR	DESCRIPTION
MC	1000	124	466	-807	953	763	149	32	49	102	15	63	MACHINE COSTS/TOTAL COSTS
LC	1000	242	189	115	92	30	-328	754	465	148	154	262	LABOUR COSTS/TOTAL COSTS
OC	1000	79	171	-274	191	56	-390	385	214	-408	423	651	OVERHEAD COSTS/TOTAL COSTS
RC	1000	554	174	170	506	151	165	479	271	-29	15	24	RAW MATERIAL COSTS/TOTAL COSTS

SUPPLEMENTARY COLUMN CONTRIBUTIONS

NAME	QLT	MAS	INR	k=1	COR	CTR	k=2	COR	CTR	k=3	COR	CTR	DESCRIPTION
TA	643	3	39	-1007	408	27	-764	235	30	-7	0	0	CLAY MASONRY PRODUCER
TB	642	7	16	407	411	11	305	231	12	4	0	0	CONCRETE MASONRY PRODUCER
TC	128	8	14	-174	90	2	47	7	0	102	31	4	BRICKS AS PRODUCTS
TD	204	6	24	342	156	6	186	46	4	42	2	0	HOLLOW BLOCKS AS PRODUCTS
TE	365	3	37	810	311	20	4	0	0	-337	54	18	USING EGG-LAYERS
TF	284	5	30	133	15	1	494	210	20	261	59	16	USING STATIC BLOCK PRESSES
TG	584	3	41	-1247	522	37	-322	35	5	-283	27	10	USING PUG-MILL
OA	416	3	39	-980	387	26	213	18	2	170	12	4	LARGE FIRM
OB	36	2	43	-330	30	2	70	1	0	-142	5	2	MEDIUM SIZE FIRM
OC	523	5	27	707	499	24	-152	23	2	-34	1	0	SMALL FIRM
C1	364	1	50	-1862	270	23	-763	45	7	-792	49	22	CLAY BRICK FIRMS WITH TUNNEL KILNS
C2	171	1	47	-426	30	2	672	75	12	622	65	27	AUTOMATIC CONCRETE BLOCK FIRMS
C3	177	1	47	663	73	6	781	101	16	-146	4	2	CONCRETE BRICK PRODUCERS
C4	62	3	39	379	57	4	-90	3	0	65	2	1	MECHANISED CONCRETE BLOCK PRODUCERS
C5	247	1	47	1038	180	14	253	11	2	-583	57	24	MANUAL CONCRETE BLOCK PRODUCERS
C6	225	2	45	-1001	219	17	-145	5	1	-80	1	1	CLAY BRICK PRODUC. EXCL. TUNNEL KILNS

Indicators for product quality are not included in the display. However, the producer quality index [Q2], is strongly associated with above average average machine cost ratios, but not related to raw material cost ratios. This quality index is mainly composed of the compressive strength of the products. Therefore, more mechanised plants produce better quality (stronger) products using more expensive raw material and labour inputs.

The implications for the choice of technique by cooperative firms are firstly, that they will have to use techniques with relatively high machine cost components if they want to produce higher quality products. If clay and automatic concrete block firms are excluded from the range of techniques that they can choose from (as is concluded elsewhere), their options are most likely some form of concrete brick or block technique [C3,C4,C5]. With egg-layers, the position is fairly fixed, and the cost structure seem to be dominated by those factors determining the first dimension: High raw material and low machine costs. But, the absolute level of material costs is lower than for the other techniques. As a result, poorer quality bricks are produced with cheaper machines and materials. With static block presses, the situation is more fluid, but overall, higher quality products are produced using techniques with above average machine cost components, and significantly higher levels of production costs per unit of output.

Secondly, the firms therefore have to decide at what level they are going to operate and accept the product characteristics which it implies. The crucial question is then whether they will be able to sell products with the characteristics as specified.

d. Capacity utilisation and cost structure.

The sensitivity of firms to variations in production levels were analyzed. Hypothetical production cost structures were calculated, by scaling up the variable costs proportionally with production volume increases to a capacity utilisation of 85%. Those already operating above 85% of capacity were not changed[121]. It became clear that the basic pattern alters very little. Most of the concrete firms moved in a direction where the raw materials cost proportion of total costs rises.

The consequence is clear: increasing the volume of output makes the raw material costs even more important, and reduces the machine, overhead and labour cost components. From the point of view of an individual firm, raw material prices are externally determined, giving the firm little control over costs. With raw material costs then contributing between 53% and 80% of total costs, mix design ought to play an important part in the technical life of any concrete brick producer. It also becomes apparent that the productivity of the larger automated concrete block plants increases. Their machine, overhead and labour cost per unit of output decreases. However, these costs are still above that of smaller mechanised production processes in absolute terms.

Two technical consequences affecting the learning possibilities of the concrete industry also follow: Firstly, with the high raw material cost content, the scope for learning and productivity increases beyond mix design is rather limited. Most learning and scaling attempts have gone into two areas which remain: product design and the design of production machinery.

Secondly, the potential for new materials to significantly reduce the raw materials costs present the opportunity for a lot of improvements in the industry.

121. This included all the clay brick firms.

The clay brick industry is affected in a different way. Between 30% and 45% of their costs are machine and overhead costs. It is likely that reduction in production volumes will affect them severely. This point was emphasised by people in the clay brick industry.

e. Cost structure and efficiency.

So far, the influence of various technical choices on the cost structure of the various firms has been analyzed. But which cost structure elements characterise the more efficient firms?

Result 10. Stepwise multiple regression of efficiency of 25 brick making firms.

Skill adjusted profit rate =		P(2 tail)
(1.369)		0.000
-(1.537)	Raw material costs/rand output	0.004
-(8.591)	Overhead costs/rand output	0.004
+(7.140)	Overhead costs/production costs	0.010
-(4.283)	Machine costs/brick equivalent output	0.065

N = 25 R = .937 R^2 = .877 ADJ. R^2 = .853 SEE = 0.150

DURBIN WATSON D STATISTIC 2.006
FIRST ORDER AUTOCORRELATION -.003

The following firms were outliers and excluded: [1,7,O]

A stepwise multiple regression analysis was performed with the skill adjusted profit rate, the index of efficiency, as dependent variable. Initially, a large number of cost indicators were included: the four major cost components as a ratio of total costs, sales in rand, sales in brick equivalents and in tonnes, and the three quality indices. The two clay face brick firms were excluded because they were outliers, as well as firm [O]. Result 10 gives the results of the analysis.

Notice that labour costs do not feature. This is most probably related to the fairly constant proportion of labour costs out of total production costs found above. Raw material costs and overhead cost per rand sales as well as machine costs per brick equivalents all have negative signs, suggesting that more efficient firms are able to reduce the raw materials, overheads and machine costs per unit of output. This is to be expected.

On the other hand, the overhead costs as a ratio of total production costs increases with efficiency. This needs some explanation. It most probably suggests that the techniques of the more efficient firms tend to be those that have a high overhead cost component. In this case it is the clay brick firms. From the section on the choice of technique, it became clear that the clay brick firms were amongst the more efficient.

This finding has a crucial implication for cooperatives. The more efficient firms were characterised by factors related to efficient management rather than 'harder labour'. The willingness of coop members to work harder than their non-coop counterparts could all come to nothing if they are not prepared to do what is needed for the enterprise to be managed efficiently.

Notice further the output measure used in each of the significant variables. Why are the raw material costs/output in Rand and the overhead costs/output in Rand measures significant rather than measures based on tonnes or brick equivalents? One answer lies in the quality of the products. Earlier it was shown that a close correlation exists between the price of a product and the quality thereof. If the quality (and cost) of the raw materials used were a significant component to the output quality, then a measure compensating somewhat for the output quality (via the price) would be better than one simply based on a weight or a volume that did not change with changes in quality. The same argument would hold for overhead costs, but in a less direct way. Clay brick firms produce better quality products, and have higher overhead costs. A output measure in sales value rather than volume or weight incorporates quality differences better.

The machine cost measure is more directly related to output volumes, brick equivalents in this case. This suggests that a different cause underlies the relation between machine costs and efficiency. But, given that the capacity of a brick press is determined by the volume of output that it can produce at a time, this is to be expected. Brick presses are more efficient if they produce more volume of output per unit of time.

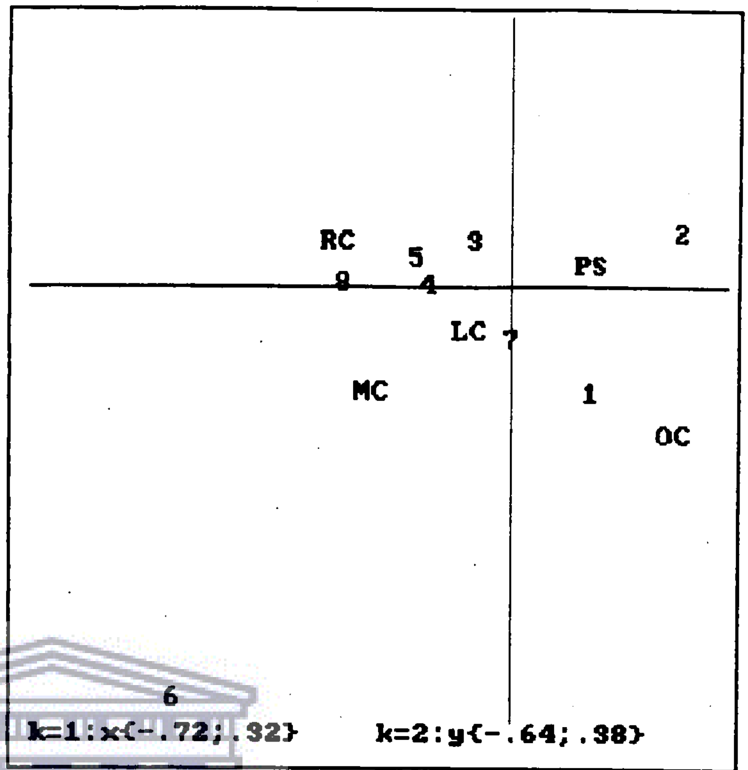


Figure III.19. Cost structure and efficiency in 7 clay brick firms.

To get a broader perspective, the standardised profit rate (π^{sk}) [PS] calculated earlier as a measure of efficiency was included with the correspondence analysis of the cost structure. The results for 7 clay brick firms[122] are displayed in Figure III.19, and Result 10. It is quite apparent that efficiency is correlated strongly with the first dimension only. Thus, firms with above average efficiency, are correlated with below average machine costs [MC] and raw material costs [RC] but above average overhead costs [OC] as a proportion of total costs. There is no correlation with labour costs. More efficient firms are able to reduce machine and raw material costs, and no clear pattern related to labour costs exists. It appears, therefore,

122. Firm [6], which has only 3 employees, exerted a very big influence over the total orientation of the display (60% of total inertia), and was treated as supplementary.

that some scale economies are present in the efficient utilisation of machine costs and raw materials relative to the overhead costs that have to be incurred.

Result 11. Results of CA plots Figure III.19 and Figure III.20.

A. CLAY PRODUCT FIRMS:

INERTIAS AND PERCENTAGES OF INERTIA

1	0.028051	68.61%	4	0.001111	2.72%
2	0.006483	15.86%		--------	
3	0.005238	12.81%		0.040883	

COLUMN CONTRIBUTIONS

NAME	QLT	MAS	INR	k=1	COR	CTR	k=2	COR	CTR	k=3	COR	CTR	DESCRIPTION
MC	997	99	221	-222	541	175	-150	247	344	-138	209	362	MACHINE COSTS/TOTAL COSTS
LC	866	92	86	-75	147	18	-63	105	57	153	614	411	LABOUR COSTS/TOTAL COSTS
OC	936	52	153	235	457	102	-214	380	366	109	99	118	OVERHEAD COSTS/TOTAL COSTS
RC	985	171	347	-275	906	459	70	59	130	41	20	54	RAW MATERIAL COSTS/TOTAL COSTS
PS	999	586	193	109	877	246	34	85	104	-22	37	55	STANDARDISED PROFIT RATE

B: CONCRETE PRODUCT FIRMS:

INERTIAS AND PERCENTAGES OF INERTIA

1	0.024488	43.58%	4	0.004805	8.55%
2	0.017833	31.74%		--------	
3	0.009066	16.13%		0.056192	

COLUMN CONTRIBUTIONS

NAME	QLT	MAS	INR	k=1	COR	CTR	k=2	COR	CTR	k=3	COR	CTR	DESCRIPTION
MC	983	37	282	83	16	10	-633	926	824	-134	41	72	MACHINE COSTS/TOTAL COSTS
LC	426	119	97	-31	21	5	56	67	21	125	338	204	LABOUR COSTS/TOTAL COSTS
OC	949	31	263	-546	627	378	-233	115	95	314	207	338	OVERHEAD COSTS/TOTAL COSTS
RC	1000	318	194	-145	614	273	56	93	57	-100	294	353	RAW MATERIAL COSTS/TOTAL COSTS
PS	931	496	163	128	890	334	12	8	4	25	33	33	STANDARDISED PROFIT RATE

This corresponds with some observations about the most efficient firm [2] in the survey. Apart from the fact that they work during winter as well, they use a clay preparation process which is the most simple of all the firms, and have produced fork-lift attachments to ordinary tractors which are much cheaper than commercially produced forklifts. They have also placed greater emphasis on the structuring of their labour processes, with no supervisor and an incentive scheme. Their machine costs and raw material cost components are therefore quite a lot below their competitors. And during the interview they mentioned that to increase the output of their plant would involve the need to purchase another tractor, bigger preparation equipment etc., which would not be cost effective. This suggests that they are operating as closely as possible to an optimum level of scale. At the same time, this firm is not the biggest clay producer. The scale effects are therefore not simply a matter of size, but a matter of learning to use and acquire inputs that go well together.

The position of firm [1] corresponds more with overhead costs [OC] than with standard profit rate [PS][123]. The reason for the inefficiency here seems to be that the overhead costs of this firm are too high[124]. This is in line with observations during the fieldwork[125].

Figure III.20 contains the display for 19 concrete brick firms[126]. Result 10 reveals that firm efficiency [PS] once again correlates almost exclusively with the first dimension, and that this corresponds with below average overhead costs [OC] and raw material costs [RC]. Table 9 suggests that the firms with the lowest proportion of raw material costs are the small mechanised block production processes. The manual production processes have a very high raw material cost component (73%), but in absolute levels they are quite close to the small mechanised production processes. Big automated production processes have a relative raw material cost component below the two mentioned above, but an absolute cost level higher than both. Overheads generally make

123. The correlation with the first dimension is only 33%, while it is 52% with the second dimension.

124. For example the cost per brick equivalent for this firm compared to firm [7] which has a similar technique is as follows:

FIRM:	[1]	[7]		[1]	[7]
Raw material costs:	7.1	7.7	Overhead costs:	5.2	2.6
Machine costs :	5.5	7.7	Labour costs :	6.2	4.1

125. The firm is currently undergoing major structural adjustments to lower their overheads. Competitors have also commented on their high overhead cost structure.

126. Firm [O], which has only 3 employees, exerted a very big influence over the total orientation of the display (48% of total inertia), and was treated as supplementary.

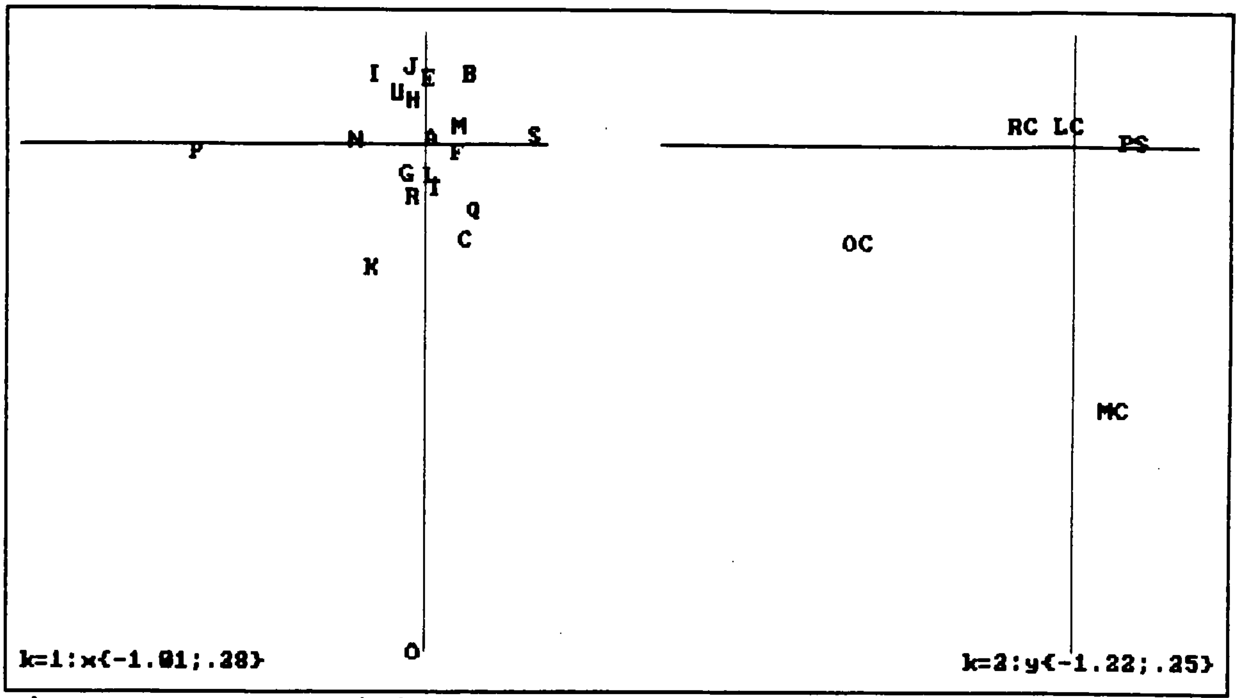


Figure III.20. Efficiency and cost structure in 19 concrete masonry firms.

up a very low proportion of total costs. The question for a concrete masonry producer is therefore whether a technique can reduce raw material costs but still produce sufficient quality products. This could involve different technical choices, but ultimately the choice is not the capital labour ratio given the wage level, but quality price level given the demand pattern for different quality and price goods.

The difference between the display for clay and concrete firms suggests that the concrete masonry industry experiences a different set of scale economies from the clay masonry industry. For clay masonry producers the objective is to design a production process in which all the equipment are used to their capacity without bottlenecks. The objective for a concrete masonry producer is to keep the raw material cost component as low as possible given quality constraints.

The message throughout this cost structures analysis is that various techniques involve cost structures which are not substitutions but complementarities. These are associated with differences in product characteristics, as well as cost per unit of output. Successful techniques are able to match these with effective demand.

Cooperatives will have to take these economies of scale seriously. It involves managing the enterprise efficiently. In the clay masonry industry the key is making optimal use of all the equipment. In the concrete masonry industry the situation is more complex. Adapting the technique and the characteristics of the products it produces to the demand for these products seems to be the key factor. This involves having the flexibility to adapt the technique to different conditions. If cooperatives do not develop the capacity to learn fast and efficiently, which involves proper management, they would probably not be viable.

E. PRODUCT CHARACTERISTICS.

In the preceding pages, the crucial role played by product characteristics in the viability of a technique has been identified. Displaying a high correspondence with the price, the product characteristics and price forms the crucial link between the market and the nature of demand on the one hand, and the technological and economic conditions and constraints under which firms operate on the other. In this section, the measurement and analysis of changes in product characteristics will be presented, and in the following section the correlation between aspects of the production techniques and the product characteristics identified.

Important characteristics in terms of which to measure technical change will be identified first. Then the characteristics of the products produced by the firms in the sample will be analyzed. These will serve as background to construct quality indices, and analyze their nature and performance. Finally, the changes that have taken place in the product characteristics over time in the sample of products will be analyzed.

1. Changes in the product technology.

No fundamental changes occurred in the VBE industry during the past 20 years. Conventional masonry construction have not been replaced by 'innovative building methods'. Changes have occurred especially in the low cost housing market though, with modular hollow concrete blocks becoming more important[127].

Schlotfeldt (1988)[128] argues that hollow concrete blocks are now dominating the low cost housing field. Large panel systems virtually disappeared when the state stopped financing large

127. See also section A.3.b.(1) page 97.

128. HSA Mar 1988 p10-11

housing schemes in 1983. Small panel systems have always been limited, but with the advent of the MANTAG system, there was a small a resurgence of interest. For blocks, a variety of systems are available which lay them in an innovative manner, with 9 having been granted Agrement certificates and 2 Mantag certificates. Little information is available about their use, but it is not high. The 'innovative' building systems encountered during the fieldwork were related largely to the choice of materials and the design of the block unit itself. They were all self-aligning units. One product was constructed using a mixture of concrete and polystyrene balls. It produced a lighter product, which was solid, and used as a dry-stacking product. Drawbacks were that it was used in the production of non-cavity walling, and that the materials were relatively expensive[129]. Another product was designed to reduce the skill needed to build them into a wall. The agent bonding different blocks is a concrete slurry that is poured into grooves after the dry products have been stacked[130].

Another system does not use a concrete slurry, but has mortar joints which are filled after the blocks have been stacked to increase their stability. Firm [H] has produced a batch run of the products, and is building a number of low cost houses with the product in order to popularise it in the low cost self-build housing market. Using some of the information supplied by the interviewee, it transpired that the cost of blocks per square metre would be R6.50 higher than comparable width (140mm) single skin concrete blocks. But building with the block enables the use of unskilled labour which is lower paid, and between 25% and 50% faster for the walls. The end result was that there was no

---

129. "The product can compete with dual skin cavity walling, but not with single skin walling". D. Doveton, October 1989.

130. They suffer from a number of drawbacks: In order to prevent the problems of water penetration, the products must by made very accurately. Coupled with the need for specialised moulds in which to make the products, this tends to increase the costs of production. Post hoc inspection to supervise whether the slurry has been poured into the grooves is also not possible, which would increase the need for direct supervision.

significant change in the cost of a house[131].

Products based on burnt clay have not been able to adapt so readily. Attempts to produce clay based products competing with hollow blocks were seemingly unsuccessful[132].

2. The characteristics used to evaluate the quality of masonry products.

A combination of the heuristic and functional approaches to technology measurement were used to develop a quality index[133]. The characteristics used were specified and weights applied to the characteristics according to a specified schedule. The characteristics are measured so that they increase with quality.

The range of characteristics selected falls into two classes: those more directly related to the design and those more closely associated with the performance of the products. The design aspect would be important for a direct user (bricklayer), and affects the ease with which products can be handled[134]. Characteristics like the ratio between the volume of a product, and its weight [VW][135] will be an important feature for the users of products[136]. But certain products are wider than others. This means that less could be used to build an actual wall. From the builders' point of view, the more wall in volume you get, with the less mass that has to be moved, the better.

131. The size of a house with $52m^2$ walls was taken as basis for the calculations. On the other hand, the production facility was erected on site, so savings in transport costs were not accurately reflected.

132. Maxi-bricks, developed by the clay brick industry to compete against hollow concrete blocks are themselves now produced by concrete brick plants. Interview with D King, September 1989.

133. See Majer, 1985:335-351 and Lenz, 1985:249-264

134. Lighter products can be built faster. Bigger products require the use of both hands to lift, while smaller products can be handled with one hand, the other applying the mortar.

135. $VW = \frac{((l^1+l^2+l^3+l^4)/4)*((w^1+w^2+w^3+w^4)/4)*((h^1+h^2+h^3+h^4)/4)}{Weight(kg)*1000000}$
where l^i is the 4 length measurements, w^i is the 4 width measurements, h^i is the 4 height measurements, all in millimetres. VW is the volume/weight ratio.

136. This was emphasised by a concrete block producer which developed a 'hollow maxi-brick', the size of a maxi brick, but the weight of an ordinary imperial brick. The same strength was attained with the inclusion of slightly more cement. The product was new for the firm, and in demand. This was due to an increase in 33% in the laying speed of the product by bricklayers.

Therefore, the surface area to weight ratio of the product was added. For products with a comparable volume/weight ratio[137], a narrower product would have a lower weight, but the same surface area. Thus the narrower product would have a higher surface area/weight ratio. This incorporates another effect, which is important in the Western Cape. Dual skin walling is regarded as preferable for rain penetration purposes. Products with a narrow width are used in a dual skin wall, which would be regarded as being of higher quality[138]. Furthermore, certain products have special features which enable easy building, or are especially pleasing aesthetically etc. This includes special 'alignment protrusions', or face brick properties. In order to accommodate for these, a dummy variable was added [FA][139].

Some characteristics are more related to the performance of the product. They will be called producer characteristics because producers themselves most often use these as indicators of quality.

Table 10. Appearance Codes and Accuracy measurements.

A. APPEARANCE CODE DESCRIPTIONS

Value	Texture	Unevenness
.7	Very smooth	None
.6	Very smooth	Yes
.5	Smooth	No
.4	Smooth	Yes
.3	Coarse	No
.2	Coarse	Yes
.1	Very poor and uneven	

B. ACCURACY MEASUREMENTS

Value	Freq	%	CUM%
.7	7	12.96%	12.96%
.6	4	7.41%	20.37%
.5	12	22.22%	42.59%
.4	12	22.22%	64.81%
.3	9	16.67%	81.48%
.2	3	5.56%	87.04%
.1	7	12.96%	100.00%

137. $SW = \frac{((l^1+l^2+l^3+l^4)/4)*((h^1+h^2+h^3+h^4)/4)}{Weight(kg)*10000}$
where l^i is the 4 length measurements, h^i is the 4 height measurements, both in millimetres. SW is the surface area/weight ratio.

138. One exception here is the use of 140 mm wide blocks for single skin low cost housing walling, which generally leaves a much lower quality house. A dummy variable for single or dual skin walling would have dealt with this. But since most of these products are used for industrial building, and make up a small proportion of our sample and of the total production we left it as is.

139. Special products with self-aligning features were coded as 1. Similarly, clay face brick products and special concrete brick features which improve the performance of concrete products (such as a water repellant silicone layer to prevent efflorescence) were also given a value of 1. Lower quality clay face products, the 'semi-face' and overburn products, as well as concrete face products were given a value of 0.5. The rest of the products were given a value of 0.

Compressive strength [ST][140] is the characteristic that is used most often. Another 'producer characteristic' is the appearance of the products, which is important in order to help market the products (Table 10). The final two measures are also more related to the production process: The squareness of the product, or the variance in the lengths of the various facets[141]; and the accuracy with which the product is made with reference to the standard product size[142]. These characteristics relate more to the production process rather than the design of the products.

At least one very important variable should have been included in the list, but could not due to the non-availability of data. That is the measures of drying shrinkage in concrete block products, and moisture expansion in clay products. Most firms do not even perform these types of testing, so it would be very difficult to determine the contribution of these factors. Other characteristics left out are related more to the nature of the material used rather than the

Table 11. Weights used in the construction of quality indices.

Code	Description	Weight
A. OVERALL QUALITY INDEX [Q]		
VW	Volume/weight	15%
SW	Surface/weight	10%
FA	Special features	10%
ST	Strength	50%
AP	Appearance	5%
DI	Squareness	5%
AC	Accuracy	5%
B. USER QUALITY INDEX [Q1]		
VW	Volume/weight	40%
SW	Surface/weight	10%
FA	Special features	20%
ST	Strength	30%
C. PRODUCER QUALITY INDEX [Q2]		
ST	Strength	70%
AP	Appearance	10%
DI	Squareness	10%
AC	Accuracy	10%

140. ST = Compressive strength (MPa)/100.
The measurements were calculated by the Portland Cement Institute.

141. $DI = \frac{1}{MAX[Var(l^1+l^2+l^3+l^4)+Var(w^1+w^2+w^3+w^4)+Var(h^1+h^2+h^3+h^4),1]}$
where l^i is the 4 length measurements, w^i is the 4 width measurements, h^i is the 4 height measurements, all in millimetres. DI is the index of squareness.

142. $AC = \frac{1}{MAX[Abs(l^i-l)+Abs(w^i-w)+Abs(h^i-h),1]}$
where l^i is the average of the 4 length measurements and l the standard length. The same applies to the width (w) and height (h). AC is an index of accuracy.

individual product. To some extent the better performance of clay products with regards to thermal qualities and acoustic performance will be reflected indirectly in the chosen measures. Clay tends to have a lower density and a higher strength/weight ratio. This means that clay products in general will reflect higher strength and lower weight consequently higher volume/weight and surface/weight ratios.

After selecting the characteristics, the weights that make up the indices must be specified. Sahal has suggested a method using the characteristics internal to the data only[143]. But in the absence of adequate data, a more heuristic approach was followed in the specification of the weights. A summary of the weights used in the calculation of the quality indices is found in Table 11. They are based largely on a subjective analysis of the importance of the various characteristics.

Product samples were collected from all the firms interviewed. The samples were not selected using a rigorous sampling routine[144], which should include samples of between 6 and 12 products per batch[145] depending on the type of product. In some cases it was not possible to get even 2 products. These were measured and an evaluation about their appearance made. After a month of curing the 101 samples were taken to the PCI testing laboratory, where they were weighed and then crushed to determine their compressive strength.

3. Products included in the survey and in the test procedure.

The products that were included in the survey are listed in

143. Sahal, 1985:1-37

144. The SABS specifies the sampling procedures that should be followed to select products for testing for both clay and concrete products. See SABS 227-1986

145. Some variability occurs within each batch due to the performance of the brick presses and the nature of the flow of materials into the moulds. The products in the outer rim might be filled less and the centre moulds more completely. That means some products would not only be heavier, but will also be compressed better. We were not able to take this kind of variability into account.

Result 12, together with an indication of the frequency with which they were mentioned as major products. The frequencies of these products used in the construction of the quality indices are also listed. While Result 12 does not represent all the products that are actually being produced by the industry, it does give some indication of the relative importance of different products. As the first CODE column indicates, the various product groups were grouped into 10 different product types.

Result 12. Products in the survey and in the testing procedure.

PRODUCT CODE	TYPE	SIZE L W H	LISTED FREQ	LISTED %	TESTED FREQ	TESTED %
1	Maxi-brick	220x115x 90	5	6.94	5	9.26
2	Stock	220x 73x105	10	13.89	8	14.81
9	Maxi (hollow)	220x 90x115	1	1.39	1	1.85
-	Driface	220x 73x105	1	1.39	-	0.00
1	Calc. Silicat	222x 73x105	1	1.39	1	1.85
3	M190	390x190x190	14	19.44	13	24.07
4	M90	390x190x 90	11	15.28	8	14.81
8	3/4M90	290x190x 90	4	5.56	2	3.70
5	M140	390x190x140	7	9.72	4	7.41
0	Lockblock	415x190x150	1	1.39	1	1.85
-	IB90	90x495x228	1	1.39	-	0.00
-	IB150	150x495x228	1	1.39	-	0.00
6	NFP	220x 73x105	6	8.33	6	11.11
7	Overburn	220x 73x105	2	2.78	1	1.85
-	NFX	220x 73x105	2	2.78	-	0.00
7	FBS	220x 73x105	2	2.78	2	3.70
7	Semi face	220x 73x105	2	2.78	2	3.70

Note *Where a firm sample consisted of more than one product it is recorded only once for the purposes of the tested values.
*CODE column indicates the recoded product code used in the text

The quality values for each product were then used to produce three sets of quality measures. The first is the firm quality indices. These were constructed by adding all the values for the tested products from a particular firm, and averaging them. The second set of indices could be regarded as product quality indices. If more than one of the same product from a particular firm were included, they were averaged to give one quality index per product per firm. All in all 54 quality measures were obtained in this manner. These will be used to analyze the nature of the quality indices in the next paragraph. Finally, the product type quality indices were constructed. These consist of the data averaged for each product type as recoded in Result 12 for all firms together.

4. Characteristics of the quality indices.

In the preceding paragraph a set of characteristics, weighted in a particular way to construct a quality index, was proposed. The weightings were based on an analysis and an intuitive feeling for the aspects that are important for the industry. These decisions will now be analyzed.

Result 13. Dimensions of the products included in the tests.

LENGTH

Code	Freq	%	CUM%
222.00-	26	48.15%	48.15%
290.00-	2	3.70%	51.85%
390.00-	25	46.30%	98.15%
415.00-	1	1.85%	100.00%

WIDTH

Code	Freq	%	CUM%
90.00-	16	29.63%	29.63%
105.00-	20	37.04%	66.67%
140.00-	4	7.41%	74.07%
150.00-	1	1.85%	75.93%
190.00-	13	24.07%	100.00%

HEIGHT

Code	Freq	%	CUM%
73.00-	20	37.04%	37.04%
115.00-	6	11.11%	48.15%
190.00-	27	50.00%	98.15%
200.00-	1	1.85%	100.00%

N=54

Firstly, the product quality index was analyzed on a CA plot. The columns contained the actual measurements as well as the quality indices. The weights were the same as those used in the calculation of the actual overall quality index, displayed in Table 11.

Figure III.21 displays the analysis. The rows, containing references to the product type, are displayed on the left set of axes. Apart from a few individual firms, all the others lie in a straight axis, perpendicular to the group of 'outliers'. The latter include all those products with a special feature component to it. Most of those are face bricks [7], but one calcium silicate brick [1] and one hollow block with self-aligning features [0] also contribute.

Result 14 indicates that the orientation for the first two

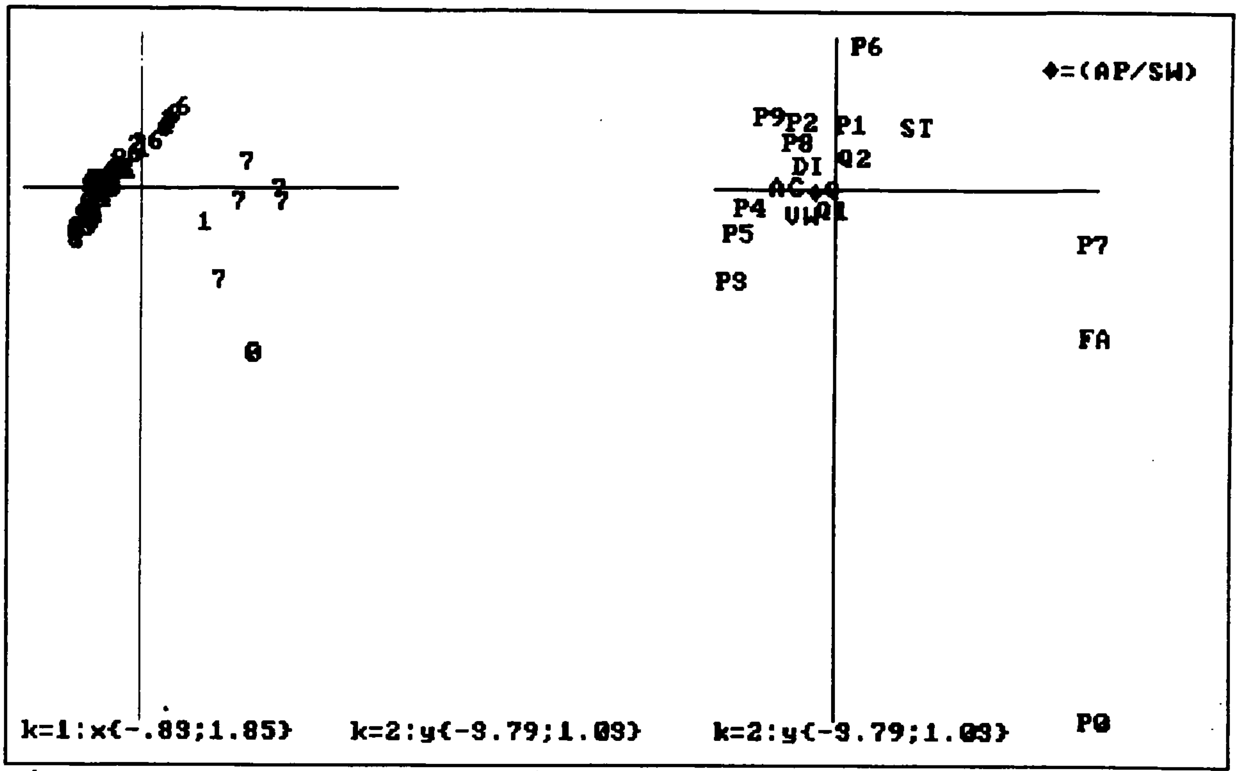


Figure III.21. Product quality index.

dimensions of the display is determined by three variables: Volume/weight [VW], strength [ST], and special features [FA]. Most of the products therefore fall along the axis between a high volume/weight ratio, and a high compressive strength. The supplementary column points give an indication of where the various products are located. Ten dummy variables [P0-P9] were recoded as binary variables to indicate product types.

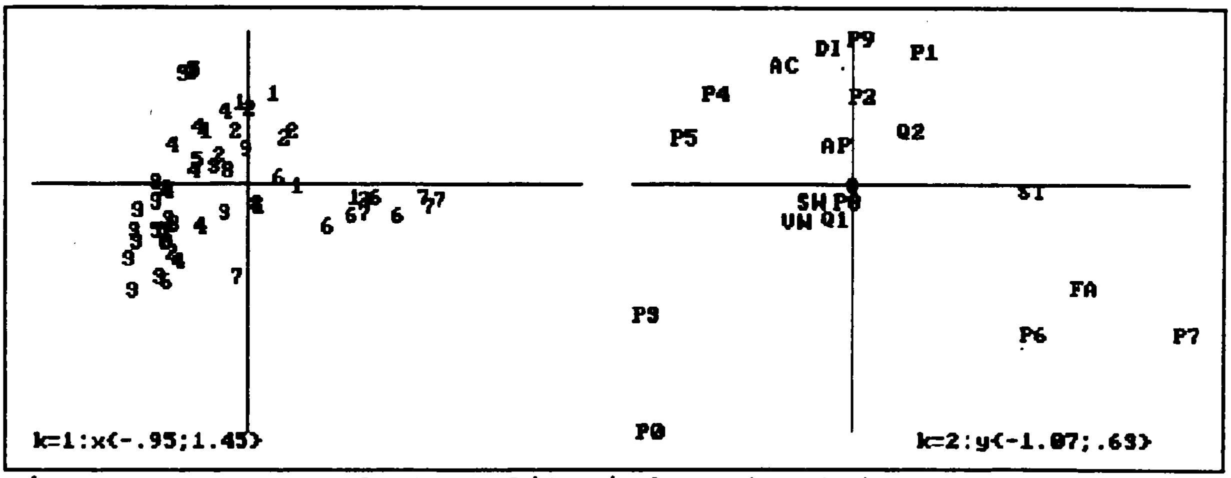


Figure III.22. Product quality index. (Cont.)

Then the special features [FA] indicator was left out of the active display, by treating it as a supplementary column. This enables a better analysis of the interrelation between the other

Result 14. Results for the analysis in Figure III.21

INERTIAS AND PERCENTAGES OF INERTIA

1	0.222886	54.82%	5	0.012016	2.96%
2	0.093776	23.06%	6	0.006430	1.58%
3	0.049679	12.22%		--------	
4	0.021819	5.37%		0.406606	

COLUMN CONTRIBUTIONS

NAME	QLT	MAS	INR	k=1	COR	CTR	k=2	COR	CTR	k=3	COR	CTR	DESCRIPTION
VW	950	359	111	-261	546	110	-173	239	115	-144	165	150	VOLUME TO WEIGHT RATIO
SW	508	199	41	-182	399	30	-53	34	6	-80	76	25	SURFACE AREA TO WEIGHT RATIO
ST	997	210	264	549	587	283	449	393	451	-94	17	37	COMPRESSIVE STRENGTH
AP	289	75	31	-129	99	6	-5	0	0	179	190	48	APPEARANCE
DI	849	80	91	-246	131	22	169	62	24	550	656	488	SQUARENESS
AC	543	44	80	-410	224	33	30	1	0	488	318	209	DIMENSIONAL ACCURACY
FA	1000	34	382	1843	742	517	-1057	244	404	250	14	43	SPECIAL FEATURES

SUPPLEMENTARY COLUMN CONTRIBUTIONS

NAME	QLT	MAS	INR	k=1	COR	CTR	k=2	COR	CTR	k=3	COR	CTR	DESCRIPTION
Q	50	997	0	2	37	0	-0	2	0	1	11	0	OVERALL QUALITY
Q1	9691350		127	-70	127	29	-143	534	295	-109	308	322	USER QUALITY INDEX (DESIGN)
Q2	972	688	176	98	92	30	235	529	404	191	350	504	PRODUCER QUALITY INDEX (PERFORMANCE
P1	49	4078610		67	1	8	480	271000		428	211497		PRODUCT 1 - MAXI BRICK
P2	53	5429130		-295	13	211	486	341364		201	6	441	PRODUCT 2 - STOCK BRICK
P3	350	8818409		-830	1772723		-644	1073900		-505	664527		PRODUCT 3 - M190 BLOCK
P4	99	5428240		-680	751124		-124	2	89	367	221471		PRODUCT 4 - M90 BLOCK
P5	53	2719040		-753	42	691	-315	7	286	227	4	282	PRODUCT 5 - M140 BLOCK
P6	272	4078093		182	4	60	1028	1314580		-1055	1389112		PRODUCT 6 - CLAY NON-FACE BRICK
P7	556	3395326		1831	5255100		-392	24	556	-207	7	294	PRODUCT 7 - CLAY FACE BRICK
P8	10	1369100		-317	4	61	347	4	174	-243	2	161	PRODUCT 8 - 3/4M90 BLOCK
P9	13	687471		-299	2	27	520	6	196	474	5	306	PRODUCT 9 - MAXI BRICK HOLLOW
P0	439	686976		1846	811037		-3792	344%103		759	14	786	PRODUCT 10 - LOCKBLOCK

characteristics.

The close resemblance between Figure III.22 and Figure III.21 can be seen. It turns out that the strength indicator becomes more important along the first dimension, and the squareness indicator [DI] more important along the second. But the negative correlation between the volume/weight and strength indicators remains. The other indicators are of a lesser quality, suggesting more variation between products.

The clay [P7] face and non-face [P6] bricks seem to have moved closer. A fairly close resemblance between the squareness [DI],

Result 15. Results for display in Figure III.22

INERTIAS AND PERCENTAGES OF INERTIA

1	0.163896	63.12%	5	0.006537	2.52%
2	0.054364	20.94%		--------	
3	0.022054	8.49%		0.259651	
4	0.012800	4.93%			

COLUMN CONTRIBUTIONS

NAME	QLT	MAS	INR	k=1	COR	CTR	k=2	COR	CTR	k=3	COR	CTR	DESCRIPTION
VW	952	372	155	-272	684	168	-167	258	191	-32	10	18	VOLUME TO WEIGHT RATIO
SW	528	206	55	-148	318	28	-80	92	24	90	117	76	SURFACE AREA TO WEIGHT RATIO
ST	1000	217	483	759	996	762	-27	1	3	-35	2	12	COMPRESSIVE STRENGTH
AP	290	77	48	-98	59	5	165	168	39	101	63	36	APPEARANCE
DI	963	83	137	-128	38	8	588	805	527	228	120	194	SQUARENESS
AC	987	45	122	-326	152	29	510	371	216	-570	464	664	DIMENSIONAL ACCURACY

SUPPLEMENTARY COLUMN CONTRIBUTIONS

NAME	QLT	MAS	INR	k=1	COR	CTR	k=2	COR	CTR	k=3	COR	CTR	DESCRIPTION
Q	2011032		29	35	169	8	-14	29	4	4	3	1	OVERALL QUALITY
Q1	7231397		247	-96	202	79	-155	520	614	-7	1	3	USER QUALITY INDEX (DESIGN)
Q2	974	712	299	233	497	236	228	476	680	-8	1	2	PRODUCER QUALITY INDEX (PERFORMANCE
P1	154	421	-	284	10	208	567	382489		950	106	-	PRODUCT 1 - MAXI BRICK
P2	22	561	-	14	0	1	375	211450		35	0	31	PRODUCT 2 - STOCK BRICK
P3	396	912	-	-946	2414977		-566	865372		-507	69	-	PRODUCT 3 - M190 BLOCK
P4	112	561	-	-631	671362		385	251534		345	20	-	PRODUCT 4 - M90 BLOCK
P5	126	281	-	-769	451013		201	3	209	-1004	77	-	PRODUCT 5 - M140 BLOCK
P6	130	421	-	768	761516		-650	543275		40	0	30	PRODUCT 6 - CLAY NON-FACE BRICK
P7	341	351	-	1454	2814529		-647	562698		-189	5	571	PRODUCT 7 - CLAY FACE BRICK
P8	25	140	-	-47	0	2	-70	0	13	800	244071		PRODUCT 8 - 3/4M90 BLOCK
P9	58	70	-	9	0	0	625	9	504	1454	496729		PRODUCT 9 - MAXI BRICK HOLLOW
PO	53	70	-	-914	15	358	-1065	201464		1044	193467		PRODUCT 10 - LOCKBLOCK
FA	202	35	787	988	168	209	-444	34	127	75	1	9	SPECIAL FEATURES

accuracy [AC], and appearance [AP] seems to exist. This is encouraging, since the latter was a subjective evaluation and the first two are calculations based on the measurement of the products.

A final feature concerns the position of the overall quality index [Q], which is included as supplementary points in all the displays. The same is the case for both the user or design quality index [Q1] and the producer or performance quality index [Q2]. The overall quality index is almost always very close to the centre, suggesting that it has no specific correlation with any of the individual points. This would suggest that the overall quality index is a relatively fair combination of all the characteristics in the equation. On the other hand, It appears as if a trade-off surface, defined by the strength and weight of the products, exists. Certain products are weaker, but lighter; others stronger but heavier.

5. Learning and changes in the product technology over time.

Table 12. Actual values of the 'Product Type Quality Indices'.

C	Q	Q1	Q2	VW	SW	ST	AP	DI	AC	FA
0	3450	6050	1100	1275	0560	0150	0350	0098	0010	1000
1	2625	3017	2175	0739	0505	0642	0250	0317	0078	0083
2	2387	2913	1919	0783	0496	0556	0194	0248	0132	0000
3	2373	3912	1254	1261	0438	0177	0204	0156	0135	0000
4	2612	3444	1750	0962	0705	0288	0203	0309	0169	0000
5	2587	3688	1713	1123	0534	0262	0225	0233	0238	0000
6	2775	3492	2058	0877	0558	1025	0133	0132	0056	0000
7	4320	5395	3250	0882	0576	1790	0180	0134	0056	0700
8	2625	3425	1800	0908	0665	0525	0200	0238	0072	0000
9	3200	3700	2600	0975	0740	0650	0350	0430	0075	0000

Note: C is the product type code (See Result 12). The other headers are the same as in the text.

The implications of the quality index data for an understanding of the learning processes in the industry needs further comment. Learning in the realm of products take two forms. The first is to learn how to produce them. The second deals with the ways in which these products could be improved. That means changing the characteristics of the products to be more suitable for the purpose that they are intended for.

Figure III.23 shows the results of a CA of the 'product type quality indices', or the average quality index for each product type over the industry as a whole. The display is essentially the same as the two above, with the exception that the weighting of the rows are different[146].

146. There are only 10 products types, and not 54 products per firm that make up the rows. Each product type will therefore contribute equally to the display, irrespective of how many actual samples there were.

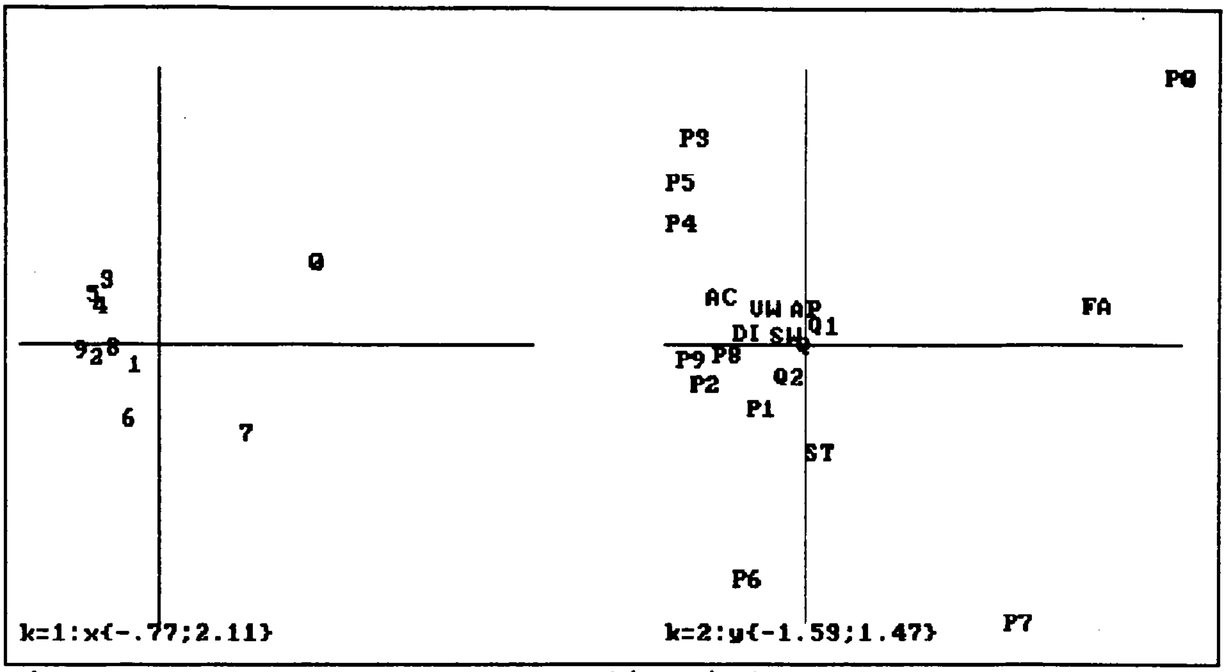


Figure III.23. Product type quality index.

Notice how closely together products [3,4,5] are in the display. They all represent different types of hollow concrete blocks and are associated with high volume/weight ratios, and low strengths. On the opposite side of the display are the clay face bricks [7]. The other solid bricks are all on an axis perpendicular to the one above. This suggests that they share the strength with face bricks on the second dimension. It is also interesting to note that the surface area/weight indicator [SW] is quite strongly correlated with the first dimension. Product [2] is quite strongly correlated with dimension 1 but not with dimension 2, which reflects the trade-off between volume and strength. Concrete maxi bricks [1] and clay non-facing bricks [6] seem to have the same characteristics profile. This would suggest that if prices of products are compared, the prices of concrete maxi bricks should be comparable with clay non-face bricks. That could explain why concrete maxi bricks as a product are suffering, and why many concrete producers which previously manufactured the maxi stopped doing so.

Products [8,9,0] are of special interest. They represent products that have only recently been developed. [8] is a 3/4 M90 block, which was developed to be lighter and handle more easily, without

INERTIAS AND PERCENTAGES OF INERTIA

1	0.191401	60.91%	5	0.002780	0.88%
2	0.097538	31.04%	6	0.000180	0.06%
3	0.015674	4.99%		--------	
4	0.006654	2.12%		0.314226	

ROW CONTRIBUTIONS

NAME	QLT	MAS	INR	k=1	COR	CTR	k=2	COR	CTR	k=3	COR	CTR	DESCRIPTION
0	999	119	401	921	798	526	460	199	258	-40	1	12	PRODUCT 10 - LOCKBLOCK
1	891	90	16	-125	274	7	-110	213	11	-151	403	131	PRODUCT 1 - MAXI BRICK
2	937	83	22	-270	884	32	-66	53	4	-7	1	0	PRODUCT 2 - STOCK BRICK
3	944	82	72	-292	308	37	359	463	108	219	172	249	PRODUCT 3 - M190 BLOCK
4	902	91	51	-335	635	53	211	252	42	-51	15	15	PRODUCT 4 - M90 BLOCK
5	913	90	67	-336	482	53	282	340	74	146	91	122	PRODUCT 5 - M140 BLOCK
6	928	96	66	-161	120	13	-400	742	157	120	67	88	PRODUCT 6 - CLAY NON-FACE BRICK
7	993	149	238	517	532	208	-477	453	347	63	8	38	PRODUCT 7 - CLAY FACE BRICK
8	817	90	23	-253	785	30	-15	3	0	-49	30	14	PRODUCT 8 - 3/4M90 BLOCK
9	970	111	43	-268	586	42	-23	4	1	-216	380	330	PRODUCT 9 - MAXI BRICK HOLLOW

COLUMN CONTRIBUTIONS

NAME	QLT	MAS	INR	k=1	COR	CTR	k=2	COR	CTR	k=3	COR	CTR	DESCRIPTION
VW	947	337	68	-87	121	13	203	652	142	105	174	236	VOLUME TO WEIGHT RATIO
SW	768	199	26	-152	558	24	56	77	6	-74	133	70	SURFACE AREA TO WEIGHT RATIO
ST	999	209	237	47	6	2	-594	990	757	34	3	15	COMPRESSIVE STRENGTH
AP	873	79	20	-37	17	1	210	558	36	-154	298	119	APPEARANCE
DI	959	79	58	-370	590	56	71	22	4	-284	347	406	SQUARENESS
AC	753	35	61	-516	493	49	272	137	27	258	123	150	DIMENSIONAL ACCURACY
FA	998	61	530	1631	981	854	211	16	28	-35	0	5	SPECIAL FEATURES

SUPPLEMENTARY COLUMN CONTRIBUTIONS

NAME	QLT	MAS	INR	k=1	COR	CTR	k=2	COR	CTR	k=3	COR	CTR	DESCRIPTION
Q	216	998	0	2	191	0	-1	20	0	-0	4	0	OVERALL QUALITY
Q1	9481345		94	73	241	37	109	542	163	60	165	310	USER QUALITY INDEX (DESIGN)
Q2	930	676	111	-129	325	59	-166	534	190	-60	71	157	PRODUCER QUALITY INDEX (PERFORMANCE
P1	164	345	-	-285	8	146	-352	12	437	-1206	144	-	PRODUCT 1 - MAXI BRICK
P2	39	345	-	-617	35	686	-211	4	158	-53	0	62	PRODUCT 2 - STOCK BRICK
P3	428	345	-	-668	40	805	1148	1174658		1746	271	-	PRODUCT 3 - M190 BLOCK
P4	121	345	-	-766	591057		676	461617		-409	173682		PRODUCT 4 - M90 BLOCK
P5	273	345	-	-768	581062		903	812882		1164	134	-	PRODUCT 5 - M140 BLOCK
P6	286	345	-	-368	14	244	-1282	1745804		957	97	-	PRODUCT 6 - CLAY NON-FACE BRICK
P7	696	3456273		1181	2442512		-1526	4078228		506	455641		PRODUCT 7 - CLAY FACE BRICK
P8	48	345	-	-577	33	600	-48	0	8	-393	153389		PRODUCT 8 - 3/4M90 BLOCK
P9	419	3458786		-613	47	676	-72	1	18	-1726	372	-	PRODUCT 9 - MAXI BRICK HOLLOW
P0	902	3458146		2105	5977979		1473	2927671		-317	142214		PRODUCT 10 - LOCKBLOCK

jeopardising the modular framework[147]. The position of [8] on the display therefore represents a shift from the position of [4]. The hollow maxi brick, product type [9], has followed the opposite path: from the position in the left bottom of the display more upwards parallel to the x axis. These two products have ended up with rather similar characteristics. That is significant, and could imply a tendency for the characteristics

147. Therefore, they developed the hollow block which is 290 instead of 390 mm long.

of products to move to a position midway between the current maxi brick and the hollow blocks. If this is indeed the case, it would imply that more pressure would come to bear on the clay brick manufacturers. The third product, [0], has moved in the opposite direction. But this is something of a special case.

Usually, with the technology measurement techniques employed, learning involves improvements of quality with time. In Figure III.24 the product type quality indices have been plotted against the year that the technique was first used by any of the firms in the sample. Learning in this case seems not to have involved producing better quality products. Initially, the quality of new products decreased. But in the late 1980's the quality seemed to be increasing again.

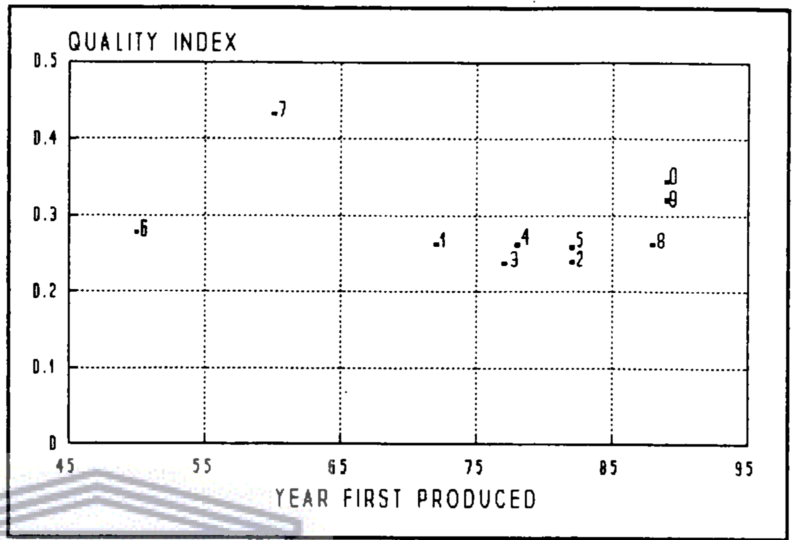


Figure III.24. Product type quality index vs. year first started producing.

6. Implications for choice of technique by cooperatives

There are indications that smaller but lighter products are the direction in which things will be moving, and that better quality products will be demanded. This will have implications for the techniques that can be chosen, especially those using egg-layers[148], as will be shown in the next section.

148. In the next section it will be shown that egg-layers tend to produce lower quality products. Furthermore, most egg-layers are used to produce bigger hollow blocks. In fact, one manufacturer of egg-layers in the Western Cape suggests that solid bricks cannot be made effectively with an egg-layer. In the next section this will be shown to be related to the large volume of materials that must be moved in the case of a solid block. Furthermore, laying bricks with an egg-layer on their sides means that a low volume of products are produced per 'drop'. But the conditions under which the egg-layer work are not sufficiently controlled to enable them to be made on their edge without a high wastage factor. All in all, the trend seems to be against egg-layers.

F. TECHNICAL PROFILES.

It was argued earlier that an industry such as the brick making industry is characterised by a number of technological systems characterised by complementarities between various of its components and subsystems[149]. The task at hand is to identify those systems, and to see which of the components are fixed, and which can be varied to serve different institutional conditions. It was alluded to in the previous section that the relationship between product characteristics and some of the technical elements are relatively fixed. Earlier it was shown that certain of the economic aspects of each firm was more variable within certain technological systems, and not within others.

This section will analyze the technical structure of the industry, identifying the technical principles at work, and the technical opportunity which they present for changes in scale (technical change) and organisation. The integration between various subsystems within the techniques and the organisational aspects of a plant's functioning will be analyzed as well. This includes the implications which certain choices in one stage of the production process have on others and on the potential for variation in productive organisation. Finally, the changes of techniques which have taken place over time will be examined.

1. Technical opportunities in the brick making industry.

To start with, a system of measurement of the nature of a particular technique within the larger whole[150] will be

149. Learning in the technical sense involves changes in scale of the technique along a set of technical principles. This often requires disproportionate changes in the scale of the sub-elements of a technique. The technical potential or opportunity for such learning is partly determined or constrained by physical laws. Bottlenecks then develop in the integration of the various parts into the whole (Sahal 1981:67).

150. Notice that the method of analysis which we develop attempts to combine two strands of technology measurement techniques. The first is generally geared to analyzing the technical trade-offs involved in single 'artifacts' (Sahal, 1985:1-13). This is usually done by measuring different characteristics which are analyzed. The second type of approach more explicitly emphasises that technology in used in a process. They therefore attempt to construct broad models whereby the different aspects that affect these production processes are evaluated (Technology Atlas Project, 1987(1); Sharif, 1986:119-172).

developed. Then an intuitive description of the various technological principles will be given. Finally, this measurement tool will be used to analyze the technical principles of the brick making technology.

a. Classification system.

Various methods have been employed to measure technology, mostly in order to determine the extent of technical change that a new product or technique involves[151]. But no single generally accepted analysis technique has so far emerged. In section II.2 a product classification matrix based on the model used by van Wyk was developed. Using this model most of the activity in the various stages of the production process can be specified.

Seven stages involved in producing bricks can be distinguished: extracting raw materials [E]; mixing and preparing the raw materials [M]; forming the bricks [F]; removing the green bricks from the place where they were formed to the place where they will harden sufficiently to be handled [C]; curing the bricks to harden sufficiently to be used for building purposes [I]; storing the completed product and repacking them [P]; and delivering the completed product [D].

In almost all stages eight different types of activity occur. Four are actions performed on materials: processing, transferring, storing, and controlling. And four are the same actions, but performed on the feedback that governs the process. These eight output-action combinations can be numbered from [1] to [8].

The seven basic processing steps combined with the eight object-action combinations form a 56 cell matrix which can be used to

151. For an overview see Appendix C and the first issue of Technological Forecasting and Social Change, Vol 27 1985, for a whole range of approaches.

characterise the production process for each brick making technique.

Within each of the 56 function cells, a large number of characteristics could be used to designate the nature of each technique. It is clear that to collect sufficient technical information on each of these would be virtually impossible in the scope of this study. A second best solution was used: each function was classified as simply one of four index numbers based on the degree of mechanisation of that function: 0 if the function was not performed, 1 if the function was performed with non-mechanically powered tools only, 2 if the function was performed with both human and mechanical power inputs; 3 if only mechanical power was used to perform a certain task[152].

Apart from the mechanisation indices, data on the number of employees and the proportion of their time spent at each stage of the production process[153] were obtained as well. These were added to get the total employment, [KT]. The ratio of workers in the raw materials extraction stage to the total number of workers is given in [KE]. The ratios in the other stages in order are [KM], [KF], [KC], [KI], [KP], [KD].

These matrices were analyzed using correspondence analysis. To do so the characteristics of each output-action were recoded into

152. For example, in the forming stage of a static concrete block making machine matter processing takes place in the shaping of the concrete in the mould. No human effort is involved in the forming process itself, thus [F1=3]. In machines where a programmable logic controller (PLC) controls the compression phase, the feedback will be mechanical. Thus [F5=3]. In the case where an operator would control the process through a set of hydraulic valves, the feedback would be manual, and [F5=1]. In certain cases, the operator would simply start the process each cycle, and the machine would control the rest. Then [F5=2]. This would also be the case if the operator used a series of gauges and other control instruments from which to control the process.

The transfer of materials from the previous mixing stage in this type of machine usually takes the form of a skip or a chute which feeds concrete into the hopper. If this process is controlled by an operator, opening a valve manually, then [F2=2] because people fill the skip with spades, and [F6=1] because feedback is manual.

The concrete is stored temporarily in a hopper which fills the mould-box. This storage operation is usually done mechanically, [F3=3]. The feedback is usually done automatically, through mechanical settings which automatically open the hopper to fill the mould-box as much as is needed. Therefore, even though no visible control instruments are used, [F7=3].

The final action is the control action, in which the flow of materials is controlled. In the case of a mechanically operated valve system, [F4=3]. In the case where a labourer controls the flow with a spade, [F4=1]. The final area is the control of the feedback. Here we generally think of measures which control the flow of feedback itself. This would involve linking the feedback in the one stage to those of other stages to ensure a smooth production run etc. In our case a central computer regulated the control between different components, but the operator had to stand by to ensure that everything went smoothly. Thus [F8=2].

153. In cases where one person performed tasks related to two stages, the contribution of that worker was divided pro rata between the two stages.

three binary variables. An output-action that did not occur in a particular technique would have 0 for each variable. For example, the feedback processing in the mixing stage [F5] would become three binary variables [F51]; [F52]; [F53] of which one would be 1 if feedback was manual, semi-mechanised, and mechanised respectively, and the other two would be 0[154].

This can be interpreted in the light of the work by Blackburn et. al. (1985:27-29;51-54). They use Bell's categorisation of three basic processes in manufacturing: transformation, transfer, and control of these two. These three can be conceived as a three dimensional space that moves outward with increased mechanisation of each of the components. In this model, the basic processes have been increased to 16, of which eight are active in the brick making industry. Furthermore, the distance which they have moved are measured in terms of a three point scale. Because there is no specific reason why the three point scale will be linear in reality, each measurement was recoded into a three variable binary code. This variable can then be displayed graphically, using correspondence analysis to display these variables in a two dimensional plane.

The recoding scheme is such that any set of three variables related to a single output-action can have only one that is '1', with the other two '0'. A horseshoe type of display would follow <u>if a single underlying gradient was ordering both the row and column variables</u>. This is a well known effect in multidimensional scaling techniques, which suggests that a non-linear effect is present.

Where the data is in a binary format, these rows and columns can be reordered into a matrix where "the mass in the columns shifts monotonically from the top to the bottom as we move across the

154. In principle this scale can be extended to many more points, but that will immediately increase the data requirements.

columns" (Greenacre, 1984:229). Such a hypothetical data matrix was produced in Example 1. Notice the reordering of the rows and columns in the bottom matrix. The CA display is provided in Figure III.25. Notice the horseshoe. Furthermore, ordering of rows and columns in the bottom matrix is the same one as the ordering of the columns on the first principal axis in the display. Thus, the band of points moving diagonally across the matrix can be seen in the shape of the horseshoe. In the classification model the gradient will be the level of mechanisation ordering brick making plants and the mechanisation characteristics simultaneously. In terms of the analysis, a composite index of the level of mechanisation from almost fully mechanised on the right hand side to almost fully manual on the left will be formed, if a single underlying gradient is present. This gradient can be interpreted as a set of technical principles, and the horseshoe a representation of the technical trade-off profile.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	1	1	1	1	1				1				1	1
2	1			1	1	1	1		1				1	
3		1	1					1		1	1	1		1
4		1	1		1				1	1	1	1	1	1

	H	J	K	L	C	B	N	M	E	I	A	D	F	G
3	1	1	1	1	1	1	1							
4		1	1	1	1	1	1	1	1	1				
1					1	1	1	1	1	1	1	1		
2								1	1	1	1	1	1	1

Example 1. Matrices showing the horseshoe effect.

The form of the display can be explained in terms of the distances between the points. Points with similar profiles are presented close to each other, while points with opposite profiles are presented as far as possible from each other. The points at the end of the horseshoe are as far as possible from each other, while attempting to place those lying adjacent in the reorganised matrix as close as possible to each other.

Thus, if all the action-output variables, as they were recoded into three variables each, are presented simultaneously, and the display remained the shape of a horseshoe, the conclusion would be that a progressive mechanisation of all the output-actions that make up the production process have taken place.

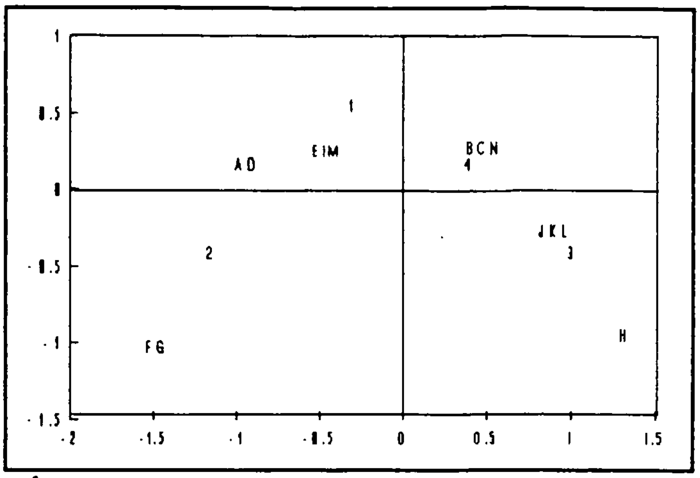


Figure III.25. Example of the 'horseshoe' effect.

This would enable two further types of analysis: Firstly, the level of mechanisation of an individual technique relative to the total can be analyzed. Furthermore, the profiles of subsets of techniques can be studied. If they were all part of the set of techniques governed by a single set of technical principles, a clear profile of the scaling aspects of that technique would be found. Firms lying adjacent on the display would have a similar technical profile. Any gaps or peculiarities in the profile will identify bottlenecks or constraints to further technical advance.

Secondly, the position of the three recoded variables of each output-action can be looked at to give an indication whether that subsystem of the process is generally above or below average in its level of mechanisation. In this way a combined picture of the behaviour of the mechanisation profiles of different subsystems relative to each other will emerge.

In conclusion, a theoretical or standard technical trade-off profile was developed, in which the firms become slightly more mechanised as they moved along the horse-shoe in a CA display. This is due to a single underlying gradient representing the technical principles and technical learning. It presents a display of the model of technical change based on learning which

Sahal first developed. Innovation, it was argued, consists in the changes of scale around a common set of technical principles. But with the scale changes, all the sub-systems have to change, and some sub-systems have to change more than others.

Of course, this type of analysis holds the possibility of being extended to include much more than three categories. One could also model different behaviours, and use that as a theoretical 'standard' against which individual firms could be displayed. But that will not be attempted here.

b. An intuitive investigation of the technical principles at work.

The most important distinction between the different techniques lies in the way in which the bricks are hardened. Table 13 shows that most firms[155] in the survey use cement. Heat used for baking clay, is next, and lime last.

Table 13. Types of hardening processes.

NO	%	CUM%	DESCRIPTION
27	72.97%	72.97%	CEMENT
2	5.41%	78.38%	LIME
8	21.62%	100.00%	HEAT
N=37			

Cement based techniques have technical principles in which a chemical process that is not dependent on high heat levels is used to bind the materials together. This leads to much better control over the nature of the final product than is the case with baked clay. Concrete products essentially only need to be moulded. The strengthening

Table 14. Types of hardening agents used by concrete brick making firms.

HARDENING AGENT

NO	%	CUM	LABEL
2	6.90%	6.90%	LIME AND STEAM
14	48.27%	55.17%	ORDINARY PORTLAND CEMENT
13	44.82%	100.00%	RAPID HARDENING CEMENT

155. But most of the output in volume is not in concrete.

occurs by itself[156]. Clay products need to be baked at very high temperatures, which is a difficult and expensive process to control. Calcium silicate based processes are in between clay and concrete[157]. A chemical reaction takes place, much like cement being made inside the product[158], requiring some heat to cure the bricks.

The concrete based production process is geared towards compacting the concrete as densely as possible in a moulded form. This adds to the final strength of the product, and ensures that the product can be extracted from the mould without breaking. The 'green' product is then left to harden to such a level that it can be handled further without breaking. Being a chemical process, the 'mix design' or mixture of various raw material components is crucial for a successful result[159].

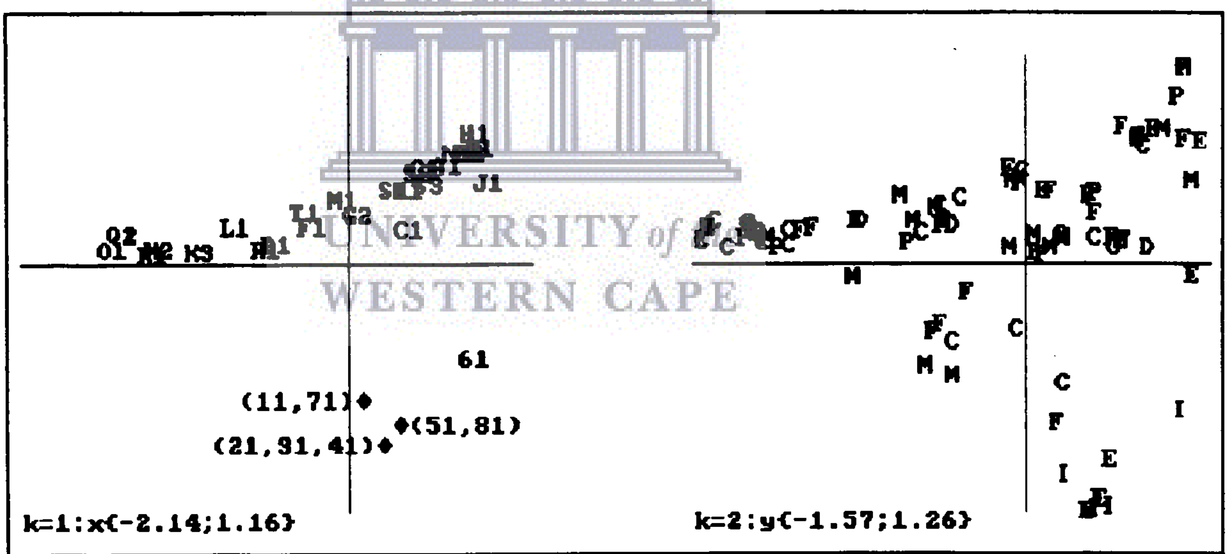


Figure III.26. In search of a technical trade-off profile. (Dimension 1 and 2.)

Crucial aspects in forming bottlenecks and constraints are the way in which the concrete is moulded, and the way in which the

156. In the survey ordinary portland cement (48%) and rapid hardening cement (45%) were mostly used.

157. In interviews it appeared that making calcium silicate bricks, using lime as a binding agent, is no longer so viable. It was originally started to use a special type of lime waste in a local quarry, which has by now been used up. New supplies are difficult to obtain, and transport costs are high. The process also requires a special high quality sand, which is becoming scarce. (R Low, November 1989)

158. Calcium and silicate are mixed. The green bricks are then compressed quite strongly, and are heated in a steam autoclave.

159. Some of the smaller firms place a premium on the mixing phase, suggesting that it is the most important in the whole process.

materials are handled. The former seems to be a crucial determinant of product quality characteristics. Stronger compaction capacity is associated with higher quality products. The way in which the materials are handled throughout the production process places constraints on the capacity of the technique, as well as the organisational and employment generating characteristics. A critical factor affecting both quality and capacity of the technique, is feeding the concrete into the moulds. This is especially important in the case of egg-layers, where the ability of the human body to feed in large amounts of material is limited, and the scope for mechanising the process is limited as well. Furthermore, handling the products after they have been moulded, and the ability to mechanise these functions place limitations on the techniques used for forming the products.

In the case of clay masonry producers, the techniques are less varied. Key technical variables are the drying and baking of the bricks.

c. Technical trade-off profiles.

A correspondence analysis of the survey data was performed to analyze the technical trade-off profiles. All the plants were included as active rows, and all the action-output subsystems - recoded into three variables each - as columns. Figure III.26 contains a display[160]. This does not have the shape of a horseshoe, with the clay firm indicators all to the bottom of the display, and the concrete indicators to the top. The bottom right of the display turns out to be those firms which do extraction and firing stages in the production process. The display on the second dimension is therefore largely governed by the fact that the concrete brick firms do not perform extraction of raw

160. The last two characters from the name of each column variable have been omitted.

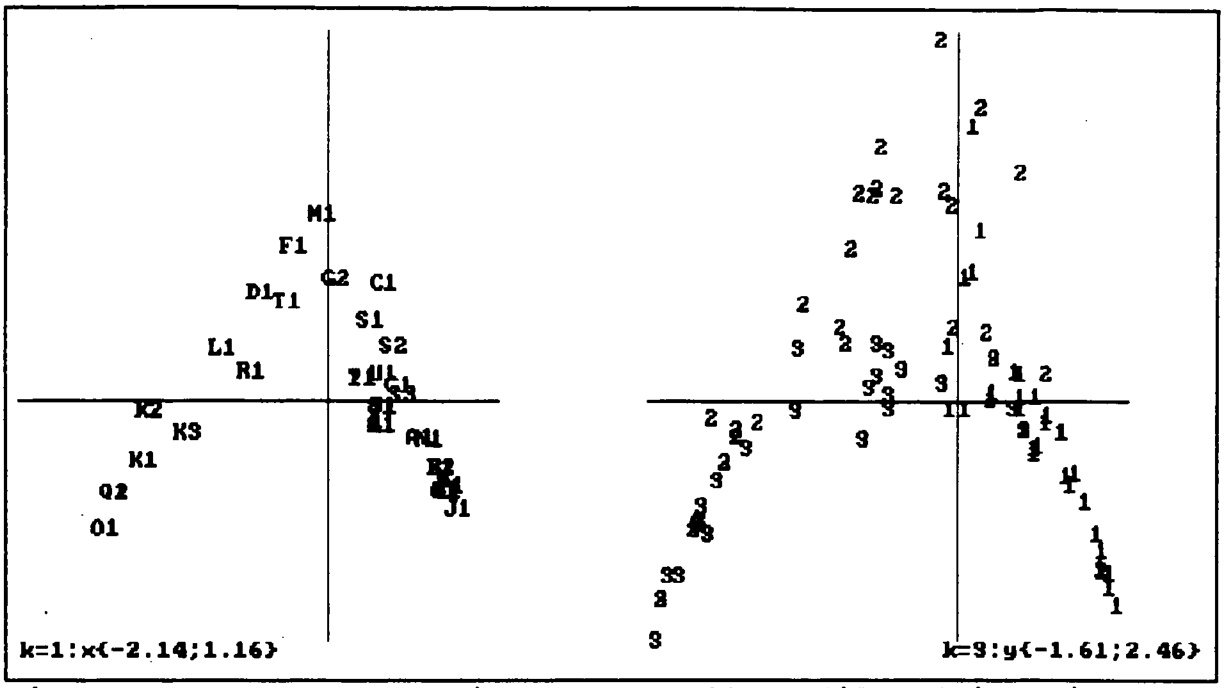


Figure III.27. The technical trade-off profile. (Dimensions 1 & 3)

materials, nor do they need to fire their products. The absence of a horseshoe on the first and second axes should have been expected, and corresponds with the two sets of technical principles in the industry.

The display was then turned on its head to show the first and third principle axes in Figure III.27. The horseshoe shaped technical trade-off curve appeared[161]. This time the first two characters from the column variable codes were omitted to show the 'mechanisation level' part of the codes only. It is clearly visible that the manual processes, recoded as 1, lie on the right hand bottom leg of the horseshoe. The 3's on the left bottom represent the fully mechanised processes, and the semi-mechanised processes with '2' codes lie on top.

The first conclusion is that firms with manual processes in one sub-system tend to have manual processes in the other sub-systems as well. The same holds for the semi-mechanised and mechanised processes. This is in accordance with what was expected on the

161. If the clay brick firms are supplementary in the display, thereby not affecting the orientation of the main axes, the same horseshoe display appears on the first and second dimension.

basis of the theory of technical principles.

Result 17. Results of column points in the CA display in Figure III.26 and Figure III.27. See page 189 for an explanation of the codes.

Ordered according to their first principal coordinates.

NAME	OLT	MAS	INR	k=1	k=2	k=3	NAME	OLT	MAS	INR	k=1	k=2	k=3
F33	205	1	13	-2140	148	-1612	M61	897	35	1	68	181	-40
C83	205	1	13	-2140	148	-1612	P31	650	15	7	118	66	887
M82	578	3	12	-2072	235	-1323	F71	331	3	12	120	469	1878
P73	578	3	12	-2072	235	-1323	M71	419	8	10	171	106	1173
C53	353	2	12	-2038	278	-1179	F42	242	2	13	172	470	2015
C63	306	2	12	-1960	116	-1172	F52	630	10	8	220	-1014	477
P43	878	6	10	-1849	171	-862	C61	647	32	2	240	186	28
P82	878	6	10	-1849	171	-862	C31	436	12	7	251	-762	52
C73	520	4	11	-1816	263	-815	M81	702	32	2	257	176	73
C33	654	5	11	-1809	227	-798	I13	174	2	8	273	-1334	312
C43	654	5	11	-1809	227	-798	I53	174	2	8	273	-1334	312
C13	503	4	11	-1793	198	-707	I82	174	2	8	273	-1334	312
P33	502	4	11	-1748	210	-893	E23	880	7	8	402	-1574	-38
C62	91	1	12	-1725	132	-99	I23	880	7	8	402	-1574	-38
M53	790	7	10	-1682	174	-536	P81	811	26	5	415	440	209
M73	790	7	10	-1682	174	-536	F32	73	1	14	457	328	1568
P32	267	3	12	-1626	107	-401	P41	803	25	5	461	452	202
P72	267	3	12	-1626	107	-401	I51	103	1	9	462	-1566	-37
C82	514	6	11	-1552	219	-176	C81	793	29	3	465	174	40
C52	155	2	12	-1549	119	-236	E13	979	8	7	481	-1493	-175
F53	806	9	10	-1484	223	-305	E33	979	8	7	481	-1493	-175
F63	806	9	10	-1484	223	-305	E43	979	8	7	481	-1493	-175
F73	806	9	10	-1484	223	-305	E61	979	8	7	481	-1493	-175
F82	603	8	10	-1402	233	-141	E81	979	8	7	481	-1493	-175
M33	634	10	8	-1127	-87	-61	I31	979	8	7	481	-1493	-175
F33	845	12	8	-1117	280	369	I41	979	8	7	481	-1493	-175
D32	158	3	12	-1070	283	663	I61	979	8	7	481	-1493	-175
M22	179	5	11	-821	446	505	I71	979	8	7	481	-1493	-175
P22	22	1	13	-777	135	399	I11	711	6	9	551	-1546	-337
P42	22	1	13	-777	135	399	I81	711	6	9	551	-1546	-337
M72	157	3	12	-737	279	1054	E51	837	9	8	556	-1240	-309
C72	72	1	13	-681	195	1423	E71	837	9	8	556	-1240	-309
M43	801	14	6	-649	-644	-241	F81	839	27	4	566	168	45
F43	778	18	5	-610	-421	109	C41	734	24	5	582	104	-293
M52	304	4	12	-581	362	1406	F12	153	5	14	637	873	196
F23	753	19	5	-557	-383	182	M51	834	25	5	639	155	-129
P23	587	18	6	-557	254	396	F61	849	25	5	651	159	-85
C32	519	6	11	-554	377	1460	M21	827	17	10	740	797	-192
F62	198	2	12	-533	274	1737	F51	872	17	10	759	824	-195
F72	198	2	12	-533	274	1737	C21	596	12	11	793	757	-489
C23	467	15	6	-482	-498	49	D31	682	16	9	815	102	-553
M23	574	13	6	-479	-705	-39	F21	915	15	11	860	860	-473
D33	358	16	7	-479	242	349	F41	915	15	11	860	860	-473
C42	550	7	11	-427	424	1405	M41	887	13	12	918	868	-670
F13	504	23	4	-377	-172	232	P21	764	10	14	1010	1068	-895
F22	183	1	13	-112	611	2462	I21	107	1	11	1038	-923	-1129
M13	206	30	2	-91	103	135	F11	571	8	14	1047	807	-1004
M42	629	8	11	-76	527	1441	M12	90	1	16	1048	1264	-1146
C71	419	18	5	-61	-408	383	P11	90	1	16	1048	1264	-1146
P61	795	29	4	-42	522	-34	P51	90	1	16	1048	1264	-1146
M32	479	7	11	-32	552	1353	M11	290	4	14	1096	531	-1164
C22	150	8	12	-9	603	512	E21	162	2	13	1097	-69	-1256
P71	673	16	7	66	70	859	E41	94	1	15	1156	786	-1382

Next, the profiles of the three subsets of firms corresponding with the different ways of forming bricks were analyzed. Concrete block plants with static presses reach right across the whole horseshoe, starting with firm [H1] in the bottom right, through [M1] on top right down to [O1]. It therefore appears as if the technical principles of a static plant will enable scale variations from the most to the least mechanised. The same cannot be said for the egg-layers, nor for the clay brick firms. Both stretch from the right-hand bottom corner to just inside the first quadrant. This suggest that their level of mechanisation is relatively low, midway between the manual and semi-mechanised centroids, and restricted. Egg-laying concrete block presses have a key bottleneck in the transfer of raw materials between the mixing and forming stages that cannot be mechanised easily. The same holds for the storing activity during the repacking stage in the production process. In the case of clay based products, the mechanisation of the transfer activities between the forming, firing and repacking stage appears difficult[162]. This is also the case for the storage activity during the repacking stage[163]. Furthermore, it appears as if economic conditions currently are against substantial increases in mechanisation. A manager of one large clay brick firm suggested that the exchange rate regime has increased the cost of capital equipment to such an extent that the replacement of labour by machines are no longer the objective that it was 6 years ago[164]. Thus, clamp kilns and egg-layers present technical constraints to further mechanisation. Tunnel kilns are experiencing economic constraints.

Finally, the data in Figure III.27 confirm another finding that has been made several times. There are quite a diverse range of technical options in the middle mechanisation range. This is seen in the relatively wide dispersion of the points in the top curve of the horse-shoe. Once you move towards either end-point, the options become fewer and the trade-offs more fixed. This would of course be expected if a single underlying gradient expresses the gradual steps in the mechanisation process.

d. The basic steps in the production process in terms of the classification matrix.

In this paragraph the seven basic steps in the production processes will be analyzed one by one, and the results will be summarised in the next paragraph.

---

162. While it is technically possible to do in certain cases, it appears as if current economic conditions do not permit. To mechanise the setting of the kilns require a tunnel kiln, or at least a chamber kiln. With a tunnel kiln, the whole setting process can be mechanised (One clay face brick factory is currently investigating the development of such a system by a resident specialist in automation technology). With a chamber kiln, the bricks have to be stacked manually on a pallet in a special format (the sc. HVH packs). A specially adapted forklift can then remove the bricks from the pallet and stack them in a kiln.

163. Face bricks have to be sorted according to colour. Due to the abrasive conditions, it is not technically possible to mechanise the sorting process.

164. H Voorma. (Nov. 1989)

Table 15. Mechanisation of the various functions during the extraction stage.

E1 MATTER PROCESSING - REMOVING MATERIAL FROM THE QUARRY

CODE	NO	%	CUM%	DESCRIPTION
0	29	78.3%	78.3%	NO MATTER PROCESSING
3	8	21.6%	100.0%	MECHANISED MATTER PROCESSING

E2 MATTER TRANSPORTING - MATERIALS TO THE PLANT

CODE	NO	%	CUM%	DESCRIPTION
0	28	75.6%	75.6%	NONE
1	2	5.4%	81.0%	MANUAL TRANSFER TO WORKS
3	7	18.9%	100.0%	MECHANICAL TRANSFER TO WORKS

E3 MATTER STORING (TEMPORARY STOCKPILE IN THE QUARRY)

CODE	NO	%	CUM%	DESCRIPTION
0	29	78.3%	78.3%	NONE
3	8	21.6%	100.0%	MECHANICAL STORING MATERIAL

E4 MATTER CONTROL - OVER THE FLOWS OF MATERIALS DURING THE EXTRACTION PROCESS

CODE	NO	%	CUM%	DESCRIPTION
0	28	75.6%	75.6%	NONE
1	1	2.7%	78.3%	MANUAL
3	8	21.6%	100.0%	MECHANICAL

E5 FEEDBACK CONCERNING THE EXTRACTION PROCESS ITSELF

CODE	NO	%	CUM%	DESCRIPTION
0	28	75.6%	75.6%	NO INFORMATION FEEDBACK
1	9	24.3%	100.0%	MANUAL INFORMATION FEEDBACK

E6 INFORMATION FEEDBACK ON THE TRANSPORTING OF MATERIALS

CODE	NO	%	CUM%	DESCRIPTION
0	29	78.3%	78.3%	NO INFO FEEDBACK
1	8	21.6%	100.0%	MANUAL INFO FEEDBACK

E7 FEEDBACK ON THE TEMPORARY STORING OF MATERIALS

CODE	NO	%	CUM%	DESCRIPTION
0	28	75.6%	75.6%	NO FEEDBACK
1	9	24.3%	100.0%	PEOPLE OBSERVE GIVE FEEDBACK

E8 FEEDBACK ON THE CONTROL OF THE FLOW OF MATERIALS

CODE	NO	%	CUM%	DESCRIPTION
0	29	78.3%	78.3%	NO FEEDBACK
1	8	21.6%	100.0%	PEOPLE OBSERVE GIVE FEEDBACK

SOURCE OF THE EQUIPMENT

NO	%	CUM%	DESCRIPTION
1	11.1%	11.1%	SECONDHAND
1	11.1%	22.2%	SELF MADE
7	77.7%	100.0%	SUBCONTRACTED

TYPES OF EQUIPMENT USED TO EXTRACT RAW MATERIALS

NO	%	CUM%	DESCRIPTION
28	75.6%	75.6%	NONE
5	13.5%	89.1%	BELLY SCRAPER AND BULLDOZER
3	8.1%	97.3%	BULLDOZER
1	2.7%	100.0%	WHEELBARROW FROM THE SAND-HEAP

(1) Extraction.

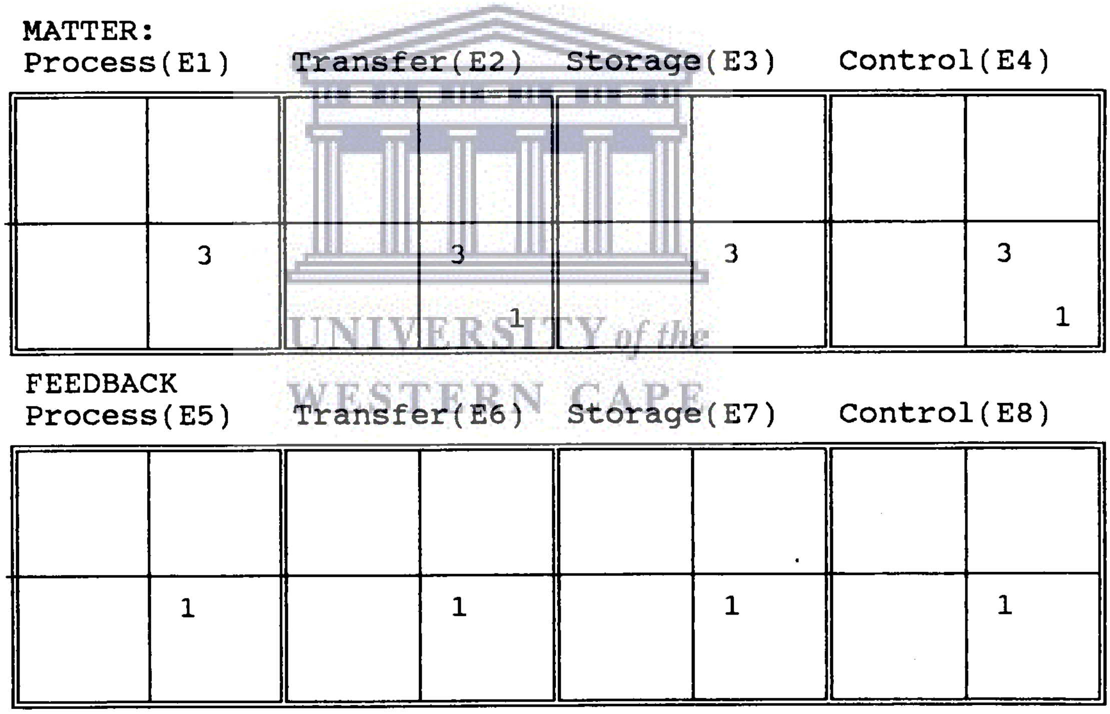
Only one concrete block firm[165] extracts some of its own raw

165. One clay brick firm is busy preparing a plant to use the wastage from the clay brick factory to produce concrete cement blocks.

materials. A worker with a wheelbarrow collects sand from a nearby sand-dune[166]. The likely reason is that the raw material requirements are both fairly standard, and diverse. It would therefore involve a large capital expenditure to get going. There are substantial scale economies in the production of cement, and most likely in crushed stone as well. Furthermore, it is not really feasible for any one firm to produce both aggregates, sand and cement.

Table 16. Mechanisation profiles of the extraction stage.

DESCRIPTION	E1	E2	E3	E4	E5	E6	E7	E8	EMPLOYEES	PLANTS
Wheelbarrow	0	1	0	1	1	0	1	0	0.80	1
Belly scraper	3	3	3	3	1	1	1	1	0.58	4
" (mining own clay)	3	3	3	3	1	1	1	1	10.00	1
Bulldozer	3	3	3	3	1	1	1	1	0.74	2
"(transfer by hand)	3	1	3	3	1	1	1	1	0.02	1



Extraction is a major component of the production of clay bricks. Clay is much scarcer than aggregates. The qualities of clay also affect the nature of the technique[167] and the products produced considerably. Therefore mining the clay is usually an integral

166. It must be removed in any case.

167. It was suggested that one of the first tunnel kilns that was established in the Western Cape was a failure because they did not take sufficient cognisance of the clay quality at the chosen site.

part of the technique. Access to a quarry serves as a significant barrier to entry[168]. In practice, the majority of firms sub-contract the actual mining out to somebody else to prevent large scale equipment being idle a lot of the time. Only one firm has its own mining equipment[169]. Some firms also opt for importing clays from other locations to combine with the clays that they mine locally to produce face bricks with colour variations[170].

The mechanisation profiles of Table 16 are schematic representations of a sub-set of the data in Figure III.27. They suggest that the materials extraction techniques are more mechanised than average. Even the most 'manual' firm uses a mechanised extraction technique. This results in 'pulling' the 3 along the trade-off profile to the right bottom, which is where most of the non-mechanised points are massed. The feedback actions on the other hand are all manual.

(2) Mixing and preparing the raw materials.

The preparation of raw materials in the clay brick factories requires a process of grinding and mixing to ensure that the clay is fine and of even texture. Apart from the firm using shovels, preparation is done mechanically. It starts with an automatic box-feeder, and a system of conveyors between a range of mixers, crushers and rollers. Most firms use a disintegrator with some other preparation equipment. Notice that the most efficient firm [2] uses very cheap preparation processes: a disintegrator, sieve and a hammer mill[171].

---

168. At least one concrete block firm explicitly mentioned this as the reason why they decided not to produce clay bricks.

169. They do so for technical reasons, and use second hand equipment to help reduce the costs. They also emphasise the need to use the scarce clay resource optimally, and mining their own clay gives better control over its management. They consequently also do not import other clays from other sites. This appears to involve significantly higher employment (10 times) in the mining stage of this firm compared to other firms.

170. Certain chemicals, especially manganese, and the way and temperature at which the product is baked also affect the colour and texture of the bricks.

171. Interviews with equipment suppliers suggested that more people are interested in hammer mills lately. That is related to experiences elsewhere suggesting that a hammer mill can work efficiently even with wetter clays. (John Lloyd, December 1989)

Table 17. Materials preparation equipment.

NO	%	CUM%	DESCRIPTION
CONCRETE MIXING			
3	10.3%	10.2%	HAND MIXING
2	6.9%	17.2%	ADAPTED CONCRETE MIXER
2	6.9%	24.1%	TILTING PAN-MIXER.
10	34.4%	58.6%	SMALL PAN-MIXER
10	34.4%	93.1%	PAN-MIXER PLUS AUTOMATIC WEIGHTBATCHER
2	6.9%	100.0%	PAN MIXER WITH BINS (VOLUME BATCHER)
CLAY PREPARATION			
1	12.5%	12.5%	HAND MIXING
1	12.5%	25.0%	WETPAN, HIGH SPEED ROLLS, STOCKPILE, CIRC. SCREEN FEEDER, SECONDARY ROLL.
1	12.5%	37.5%	DISINTEGRATOR, SIEVE, HAMMER MILL
2	25.0%	62.5%	DISINTEGRATOR, HAZOMAG, FINE MILL ROLL
1	12.5%	75.0%	DISINTEGRATOR, HAZOMAG
1	12.5%	87.5%	DISINTEGRATOR, STOCKPILE, HIGH SP. ROLL.
1	12.5%	100.0%	LUMPBREAKER,PRIM ROLL,MIXER,FINAL ROLL

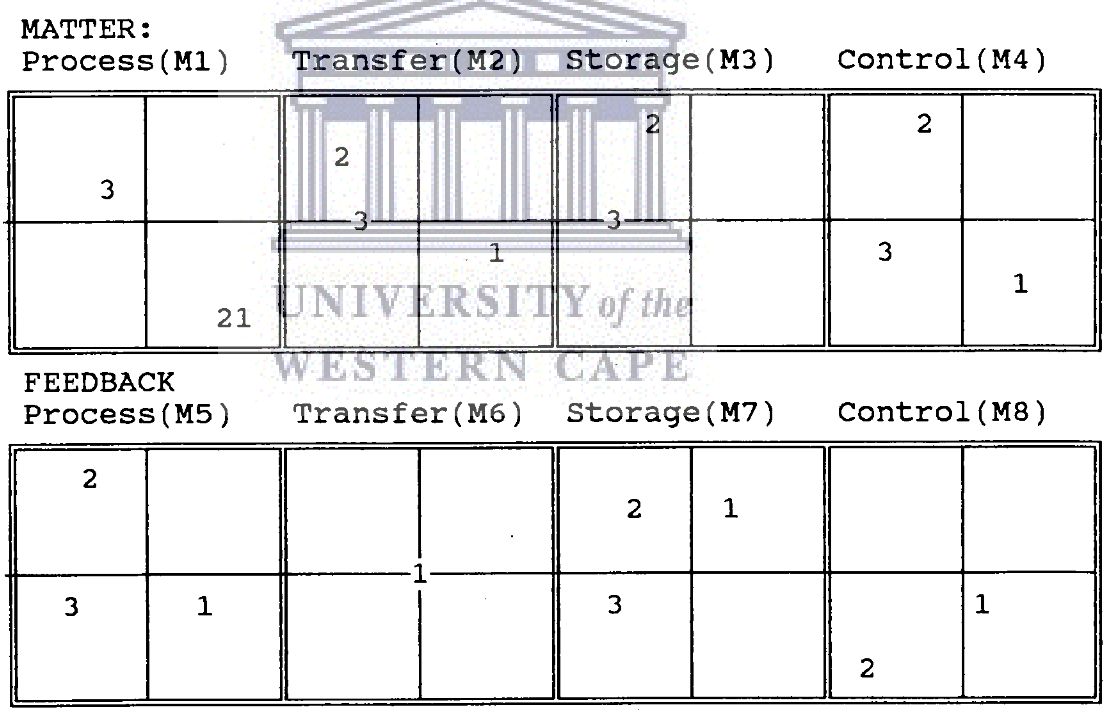
In the concrete brick making techniques, loading the materials into the mixer has been mechanised to some extent. One can distinguish between processes where the materials are loaded into the mixer directly, and where the materials are first stored in a container, which usually serves a batching function as well. In 68% of the production lines, aggregates are loaded manually of which 63% goes directly into the mixer. 32% of techniques mechanically load the raw materials into a batcher.

Transferring the mixed materials from the mixer to the press can take a number or routes. More than half the firms have a manual link between these two processes. Some techniques (10%) mount the mixer on top of the press, so that the materials are dropped directly into the mould box or its hopper. About 36% use another piece of equipment to effect this linkage. It is usually a skip which hoists the materials up to the level of the mould box. But it could be a conveyor or simply a chute.

The mechanisation profile in Table 18 shows a bigger spread of points along the 'horseshoe'. The processing of materials is generally mechanised more than average. Even firms using generally manual production techniques have semi-mechanised mixers. For the transfer of materials into the mixer, the level of mechanisation

Table 18. Mechanisation profiles of material preparation techniques.

DESCRIPTION	M1	M2	M3	M4	M5	M6	M7	M8	EMPLOYEES	PLANTS
CONCRETE MIXING:										
Mix by hand	1	1	0	1	1	1	0	1	4.20	3
Pan-mixer with no batching plant:										
Tilting	3	1	0	1	1	1	0	1	3.30	2
With skip	3	1	2	2	1	1	1	1	3.63	4
Small ordinary	3	1	0	1	1	1	0	1	1.58	4
With hand pre-mix	2	1	0	1	1	1	0	1	5.00	1
With scoop loader	3	2	0	1	1	1	0	1	3.52	1
Pan-mixer with batching plant:										
Conveyor, loader	3	3	3	3	3	1	3	1	1.43	4
Automatic batcher	3	3	3	3	3	1	3	2	1.00	1
Boom scraper	3	2	3	3	3	1	3	2	1.50	2
Weight batcher	3	3	3	3	2	1	2	1	1.26	1
"	3	2	3	2	2	1	2	1	3.00	1
"	3	1	2	2	1	1	1	1	0.60	1
Bin batcher	3	2	2	2	2	1	1	1	3.00	1
Mechanical	3	3	2	2	2	1	2	1	4.00	1
Adapted concrete mixer	3	1	0	1	1	1	0	1	0.80	2
CLAY PREPARATION										
Manual	1	1	0	1	1	1	0	1	0.75	1
Mechanical	3	3	0	3	1	1	0	1	3.80	5
With stockpile	3	3	3	3	1	1	1	1	8.50	2



is generally on par with the other processes. The temporary storage of materials in a batching unit is generally not performed by firms with manual production processes. But for semi-, and mechanised firms the level of mechanisation of storage is generally on par with other sub-systems. The general control of material flows are on an average mechanisation level, while the level of mechanisation of the feedback actions are slightly below average.

Of interest is the feedback on the transfer of raw materials into the mixer, which is only done manually. This includes things like loaders, cable scoops etc. which cannot be mechanised easily. The same is the case with control of the feedback. In fact, no fully mechanised feedback control exists in this stage, even in the most mechanised plants.

Thus, the pattern emerging is that the level of mechanisation is above average when processing the raw materials. Mechanisation of feedback is not possible for the loading of materials into the mixer or storage device. But bigger firms have been able to mechanise the batching function, as well as the feedback processing on the batching function. For smaller producers though, this is not possible, and they generally load the raw materials directly into the mixer. These comments should be seen against the background of the critical nature of the materials preparation stage for the quality of the final products. Because changes in the moisture content of the raw materials, as well as in the consistency of these raw materials affect the consistency and quality of the concrete mix that is produced, the batching process must take these into account. This is a difficult matter to mechanise. So, the bigger producers which mechanise the batching process, in order to ensure consistent mix qualities, must ensure a consistent quality of raw materials. This contributes to higher raw material costs.

Smaller producers, on the other hand, have workers that handle the mixing component. Efficient production and high quality products therefore depend on the motivation and efficiency of the individual workers responsible for the mixing process. Quite a

Table 19. Mixing process mechanisation.

M1 MIXING PROCESS ITSELF

CO	NO	%	CUM%	DESCRIPTION
1	4	10.8%	10.8%	HAND WITH SPADES
2	1	2.7%	13.5%	BOTH HAND AND SOME MECHANICAL
3	32	86.4%	100.0%	MECHANICAL MIXER

M2 TRANSFERRING INTO THE MIXER OR BATCHER PLANT

CO	NO	%	CUM%	DESCRIPTION
1	18	48.7%	48.6%	HAND
2	5	13.5%	62.1%	DRAGLINE/SKIP
3	14	37.8%	100.0%	CABLE SCOOP ON CRANE

M3 TEMPORARILY STORED BEFORE THE MIXING PROCESS IN BATCHER BINS

CO	NO	%	CUM%	DESCRIPTION
0	19	51.3%	51.3%	NONE
2	7	18.9%	70.2%	BATCHER OPENED MANUALLY
3	11	29.7%	100.0%	BATCHER OPENED MECHANICALLY

M4 CONTROL OF FLOWS OF MATERIALS

CO	NO	%	CUM%	DESCRIPTION
1	14	37.8%	37.8%	PEOPLE WITH HAND TOOLS(SPADES)
2	8	21.6%	59.4%	PEOPLE OPERATING VALVES.
3	15	40.5%	100.0%	VALVES OPERATED MECHANICALLY

M5 CHECKING MIXING PROCESS AND THE CONSISTENCY

CO	NO	%	CUM%	DESCRIPTION
1	26	70.2%	70.2%	PEOPLE CHECK THE TIMING ETC.
2	4	10.8%	81.0%	MECHANICAL TIMERS
3	7	18.9%	100.0%	MECHANICAL TIMERS AND FEEDBACK

M6 INFO TO SEE THAT QUANTITY AGGREGATE INTO MIXING/BATHING PLANT ACCURATE

CO	NO	%	CUM%	DESCRIPTION
1	37	100.0%	100.0%	MANUAL

M7 FEEDBACK TO DETERMINE THE AMOUNTS TO BE RELEASED FROM THE STORAGE DEVICE.

CO	NO	%	CUM%	DESCRIPTION
0	19	51.3%	51.3%	NONE
1	8	21.6%	72.9%	PEOPLE DECIDE
2	3	8.1%	81.0%	PEOPLE READ INSTRUMENT
3	7	18.9%	100.0%	MECHANICAL DECISION

M8 CONTROLS OF THE FLOWS OF FEEDBACK INFORMATION THROUGHOUT THE COURSE OF THE MIXING PROCESS.

CO	NO	%	CUM%	DESCRIPTION
1	34	91.8%	91.8%	PEOPLE CONTROL THE FLOWS
2	3	8.1%	100.0%	PEOPLE USE INSTRUMENTS

MIXING EQUIPMENT

NO	%	CUM%	DESCRIPTION
13	-	-	MISSING
16	66.6%	66.6%	NEW
7	29.1%	95.8%	SECOND HAND
1	4.1%	100.0%	SELF MADE

number of small firms complained about this aspect[172], and most identified it as a key matter in ensuring product quality. On the other hand, a skilled and efficient worker could be much more efficient in controlling the output quality of the concrete mix, and incorporate variations in the moisture content etc. than an

172. The most efficient concrete block producer is currently investigating the installation of a flow meter to control the flows of additives and water into the mix. They ascribe part of their current success to a reorganisation of the mixing process. They have fragmented the jobs involved so that each person only takes responsibility for one task in the mixing process. Now they are attempting to mechanise some of those tasks.

automatic batching plant can easily be.

Therefore, an interesting relationship exists between the technical structure, the firm organisation and the product characteristics. Firms that fail to deal with these in an efficient manner will face considerable obstacles. For a cooperative, a minimum level of mechanisation at this level seems unavoidable. But the batching function will most probably still be done manually. If cooperative workers have higher levels of motivation, requiring less supervision, they could have an advantage over non-cooperative firms.

(3) Forming the masonry units.

The clay firms are using a number of different makes of extruders. Important factors influencing the choice were maintenance costs[173], reliability[174] and the source of the equipment. Most firms use second-hand refurbished machines brought in from overseas, at a third of the price of a new machine. Figures of up to 80% of extruder sales being second hand were mentioned. It was also suggested that it killed local attempts to build extruders[175].

In the concrete brick forming stage, a range of equipment sizes[176] is found. A significant number of the larger machines were imported second-hand, but smaller machines tended to be new and locally produced.

Table 20 reveals that even equipment of the same type have different mechanisation profiles. There are also a large range

173. It was suggested that some cheaper extruders have higher maintenance costs.

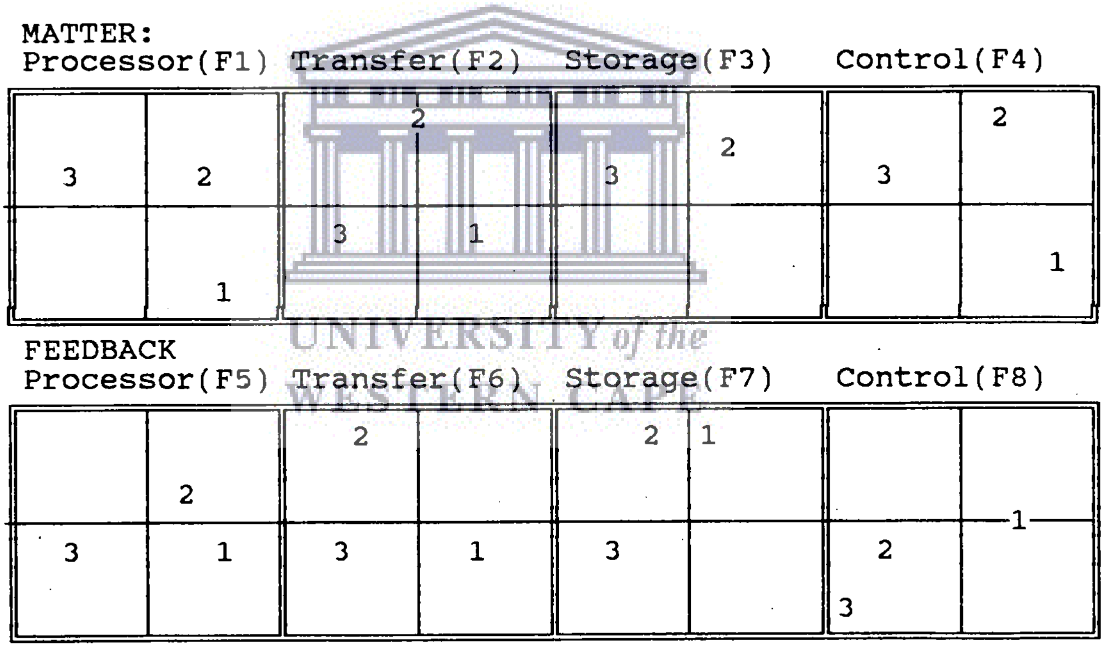
174. High down time meant substantially lower capacity utilisation.

175. Although, technical and design problems with the prototype also played a role. The local company attempted to use a hydraulic rather than an electrical power source, but it did not work. The company went bankrupt. (Mr. Peisal, February 1990)

176. The size here is based roughly on the size of the mould.

Table 20. Mechanisation profiles in the forming stage.

DESCRIPTION	F1	F2	F3	F4	F5	F6	F7	F8	EMPLOYEES	PLANTS
CONCRETE:										
Small egg-layer	1	1	0	1	1	1	0	1	2.0	7
Large egg-layer										
Coronet type	2	1	0	1	1	1	0	1	3.2	3
Profile Probrick	3	1	0	1	1	1	0	1	3.5	2
Small static										
Doubell Hyperstat	2	1	0	1	1	1	0	1	4.5	2
Birkenmayer VB0	3	1	0	1	1	1	0	1	2.0	1
Rosa Commetta	3	3	2	2	2	1	1	1	1.2	1
Medium static										
VB 1/2	3	3	3	3	1	1	1	1	2.7	1
Meta Galante	3	2	3	2	1	1	1	1	4.0	1
VB 1/2	3	3	3	3	2	2	2	1	2.0	1
Schlosser	3	3	3	3	3	3	3	2	1.0	1
Advance Engineering	3	3	3	3	3	3	3	2	1.0	1
Large Static										
VB 3/4	3	3	3	3	2	2	2	1	4.0	1
VB 3/4	3	3	3	3	3	3	3	2	2.0	1
Schlosser	3	3	3	3	3	3	3	2	2.5	2
Columbia	3	3	3	3	3	3	3	2	2.0	1
Alfa 3000	3	3	3	3	3	3	3	3	2.0	1
Duplex	3	3	3	3	3	3	3	2	1.0	2
CLAY:										
Hand moulded	1	1	0	1	1	1	0	1	0.7	1
All extruders	3	3	0	3	2	1	0	1	3.2	7



of profiles. This suggests that there are quite a large number of efficient combinations of subsystems in this stage of the process. Once again, this is especially true for the medium sized plant. The mechanisation profiles of the forming stage are similar to that of the mixing stage. The materials processing (actual forming) is more mechanised than average, with the materials transfer and control functions on average. The feedback actions are similar to the mixing stage as well. But whereas the

Table 21. Equipment used for the forming of masonry units.

NO	%	CUM%	DESCRIPTION
1	-	-	MISSING
SMALL HAND EGG-LAYERS			
2	5.5%	5.5%	DOUBELL DIY
2	5.5%	11.1%	DOUBELL JUMBOSTAT
3	8.3%	19.4%	WILKENSON
EGG-LAYERS			
2	5.5%	25.0%	PROFILE PROBRICK
1	2.7%	27.7%	PMSA CORONET
1	2.7%	30.5%	KADETTE
1	2.7%	33.3%	CORONET LIKE
SMALL STATIC MACHINES			
2	5.5%	38.8%	DOUBELL HYPERSTAT
1	2.7%	41.6%	ROSA COMMETTA ITALY - IMPORTD
1	2.7%	44.4%	BIRKENMAYER VB 0
MEDIUM STATIC MACHINES			
1	2.7%	47.2%	ADVANCE ENGINEERING
2	5.5%	52.7%	VB1/2
1	2.7%	55.5%	SCHLOSSER (HIGH PRESSURE?)
1	2.7%	58.3%	META GALANTE
LARGE STATIC MACHINES			
2	5.5%	63.8%	VB3/4
2	5.5%	69.4%	AUTOMATIC SCHLOSSER
1	2.7%	72.2%	AUTOMATIC ALFA 3000
DUPLEX MACHINES			
2	5.5%	77.7%	DUPLEX
EXTRUDERS			
1	2.7%	80.5%	MURANDO
2	5.5%	86.1%	BRADLEY & CRAVEN
2	5.5%	91.6%	FRH
1	2.7%	94.4%	THOMAS
1	2.7%	97.2%	STEELE 75
FAST HIGH QUALITY STATIC MACHINES			
1	2.7%	100.0%	COLUMBIA - AMERICAN

NEW OR SECOND HAND FORMING EQUIPMENT USED

NO	%	CUM%	DESCRIPTION
9	-	0.0%	MISSING
18	64.2%	64.2%	NEW
10	35.7%	100.0%	SECONDHAND

feedback on the transfer of materials was totally manual in the mixing stage, it is mechanised to the same level as the actual transfer processes. Some firms even have mechanical feedback control[177]. Finally, note that the smaller plants, using manual egg-layers and some small static machines, do not have a material storage component in their forming stage. This means that the concrete is poured directly into the mould box, and not into a hopper. This makes sense because it would be almost impossible for human power to operate a manual hopper storage facility. Instead, the concrete is dropped into the mould box in small manageable quantities. For egg-layers, which have to move around,

177. The firm with these equipment have a central computer that monitors the integration of the various subprocesses, and ensures that everything goes according to plan.

the added weight will impede mobility of the machine.

It appears to be more difficult to automate successfully with second hand equipment. This is due to the abrasive environment, with machines which are slightly run down requiring more active human input to ensure effective functioning. Furthermore, relatively little advance in technology of large brick presses has taken place. The advances that were made, were often made locally, and were based on adapting smaller overseas designs for local conditions.

The physical constraints in the brick forming machines seem to be related to the way in which the compaction process is organised. The factors which govern it are the size of the mould, and the way in which the mould is filled. As the mould gets bigger, the volume of material that must be fed in increases. The possibilities for unequal filling of the mould in the centre and the edges therefore increase with size. This is less of a problem with egg-layers, because the mould is generally filled manually. Related is the problem of uneven compaction: the larger a mould, the more likely that the pressure on the products on the sides will be less than the centre.

It appears as if a number of scale factors affect the output capacity of these firms. Bigger firms tend to install more production lines rather than design massive presses. In order to compensate for the speed which static machines can achieve due to their inability to mechanise the transfer of mixture into the mould box, egg-layers tend to have bigger mould sizes. This also reduces the space on the concrete slab that is wasted due to the movement requirements of the machine.

The interrelation between the mixing and the forming stages seems to be an important potential bottleneck, especially for egg-layers. It is very difficult to mechanise this transfer link between the stages in the production process. The phase of loading the concrete into the mould box then becomes the factor determining the rate of output. More than one firm using egg-layers suggested that the larger egg-layers, where only one person can fill the mould box, tend to be slower. This is also very hard work for a single labourer. Quite a few tons of raw materials must be moved into the mould box efficiently and evenly on a daily basis.

Egg-layers also need to be relatively low weight to be mobile. This places limits on the compressive pressure which can be applied to compact the concrete without the whole machine lifting. The upper end of the range of egg-layers currently in use experiences this problem already.

A final scale effect is in the labour required to operate the machine. A big and small machine are generally operated by roughly the same number of workers. But the overall number of workers relative to the machine costs are relatively low. 51% of firms had 2 or less workers on the forming stage. Most of these were clay brick firms. 40% had between 2 and 4 workers, and only 9% had been between 4 and 5,22 workers in the forming stage. The small range is significant, given the wide range in output and level of mechanisation.

On the other hand, it appears as if a bigger press is needed to justify the costs of installing the control equipment in order to automate the clearing and the storage as well as the repacking stages. Only the plants with bigger machines have installed such equipment. This suggests that the nature of the forming stage is determined by (and determines) the requirements of other stages of the production process: the materials handling during and after the forming stage, the nature of the products, the organisation of the production process etc..

It should also be noted that changing over from one to another mould could be a rather time consuming exercise. Some firms mentioned periods of up to 6 hours for a small egg-layer. This could lead to some specialisation amongst producers, as has already happened. One firm has virtually captured the market for maxi-bricks. This firm produces mainly maxi bricks. The only other option is for firms to build up stockpiles of one product before starting with the next. This tend to reduce flexibility. On the other hand, large firms with many production runs can more easily dedicate some production lines to a specific product. This would therefore constitute an increased returns to scale effect.

Finally, note that the raw material costs are related to the amount of raw materials per product unit, or the weight/volume ratio. But the machine costs are largely related to the costs of each compression. This means that filling the machine board with as much 'value' as possible will lead to lower machine costs on average[178]. This involves a product design which is high, fills the board completely while using as little raw materials as possible.

Earlier it was suggested that static brick presses are associated with higher quality concrete products. It was mentioned by some of the equipment manufacturers that static machines allowed for greater control over the forming process[179]. And static presses were shown to produce products with a higher compressive strength.

<u>The choice of technique for the forming stage of a cooperative is not straightforward. It will depend on a number of factors</u>

178. One firm was suffering because it was producing modular blocks on a mould designed for imperial sized blocks (an imported machine). It could only fill the machine board 70%. This immediately added a premium of 30% to their already high machine cost component.

179. Profile Engineering (August 1989)

mostly related to other stages in the production process. But the quality and characteristics of the output and the future learning potential of techniques should be key components. If the argument that product characteristics are going to move in the direction of smaller units is correct, then static rather than egg-laying presses should be chosen. Furthermore, it seems as if firms should attempt to specialise. But that could be a limitation in terms of marketing. Consequently, a form of horizontal integration between a number of smaller firms each producing a single type of product should be investigated.

(4) The clearing stage.

Table 22. Materials handling equipment.

EQUIPMENT USED TO REMOVE THE PRODUCTS FROM FORMING STAGE

NO	%	CUM%	DESCRIPTION
16	-	-	MISSING
CONCRETE			
2	14.2%	14.2%	MANUAL TROLLEYS
2	14.2%	28.5%	MECHANICALLY POWERED TROLLEY CARTS
5	37.7%	64.2%	GANTRY PLUS CONVEYOR SYSTEMS
3	21.4%	85.7%	FINGER CARTS AND SHELVES
2	14.2%	100.0%	FORKLIFT LOADING STACKED PALLETS
CLAY			
5	71.4%	71.4%	FORKLIFT AND PALLETS
2	28.5%	100.0%	KILN CARS

EQUIPMENT USED TO REPACK THE HARDENED PRODUCTS
CASES --> 18 MISSING --> 19 CODE (00)

NO	%	CUM%	DESCRIPTION
19	-	-	NO EQUIPMENT
BY HAND			
10	55.5%	55.5%	FORKLIFT
3	16.6%	72.2%	OVERHEAD CRANE AND GANTRY SYSTEM
MECHANICAL PALLETISER			
4	22.2%	94.4%	FINGER CART
1	5.5%	100.0%	FORKLIFT AND DEPALLETISER

EQUIPMENT USED DURING THE DELIVERY (EXCLUDING LORRY)

NO	%	CUM%	DESCRIPTION
17	-	-	MANUAL LOADING
17	85.0%	85.0%	FORKLIFT ONTO LORRY
3	15.0%	100.0%	GANTRY OR CRANE ONTO LORRY

This stage deals with the process from where the green bricks are formed to where they are strong enough to be handled. For the clay brick firms this includes stacking them on a kiln car into a drier for the tunnel brick techniques, and on pallets which are removed by forklifts to dry in the sun by the other mechanised clay firms. For the manual clay firm it means carrying the bricks to an open area where they are left to dry. For the egg-layers, the clearing action consists in moving the machine on. The products remain where they were formed until they are hard enough to handle. The static machines require an action which removes the machine boards from the press and places a new board under the mould box.

Of those firms using some equipment, nearly 15% use manual trolleys of some kind. 20% uses a finger cart system stacking the products in shelves. This is the most mechanised way of doing it, and is usually associated with mechanical palletisers. 40% are using gantry and conveyor systems, while the rest use forklift and shelf systems.

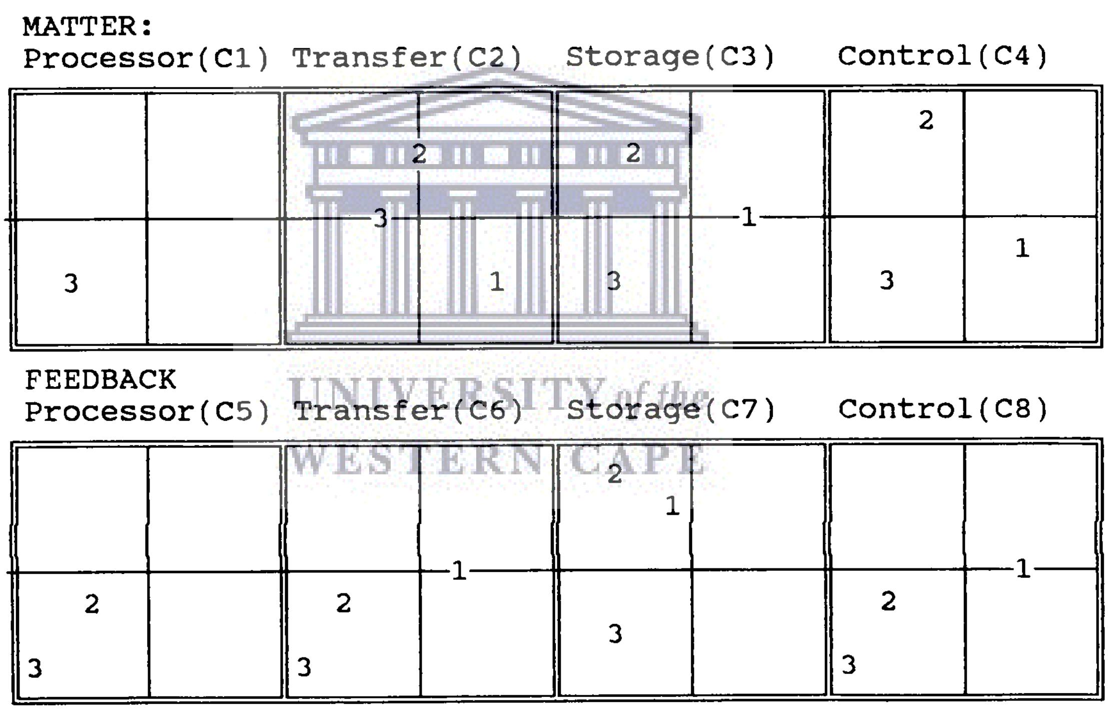
Table 23 shows the big variation that are found during the clearing stage. There is usually no matter processing involved. But some of the plants that do heat or steam cure their products do so essentially as part of the clearing operation[180]. Amongst the static concrete plants, the level of mechanisation of the materials transfer function is above average. But in the storage function (stacking the machine boards with green bricks) the level of mechanisation is more or less average. The same is the case with the matter controls.

The feedback actions are generally mechanised well below the average in this stage. This re-emphasizes the point made earlier that only the bigger plants have the scale that can make an investment into the mechanisation of the feedback functions viable. For the rest, firms use manual feedback on the clearing process. In one case of potential mechanised feedback, a firm with an 'automatic' gantry did not use it because of breakages

180. This could have been placed in a separate stage or with the firing stage of the clay bricks. But the transfer and storage activities are more pronounced.

Table 23. Mechanisation profiles of the clearing stage.

DESCRIPTION	C1	C2	C3	C4	C5	C6	C7	C8	EMPLOYEES	PLANTS
CONCRETE:										
Egg-layers										
Push machine on	0	1	0	1	0	1	0	1	1.00	10
Partly motorised	0	2	0	1	0	1	0	1	0.33	3
Fully mechanical	0	3	0	2	0	1	0	1	0.50	1
Static machines:										
Trolleys	0	1	1	1	0	1	1	1	2.73	2
Conveyor	0	2	1	1	0	1	1	1	3.00	1
Gantry & forklift	0	2	2	2	0	1	1	1	1.50	1
Gantry & conveyor	0	2	2	2	0	1	2	2	3.00	1
Trolley carts	3	2	1	1	2	1	1	1	9.00	1
Gantry & conveyor	0	3	2	2	0	1	1	1	3.60	3
Trolley carts	3	3	2	2	2	2	1	2	2.00	1
Finger cart/shelves	0	3	3	3	0	3	1	2	0.50	1
Forklift/ shelves	3	3	3	3	3	1	3	2	1.00	2
"	0	3	3	3	0	1	3	2	3.00	1
Finger cart/shelves	0	3	3	3	0	3	3	3	0.00	1
CLAY:										
Manual stacking	0	1	1	1	0	1	1	1	0.45	1
Forklits & kiln cars	0	3	1	1	0	1	1	1	13.29	7



caused if something went wrong. The only form of really effective mechanisation of the feedback during the clearing stage seems to be if finger carts and shelve systems are used. The same goes for an automatic stacker system which stacks the machine boards 8 levels high before being removed by a forklift. For the rest, semi-mechanised forms of clearing, with manual feedback seems to be the only alternative.

The differences between the way in which static and egg-laying presses clear finished products are instructive. Egg-laying plants do not use an added storage function, whereas static plants have to store the green products first. This means that ways of mechanising the further materials handling actions are limited when using egg-layers. Furthermore, the handling systems involved in storing the machine boards with green products from static machines are significantly more complex than is the case with egg-layers.

The consequences for a cooperative firm choosing the techniques are therefore that the shift from an egg-laying to a static machine press will involve more sophisticated techniques for handling the materials. In the end, the capacity for a cooperative firm to manage this will be crucial.

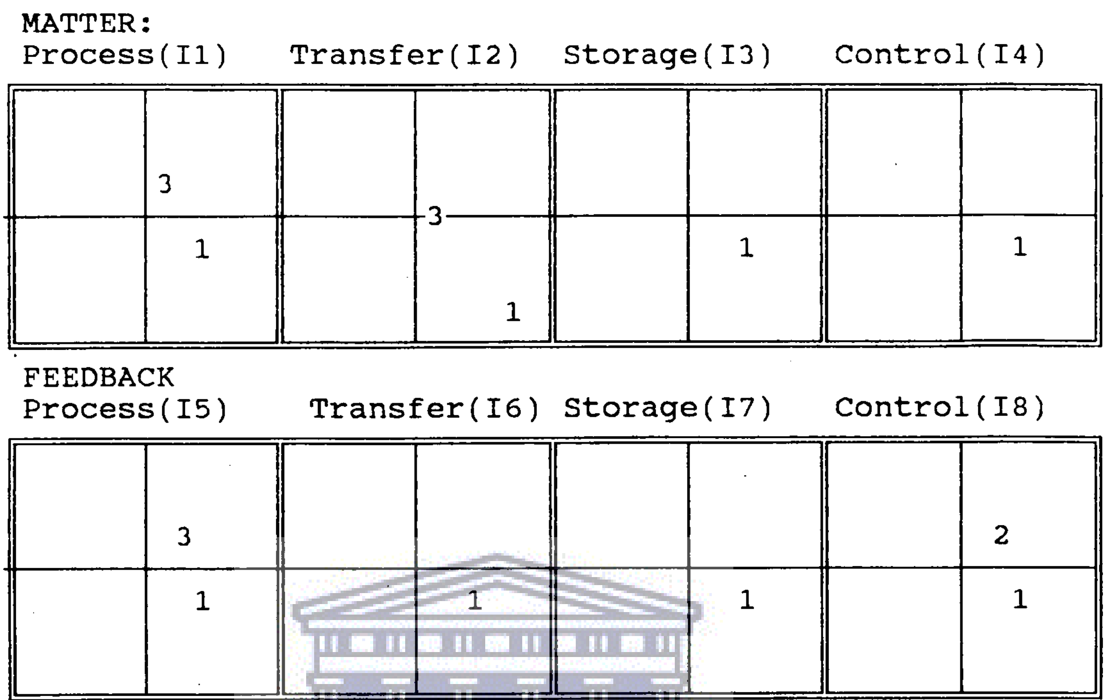
Notice also that most of the employment created is in the handling of materials and green products.

(5) Firing the products.

Only clay brick firms fire their products. Drying and firing are both matter processing sub-systems. The technical constraints to mechanising the transfer and storage function of this stage have been discussed. Table 24 shows that with clamp kilns the products are sun-dried and stacked into a clamp kiln by hand. There is usually no control over what happens once such a kiln has been lit. Therefore, the feedback processing is 0. Chamber kilns do afford some control which can be excercised manually. Therefore the feedback processing becomes 1. In the case of tunnel kilns, the processing becomes mechanical. So does the feedback, and significant control instrumentation goes with controlling the temperatures in and movement of bricks through the kiln.

Table 24. Mechanisation profiles for the firing stage of clay bricks.

DESCRIPTION	I1	I2	I3	I4	I5	I6	I7	I8	EMPLOYEES	PLANTS
Manual clamp kiln	1	1	1	1	0	1	1	1	1.05	1
Forklift/ clamp kiln	1	3	1	1	0	1	1	1	13.50	4
Forklift/chamb. kiln	1	3	1	1	1	1	1	1	34.00	1
Kiln car/tunnel kiln	3	3	1	1	3	1	1	2	17.50	2



Notice that the interrelation between the burner, the control equipment and the movement of the kiln cars through the kiln are all variables which affect the heat in the kiln. One firm has installed a self-developed computerised control system which enables it to keep the kiln temperature at a more stable level. They are then able to burn the kiln at a higher and more stable temperature, which improves the quality of their products. They have also been able to increase the production of their kiln to above the supplier's specifications[181].

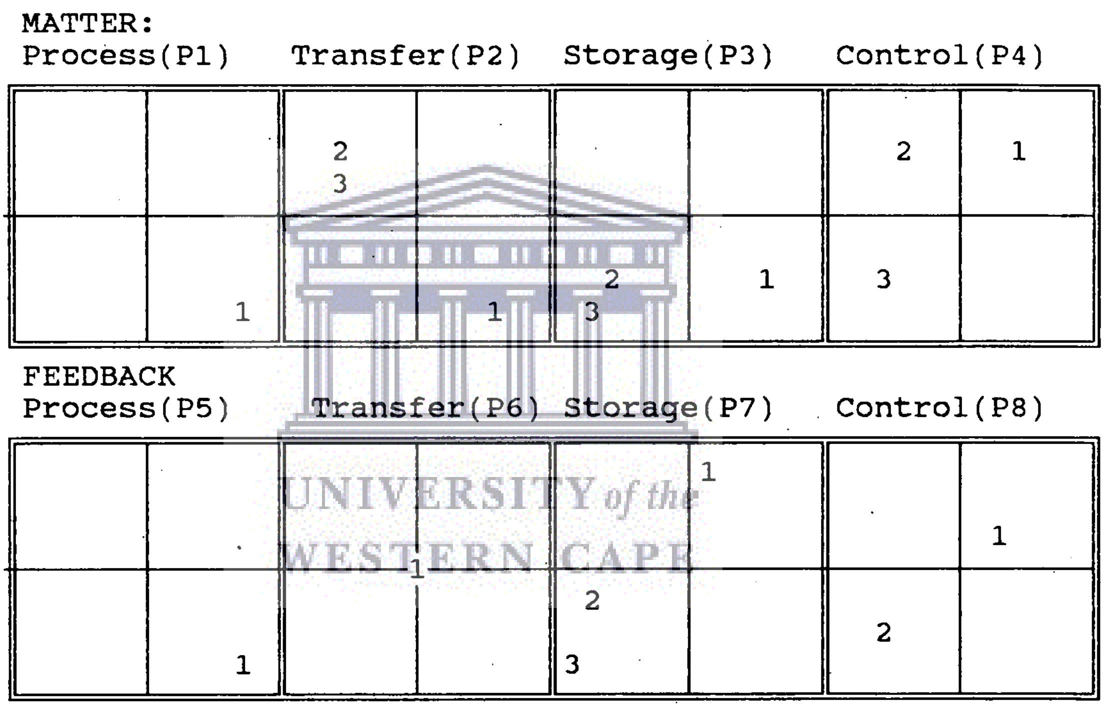
(6) Packing the hardened products.

For clay firms producing face bricks, this usually involves sorting the products, and then stacking them onto pallets. Where colour is very important each brick might have to be restacked

181. Mr. Watermeyer. (November 1989)

Table 25. Mechanisation profiles for the repacking stage.

DESCRIPTION	P1	P2	P3	P4	P5	P6	P7	P8	EMPLOYEES	PLANTS
CONCRETE:										
Manual restacking										
Clean pallet in oil	1	1	0	1	1	1	0	1	3.00	1
Restack pallets	0	0	1	1	0	0	1	1	2.00	1
From concrete slab	0	1	0	1	0	1	0	1	1.86	9
With forklift	0	3	1	1	0	1	1	1	6.68	10
Train/chain system	0	2	3	2	0	1	1	1	0.38	1
Stackers and depalletiser										
Wrapped by hand	0	3	2	3	0	1	2	2	4.50	1
Wrapped mechanic.	0	3	3	3	0	1	3	2	4.89	3
Crane and gantry system:										
"	0	3	1	1	0	1	1	1	8.10	1
"	0	3	2	3	0	1	2	2	2.00	2
CLAY										
None	0	0	0	0	0	0	0	0	0.00	4
Manual	0	0	1	1	0	0	1	1	15.00	2
Forklift	0	3	1	1	0	1	1	1	54.50	2



quite a number of times to ensure that different batches do not have visibly different colour shades[182]. Other clay firms do not restack the products, and the delivery vehicles are loaded directly from the kiln. A significant amount of materials handling is avoided this way[183].

182. The leading firm is currently investigating mechanising this aspect. A substantial number of people are involved in the sorting process. At least one firm has contracted this labour intensive task to a subcontractor.

183. The clay firm that is most efficient, [2], has investigated the possibility of palletising their products. They found it to be not viable.

Concrete firms with egg-layers repack either on a stockpile, or directly onto a pallet, depending on the way in which it will be loaded for delivery. 72% use some form of mechanical assistance, while the rest repacks the products totally mechanically.

The mechanisation profiles in Table 25 suggest that the materials transfer action is relatively more mechanised, while the other functions are mechanised below average. Note that only one firm has some processing associated with the packing stage. That is the firm producing a special block with protrusions[184]. It appears as if some technical constraints in mechanising many of the steps associated with special block shapes exist. That could make them too expensive and difficult to produce for the market they are aimed at.

Notice that the transfer of products to the place from where they will be delivered is fairly manual for those firms that have pre-dominantly manual techniques. But for the rest, the transfer function is significantly mechanised. The use of forklifts or other mechanical material handling equipment is prevalent. Other firms use manual trolleys or carry the products by hand. Feedback on this stage is manual for all the production processes.

The storage function has an opposite profile. Notice that the storage function is either totally manual in the case of the manual firms, or they are highly mechanised in the totally mechanised firms. It appears as if very little 'middle ground' exists in this sub-system. Once again this confirms the observation that mechanisation of this action is difficult, and usually only goes with fairly mechanised plants. When it comes to the feedback of the storage function, the picture becomes more clear. This is one of the 'below average mechanised' sub-systems.

184. This block requires a specially shaped metal machine board. To prevent them from rusting, they have to be cleaned in oil after being cleared. This is a labour intensive process.

The same tends to be the case with the control over the movement of materials, and especially over feedback in the packing stage.

(7) Delivery.

The delivery stage is much the same for all the techniques. The only difference lies in the matter storage function. This deals with the loading of the products onto the truck. The mechanised techniques include forklifts and overhead cranes with gantries. Some firms load by hand. Other do both. But, this function is usually relatively mechanised. The [2] and [3] points are both in the top left quadrant, while the [1] is in the bottom right. (The profiles have not been provided.)

Notice that some of the firms with clamp kilns load by hand straight from the kiln to the lorry. This removes one of the stages of materials handling. On the other hand, firms that load with a forklift must usually have the materials loaded on pallets. This requires that the repacking stage be of a certain nature. Firms which load by hand might be able to exclude some of the extra work which comes from handling the materials as well. In cases where products are loaded manually, it is often left to the transport subcontractor to supply the labour as well[185].

Therefore, as the level of mechanisation declines, the organisation of production becomes much more important to achieve efficient operation. Obviously, where the production process is highly mechanised, including the integration between the various stages in the production process, the organisation of production has become fixed and relatively inflexible.

185. It should be noted that to keep the workers employed on the different stages of the production process in order, I added 1 worker for each 10 tons of products that have to be loaded every day.

e. Some conclusions and implications for the choice of technique.

The general pattern emerging here is therefore that the earlier forming stages are relatively mechanised. The factors which act as constraints are generally the flow of concrete and matters affecting that. Thereafter the later stages in handling the formed products are quite different. The matter storage functions are more difficult to mechanise, and the feedback on them even more so. They are largely constrained by the way and scale in which the units were formed in the first place.

The consequences of this technical analysis for the traditional choice of technique function is important. Only in the case of static concrete block plants is it possible to substitute capital for labour. The other techniques present technical barriers to such substitution. Moreover, there are significant differences in output characteristics between the less and more mechanised techniques even within the group of static plants. And associated are quite clear differences in output characteristics of the various techniques. In the case of high quality face bricks, the amount of labour required to produce them is relatively higher than lower quality products. The reason is that certain aspects of the materials handling component (sorting) in this regard is very difficult if impossible to mechanise. This is exacerbated by the unevenness of some of these products. The profile is therefore not primarily a substitution between labour and capital, but scale change of the characteristics of one or more of subsystems of the technique. This requires associated changes in the characteristics of the other subsystems. And the choice of technique involves matching these sets of technical characteristics with the required product characteristics on the demand side, and the firm's characteristics on the institutional side.

2. Technical profiles and productive organisation.

In the previous section the technological systems were analyzed from a purely technical perspective. However, these systems extend into the economic and institutional domains as well. In this section, these interrelations will be shown.

a. Technical profiles and efficiency.

The mechanisation indices were then included together with information for product quality and firm efficiency in a CA plot. The results of this analysis are remarkable in a number of ways. Not only did it result a fairly stable display, but the orientation of the firms were very close to those found in the analysis of the interrelations between various factors involved in earlier determination of the choice of technique function[186]. This suggests that some related phenomena were ordering the firms on the first principal axis in both cases. It also presents further evidence of the interrelationship between technical and economic factors. In the theoretical model this was formulated in terms of transition formulae whereby technical characteristics get translated into economic inputs and consequently scale economies.

The only firms that do not correspond all that well, are the clay brick factories. This is possibly due to the coding system which under-represented size factors in favour of function. But an alternative explanation is that the technical principles of the clay brick factories are such that they require a much larger scale of operation in order for the reduced level of mechanisation to be efficient. This would be supported by the big

186. The display has not been included in the text. There the basis of the analysis were firms, and not plants, as is currently the case.

costs and size of a minimum sized mechanised clay brick plant[187].

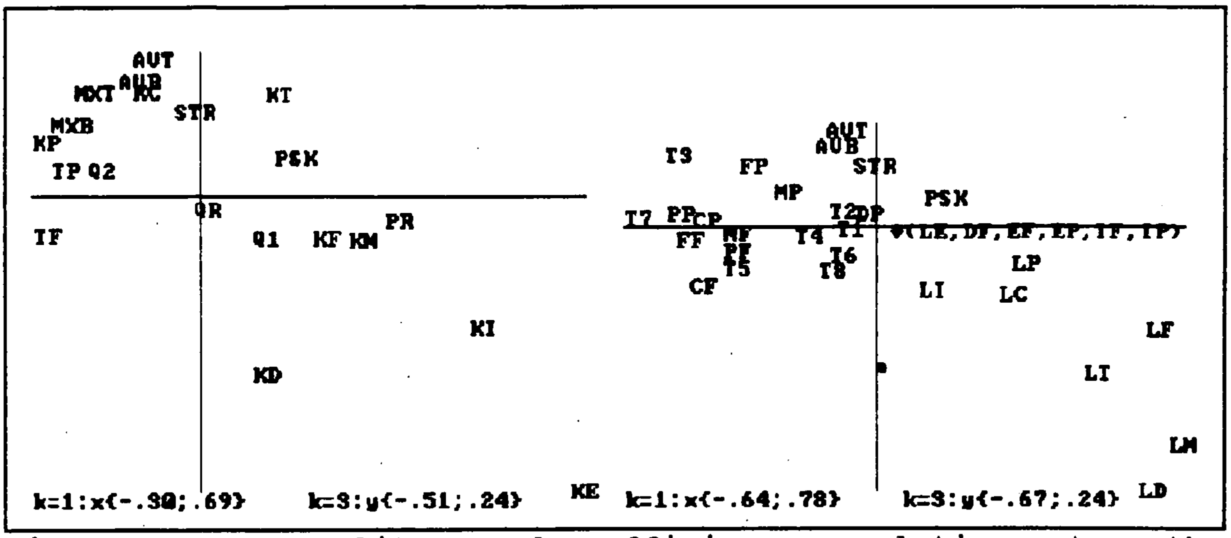


Figure III.28. Quality and efficiency relative to the mechanisation indices.

Note: Two sets of supplementary column indicators are presented on the two sets of axes.

The results are strengthened by the quality and efficiency indicators in the correspondence analysis display (Left set of axes in Figure III.28). Care should be taken when interpreting them, as they were added as supplementary columns. Notice that the general orientation is similar to that in the choice of technique context. It appears that the most mechanised processes are the least efficient in the 1989 economic environment. At the other end of the spectrum, the upper end of the egg-layer plants are associated with above average efficiency [PSK]. For static plants, the efficiency indicator is negatively associated with the most mechanised plants. (The same is the case with the clay brick firms). However, the quality in display of [PSK] is low (19.9%), and most of that (15.1%) is along the first principle axis. But the suggestion is that the less mechanised static concrete and clay brick plants, as well as the slightly more mechanised egg-laying plants were relatively more efficient. This

187. Estimates for the cost of a basic clamp kiln factory ranged between R4 million and R9 million rand, depending on the type of preparation plant installed. For a tunnel kiln factory, the lowest estimate was R18 million. On the other hand, firms with the same level of mechanisation (not necessarily with the same output capacity) could be established for under R250000 if the cost of a forklift was included. In comparison a concrete plant with a level of mechanisation comparable to that of a clay brick plant can be much smaller if it used a static machine press.

is comparable to the findings throughout the analysis which could be summarised in two points: they were more flexible and adaptable to changing circumstances, and they were able to provide cheaper products with lower quality in smaller quantities in a time when these were required due to changing economic and institutional conditions.

This is further illustrated by an analysis of quality factors of different products that are associated with mechanisation levels. Looking at the design characteristics, it appears that [Q1] representing bigger and lighter products are associated with the egg-layers, and smaller static plants. Furthermore, the finding that these firms produce products which are below average in strength is reflected here as well. [STR] indicating compressive strength is situated at the opposite side, suggesting that firms with static mechanised presses produce stronger blocks. However, the quality of the display in Result 18 is 60.5% with 56.6% along the second principle axis. This suggests that the strength is not so much associated with the increasing mechanisation of the production processes as a whole (along the first principle axis), but with the different sets of technical principles (along the second principle axis).

The conclusion is therefore that different sets of technical principles present different learning potential with regards to changes in the technique itself. But, even techniques which are relatively limited in terms of potential for technical change still has scope for learning to be used efficiently. Some of the most efficient firms use such egg-layers, which have been mechanised up to their technical potential limit.

Smaller static machines, however, appear to yield higher learning potential both in terms of their use and innovation aspects. A similar conclusion can be made with regards to product character-

Result 18. Supplementary column indicators for Figure III.28.

NAME	QLT	MAS	INR	k=1	COR	CTR	k=2	COR	CTR	k=3	COR	CTR	DESCRIPTION
KT	438	871	368	133	16	27	-658	394	881	179	29	103	TOTAL LABOUR TIME EXPENDED
KE	92	0	1	686	45	0	-480	22	0	-512	25	0	LABOUR TIME IN EXTRACTION STAGE
KM	589	7	2	283	129	1	529	451	4	-74	9	0	LABOUR TIME IN PREPARATION STAGE
KF	551	7	2	268	94	1	585	451	6	-70	6	0	LABOUR TIME IN FORMING STAGE
KC	69	5	1	-107	16	0	-58	5	0	184	48	1	LABOUR TIME IN CLEARING STAGE
KI	889	2	2	502	85	1	-1530	787	11	-229	18	0	LABOUR TIME IN CURING STAGE
KP	356	9	2	-297	182	1	275	156	2	95	18	0	LABOUR TIME IN PACKING STAGE
KD	177	5	1	111	20	0	-34	2	0	-308	155	2	LABOUR TIME IN DELIVERY STAGE
LT	348	2389	1241	563	234	1321	142	15	113	-368	100	1194	TOTAL LABOUR TIME/TOTAL OUTPUT
LE	123	49	8	59	9	0	216	114	5	-14	1	0	LABOUR TIME IN EXTRACTION/OUTPUT
LM	484	458	418	783	257	490	482	98	248	-555	129	521	LABOUR TIME IN PREPARATION/OUTPUT
LF	305	535	587	719	181	483	535	100	357	-262	24	136	LABOUR TIME IN FORMING/OUTPUT
LC	92	305	188	342	73	62	-42	1	1	-171	18	33	LABOUR TIME IN CLEARING/OUTPUT
LI	233	907	154	135	41	29	245	135	127	-159	57	85	LABOUR TIME IN CURING/OUTPUT
LP	274	392	217	379	100	98	492	168	221	-97	6	14	LABOUR TIME IN PACKING/OUTPUT
LD	283	352	455	701	146	302	-137	6	15	-667	132	579	LABOUR TIME IN DELIVERY/OUTPUT
EP	989	91	85	484	97	37	-1457	879	453	-180	13	11	MATTER-ACTIONS IN EXTRACTION STAGE
EF	953	32	28	521	119	15	-1359	808	139	-246	26	7	FEEDBACK-ACTION IN EXTRACTION STGE
MP	790	280	9	-247	702	30	1	0	0	87	88	8	MATTER-ACTIONS IN PREPARATION STGE
MF	920	159	12	-377	736	39	185	177	13	-35	6	1	FEEDBACK-ACTION IN PREPARATION STG
FP	831	272	17	-333	689	53	-7	0	0	151	141	23	MATTER-ACTIONS IN FORMING STAGE
FF	850	193	24	-503	782	85	144	64	9	-35	4	1	FEEDBACK-ACTION IN FORMING STAGE
CP	825	174	17	-457	817	63	43	7	1	13	1	0	MATTER-ACTIONS IN CLEARING STAGE
CF	894	124	13	-468	774	47	104	38	3	-151	81	10	FEEDBACK-ACTION IN CLEARING STAGE
IP	960	48	47	443	76	16	-1503	880	251	-98	4	2	MATTER-ACTIONS IN CURING STAGE
IF	813	31	34	430	65	10	-1457	747	155	-53	1	0	FEEDBACK-ACTION IN CURING STAGE
PP	854	143	22	-492	613	60	307	238	31	33	3	1	MATTER-ACTIONS IN PACKING STAGE
PF	873	97	11	-377	473	24	341	386	26	-65	14	1	FEEDBACK-ACTION IN PACKING STAGE
DP	778	211	4	-31	20	0	192	741	18	29	17	1	MATTER-ACTIONS IN DELIVERY STAGE
DF	897	106	2	68	106	1	181	755	8	-40	37	1	FEEDBACK-ACTION IN DELIVERY STAGE
TP	957	1220	26	-206	759	90	-94	158	25	47	40	10	TOTAL MATTER ACTIONS - ALL STAGES
TF	979	743	26	-288	906	108	44	21	3	-69	52	13	TOTAL FEEDBACK ACTIONS - ALL STAGE
T1	439	230	5	-78	111	2	-133	326	9	11	2	0	MECH. INDEX - MATTER PROCESSING
T2	634	429	5	-97	285	7	-100	305	10	38	44	2	MECH. INDEX - MATTER TRANSFER
T3	929	255	33	-527	824	124	-50	7	1	181	98	31	MECH. INDEX - MATTER STORAGE
T4	899	307	6	-187	710	19	-93	176	6	-25	13	1	MECH. INDEX - MATTER CONTROL
T5	839	140	10	-378	768	35	-42	9	1	-106	61	6	MECH. INDEX - FEEDBACK PROCESSING
T6	726	209	3	-95	249	3	108	321	6	-75	156	4	MECH. INDEX - FEEDBACK TRANSFER
T7	954	179	30	-641	953	128	-10	0	0	20	1	0	MECH. INDEX - FEEDBACK STORAGE
T8	851	215	3	-124	376	6	82	166	3	-112	309	10	MECH. INDEX - FEEDBACK CONTROL
MXB	269	31	12	-260	69	4	-423	184	13	127	17	2	MAX. CAPACITY IN BRICK EQUIVALENTS
MXT	296	86	38	-218	41	7	-509	225	52	182	29	10	MAX. CAPACITY IN TONNES
AVB	440	19	6	-134	22	1	-554	370	13	200	48	3	AVE. CAPACITY IN BRICK EQUIVALENTS
AVT	471	52	20	-107	12	1	-636	403	49	238	57	11	AVE. CAPACITY IN TONNES
STR	605	4	1	-35	2	0	-593	566	3	151	37	0	COMPRESSIVE STRENGTH
QR	31	10	0	2	0	0	19	12	0	-24	19	0	TOTAL QUALITY INDEX
Q1	517	13	0	112	193	0	126	245	0	-71	79	0	USER QUALITY INDEX
Q2	415	7	0	-190	261	0	-139	140	0	45	15	0	PRODUCER QUALITY INDEX
PR	368	27	4	348	359	6	37	4	0	-42	5	0	PROFIT RATE
PSK	199	37	3	151	123	1	97	50	1	69	26	1	STANDARDISED PROFIT RATE

istics. The egg-layers are more limited in terms of the nature and characteristics of the products that they can produce. If the analysis in the previous section on product characteristics is correct, the nature of the products demanded would move closer to ordinary bricks (smaller from the blocks side and lighter from the bricks' side). Techniques using less mechanised forming processes can be expected to become progressively less efficient. Smaller blocks tend to be heavier per unit volume, and to get them strong enough a stronger press might be needed. This would affect the egg-layer viability severely.

Finally, the technical factors which are associated with the relative efficiency of various techniques can be identified. The demand for a certain type of product with specific characteristics emerged due to various institutional factors[188]. Markets for poorer quality but cheaper hollow block products were created, which suited the technical conditions of less mechanised production processes. At the same time it presented significant obstacles for the larger scale highly mechanised plants, that have to produce high quality products at fairly constant high volumes to recover the higher production costs that they face.

b. Productive organisation.

<u>The finding that a great deal of the efficiency of various techniques are not related to machine capacity per se, but to the way in which the technique is operated within the firm, places productive organisation as a key determinant of success and viability.</u> The object then is to identify those areas that are fairly fixed given the technique and those more dependent on the organisation of production.

Two sets of measures reflecting the amount of labour time used in each stage of the production process were calculated. The first was the proportion of the total labour time [KT] that went into each stage of the production process. They were labelled [KE,KM,KF,KC,KI,KP,KD] for each stage respectively. The labour/overall output ratio for each stage of the production

188. These include the change of state policies which only really worked through in the mid to late 1980's; the slowdown in building 'high-income' houses and greater emphasis on low cost housing; less high volume contracts; the need to cut costs in both the construction and material costs of walling in low cost houses; the relatively low wage levels; and the local development of little-mechanised production techniques to suit the local environment.

process, labelled [LE,LM,LF,LC,LI,LP,LD], and for the production process as a whole [LT][189] were also calculated. These points were added as supplementary columns, and are displayed on the right hand set of axes in Figure III.28. Notice that the orientation of the display is the same as before, but the scale of the axes is different.

The previous findings that the feedback actions in all stages are mechanised below average are now extended to the materials actions in the packing and clearing stages. This is confirmed strongly by the position of the indicators for the proportion of the labour time spent on the clearing and packing stages [KC,KP], which lie towards the top left of the display. Most of the labour time used in the more mechanised plants are thus used in the clearing and packing stages. All the other indicators of labour time ratios are on the opposite side, with the delivery stage [KD] somewhat on its own. This supports the earlier observation that mechanised loading of materials on trucks can only take place if the products have been prepared for this. But it is more difficult to mechanise these matter storage functions. This suggests that less mechanised plants had above average labour ratios in the extraction, preparation, forming and firing stages [KE,KP,KF,KI].

The labour/output ratios for the clearing and the packing stages [LC,LP] are both to the left of the total, preparation, forming and delivery indicators [LT,LM,LF,LD]. This confirms once again that the labour productivity in the clearing and packing stages are below average for the more mechanised plants. Thus the indicators for above average labour/output ratios for these stages are pulled in the direction of the more mechanised production processes. But in the mixing, forming, and delivery stages, the labour productivity of the more mechanised stages are

189. In the case of the labour/output ratios, we replaced the values for those firms that do not perform extraction or firing with the column average of the rest of the firms.

higher.

Thus, the key aspects governing the viability of enterprises from the technical system can be identified. The principal finding is that all those activities which involve feedback, as well as those involving materials handling (and storage) are mechanised with great difficulty given the technological principles at work. Attempts to mechanised these aspects of the production processes places constraints not only on the technology that can be used in the other parts of the production process - especially the forming stage - but also the quality of products and the flexibility of production volumes. The resultant efficiency is low given current institutional arrangements. Mechanising the materials processing functions seemed to be easier, and related to product characteristics rather than efficiency per se. The ability of a firm to produce quality products therefore depends on the machinery in the forming stage. The efficiency of the process as a whole is largely determined by the efficient organisation of production as a whole, with much less opportunities to mechanise these. This largely involves materials handling and feedback and control over the production process.

In the light of the observed greater variation in the organisation of production by the middle sized concrete block producers, the options for cooperatives are beginning to emerge. Leaving aside the clay brick segment in which the barriers to entry are largely economic in view of the minimum scale requirements, limited access to critical raw materials etc., two sets of conditions emerge in the concrete brick making area. In those plants where the feedback is mechanised, most of the materials handling has to be mechanised, and the nature of the materials forming stages has to be of a certain type and nature. These highly mechanised plants have to produce higher quality products for economic and technical reasons, and need a relatively high capacity utilisation to be efficient. On the other hand, most of the other concrete brick producers have a range of options as to how to organise their production process. The quality of the products they produce is largely determined by the choices thy make in the forming stage, for which a whole range of equipment options are available. On the other hand, efficiency of the plant as a whole depends on the way in which the production process is organised, leaving much more scope in the hands of the people in the enterprise to manage it efficiently, with sufficient scope to alter the organisational arrangements to suit the needs for cooperative type ventures. Whether these opportunities will be used effectively, is another matter. No a priori judgement can be made on this score, and it depends on the people involved whether they will be able to get it together. That question lies beyond the scope of this this study which seek to identify the technological opportunities and constraints.

3. Learning and changes in the production technique.

Before analyzing the institutional and organisational aspects within the enterprises and the industry in the next section, the evolution and impact of technical changes on enterprises and the industry and the way in which technical choices are made within enterprises will be investigated.

a. Historical perspective.

In order to analyze the history of the choice of technique in the industry, the firm codes in Figure III.27 were replaced with the year in which the technique was first chosen; the year in which the last major technical change took place; and the year in which the last major organisational change took place respectively.

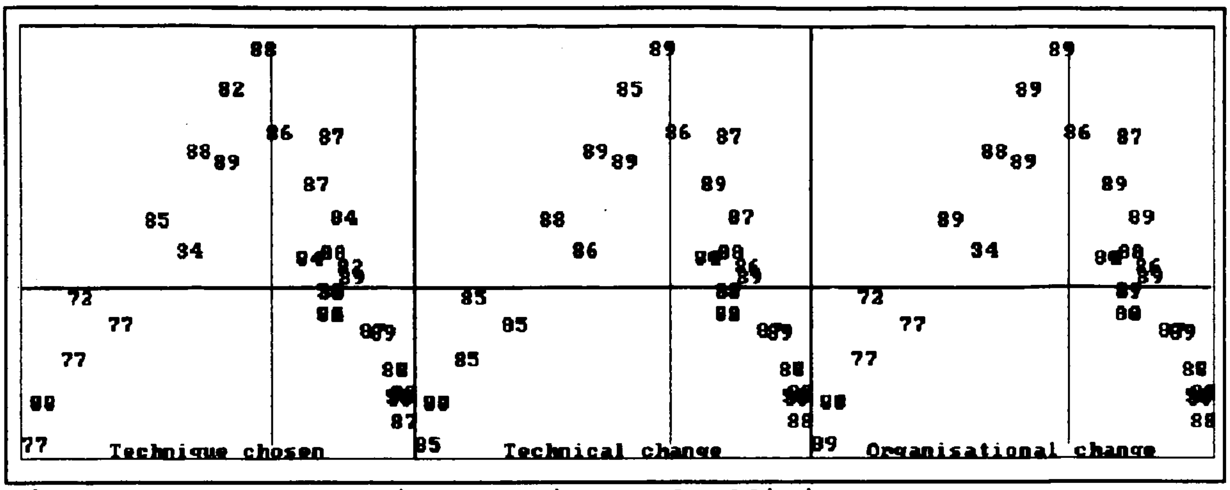


Figure III.29. Technical choice and efficiency.

From the display in Figure III.29 containing the three plots, a number of observations can be made. Firstly, there seems to be two sources or 'locations' of learning in the industry. The first deals with learning in the machine producing industry. The second in the machine using industry. A lot of learning has taken place in the former, as suggested by the establishment of new firms rather than changes in existing firms. Most of the newly established firms are towards the right side of the display - also the more efficient side. Many of the less efficient techniques were chosen in the late 1970's, while the more efficient less mechanised techniques were first chosen in the mid 1980's.

The importance of local technological capacity, especially in the machine producing sector, has been emphasised in the literature[190]. It appears that similar results follow from this analysis. Taking the forming stage as indicative of the technical principles, the source of the equipment was analyzed. Evidence suggests that the more efficient techniques adopted later were produced locally.

The techniques chosen before 1975 were produced overseas. These were all clay brick techniques. During the period 1975 to 1985, 6 new techniques were chosen. Of these only 1 was produced

190. See Fransman 1984:303

Table 26. Source of technique and year of adoption.

	1934-1975	1975-1985	1985-1989
Locally produced	0	1	14
Locally produced under licence	0	2	1
Imported.	7	3	5

N=33

Note: The Pearson Chi-square statistic is significant at the 1% level, but is suspect because more than 20% of the cell populations below 5.

locally, while 2 were produced locally under licence and 3 were imported. In the period after 1985, 70% of the techniques chosen were of local origin, with 5% produced under licence and 25% imported.

But a further significant point is that of those techniques that were imported during the past 5 years, four out of the 5 (80%) were second hand equipment[191]. In contrast, only 2 out of the 14 (14.3%) locally produced techniques chosen after 1985[192] were second hand. This also corresponds with the reasons why the particular firm adopted the technique[193].

Finally, note that the imported equipment was on average of a much larger capacity than the locally produced techniques. It is also interesting to note the relative absence of organisational change in the concrete plants using imported technology. We would not like to attach too much weight to it, given the difficulty of assigning dates to technical events. But it does seem that these techniques have much more fixed production organisation,

191. The remaining piece of equipment was a smaller one, and the reason for importing was given as producing quality products at a smaller scale. During the interview it also transpired that strong family contacts with the source country played a significant role in the actual decision on the type of machine to purchase. It is also less efficient. (Firm [C])

192. Or 3 out of 15 after 1984 (20%)

193. Table 27 shows that 6 firms (21.4%) suggested that they chose the technique because the second hand or cheap equipment was available at the time.

confirming the earlier observation that certain techniques places technical constraints on organisational flexibility.

b. Reasons why technical choices were made.

Table 27. Reason why the technique was chosen.

FREQ	PCT	DESCRIPTION
9	25.72%	MACHINE INPUTS
2	5.71%	Problems with previous machines
6	17.14%	Second hand (cheap) machine availability
1	2.86%	Latest technology
3	8.57%	RAW MATERIAL INPUTS
1	2.86%	To work away quarry waste
1	2.86%	Best utilisation of clay resources
1	2.86%	Machines do not work on these clays
8	22.86%	PRODUCTS
3	8.57%	Quality of products
1	2.86%	Made for own use. Started to sell
1	2.86%	Brick shortage in 1977 decided to make
1	2.86%	To expand production and product range
1	2.86%	Promote product in the self-build market
1	2.86%	Capacity to make cheap face brick
8	22.86%	SIMPLICITY AND MAINTENANCE
2	5.71%	Spare parts locally available
1	2.86%	Local manufacturer in WC - for repairs
2	5.71%	Simple and easy to maintain
1	2.86%	Less training required for workers
1	2.86%	If break less down time - repair self
1	2.86%	Easiest and most economical
2	5.71%	PRODUCTIVITY, EFFICIENCY
1	2.86%	Productivity and efficiency
1	2.86%	Most efficient
5	14.29%	FINANCE
1	2.86%	Slowly expanding, less capital expensive
3	8.57%	Finance limited
1	2.86%	Cheapest preparation process

N=37 MISSING=2

Table 27 presents the reasons proposed by respondents why they adopted the particular techniques. Significantly, wage levels never featured, and 'economic' reasons barely feature[194]. The rest of the factors were roughly evenly divided between the characteristics of the technique, of the products, of the material inputs and of the maintenance and operation. All of these can be regarded broadly as 'technical' reasons. The interesting element here is that firms discounted the

194. Lack of finance is the most important single factor.

institutional changes in their technical choices without explicitly recognising it. No firm suggested that a technique was chosen because state policy or the nature of demand changed. The enabling role of the institutional component is not always recognised by those affected by it.

This result would support the theoretical presumption which suggested that matching a technique, its product characteristics, the economic conditions which it faces and the technical capacity of the firm itself are key determinants of technical choices rather than simply economic criteria alone. The technical choice function therefore becomes extremely complex, and is time specific. Any of the conditions that affected the choice of technique might change, leading to different choices in a different period. That this has happened in the brick making industry in which the pace of technical change is 'supposedly' very small is significant.

The changes in technique which the firms were busy introducing, or which had been introduced since the technique had been chosen are presented in Table 28. Notice the importance of changes in the mixing and materials handling components, relative to the forming stages. This confirms the observation that learning within firms has to do with the materials handling components, while learning about the materials forming component largely takes place outside the firm. The earlier conclusion that a lot of learning in the industry took place outside the brick producing firms themselves seems to be supported as well.

Some evidence of interaction between locally produced equipment manufacturers, and the users of their equipment in so far as the forming equipment goes were found[195].

195. In one case, a firm using a small Doubell static brick press developed changes to the equipment which were subsequently introduced into later designs of the equipment by the manufacturer. In another case, the equipment producer uses it to produce paving bricks.

Table 28. Changes in technique brought about or in the process of happening.

FREQ	%	DESCRIPTION
10	27.03%	NONE TOO MENTION
8	21.62%	CHANGES TO THE MIXING AND PREPARATION
1	2.70%	Changed from ash to concrete
3	8.11%	Changed the mix consistency
3	8.11%	Better control over the mixing process
1	2.70%	Refining rolls installed
5	13.52%	INCREASED MECHANISATION OF MATERIALS HANDLING
1	2.70%	Installing conveyors etc. More automatic
1	2.70%	Plan to computerise the sorting process
2	5.41%	Mechanised setting
1	2.70%	Mechanised handling
2	5.41%	INTRODUCED NEW TYPES OF FORMING MACHINES
2	5.41%	German instead of American machines
2	5.41%	BUILT OWN AUXILIARY EQUIPMENT
2	5.41%	Own brick splitter
4	10.82%	PRODUCT CHANGES
3	8.11%	Stopped making bricks
1	2.70%	Preparing to make face bricks
5	13.52%	WANT TO EXPAND
2	5.41%	Increase production
3	8.11%	Increase capacity
1	2.70%	REORGANISED TO SOLVE SEASONAL PROBLEMS
1	2.70%	Increase dryer capacity

N=37 MISSING=0

c. Technical and organisational change

Organisational change was often the result of technical choices. For most firms the establishment of the firm was the last organisational change as well. But in roughly half of the remaining firms organisational change was associated with changes in the organisation of production (Table 29). In the other firms organisational changes were required to enable further technical development and changes[196]. This corresponds to the importance of the organisational aspects, especially in the less mechanised firms, in order to improve their efficiency which we identified earlier.

In order to get an understanding of the nature of the technical

196. This mostly related to technical change in one of two ways. In some cases new managerial staff were brought in to introduce technical change. In another case, a management buy-out resulted in significant product and process innovations.

Table 29. Organisational change experienced by each plant.

FREQ	%	DESCRIPTION
19	52.78%	NO CHANGE
4	11.11%	NEW MANAGEMENT
1	2.78%	Problem with old manager
1	2.78%	To do quality control, Research & Development
1	2.78%	Management buy-out of disinvesting firm
1	2.78%	Help with new product line
10	27.78%	CHANGE THE ORGANISATION OF PRODUCTION
1	2.78%	New machines less dependent on experienced worker
3	8.33%	New static machines
3	8.33%	Changed mixing procedures
1	2.78%	Depends on the number of shifts worked
1	2.78%	Introduced a bonus-piecework system
1	2.78%	Reduce staff, rationalise to increase product.
4	11.11%	FIRM REORGANISATION
1	2.78%	Restructure to reduce overheads
1	2.78%	More efficient organisation
1	2.78%	Economic crisis - reorganised and moved
N=37	MISSING=1	

changes that took place inside the firm operation, they were asked about the nature of the last significant technical changes which they introduced. The results are summarised in Table 30. Roughly one third experienced no change, one quarter introduced a new line of the same type, and another quarter changed the type of brick press that they were using. In all cases this involved moving up the ladder of mechanisation. This is most clearly visible in the movement from DIY hand moulds to small manual egg-layers to bigger mechanised egg-layers. Some producers changed from egg-layers, mostly for reasons of product quality and high levels of wear and tear on egg-laying plant.

The position of the clay brick firms are slightly at odds with what has been said so far. Most of the clay brick techniques were chosen in the late 1960's, or the early 1970's, and they experienced little major change during the past 20 years. But they are busy undergoing some change at the moment, with a number of firms moving towards face brick production in chamber kilns. Another item which some firms are looking at, is the mechanical setting of the chamber or tunnel kilns. Organisational changes involved replacing the supervision of labour function with a

Table 30. Technical change undertaken.

FREQ	%	DESCRIPTION
11	29.73%	NO CHANGE
10	27.02	ADDED ANOTHER LINE TO CURRENT PLANT
1	2.70%	Another profile probrick
1	2.70%	Another duplex
7	18.92%	Added an automatic machine line
1	2.70%	New face brick line in chamber kiln
9	24.32%	CHANGED THE FORMING STAGE EQUIPMENT
1	2.70%	Went from simple block to diy egg-layer
2	5.41%	From diy to wilkenson/jumbostat egg-layer
2	2.70%	Bigger mech. Egg-layer (poor quality products)
3	8.11%	Introduced static machines
1	2.70%	Bigger extruder
3	8.11%	CHANGES TO A SUBSYSTEM
1	2.70%	Changes to improve machine quality
1	2.70%	Added cement silo
1	2.70%	Changed gentry from manual semi-automatc
4	10.81	CHANGES TO THE PLANT AS A WHOLE
2	5.41%	Renew the plant totally
1	2.70%	Moved to cheaper land without roof
1	2.70%	Install concrete plant. Chamber dryers
N=37	MISSING=0	

comprehensive scheme of progressively increasing production bonuses.

d. Technical change and efficiency.

Unfortunately, it is not possible to relate specific forms of technical change to the efficiency of the firms directly due to lack of data. But it did appear as if changes in the organisation of production are associated with efficiency firms in a general type of a way.

The most efficient firms in both the clay and concrete brick industries are characterised by changes in the organisation of production. The former introduced a system of progressive production bonuses discussed earlier. This was supplemented by some of the cheapest clay preparation processes in use[197].

The most efficient concrete masonry firm on the other hand had

197. Including a hammer mill and a sieve.

a very 'Taylorist' organisation of production, with jobs fragmented as much as possible. They have also focused on changes to the mixing stage, and have introduced mechanised egg-layer machines produced locally in the Western Cape. But this firm has strong links with the small builder sector of the building industry. The family running the plant have been builders themselves. It therefore appears that they have been able to position themselves very close to the market developments as outlined earlier.

On the other hand, the most inefficient firm was a small scale worker cooperative, which did not have the technical capacity to run the firm efficiently. Neither did they have sufficient finance and the managerial ability to organise the production process efficiently.

e. Constraints to increased production

Table 31. Technical limits to expansion.

FREQ	%	DESCRIPTION
10	27.02%	Market demand
5	14.28%	Labour skill, management, only one shift
16	43.24%	Fixed plant limitations
9	24.32%	Weather related
15	40.54%	Machine capacity related

The firms identified the machine and fixed plant capacity as the most important limitations to further expansion. Market and weather factors are next, while labour is last on the list.

f. Learning, productive organisation and labour processes

With the low levels of mechanisation of feedback as background, the firms were asked about the importance of the skill and training of the workers in the production process. They were asked whether the machine or the workers determined the quality

Table 32. Workers role in the production process.

A. DO WORKERS AFFECT THE QUALITY OF OUTPUT?

FREQ		%		DESCRIPTION
18		51.24%		WORKERS DO AFFECT QUALITY
	9		25.71%	Does affect
	7		20.00%	If not properly mixed.
	1		2.86%	Clearing from the press and transit
	1		2.86%	If not vibrated properly
5		14.29%		WORKERS DO HAVE SOME EFFECT
	2		5.71%	Do affect, but not in any key activity
	3		8.57%	Some workers element but mostly machine
12		34.29%		WORKERS HAVE NO EFFECT
	6		17.14%	Do not affect
	6		17.14%	Small percentage worker effect

N=37 MISSING=2

B. DO WORKERS AFFECT THE PACE OF PRODUCTION?

FREQ		%		DESCRIPTION
15		40.54%		WORKERS DETERMINE PACE
4		10.81%		WORKERS DO HAVE SOME EFFECT
	2		5.41%	The mixing speed is crucial
	2		5.41%	Workers can slow down
18		48.64%		WORKERS DO NOT AFFECT SPEED
	17		45.95%	Do not affect
	1		2.70%	Speed determined by quality requirements

N=37 MISSING=0

of the output. The results are summarised in Table 32. Two aspects are significant. Firstly, the large number of firms in which workers have a determining influence on the quality and the pace of production. And the equipment of all 13 plants where workers do affect the quality of the output were produced locally. That is to be expected, given the labour intensive nature of the locally produced equipment. Secondly, the importance of the mixing process as a key factor amongst these firms.

Then the focus shifted to the training policies of each firm. 24 (64.86%) had no training policy. Two of these were contemplating or busy bringing in training policies. A further 7 (18.92%) had on the job training only. This suggests that more than 80% of the plants had the most minimal training schemes for workers[198].

198. Of the 6 plants that had some form of training, one emphasises training operators, another practised job rotation, and a third had a ten day training programme to train the people that have to unpack the bricks from a duplex press. Only one firm, operating three plants has a training policy whereby each employee receives some form of formal training. Incidentally, this is a firm with quite a mechanised production process.

It turns out that not only is the organisation of production an important area, but the role of workers becomes more important. Given the low levels of training, worker motivation could significantly add to the efficiency of the firm, as well as the quality of the output. However, 48% of the firms had no productivity scheme apart from ordinary supervision and setting targets. 28% of the firms had systems of production or attendance bonuses, while 12% of the firms had systems of piecework. In one case workers got a certain amount per block produced which they could share amongst themselves. In another case the machine operators were paid per drop, and in a third case the workers were paid per pallet produced.

When it comes to consultations with workers over technical issues, 70.8% of the firms had no consultations with workers whatsoever. One firm suggested that unions are not interested in technical matters. 8.3% of the firms had some form of consultation with workers if changes affected them. 12.5% of the firms had regular contact with workers or union committees. One firm called general meetings of workers if this was required. Finally, only the workers cooperative responded that workers were part of all decisions.

g. Conclusion.

Two aspects emerge that have a bearing on the choice of technique function. Firstly, the opportunities for learning presented by the small to medium sized concrete brick plants emerges as quite significant, with a learning curve of technical choices going from simple to more sophisticated machinery taking place. This links in with the earlier observation of greater organisational flexibility in this industry segment. There was quite a bit of evidence of such organisational adaptation in the industry already, with various piecework and incentive schemes. This is counterbalanced with the very limited attention given to worker training in the industry. Given the critical role which often quite unskilled workers performed, one would expect more initiatives in this direction. In the longer term, the hard and often menial nature of some of the work in the industry will present a different set of problems, which might force higher levels of mechanisation of the materials handling processes.

4. Consequences for cooperatives.

The technical imperative outlined above can be summarised in two parts: Firstly, the forming component has an important effect on product characteristics. Learning in this component mainly takes place outside the user firms, and the requirements for cooperative enterprises would simply be to be able to slot into existing networks and to develop the capacity to use the equipment. Here choosing techniques which would allow the enterprise to produce products with appropriate characteristics is of the essence.

The second part includes those areas where learning generally takes place within the firm. This includes the productive organisation, specifically with regards to the material handling and feedback functions. These areas are difficult to mechanise efficiently. Consequently, workers do have a lot of control over these functions. The ability of cooperative structures to enable enterprises to have highly motivated workers, as well as the ability to manage the production processes efficiently, will be crucial for their success.

G. INSTITUTIONAL FRAMEWORK.

This section analyses the institutional framework in which technical choices are made, and its relationship with both the technical and economic imperatives. The institutional framework is social in nature, and constitutes embodied knowledge or learning. A key feature of an institutional framework is that it is characterised by power relations between groups of people.

The history and the motivation of the managers that run the individual firms included in the survey will now be analyzed. Then the focus shifts to the market structure that integrates the firms horizontally, and thereafter the vertical integration between the firms, and their input suppliers.

1. The firms, their objectives and histories.

Table 33. Ownership of 29 brick making firms.

FREQ	%	CUM%	DESCRIPTION
7	24.1%	24.1%	OWNER MANAGER
9	31.0%	55.1%	FAMILY MEMBERS
6	20.7%	75.9%	OWNER MANAGERS WITH OUTSIDERS
3	10.3%	86.2%	MANAGERS WITH SOME OUTSIDE COMPANIES
3	10.3%	96.6%	ANOTHER COMPANY
1	3.5%	100.0%	WORKER MEMBERS
CASES -->		29	
MISSING -->		0	

The managerial theories of the firm take their point of departure from the separation between the owners and managers. Some of these theories then suggest that owners strive for higher returns, and managers for higher growth. This survey suggests a different and much more complicated picture. Firstly, the extent of separation between ownership and control was not all that marked. Of the 29 firms, only 10% were owned by companies other than the managers. In 86% of the firms, the owners have at least some direct input into the management of the firms. Only one firm is worker owned and managed. In 76% of firms the owners played a direct role in making technical decisions. In the rest of the firms (except one) professional management took the decisions. In the worker managed firm the 'manager' advised the workers on the decisions to take.

Table 34. Minimum return on investment requirements by different categories of managers.

RETURN ON INVESTMENT	Owner Manager/s	Profess. Managemnt	Worker Managers	Total
Not Important	12 (57%)	1 (25%)	1(100%)	14 (54%)
Important	9 (43%)	3 (75%)	-	12 (46%)
TOTAL	21	4	1	26
MISSING	1	2	-	3

Reasons given by the various categories of respondents:

Owner Managers - Not Important:

4 Personal reasons (satisfaction, keep busy, etc.)
2 Investment minimal. Need no consideration.
2 Expansion or promoting a product with growth potential.
4 No intension of leaving because of capital invested.

Owner Managers - Important:

7 Some financial reason the minimum between 10-15%. (Mostly the bank rate)
2 Require higher rates of return to provide for uncertainty.

Professional Managers - Not Important:

1 Vertical integration. Would not want to buy bricks from competitors.

Professional Managers - Not Important:

3 Financial reasons (given fluctuations in the industry)

Worker Managers - Not Important:

1 To create jobs.

However, the objectives stated by decision makers were quite different from that generally assumed. 52% of the firms (mostly owner-managed) regarded a question on the minimum rate of return that the firm would find acceptable[199] as not important. In those firms where 'professional' or non-owning management took decisions, they had above average minimum return requirements. This is a reversal of the managerial firm growth and the neo-classical theories' expectations. It therefore appears as if other motivations than profit maximisation are prevalent, and

199. Before they decided to leave the industry.

that 'satisficing' is more common than maximisation even in firms owned and managed by individuals. Obviously, it is doubtful that most of these firms will operate continually with almost 0% returns on their capital invested. But it does say something about the motivations.

Table 35. Objectives of decision makers when making technical choices.

	Owner Manager/s	Profess. Managemnt	Worker Managers	Total
Firm characteristics:			8 (31%)	
Personal	4 (20%)	-	-	4 (15%)
Growth	1 (5%)	-	-	1 (4%)
Employment	1 (5%)	1 (20%)	1 (100%)	3 (13%)
Product characteristics:			18 (69%)	
Product Quality	6 (30%)	3 (60%)	-	9 (35%)
Customer satisfaction	1 (5%)	1 (20%)	-	2 (8%)
Process characteristics:			7 (30%)	
High Tech.	1 (5%)	-	-	1 (4%)
Cost implications	6 (30%)	-	-	6 (26%)
TOTAL	20	5	1	26
MISSING	2	1	-	3

Respondents were asked about the objectives which they have in mind when making technical decisions. Growth of the firm was stated as the most important by only one firm, and an owner managed one at that. Another four firms had aims of a personalised nature. More significant is that product or service characteristics were by far the most important objectives. (Almost 42% of all firms, with almost 80% of the professionally managed firms.). The other 30% of firms concentrated on matters related to the production process, of which only one emphasised high technology. The other firms emphasised reduction of production costs and the cost implications of technical choices.

There are two basic implications of the results. Firstly, the goals that managers pose are far different from those generally assumed by managerial theories of the firm. In the case of the brick making industry, quality products rather than high growth rates seem to be a more important motivation for technical managers. For firms where owners have a more direct input into management, the picture becomes more diverse, with cost constraints and other objectives related to the firm itself becoming more important. Secondly, these motivations should not be isolated from the other constraints which the firms face, and the existence of multiple objectives which get lost in the simple classification scheme that were used. This is close to the Penrose argument that a firm should be seen as a bundle of resources, both physical and human.

Table 36. Experience and educational background of 40 decision makers in 29 brick making firms.

A. EXPERIENCE OF THE DECISION MAKERS:

FREQ	%	DESCRIPTION
5	17.2%	OTHER FIRMS PRODUCING BRICKS
8	27.5%	CIVIL ENGINEERING, HOUSING, CONSTRUCTION
9	31.0%	MECHANICAL ENG., FITTER, TURNER, TOOLMAKER ETC.
5	17.2%	OTHER BUSINESS
3	10.3%	COMPUTERS PROGRAMMING/ DEVELOPMENT
7	24.1%	NO RELEVANT EXPERIENCE

B. EDUCATIONAL BACKGROUND OF THE DECISION MAKERS

	PROFESSIONAL	NON-PROFESSIONAL	TOTAL
TECHNICAL	8 (28%)	12 (41%)	20 (50%)
BUSINESS	7 (24%)	4 (14%)	11 (30%)
NONE/ NOT RELEVANT	1 (3%)	7 (24%)	8 (20%)
	16 (40%)	24 (60%)	40

Therefore, the managerial resources of the various firms were analyzed. Information about the educational background and previous work experiences of decision makers were recorded. They were generally white males[200]. In five cases black people were decision makers in mainly small firms operating manual type of equipment. Table 36 shows the variety of backgrounds that decision makers have, and the large number of people that had no experience in the brick making field whatsoever. This suggests that people have been able to enter relatively easily, mostly with some mechanical or building construction experience. Educationally, the importance of some technical education is

200. One white women owned and managed a small backyard operation so that she could work from home.

reflected in the results. Half of the decision makers have a technical background, with 30% having a business background. 20% people had no educational at all, or in one case had a social work qualification.

If the Penrose argument is accepted, some correlation between the nature of the decision makers, and the nature of the firms which they decide upon would be expected. This nas been seen in motivational differences that occur. But two other aspects are relevant too: Their sources of information. And the importance which they give to different 'functions' within the firm.

Table 37. Sources of information used by brick making firms.

A. MOST IMPORTANT SOURCE OF INFORMATION:

FREQ	%	DESCRIPTION
9	33.3%	OWN EXPERIENCE, RESEARCH, TENDERS ETC.
6	22.2%	INPUT SUPPLIERS, AGENTS, FRANCHISES.
5	18.5%	LITERATURE, JOURNALS, BROCHURES ETC.
2	7.4%	CUSTOMER FEEDBACK AND MARKET RESEARCH
2	7.4%	CONCRETE TECHNOLOGIST AND CONSULTANTS
2	7.4%	COPY WHAT OTHER FIRMS DO
1	3.7%	BUILDING INSPECTORS
MISSING	2	

B. SOURCES OF INFORMATION USED DURING THE PREVIOUS YEAR:

FREQ	%	DESCRIPTION
19	65.5%	SUPPLIERS OF MATERIALS AND EQUIPMENT
14	48.3%	OTHER FIRMS
13	44.8%	RESEARCH INSTITUTES (PCI, SABS, UNIV., CSIR)
13	44.8%	JOURNALS
8	27.6%	INDUSTRY ASSOCIATIONS (BIFSA, WPCMMA, BDA)
6	20.7%	TRADE FAIRS (50% OVERSEAS, 50% LOCAL)
6	20.7%	OTHER (BUILDING INSPECTORS, ETC.)
4	13.8%	CONSULTANTS

The sources of information are analyzed first. A general question, was followed by the checklist of information sources in Table 37.B. It turns out that the most important source of information was the firm's own experiences. This was generally the experience of the owner manager. This is an interesting result, and corresponds with the theories of learning by Sahal (1981), in which knowledge is treated as tacit and firm specific.

When asked about specific sources of information used, suppliers were important, followed by other firms, research institutes[201] and literature. Thus, the importance of learning in the industries that supply inputs is seen again. It takes place directly or through literature etc. Alternatively, learning takes place within some firms, with others copying from them. Surprisingly, little information comes as feedback from consumers. However, it should be kept in mind that most of the firms that perform research and development are bigger firms that tend to be vertically integrated with housing construction firms. They are especially, but not exclusively, responsible for the development of new brick products. Other firms then take these over.

The implications for coops are significant. Entry is relatively easy, and learning takes place within the firms, and through the suppliers of inputs. Bigger firms tend to do R&D into new products which the smaller ones follow. Therefore, scope should be provided for cooperative firms to learn by doing. This is related to the earlier finding that most of the technical change involves firms upgrading their techniques to more mechanised production processes.

A correspondence analysis of the firm characteristics in Figure III.30 suggested some correspondence between the type and characteristics of the decision makers[202] and the sources of information that they use, and the other characteristics of the firms. The quality of the display is relatively low (18% of total inertia on the first dimension, and 14% on the second). Thus, only the broad orientation of the display will be examined. When the analysis was separated into 4 subsections, the quality of the individual displays improved considerably. But the results are

---

201. However, by far the most firms that used research institutes used the Portland Cement Institute as a source of information. And the PCI could be regarded as part of a supplier's information network.

202. We excluded worker managers from the analysis, because there is only one such a firm.

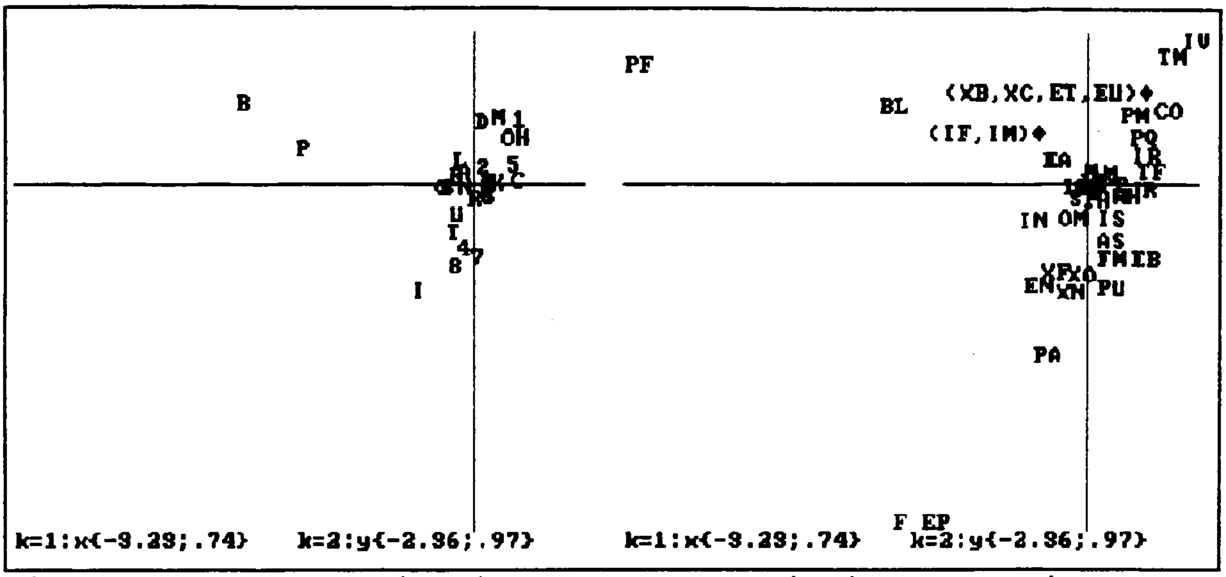


Figure III.30. Institutional characteristics of firms and decision makers of 29 brick making firms.

similar to that found above. Therefore the analyses of the subsections are not included.

The major orientation is the axis lying across the display from the top right to the bottom left. This axis represents the professional management [TM] and the owner managers [OM]. Associated with the professional managers are the indicators for decision makers with professional education both technical (engineers) [ET] and business (MBA degrees) [EU]. These people have also had previous business experience [XB] or civil engineering or housing construction experience [XC]. The only source of information that is to some extent correlated with these managers are trade fairs [TF]. On the other hand, the owner managers tend to be associated with experience in other firms [XF], computer experience [XO] or no experience at all [XN]. Furthermore, they tend also to be associated with no education [EN] or professional education not relevant to the industry [EP]. The only woman decision maker is also associated with the owner manager category.

A further axis perpendicular to the owner-professional management axis outlined above stretches to the top left. It reflects the conditions of those characteristics which are associated with black decision makers [BL]. They tend to have technical non-professional education [EA].

Furthermore, the firms where professional management takes decisions tend to have vertically integrated relations with other firms [IV], while having no relations with other firms [IN] is associated with the owner managed firms.

From this analysis there seems to be some support for the argument that different types of firms, with different managerial resources have different characteristics. And it would lend support to a hypothesis that managerial resources play a key role in the technical choices made by the firm. The bigger firms tend to have professional management, tend to be vertically related to other firms (especially housing companies), and tend to be producing information in house. On the other hand, owner managers tend to run smaller and more atomised firms, with information gained from other sources especially other firms and suppliers of inputs. They come from a vast array of backgrounds, suggesting relatively little technical (informational) barriers to entry. The firms where the decision makers are black tend to be small, and the experience of the decision makers some sort of technical training.

These findings have significant implications for strategies to promote cooperatives. Limited access to managerial resources would definitely constrain the types of technical choices that can be made. Furthermore, housing strategies that would favour the bigger firms would seriously undermine the ability of cooperatives to choose the types of techniques that are more suited to such an environment. On the other hand, given that most of the information used originate outside the smaller firms, support structures to facilitate the learning process could be important. Finally, some form of horizontal integration to pool resources and help coops develop new products would probably be necessary to make them successful in the longer run. This does not seem to take place in the smaller firms at present.

Another question arises. How do the managerial resources relate to the way in which the various functions in each organisation are dealt with. In other words, how do the various types of firms deal with the organisational conflicts between departments that might arise? The respondents were asked to evaluate the importance attached to seven different functions, and the problems associated with each. The seven functions are production, R&D, administration, finance, quality control, marketing and human resources management. Respondents were asked to rate the importance of each function on a scale between 0 and 10, with 0 being not important at all for their firm's functioning. The problems were assessed similarly, but in terms of seriousness rather than frequency. Thus, 10 would mean very serious problems not necessarily frequent problems. The responses from each firm were rescaled to a percentage of the total responses for each question. In this way the importance of each function relative to the other functions could be determined. The same is the case with the problems experienced.

The averages for the responses of all the firms together are presented in Table 38. If each function was equally important, each would have had a value of 14.3. Notice that R&D is much below what is expected, and finance slightly below. If R&D is excluded, as is the case with the problems experienced, the expected weight becomes 16.6. In this case only production and quality control are viewed as higher than expected, and finance less than expected. However, as a problem area, production has increased significantly, with problems in human resources and quality control not far behind. On the other hand, finance, administration and marketing have had less than expected

Table 38. Decision makers' evaluation of each of seven functions in the operation of each firm.

Function	Employees	Importance	Problems	Comp
Production	89	20 (21)	27	31
R & D	0	6 (-)	-	7
Quality Control	1	18 (19)	19	7
Marketing	1	14 (15)	15	14
Finance	6*	10 (11)	6	45
Administration	3	15 (16)	10	48
Human Resources	0	17 (18)	22	41
	100	100 (100)	100	-

* Includes managerial employees.

Note: All data given as percentages. The Employees are the percentage of workers in all firms performing each function. (Firms are weighted equally). In the Importance and Problems columns, the responses for each firm was scaled up to total 100. The averages for all the firms are presented. In the brackets in the Importance column, the R&D function was excluded to enable comparability with the problems column. Here R&D was excluded because only a few firms had a separate R&D function. The COMPuters column indicates the percentage of firms using computers in each function.

problems.

This is an interesting finding. The emphasis on production is to be expected, while the emphasis on quality control and human resources were anticipated. In any event, it appears that these are the most important functions in the brick making industry. This has implications for establishing coops. In at least one of these functions, namely human resources, a cooperative institutional setting could have some institutional advantage over comparable capitalist firms.

The different emphases placed on the various functions by the groups of firms defined in terms of the type of managerial resources they possess are also shown in Figure III.30. Associated with the professional managers in the top right hand corner are the above average importance of R&D [IR], and above average problems with quality control [PQ] and marketing [PM]. To the bottom end of the display on the other hand are the mainly white owner managers. The main problems which they face are human resources [PU] and administration [PA]. Finally, the black managers to the top left rate finance [IF] as of above average importance, and experienced above average problems with finance

[PF] and marketing [PM]. The display is not of such a good quality, but the result is intuitively plausible. The bigger firms experience marketing and quality problems. This corresponds with previous findings. The owner managed firms experience problems with administration and human resources. And the smaller firms experience problems with finance.

The most interesting result is probably the human resources finding. This places an interesting slant on the suggestion that coops could be in a better position due to an expected ability to deal more creatively with the firm as human resources. But, in so far as cooperatives are not able to generate the managerial resources which owner managers usually bring into the firm, this potential benefit might remain unrealised.

2. Industry Structure.

The technical choice model was extended in the section above to incorporate a resources view of the firm as an organisational unit. These types of extensions are important, because they provide essential information of the complexities of the choice of technique which cannot be reduced to single phenomena. Each firm faces a unique set of technical choices because of the particular conditions prevalent within that firm.

However, some mechanism exists which integrates all these firms, with the technical choices that they have made, into a single industry. These are regulated by various institutional mechanisms like the market and its structure, the institutional relations between firms and the structure of the industry as well as the structure of the industries supplying inputs. Furthermore, state policies play a role as well as various industry organisations etc.

a. Type of business in which each firm is engaged.

A number of firms were not only making bricks, but were also engaged in other types of business. Table 39 summarises the results. The majority of firms (66%) were engaged in brick making as a major business. All the clay brick firms fall into this category. 13% of the firms were actually housing or other construction firms, for whom making bricks were a form of vertical integration or in one case of diversification[203]. Two of the firms were located on farms[204]. Three firms were selling and transporting building materials, and one operated a quarry, with brick making as a secondary activity.

Table 39. Type of business.

Making Bricks (1)	(66%)	20
Housing/Construction (2)	(13%)	4
Farming (3)	(6%)	2
Quarrying (4)	(3%)	1
Building materials (5)	(10%)	3

This compares with Nairobi where F Steward (1977:242) interviewed 30 firms, of which 16 were quarriers, 12 builders and 2 others. This should not be misinterpreted, as neither Steward's nor the current data were based on a rigorous sampling procedure. However, it still appears as if the structure of the industry in the WC is substantially different from Nairobi. One possible explanation could be the high degree of concentration in the quarrying industry in the WC. In the WC the brick making industry as a separate industry also seems to be established far more strongly than was the case in Nairobi in 1977[205].

203. One construction firm was making bricks in order to retain key staff while activity in the branch of construction in which they were usually engaged were down.

204. In these cases the workers worked partly in the brick making and partly in the farming section.

205. However, it is possible that the structure of the industry in the WC could have looked quite different in 1977. We will return to this matter when we look at the history of the firms involved in the brick making industry in the WC.

Furthermore, we did not follow up any building firms that might be making bricks with hand equipment. More than 50000 units have been sold in the past decade, and it is likely that some of these would have ended up in the WC.

b. Barriers to entry.

The barriers to entry were looked at in paragraph D.1.d page 142. Small firms, have difficult access to credit with manual equipment. Their locational advantages and the market segment that they serve, together with the low prices that they charge, help them to survive.

For medium sized concrete producers, who are mainly financed by commercial banks and are generally using static machines, the competition seems to be much more accute. They see market share difficulties as a major constraint. The same applies to the bigger firms, which also have some element of financial constraints as a barrier to entry.

The clay firms have bigger entry barriers both in terms of technical and financial requirements. The seasonal and cyclical factors reinforce this pattern. These are access to suitable clay deposits, and the large minimum investment size of a firm. This is especially the case for the production of higher quality face bricks, in tunnel kilns. A number of currently operating clay brick firms have investigated the possibility of setting up tunnel kilns, but have decided against it as a result of the big capital investments required[206].

Fewer barriers exist for firms to enter the concrete masonry industry. This is especially the case for the bottom end of the industry. However, here more economic barriers exist in the case of marketing high volumes of products. Many of the bigger firms are vertically integrated into housing or construction companies, limiting the marketing potential for new entrants to a much smaller market segment: smaller building firms and individual and owner builders.

206. Figures of between R40 and R80 million were cited.

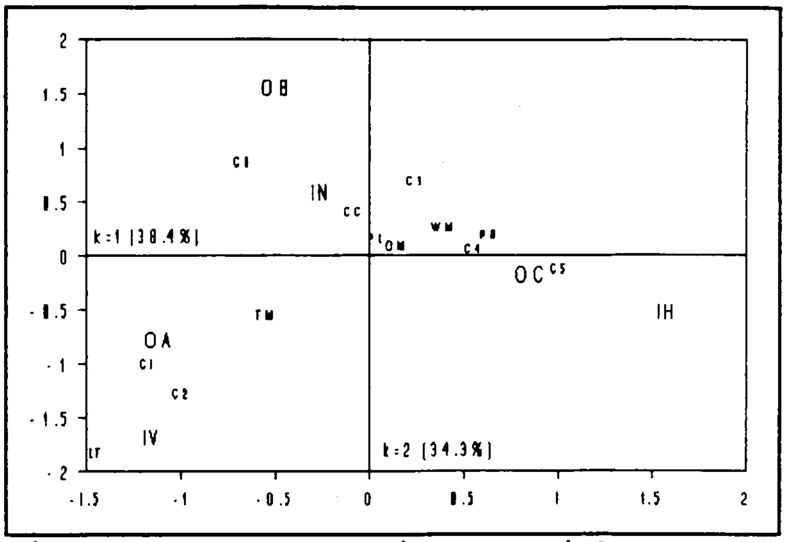


Figure III.31. Relations with other firms and firm size.

The relationship between firm sizes and relations with other firms were analyzed with a CA plot. Firms were classified into three categories [OA;OB;OC] from large to small (as had been done in previous sections). The relations with other firms were also recoded into three categories: [IN] - no relationship; [IV] - a vertically integrated relationship; and [IH] - a horizontal relationship. A vertical relationship suggests that either from the inputs but mostly from the user side, the firm is directly linked to another firm. A horizontal relationship suggests that the firm is related to another production unit not supplying inputs or buying outputs. These are mostly other activities like farming, transport etc. Figure III.31 suggests a close relation between the firm size and the relations with other firms. The quality of the display is high (73%). Vertically integrated firms tend to be bigger firms making face bricks as well as automated block making plants [C1;C2]. This is associated with professional management, and public companies [LT]. At the other end of the spectrum, small firms [OC] tend to be horizontally integrated with other activities [IH]. These also tend to be the firms using manual concrete block machines. Medium sized firms [OB] tend not to have relations with other firms [IN].

Thus, the already bigger producers are generally part of larger groups of companies with some form of housing or construction component. But, small firms tend to combine their brick making activity with something else to help cover overhead costs.

In this regard, the result of state housing policies would be significant. Policies which benefit large housing companies would lead to conditions favouring the larger concrete block producers, with potentially less benefit to smaller producers of concrete masonry. But, the way in the policies are executed is also important. An example is the self-build housing scheme administered by the Regional Services Council. Most of the concrete blocks used are bought from the bigger suppliers and then distributed to the self-builders. The justification for this was quality standards, but some attempts were made to support newer and smaller companies producing blocks at the quality levels required as specified by the SABS regulations[207].

A number of matters can be seen as constraints rather than barriers to entry for small scale cooperative firms. The first is technical - producing sufficiently high quality products. The second is financial - getting access to sufficient sources of finance especially for egg-laying equipment. Access to skilled managerial resources is a third constraint. But, the barrier is access to markets. This barrier can be removed by changes in state policies which favour supply of housing by smaller scale builders. Key elements in such a strategy will most probably be changes in the financing of housing and supplying serviced land for building. Conventional self-build housing schemes building essentially conventional housing but with sweat equity has a fundamental problem in that the poorest, for whom it is intended, don't have the time to build. Rather, a programme of squatter upgrading, with financial arrangements allowing for small scale improvements to squatter shacks would best lead to an increase in demand for cheaper and lower quality masonry.

Without such new markets opening up, it appears that excess capacity in the industry locally will make it very difficult for

207. Interview with W. Cloeraine, 3 October 1989.

even small scale cooperative firms to start up and be viable.

c. Industry structure and price formation.

Industry structure refers to the relations between different production enterprises. Earlier it was shown that the industry is composed of a relatively large number of smaller firms. It was also suggested that matters other than merely quality and efficiency differentials were at work in determining prices in the industry.

It was anticipated that prices were determined through a cost plus method, especially with the bigger firms. Information on this level was scarce, but some pattern could be pieced together. It reflects a picture of an industry under pressure, in which the structure was changing. The situation in which a price leader could function was undermined amongst other things from technical changes and a change in the market conditions.

People close to the industry commented on the complex price formation process active in the industry. The biggest producer of bricks country-wide would act as a price setter, and the other firms would follow with prices slightly below. Evidence for these tendencies were found amongst the clay brick producers. But amongst concrete brick producers it was more complicated. In the clay brick industry, this was usually complemented by a type of price setting in which firms had specified areas in which they sold their products, and they charged a premium (above added transport costs) to sell to somebody outside that area. One producer mentioned that in the recent past, the price of bricks set by the leading firm was so high that even this premium could not prevent them from entering markets previously held by the larger firm. A number of firms also indicated that the leading firm lost some of their medium sized customers due to particular marketing strategies aimed at bigger construction firms. This has also led to a move away from the larger dominant firms[208]. The second major factor was the impact of the concrete brick manufacturers given the changes in the market towards cheaper products. It seems that clay brick producers were not that able to pursue these new market opportunities. This has given concrete producers, and especially smaller ones an opportunity to enter. And the competition from these producers were putting pressure on the clay brick producers by the late 1980's. Some firms were breaking rank with the previous price regime to lower prices in order to remain competitive.

Questions were asked about how prices were determined. At the outset it should be noted that a large variety of responses emerged. But two aspects played a significant part in shaping the marketing situation in the industry: The removal of price control in the early 1980's, and the emergence of quite large numbers of concrete masonry manufacturers since the late 1970's.

It appears as if the bigger clay brick firms have changed their strategy to start producing more clay face bricks. This has left the smaller clay brick firms to compete with the concrete masonry manufacturers. At least one of these firms have started a concrete brick and block plant next to the clay brick plant.

It is obviously difficult to document these trends in great detail with a lot of evidence being anecdotal comments made by interviewees. But it does suggest that the industry is going through a period of structural change. This makes it difficult to say with certainty what the future will be, and how it would affect coops. It is also likely that these will be influenced by events outside of the industry to a large extent. The one important aspect is government housing policy.

---

208. This could be interpreted as letting them wait for a considerable time while other bigger clients were supplied in the time of brick shortages.

3. Vertical Integration.

Learning exists not only in the relations within the firm, but in the relations between the various firms that make up the industry. The same applies for the relations between firms in different stages of the production process. Recently the importance of these relations have been emphasised with greater emphasis on 'Just in Time' production techniques in the Japanese motor industry. These matters could be of importance for coops in the brick making industry in two senses. The first is the existence of networks which guide the sale of products. It has already been indicated that such networks exist and are important in the marketing of bricks. The argument was that at least three types of networks could be distinguished: big producers selling to big construction companies; smaller producers selling predominantly to smaller contractors; and very small producers largely selling to owner builders.

The second area of importance deals with the supply of inputs, and the control thereof. This would be important for coops if some monopolistic conditions in the supply of key inputs were used to limit the scope for coops to function efficiently. The rest of the section will concentrate on this issue.

a. Inputs into the production of clay bricks

Apart from clay that is generally mined in quarries owned by the brick firms themselves, the major inputs are energy and equipment. Energy inputs are coal for the clamp kiln factories, and heavy furnace oil for the tunnel kiln factories. The cost of coal in the Western Cape is significantly influenced by the costs of transporting the coal from mines located far away. This has been one aspect that influenced the relationship between concrete and clay based products.

Most of the equipment used is imported[209]. This is especially the case with extruders, but also with some forms of preparation equipment. Figures are hard to come by, and estimates by some equipment suppliers are used here. About 80% of box feeders are produced locally. Disintegrators (a type of primary crusher) are almost totally made locally. 80% of the high speed rollers in use are imported second hand equipment. Similarly, almost all extruders are imported, most of them second hand. Wearing parts are made locally for most types of machine. On the other hand, most cutting tables are produced locally, as are some of the handling equipment. Tunnel kilns are totally imported.

Most of the second hand equipment is brought into the country at one third the price of new equipment, and is then reconditioned locally.

b. Inputs into the production of concrete bricks

The main inputs are equipment, aggregates, cement and sand. Of these, all but the provision of equipment operate under fairly monopolistic conditions.

The cement industry has been a price cartel since 1971, and price control measures have been instituted since 1964[210]. The sand industry has had price control from 1964 to 1980. Prices of sand are directly affected by the quality of different sands. In the Western Cape, most of the higher quality sand is fairly scarce[211]. The best quality sand is 'Klipheuwel' sand, with Phillippi Dune sand and river sand of lower quality[212]. The supply of aggregates has had an oligopolistic structure in the

209. Interviews with agents supplying equipment inputs for the clay brick industry.

210. Competition Board. Third Annual Report. 1982 p13. The Competition Board finds that they have functioned responsibly, and therefore price control was maintained in 1982. See also Lambrechts (1988).

211. R Low, November 1989

212. Peters, June 1989.

Western Cape for a long time, with most of the quarries in the hands of a firm that is also the owner of one of the bigger block making plants[213]. Recently, the government has taken some steps, but there is still a widespread feeling in the industry that not much have changed.

The equipment used in the industry is largely locally produced. Some firms have imported second hand equipment. These tend to be large block presses. Most of the equipment is produced locally. The bigger block making plants are produced under licence, while many of the smaller to medium size presses are produced locally to local designs. These designs were mostly copied from other overseas equipment, but especially in the cheaper manual equipment, locally developed designs are generally used. Two examples are the Doubell and the Wilkenson equipment. The former was developed and patented by a Port Elizabeth based engineering firm. The equipment were initially aimed at the farming and rural areas, and by 1989 more than 50000 units had been sold. Quite a number of models have been produced, but the basic unit cost of this machine was in the region of R8000 for an egg-laying type and R15000 for a static type machine with a 13 brick equivalents per drop capacity producing blocks. The Wilkenson machine was designed and patented by a farmer living close to Johannesburg. The Wilkenson machine has a capacity of 15 brick equivalents per drop producing ordinary bricks, and 26 brick equivalents producing blocks. But in 1989 it cost R1500. The units are produced by the farmer and his family members on the farm, and a long waiting list for equipment exists. They produce about 450 machines per year.

In the Western Cape, a number of engineering firms produce slightly larger equipment. Profile engineering has developed both an egg-layer, and a small static machine. But the slump in the

213. Competition Board. 1982:16, and Peters, June 1989

industry during the second half of 1989 have caused marketing problems. Their equipment were designed locally, with the local conditions in mind. The static machine can be operated manually, or is fitted with a programmable logic controller unit which makes the operation of the press itself almost automatic. The unit sells for about R100000. The size of the static machine was derived from the weight of the pallet complete with products. Being designed for local conditions, the pallet is carried by two workers to be stacked rather than using a mechanical handling system. It has a capacity of 20000 bricks per day. Production is custom built, and the first units were produced in 1987.

Another engineering firm, Advance Engineering, produces a medium scale static machine. The units are built as one-off's in the engineering firm, without even detailed engineering drawings. But the equipment selling around R130000 are used quite effectively in the industry, and some of them are included in the sample. The machine has a programmable logic control unit, and a capacity of 28000 brick equivalents per day. 15 of these units have been produced so far. Another firm produces egg-layers, and components for imported large scale equipment.

4. State policy and the employment creating capacity of various techniques.

Finally, employment creation is one of the objectives that many cooperatives have. A vertically integrated analysis is needed to understand the employment generating capacity of different techniques in the brick making industry.

In Table 40 the employment creation capacity of various types of techniques are compared. Notice that data on employment in the equipment producing and other input industries are not taken into account. Neither is employment in the construction of houses. The

Table 40. Job creating capacity of various technologies.

JOBS/1000 BRICK EQUIVALENTS OUTPUT PER MONTH AVERAGE OUTPUT	MAXIMUM OUTPUT	TYPE OF TECHNIQUE
0.015	0.0065	Automatic concrete block plant
0.035	0.0115	Mechanised concrete brick plant
0.036	0.0188	Mechanised static concrete block plant
0.065	0.06	Clay face brick plant with tunnel kiln
0.068	0.05	Clay brick plant with clamp kiln
0.07	0.034	Mechanised egg-layer concrete block
0.0775	0.0325	Manual concrete block
0.108	0.044	Manual concrete brick
0.11	0.05	Mechanised concrete face brick plant
0.12	0.08	Self aligning concrete blocks
0.48	0.16	Manual clay brick plants

average output column took the employment at the average production levels in 1989. The maximum output column took the maximum output capacity with roughly the same labour complement. Cooperatives with such objectives will therefore be constrained in the types of techniques that they can choose.

H. CONCLUSION.

The technological constraints and opportunities in the brick making industry were then investigated in the light of the above conclusions. These were of an economic, technical and institutional nature.

On a theoretical level, a key component of the economic imperative was seen as the effective demand conditions in the industry. Furthermore, the importance of heterogenous products for this type of analysis has been a major finding of the study. A close correlation was seen between the prices of products and their characteristics. Furthermore, it was seen that the demand for bricks was also structured in a way that corresponded with the characteristics of the products and the firms that produce them. The implication for the establishment of coops is that effective demand under current conditions would most probably not present sufficient scope for the establishment of viable cooperatives. A major reason is the fact that most of those people requiring houses cannot afford to pay for them. This suggests that cooperative enterprises would only be viable once income distribution and institutional changes have facilitated the creation of more effective demand for housing[214].

The market for vertical building elements in the Western Cape is segmented along a number of lines. Firstly, the clay brick and the concrete masonry market is fairly separated. Secondly, a threefold segmentation in the concrete masonry market was found. The bigger firms capable of producing large volumes of high quality products were found to be linked into the bigger housing companies. Often these relations were structural rather than merely contractual. The second segment is the smaller builders and contractors buying mostly from the smaller to medium sized

214. For instance, Huppert (1987:viii) concludes that "the major limitations on private provision of black housing [are] first affordability ... and second availability of land".

brick making firms. It was found that the most variation occurs within this group. Finally, the very small firms sell mostly to owner builders. Cheap prices and a suitable location was found to be of crucial importance for these producers.

The technical imperative was shown to be determined by the application of physical laws. Learning in this context takes the form of changes in scale of one or more of the subsystems of the technique. In this way, technical systems are created which constrains further development, but also forms the basis for such development.

The nature of the economies of scale in the various technical systems in the brick making industry in the Western Cape was then identified. For clay brick manufacturers, this lay primarily in an efficient combination of the various types of equipment used throughout the production process. With concrete based techniques the key factors were the way in which the products were formed, and the impact thereof on the product characteristics, as well as the way in which the materials were handled and the impact of the organisation of production there-on. An analysis of the nature of the products produced suggested that movements towards smaller but lighter products would most probably take place. And an analysis of the various technical systems suggested that while egg-layers seem to be most efficient under 1989 conditions, small mechanised static machines most probably present the greatest scope for future learning and productivity enhancements.

The differences in product characteristics are related to the cost structure of the techniques that produce them. Higher quality products seem to use more expensive raw materials as well as a more mechanised production process. At the same time, products produced using a less mechanised production process were generally identified with a significantly lower absolute material cost per unit of output, and even less machinery cost per unit of output. The level of mechanisation of the forming process was shown to determine product quality, especially compressive strength, while the type and scale of the forming process limited further mechanisation of the materials handling aspects of the technique.

Changes in techniques actually chosen over the years suggest that three periods saw significant differences in the techniques chosen. Before the late 1970's, firms usually chose mechanised clay brick techniques. But in the late 1970's, with the advent of massive housing efforts by the state, most of the larger block making techniques were chosen. By the middle to the end of the 1980's, the new techniques chosen were largely small scale egg-laying and static machines. The techniques chosen later on were also more likely to have been produced locally, rather than imported.

The importance for establishing viable cooperatives seems to be that they should attempt to choose concrete based techniques with small but mechanised forming stages. Clay techniques seem out of the question because of large financial implications and significant technical barriers to entry. The experience of other smaller producers is that they start small with egg-layers and later 'graduate' to static machines. This might be a route to take. This would be complemented by the significantly increased managerial capacity requirements with more mechanised production processes. Furthermore, it was seen that the firms using these types of techniques showed great variability in their productive organisation. This suggests that scope would exist for cooperatives to adapt the organisation of production to their advantage. Once again this is dependent on the capacity of the enterprise to learn and adapt.

The institutional imperative was shown to consist of the embodied learning and power relations on various levels. Apart from the situation within the enterprise, key areas are the nature of the market and the ability of firms to enter, as well as state policies. Within the enterprise, a key function was to learn how to deal with uncertainty. This was shown to be done through the creation of firm specific decision rules.

The significant impact of state housing policies on the choice of technique in the brick making industry was noted. This essentially refers to the choice by the state not to engage in large scale housing development since 1983. Consequently, the volume of housing built did not only decline, but became more erratic. This was a major disadvantage to the big automated concrete block plants, which were planned for high volumes, but experienced difficulties in maintaining those volumes. Other state policies regulating land use also affect the production of houses, thereby affecting the producers of bricks.

In terms of barriers to entry and the structure of the industry, barriers to entry were most likely to be limited markets especially for smaller producers. Big construction companies prefer to buy from big producers because they need the security that products of adequate quality will be available on time.

CHAPTER IV

TOWARDS A FRAMEWORK FOR ESTABLISHING VIABLE WORKER CONTROLLED ENTERPRISES IN THE WESTERN CAPE BRICK MAKING INDUSTRY.

This thesis investigated the choice of technique in the Western Cape brick making industry with a view to identify the potential for establishing viable worker controlled enterprises. In this final section, a simple framework with which to evaluate this potential will be presented. It is limited in scope, and is really the beginning of a problem statement about the particular role which institutions play in economic events.

The viability of any enterprise can analytically be separated into two aspects: the opportunities and constraints present in the industry, and the human interventions in the form of an enterprise with a vision to build on these opportunities and deal with the constraints. This second aspect that is often discussed under the rubric of 'entrepreneurial' actions will fall beyond the scope of the framework, which will focus on evaluating the opportunities and threats in the industry and the possible ways to deal with them.

A further clarification needs to be made. The viability of cooperative enterprises can be seen from two perspectives as well. The one, that will also not be dealt with, comprise those matters crucial to cooperative functioning in general not only in the brick making industry. The second, with which the framework will deal, are those aspects specifically related to cooperative enterprises in the brick making industry.

Within the limitations identified above, the framework will have two main components. The first will deal with the technological opportunities and constraints that face all cooperative and non-cooperative enterprises. Enterprises function in the an environment usually not of their own making - in any case in the brick making industry - and whatever the types of institutional arrangements, they face similar conditions. The second component will deal with those aspects in which the cooperative institutional framework find added opportunities or constraints in the brick making industry not present for other firms.

1. <u>Opportunities and constraints pertaining to all the enterprises in the industry.</u>

A choice of technique model was developed to serve as basis for the framework, since the choice of technique was seen as one of the key activities linking the enterprise with its characteristics with the environment in which it operates. Firms choose techniques in uncertain conditions. The criteria according to which choices are made are not well defined, and insufficient information is available, precluding maximising solutions. As a result, firms develop rules of thumb which set criteria according to which choices are made. These decision rules are influenced by the prior learning and experience that people within the enterprise have gained, as well as the conflicts of interest that follow from different groups of individuals with differing objectives. The enterprise should therefore be seen as a bundle of both human and material resources, which is internally differentiated. This view corresponds closely with the experience of worker controlled enterprises elsewhere.

A central feature of the choice of technique model has been the crucial role played by heterogenous products, partly contributing to and partly the result of different technological systems operating in the industry at the same time. The heterogenous products translate in different quality products, which forms the link between the structure of the market and effective demand conditions on the one hand, and the technological opportunities and constraints.

In the case of the brick making industry, changing state policies which no longer sponsor massive housing developments together with a lack of affordability especially in the lower cost housing market have contributed to demand for cheaper even lower quality vertical building elements, delivered in smaller batches and in a more uneven manner. Under current conditions, the scope for starting any new brick making enterprises seems limited until such time as the state and other agencies involved in the low cost housing field can facilitate support systems to change the situation. Furthermore, because or the existence of technological systems, the way in which this support is given will have a major bearing on the implications for the brick making industry. In this regard, two major approaches can be identified. A return to developing massive state housing schemes will most likely support large automated brick producers more than smaller scale producers. On the other hand, a policy based on squatter upgrading coupled with financial and other institutional changes to provide for the gradual replacement of squatter settlements with with more permanent brick and mortar housing will undoubtedly support smaller brick making enterprises more. Government housing policies since 1983 have in effect been in this direction, and the effects on large numbers of smaller brick producers being established as was shown in the study can act as a pointer in this direction.

The reason for these effects can be found in the existence of complementarities in the technological systems characterising the brick making industry. These systems exist around a set of technological principles with order them, producing both opportunities and constraints for further development. In the brick making industry, the major technological principles revolve around two aspects of the production process, as well as the key choice about the materials that will be used. The first is the process of forming the material into products. These largely determine the quality and characteristics of products produced. The second aspect way that the materials are handled before and after the forming stage. Choices in this regard will not only affect the overall efficiency of the system, but will also constrain the choice of materials and the way in which the products are formed. On this basis roughly five technological systems can be identified in the industry:

a. Clay brick producers with tunnel kilns
b. Clay brick producers with clamp kilns
c. Automatic concrete brick producers with mechanised feedback control.
d. Concrete brick producers with mechanised materials handling
e. Concrete brick producers with manual materials handling.
f. Concrete brick producers with manual product forming.

The first three types of technology require relatively high capacity utilisation and in the case of automatic concrete brick producers a demand for relatively high quality products to be viable. The next two groups have much greater scope to adapt and alter their production systems including lowering costs by using cheaper materials and producing smaller batches. However, the completely manual producers have very little flexibility in some of the product and quality spheres.

The observed and anticipated technical changes in product characteristics and technical choices suggest that demand for better quality products will most probably increase. Furthermore, a movement towards lighter products with a bigger volume than standard bricks was anticipated. Both these developments will constrain the ways in which the concrete products are formed, requiring better mechanised presses. That development is already taking place, with producers have started small 'graduating' upwards in the list.

In conclusion it is suggested that most opportunities most probably lie in the concrete producers with mechanised forming stages, but manual or mechanised materials handling stages. However, this is dependent on the changes in state housing policy and other institutional measures supporting the industry such as appropriate financing mechanisms that can incorporate small loans delivery systems.

2. <u>Opportunities and constraints pertaining specifically to cooperative enterprises in the industry.</u>

This aspect is in many ways a difficult one to to deal with in a simple and unambiguous way. However, one of the more important questions that will have to be answered was identified earlier: To what extent is the functioning of the enterprise technologically determined? If it is the case to any significant degree, the scope for specific cooperative interventions is most likely reduced, and vice versa.

The results of the study suggests that a simple linear answer to this question cannot be given. It appeared that certain technological systems present greater scope for institutional variability than others. If the organisation of production is used as a proxy for for this institutional variability, some of the technical systems that most likely present more scope for cooperative enterprises can be identified. In the study, these seemed to be smaller concrete brick and block plants, falling the the same group as those identified as having opportunities in the previous section, but manual concrete brick producers would most probably be included as well.

If the presumption that cooperatives present scope for increased motivation and reduced supervision requirements reported elsewhere is accepted, then it could be expected that cooperatives would have an added advantage in cases where human inputs into the production process are critical and are supervised or controlled with difficulty. Some evidence in this regard did come out of the study, especially in those smaller and less mechanised enterprises, where mechanising key areas were not a viable proposition.

However, these remarks should be contrasted with potential added constraints that cooperative enterprises in this industry could anticipate. If the argument that they will have difficulty in obtaining sufficient resources, both managerial and financial, the potential advantages above might not be realised. It was suggested in the study that access to suitably capable managerial resources would most likely be a prerequisite for effective organisation of the production process. On the other hand, it was also suggested that a number of horizontal integration approaches to dealing with these requirements in the brick making industry would most probably make sense, and cooperative enterprises might be more capable of making use of such opportunities.

To summarise what has been argued, the technological opportunities conducive to efficient cooperative enterprise being established seems to exist, but they are dependent on the constraints of external policies in two areas: firstly, housing policies and actions that will create effective demand for their products and the way in which it is done will be critical. This will open new markets for their products. Secondly, institutions to promote cooperatives in the brick making industry and the way in which they operate will be just as important. Until these are sorted out, the prospects are limited.

New markets can possibly be opened up for the smaller scale firms if state policies or other institutional changes allow present squatters to upgrade their current housing with masonry construction on a piecemeal basis. The current experience is that such owner builders buy materials as they have money available, from the cheapest or the most easily available source. Since they require very small volumes, location close to where the products will be used will most probably present scale economies which larger manufacturers cannot meet. A key institutional precondition will therefore be that squatters must get ownership of the land on which they are living without that reducing the amount of money which they have available to upgrade their houses. Furthermore, access to small scale loans to buy building materials with would most probably also be critical. But the experience of such firms is that they are usually integrated horizontally with some other economic activity. This can be understood in the light of the above average managerial to total labour requirements which such small producers have. Horizontal integration between various cooperative firms, if executed on a sound economic footing, could provide some of these scale economies in the provision of managerial inputs. This could provide scope for regional cooperative strategies which, if the necessary institutional support mechanisms are forthcoming, could lead to the establishment of a viable cooperative brick making sector. Furthermore, the experience of many other firms is that they use the initial manual operating phase as a period of learning before advancing to more mechanised production processes.

BIBLIOGRAPHY.

ABELL P, MAHONEY N na. The Social and Economic Potential of Small-Scale Industrial Producer Co-operatives in Developing Countries. Hackney Co-operative Developments. London. UK.

ALEXANDER AJ, MITCHELL BM 1985 "Measuring Technological Change of Heterogenous Products.". in Technological Forecasting and Social Change 27, 161-195

AYERS RU 1985 "Empirical Measures of Technological Change at the Sectoral Level." in Technological Forecasting and Social Change. Vol 27 pp 229-247.

BALCEROWICZ L 1986 "Enterprises and Economic Systems: Organisational Adaptability and Technical Innovativeness." in LEIPOLD H, SCHÜLLER A. eds. Zur Interdependenz von Unternehmens- und Wirtschaftsordnung. Schriften zum Vergleich von Wirtschaftsordnungen. Band 38. Gustav Fisher Verlag. Stuttgart.

BELL M 1984 "'Learning' and the Accumulation of Industrial Technological Capacity in Developing Countries." in FRANSMAN M, KING K eds. Technological Capability in the Third World. Macmillan.

BELLAS CJ 1975 "Industrial Democracy Through Worker Ownership: An American Experience." in VANEK, J. Self Management: Economic Liberation of Man. Penguin. Hammondsworth.

BLACKBURN P, COOMBS R, GREEN K 1985 Technology, Economic Growth and the Labour Process. Macmillan. London.

BORNECRANTZ L, VISSERS EF 1986 Marketing an Alternative Building Block in South Africa. Graduate School of Business. UCT. Cape Town.

BRADLEY K, GELB A 1981 "Motivation and Control in the Mondragon Experiment." Vol 19. British Journal of Industrial Relations. pp211-231.

BURKITT B 1984 Radical Political Economy. Wheatsheaf Books.

CAPE UTILITY HOMES. 1986 Coloured Housing Need and Demand: Cape Metropolitan Area. Confidential report.

1988 Black Housing Need and Demand: Cape Metropolitan Area. Confidential report.

CHAPLIN P, COWE R 1977 A Survey of Contemporary British Worker Co-operatives. mimeo.

CHILD J 1986 "Technology and Work: An Outline of Theory and Research in the Western Social Sciences." in GROOTINGS P. Technology and Work. Croom Helm. London.

CLARKE M 1982 Industrialised Building and Its Impact on Labour. SALDRU Working Paper no 44. Saldru. UCT. Cape Town.

CLAYRE A 1980 "The Political Economy of a Third Sector." in CLAYRE A. The Political Economy of Co-operation and Participation. Oxford University Press.

CLEWS FH 1969 Heavy Clay Technology. Academic Press.

COLLINS R, COLLINS A 1982 Do Workers' Co-operatives Work? Carnegie Conference Paper no 240. Saldru. UCT. Cape Town.

COOMBS R, SAVIOTTI P, WALSH V. 1987 Economics and Technical Change. Macmillan.

CORNFORTH C 1989 "The Role of Support Organisations in Developing Worker Cooperatives: A Model for Promoting Economic and Industrial Democracy?" in SZELL, G et. al. The State, Trade Unions, and Self Management. Walter de Gruyter.

COSATU 1987 2nd National Congress Report. Cosatu.

DORFMAN NS 1987 Innovation and Market Structure. Ballinger. Cambridge, Massachusetts.

DUNN W, OBRADOVIC J 1978 "Workers' Self-Management and Organisational Power." In OBRADOVIC J & DUNN WN (ed.). Workers' Self-Management and Organisational Power in Yugoslavia. University Center for International Studies. Univ. of Pittsburgh.

ENGLAND R 1987 "Zimbabwean Coops and Class Struggle." in SALB. Vol 12(6/7). Aug/Sept 1987.

ENOS JL, PARK W-H 1988 The Adoption and Diffusion of Imported Technology. Croom Helm. London.

ELLERMAN D 1984 "Workers' Cooperatives: The Question of Legal Structure." in JACKALL R, LEWIN H, Workers Cooperatives in America. Univ. Of California Press.

FRANSMAN M 1984 "Some Hypotheses Regarding Indigenous Technological Capacity and the Case of

Machine Production In Hong Kong." in FRANSMAN M, KING K eds. Technological Capability in the Third World. Macmillan.

1985 "Conceptualising Technical Change in the Third World in the 1980's: An Interpretative Survey." in Journal of Development Studies. Vol 21, No 4. July. pp 572-652.

GREENACRE MJ 1984 Theory and Applications of Correspondence Analysis. Academic Press. London.

1987 "Influential Analysis and Presentation of Survey Data." in The Journal of Applied Statistics. 1987. Vol 14/2. pp153-164

GREENACRE MJ, HASTIE T 1987 "The Geometric Interpretation of Correspondence Analysis." in The Journal of the American Statistical Association. June 1987. Vol 82/398. pp437-447

GRIMES OF jr. 1976 Housing for Low-Income Urban Families. World Bank.

GUNN C 1984 "Hoedads Coop: Democracy and Cooperation at work." in JACKALL R, LEVIN H. Worker Cooperatives in America. Univ. Of California Press.

HARDACH G, KARRAS D, FINE B 1979 A Short History of Socialist Economic Thought. St. Martin's Press. New York.

HILLEBRANDT PM 1985 Economic Theory and the Construction Industry. (2nd. ed.). Macmillan.

HORVAT B 1975 "An Institutional Model of a Self-Managed Socialist Economy." in Vanek (ed.). Self-Management. Penguin.

1982 The Political Economy of Socialism. Martin Robinson. London.

HUPPERT RNC 1987 An Assessment of constraints on Private Provision of Housing for Blacks in the Cape Metropolitan Area. MBA Technical Report. Graduate School of Business. UCT. Cape Town.

JACKALL R 1984 "Paradoxes of Collective Work: A study of the Cheeseboard." in JACKALL R, LEVIN H. Worker Cooperatives in America. Univ. Of California Press.

JACKALL R, LEVIN H 1984 Worker Cooperatives in America. Univ. Of California Press.

JAFFEE G (ed.) 1988 Building Worker Co-operatives in South Africa. LERC. Papers of a conference:

PERSPECTIVES ON THE ROLE OF COOPERATIVES held at Koinonia Sept 2-4 1988.

JAFFEE G 1992 Co-operative Development in South Africa. Mimeo.

JAY P 1980 "The Workers' Cooperative Economy." in CLAYRE A. The Political Economy of Co-operation and Participation. Oxford University Press.

JUNGE-JENSEN F 1981 "The Control of the Workplace in 1990." in INGERSLEV P et. al. 1985. Producer Cooperatives in Denmark. Copenhagen School of Economics and Social Science.

KAPLINSKI R 1990 "Is and What is Post-Fordism." mimeo.

KEDDIE J, CLEGHORN W 1980 Brick Manufacture in Developing Countries. Scottish Academic Press. Edinburgh.

KNIGHT K 1985 "A Functional and Structural Measurement of Technology". in Technological Forecasting and Social Change 27, 107-127

LAMBRECHTS IJ 1988 "The Market Structure of a Cement Industry: An International Perspective." Paper delivered at EBM Research Conference. University of Stellenbosch.

LAMMERS C 1989 "Competence and Organisational Democracy: Concluding reflections." in SZELL, G et. al. The State, Trade Unions and Self Management. Walter de Gruyter.

LANCASTER K 1966 "A New Approach to Consumer Theory." in Journal of Political Economy. Vol 174, pp132-57.

1971 Consumer Demand - A New Approach. New York.

LENZ RC 1985 "A Heuristic Approach to Technology Measurement". in Technological Forecasting and Social Change. Vol 27, 249-264

LEVIN H 1984 "Employment and Productivity of Producer Cooperatives." in JACKALL R, LEVIN H. Worker Cooperatives in America. Univ. Of California Press.

LEYS C 1984 "Relations of Production and Technology." in FRANSMAN M, KING K eds. Technological Capability in the Third World. Macmillan.

LINDKVIST L, WESTENHOLZ A

1987 Employee Owned Companies in the Nordic Countries. Nordic Council of Ministers. Copenhagen.

LOOTS LJ 1985 Facts and Figures: Housing in the Greater Cape Town Area. Part 1. Institute for Social Development. U.W.C. Bellville.

MAJER H 1985 "Technology Measurement: The Functional Approach." in Technological Forecasting and Social Change 27, 335-351

MARTINO JP 1985 "Measurement of Technology Using Trade-off Surfaces." in Technological Forecasting and Social Change 27, 147-160

MELLOR M, HANNAH J, STIRLING J 1988 Worker Cooperatives in Theory and Practice. Open University Press.

MEYER DE 1982 "The Technical Evaluation of Industrialised Housing in the South African Context." Reprinted by the NBRI from Affordable Housing in the Eighties and Nineties. Milner Park. 23-35 August 1982 CSIR.

MILENKOVITCH D 1984 "Is Market Socialism Efficient?" in ZIMBALIST A. Comparative Economic Systems. Kluwer-Nijhoff.

MÜLLER J 1984 "Facilitating an Indigenous Social Organisation of Production in Tanzania." in FRANSMAN M, KING K eds. Technological Capability in the Third World. Macmillan.

MYGIND N 1981 "How Workers' Ownership can Eliminate the Contradiction between Labour and Capital." in INGERSLEV P et. al. Producer Cooperatives in Denmark. Copenhagen School of Economics and Social Science.

1984 "From the Illyrian Firm to the Reality of Self-Management." in INGERSLEV P et. al. Producer Cooperatives in Denmark. Copenhagen School of Economics and Social Science.

NBRI 1987 Low-Cost Housing. CSIR. Pretoria.

NELSON RR 1981 "Research on Productivity Growth and Productivity Differences: Dead Ends and New Departures." in Journal of Economic Literature. Vol XIX (September 1981). pp1029-1064

NELSON RR, WINTER SG 1974 "Neoclassical vs. Evolutionary Theories of Economic Growth: Critique and

Prospectus." in The Economic Journal December 1974. pp886-905

OAKESHOTT R 1978 The Case for Workers' Co-ops. Routledge & Kegan Paul. London.

PASINETTI L 1977 Lectures on the Theory of Production. Macmillan.
1980 Essays on the Theory of Joint Production. Columbia University Press.
1981 Structural Change and Economic Growth. Cambridge Univ. Press.

PORTLAND CEMENT INSTITUTE 1980 Principles of the Manufacture of Concrete Masonry Units. Portland Cement Institute. Halfway House.

PRASNIKAR J, SVEJNAR J 1988 "Economic Behavior of Yugoslav Enterprises." in Advances in the Economic Analysis of Participatory and Labour Managed Firms. Vol3 pp 237-311. JAI Press.

RONCAGLIA A 1978 Sraffa and The Theory of Prices. John Wiley & Sons. Chichester.

ROSEGGER G 1980 The Economics of Production and Innovation. Pergamon.

RUSHING WA, ZALD MN (ed.) 1976 Organisations and Beyond. Lexington.

SAHAL D 1981 Patterns of Technological Innovation. Addison Wesley.
1985 "Foundations of Technometrics." in Technological Forecasting and Social Change 27, 1-37

SAWYER MC 1989 The Challenge of Radical Political Economy. Wheatsheaf Harvester. New York.

SAVIOTTI PP 1985 "An Approach to the Measurement of Technology Based on the Hedonic Price and Related Methods". in Technological Forecasting and Social Change 27, 309-334

SCHEIN E 1980 Organisational Psychology. (3rd. Ed.) Prentice Hall.

SCHERER FM 1984 Innovation and Growth: Schumpeterian Perspectives. MIT Press.

SCHUMPETER J 1928 "The Instability of Capitalism". in Economic Journal. pp 361-86.

SHARIF MN 1986 "Measurement of Technology for National Development". in Technological Forecasting and Social Change 29, 119-

SRAFFA P 1960 The Production of Commodities by Means of Commodities. Cambridge Univ. Press.

STEEDMAN I 1981 Marx after Sraffa. Verso. London.

STEWARD F 1977 Technology and Underdevelopment. Macmillan. London.

STEWARD F, JAMES J (eds.) 1982 The Economics of New Technology in Developing Countries. Francis Pinter. London.

THOMAS W 1990 "The Western Cape Economy on the way to 2000". mimeo.

THOMPSON JD 1957 "Technology, Organisation and Administration." in RUSHING WA, ZALD MN (ed.) 1976. Organisations and Beyond. Lexington.

TRIPLETT JE 1985 "Measuring Technological Change with Characteristics-Space Techniques." in Technological Forecasting and Social Change 27, 287-307

VAN DER WESTHUIZEN WA 1990 "Worker Managed Cooperatives and Income Distribution: Questions of Finance and Ownership." mimeo.

VANEK J 1970 The General Theory of Labour Market Economics. Cornell University Press.
1975 "The Basic Theory of the Financing of Participatory Firms." in VANEK, J (ed.) Self-Management. Penguin.
1977 The Labour-Managed Economy. Cornell University Press.

VAN WYK RJ 1988 "Technological Advance: Unravelling the Strands". in TISDELL C, MAITRA P, Technological Change, Development and the Environment. Routledge. London.

WARD B 1958 "The Firm in Illyria: Market Syndicalism." in American Economic Review. Vol 48 pp 566-589

WIENER H, OAKESHOTT R 1978 Worker-Owners: Mondragon Revisited. Anglo-German Foundation.

WRIGHT DH 1979 Co-operatives and Community. Bedford Square Press.

ZVONAREVIC M 1978 "Social Power, Information, and Motivation." In OBRADOVIC J & DUNN WN (ed.). Workers' Self-Management and Organisational Power in Yugoslavia. University Center for International

Studies. Univ. of Pittsburgh.

PERIODICALS

FINANCIAL MAIL [FM] 7/7/1989

HOUSING IN SOUTHERN AFRICA [HSA]
October 1987
November 1987
Jan/Feb 1988
March 19882
June 1988
August 1988

HOUSING RESEARCH REVIEW. National Building Research Institute. CSIR.
No 9 1987.
No 11 1988.

QUARTERLY HOUSING REVIEW. United Building Society.
July - September 1989

SA BUILDER March 1988

SA CONSTRUCTION WORLD.
March 1989
May 1989

GOVERNMENT PUBLICATIONS

CAPE METROPOLITAN AREA:DRAFT GUIDE PLAN.
1984. Guide Plan Committee for the Cape Metropolitan Area.

CSS. STATISTICAL NEWS RELEASES.
P.3. BUILDING STATISTICS - PRIVATE SECTOR. 22 PRINCIPAL MUNICIPALITIES AND SURROUNDING AREAS.