A PHENOMENOLOGICALLY BASED CONTINGENT ANATOMY OF COMPETITIVE ADVANTAGE WITHIN THE CONSTRUCTION INDUSTRY.

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DECLARATION

This thesis is submitted under the University of Salford Regulations for the award of a PhD by Research. It is partly based upon research that has been published prior to this submission. Full details of the publication are provided below.

The paper, A Comparison of Environmental and Ethical Reporting within the Construction and Property Industry, was the result of collaborative research with Mr David Baldry, School of Construction and property Management, University of Salford. The agreed contribution to this paper was 2/3rd David Eaton and 1/3rd David Baldry.

The papers entitled, Towards a Zero Defects Construction Industry Culture, where prepared by a research team funded by the DETR under their Partners in Technology (PIT) programme. I was one of a five-member management team for the project, representing the University of Salford. Other management team members represented Taywood Engineering Ltd., CWCT, Slough Estates and Warwick Manufacturing Group. The agreed contribution for these papers is an equal split of 20% each.

The research papers are:

EATON, D. (1993). "The Development of a Conceptual Model for the Improvement of Technical Quality within the Quantity Surveying Practices of the United Kingdom Construction Industry". CIB W-65, Trinidad, West Indies.

EATON, D. (1994a). "*Interpretive and Modelling Problems of Risk and Uncertainty in Bidding Techniques*" Computing in Civil Engineering. Pp. 2038-2045. Proceedings of the 1st World Congress. Washington. Ed. Khozeimeh K. ASCE. New York.

EATON, D. (1994b) "Lean productivity improvements for the construction industry". World Congress of Cost Engineers, London.

EATON, D. (1994d). *"Lean production productivity improvements for construction professions"*. Revista de Ingenieria de Construccion, Pontificia Universidad Catolica de Chile, Chile. September.

EATON, D. (1994e). *"Lean production productivity improvements for construction professionals"*. 5th Seminario International de la Industria de la Construccion, Edifica 94 Construction Fair, Santiago, Chile,

EATON, D. (1994f). *"Lean productivity and small construction practices"*. Revista de Ingenieria de Construccion, Pontificia Universidad Catolica de Chile, Chile.

EATON, D. (1994g). *"Lean Productivity and the Focused Firm"*. Arcom 10th Annual Conference, Loughborough University.

EATON, D. (1994h). *"Lean productivity and the small private practice"*. 2nd International Workshop on Lean Construction, Edifica 94 Construction Fair, Santiago, Chile.

EATON, D. (1994i). *"Lean Productivity for the Building Professions"*. Internet'94. 12th World Congress on Project Management, Oslo,(Pp 469-478).

EATON, D. (1995a). *"Further' Modelling and Interpretive Problems of Risk and Uncertainty in Bidding Techniques"*. Cobra (RICS), London.

EATON, D. et al. (1996c). "Towards a zero defects construction industry culture: Key features, Milestones & Metrics". 2nd working party report. Taywood Engineering / DOE.

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EATON, D. (1997a). "Lean Production Productivity Improvements for Construction Professions". In Lean Construction Ed L.F. Alarcon.(Pp.279-290). A.A. Balkema. Rotterdam.

EATON, D. (1997b). Lean Productivity and the Small Private Practice. In Lean Construction Ed L.F. Alarcon (Pp.273-278). Balkema. Rotterdam. January.

EATON, D. (1998). "Towards a zero defects construction industry culture - Final Report". Taywood Engineering / DOE.

EATON, D. (1999). "The Temporal Development of a Competitive Advantage Hierarchy within the Construction Industry". Cobra (RICS), Salford.

EATON, D. (2000). "A 'Detail' and 'Dynamic' Competitive Advantage Hierarchy Within the Construction Industry" W92 Procurement System Symposium – Information and Communication in Construction Procurement. Santiago, Chile.

ABSTRACT

Sustainable competitive advantage (CA) is a necessary requirement of a rational economic business organisation. Without this CA a business does not have a rational source for appropriating added value in the form of retained profit. Various management research papers have identified numerous factors that may create a source of competitive advantage. Other researchers have shown how industries have changed through time. This thesis shows a temporal development of competitive advantage for the construction industry (CAC). The thesis will structure sources of CA to show the significance of each source during the lifecycle of the business and the industry.

The thesis shows how the identified sources vary over time.

The thesis will develop the concept of a temporal hierarchy as a model for identifying and developing potential sources of CA at any point in the lifecycle of a particular business entity.

The research identifies which sources of CA may be most appropriate (at a given point in the lifecycle) to sacrifice in order to create a further (and higher) source of CA. The proposed temporal hierarchy suggests four 'dynamic' epochs, Factor, Investment, Innovation and Wealth and when these epochs are combined with the 'detail' hierarchies of internal 'detail', distinctive capability 'detail' and external 'detail' a comprehensive anatomy of competitive advantage within the construction industry is presented.

The conclusion of the thesis includes examples of the application of the temporal model to a small sample of case studies, showing the representativeness of the model to 'real-life' businesses.

The phenomenological reservations implicit in the study are evaluated and recommendations are made for further research.

CONTINGENT ANATOMY OF COMPETITIVE ADVANTAGE WITHIN THE CONSTRUCTION INDUSTRY.

CHAPTER ONE: INTRODUCTION

THE TELEOLOGY OF COMPETITIVE ADVANTAGE WITHIN THE CONSTRUCTION INDUSTRY (CAC).

The Truth And Reality Of Competitive Advantage Within The Construction Industry.

For any construction organisation to remain viable, standard Cartesian economic theory (see reservations to the study) assumes the organisation is required to make a profit. To do this the organisation must obtain work. It is then necessary that the organisation execute such work. Whilst executing the work it is necessary to satisfy 'other people' that the work so executed is or will be, of an acceptable standard, delivered at an acceptable cost within an acceptable time. Satisfying these 'other people' is the key to repeated opportunities and continued existence. The way that one firm satisfies these 'other people' by performing 'better' than another is this phenomenon defined as 'Competitive Advantage within the Construction Industry' (CAC).

Therefore obtaining work and executing the work are both difficult tasks to complete. Both tasks are complicated and subject to many inherent risks and exogenous uncertainties. If the construction organisation cannot manage the various tasks and activity 'better' than any alternative organisation then it should not have an economic future within the construction industry. (There are a number of reservations implicit in this statement, which will be discussed later).

Competitive advantage is vital to any construction firm's performance. Without competitive advantage the construction organisation is reliant upon the defective decision making processes of those purchasing the goods or service. A rational organisation cannot rely upon purchasers continuing to make errors of judgement.

For example: why would a purchaser continue to re-employ a 'builder' when other builders could offer the same quality of completed building at a lower price and at a speedier rate of completion? The answer historically, has been that the purchaser has not been in the position to realise that alternatives were available. This has meant that organisations could exist because of the purchasers' lack of knowledge and information.

Today's economic climate is such that purchasers can no longer accept sub-standard performance. The consequence of sub-standard performance is a loss of 'value'. Significantly, attention is now placed upon the purchaser obtaining 'value for money'. These purchasers are also increasingly is a position to define standards of performance. Data is now available to allow comparisons to be made and individual performance to be evaluated. Benchmarking techniques have been established, Governments have publicised best practice guidance.

However, the way any individual construction organisation performs is idiosyncratic. Virtually every aspect of the construction process can be subject to equifinality. That is, different combinations of resources can be applied to achieve the comparable result. Thus it is the combination of the tasks and the resources in the completion of the overall project that is important. The concept of synergy therefore becomes significant. That is, the combination of resource components to create an output that is greater than the sum of the individual resources input.

In an examination such as this the combinations of organisation culture, organisational climate, technological resources and people that can be utilised to complete a project is infinite. There is no single definitive solution, indeed so many solutions exist that it may be impossible to define all solutions. What tends to happen is that via a process of organisational learning, certain types of solutions are more satisfactory for a particular firm than others. A process of filtering and pruning of the project requirements leads to the development of 'satisficing' solutions. Maximisation of economic utility is sacrificed for simplistic solutions that yield a satisfactory outcome.

Defining how one firm performs 'better' than another within construction is therefore a complex issue. It involves many perspectives and issues. The model will explicate these perspectives and identify issues for detailed examination.

CAC is an essential element of the management of any construction organisation. CAC is a fundamental component of the strategic management of the relationship between the firm and its business environment. Identifying the linkages between sustainable sources of CAC becomes an imperative in the strategic management of the firm and identifying the linkages between strategy formulation and implementation is vital in creating a sustainable CAC. The temporal hierarchy identifies these potential linkages.

The intention of this work is to create a model framework to allow the mapping of sources of competitive advantage for individual firms. Having mapped the known sources of CAC for a particular firm it is intended that the model should identify potential additional sources of CAC. Evidence is presented later that a large proportion of the competitive advantage of firms arises from unknown sources. Therefore the identification of the source of CAC is a necessary prerequisite to the firm appropriating maximum benefit from it.

The phenomenological approach is used to develop a clustering and hierarchy of sources of CAC. This would then allow the organisation to formulate alternative strategic options for the development of CAC. These strategic options would identify the critical elements that must be present for any particular option to be feasible. The clear identification of such critical elements would assist in reducing the risk of failure during implementation.

Competitive advantage within the construction industry (CAC) is a phenomenon. It can only be explained holistically (as a whole, not in terms of processes or parts) because of the interdependency of the processes and parts contributing to the equifinality and synergy of the system as a whole. Work by Skitmore, (1989), Eaton (1994. (a) & 1995 (a)) et al. highlights the difficulties of a quantitative approach. Elements that contribute to the creation of CAC can, however, be described in terms of the processes or parts. This allows the framework mapping to be achieved.

It is however, impossible to quantify the contribution of these parts. Equifinality makes the quantification of the elements of CAC impossible. Thus the qualitative approach adopted by this study will present a 'rich picture' of the linkages hierarchy and elements of CAC.

It is presented as a foundation theory because of the many reservations and exclusions specifically identified in the text. The reservations and exclusions mean that the findings of the study are limited and constrained. The development of a comprehensive theory is subject to further research as identified in the reservations to the work.

It is therefore the intention of this study to provide a qualitative foundation theory to explain the phenomenon of CAC. The methodological issues will be discussed later.

CAC Is Necessary.

The global construction industry is large and complex. Stallworthy and Kharbanda (1985) estimate that it is the single most important industry in any national economy. Construction normally represents between 7-15% of gross domestic product (GDP).

There are many excellent companies operating within the United Kingdom construction industry. They compete in the market place, both at home and overseas. They produce the right products and services of the right quality, at the right price and right time, meeting stakeholder needs more effectively and efficiently than other firms.

However the general perception of the construction industry is that of poor products and services often of inappropriate quality that fail to meet client demands for price certainty and guaranteed delivery. The Latham Report (1995) and the Construction Task Force Report (1998) (commonly known as the Egan Report) support this view.

> ***"Nonetheless, there is deep concern that the industry as a whole is under-achieving. It has low profitability and invests too little in capital research and development training. Too many of the industry's clients are dissatisfied with its overall performance."***
>
> DETR.1998. Rethinking Construction. Executive Summary. Pp1.

A number of solutions have been proposed to address parts of these problems. These solutions tend to be versions of procedures adopted by the manufacturing industries and modified to suit the conditions of the construction industry.

However the results of such introductions have failed to match expectations, and frequently fall short of the improvements achieved in other industries. (Eaton. 1994(a)). It is apparent from the introduction of these procedures as attempted remedies that the problems addressed are not definitive for construction but are merely symptomatic of a more deeply rooted and fundamental problem for the construction industry. The root of the problem is defined by the nature of the construction industry itself.

Whilst it has no characteristics that are unique to construction, sharing features with many other industries, it does have a combination of these characteristics that is unique. (Hillebrandt PM. 1985.) The construction industry is subject to exceptional national and international cyclicality in total demand, fragmented and sporadic client led changes in specific work type demands, which are extremely volatile, and the construction industry is also very sensitive to economic and environmental changes.

The construction industry professions' output and construction output in general is very slow to complete, this means that individual contracts are a significant proportion of annual production for all firms. This necessitates an approach to business that is risk averse. The service provision from the professions is largely tailored to individual clients requirements and thus cannot benefit from learning curve productivity improvements as fixed manufacturing can.

There is also a slow trend towards the globalisation of construction and therefore the globalisation of professional services for construction. Competition in the global arena for any industrial sector is seen as an indication of the maturity of the industry (Porter 1990). This has significance for the sustainability of CAC as will be shown in the development of the temporal hierarchy model. Maturing industries have a different set of CAC components, than a developing industry. Work presented by Porter (1990) suggests that some sources of CAC in a developing industry may need to be deliberately destroyed in the progression to a mature industry. This will have significance for the strategic options of a business.

The industry is therefore highly fragmented, highly specialised, highly autonomous, typically under-remunerated and extremely competitive.

However within this environment certain companies stand out as clear market leaders. These companies have a competitive advantage that the 'also-rans' lack.

In considering the phenomenon of CAC it is necessary to establish the fundamental philosophical and cultural basis for the examination. This will create overt constraints and reservations upon the universal application of the model.

Wealth creation and value systems intertwine, it will be necessary to define and illustrate these linkages. National cultures, ethical values and business ethics will affect the interpretation of CAC. Hofstede (1980), Tayeb (in Male & Stocks (1991)), Trompenaars (1993), Canon (1994), et al. provide analysis of the factors. These issues will be addressed later.

Prahalad & Hamel (1990) have used a system of defining 'distinctive capabilities' as a method of demonstrating how wealth is created. The principle of distinctive capabilities will be discussed later, and applied to the analysis of CAC.

Porter (1980) has produced value chain analysis and industrial structural definitions to demonstrate competitive behaviour. These will be utilised to develop a CAC framework.

Pfeffer (1984) has shown that competition is derived from the personnel employed. Once again the CAC factors associated with people issues will be addressed.

Checkland (1981), Gregory, Merali, Mingers, Miles, Wood-Harper and Galliers (All in Information Systems Provision. (1995) Ed. Stowell FA. McGraw Hill.) have all, independently, developed nomenclature mapping techniques to allow structured definition of the complex issues. These tools and techniques will be utilised to provide the definition of the foundation theory of CAC.

Checkland, (1972) et al. has provided systems theory analysis to aid the definition of the processes and parts.

CAC Is A System Manifested By Design

Every organisation competing within the construction industry **must** have a competitive strategy. This strategy may be implicit; it may have evolved through the activities of the individuals employed within the organisation. It may reflect the multiple goals of those individuals. It may have competing tensions. Nevertheless it is a competitive strategy to allow a rational organisation to have a sustained future.

It is however more likely that the organisation will have an explicit competitive strategy. This will have been developed through a planning process. This explicit plan (mission statement, corporate goals, aims and objectives) will entail a systematic approach to the management and co-ordination of organisational activity.

The organisations' corporate strategy will attempt to deliver the aims and objectives. It will allow the organisation to highlight questions such as, what actions are competitors likely to take, what is the best way to respond, how can the organisation be best positioned to compete in the long term?

This CAC study is intended to allow a rational and explicit structure to the answers to such questions.

An Inquiry Into The Order And System Of CAC.

In the broadest sense of the definition of construction provided later, construction globally represents US$ 500,000,000. (Stallworthy & Kharbanda.1985.)

"Value is added at the level at which competitive advantage is created"

Rumelt. (1991)

"Only around 10% of the overall variance of added-value was accounted for by industry factors - the balance [90%] relates to factors which are specific to firms themselves."

Kay. (1993), pp.177-178.

Therefore 90% of CAC is created within the firm and, according to Rumelt over 1/3rd of the CAC is unexplained/unidentified.

Industry	8.3%
Corporate Ownership	0.8%
Cyclical effects	7.8%
Business unit	46.4%
Unexplained	36.7%

Table 1.1

Sources Of Competitive Advantage. Rumelt, in Kay (1993)

Thus over 1/3rd of the CAC is therefore currently unexploitable.

The Structure Of This Study.

Chapter 1 has presented an introduction to the phenomenon of CAC. It has identified the reality and necessity of a company attaining CAC. It exposes a presumption that CAC can be examined holistically and that only by examining CAC in this way can the sources of CAC be identified, and hence utilised in increasing the appropriation of the sources of CAC.

Chapter 1 also identifies that studies of 'added value' (a metric for evaluating the quantum of CAC) find that much of the added value is unexplained by the process of disaggregating the components of an organisation. The premise of this study is that such disaggregation fails to understand the complex interactions between the variables. It fails to appreciate the interactions between the differing hierarchical levels and components of an organisation. Hence a phenomenological contingent anatomy is proposed as a methodology to capture the richness and variety of such linkages.

The phenomenological methodology adopted in this study necessitates a comprehensive explanation of the constraints and limitations of the study as presented. These are made explicit in the section of chapter 1 entitled Reservations To The Study.

Chapter 2 presents an explanation of the methodology of research adopted in this study. It establishes the philosophical and cultural basis of the study, which sets the constraints and limitations for the abstraction of the conclusions to the study. It helps to define the pre-existing prejudices and biases and identifies the reservations and limitations that could otherwise remain covert within the study.

Chapter 2 also describes alternative methodologies that where considered and explains why a phenomenological methodology was adopted. Chapter 2 then briefly provides a structural analysis of the phenomenological methodology, in terms of the identification of the epoch, the process of phenomenological reduction, and the process of imaginative variation and finally the synthesis of meanings and essences of the conclusions to the study.

Chapter 3 presents the literature review. This provides the theoretical detail that underpins the evolution of the CAC framework. The theoretical framework exposes the idiosyncrasies of much of the published work on CA. Different authors considered different variables as the major source of CA. The theoretical review sub-divides the published work into four categories:

- General Literature;
- Exogenous Literature;
- Distinctive Capabilities Literature;
- Endogenous Literature.

General literature, which informs the evaluation of all sources of CA. For example, Lovelock's Gaia hypothesis, Kay's 'Distinctive Capabilities', Waldrop's Complexity Theory, Gleick's Chaos Theory, Checkland's Systems Theory, Zadeh's Fuzzy Theory, Holland's Genetic Algorithms, et al.

Exogenous literature informs the evaluation of sources of CA that are essentially external influences on the creation of CAC. For example, Hofstede's Corporate Culture, Rousseau's Corporate Ethics and Ademe's Environmental Ethics. The study makes explicit that the ethical theory adopted within the study is that of a Cognitive Consequential Utilitarian Egoistic philosophy. The reasons for the adoption of this philosophy are presented.

The Distinctive Capabilities section of the literature review presents material that lies at the interface between the organisation and its environment. It identifies the variables that illustrate the interaction between the firm and its suppliers and clients etc,.

The Endogenous literature review informs the evaluation of sources of CA that are essentially internal to the organisation. For example, Womack et al's Lean Productivity Theory.

The Methodological Literature Review informs the development of the conceptual models by the utilisation of, for example, Checkland's Systems Theory, Hunt's Sub-System Descriptions.

Chapter 3 continues with a Thematic Literature review. This review organises the core themes of the published literature into a structure that can be presented within the model framework. Key CAC variables are identified and referenced to the Key authors for the named variable. The linkages between variables are identified by the reference to sub-level detailed variables. For example, Michael Porter (1980,1985, 1990) identified his notable competitive 'diamond' CAC variables of Rivalry, Demand, Factor Conditions, and Supporting and Related Industries. He also detailed a sub-level of the CAC variable of Market Structure, by identifying markets, industries, demand, supply, competitors, new entrants, clients, suppliers and substitutes.

The identification of these key variables and the relevant linkages forms the premise of the establishment of the model structures to be presented in chapter 4.

The final part of chapter 3 presents a theoretical integrative review of the literature. It identifies the authors that have informed the structural content of the models to be presented in chapter 4. For example, the work of Checkland in the use of soft-system methods, the work of Merali in the clustering and hierarchical ranking of model variables, the works of Mingers and Miles, both of whom model conceptual flow utilising conceptual data models for the structuring and segregation of detail and dynamic models. This section also describes the process of qualitative causal analysis and identifies the phenomenological criteria that are used in interpretation of the CAC variables. For example, consistency, specificity and temporality.

Chapter 4 presents the initial models of static 'detail' sources of CAC and the 'dynamic' transforming sources of CAC. The literature review presented in Chapter 3 identified CAC variables that existed at nine differentiable hierarchical levels. The literature did not distinguish between the levels. The author has produced the model of the hierarchy (Fig 4.1) using generic descriptors of the different levels. Three models have been constructed to represent the static 'detail' variables of CAC as identified within the literature. These are presented in the conclusions of Chapter 6.

Three models have been developed to represent the nine levels of the hierarchy. This was necessary since the inter-relationships between the variables moved between levels of the hierarchy. For example in figure 6.7, the CAC variable relating to educational qualifications of a staff member would be individual specific and would reside at level 9 (the individual level) , but would be connected to major variables of Cultural, and Institutional variables. The cultural variable exists at level 9 for the individual, but also at levels 7 (for the team) and level 6 (for the organisation). The Institutional Variable exists at level 6 (for the firm).

The three static 'detail' models represent:

- Internal 'Detail' (encompassing levels 6-9);

- Distinctive Capabilities ' Detail' (encompassing level 6 the firm interface);
- External 'Detail' (encompassing levels 1-5).

The inter-connections between these three models have not been modelled. This is a recommendation for further development.

Chapter 4 also identifies the temporal epochs. Alternative temporal structures could have been utilised, however this study utilises Porter's conditions epochs of Factor, Investment, Innovation and Wealth. Each epoch is modelled independently and a simplified composite model of the 4 epochs is also presented.

All of the models are developed in the same manner. Firstly by taking the CAC variables and linkages identified by the literature sources and allocating the key variable to either a static or dynamic model. The allocation was made by determining whether the variable would remain relatively consistent for an organisation throughout it's lifetime, in which case it would be allocated to the static 'detail' model. If the key variable altered significantly during the organisations lifetime then it would be allocated to the 'dynamic' model.

Following from this allocation the static 'detail' variables where differentiated by significant position within the hierarchy, hence, internal detail, interface detail or external detail.

The dynamic variables where allocated to an epoch based upon a judgement made by the author of when within the dynamic lifetime of the organisation each variable became significant. Hence the key variable 'factor endowment' becomes significant within the Factor Conditions epoch and the key variable 'excess cash flow' becomes significant within the Wealth epoch.

The linkages between the key variables within a single model are then examined for evidence of the four-sided polygonal systems archetype. The models are drafted and redrafted to achieve the simplest representation of the key variables. This is done by repeatedly nesting layers of the model one layer within another to achieve significant system archetype structures. Completed system archetypes are considered to be at systemic equilibrium. When a system archetype is incomplete the archetype is considered to be at systemic dis-equilibrium. These concepts are considered in more detail within the conclusions of chapter 6. Figs. 4.3 – 4.6 represent the epoch models for each temporal phase. The simplified epoch transition model, fig. 4.7 represents a simplified systemic equilibrium model of the dynamic features of CAC.

The dynamic epoch models are then tested by a series of industry case studies in Chapter 5. Normally a phenomenological study does not require such testing. However in this instance the author has modified the typical phenomenological methodology. The testing of the models was to serve two purposes. Firstly to provide evidence that the proposed dynamic models of the four epochs correlated with industrial experience, such that the author could intuitively allocate an organisation to a particular epoch and that subsequent examination of the organisation would substantiate the allocated position. Secondly, that industrial collaborators could examine the key variables and linkages of the models and supplement the theoretical variables and linkages by adding as necessary. The outcome of this testing identified that the models realistically represented the sources of competition of organisations at a particular epoch, although not all sources where represented within the test organisations. It also revealed that one modification was required in the Factor Condition Model. This was a modified linkage that is revised within the models presented within the conclusions.

The key variables of CAC considered to represent a source of CA for a particular organisation are shown within the models by the box and check mark symbol. It is important to note that the sources of CAC within the case studies are identified from the perspective of the organisational member associated with each case study. They do not represent the author's opinion of the sources of CAC residing within each organisation. A development of this case study approach could be to take the completed CAC studies back within the organisation and examine those key variables not noted as a source of CAC to see whether they could be developed as a potential improvement in sources of CAC. This has not been done within this study.

Chapter 6 represents the conclusions to this study. Each of the five research objectives is examined in detail.

1. To identify the variables and conceptual patterns of CAC utilising a generalised systems model;
2. To build a mapping framework;
3. To identify the process, chronologies and connections showing temporal development and hierarchy;
4. To bring order to the individual experience of CAC by generating reliable and rich pictures of potential strategy options;
5. To show that this is a rational reflection.

Figures 6.2 – 6.6 represent the concluding models of the dynamic features of CAC for each of the Factor Condition, Investment, Innovation and Wealth epochs and a simplified composite model.

Figures 6.7 – 6.9 represent the concluding models of static 'detail' features of CAC for each of the internal, interface and external segments of the structural hierarchy.

These are the finally reflections of the phenomenological contingent anatomy of CAC.

A substantial section positing future recommendations for further developmental work completes the conclusions. The section includes recommendations for the elimination or reduction of the impact of the reservations and limitations of the study as presented.

Structural Issues Of This CAC Study.

The study title itself requires many definitions:

- **Phenomenologically based**: the study as it appears to consciousness from our own point of view. Which is inevitably limited and experience-bounded. The research methodology necessary for a phenomenological investigation is presented later.

  The merit of the proposed methodology is that it explicates the process of deductive reasoning and forces this process into the open. It spells out the assumptions on which it is based, and identifies those features of reality to which its conclusions may be sensitive.

- **Contingent**: as it happens to be. This is the perception and description of the experience of competitive advantage in the construction industry.

  The merit of the proposed methodology is that it does not make any fundamental philosophical or cultural assumptions. It is not based on a 'western' neo-classical economic analysis. It will be capable of assessing global issues. It avoids the interpretive and modelling problems of risk and uncertainty, which are inherent in the construction industry.

- **Anatomy**: a detailed analysis of the processes and variables. Providing identification of the conceptual patterns, chronologies and linkages of the temporal and hierarchical development of CAC.

Despite extensive research no definition of CAC was identified, indeed there appeared to be many idiosyncratic assumptions as to the definition. Therefore a tentative definition has been constructed.

- **Competitive Advantage:** that special capability or combination of capabilities identified by the firm that will enable it to attain a sufficient and sustainable winning position in the market with respect to major competitors and realising the firms own corporate mission statement.

- **Construction Industry:** taken in its broadest sense to include all built structures and the professional services necessary to execute such work. It would include, inter alia, house-building, building and civil engineering, power, process and heavy engineering, the built environment professions including architecture and the RIBA, surveying and the RICS, building and the CIOB, engineering and the ICE, I Struct E, CIBSE et al.

A deduction is required at this point to ground the research; namely, that CAC causes those 'qualities' that are necessary to produce CAC and no more. This is a sufficient condition for CAC. Thus in seeking an explanation of contingent facts, we are not entitled to infer the existence of anything beyond what is necessary to explain them. [Schopenhauer. (1813) - The Fourfold Root of the Principle of Sufficient Reason.]

Aims Of The Study.

Therefore the aim of the study is to present a foundation theory of CAC as it happens to be, not as it should be.

The objectives:

- To identify the variables and conceptual patterns of CAC utilising a generalised systems model;
- To build a mapping framework;
- To identify the processes, chronologies and connections showing temporal development and hierarchy;

- To bring order to the individual experience of CAC by generating reliable and rich pictures of potential strategy options;
- To show that this is a rational reflection.

Reservations To The Study:

The first reservation to this study is the exclusion of the consideration of the philosophical metaphysics of first cause. Metaphysics is the philosophy of being. What exists? What are the basic constituents of the world? Do properties exist independently of the individuals that possess them? Since CAC is considered to be a phenomenon demonstrated by the behaviour of individuals within organisations the philosophical question of whether CAC exists independently of the individuals has been ignored.

The second reservation is that phenomenologically based philosophy requires a perspective. Phenomenology literally means the study of appearances. Since appearances are dependent on the observer they are inevitably limited and experience-bounded. Phenomenology, founded by Edmund Husserl (1859-1938)(Cartesian Meditations (1896) & Logical Investigations (1900) from a term introduced by J.H. Lambert (1728-1777) was also used by Hegel (1770-1831) to provide a description of the theory of consciousness. Aptly illustrated by the Cartesian quotation, cogito, ergo sum, "I think, therefore I am".

Thus the reader must be aware of the professional background and construction experience of the author. A chartered quantity surveyor now practising as a university senior lecturer, with a first degree in quantity surveying and construction economics and a higher degree in construction project management and corporate strategy. This briefly sets the experiential boundaries that limit and constrain the study.

The third reservation is the covert assumption that CAC can only be explained as a whole, not in terms of processes or parts. Thus a holistic approach has been adopted. Advocates of holism include Hegel (1770-1831), von Schelling (1775-1854), and Bradley (1846-1924). The justification for this assumption is the diverse literature sources that all present elements of competitive advantage but fail to offer a complete or comprehensive definition of competitive advantage.

The fourth reservation relates to the covert assumption that for any construction company to remain viable it must make a profit. The study has adopted a cultural and political perspective that is of a classical Western European capitalist society. Therefore alternative political perspectives, for example, communism, have been excluded. Alternative cultural perspectives based upon religious principals, such as Islamic nations have also been excluded. Classical European economic theory referred to as standard Cartesian economic theory has been assumed throughout the study.

A corollary to this reservation is that the term 'construction organisation' relates to the entire corporate body, and therefore there is recognition that cross-subsidisation of business units is possible. It is however essential that the entire corporate body remains profitable.

A fifth reservation is the assumption of rational economic behaviour.

Included within this assumption of rational economic behaviour is an acceptance of a long-term perspective. Therefore this examination of CAC assumes that the organisation wishes to continue its business operations indefinitely. Rogue trading behaviour and opportunistic profiteering (including monopolistic profits) whilst existing have been excluded from the study.

A further reservation is the implicit assumption of necessary or contingent truth. This includes reservations relating to the truth-value.

> *"The question whether objective truth can be attributed to human thinking is not a question of theory, but a practical question. In practice man must prove the truth, that is, the reality and power, the this-*

sidedness of his thinking. The dispute over the reality or non-reality of thinking which is isolated from practice is a purely scholastic question."

Theses on Feuerbach, in Lewis S FEUER (Ed), *Marx and Engels: Basic Writings on Politics and Philosophy* (London, 1969) p.286.

This special kind of action-orientated theory is sometimes known as 'emancipatory knowledge', and has a number of distinctive features. It is the kind of understanding of one's situation that a group or individual needs in order to change that situation. It is not just that this kind of knowledge can be put to valuable use, but that the motivation for understanding in the first place is bound up with a sense of value.

There has been no consideration of the fuzzy approach, TV=o1-0 o. Despite much research regarding the applicability of fuzzy systems (Zadeh (1965), Kosko (1994), (and indeed genetic algorithms, Mitchell (1996)) to the solution of construction problems. As an alternative approach to the improvement in sensitivity of data it undoubtedly has a use. However in the development of the anatomy of CAC it is of little significance.

There has been no consideration of the statistical approaches to the management of risk. If the selected organisation cannot manage the risk and uncertainty of construction activity 'better' than any alternative organisation then it should not have an economic future within the construction industry.

CHAPTER TWO: METHODOLOGY

CHAPTER TWO.

METHODOLOGY OF RESEARCH.

The Fundamental Philosophical and Cultural Basis of the Study.

In an examination of the phenomenon of competitive advantage in the construction industry it is necessary to establish the philosophical and cultural basis of the study. The underlying philosophy will ground the study and set the constraints and limitations for the abstraction of conclusions.

The cultural basis of the study will define the pre-existing prejudices and biases and therefore will help to identify the covert reservations and limitations of the study.

Scruton (1994 pp12.) has identified the four tenets of 'pure philosophy':

- Logic;
- Ethics and aesthetics;
- Metaphysics;
- Epistemology.

Acknowledging the reservation of the metaphysical principle of first cause the principles' and methodology of the study can be supported by citation to acknowledged philosophers.

Aristotle (384 -322 BC.) in the Doctrine of Four Causes (Bekker et al, 1831.194b19, 983a26, 1013a24) identifies four modes of explanation. These have come to be known as:

Material cause;

Formal cause;

Efficient cause;

and

Final cause.

"In the case of a building, for example, its material cause may be bricks and mortar, its formal cause the architectural blueprints, its efficient cause the builders, and its final cause the providing of shelter." Cahn. (1990.pp193)

Descartes (1596 – 1650) in the Discourse on Method (1637) wanted to show that beliefs based on sensory data are not certain, thereby establishing the superiority of the understanding in acquiring knowledge. He stated four principles that reinforce Aristotle's causes, namely:

Only accept as true what you recognise as true;

Start small;

Simplest first;

Thorough and general finally.

Spinoza (1632 – 1677) in The Principles of Descartes' Philosophy (1663) presented the work in geometrical form, presenting the principles (relabelled) at the corners of a four-sided polygon. A format and structure that has been continued in this study. Spinoza's principles became:

Reason;

Opinion;

Intuition;

and

Imagination.

Kant (1724 – 1804) in the Critique of Pure Reason (1781, 1787) identified four analytic principles:

Empirical thought;

Intuition;

Perception;

and

Experience.

(He also identified two less significant principles.)

Schopenhauer's (1788-1860) Fourfold Root of the Principle of Sufficient Reason (1813):

Becoming (causality);

Being (a priori intuitions);

Acting (motives);

and

Knowing (reason and truth).

This also follows the Aristotelian model.

Other writers, such as Bacon (1561-1626), Hegel (1770-1831), Locke (1632 - 1704), Hume (1711- 1776) and Russell (1872-1970) had four-fold principles of philosophical explanation that can be structured in the same geometry.

Alternative Philosophical Methodologies.

In determining the methodological approach to the study alternatives had to be considered. Four possible methodologies were identified: Thomism, Critical Philosophy, Conceptual Analysis, and Phenomenology.

Thomism, named after its originator, St Thomas Aquinas (1226-74) attempts to define the first cause of all things. It therefore defines the ultimate 'ground' and explores how the world must be if assumptions and reservations are to be valid. It considers that conclusions are defined by reason alone and cannot base results upon experience.

Critical philosophy derives from an expression used by Kant (1724-1804). Philosophy must define the limits of the thinkable. The creation of the boundary (limit) causes some difficulties, Hegel, for example, criticised the boundary stating that there is no such thing as a one-sided boundary. Kant published numerous papers attempting to establish the possibility of critical philosophy.

Conceptual analysis or 'linguistic analysis' is no longer in general usage. It was intended to be the interpretation of meaning. Scruton (1994 pp9) concludes his analysis of conceptual analysis thus, " and the method of ...conceptual analysis... has left people seriously puzzled by them."

A Spinozarean geometric model of the philosophical alternatives is presented in Figure 2.1.

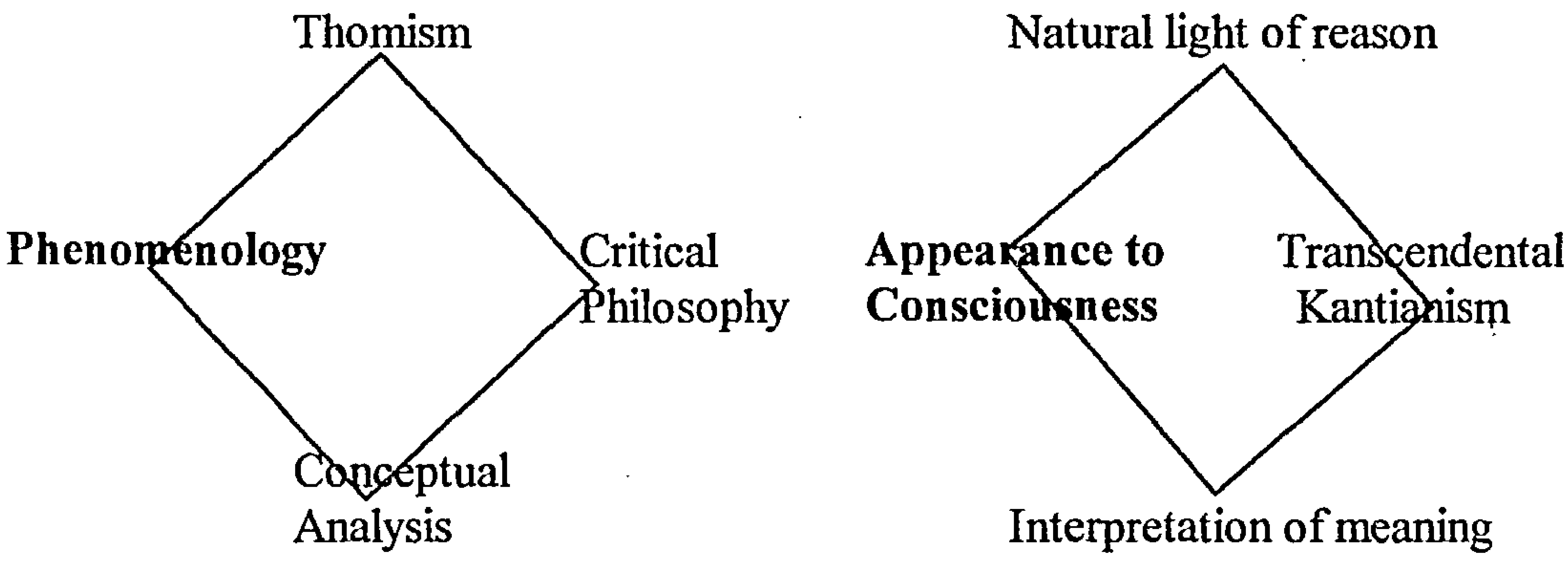

Fig.2.1 Alternative Philosophical Methodologies.

The alternative methodologies described above have to be evaluated and compared to the philosophical arguments to the research:

- **Abstraction**: the study required the development of conceptual patterns, connections and chronologies, generating the generalities from the specific.

- **Ultimacy**: the study required the development of rational explanations, reasons and causes. A break in the chain 'un-grounds' it.

- **Truth**: if the study could identify that there is a first cause of CAC then this would be of fundamental importance. If not, a foundation theory of competitive advantage in construction would enhance the future analysis of CAC.

Thomism relates to the 'natural' light of reason, critical philosophy to transcendental Kantianism and the limits of the thinkable and conceptual analysis to the interpretation of abstract meaning. Thus the methodologies were unbounded. Phenomenology, however, relates to the appearance to consciousness and satisfies the rationale of the research question. Namely: how do people perceive and describe their experience of competitive advantage in the construction industry.

In the determination of an appropriate methodology a quotation from a contemporary philosopher was significant:

> *"The truth of an epoch has no authority outside the power-structure that endorses it."*

Michel Foucault. (1966)
The Order of Things: Archaeologies of Human Sciences.
Osborne, London.

Therefore a phenomenological approach appeared to satisfy the research question and the philosophical arguments necessary to substantiate the conclusions.

Therefore the adopted approach, namely phenomenology, is to study all aspects of CAC as it appears. Therefore acknowledging that CAC will have an intentional content directed towards a goal. This goal is the improvement of the CAC that will enable a firm to attain a sufficient and sustainable winning position in the market with respect to major competitors and realising the firms' own corporate mission statement.

Methodological Process.

Moustakis (1990) pp95 provides a structured analysis of the phenomenological methodology.

1. **Identification of the epoch.** The point in time when the phenomenon begins.

2. **Phenomenological reduction.** Creating the structures of time, space, materials, causality and relationships. In this study the reduction will involve the creation of geometric models of the features of CAC. Reduction will

involve the bracketing, horizonalizing, reducing, clustering and organising the features of the geometric models of CAC.

3. **Imaginative Variation.** The systematisation of themes and contexts, universal structures and exemplars. This will involve the creation of frames of reference, polarities and reversals, divergence, differences of positions, differences of roles, differences of functions etc.

4. **Synthesis of Meanings and Essences.** Evolving the conclusions to the study.

This structure addresses the research question adequately, and has therefore been adopted.

CHAPTER THREE: LITERATURE REVIEW

CHAPTER THREE

LITERATURE REVIEW.

Introduction

The study of the phenomenon of competitive advantage within the construction industry requires an appreciation of diverse academic subject areas, for example, philosophy, economics, culture and ethics, sociology, organisational behaviour and psychology. It also requires the study of business management and construction disciplines.

It would be impossible to reprise all of the material accumulated to develop this study. Relevant material is identified and detailed in the bibliography. However key facets of this study can be linked to particular texts, and this approach has been utilised in the development of the literature review for this thesis.

Such diverse material requires a robust structure to allow a coherent presentation. The Spinozarean four-sided polygon (archetype) structure is also used to create a framework for the literature review.

At a supra-system level the literature review is divided into four sections, namely:

- Theoretical review;
- Methodological review;
- Thematic review;
- Integrative review.

At a systems level the CAC literature of the theoretical review is sub-divided into four sections, namely:

- General;

- External;
- Distinctive capabilities;
- Internal.

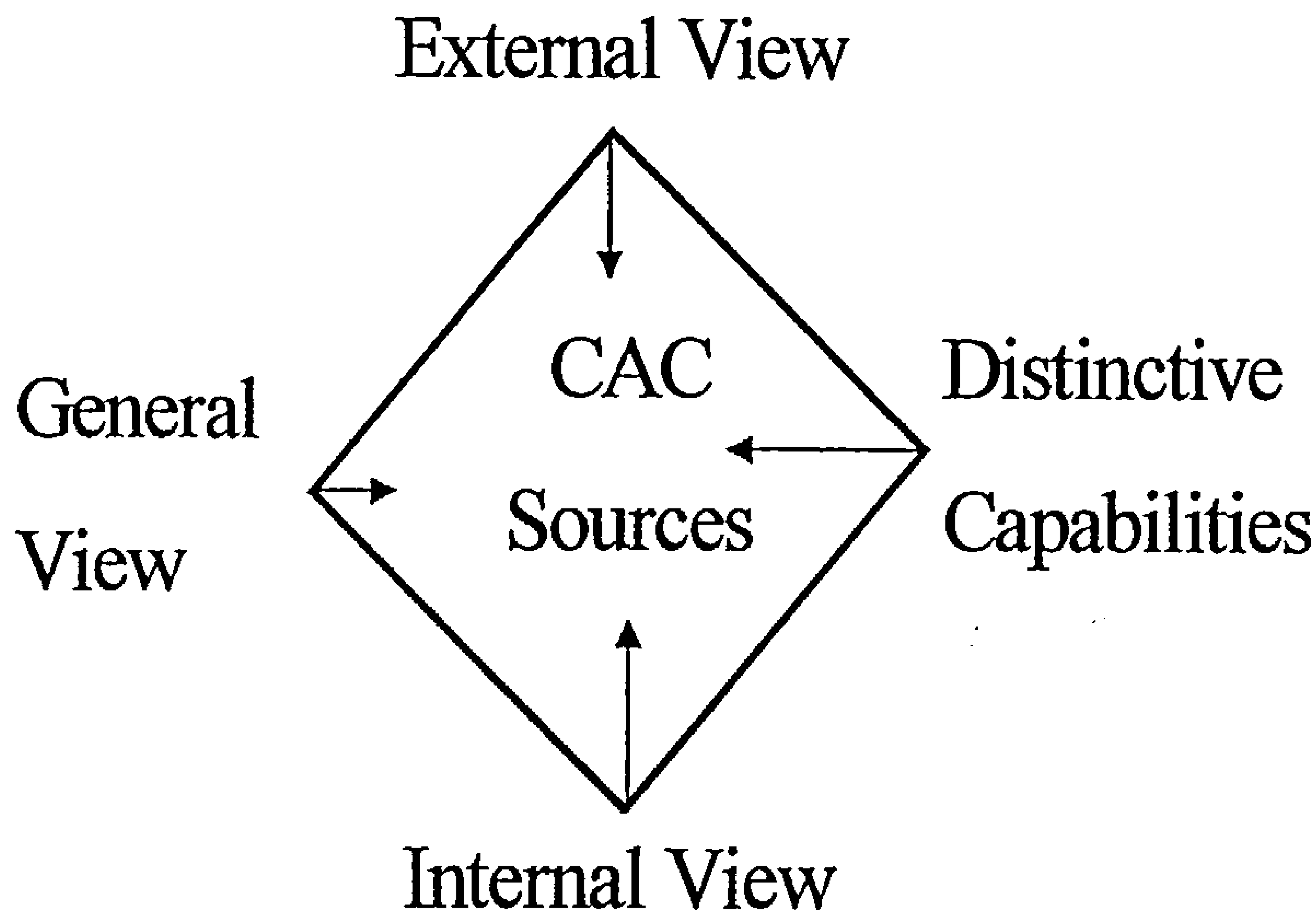

Fig.3.1 Sub-System Review of Theoretical Literature.

Theoretical Review

General literature.

Lovelock (1979) postulated his Gaia hypothesis in which he argues that the entire world behaves like a single complex living organism; this organism is referred to as Gaia (the Greek name of Mother Earth). Gaia is capable of making the necessary adjustments to the composition of its components, and to the exchange of materials between them, to maintain the right conditions for the planet as a living system to evolve and survive.

The identification of these components suggests a static solution, however the maintenance of the right conditions for the system to evolve and survive suggests a dynamic solution. Hence it can be inferred that both static and dynamic factors contribute to the Gaia equilibrium.

On a much smaller scale, businesses are a complex 'organism' (organisation) and must make similar adjustments to the composition of its components, and to the exchange of materials between them, to maintain the right conditions for the business system to evolve and survive.

The identification of businesses' components suggests a static solution. These components can be referred to as assets, however this is a simplistic reference as will be demonstrated later. Maintenance of the right conditions for the business system to evolve and survive suggests a dynamic solution.

The fundamental aspiration of these static and dynamic mechanisms is the continued survival of the organisation.

However the pre-eminent organisations are more than survivors, they can be considered to be successful. There is no consistency or coherency in the identification of successful companies. Most published literature uses these organisations as exemplars of a particular facet of success.

For example Peters and Waterman in their seminal work, In Search of Excellence-lessons from America's best-run companies (1982):

> *"In order to qualify as a top performer, a company must have been in the top half of its industry in at least four out of six ...measures over the full twenty-year period...Thus,* ***any top performer must have scored well, over the long***

haul, on both growth measures and absolute measures of economic health." *p23.*

Ghoshal & Bartlett (1998) in The Individualised Corporation contains the following subtitle:

> ***"great companies are defined by purpose, process, and people.***

Collins & Porras in Built to Last (1998) (p2.):

> *"... Visionary companies [are those] ...that meet the following criteria:*
>
> *Premier institution in its industry;*
> *Widely admired by knowledgeable businesspeople;*
> *Made an indelible imprint on the world in which we live;*
> *Had multiple generations of chief executives;*
> *Been through multiple product (or service) life cycles;*
> *Founded before 1950."*

Peter Senge in The Fifth Discipline (1990) (Pp4), quoting from Fortune magazine and Arie De Geus, head of planning for Royal Dutch/Shell respectively:

> *" The most successful corporation of the 1990s will be something called a learning organisation", "The ability to learn faster than your competitors may be the only sustainable competitive advantage."*

Larraine Segil in Intelligent Business Alliances (1996)(Frontispiece: emphasis added):

> *"Alliances between companies have become a critical weapon in the battle for competitive advantage,* ***and managed wisely can help firms develop and exploit their unique strengths."***

Thus successful companies are perceived to be successful yet the features of such success are markedly different for each company. Within the construction industry this is immediately apparent. Namely, the successful companies do not appear to have much in common.

Alfred McAlpine documents the companies first fifty-years in a biography entitled "The Road to Success" The frontispiece ends (emphasis added):

> *"..., Alfred McAlpine will also look back over the fifty years with pride,* ***striving to preserve that special, different blend for which it is known, and respected."***

This "***special, different blend for which it is known, and respected***" has been denoted by the term 'Distinctive Capabilities' by John Kay in The Foundations of Corporate Success (1993) and as 'The Core Competence' by CK Prahalad and G Hamel.

> *"Core competencies are the collective learning in the organisation, especially how to coordinate diverse production skills and integrate multiple streams of technologies."* (Prahalad & Hamel in Montgomery and Porter 1991 p281)

> *"A Distinctive capability, ... becomes a competitive advantage only when it is applied in a market or markets."* (Kay p127.)

Therefore the idiosyncratic definition of successful companies has little in common other than indicating the need for both the static detail and dynamic temporal analysis of competitive advantage, which forms the substance of this research.

A commonality is that all construction organisations are incredibly complex, self-organising systems that are adaptive, by which is meant, they don't just passively respond to events, they alter and change to actively try to turn whatever happens to their advantage.

MM Waldrop in his book, Complexity: the emerging science at the edge of order and chaos, (1992) noted:

> *"...that corporations and industries evolve for better survival in a changing environment. And the marketplace responds to changing tastes and lifestyles, immigration, technological developments, shifts in the price of raw materials, and a host of other factors.*
>
> *Finally, every one of these complex, self-organising, adaptive systems possesses a kind of dynamism that makes them qualitatively different ...... Complex systems are more spontaneous, more disorderly,* ..[yet].. *at the same time, however, their peculiar dynamism is also a far cry from the weirdly unpredictable gyrations known as chaos.*
>
> *These complex systems have somehow acquired the ability to bring order and chaos into a special kind of balance."* (Waldrop 1992 Pp11-12).

Gleick in his book, Chaos; making a new science, (1987) noted:

> *"...in a universe ruled by entropy, drawing inexorably toward greater and greater disorder, how does order arise? .... The simplest systems are now seen to create extraordinarily difficult problems of predictability. Yet order arises spontaneously in those systems - chaos and order together.... When they saw a random relationship between what goes into a system and what comes out, they* [traditional researchers] *assumed that they would have to build into any realistic theory, by artificially adding noise*

or error.... Tiny differences in input could quickly become overwhelming differences in output - a phenomenon given the name 'sensitive dependence on initial conditions'." (Gleick 1987 p7-8).

Therefore both chaos theory and complexity theory are fundamental to determining the dynamic and detail complexity of CAC. Chaos theory is very hard to define. It is still a young and rapidly developing field. Chaos theory was originally considered to be disorder or confusion within data. This often arose in scientific investigations when there seemed to be no logical connection between the inputs and outputs of a study. Repetitions of an experiment produced different results. The researchers could find no 'logical' explanation for the apparent differences. (Imho 2000). The most significant factors, which cause chaos, are change and time. Williams (1997) defines chaos theory as:

"Chaos is sustained and disorderly looking long term evolution that satisfies certain special mathematical criteria and that occurs in a deterministic non-linear system."

(Williams, 1997, p9).

This quotation makes the covert qualification that, chaos only happens in deterministic, non-linear, dynamical systems. Deterministic means that the results follow set rules and are not just random numbers (Schuster 1989). Non-linear signifies that the output is not directly proportional to the input and a dynamical system is a process, which evolves over time, moves or changes.

The first experimenter in chaos was the meteorologist Edward Lorenz. In 1961, whilst experimenting with weather prediction, using twelve complex formulae, (Frank 1998, Gleik 1987, Imho 2000, Shulka 1998) Lorenz required to run a particular sequence again and started the computer process in the middle to save time by inputting the previous figure. After one hour the process evolved differently (Dev 1998), when Lorenz analysed the reasoning for the differences in results it was found that the number inputted was 0.506 which had been rounded down on the print out to save paper from 0.506127. The results are shown below in the chart.

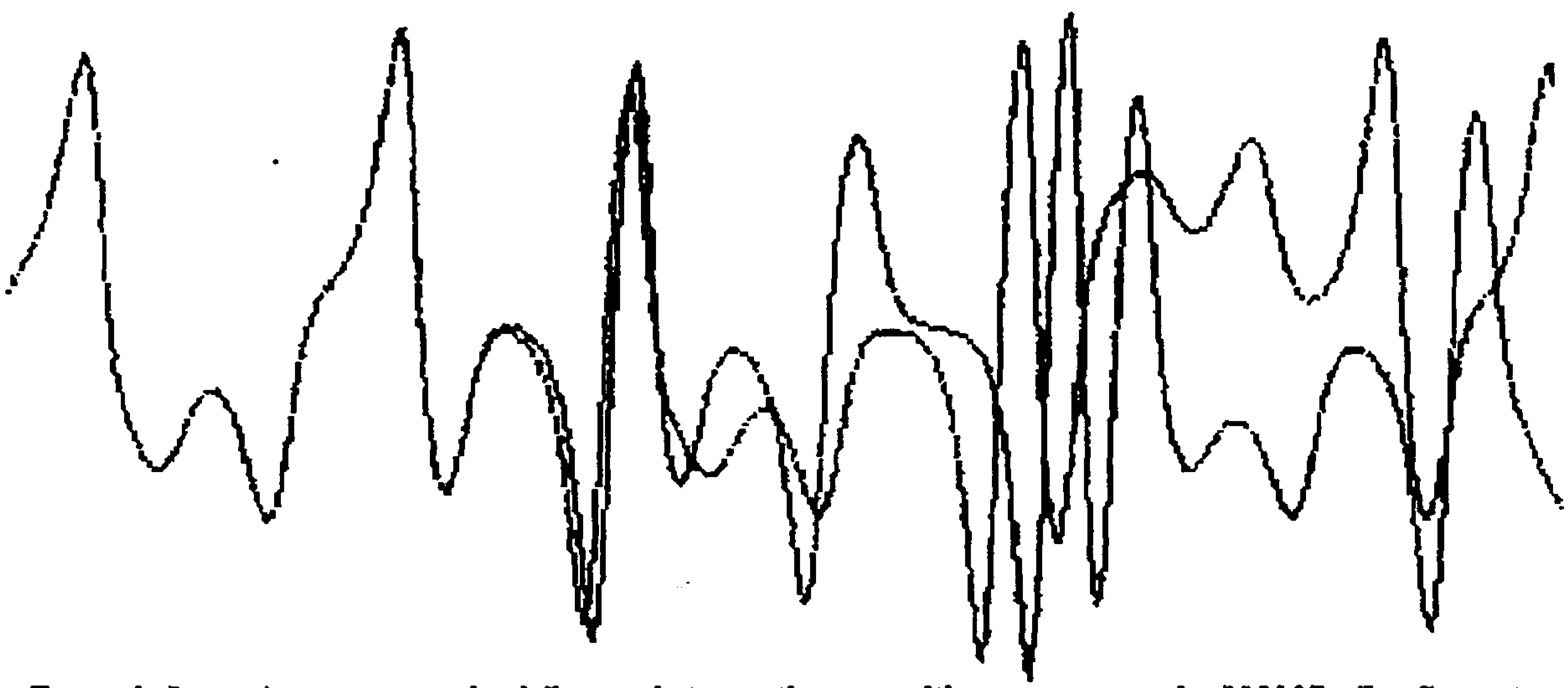

Figure 1: Lorenz's experiment: the difference between the start of these curves is only .000127. (Ian Stewart, Does God Play Dice? The Mathematics of Chaos, pg. 141)

Figure 3.2 Lorenz's Chaos Schematic (From Imho 2000 Pp. 1 of 6)

The diagram shows that chaos had arisen from a very small change in the input value (0.000127).

> *"Tiny differences in input can give rise to large discrepancies in output, a feature*
> ***acquiring a technical name known as sensitive dependence on initial conditions or the 'butterfly effect'"***

(Gleick,1987)

The biggest unresolved matter in the field of chaos theory to date is that it is extremely difficult to identify any uses in real life situations (Roberti 2000). Chaos is used in mathematics and scientific laboratories where controlled environments exist, but there seems to be very little work on real life situations. Therefore three alternative perspectives have developed in the debate over the applicability of chaos theory in a real life situation. There are:

- Scientists who believe it is a mathematical curiosity (Roberti, 2000);

- A middle group who feel it may be real but to date it is no more than a scientific illusion (Berryman & Millstein 1989);

- Scientists on the other extreme who believe that chaos theory is the third scientific revolution of the 20th century after relativity and quantum mechanics. This stems from reports that chaos was discovered in chemical reactions and weather prediction etc. (Williams 1997).

The practical implications of chaos theory in long-term predictions under chaotic conditions are worthless, as the chaotic behaviour can stem from the simplest of causes (Butterfly effect). (Gleik 1987, Dev 1998) Chaos theory has been used in biology over recent years to help understand new evolutionary process like GA's and to give a better understanding of the brain. This research can be traced back to the work of Charles Darwin, which challenges Newton's understanding of the nature of time. (Thinkquest 2000)

However, simplistic generalised applications of chaos theory have already affected our lives. It has had a great impact on all sciences (Tsonis 1992). Some toys and computer games have been based around chaos theory such as SimLife, SimCity etc.

Chaos theory has developed an adjunct, namely, complexity theory.

Complexity theory arises between order and chaos.

> *"Complex systems tend to locate themselves at a place we call the edge of chaos.*
> *We imagine the edge as a place where there is enough innovation to keep a living system vibrant and enough stability to keep it from falling into anarchy. Only at the edge of chaos can a complex system flourish."*
>
> (Malcolm, 1995)

Research has shown that complexity is very similar to chaos theory (Decker, 2000; Flood, 1988) but requires a structured environment to exist. Therefore the majority of research (Ambos-spies, 1993) has followed on from the basis of the chaos theory and is still an emergent theory with many unknowns. Due to this, no definitive definition is accepted and the statement above tries to put complexity theory into context. Research on complex systems in biology (Phelan, 1995) has focused on the use of cellular automata. These models view single cells via a set of rules or by the state of its immediate neighbours. The Game of Life, a simple computer program popular among computer programmers in the early 1980's, is a well-known form of cellular automata. (Wolfram, 1986; Hubler, 1986).

Complexity is well suited to specific physical or chemical applications as these types of examples look very chaotic but are based solely around a well-structured environment. (Lloyd, 1995; AppliedFutures, 1998).

Chaos and complexity theories will be drawn upon in developing the models of CAC presented in this thesis.

A further strand of literature relates to the resolution of large ill-defined complex problems. Soft-systems theory presents a methodological approach. Authors such as Checkland, Jenkins, Vickers, Wood-Harper, et. al. have identified approaches that have been adopted in this thesis. Details of soft-systems are presented in the methodological section of the literature review.

Two other areas of research have been examined in relation to competitive advantage; namely fuzzy theory and genetic algorithms.

Fuzzy logic is not a new science, its roots stretch back 2500 years. Aristotle asserted that there were various degrees of true and false. It is only in the last 25 years that this concept has been labeled fuzzy logic, after the work carried out by Lotfi Zadeh. The theoretical basis of fuzzy logic is that mathematics can be used to link language and human intelligence. (Zadeh 1975)

Fuzzy theory has evolved to represent data or activities, which cannot be clearly determined within boundaries. It is the opposite of binary data which is always a Yes/No or 1 and 0 outcome. An extreme fuzzy logic set known as a crisp set only has 2 possibilities, but this is an example of a special set and is not representative of typical fuzzy sets.

The expression which defines fuzzy theory is TV ||0-1||. When simplified into terms, the meaning is that the truth-value lies between zero and one, the two extremes. (Abe 1995). As fuzzy logic uses approximate reasoning, the outcomes that are generated are neither exact nor inexact and when dealing with complex data, fuzzy theory can be used to simplify the results. The fuzzy process also makes very complex results easier to prove due to grouping of the data, this is called the rules of inference. (McNeill 1994).

The first practical application of fuzzy logic came about in the 1970's when a British engineer Ebrahim Mamdani discovered it by accident. He was trying to develop an automated control system for a steam engine, which was currently being operated by a skilled operative. The automated control system had to adjust the throttle to maintain the steam engines speed and boiler pressure but by using a mathematical formula (intelligent algorithm) the results were poor (Sanchez 1997). When he tried an artificial intelligence method called 'rule based expert system' (a type of fuzzy logic), which combines human expertise with a series of logic rules, the results were beyond expectations. From this time, fuzzy systems have becoming increasingly a part of our lives as they have many uses. The idea has developed rapidly in Japan as many of the leading companies such as Nissan and Matsusisha have incorporated fuzzy logic into their products. (Klir 1995). For example, Matsusisha have developed a fuzzy logic washing machine. At the beginning of the washing cycle the machine carries out a pre-wash and assesses the dirtiness of the water and applies a certain measure of detergent to the cycle. The idea is that it maximises the efficiency of the cycle and does not bleach the clothes with too much detergent. Examples of other uses of fuzzy logic in today's environment are in traffic light systems, video and television tuning automation and anti-lock brakes on motor vehicles.

The advantages of employing fuzzy logic to situations (in particular construction) with multiple complex solutions are that linguistic, not numerical, variables are used, making it similar to the way humans think (McNeill 1994). Also rapid prototypes or budget costs can be created as the information produced is not detailed. Other advantages are that fuzzy logic is cheaper to develop than other intelligent systems, simplifies knowledge acquisition and representation and can accommodate rules on complexity.

The drawbacks of a fuzzy logic system are that it is very hard to develop a model from the outcome, as it is so broad and imprecise. Also compared to other control systems fuzzy logic relies on a degree of detailed input and requires fine-tuning before it can become operational. As construction projects are usually one-off designs there is little room for trial and error. Probably the biggest drawback is that humans are culturally biased towards an avoidance of uncertainty (Hofstede, 1980) which fuzzy logic can generate, where as, mathematically precise or crisp systems produce linear control models which minimise risk and are culturally more acceptable.

Genetic Algorithms (GA's) have developed through the research carried out in the field (Cmu, 2000_a) of evolutionary programming. Lawrence J. Fogel (Purdue, 1999) originally discovered evolutionary programming in 1960 (Davis, 1991), which focuses on the behavioural linkage between parents and their offspring. John Holland in the early 1970's examined Fogel's work and expanded on the theory to create GA's. Holland's research was to mimic natural evolution by seeking to emulate specific genetic operators. When Holland started his research into how to incorporate natural evolution into an algorithm, he was astonished at the level of complexity observed in life which has evolved in such a relatively short time as suggested by fossil records. (Banzhaf, 2000; Petit, 1998)

When life is broken down it consists of chromosomes, which are strings of encoded information. The encoding and decoding (Goldberg, 1989) of chromosomes is not fully understood today but general features which are accepted in science today are evolution, natural selection and the process of reproduction including mutation, inversion and crossover. (Cmu, 2000_c , Ridley,1999)

The theory associated with GA's was that if a problem could be encoded into a bit string to form a chromosome and then inputted into a computer, the process could yield a technique to solve problems. (Mitchell, 1996). At the time, the 1970's, binary data analysis was well established, so Holland started by using binary data to represent the chromosomes. (Prechelt, 1994). This had the advantage of easy processing by the computer and a relatively simple inputting process for the operator. When Holland ran these simple GA's he found that by using simple encoding and reproduction mechanisms the GA displayed complicated behaviour, which in turn solved some extremely difficult problems. (Goldberg, 1999). From this, could be deduced that GA's had started to mimic nature by solving problems without the knowledge of the decoding world. (Mitchell, 1996).

From the findings of these very early experiments, GA theory was developing in parallel with neural network developments. (Elhag, 1999; Prechelt, 1994). GA's became a recognised specialism, instead of being considered as a branch of biology or genetics.

> *"Algorithmic computing issued in areas where the processing can be described as a known procedure or a set of known rules. Neural computation allows the development of information processing for which the rules and relationships knowledge are not available."*
>
> (Hecht-Nielson, 1990)

GA's work by first creating a population which consists of chromosomes (Mitchell, 1996) of the encoded problem. A chromosome is a string of all the individual elements that need to be considered in order to solve the problem. The most important factor is the element at the front of the chromosome with the other elements being ranked in receding order.

The genetic algorithm starts to produce every combination possible in the order of the elements or bits. Strings with multiple bits have to be limited (Goldberg, 1999; Purdue, 1999), as there are so many possible permutations and combinations. The minimum number of iterations is usually set to 25,000 to ensure a wide variety of outcomes have been considered. Every possible outcome is evaluated and given a fitness value in order to access the suitability of the outcome to solve the problem. In the process of reproduction, crossover, mutation and inversion are used to add variety to the outcome. The process is repeated until by testing the fitness of the next generation the improvement difference falls below a set parameter. If n represents the last generation, a typical function for the process to stop would be:

Stop if (n + 1) Fitness < 0.0003

The fitness of each chromosome is evaluated first. The fitness value has to represent the capability of that chromosome to solve the problem. The purpose of finding the fitness is to ensure that the best chromosomes (Miagkikh, 1999) have the highest chances of reproduction. This process is in practice an artificial version of natural selection (Goldberg, 1989), a Darwinian survival of the fittest among string creatures. The formula that measures the fitness by giving it a numerical value is set at the beginning of the test. These formulae are complex and require experience and knowledge to produce. A simple example from Mitchell's (1996), An Introduction to Genetic Algorithms, is:

$$f(y) = y + |\sin(32y)|$$

This function could be used to identify the real-valued one-dimensional function by representing a bit string as a real number.

The actual selection of the parent chromosomes is often based on 'roulette wheel' parent selection. (Maigkikh, 1999). This means that the parents with the highest fitness are given a proportion of the wheel that is proportional to the fitness value. Therefore once the wheel is rotated the parents who have the highest fitness have a greater probability of selection for reproduction. (Davis, 1991) Another form of reproduction that is commonly used is to select a fitness evaluation process. The computer will automatically select the best offspring, (usually the top 0.1%) due to the fitness value. With a minimum of 25,000 chromosomes being considered in this case the 25 fittest will be selected. These 25 chromosomes form the population of the second generation, which go through the same process. (Goldberg, 2000).

To add variation into the results, as in nature, crossover, mutation and inversion are used. One-point crossover in GA's recombines the genetic material of two parents and creates two children. With one-point crossover the children are created by randomly selecting a cut off point and swapping the tails of the chromosomes over.

Parent 1: 1 1 1 1 | 1 1 Parent 2: 0 0 0 0 | 0 0	⇒	Child 1: 1 1 1 1 0 0 Child 2: 0 0 0 0 1 1

⇧ Cross-over Point.

(Adapted from Davis, 1991, Pp. 17)

An important factor, which must be recognised, is that the children generated can vary dramatically from their parents. Many researchers feel that unless crossover occurs, the process ceases to be a GA as it is such an influential feature in differentiating it from other optimisation algorithms. (Beasley, 2000). A limitation to crossover, which must be recognised, is that if the bit strings are identical after the cut off point no variation will occur. (Banzhaf, 2000). Over recent years, research has examined the use of crossover, and it has found that the performance is affected drastically if crossover is not incorporated in the process. (Goldberg, 1999). The probability of crossover is set at the commencement of the process and it is often in the region of p(0.7). (Maigkikh, 1999).

Mutation is a process that sweeps through the chromosomes and randomly selects a bit within the strings, if the probability test is passed it reverses the bits command. The probability of mutation is usually set very low to a typical (Prechelt, 1994) value of p(0.001), therefore on average one in a thousand chromosome bits are mutated and changed. As binary data analysis is often used to represent the chromosome bits within the computer, when a bit is selected for mutation (Cmu, 2000_a) there is still a probability of 0.5 that it will remain in the same form. The example below is based on the probability of mutation being 0.008.

Old Chromosome	Random Number	New Bit	New Chromosome
1 0 1 0	.801 .102 .266 .373	-	1 0 1 0
1 1 0 0	.120 .096 **.005** .840	0	1 1 0 0
0 0 1 0	.760 .473 .894 **.001**	1	0 0 1 **1**

(Davis, 1991. Pp 16)

Holland's third technique for causing variation is inversion. (Mitchell, 1996). Inversion operates on a single chromosome. The process randomly identifies two points within the chromosome and reverses the order within the selected section. The probability of this occurrence is also set very low, as similar to mutation it can have an influential effect. This process was inspired by biologists (Cmu, 2000_c), but feedback from researchers suggests that inversion has not been found to be beneficial in the use of GA's in present research. It is thought that if the chromosomes are longer in length then it could be a valuable technique. (Goldberg, 1989). Bit string development of construction GA's would appear to require the use of inversion, since there is a lack of data relating to the relative weighting of construction variables, and bit string ordering places significant emphasis on the position of a variable within a chromosome. The use of La Place equivalence in the assessment of the significance of construction variables could undermine the effectiveness of the GA, unless significant inversion was incorporated.

GA's have a large number of potential applications. Much of the work to date was inspired by John Holland in the 1970's, as recommendations for future work. When GA's are applied to a real life problem they can be limited in their uses due to several constraints. Bit strings or chromosomes cannot represent many problems, the fitness proportionate selection is not always the best option and genetic operators are not always the most effective.

Although there are no rigorous rules for when GA's can be applied, researchers have reached a consensus on potential applications:

Nr.	Description of Problem Circumstances	Explanation for Use
1	Possible permutations of variables is large	Combinatorial explosiveness, follows exponential numbers
2	Variables are not completely discrete	Fuzzy boundaries and Multi-function variables
3	Distribution is not unimodal	Inappropriateness of typical statistical methods
4	Form of distribution is not readily defined	Statistical methods requiring details of distribution
5	Distribution has abnormal kurtosis	The results can be skewed
6	Degree of fitness function is imprecise	The standard deviation is not known
7	Task requires a 'best fit' solution	The answer does not have to be the global optimisation or 100%

Table 3.1 Rules for Application of GA's.

A brief analysis of the explanation of use demonstrates the applicability of application within the construction industry.

A critique of the modelling problems of risk and uncertainty associated with the accuracy of construction bids identified similar reservations for typical stochastic methods. (Eaton, 1994_a)

The performance of GA's within these situations depends greatly on the level of detail inputted into the GA. The main elements that govern performance are the encoding method, operators, parameter settings and the criterion for success. (Mitchell, 1996).

The encoding method is the way in which the problem circumstances are represented. In the past these representational strings have been limited to fixed-length, fixed order-encoding solutions. Research and experiments are now being carried out into different encoding methods, such as, real values (fuzzy codes) and multiple character strings (Goldberg, 1989) using the alphabet, examples include Kitano's many character representation for graph-generation grammars.

The operators are the techniques, which are applied to add variation to solutions (crossover, mutation and inversion) and stop stagnation in the GA.

The parameter settings are the factors that govern the occurrence of the operators, which can have an influential effect on the performance.

The success criterion is the level at which the GA is stopped as the fitness value ceases to increase by more than a preset value.

From these points it can be seen that GA's can be applied to many solutions but the ultimate factor of success is subject to the operator, in the level of detail entered into the function.

Whilst providing useful insights into the development of potential tools for analysing discrete components of competitive advantage, they do not have much potential in the initial mapping of the sources of competitive advantage. They have therefore provided only limited insights towards the body of research. Specific details of Fuzzy and GA theory exclusions have been provided in the reservations to the work, contained in chapter one.

Having completed a general literature review, it is now necessary to provide an applied literature review. The structure of the applied literature review is to present published material in a further three sections, firstly an external view of the sources of CAC, secondly a distinctive capabilities view of sources of CAC, and thirdly an internal view of the sources of CAC.

An External View of Sources of CAC.

What makes a Construction and Property Company successful? Why is one company, with an apparently similar background and staff, highly successful whilst the other fails? These and other similar questions can and do lead towards consideration of corporate culture, corporate ethics and environmental ethics.

'Western' researchers who have listed definable characteristics of successful companies have identified certain aspects, such as strength and pervasiveness of core values, internal 'drivers' etc. as being significant elements in their success. Thus it has been assumed that the 'soft' people issues of companies play a vital part in any organisation's success (or failure). The significant 'soft' people issues relate to business ethics, corporate culture and environmental ethics of the people within the property and construction industry.

Business ethics is concerned with the way that business should be conducted to conform to the requirements of law and to meet the general satisfaction of the general public.

There may then be three elements of the business ethic:

- **Descriptive** - observing and describing what actually happens;

- **Normative** - concerned with defining what is considered to be good practice;
- **Deterministic** - proactive solution of difficult morally contentious business issues.

It is apparent that the conduct of any business within the construction and property industry is thus a combination of all three elements.

How is it done? Essentially there are three tests for which affirmation is required before a decision can be considered to be ethical. These tests are:

- **Evidentiary agreement** - the observation of what is happening confirms that this decision has been made by others; ie. Comparative business ethics;

- **Internal consistency and coherence** - the decision proposed does not conflict with the basic principles of each of the major ethical theories; ie. Comparative corporate culture;

- **Environmental and cultural compatibility** - does it fit with what WE generally take to be true; ie. Comparative environmental ethics and Comparative Cultural Ethics.

Thus the critical analysis of construction and property decisions is at the centre of a dynamic system, where it both uses and assesses ethical theory to examine existing moral behaviour and beliefs in order to arrive at critically evaluated prescriptions, which aim to replace, endorse, modify, or add to existing ideas and thereby alter or reinforce existing ethical practices in some way.

How is it possible? Any construction and property decision (of significance) contains an element of uncertainty. These decisions are generally complex and often require a soft systems approach to solution generation. As well as this, ethical decisions are often contentious, with not just different solutions, but opposing solutions based on contrasting theoretical perspectives?

Thus there can be no definitive right answer. So why bother?

Firstly, it is inescapable, society exists within ethical bounds and society therefore has a sanction against those who overstep those bounds.

Secondly, it is important, business within the construction and property industry cannot be conducted without the loyalty and trust that ethical behaviour confirms.

Thirdly, it is part of the process of professionalisation of decision-making defining the expectations of client, employee and manager. Consider the impact that quality assurance, total quality management and performance related review have made on professional service provision.

Fourthly, it is concerned with the self-interest of the decision-maker. Decisions are not made without some element of idiosyncratic personalisation of the decision. The consequences of a decision have to be borne by the decision-maker.

Finally, it is concerned with the moral correctness of decisions. It provides a framework to identify the salient issues in controversial circumstances, allows the evaluation of various possible courses of action and allows the manager to make informed decisions.

> *"As a general strategy for business, 'ethics' pays. Companies which strive to be ethical will, on balance and all other things being equal, have a competitive advantage over those which do not."*

Chryssides & Kaler (1993) p29.

There is however a limit to the degree to which morality and commercial self-interest can converge. Generally, business ethics constrains the organisational drive for profit within broadly legalistic and moralistic limits. If all businesses attempted grossly to exceed these limits for the sake of profit, and then not only would public and political opinions stop them, but the conduct of business itself would become impossible. This concatenates with research on 'relational contracting' currently receiving much attention in the construction and property press.

Does it work in the construction and property industry? The answer must be equivocal. It can make it more difficult for other people to behave unethically. However ignorance may not be the sole cause of unethical behaviour. The ability to have an explicit framework for analysis will enhance rigorous examination and therefore improve decision-making. Figure 3.3 presents an ethical hierarchy showing the philosophical derivation of the construction industry's ethics. Such definition requires the explication of a covert ethical hierarchy that underpins such a definition. The philosophical background to the issues creates a constraint to the study since a 'Western' or European approach has been implicit. No oriental philosophy has been considered in presenting the issues. The ethical theory adopted within this study is supported by a **cognitive consequential utilitarian egoistic** philosophy.

Cognitive since it assumes that it is possible to 'know' the moral 'right' from 'wrong'. Therefore objective assessment of moral issues is possible. An alternative non-cognitive theory has been disregarded since its basic premise is that it is not possible to 'know' the moral 'right'. This would prevent the development of a useable framework.

Consequential since it assumes that the consequences of a decision should be considered as a part of the decision-making process. This is a pragmatic approach to allow flexibility within the framework. An alternative deontological (non-consequential) approach would have required an adherence to principle without consideration of the consequences. This has been disregarded since it would require a level of altruism that is not demonstrated by current practise within the property and construction industry.

Utilitarian (welfare ethic) has been adopted utilising the Bentham principle that the balance of disutility over utility will make a decision wrong. This has a close link with classical Cartesian economic theory, which is evidenced in UK construction and property practise. Alternative ethical theories of Kantianism (duty ethics) and Natural law (rights ethics) become subsidiary to Utilitarianism in an ethical decision making hierarchy. [Fig 3.4 Ethical decision tree]

Egoistic has been adopted to support the provision of ethical and environmental reporting. The alternative hedonistic approach becomes self-centred. This would not permit ethical and environmental reporting since it would fail to create utility for the organisation.

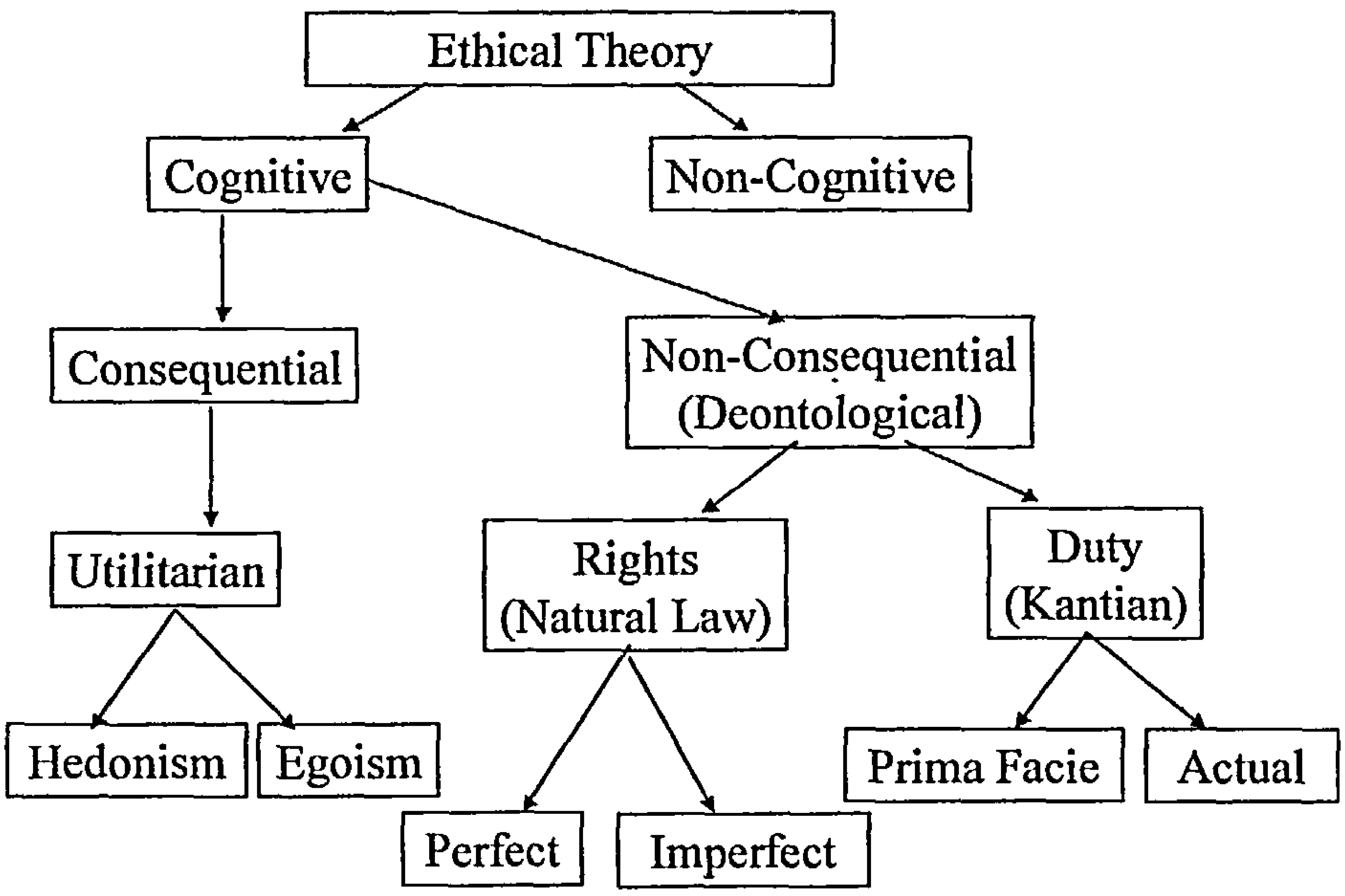

Figure 3.3 Ethical Hierarchy.
(Eaton & Baldry, 1999)

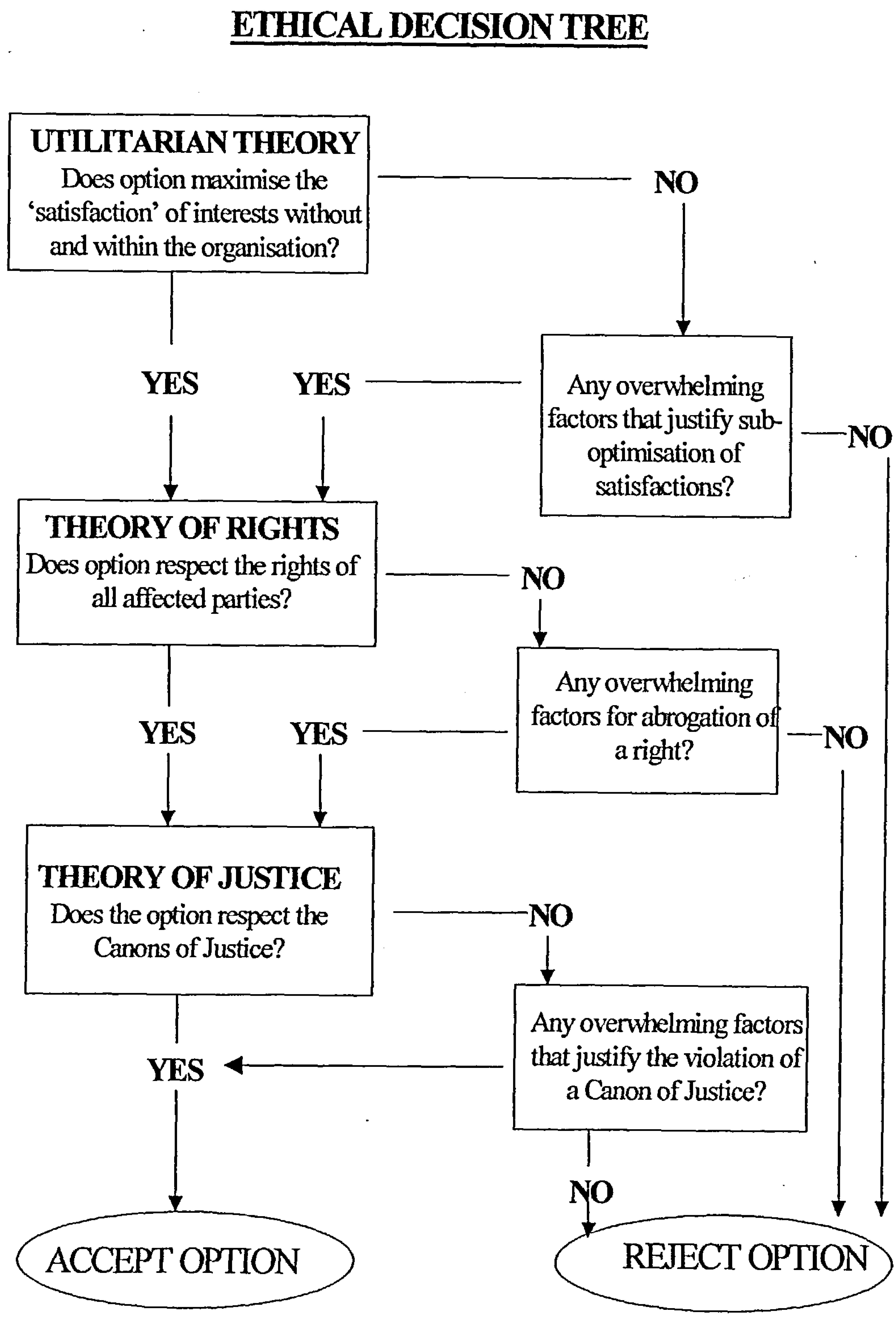

Figure 3.4 Ethical Decision Tree.

(Modified and Adapted from Koontz & Weihrich, 1990)

A tentative definition of Corporate Ethics for the Construction and Property Industry is offered to underpin the examination:

> To identify and apply in practice that which is morally correct behaviour for the conduct of business in the construction and property industry.

This ethical hierarchy (Fig 3.3) and ethical decision-making tree (Fig 3.4) reveal some of the cultural constraints that are typically covert in research findings.

Placed in a construction and property industry perspective, it should be obvious that an understanding of invisible cultural differences can make a significant contribution to the effectiveness of industry collaboration.

> *"The survival of mankind will depend to a large extent on the ability of people who think differently to act together."*
>
> Geert Hofstede (1980), p8

And,

> *Verite en-deca des Pyrenees erreur au-dela.*
>
> Blaise Pascal (1623-1662).

A translation gives the following meaning: "There are truths on this side of the Pyrenees which are lies on the other." It should be apparent that within a construction and property industry the culture within a single organisation can have a significant effect on the business performance of the industry.

Culture can be defined as:

> "Historically evolved values and attitudes and 'meanings' which are learned and shared by the members of a given community and which influence their material and non-material way of life."
>
> M Tayeb (1988)

Thus organisational culture creates a mental program of reaction to situations at a collective level. This gives an indication of the predicted behaviour of a member of a given collective group. It is only an indication, since at the individual level no two people have a mental program that is identical. No two people will be members of exactly the same groups. This allows for the wide differences in reaction demonstrated by individuals.

Why is this of significance? In the context of CAC the existence of discrete professions create significantly different mental programmes for the different professions. The requirements of multidisciplinary team work means that a failure to consider how these people may react in a given situation could create a potential difficulty. The problems of construction and property industries are difficult enough without creating further ones!

In a personal context, failure to recognise culturally dependent differences may create further problems. It is likely that question marks should be attached to the universal validity of much that has previously been taken for granted so far and that has become important.

The construction and property industry does not exist in a vacuum. It operates within systems. These systems determine:

What the Construction and Property Industry can do;

and

The cost to the Construction and Property Industry of doing it.

Special interest groups operate in this pluralistic society. Groups such as trade unions, employers groups, professional bodies, etc. tend to have an interventionist brief. They act to maintain a dynamic equilibrium or to promote specific interests, or they work towards a 'better' society. They invariably affect what the Construction and Property Industry can do and how much it costs to do it. They are a significant exogenous factor and further examination is presented later.

These special interest groups, and indeed, most groups, work within 'social norms'. Typically British norms are a respect for the individual, a belief in competition, etc. generally such beliefs are defined, delimited and constrained by the cultural, political and legal systems of the nation.

Smircich & Calas (1987) have described the popularity of these corporate 'culture' concepts in business writing. They offer three explanations for its significance:

1. Business managers have realised that national and corporate culture may be more important than strategy in improving organisational efficiency and effectiveness (hence appropriating CAC);
2. Organisational and communications theory has shifted towards a 'soft' people oriented social approach to management;
3. Social sciences research now emphasises the importance of subjective perception of employees in preference to normative/descriptive explanation.

Eldridge & Crombie (1974) drew attention to three dimensions of corporate culture:

1. Depth- exemplified in the formulation of policies, procedures and practices that define the basic values of the organisation as a whole;
2. Breadth- the lateral co-ordination of all the sub-systems within the organisation;
3. Time- the co-ordination of the organisation through time.

There are numerous definitions of corporate culture:

1. .... is the fabric of meaning in terms of which human beings interpret their experience and guide their actions. (Geertz 1973.);
2. .... is the best way we do things around here. (Bowers & Seashore 1966.);

3. .... is a system of ... rules that spells out how people are to behave most of the time. (Deal & Kennedy 1982.).

Corporate culture is therefore one of several organisational variables which serves many functions which contribute to the success of the organisation and hence the CAC. The most significant functions of which are:

1. Internal integration and co-ordination. The 'social glue' and 'we-feeling' which counteracts the negative entropy and differentiation of systems;
2. A shared system of meanings. The basis for effective communication and comprehension.

It is the first of these functions that receives the research attention, yet without the second, much of the research is flawed.

Schein (1990) identified 7 dimensions of corporate culture:

1. The organisation's relation to its environmental supra-system - dominant, submissive, harmonising, niche, etc.;
2. The nature of activity within the system - proactive, harmonising, passive, reactive;
3. The nature of reality / truth - what does the organisation believe?;
4. The nature of time-orientation to the past / present / future, the relevant time horizon and time spans;
5. The nature of employees - 'theory X, Y or Z';
6. The nature of human relationships - power distance index, masculinity / femininity, individualism / collectivism, and uncertainty avoidance;
7. Homogeneity versus diversity - same 'types' of people?

It is the first three of these dimensions that gives effect to the exogenous culture and the use of ethical and environmental reports published by construction and property organisations.

It is the final four of these dimensions that gives effect to the endogenous culture; the internal 'organisational culture' exhibited by construction and property organisations.

Various taxonomies have been developed to classify corporate culture, Hofstede, Deal & Kennedy, Williams Dobson & Walters, Graves, etc.

1.Deal & K1	**2.D&K 2**	**3.Graves**	**4.Williams et al.**
Tough Guy	Power	Barbarian	Power Oriented
Work/play hard	Achievement	Presidential	People Oriented
Bet your Company	Support	Monarchical	Task Oriented
Process	Role	Pharoanic	Role Oriented

Table 3.2 Cultural Taxonomies.
(Tabulated from named sources)

There are remarkable consistencies in the taxonomies even though the imagery is different! A further consistency is the representation of four distinct classes. The Spinozarean archetype.

What is now needed is to explain the aetiology and mechanism (origin and process) by which these cultures arise and perpetuate themselves. To date no comprehensive and conclusive research is available. Some components are researched and various methodologies and metrics exist.

Rousseau (1988) identifies:

1. Norms diagnostic index (Allen & Dyer 1980);
2. Kilmann-Saxton culture gap survey (1983);

3. Organisational culture profile (O'Reilly et al. 1988);
4. Organisational beliefs questionnaire (Sashkin 1984);
5. Corporate culture survey (Glaser 1983);
6. Organisational culture inventory (Cooke & Lafferty 1989);
7. Organisational values congruence scale (Enz 1986).

However schematics can indicate how corporate cultures arise. Fig.3.5 demonstrates the internal cultural impacts associated with the organisation and the organisational strategy.

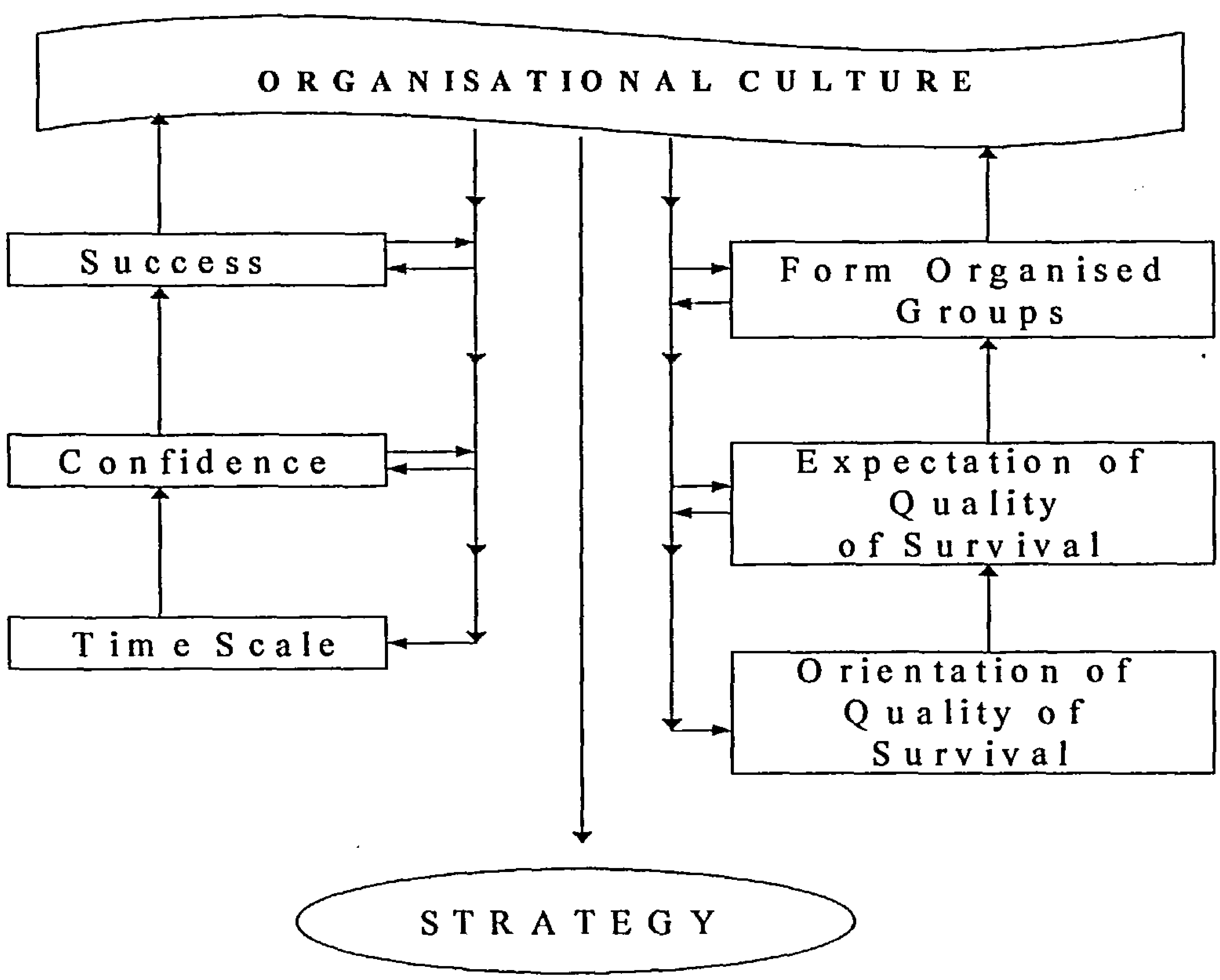

Figure 3.5 Internal Organisational 'Drivers'.

Figure 3.6 demonstrates the external cultural impacts associated with the organisation and the organisational strategy.

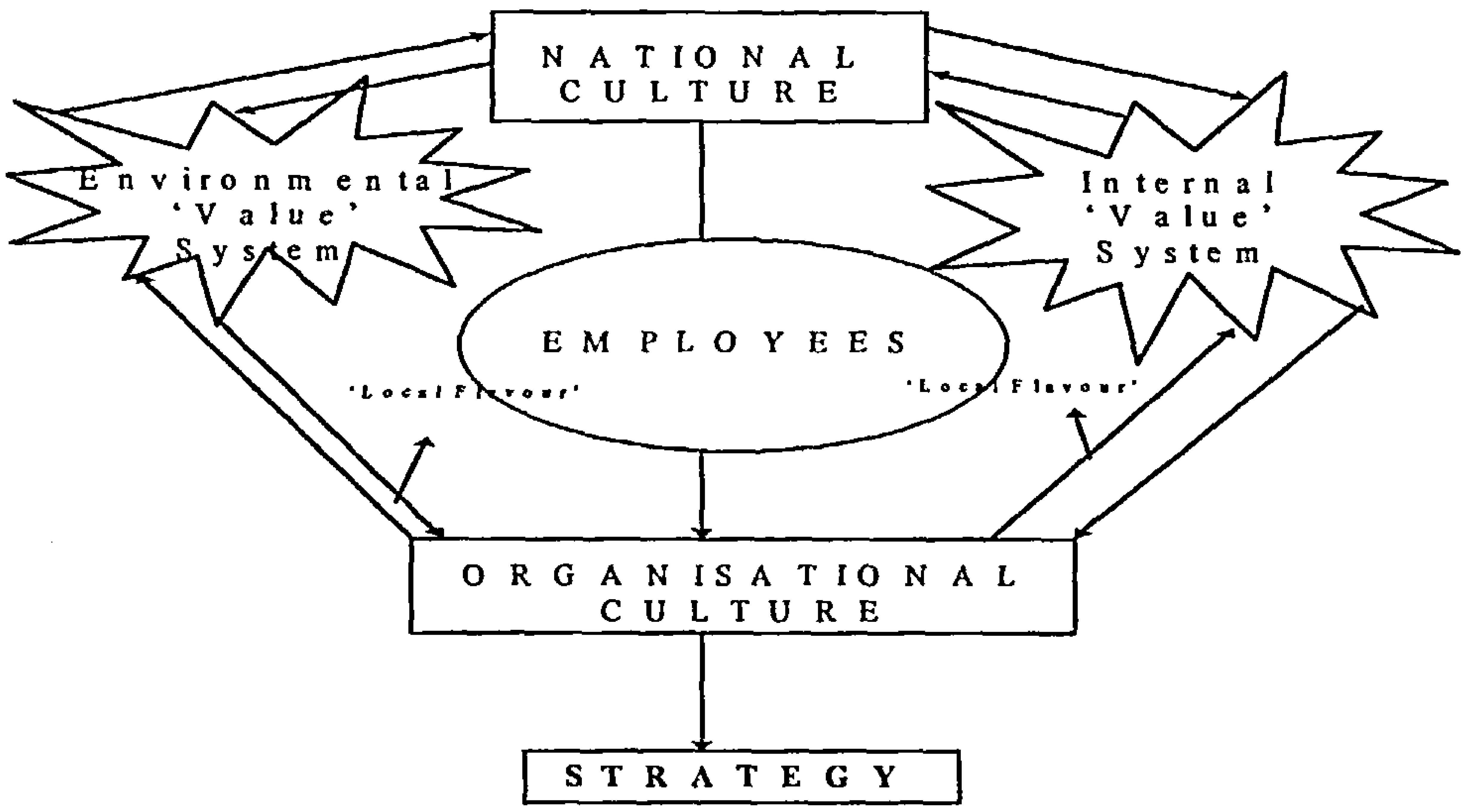

Figure 3.6 External Organisational 'Drivers'.

Corporate climate is the quality of the internal environment of the organisation, the 'feel' of the organisation, perceptible by 'insiders' and relevant to those that come into contact with the organisation. There are four different types of corporate climates. (Rousseau 1988):

1. Psychological climate. Un-aggregated individuals perceptions;
2. Aggregate climate. Averaged perceptions at some hierarchical level;
3. Collective climate. Agreed clustering of systems;
4. Organisational climate. Representations of how organisations feel to:
    a) People within the organisation;
    b) People who deal with them.

Corporate culture is a continuously developing factor that shapes the internal drivers of an organisation (but also affects the external drivers of national culture). Strong organisational cultures are not necessary for effective organisations; rather the organisational culture must be in empathy with the organisational mission. Conflicts between organisational culture and organisational strategy can lead to organisational strain. This will undoubtedly lead to less effective and / or less efficient performance and may lead to system / environment incongruence.

There are significant incongruences within UK Construction and Property organisations. A number of these have been identified within an EPSRC research project entitled, Towards a Zero Defects Construction Culture (Eaton et al. 1998.) The critical success factors, milestones, metrics and actions identified below are a synoptic appraisal of the reports conclusions. The reader is referred to the final report for full details.

1. Defining Clients Needs And Priorities - This means determining the clients needs and priorities in terms of quality, cost and time. Cultural, ethical and environmental issues will form a significant part of the clients' agenda. This will include a procedure for the client and all the project team signing-off the brief agreeing that it is realisable and contains objectives that are acceptable to all parties. It will also include procedures for ensuring that the client is continually debriefed throughout the process and a psychological stop button that any party can invoke should they believe that the project is failing to meet the agreed performance criteria;

2. Establishing The Standards - This means that there is a defined specification for the performance requirements of the building. These standards would include ethical and environmental standards specified for the economic and sustainable life of the project;

3. Briefing The Team - This means that the client and project priorities have been clearly defined and communicated to the team. This would include an acceptance of 'best practice' guidance and the publication of an agreed action plan for the project;

4. Establishing The Team - This means the composition must be agreed and complete at inception. The team composition would include expertise in cultural and ethical practices. The team leader would be selected on the basis of project specific needs;

5. Managing The Process - This means ensuring that the resources are controlled and co-ordinated effectively with consideration of ethical and environmental consequences. The agreed project plan would be published and have clearly defined processes for resolving difficulties. A defined requirement of the project would be team debriefing to ensure that all learning experiences are captured to enhance future projects via cybernetic feedback and generative learning;

6. Establishing The Rules - This means that the roles and responsibilities of the team have been defined in terms of milestones, measures and defined procedures. The milestones, metrics and measures would be used to evaluate performance against the published project plans and protocols;

7. Communication Mechanisms - This means that feedback and understanding of the feedback takes place at all points in the process.

8. Logistics -This means that the team has a full understanding of the flow and conversion of information and materials to achieve design, construction, commission and handover;

9. Planning Resources - This means ensuring a plan is in place for the availability of all resources including time.

The nine end factors identified above will require significant changes to the culture and practices of the Construction and Property Industry. The authority and power to achieve such changes rests within the industry.

It is anticipated that significant changes in ethical and environmental reporting will take place within the UK Construction and Property Industry. Clients and society in general will require that the past ethical and environmental performance of developers and contractors be considered in evaluating future project proposals.

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There is some indication of the increasing significance of a part of this issue. Many local planning authorities now require environmental assessments as part of Schedule 2 planning proposals. The RICS should be commended for setting a positive example in the promotion of environmental and ethical reporting within the UK Construction and Property Industry.

The Body Shop approach to environmental and ethical reporting is commended as an exemplar of 'best practice' for introduction within the UK Construction and Property Industry.

Key Performance Indicators (KPI's) are being produced to benchmark construction activity.

The capture of all learning experiences to promote cybernetic feedback and generative learning would require a change in procurement and contractual arrangements. The use of relational contracting 'Partnering' initiatives is commended.

The literature review has, so far, concentrated upon exogenous factors. The next section concentrates on literature detailing the interface between the organisation and its environment.

A Distinctive Capabilities Review of the Sources of CAC.

Value is added at the level at which competitive advantage is created.

> *Only around 10% of the overall variance of added value* (the metric for competitive value at the level of the firm) *was accounted for by* [exogenous factors] ... *the balance relates to factors which are specific to firms themselves.*
>
> Kay 1993 pp177-178.

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synonymous with photocopiers, Hoover with vacuum cleaners. However Xerox failed with the introduction of both fax machines and personal computers! Hoover has continued to struggle with the introduction of other household appliances. Construction is not immune from these failures. Barratt Homes suffered near catastrophic consequences in the 1980's after the introduction of innovative timber framed housing, they withdrew from this technology, returning to more traditional construction. In the 1990's this technology became the predominant form of housing construction. Yet Barratt were not the market leader in this technology. Low-fines and no-fines concrete, modular buildings and lift-slab construction are all similar examples.

These failures lead to the next pair of determinants, those of patent exploitation and common standards.

Patent exploitation and the protection of innovation is clearly demonstrated in pharmacology products. Glaxo-Wellcome's Zantac, an anti-ulcer drug, transformed Glaxo from a medium-order drug company into Europe's leading pharmaceutical producer. This transformation was not based solely upon the introduction of the drug, but more importantly upon the patent protection afforded to the discovery. Smith Kline Beecham had created another anti-ulcer drug, Tagamet, however, patent problems led to significant replication of the Tagamet formula by other drug companies. Patent exploitation has not had the same significance in the construction industry. Recent Intellectual Property Rights legislation could lead to significant developments of this determinant within the construction industry.

Common Standards is an issue for markets that require complementary equipment or services. Dimensional coordination within the construction industry is a good example of this determinant. For example, block and brick products have proportional dimensions to ensure the simple combination of these products. Excavation equipment has bucket sizes that relate to the varying trench widths of differing excavation activities. These are common examples of a standard game theory technique known as the battle of the sexes. There is no easy solution, it can have an infinite number of solutions if played over the long-run. In such situations it is possible that no satisfactory outcome is reached. In some situations a satisficing solution evolves, in which a solution is accepted but it is not the most efficient or effective solution. These option-oriented and outcome-oriented solution techniques can be 'solved' by the use of fuzzy theory or genetic algorithms, details of which have been presented.

The organisational reputation is a mechanism for conveying information to potential customers. However organisational reputation is not equally important in all markets. It can be significant for products or services where the product or service quality is important but can only be established through experience. The commissioning of an Architect is an example of where reputation can be significant. Equally, the appointment of electrical contractors and lift manufacturers places much significance on the firm's reputation. It is not intended to examine the factors that affect the creation of a firm's reputation. However the mechanism for exploiting a firm's reputation is a significant factor in creating competitive advantage. It is examined in detail later, but briefly, a firm can maintain a reputation, or in certain circumstances it may harvest competitive advantage by deliberately degrading its own reputation. In construction it would appear that there is not significant competitive advantage based upon reputation. There are however indications that the move towards relational contracting, based upon partnering philosophies, could lead towards an improvement in competitive advantage based upon reputation. Professional construction consultancies appear to believe that reputation is a determinant of their success. There is little evidence to support this.

The organisational architecture is the network of linkages both within the firm (internal architecture) and externally (external architecture) with all other elements of the environmental supra-system. The other determinants of architecture are monopolistic opportunities and inequalities of information.

Organisational architecture equates to organisational knowledge and expertise, which in synergistic terms is in excess of the knowledge and expertise of the individuals within the organisation. The architecture determines internal and external experiences of competitive advantage.

Monopolistic opportunities may be present based upon either a natural monopoly or a strategic monopoly. Sources of CAC related to natural monopoly may be typically restricted to the utilisation of natural assets, for example, road aggregates, or scale economies and focused market niches. Strategic monopoly will relate to corporate objectives being supported by sunk costs from either tangible capital investment or from reputation, advertising and market knowledge.

Inequalities of information can be associated with proprietary knowledge based upon strategic action, or exclusivity of information through licensing, patents and intellectual property rights.

Internal architecture is presented in detail in the section entitled A Review of Internal Sources of CAC, and the external architecture in the section entitled A Review of external Sources of CAC.

This structuring of the literature review once again demonstrates the inter-relatedness of the sources of competitive advantage.

It is now necessary to present the literature review detailing internal organisational operational theory.

An Internal Review of Sources of CAC.

Fee scales for construction service provision are no longer mandatory. During the 1980's practices competed by offering percentage reductions from the published recommended fee scales. To my personal knowledge, bids to provide full quantity surveying services (as based on scale 36) offering reductions of 49% of the recommended fee were unsuccessful. The situation has not improved. Indeed the 90's have seen even fiercer price competition.

In periods of high activity most construction firms could win sufficient work (based upon lowest price competition) to remain viable. They were successful inn bidding for work that the larger organisations found uneconomic, either because of the small size and value of the project or the higher overhead costs as a percentage of project fees associated with the larger company. In a recessionary period however, the larger firms compete more vigorously for all projects, including the small projects, which previously they had ignored. The larger firms use the smaller project to maintain turnover and retain staff, awaiting an upturn in the economy to return to more profitable activity. The larger firm also has the capacity to downsize without affecting its core activities. Downsizing for a small organisation is typically impracticable. For example, the elimination of one administrative post from a pool of one can be quite catastrophic! An equivalent percentage reduction of overhead costs is perhaps easier to achieve in the larger firm or has a less significant impact. Over a period of time a firm competing purely on fees may lose its markets.

To avoid this outcome the organisation must adopt a new business strategy. The strategy is based on the lean productivity philosophy and assumes that competition will be based upon the utilisation of all potential sources of competitive advantage.

The origins of lean productivity.

The new philosophy undoubtedly has its origins in Japan of the 1950's. However the philosophy has such a combination of attributes that a more definitive origin is difficult to achieve.

A prominent element of this philosophy was the Toyota (JIT, Just-in-Time) production system, (Womack et al.(1990). This system consisted of the elimination of inventories, reduced set-up time, small lot production capability and the elimination of production peaks and troughs (collectively referred to as Heijunka 'production smoothing').

At the same time, quality issues where being addressed in Japan, and indeed America, by a workforce wide involvement in incremental production improvements (Kaizen) and importantly the refinement and consolidation of service groupings with inter-related holdings and strong 'relational' contracts, commonly referred to as Keiretsu.

These three elements, Heijunka, Kaizen and Keiretsu are the basis of a production management philosophy that emphasises that all activities consist of conversions and / or flows.

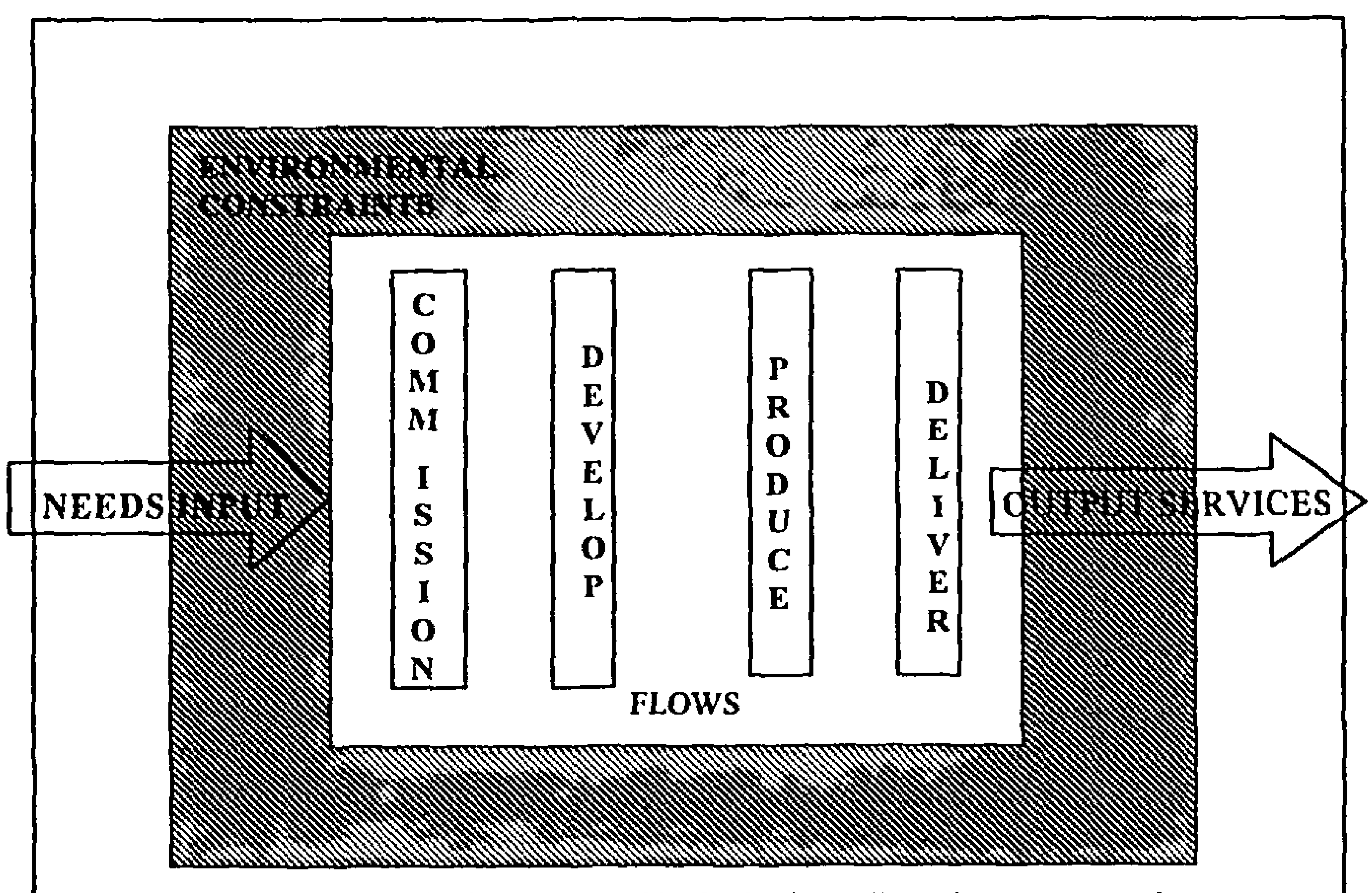
Conversions are activities that add value, and hence CA, to the transformation of material or information into a final product.

Flows are non-value adding activities which exist merely to link conversion activities together. Typically flows are activities such as inspection, testing, waiting, moving, delivery etc.

The aims of lean productivity for the CAC focused firm.

All service activities can be controlled and improved if a methodology is created that allows rational analysis. For example, typical quantity surveying service provision is fragmented and segmented to such a degree that current analytical frameworks fail to recognise the inherent heterogeneity. The larger the firm the greater the tendency for this phenomenon to increase. Figure 3.7 illustrates the philosophy of lean productivity. The analysis of flows and conversions can be used to create an alternative cost curve for the CAC focused firm. In the CAC focused firm *significantly more attention* can be given to each flow and conversion activity. It may be possible for certain elements to be defined as a Leibnizian 'monadal closed system'. Each element reflects the process from its own point of view, but has no effect upon, and is not affected by, any other monad. This approach allows continuous incremental improvements to be made without reflection upon the impacts that such changes will make on other elements. This is certainly not as applicable to the larger firm where the interactions are more complicated.

Figure 3.7 shows a schematic transformation system for a CAC focused chartered quantity surveying practice (CQSP). In the simplified form shown, the focused firm is modelled by only four Leibnizian 'monadal closed systems'. The four monadal sub-systems are namely: commission, develop, produce and deliver. They are linked to each other only by flow activities, represented by the white flow envelope. Surrounding the flow envelope is the environmental supra-system, which places a constraint on the operation of the entire CQSP system. No details of this supra-system are shown but they can be modelled.



"Conversion activities performed by indicative collateral groups, named: Commission, Develop, Produce and Deliver"

Figure 3.7 Simplified Schematic Transformation System.

Figure 3.8 models the lean productivity improvements of the CAC focused firm. By concentrating on the conversion activity attention is directed towards creating sub-system congruence. The sub-systems are modified so that they converge on a focal point at the axis of the entire system, creating a smaller and more closely knit system. The flow activities are examined and reduced or eliminated so that the flows shrink until they match the outlines of the conversion systems. The extent of the lean productivity improvement represented as system congruence is shown by the decrease in area of the focused firm system.

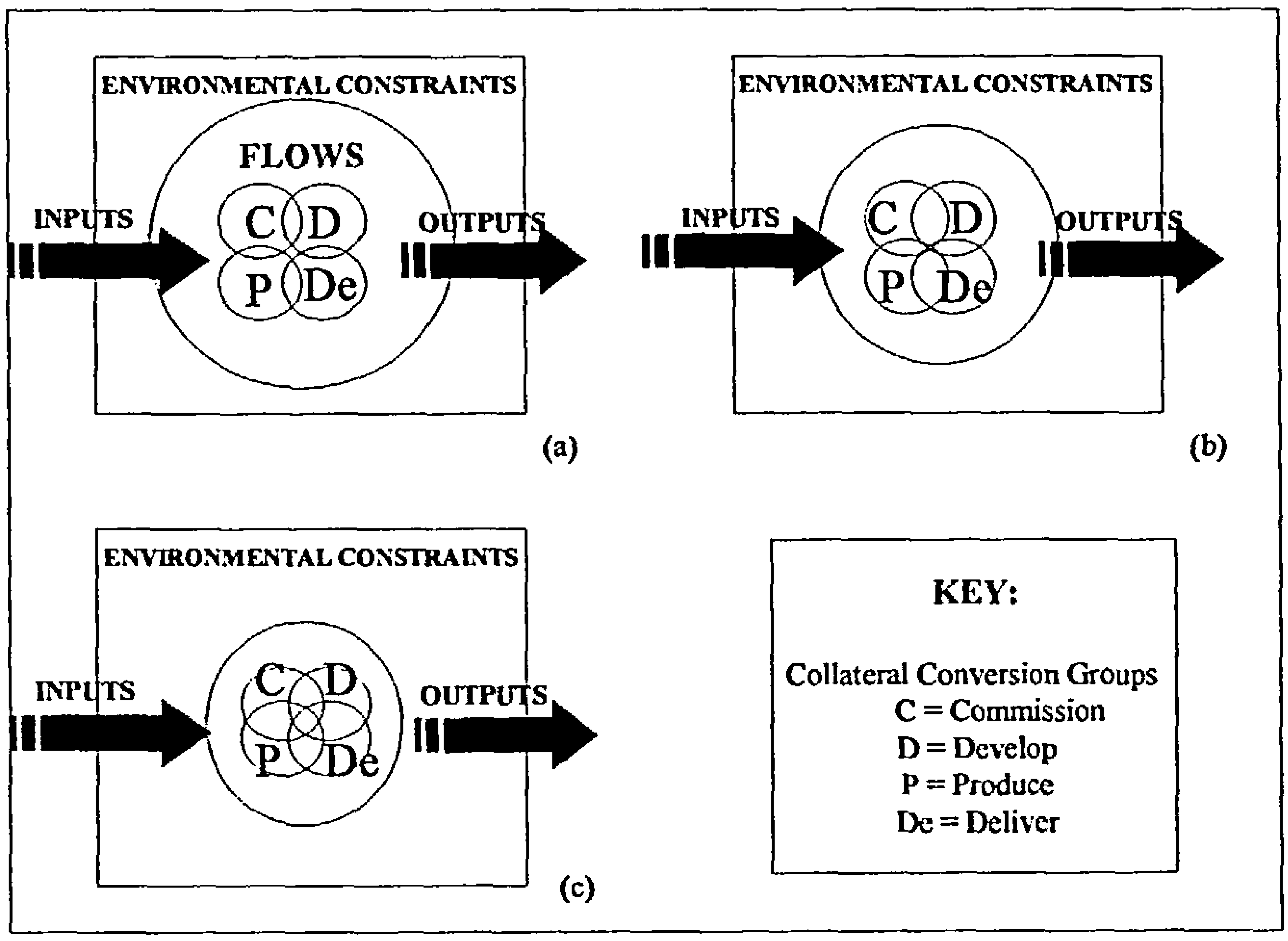


Figure 3.8 Congruent Multi-systems Schematic.

Figure 3.9 shows that the organisational sub-system analysis framework is independent of the lean productivity analysis by using a multi-systems model (Eaton 1993) to represent a conversion and flow analysis. The connected area between the staff role and the job role areas show the additional flows that are necessary because of system and sub-system incompatibilities. This area would be a prime candidate for targeted high impact lean productivity improvements.

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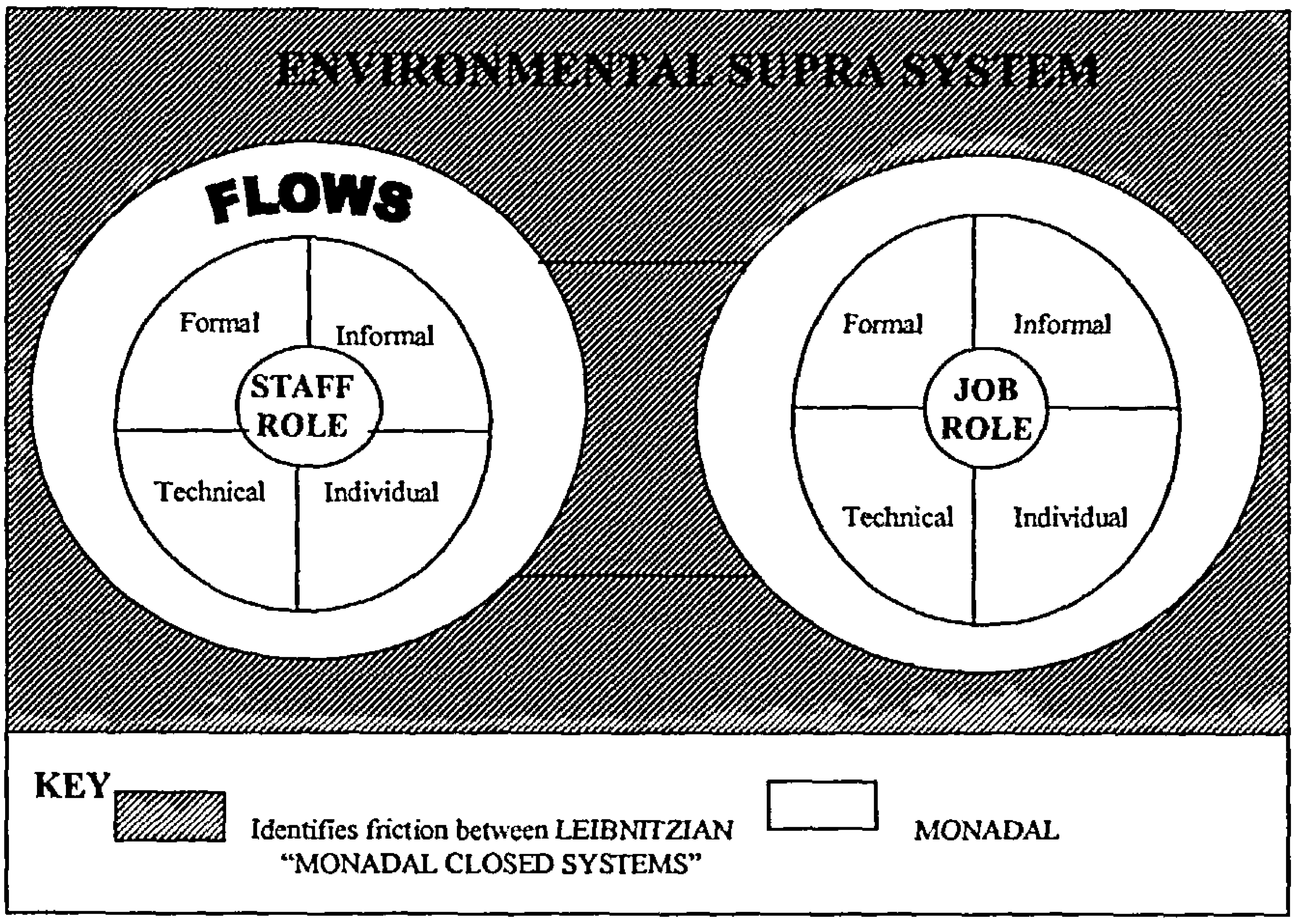

Figure 3.9 Monadal Multi-systems Schematic.
(Internal System Anatomy Adopted from Hunt, 1986)

Achieving lean productivity.

The implementation of lean productivity for the construction organisation may be considered as a four-stage process. An initial or preliminary stage is created that allows the analysis and separation of service provision, (as provided by the individual professional) into flows and conversions. Stage 1 then allows the conversions to be examined and improved by current quality control techniques, whilst the flows can be simplified, or if possible, eliminated. Stage 2 allows the conversions to be improved by typical quality assurance techniques, whilst the flows are improved by further simplification and automation. Stage 3 sees the conversions improved by total quality management techniques, whilst the flows that remain are fully automated. This process is illustrated in Figure 3.10.

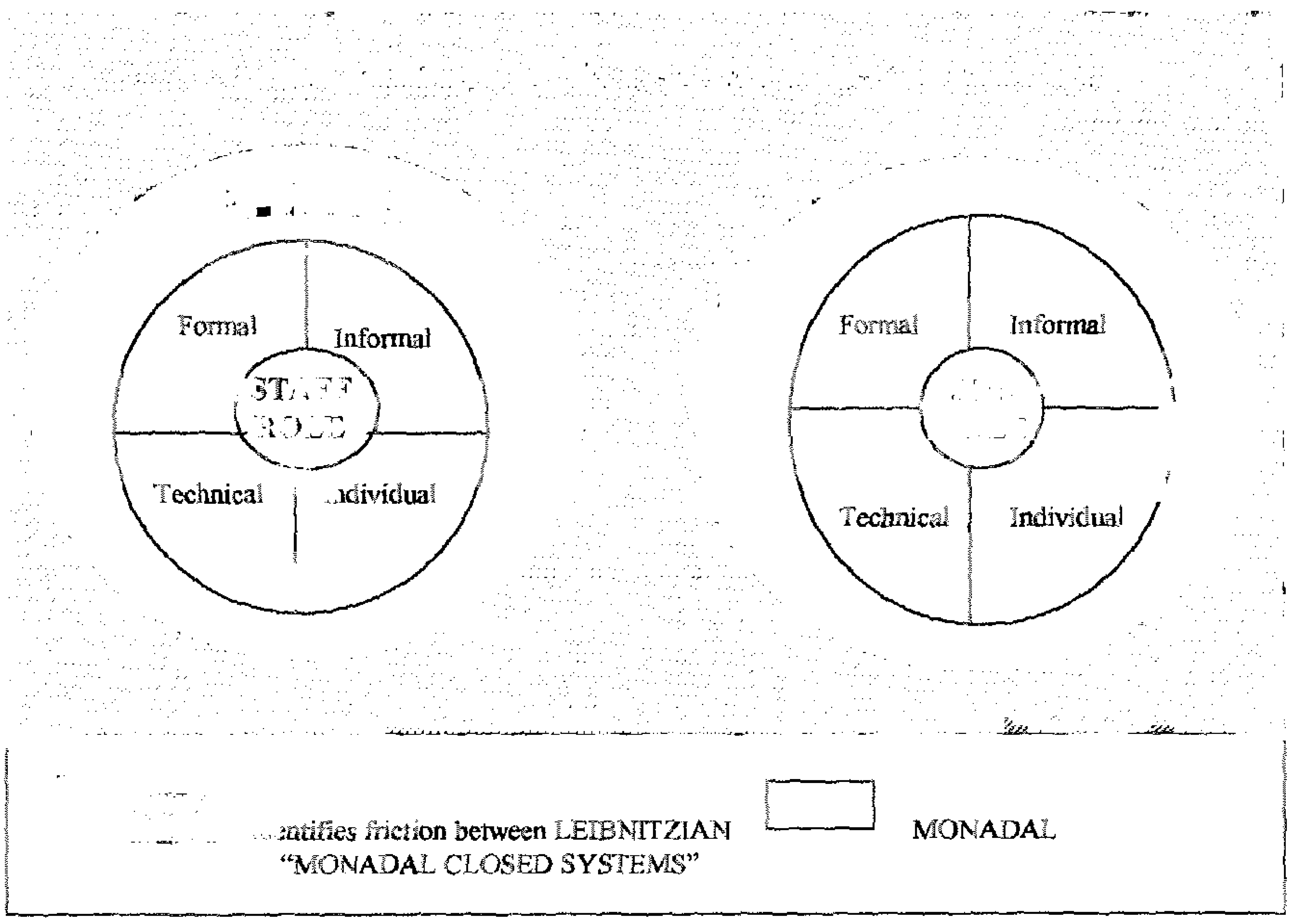

Figure 3.9 Monadal Multi-systems Schematic.
(Internal System Activity Adapted from [illegible])

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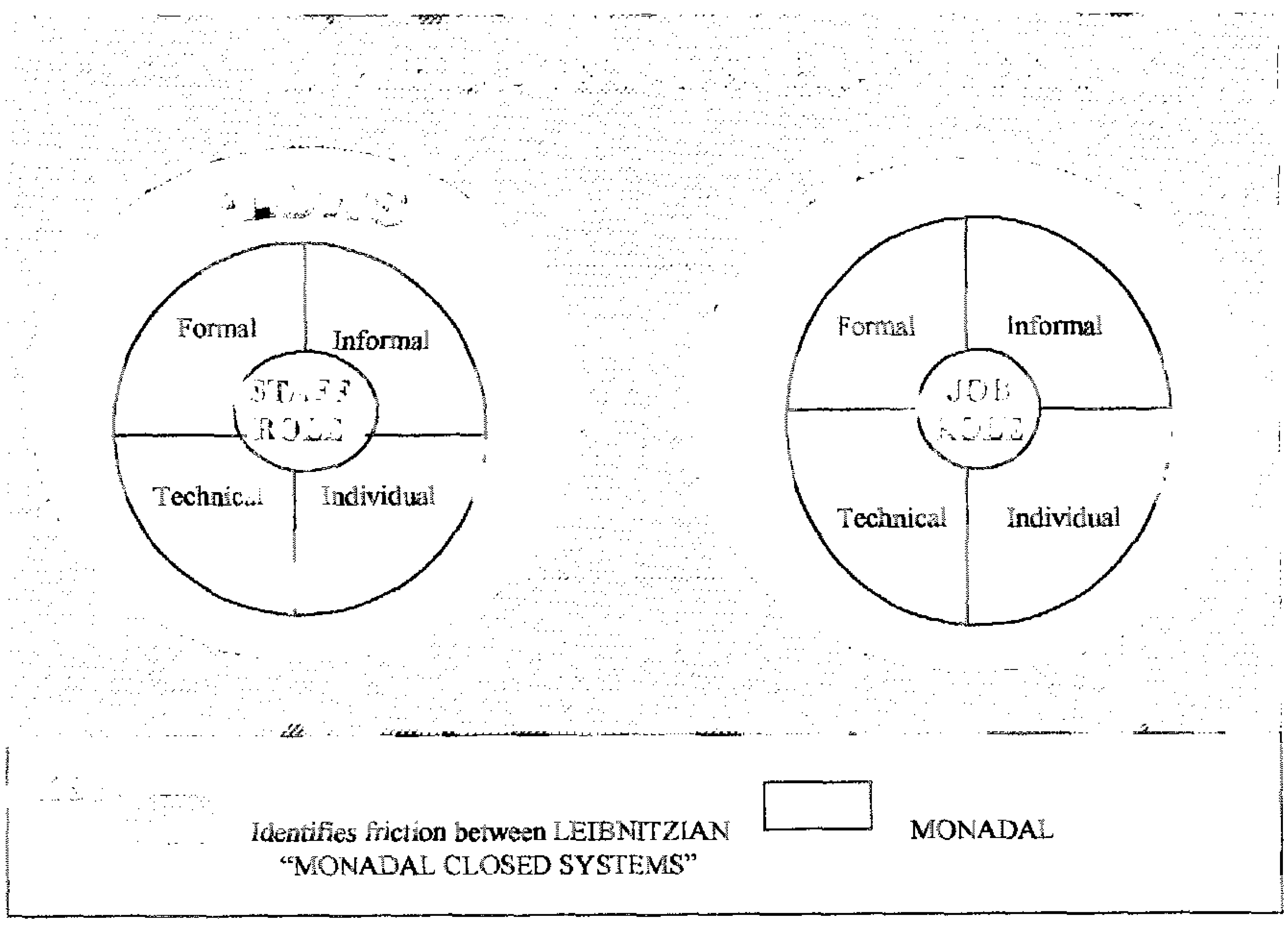

Figure 3.9 Monadal Multi-systems Schematic.
(Internal System Anatomy Adapted from Handy, 1986)

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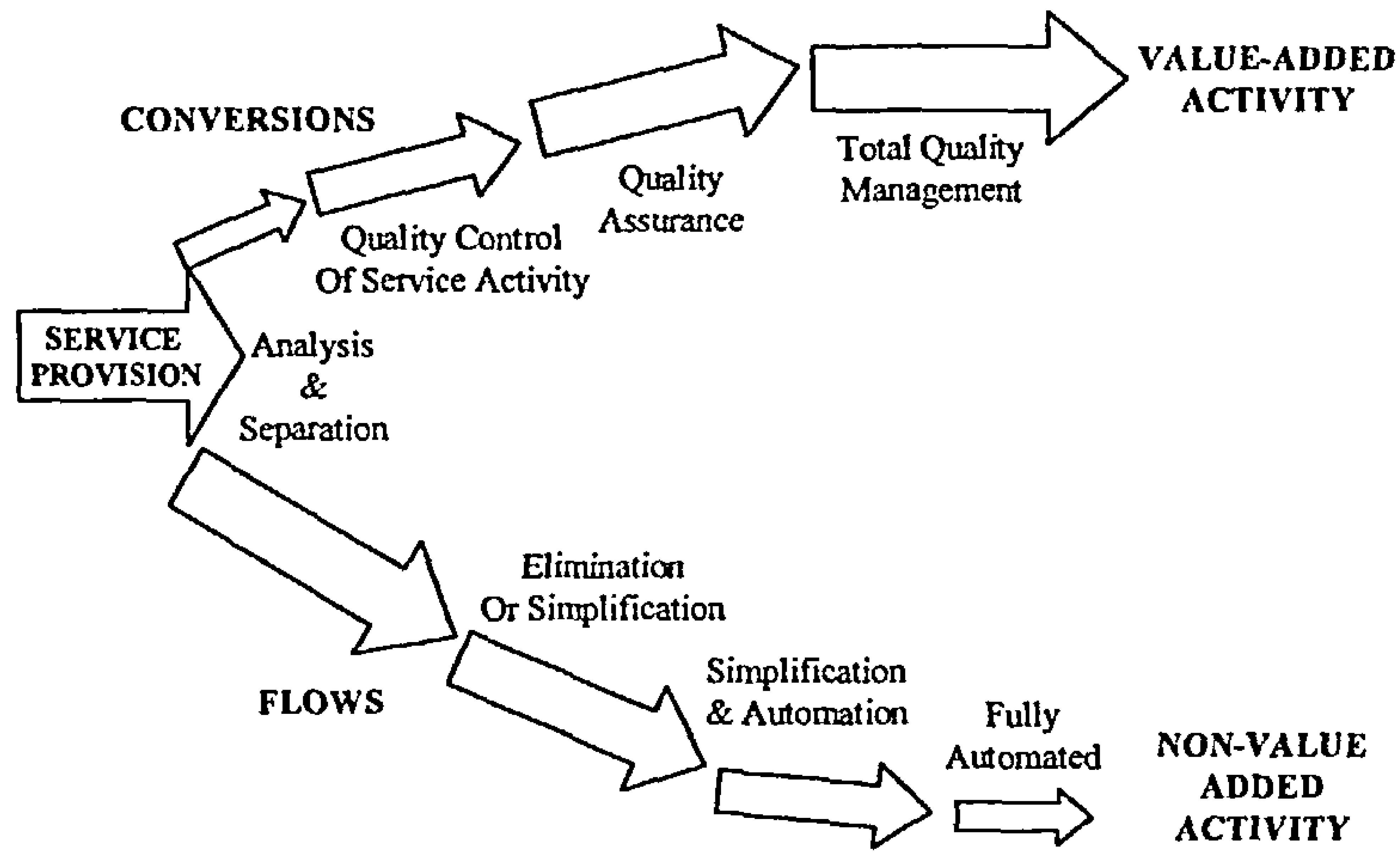


Productivity Improvement Technique	Increase Process Efficiency	PRELIMINARY STAGE	STAGE ONE Reduce cost of non-Conformance and Increase process efficiency	STAGE TWO	STAGE THREE Reduce or eliminate Non-value added Flow and increase Efficiency of value Added conversions

Figure 3.10 Lean Productivity Focus Schematic.
(Flow and Conversion Concept Modified from Koskela, 1992)

For the construction organisation, benefits can be achieved in all areas of the lean philosophy, (Eaton 1994g) namely:

Process transparency: the essence is that the process cycle should become more transparent. Each part of the process is analysed as either a flow or conversion activity. Having thus separated each activity it then becomes more obvious as to how the activity can be improved. The focus of control of the process moves from the manager to the staff, this reduction in power-distance indexing (Hofstede, 1980) creates cultural conditions under which the entire process is subject to review and examination rather than individual elements. In this way a balance of flow and conversion improvements can be attained, rather than a lop-sided concentration on conversion activity only.

For the construction organisation the depth and breadth of managerial hierarchy is reduced and consequently the entire process including all links has fewer elements for review. The process is thus more transparent. This greater degree of transparency enhances the possibility of other improvements.

Conversion improvements: incremental alterations to the conversion process to either reduce the variability of output, and therefore improve the quality of the typical product, or improve the effectiveness of the conversion process thus reducing the conversion cycle time and consequently improving productivity.

Flow improvements: by reducing the share of non-value adding activities as part of the whole process. This can be done by incremental improvements in the flow process to improve productivity or occasional process redesign which eliminates elements of the flow process therefore simplifying the entire process cycle by minimising the number of steps and linkages and thereby increasing productivity.

Added value improvements: by a systematic consideration of customer requirements. This is achieved by value chain analysis (Porter 1985) of the supply chain and close contact to regional markets as an 'insider'. Added value can, to a large degree, be that of satisfying individual perceptions. The construction organisation with its client base can attempt to improve individual client perceptions of performance.

Keiretsu created improvements: regional clustering of 'relational' contractors can establish the 'insider' thus avoiding regional cyclicality and product diversity. This avoidance of regional diversity allows the development of a focus strategy (Porter 1985) which can then establish a regional mass demand. The regional keiretsu can develop a sophisticated demand management system because of the cultural and environmental relationships between the parties. The 'local' construction organisation with local knowledge has a strategic asset (distinctive capability) that can be exploited. Relational networks operate by personal contact, it is easier for local contacts to be maintained.

This regionalising keiretsu can also prevent regional harvesting by a larger multi-regional or international firm because of the local integrity of the markets.

Kaizen improvement conditions: by incorporating incremental and continuous improvements into the process the staff have a lean productivity ethic inculcated.

This ethic creates the culture and conditions necessary for such incremental and process redesign. In the lean construction organisation, with fewer flow activities and more monadal conversion activities, the staff has proprietary responsibility for the entire process and thus the drive for improvement becomes workforce 'pushed' rather than management 'pulled'.

Output flexibility improvements: The improvements in both flow and conversion activities can increase total productivity but, perhaps more importantly, can allow the introduction of conversion activity options at various stages in the process that improves the overall responsiveness to output requirements and creates a rapid and flexible variety of provisions that can be suited to individual client needs. Rather than Henry Fords' "You can have any colour you want - so long as it's black!" you can have the Burger King " You Want It - You Got It!" Productivity and performance measures can thus become benchmarks rather than fundamental targets. They can become motivators rather than de-motivators. The lean construction organisation is inherently flexible and can therefore respond much quicker to changes in client demands.

An illustrative example.

Figure 3.11 illustrates the lean productivity approach for a typical quantity surveying service, the production of measured bills of quantities for competitive tendering purposes.

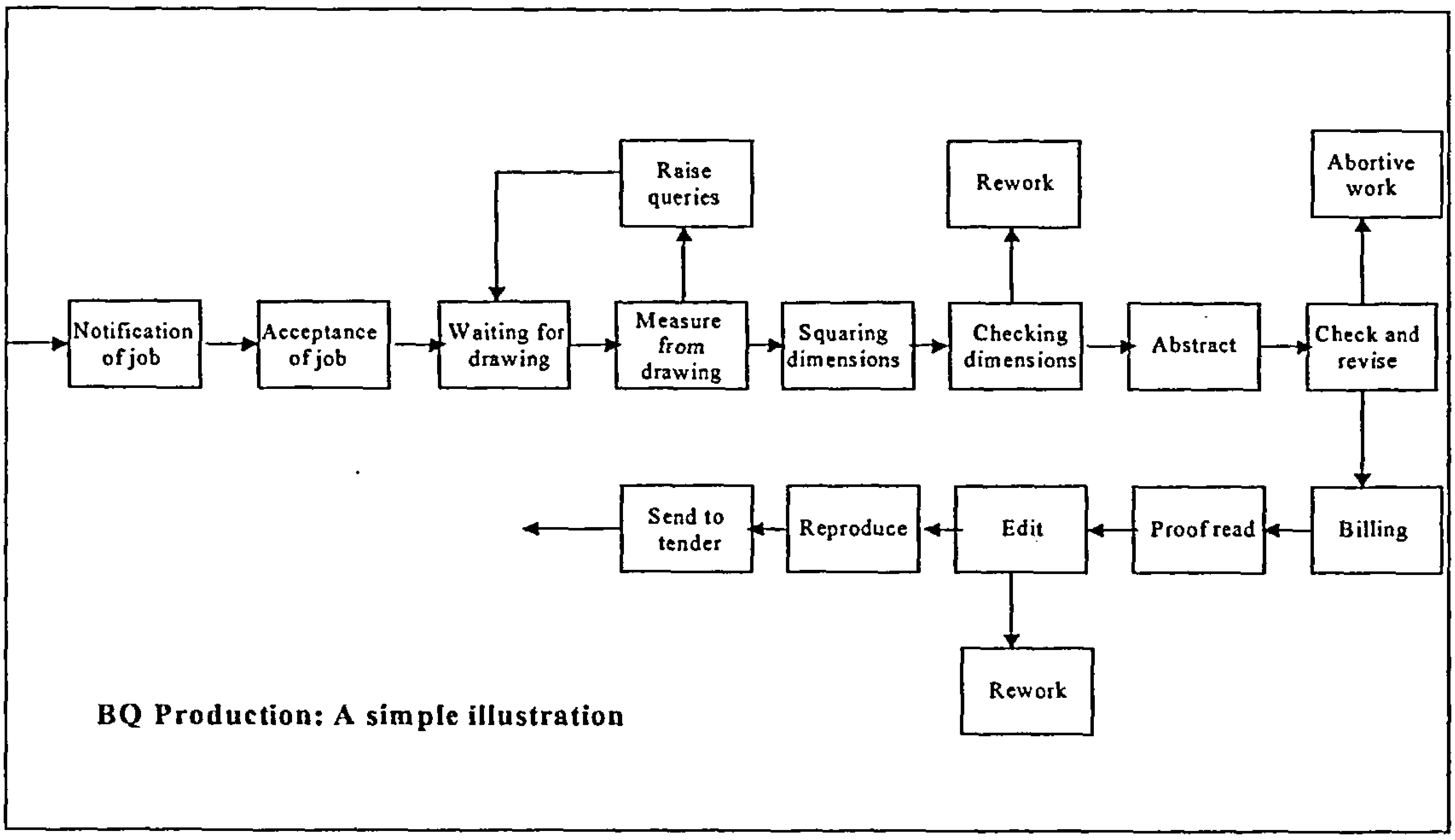
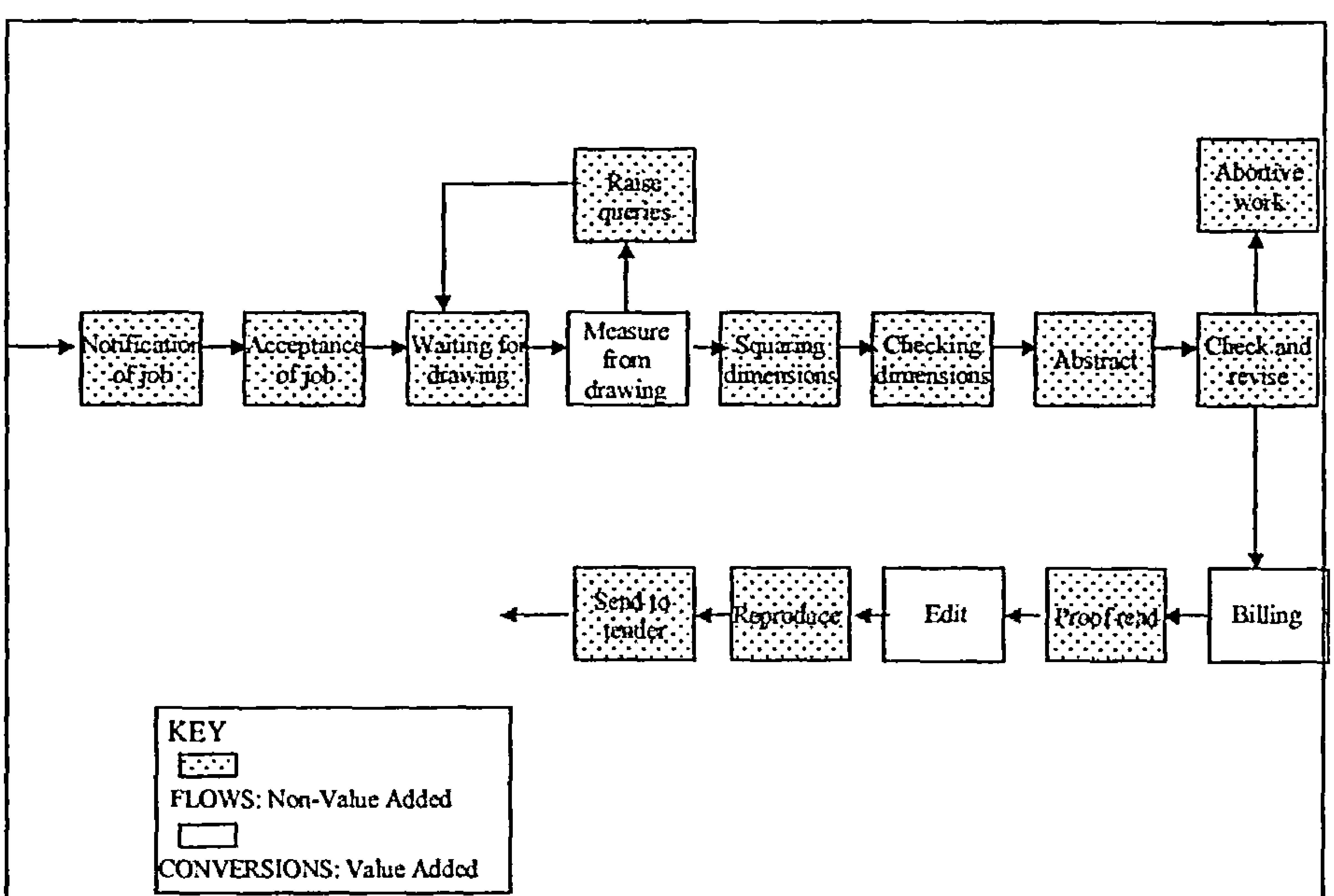
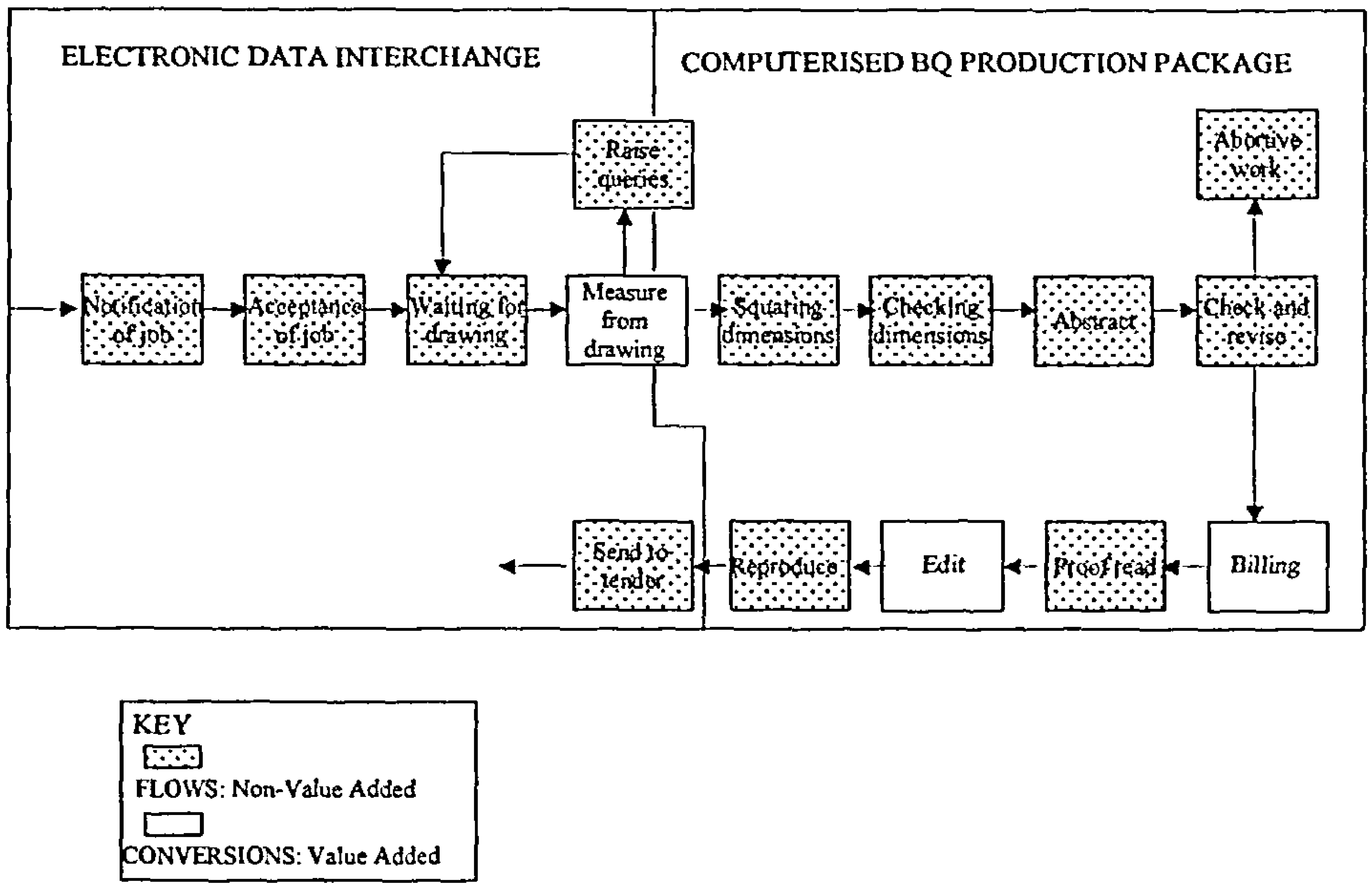


Figure 3.11 Lean Productivity Example.

Lean productivity results.

Figure 3.12 (a-c) illustrates schematically the potential productivity improvements that are possible by adopting the lean productivity philosophy in the analysis of service provision.





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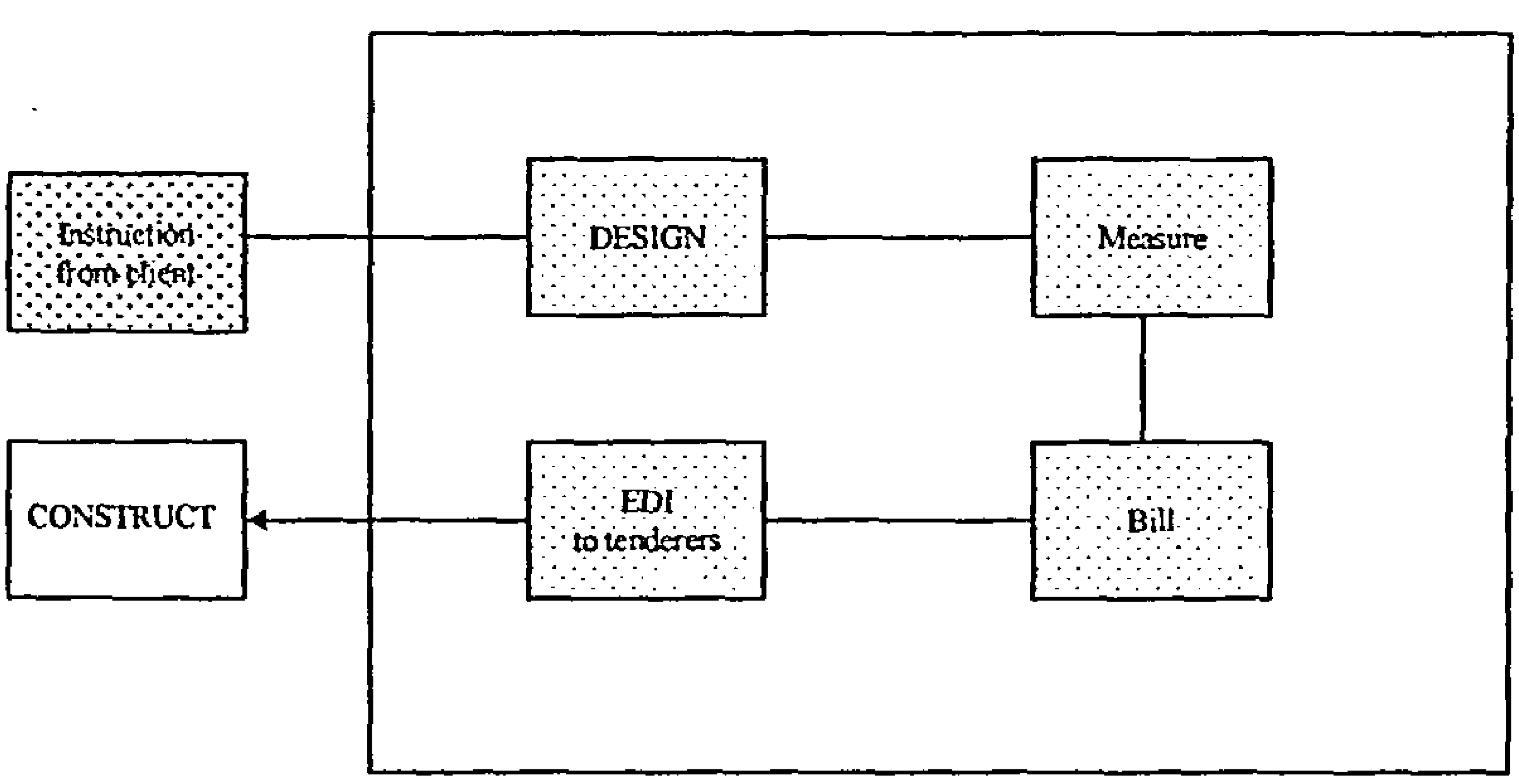

BQ Production: As a flow and conversion process: A simplistic illustration STAGE 3: Total quality management and fully automated.

Figure 3.12 Quantity Surveying Potential Productivity Improvements.

A strategy is therefore required to implement this system.

System level restructuring (an organisational monad) is accomplished via the four sub-systems of reflection, recruiting, rewarding and re-orientating.

Reflecting means providing the worker with a periodic opportunity to reflect on the possibilities for flow and conversion improvements. A specific allocation of time for debriefing after each project is an essential element of the lean productivity process. A time for reflection on what went well together with the problems incurred is necessary to provide feedback for future improvements. Senior management must make reflection and feedback the priority rather than rushing into the next project and repeating the same mistakes.

Recruiting of personnel is obviously a key factor. Personnel who are capable of identifying potential changes are obviously essential. This may entail training and further support. What is perhaps less obvious is that the manager of such lean productivity improvement schemes must also be selected carefully. Management becomes support to workers and not control of worker. The wrong managerial approach will lead to worker alienation and avoidance activities rather than improvement activities. Thus the managers of such a process must have the knowledge and recent experience of the workers activity. This presents a conflict with the approach of some firms in using the process as a training opportunity for junior managers or as a safe haven for otherwise redundant senior managers.

Rewarding is a crucial aspect of the lean productivity improvement process. The formal reward structure often acts as a disincentive. Why should the worker make suggestions for improvements if the entire benefit goes to the firm. The manager should also be rewarded for providing the type of management that evokes improvement from the workers.

Re-orientating the managerial structure so that managers face downwards within the hierarchy rather than the more typical upwards. Managers should expect their rewards to be generated by the performance attainment of those they supervise, rather than in recognition of the service that the manager provides to his immediate superior. A support relationship is necessary from the top downwards within the management hierarchy.

This leads to restructuring at the next hierarchical level, the hardest way to achieve lean productivity improvements. It is however, probably the most effective way. If the firm treats every managerial role as a coordinative requirement, therefore implying that it is a flow rather than a conversion, it can be examined to see if it can be eliminated completely. Such flows are costs. The managerial role is to coordinate the monads. For each monad the organisation should ask how independent can it be made of others? What is the minimum number of intra-monadal flows and what are the essential monadal connections of these flows? Coordination then only applies when it is justified by monadal requirements or supra-system coordinative requirements. The organisation which follows these principles, will be decentralised, flat and lean.

However, there are problems associated with lean productivity techniques that need to be addressed. The strategy implicit in lean productivity is that of extreme centralisation of policy and isolated decentralisation of service provision. This will require more talented production groups capable of managing themselves. This has inherent implications for management styles, systemisation of service provision and mobility of staff and management. Such implications need to be evaluated in the contingent anatomy model.

Methodological Review.

The concept of systems theory is to provide a framework for understanding and analysing organisations through their internal and external relationships (Checkland 1972). The approach is essentially a way of analysing a complex process, so that the inter-relationships of the parts and their influence upon the effectiveness of the total process can be better understood.

For any organisation this analysis is essential for the successful comprehension of awkward and or complicated problems.

Consider, for example, the complexities of the successful recruitment and retention of qualified and competent staff. What keeps them happy? What makes them leave, just when they are starting to become a vital cog within the organisation?

The particular needs of the individual have to be equated with the needs of the organisation. Seeking congruence is the key to the satisfactory resolution of the problem. Achieving such congruence may require the evaluation of salaries, future potential, ability, etc. of the employee and the structure and hierarchy of the organisation. The analysis and evaluation of such diverse factors and the resolution of a finite solution requires a methodology. This methodology or framework for solving problems is in essence systems theory.

> *"We need simultaneously to be precise enough to provide guidelines which can actually be used, and vague enough to remain problem oriented, avoiding distorting the problem into a particular structure just because we would know how to tackle it if it came to us in that form.*
>
> A methodology creates an explicit, ordered, non-random way of analysing an activity. As such it is independent of the content of the activity [process] and can be considered separately from the content."
>
> *Vickers (1981)*

The systems approach consequently emphasises the need to seek congruence between the organisation and its environment and amongst its various sub-systems.

Systems Theory: The Framework Definitions

SYSTEM: *"An organised, unitary whole composed of two or more identifiable interdependent parts, components or sub-systems and delineated by identifiable boundaries from its environmental supra-system."* (Kast FE and Rosenzweig JE (1988)).

ENVIRONMENTAL SUPRA-SYSTEM: The remaining parts of society with which the system is in interaction. Within the construction industry this will include clients, architects and other designers, quantity surveyors, legal organisations, political organisations, professional bodies, et al. within which and with whom they all must interact to provide a satisfactory service.

SUB-SYSTEM: A single identifiable part, component or element of a system which has clearly identifiable boundaries and which interconnects with other parts, components or elements of the system. For example, within a quantity surveying practice this could be the pre-contract or post-contract sections, or the qualified and unqualified staff etc.

CLOSED SYSTEM: An organised unitary whole which does not respond or adapt to events or occurrences in the environmental supra-system. Since it cannot adapt to such changes the system is therefore predictable.

OPEN SYSTEM: An organised unitary whole which may exchange information, energy or material with its environmental supra-system. It may respond or adapt to events or occurrences in the environmental supra-system. Since the open system may adapt to such changes the system is therefore unpredictable. Parson (1960)

The open and closed system definitions are in reality poles of a system scalar ranging in possibility from wholly open systems across a spectrum to wholly closed systems.

BOUNDARY: Establishes the domain of a system or sub-system. In closed systems these boundaries are typically rigid and impenetrable whilst in open systems these boundaries are flexible and permeable. Vickers (1981)

One possible set of sub-systems attached to systems theory have been identified [Hunt (1986)] as:

1) FORMAL SUB-SYSTEM

2) INFORMAL SUB-SYSTEM

3) INDIVIDUAL SUB-SYSTEM

4) TECHNICAL SUB-SYSTEM

The Hunt Sub-System Descriptions

The values and beliefs of the staff within an organisation about the way processes are conducted produce a group law or culture. It is this law that is used to identify the formal structure of the organisation.

In a simplistic model the organisational variables that can be categorised as forming part of the formal sub-system are the corporate mission, organisational policy, approved tasks, jobs, the formal hierarchy, information systems, resource procurement systems, the service distribution network, personnel procedures, et al. It can be seen that these variables are often the most structured elements of the organisation. These variables are the devices that are implemented to attain rational job processes.

These formal devices are codified to ensure that all operatives can attain the objective, of rational and consistent job processes.

However the formal sub-system is only a part of the overall organisation system.

Organisations that are evolving rapidly or indeed newly established organisations have not achieved the collective agreement of the values and beliefs and thus operate on an informal basis. The informal sub-system represents such new or changing values and beliefs before they can be absorbed into the formal laws of the organisation.

It can also represent those values and beliefs about day-to-day relationships that are not agreed by all members of an organisation but may be accepted by sub-groups or even individuals within the organisation. Such informal values and beliefs can have a significant impact on the operational success of the entire organisation.

The values collected together under the informal banner relate to unofficial relationships, peer group norms, and task and maintenance relationships outside the formal requirements of the hierarchy. Unlike the formal structure, the informal structure is very rarely a unified set of values. Instead it represents a collection of values and interpersonal links relating to a multiplicity of groups, sub-groups or individuals. Very rarely do these values become sufficiently adopted to be absorbed within the formal sub-system. They may vary with time, with the links that are necessary to achieve a job task etc.

Most of the time the values and beliefs of such informal sub-systems are erratic and relatively unpredictable. Yet it is through these informal links that problems are solved, new solutions to difficult issues are devised and innovation and creativity are encouraged. Once solutions are found informally they may be locked into the formal sub-system structure, thereby institutionalising the solution. Thus the informal sub-system can modify and amend the formal sub-system and vice-versa.

These informal sub-systems are less manageable than the formal but are equally observable. If observations identify conflicts or frictions then improvements may be possible.

Conformity with the formal sub-system must be monitored (by an ISO 9000 Quality Assurance System for example) and any divergence must be analysed and if necessary the formal sub-system must be altered to accommodate the new requirement as a part of the revised formal sub-system.

In the transformation process equipment such as telephones, computers etc and infrastructure such as accommodation are used in the execution of the job tasks within the organisation. Perceptions and beliefs about those physical influences are collectively referred to as the technical sub-system.

Technical sub-systems are generally used to increase efficiency or to provide the opportunity for people to operate effectively. The importance of the technical sub-system is in the effect that it has on the members of the organisation, the degree of influence the technical sub-system has on the method, rate and sequence of task performance.

The impact of the technical sub-system on the formal and informal sub-systems can be great. Indeed some research (Woodward (1965)) implies that the technical sub-system is the major influence on the structure of an organisation.

All of the previous three sub-systems affect and give effect to that of the individual performing job tasks within an organisation. The performance of the individual depends upon the interactions of the other three sub-systems with that of the individual sub-system. Frictions and conflicts within the other three sub-systems impinge on either the effectiveness or the efficiency of the role person or in extreme situations deny the role person the opportunity to undertake or complete the task.

Thus, the concept will be developed, to mitigate or eliminate frictions or conflicts as they are identified so that the role person has the opportunity to operate as effectively and efficiently as possible. The methodology adopted is to achieve sub-system, system and environmental congruence. The conclusions identify a system archetype to demonstrate the attainment of congruence.

Just as the internal organisational environment can be segmented for analytical purposes, so to can the task or function. Thus each task performed within the organisation also has a system and system boundaries. The task environment is segmented in an identical manner to that of the organisation. Thus each task has a formal, informal, technical and individual sub-system associated with its execution.

As in the organisational system, the task system requires the mitigation or elimination of frictions and conflicts within the sub-systems.

In a systems analysis it should now be apparent that any individual role person will have an organisational systems environment and also a task systems environment. Thus it is also possible that conflicts and frictions will arise between the organisational and task systems. These intra-system frictions and conflicts must also be mitigated to allow the role person to perform effectively and efficiently.

Systems Concepts

HOLISM: The sum effect of the combination of sub-systems operating as a unitary whole is greater than the sum of the sub-system parts (vis: systems synergy). Hence the characteristics of the system will differ qualitatively and quantitatively from those of the constituents.

NEGATIVE ENTROPY: A process by which an open system may arrest the natural tendency towards chaos and disorder and indeed achieve more complete organisation. This occurs because an open system can import resources and transform them to adapt to changes in the environmental supra-system. Hence internal elaboration, differentiation and specialisation can occur within an open system.

INTERNAL ELABORATION: The open system has the ability to import additional resources from the environment and uses these resources to adapt and create more sophisticated and specialised sub-sub-systems. This leads to the system creating a hierarchy of organisation. (Checkland (1981)).

DIFFERENTIATION: The open system has the ability to adapt any or all sub-systems to accommodate changes necessitated by environmental reactions. The division of tasks within a system creates segmentation of the system, that is, sub-systems, each of which tends to develop particular attributes in relation to requirements posed by its relevant environment. (Kast & Rosenzweig(1988)). This segmentation or differentiation occurs in two ways: horizontally - the separation being referred to as departmentalisation; vertically the separation being referred to as organisational hierarchy.

DYNAMIC EQUILIBRIUM: An open system has the ability to adapt to the environment. A prime objective of the system is to maintain conditions capable of continuing the organisations existence. It is achieved by maintaining a balance of inflow and output of materials, information and energy. This balance is continuously monitored and maintained and is referred to as dynamic equilibrium.

EQUIFINALITY: An open system can adapt. The quantity of each resource used by the organisation is determined internally; differing organisations requiring differing mixes of resources. If the ultimate objective is attained, then it may have been attained in differing ways using different quantities of resources. The attainment of the identical objective in different ways is referred to as equifinality. (Lawrence & Lorsch (1967)).

MULTIPLE GOALS: Systems may have any number of ultimate objectives. Such objectives are referred to as multiple goals, these may all be compatible, but certain goals may occur which are incompatible. These incompatibilities can be explained by consideration of system theory and in particular boundary friction.

BOUNDARY FRICTION: The mutual incompatibility of objectives of sub-systems as compared to other sub-systems, systems or environments.

FEEDBACK: In order to maintain a dynamic equilibrium an open system must act and react to information received from the environment. This feedback of information allows the system to adjust and adapt. The feedback can be either positive; suggesting that the system is compatible with the environment; or negative, which is more important; indicating that the system may be deviating from a position that is compatible with the environment.

Why A Systems Approach Is Adopted.

A systems approach is often adopted when a problem is being tackled that fails to allow analysis by purely quantitative methods. For example, if you wished to ascertain the average cost per month of running your car, you could do this by recording all costs over a year and dividing by 12. This would give you a reasonable approximation of your monthly costs.

However, in certain circumstances, this mathematical approach is difficult to complete. Consider, as an example, a request from the managing director of a company to provide an analysis of the quality of performance of a chartered quantity surveying practice. How can you quantify quality?

What inevitably happens is that a qualitative approach is adopted. The practice is compared to other quantity surveying organisations on the basis of a number of discrete implicit factors that affect quality, including inter alia, reliability, accuracy, cost, reputation etc. A subjective weighting is adopted and a conclusion drawn.

A systems approach allows the explicit identification of the discrete factors and the careful consideration of the total picture.

This systems approach allows complex problems to be accurately defined and broken down into manageable portions, so that a solution can be sought.

All organisations are complex socio-technical 'units' which are constrained and shaped by the inter-actions of the 'unit' and the environment and the inter-actions of the separate elements of the 'unit'. The organisation is thus a complex system, however, for any useful analysis, the organisation needs to be broken down into smaller parts, or 'sub-systems'.

The functions of the organisation are based upon human interpretation and analysis of data and idiosyncratic reactions to the data.

In using a systems approach it is likely that this methodology will eventually cease to be a major object of study and attention will then be concentrated wholly on the problem content.

Thus having developed a systems methodology for analysing the process and the organisation inter-actions it will then be possible to propose a diagnostic taxonomy for achieving the objectives of improving CAC.

It is essential at this point to recognise that the above is the ultimate objective but in reality this systems approach must be flexible enough to accept the reality of human fallibility.

A systems view of human error avoids such subjective questions as what is good quality? And directs attention to the practical problem of identifying and reducing the causes of error. A systems view of failures is that these errors are a result of an inappropriate interaction between people and other elements.

The systems approach consequently emphasises the need to seek congruence between the organisation and its environment and amongst its various sub-systems.

Congruence in terms of this systems model is the term adopted for making the needs of a sub-system the same as the needs of each and every other sub-system. It also requires that the needs of the organisational system are the same as the process system and that these in turn are matched to the needs of the environmental supra-system.

The fundamental relationships of the sub-systems will be shown in the next chapter which provides a preliminary pilot study of soft-systems analysis. The closer to the axis of the system each sub-system attains the greater the degree of congruence and thus the less conflict and friction there will be in the system as a whole.

The key to congruence is that it considers the two systems, namely, the organisational and the process, as two harmonic waves, proceeding in the same direction. The more simultaneous the harmonic wave structure, the more balance and harmony will be maintained in the wave and the more powerful the CAC will be. (As an example, a wheel, which is rolled straight, will role further than one, which is sent wobbling.)

To attain this simultaneity, both the environmental supra-system and the organisational system have to achieve congruence.

The common element in both the language and the structure is the linearity. The traditional approach is of sequential structure along single channel, linear lines. For example, when one reads a quality assurance manual or a quality job plan, the message is built up word-by-word, line-by-line. For improvements in any process the reader must receive multiple messages.

The complexity, balance and harmony of CAC requires perfection in simultaneous communication of the role persons harmonic wave. This is generally conveyed through the processes of feedback, whether orally given, written or through actions. This process is bound up in the principle of a non-linear process.

Thus in relation to the improvement of CAC the concept of congruence is that of matching needs, this therefore involves the reduction of system and sub-system friction and conflict.

Congruence of the systems framework is demonstrated in a pilot-study in Chapter 4. Before completing the system framework it is necessary to identify the themes and variables associated with CAC. The next section of the literature review identifies the systems and sub-system concepts.

THEMATIC REVIEW

The thematic review organises the core themes presented in the literature and structures them within the geometrical framework for a conceptual analysis of CAC.

The case for the a priori nature of the geometry must be established. Immanuel Kant forcefully supported Euclidean geometry. Kant showed that Euclidean geometry delivers synthetic a priori knowledge, and secondly that the meaning can only be grasped by intuition, since there is no way of deriving the truth from the meaning of the terms used to express them. Fichte, Hegel and Schopenhauer supported this philosophical argument. It happens that the factors of the CAC system that 'we' encounter can be quickly and usefully ordered in Euclidean terms.

Bertrand Russell also used this form of Euclidean geometry in establishing the four principles of proof. The idiosyncratic definitions of such proof as utilised within this phenomenological research are attached to Russell's principles, namely:

- Time: as exemplified by the temporal hierarchy and the identification of four epoch transitions;
- Causality: as identified by the linkages between the 'detail' and 'dynamic' features of the models;
- Space: as represented by the co-location of features within the 'detail' and 'dynamic' models;
- Identity: as represented by the 'labels' attached to the features of the models. The 'labels' are attached to representational averages.

The significance of this assumption is discussed in detail within the conclusions.

These principles have been adopted in the methodological evaluation of the causal network presented later.

It is now necessary to identify the factors of CAC as presented in the literature.

As previously stated every firm competing within the construction industry must have a strategy, whether implicit or explicit.

Michael Porter (Competitive Strategy, 1980) raised a series of questions that have proved important in the development of this thesis, namely:

- How can the firm be best positioned to compete in the long run?
- How will the industry evolve?
- What is driving competition in the industry?
- What actions are competitors likely to take?
- What is the best way to respond?

In his introduction (p. xviii) he presented a figure demonstrating the context within which competitive strategy is formulated:

- Company strengths and weaknesses;
- Personal values of the key implementers;
- Industry opportunities and threats;

- Broader societal expectations.

The figure was a classical SWOT (strengths, weaknesses, opportunities and threats) representation. It also demonstrated the Euclidean geometry.

Porter (Ibid p. 4) presented his classic 'diamond' structure entitled 'Forces Driving Industry Competition';

- Potential Entrants;

- Buyers;

- Substitutes;

- Suppliers.

This diamond structure and the competitive forces identified have been evolved and refined into the structures and details presented in the conclusion of this research.

Porter's Competitive Advantage (1985) and Competitive Advantage of Nations (1990) produced evidence of the complexity of competitive advantage. In particular, Competitive Advantage highlighted areas of endogenous detail that required examination, and Competitive Advantage of Nations produced evidence of exogenous detail that required examination. These elements have been examined in detail and are presented later in the thesis.

Male & Stocks' (1991) Competitive Advantage in Construction provided some detail of both exogenous and endogenous factors for examination.

In developing a temporal and causality scale to the sources of competitive advantage, many potential scales where considered. The scale that has been adopted is that utilised by Porter. The stages in the temporal development are:

- Factor;
- Investment;
- Innovation;
- Wealth.

The mapping framework will therefore represent the space and identity of the themes and variables.

The themes and variables expressed in the conclusions have been developed from disparate sources. It would not be possible to provide a comprehensive review of all the literature that has been used to source the development of the model structures. It is however important to recognise the developmental nature of the research and to this end a brief identification of the major source of a relevant factor is now presented.

Exogenous Factors: Exogenous factors are those supra-system themes and variables associated with industrial competition and not necessarily restricted to competition within the property and construction industry.

Michael Porter (1980,1985, 1990) identified the following competitive advantage factors: Rivalry, Demands, Factor Conditions, Supporting and Related Industries. He also detailed a sub-level of Market Structure: markets, industries, demand, supply, competitors, new entrants, clients, suppliers, substitutes.

Henderson(1989) and Ghemawat(1986) identified the following competitive advantage factor: Environmental Variables: and provided some detail of the sub-levels: Social, Legal, Economic, Environmental, Political, Technological components.

Henderson(1989), Ghemawet (1986), Ansoff (1984), Chandler (1990) and Drucker (1977) et al identified Competition between industries, businesses or between individuals as a significant feature of the development of competitive advantage. The absence of competition (as demonstrated in monopolistic industries) was a feature making a significant contribution to the lack of other competitive advantage sources

Henderson (1989) identified: market share and market boundaries, and differentiation as a factor in the development of competitive advantage.

Ghemawat (1986): identified Firm advantages: with a sub-level detail of size and scale, experience, scope, access, know-how, inputs, markets, and public policy.

Andrews (1980) and Christensen et al (1973): identified industry conditions as a determinant of competitive advantage.

Kay (1993) and Porter (1985) identified the elements of the Value Chain and the sub-levels of history, culture, strategy, management process, cost and factor endowment.

Kay (1993) identified the features of: Innovation variables: with the sub-level detail of: technological, organisational, product, process, market pull and technology push.

Stalk (1992) identified the significance of timescales in the development of competitive advantage.

Ohmae (1989) identified the factors of positioning and customers

Interface Variables: Interface variables are those variables that reside at the boundary between the organisation and its environment.

Kay (1993) identified the system components of Distinctive Capabilities and in particular the hierarchical elements of: Innovation, Architecture, Reputation, and Strategic Assets. Within the system Architecture he identified the sub-level components of: externalities, inequalities of information, strategic monopoly and natural monopoly. Within the system of Strategic Assets he identified the sub-level components of: geography, incumbency, economies of scale, sunk costs, brand, economies of scope and regulatory restrictions.

Exogenous-Societal: Exogenous-societal variables are those that reside with all economic endeavour and relate to all business activity.

Hofstede (1980) identified the system constraint of: Humanisation with sub-level elements of: Political, Institutional, Educational and Cultural.

Hamden-Turner & Trompenaars (1993) noted the concepts of Rules & Exceptions, Constructing & Deconstructing, Communities & Individuals, Internalising & Externalising, Sequential & Synchronous. They also noted the psychological elements of Achieved Status & Ascribed Status and Equality & Hierarchy.

Bartlett & Ghosal (1986) and Levitt (1983) noted: Location, Coordination, Integration and Configuration.

Ohmae (1988) identified: Access and Factor Conditions with a sub-level of macro economic variables: interest rates, currency values, natural resource and labour.

Endogenous: Endogenous variables reside within the particular organisation.

McFarlan (1984) identified Information Technology (IT) as a significant determinant of competitive advantage.

Wheelright & Hayes (1985) identified manufacturing capability as a determinant of competitive advantage.

Donaldson (1985) identified financial goals and financial management as a critical requirement of a competitive strategy.

Prahalad & Hamel (1985) identified the explication of the core competence of the organisation as a prime source of competitive advantage.

Behavioural Characteristics & Motivational Assumptions: The implicit behavioural characteristics of the organisation have been previously presented. It is necessary to consider the following questions in determining the themes of the thesis. What model of behaviour is implied? How consistent is this with individual behaviour at work? How consistent is this with individual behaviour needed to achieve CAC?

Pfeffer (1994) identified Competitive Advantage Through People as a significant concept.

Hunt (1986) presented a systems approach in the form of the Euclidean geometry with the concept of: Formal, Informal, Technical and Individual.

McGregor (1960) identified implicit beliefs that influence managers to adopt one strategy rather than another, namely Theory X (X=negative, " There is good reason to believe that the agent will not always act in the best interests of the principal" Pp 111), and Theory Y (Y=positive, in which it is anticipated that the agent will use 'best' endeavours in the interests of the principal) reinforcing a self-fulfilling prophecy (equivalent to expectation theory). He also identified Agency Theory, and transaction cost economics as important elements in the evaluation of competition.

Langford, Hancock, Fellows & Gale (1995) identified various issues related to human resources in construction. These have been incorporated into the

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nested within each other, the intention here being to represent the complex interrelationships around the core feature;

- Consistency: the models utilise features of CAC that are special or unique to a particular organisation, however the models represent these unique features as an average or universal 'label' within the explicit model. This contradiction is noted, yet in the field-testing it did not create any major difficulties. The consistency can be elicited from the way the organisational features are described in a normative manner;

- Specificity: a specific feature is given an 'average label' when it is a feature which has an identifiable content that is applicable to many organisations. Thus the CAC feature given the average label named 'physical resources' could equally apply to the Westmoorland slate, the Zantac drug constituents or any other physical resource that could create a source of competitive advantage;

- Temporality: the location of a CAC feature within a particular epoch is indicative of the average position of the feature in a linear time scale. The indication of a linear time scale does not suggest the unit of measurement within the time scale is consistent within each organisation. The literature review has been equivocal about organisational life spans; there is some evidence that organisational time span is linked to ethnic or cultural drivers. The 'dynamic' models whilst indicating epochs do not indicate durations or a particular time scale in years. The conclusions to the research do however suggest qualifications to the temporal placement of features within the linear timescale;

- Biological Gradient: the co-location of CAC features indicates a relationship between the features. The biological gradient is intended to be a measure of this relationship. This study has not attempted to evaluate the biological gradient of the dependency. The recommendations for future work as presented in the conclusions makes reference to a quantitative measure that could be adopted in the refinement and improvement of the models as presented;

- Plausibility: the phenomenological investigation attempts to present an improved understanding of the essential and invariant structure of CAC. Polkingholme,(1989,p46) in Creswell's Qualitative Inquiry and Research Design states, " The reader ...should come away with the feeling that "I understand better what it is like for someone to experience that";

- Coherence: the features of CAC have been transformed into clusters of meanings, which are transformed and tied together to make a general description of the experience of CAC, including a textural description of what CAC is and a structural description of how CAC is experienced. This is presented in the 'detail' and 'dynamic' models respectively;

- Experiment: following the 'detail' description of what CAC is, imaginative variation is used to seek all possible meanings and divergent perspectives of CAC. Variation in the frames of reference about the phenomenon are sought to allow experimentation with the modelling of the phenomenon. In this study intermediate models can be demonstrated by the changes between the conditions matrices field-tested in chapter 4 and the defined models as presented in the conclusions. The research does not present all of the intermediate stages as the concluding models are intended to be experimental and emergent;

- Analogy: a form of inductive research has been introduced that contrasts the a priori nature of the literature review with the a posteriori nature of the understandings of the interpretations presented in the conditions matrices. The conclusions posit tentative causal models of the phenomenon of CAC.

Within the models as presented in the conclusions these features can be evaluated by the prototypical testing of the models. Objections to the model structure can be evaluated and the model restructured as required to satisfy the objections.

The causal factors of CAC must be structured to present a consistent and coherent model that can be validated by experiment and analogy. The structure adopted follows the recommendations of Strauss & Corbin (1990), in the text, Basics of Qualitative Research: Grounded Theory Procedures and Techniques. Sage.

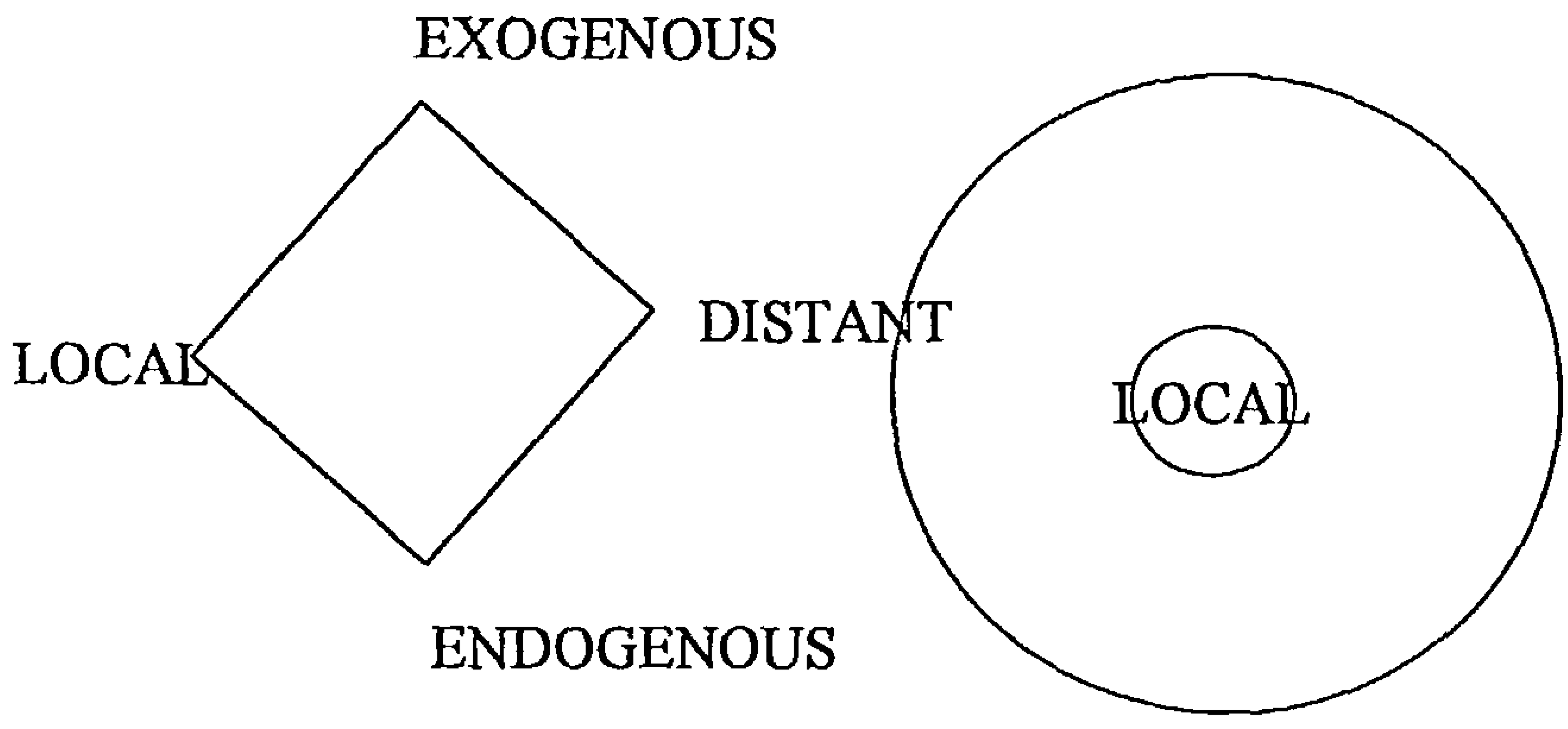
The following theoretical positional indicators are used throughout the analysis:

Local: a factor that presents influence close to its own position within the structural framework;

Distant: a factor that presents influence at some distance from its own position within the structural framework;

Exogenous: a factor that causes influence external to its own organisational system or sub-system;

Endogenous: a factor that causes influence internally to its system or sub-system.

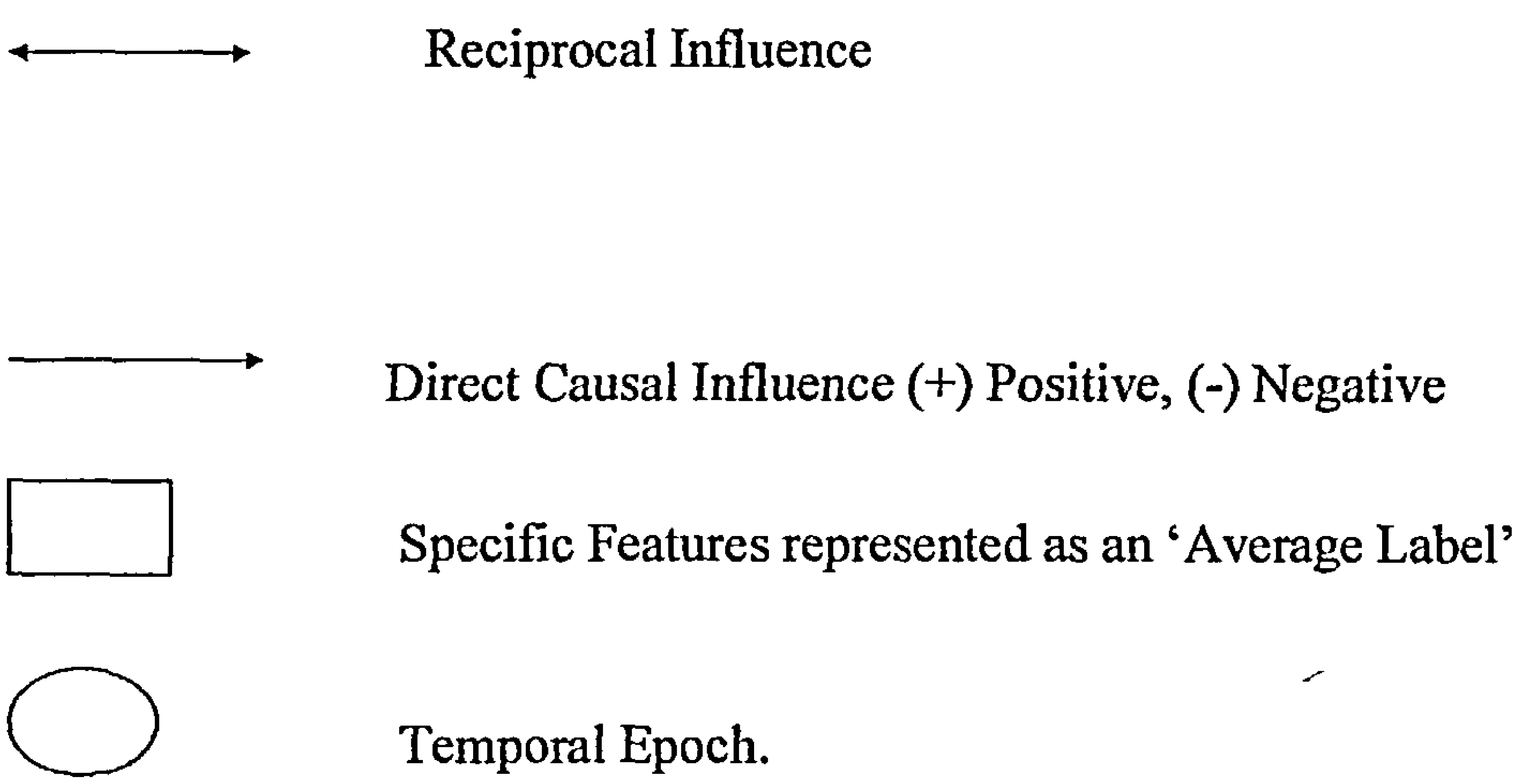


CAUSAL FACTOR STRUCTURE

Adapted from Strauss & Corbin (1990)

Fig. 3.13. Causal Factor Structure.

The causal network is represented by the following symbols:



CAUSAL NETWORK SYMBOLS.

Fig 3.14. Causal Network Symbols.

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- Check: the field-test provides some degree of verification of the validity of the models. Qualifications to the universal validity of the models are presented in the conclusions;

- Feedback: the field-test and subsequent published works have provided an opportunity for feedback. Reservations about the need for cybernetic feedback mechanisms and generative learning are presented within the conclusions.

The following features of the phenomenological contingent anatomy as represented by the causal network analysis will be presented in the conclusions: Action Orientation, Application, Auditability, Authenticity, Confirmability, Credibility, Dependability, Endogenous Validity, Exogenous Validity, Fittingness, Objectivity, Quality, Transferability, Utilisation.

The verification and validation of the phenomenological experience of CAC is largely a researcher-validated exercise. However in this instance the validation of the researchers clustering and imaginative variation is supported by a small-scale field test. This field-test is presented in the next chapter.

CHAPTER FOUR: THE MODEL OF CAC.

CHAPTER FOUR: THE MODEL OF CAC

A 'DETAIL' AND 'DYNAMIC' COMPETITIVE ADVANTAGE HIERARCHY WITHIN THE CONSTRUCTION INDUSTRY.

The CAC Hierarchy.

Researchers have identified various static-'detail' sources of competitive advantage. For example, Porter (1990) The Competitive Advantage of Nations, discusses the sources of competitive advantage associated with national and international economies. However, Pfeffer (1994) Competitive Advantage Through People, discusses the sources of competitive advantage associated with the performance of individual employees. Between these two extremes other researchers have identified various sources of competitive advantage. For example: Tayeb (1991) – cultural issues, Skitmore (1989)– competitors behaviour, Wade & Harris (1976) – local markets, Male & Stocks (1991) – project specific factors, De Neufville et al. (1977) – national economic factors, Morin & Clough (1977) – firm specific factors, Male & Stocks (1991) – industry structure factors.

These factors are complex, yet they are structurally static. They do not reveal the iterative and changing nature of the inter-relationships.. Therefore a key theoretical problem is the creation of an anchorage or foundation from which a practical and strategic rather than philosophical solution can be created. To allow any rational analysis of such factors, the disparate sources must be structured. The proposed structure is that of a hierarchy (Fig 4.1). These factors can then be utilised to explain the origin, character and strategy of the organisation in terms of the historical factor conditions that they inherit. The levels of the hierarchy have been given generic titles, it is not intended to provide definitions of these terms but the reader should easily appreciate them. A consistent feature of the previously published research was the difficulty of drawing adequate boundaries around the stated sources of competitive advantage. In the proposed hierarchy, this difficulty has been recognised by the creation of permeable boundaries between the levels of the hierarchy. Thus allowing the transfer of sources of competitive advantage between levels of the hierarchy. The proposed levels of the hierarchy reduce in complexity through the ascending levels. It therefore becomes easier to readily identify discrete sources of competitive advantage moving up the hierarchy. This also suggests that the permeability of the boundaries reduce in ascending levels of the hierarchy. It also follows that sources of competitive advantage at higher levels of the hierarchy can have greater significance than those lower in the hierarchy. A corollary of this is that the transferability of competitive advantage between levels also diminishes in ascending levels of the hierarchy. Thus defending a source of CAC from a rival at the industrial cluster level is more difficult than at the firm level. Therefore competitive advantage derived from the individual employee is vital to the firm.

Thus identification and definition of these levels has significance for the company. Levels 1-5 are external to the company, and increase in importance to the firm in the order of ascendancy. Thus the level nearest to the firm, level 5 The Market, is more important as a source of competitive advantage than level 3 The National Industry, there is published agreement to this assertion. (Porter 1984. Kay 1993.) However, levels 6-9 are internal to the company and increase in significance, moving further away from the focal point of the firm. Thus level 9 The Individual is more important as a source of competitive advantage than level 7 The Team. There is much less agreement to this assertion regarding internal significance. Pfeffer (1994) infers such a hierarchy without explicit identification of the levels. Therefore to appropriate competitive advantage, the firm must scan both up and down the hierarchy to identify such sources.

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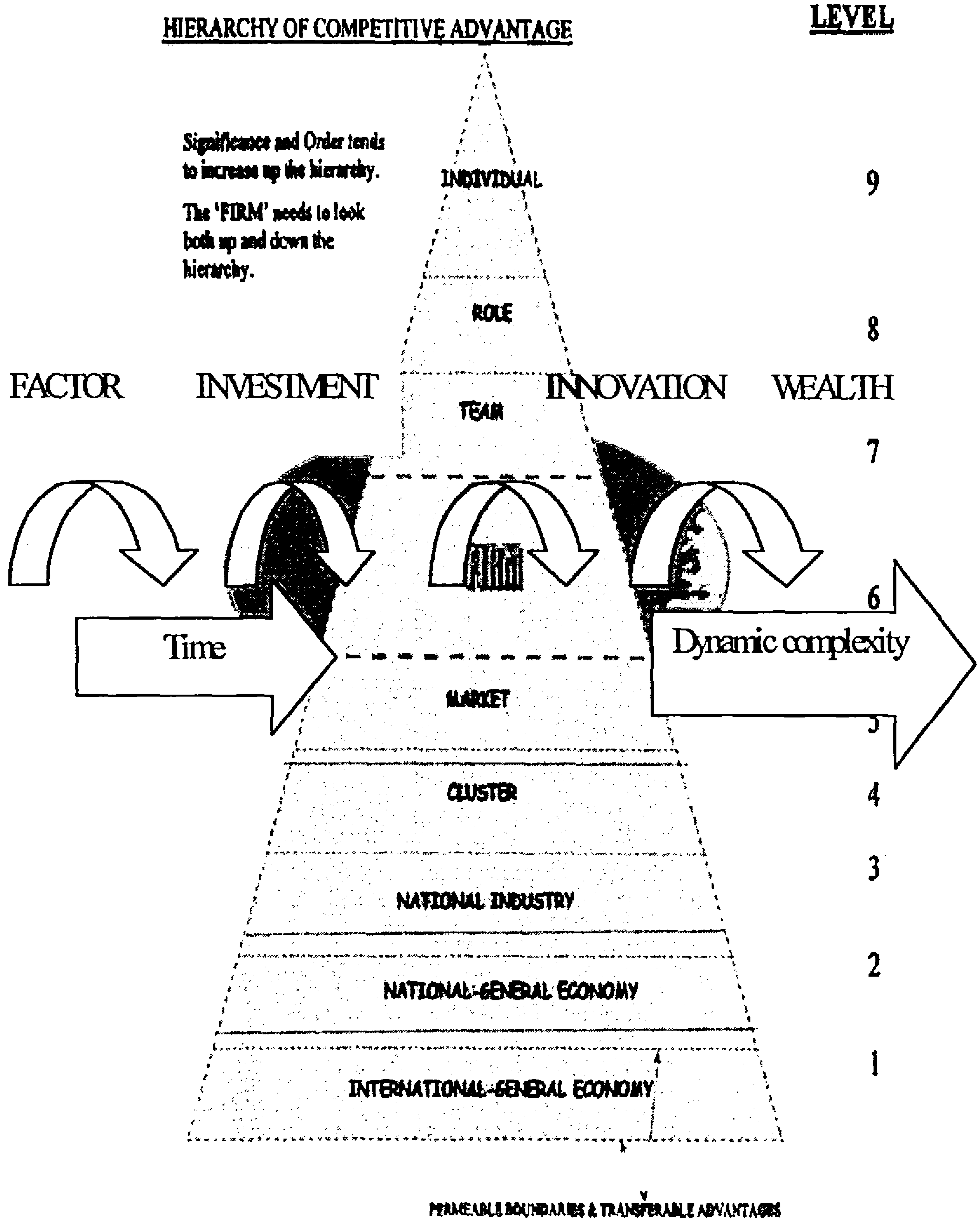
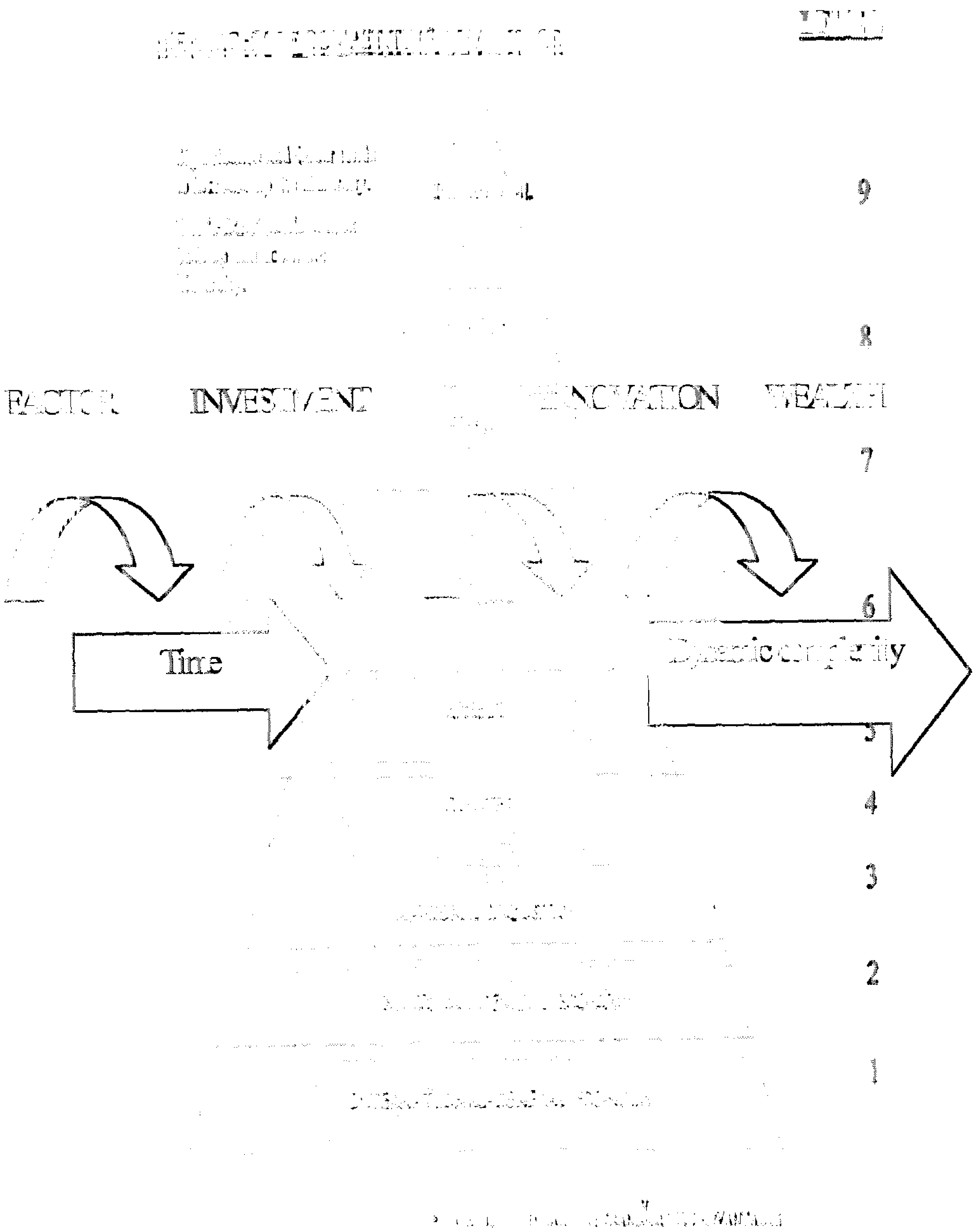


A HIERARCHY OF COMPETITIVE ADVANTAGE: FIGURE 1

THE TEMPORAL DEVELOPMENT OF CAC.

It is also necessary to recognise that the sources of CAC will dynamically alter through time. The quantum of such sources will also vary through time. It is therefore necessary to structure the sources of CAC in such a way as to indicate when they arise and when they cease to yield CAC.



HIERARCHY OF COMPETITIVE ADVANTAGE: FIGURE

THE TEMPORAL DEVELOPMENT OF CAC.

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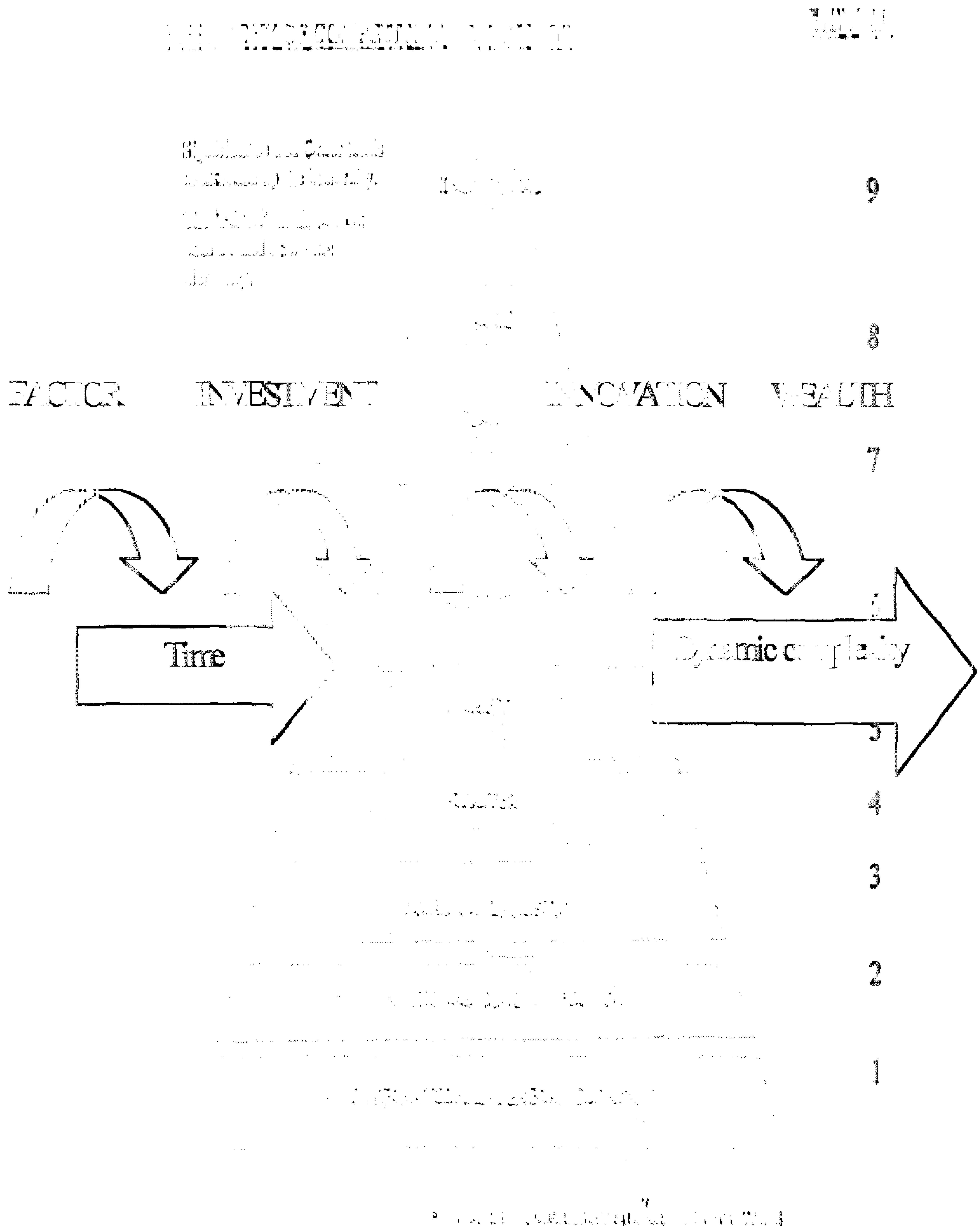


A HIERARCHY OF COMPETITIVE ADVANTAGE: FIGURE 1

THE TEMPORAL DEVELOPMENT OF CAC.

It is also necessary to recognise that the sources of CAC will dynamically alter through time. The quantum of such sources will also vary through time. It is therefore necessary to structure the sources of CAC in such a way as to indicate when they arise and when they cease to yield CAC.

At each stage there is found a material result: a sum of productive forces, an historically created relation of individuals to nature and to one another, which is handed down to each [epoch] from its predecessor; a mass of productive forces, capital funds and [factor] conditions, which on the one hand, is indeed modified by the new [epoch], but also on the other prescribes for it its conditions of life and gives it a definite development, a special character.

Karl Marx, The German Ideology,
(ed) CJ Arthur. London, 1974.p47.

The development of sources of CAC at each level within the hierarchy will require certain pre-conditions. For the purposes of this research a temporal stages model is adopted utilising work by *Porter, 1990, Competitive Advantage of Nations*. The earliest pre-conditions stage, necessary to develop CAC, is defined as the Factor Conditions Epoch. Subsequent pre-condition stages are Investment Conditions Epoch, Innovation Conditions Epoch and finally Wealth Conditions Epoch.

THE TEMPORAL HIERARCHY STAGES: FACTOR CONDITIONS EPOCH.

Factor Conditions are considered to be comparable to Cartesian economic factors of production. Typically these factors of production are classified as labour, material, plant, capital. They are however, too broadly grouped to allow useful differentiation in the consideration of CAC. Therefore, to understand the role of factors of production in CAC, it is necessary to discriminate among types of factors. A model (Fig.4.2) can best explain this discrimination.

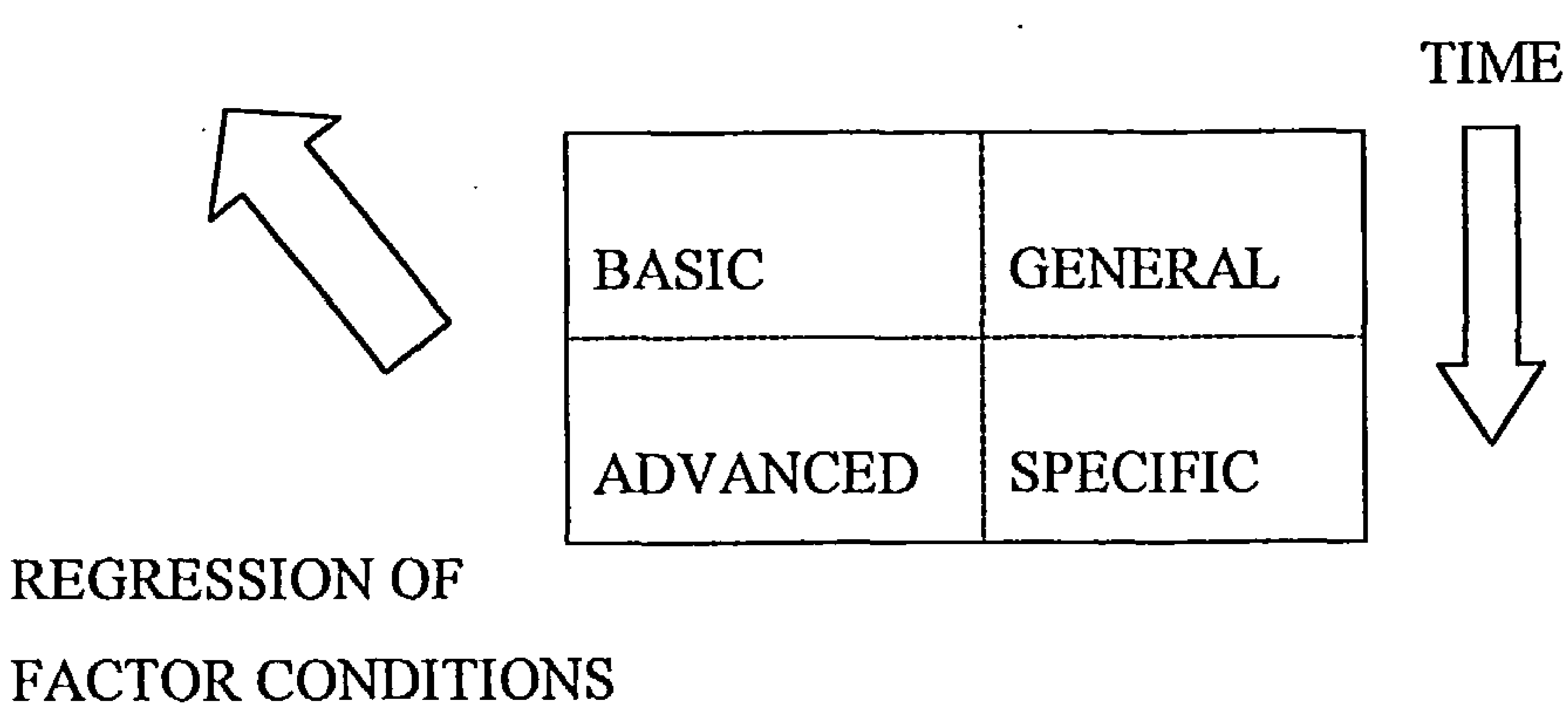
Basic Factor Conditions include, inter alia, natural resources, climate, location, unskilled and semi-skilled labour, and debt capital.
Generalised Factor Conditions include, inter alia, the quality of the infrastructure systems, the supply of well- trained and well-motivated personnel.
Specific Factor Conditions may include, inter alia, the availability of: specialised construction equipment; specialised construction personnel; specialist

and proprietary technical knowledge; high levels of customer care; response to client needs; client management systems.

Advanced Factor Conditions may include, inter alia, digital communications infrastructure, highly educated skilled personnel, access to sophisticated research, and professional control and regulation of these advanced factors.

Basic and General Factor Conditions independently may only contribute rudimentary sources of CAC. Nevertheless they can yield significant competitive advantage when combined in some way to create an Advanced or Specific Factor Condition. Specific and Advanced Factor Conditions can create more decisive and appropriable sources of CAC. It is not necessarily the existence of any particular factor condition that is required per se for CAC, but the possibility of factor condition combination to create equifinality in a particular activity. Thus the four factor condition elements inter-link to permit the creation of CAC. This is indicated by one of the diamond shaped structures in Figure 4.3 the Factor Conditions Matrix below. This mix of factors, (referred to as factor proportions) can vary enormously and still yield CAC. The most significant and sustainable CAC can be achieved (utilising only Factor Conditions) when the quality and availability of Factor Conditions leads to sufficient quantity and continued growth in those Factor Conditions.

The significance of the factor conditions will vary over time, the emphasis will move from basic to advanced factor conditions, and from general to specific factor conditions over time as indicated below in figure 4.2.



Factor Condition Trends. Figure 4. 2

The significance is most noticeable as the Factor Conditions begin to deteriorate. Factor Conditions will inevitably deteriorate over time. There are numerous comparisons that can be drawn from other industries, especially the UK coal-mining and shipbuilding industries. This is implicit in the definition of competitive advantage, presented earlier. Specifically the requirement to "...attain a sufficient and **sustainable** winning position..." This also demonstrates the dynamic nature of the Factor Conditions Epoch. The utility of a Factor Condition in creating and sustaining CAC must continually rise. Thus the rising factor standards of rivals contributes to the continual regression of a firms own Factor Condition CAC. For example, an Advanced Factor Condition CAC associated with the utilisation of computer software is negated if a rival has access to the same software. Indeed if the rival has access to superior software then not only is the CAC negated but the source of that CAC has effectively been appropriated by the rival. This illustrates two essential elements of the temporality of CAC Factor Conditions; the necessity for up-raising Factor Conditions standards; and that there will always be rising Factor Conditions specialisation. Current Specific Factor Conditions will over time become General Factor Conditions. For example, a source of CAC associated with the use of a bespoke CAD (computer-aided design) package regresses to a General Factor Condition source when off the shelf CAD packages are available to rivals. Perversely the lack of factor condition advantages can also lead to the formation of sources of CAC. The firm will strive to create missing factors or it can strive to adjust the factor condition hierarchy so that missing factors cede significance. This is demonstrated in figure 4. 3 by the structure with linkages between factor creation, factor endowment and factor hierarchy. These elements will inevitably force the firm to develop towards appropriating Investment Conditions sources of CAC and thus completing the geometry of the diamond structure.

FACTOR CONDITIONS MATRIX

Figure 4.3

INVESTMENT CONDITIONS EPOCH.

When CAC derived from factor conditions has ceased to yield a sustainable and acceptable level of profit for the firm, (or alternatively, rivals have progressed to appropriating CAC utilising Investment Condition stages of CAC) the firm must attempt to appropriate CAC at the Investment Conditions Epoch or it will concede CAC to competitor firms. This investment epoch is characterised by increasing demands for capital to support business developments. At this time the specific and advanced factor conditions are absorbed within the firm and technology and advanced methods are brought in-house. The firm seeking CAC starts to develop refinements to its products and processes. These refinements are often seen as a way of upgrading the provision of service or product provided. Elements of specialisation and segmentation arise, but the firm is still competing in relatively standardised markets and prospective purchasers are extremely price sensitive. At this point the firm seeking investment conditions CAC needs capable rivals to create truly competitive behaviour. The purchaser must become sufficiently informed to allow rational decision making to take place. The firm can no longer exist on erroneous decision making by the purchaser. (Eaton 1994). Markets and clusters start to develop international competitiveness. The indigenous national market no longer provides adequate profit potential and firms will seek to exploit international opportunities. These international opportunities are often successfully bid by utilising advanced and specialised factor conditions. This advantage is however unsustainable because of the ultimate deterioration of such factor conditions as previously described. The barriers to entry into the market are becoming higher. Economies of scale and scope start to have more significance in the competitive arena. Products are still relatively primitive, yet employment conditions bid up wages of the labour force (since a significant source of factor CAC resides with the individual, and the firm must respond to retain the work force) and rapidly increase factor costs. Primitive products and increasing factor costs causes a deterioration of factor condition advantage and as a consequence necessitates an appreciation of factor condition specialisation.

The economic time horizon of the CAC seeking firm must increase, long-term growth must be favoured over short-term profitability. This is essential as the quick-fix strategies have been exploited and what remains requires a longer implementation period. Economic accounting practices to assess viability should now allow longer pay back periods. Failure to modify the time horizon will lead to the inappropriate rejection of necessary strategies. Political and economic security is important, and access to political influence to counteract special interest lobbies is necessary. Market stability is sought. The Investment Conditions Matrix is shown in Figure 4.4.

INVESTMENT CONDITIONS MATRIX

Figure 4.4

INNOVATION CONDITIONS EPOCH.

As investment condition sources of CAC wane the organisation should up-grade these sources or move towards exploiting innovation sources of CAC. The inexorable deterioration of investment sources will eventually force an organisation seeking continued existence to move towards the appropriation of innovation sources of CAC.

An alternative approach is to harvest capital from investment sources of CAC and to degrade the business enterprise. This can only be a short-term strategy since the liquidation of these CAC sources will accelerate the degradation of these same sources. Eventually no CAC will remain and the organisation can have no realistic expectation of survival. To avoid such business failure the organisation must move towards appropriating CAC through innovation. Just as an organisation develops so too does consumer sophistication. This leads to demand changes within the market. The successful organisation must respond by creating a dynamic equilibrium between what it can supply and what the consumer requires. A good example of this innovation process is the motor industry. Henry Ford's Model T customers in the 1920's could have any colour they wanted as long as it was black! Consider the number of paint options that are now available from an industry that is now clearly in the innovation epoch.

The response time of the construction industry to changes in demand is such that the successful exploitation of innovation sources of CAC resides almost exclusively with the organisation that:

a) Anticipates changes in demand;

b) Promotes these changes in demand.

These changes in demand can be anticipated or promoted by endogenous organisational developments. For example the organisation can change its internal structure by creating specialist units and segmenting its business operations. This specialisation, segmentation and internal elaboration is a readily recognisable feature of organisational development over time. These developments create a mutually supportive environment. The improved ability to maintain dynamic equilibrium between demand and supply thus becomes a source of CAC. With internal specialisation, the organisation creates the opportunity to respond to demand sophistication from prospective clients. For example, a proprietary construction material manufacturer could develop to provide in-house design services. These 'free' design services create a source of CAC by committing a clients design team to the use of construction materials from the proprietary material manufacturer! Such specialisation and segmentation continues to develop and discrete business segments can become mutually supportive. For example, a professional practice offering project management services to a client could also offer quantity surveying services. Vertical integration through the value chain may occur. For example, a building surveying practice appointed to execute a condition survey could offer services as project managers for the repairs and renovation contracts and as facilities managers for the client.

Organisations will absorb technology developments in-house. The specialisation of tasks will lead to the development of specialist tools. A practice offering forensic diagnosis of post-construction defects would need to develop a forensic construction diagnostic tool-kit. It could then 'spin-off' a service to offer a pre-construction defect analysis service. This would utilise the same technological tool-kit. Organisations will enter niche markets with niche services. For example, a cost consultancy practice with a specialist motorway development group can offer a highways risk management service. This would utilise the in-house expertise.

The construction industry has a reputation for volatility. Frequent and rapid changes in demand can occur. However effective an organisations environmental scanning is, it will never be able to anticipate all of these changes in client demand. Some changes may be the result of exogenous factors beyond the scope of the construction industry. Typical examples would be a paradigm shift in Central Government policy. For example, the introduction of the recent planning directive, which virtually eliminated construction of new out-of-town-shopping developments in the UK. Thus the selective advanced and specific factor condition sources of CAC associated with out-of-town-shopping centre development are eliminated. Indeed they switch to become a disadvantage causing a radical re-alignment of the organisation. It is forced to up-grade any retained sources of CAC to maintain its existence. This up grading will inexorably lead to the development of new innovation sources of CAC. Failure to create these new sources will inevitably lead to the financial failure of that specialist unit.

Competitive advantage obtained through retained factor cost sources is rare at this stage. The reasons for this are related to standard economic theory and the temporal deterioration of factor conditions as explained above. A typical defensive response to the necessity of developing innovation sources is to promote the harvesting of investment sources in a widened market. Firms develop a global strategy for the maximum appropriation of CAC from factor and investment sources. This capitalisation of these sources is utilised to finance the necessary development of the new innovation sources of CAC. A further response from the organisation is to develop a resistance to the harmful consequences of macro economic and exogenous events. The organisation seeks immunity from such events. Specialist units seek contractual opportunities that offer security from adverse extraneous events. The risk-taking orientation of the organisation changes. Senior management becomes more risk-averse. Management attention is turned towards industry control rather than business unit control. Industry conduct is regulated by institutional directive. Senior figures within an organisation accept institutional and regulatory roles within the industry. Government intervention tends to increase at this point. The major organisations have succeeded in establishing a major presence in the construction industry. Quasi-monopolistic economic behaviour is exhibited and Government seeks prevention of un-competitive behaviour through regulation. Prominent individuals within these major organisations seek to obtain a role in influencing Central Government activity. Signals and industrial directives are derived from this industrial advice. Thus the emphasis has changed from creating innovatory sources of CAC to sustaining existing sources of CAC. The major organisations at this point move towards wealth sources of CAC. The Innovation Conditions Matrix is shown in Figure 4.5

INNOVATION CONDITIONS MATRIX

Figure 4.5

WEALTH CONDITIONS EPOCH.

At this point in the temporal hierarchy those few firms that reach this stage, change orientation once again. The firm seeks to create wealth sources of CAC. Organisational orientation changes from product and process innovation to management and stewardship of cash flow. The firm wants to protect its present position, including the generation of profit levels. The risk orientation of the firms' management becomes more risk averse. The financial benchmarks against which new ventures are judged tend to rise, since many internal business units are competing for the same investment capital. A firm at this stage exhibits many features that can be evidenced in other industries. Most significant is that the firm generates a large excess of cash. Acquisition of other companies rather than the development of internal sources of CAC is frequently used to achieve business expansion. There is evidence of diminishing rivalry, some previously competitive rivals have failed to attain sufficient CAC from innovation sources to challenge effectively, others have ceased to exist either through failure or merger and acquisition. A wealth source of CAC is derived from previous cumulative investment; other firms find the cost of entry into the market prohibitive. Yet consumer demand continues to become more sophisticated and advanced. The CAC derived from environmental supra-system scanning creates early mover advantage for the firm. They have access to liquid assets that can be utilised with little delay. Any remaining CAC from retained factor conditions is likely to be due to the firms factor endowment. For example, the sources of construction aggregate reside within the business portfolio of a small number of companies. The scarcity of these sources means that other firms will struggle to replicate CAC derived from the control of aggregate supply. Significant anti-competitive behaviour will be controlled by Government policy.

Competing demands from business units within the firm leads to under investment in some business units. These units then need to compete via price, rather than sophisticated and differentiated product. This reinforces the lack of investment and as a consequence failure to meet demanding profit targets leads eventually to de-clustering and retrenchment. In a 'wealthy' firm the most significant sources of CAC rest with the employee. These employees try to appropriate additional pay. As a consequence labour relations tend to harden as management try to preserve the previous profit margins. Prominent individuals within these major organisations use political roles to influence Central Government activity. Signals and industrial directives are derived from this industrial advice. Thus the emphasis has changed from creating new and additional sources of CAC to sustaining and protecting existing sources of CAC. The major organisations at this point move to exploiting and harvesting wealth sources of CAC. The Wealth Conditions Matrix is shown in Figure 4.6

WEALTH CONDITIONS MATRIX

Figure 4.6

A future planned refinement of the mapping process is to code the condition matrices to match the CAC hierarchy of Figure 4.1. In this way the condition matrix would also identify the location of the source of CAC. For example, a factor condition relating to the cost of borrowing capital could be identified as a level 2, national economy factor. A factor condition relating to the quality of human resources would be a level 9 individual factor. The transferability of advantages between levels and the permeability of the boundaries could then be expressed in the matrices.

Figure 4.7 presents a simplified composite model of the dynamic temporal hierarchy of competitive advantage within the UK construction industry.

The temporal hierarchy as presented is a management tool that can be used to map current sources of CAC within a construction organisation. At this stage, with the limited testing conducted to date, the results from the organisational mapping appear to correlate with anticipated results. More importantly it can be proactively used to identify potential sources of CAC for development and to plot a development strategy. It could also be used to explicitly deteriorate the CAC from a source in a measured and planned manner. This would enable the organisational manager to position the organisation at a point in the temporal hierarchy that matched consumer demand. It would also allow the manager to define and appropriate more of the rewards from its business activity in an industry that has very marginal rates of return. This could help to develop the economic prosperity of the construction industry as a whole.

The significance of the level of a source of CAC has been discussed. Frequently the construction industry experiences unexpected 'side-effects' from improvement initiatives. When an action has one set of consequences locally and a very different set of consequences in another level of the system, this is an indication of the dynamic complexity. When obvious interventions produce non-obvious consequences this also indicates dynamic complexity. There is dynamic complexity in construction activity. It takes months to design a project, many weeks to obtain approval to construct, months to hire and train people to build the project, and years to develop new products, nurture management talent, and build a good reputation. And all of these processes interact continually. The real CAC leverage in most construction management situations lies in understanding dynamic complexity, not 'detail' complexity. The model as presented should aid the identification of level interactions and allow explicit consideration of the consequences at each level in the system.

A deterministic system such as the construction industry can produce much more than just periodic [sic: epoch type] behaviour. A complex system can give rise to turbulence and coherence at the same time. There are classical models where everything is determined by initial conditions, and then there are quantum mechanical models where things are determined but you have to contend with a limit on how much initial information you can gather. Einstein's Theory of Relativity eliminated the Newtonian illusion of absolute space and time;

EPOCH TRANSITIONS SIMPLIFIED MODEL. Fig.4.7

Heisenburg's Quantum Theory eliminated the Newtonian dream of a controllable measurement process; and Chaos Theory eliminated the LaPlacian fantasy of deterministic predictability. This model can eliminate the unintended consequences of system interventions.

Coherence is the evolution of consistent shape in space and the evolution of shape in time. Coherence has been demonstrated by the dynamic epochs of figures 4.3 – 4.7. The initial testing of the representativeness of the dynamic epochs produced only one minor amendment to the factor conditions matrix (Eaton (unabridged version) September 1999). Further testing demonstrated that the representativeness of the dynamic model is acceptable for all sectors of the construction industry.

The conceptual patterns of CAC are demonstrated by the scaling structures- how big details relate to little details, complicated structures in which the complexity has come about by a persistent process. It's certainly not how a human being perceives these things, and it's not how an artist perceives them. It does however provide a method for modelling 'dynamic' and 'detail' complexity. The scaling structures have a philosophical and methodological pedigree identified in previous research. The scaling structure archetype adopted in presenting the research is the four-sided polygon. This aids the identification of interrelationships rather than linear cause-effect chains.

This highlights the processes of change rather than a single snapshot at a particular point in time. The reason that structural explanations are so important is that only they address the underlying causes of behaviour at a level where patterns of behaviour can be changed. Structure produces behaviour, and changing underlying structures can produce different patterns of behaviour (Eaton & Baldry 1999). Systematic structural solutions are inherently generative. Generative learning cannot be sustained in an organisation where 'detail' thinking, and therefore adaptive learning is the sole or predominant viewpoint.

CHAPTER 5 THE A PRIORI OF CAC

CHAPTER FIVE: THE 'A PRIORI' OF CAC

Testing the Model.

The temporal stage matrices have been presented in Chapter 4. These have been derived from literature review and deductive and inductive reasoning. Whilst not strictly necessary as a part of the phenomenological process a field-test of the validity would provide additional support to the model features. Therefore a limited field test of the temporal hierarchy was conducted.

Three case studies were conducted. The organisations were selected on the basis of personal links with the firm and previous experience of the organisations preparedness to assist in developmental work of this nature. Anonymity was assured to all collaborators. In some instances the standardised descriptive data was inclined to allow easy identification of the organisation. To allay any worries this sensitive data has been replaced by a blank data set, represented by X.

Case study A is of a small professional practice. It has three chartered surveyors and three technical / administrative staff. It has one office location. It has been established for approximately six years at the time of interview. This organisation was selected because it seemed to represent an 'early' form of organisational temporal development. This organisation would be expected to achieve its sources of CAC from factor conditions.

During an informal interview with the sole partner the business process was discussed and the possible CAC factors where identified. The only factors identified where on the factor conditions matrix. The identified CAC factors are shown in figure 5.1. A revision to the model was required in the technology usage factor and the causal links that have been added are identified. As expected the mapping firmly locates this organisation in the factor conditions epoch.

CASE STUDY A

Figure 5.1

Case study B is of a large multi-disciplinary surveying practice. It has X chartered surveyors and X technical / administrative staff. It has X office locations, including X international offices. It had been established for approximately 50 years. This organisation was selected because it demonstrated a complex organisational structure and seemed to indicate a 'later' form of temporal development. From previous knowledge of the organisation it would be expected to demonstrate features of organisational innovation.

The informal interview process was repeated (with an equity partner) and the sources of CAC mapped. In this case factor, investment, innovation and wealth conditions where identified. The identified CAC factors are shown in figures 5.2a.-d. The mapping appears to indicate that this firm is at the interface between the investment and innovation epoch. However, the occurrence of wealth factors indicates that the organisation strategy may not be in congruence with the organisational structure. This issue will be considered in the conclusions.

CASE STUDY B

Figure 5.2a

CASE STUDY B

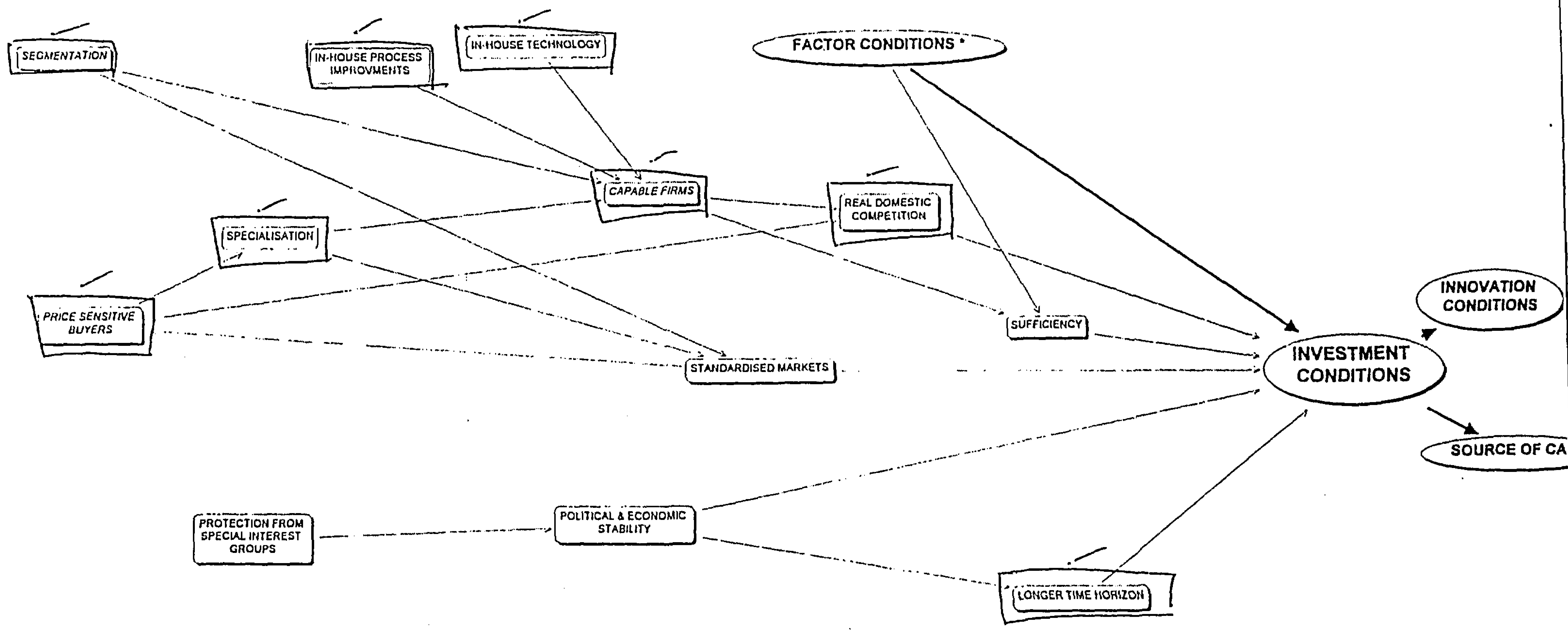


Figure 5.2 b

CASE STUDY B

Figure 5.2 C

CASE STUDY B

Figure 5.2d

Case study C is of an international construction conglomerate. In this case study the organisation was selected because of its prominence within the construction industry. It would be expected to demonstrate a 'senior statesman' position and be situated within the Wealth Conditions Matrix. The sources of CAC where mapped from the company annual reports and an informal interview with a regional surveyor. The organisation detail has been omitted. In this case study a few factor conditions where identified, together with significant numbers of investment and innovation conditions. However all wealth conditions identified in the matrix where identified. The mapping indicates that the organisation is firmly located in the wealth epoch yet retains a significant number of CAC advantages from earlier era. The identified sources of CAC are shown in figure 5.3 a-d.

CASE STUDY C

Figure5.3a

CASE STUDY C

Figure 5.3 b

CASE STUDY C

Figure 5.3d

The case studies tentatively indicate the representativeness of the temporal models to the identification of sources of CAC. The CAC hierarchy and the condition matrices can explain the historical development of the construction organisation. It can identify the:

> ... *Material result..., which is handed, down to each [epoch] from its predecessor; ... prescribes for it its conditions of life and gives it a definite development, a special character.*
>
> (Marx. ibid.)

Having concluded a satisfactory (although limited) field-test of the identification of the phenomenological epoch it is now necessary to conduct the phenomenological reduction and imaginative variation to allow the synthesis of meaning and essence of the contingent anatomy of competitive advantage within the construction industry.

CHAPTER SIX: CONCLUSIONS

CHAPTER SIX: CONCLUSIONS.

A Phenomenologically Based Contingent Anatomy Of Competitive Advantage Within The Construction Industry

The aim of the study was to present a foundation theory of CAC as it happens to be, not as it should be.

The alternative methodologies described in Chapter Two have been evaluated and compared to the philosophical arguments to the research:

- **Abstraction**: the study required the development of conceptual patterns, connections and chronologies, generating the generalities from the specific.

- **Ultimacy**: the study required the development of rational explanations, reasons and causes. A break in the chain 'un-grounds' it.

- **Truth**: if the study could identify that there is a first cause of CAC then this would be of fundamental importance. If not, a foundation theory of competitive advantage in construction would enhance the future analysis of CAC.

In the determination of the appropriate methodology a quotation from the philosopher Michel Foucault was significant.

> *"The 'truth' of an epoch has no authority outside the power-structure that endorses it."*
>
> (Michel Foucault 1966)

Phenomenology, however, relates to the appearance to consciousness and satisfies the rationale of the research question. Namely: how do people in the construction industry perceive and describe their experience of competitive advantage within the construction industry.

Therefore a phenomenological approach appeared to satisfy the research question and the philosophical arguments necessary to substantiate the conclusions.

Therefore the adopted approach, namely phenomenology, was to study all aspects of CAC as it appears. Therefore acknowledging that CAC will have an intentional content directed towards a goal. This goal is the improvement of the CAC that will enable a firm to attain a sufficient and sustainable winning position in the market with respect to major competitors and realising the firms' own corporate mission statement.

The methodological process as defined by Moustakis (1990) pp95, provided a structured analysis of the phenomenological methodology.

1. **Identification of the epoch.** The point in time when the phenomenon begins.

2. **Phenomenological reduction.** Creating the structures of time, space, materials, causality and relationships. In this study the reduction involved the creation of geometric models of the features of CAC. Reduction involved the bracketing, horizonalizing, reducing, clustering and organising of the features of the geometric models of CAC.

3. **Imaginative Variation.** The systematisation of themes and contexts, universal structures and exemplars. This involved the creation of frames of reference, polarities and reversals, divergence, differences of positions, differences of roles, differences of functions etc.

4. **Synthesis of Meanings and Essences.** Evolving the conclusions to the study.

This structure has been addressed and the research objectives have been met.

The objectives of the research as stated in Chapter Two were:

a. To identify the variables and conceptual patterns of CAC utilising a generalised systems model;
b. To build a mapping framework;
c. To identify the process, chronologies and connections showing temporal development and hierarchy;
d. To bring order to the individual experience of CAC by generating reliable and rich pictures of potential strategy options;
e. To show that this is a rational reflection.

<u>Original Contribution Of This Study.</u>

This study differentiates between static 'detail' sources of CAC and temporal 'dynamic' sources of CAC. The distinction is important in terms of utilising the study for any improvement in the appropriation of CAC for a particular organisation.

The static 'detail' models of CAC present an explanation of the appropriation of CAC by passive reactive management. Such static sources of CAC are more readily replicable within other competing organisations and hence yield only minimal sources of sustainable CAC.

The temporal 'dynamic' models of CAC present an explanation of the appropriation of CAC by proactive and generative learning. Such dynamic sources of CAC are less readily replicated within other competing organisations and hence can yield more significant sources of sustainable CAC.

This study identifies the temporal 'dynamic' sources of CAC as being regressive. That is, they deteriorate over time and transform from advanced specific variables to basic and general variables. This regression of factors explains the necessity for CAC to be "sufficient and sustainable" and explains why the dynamic variables change through the life span of an organisation.

The models have the potential to be utilised within an organisation as a framework to map existing sources of 'detail' and 'dynamic' CAC. They can also, and more importantly, be utilised within an organisation to identify potential CAC sources that completes a system archetype equilibrium.

The models presented are an industry 'average' representation and a key feature of this study is the identification of 'temporal attractors' identifying definable epochs during which the organisations change gradually before a systemic 'push' causes an aperiodic dynamic complex epoch transition. Such epoch transitions are explained within the study and the concept of 'intransitive chaos' explains why some organisational transformations fail to succeed. The mapping of CAC sources could assist in identifying when such an epoch transition is being approached and hence allow an organisation's management to plan for the intransitive chaos that such a transition incurs.

Further and detailed conclusions are presented below. They are structured to identify the particular research objective.

The conclusions will now address the research objectives.

To Identify The Variables And Conceptual Patterns Of CAC Utilising A Generalised Systems Model.

Blake (1899) wrote, " to see the world in a grain of sand". Leibniz (1714: Monadology) imagined that a drop of water contained a whole teeming universe, containing, in turn, water drops and new universes within.

This study necessitated the development of macro-scales and micro-scales, layers of consistent detail feeding both up and down a hierarchy, leading to the identification of sources of Competitive Advantage in Construction (CAC).

The idea of consistency on new scales may at first seem to provide less information. In part, that is because a major trend in science has been toward reductionism. Newtonian scientists break things apart and look at them one at a time. This is a fundamental presumption in physics, the way you understand the world is that you keep isolating its ingredients until you understand the stuff that you think is truly fundamental. Then you presume that the other things you don't understand are details.

This research has adopted a different philosophical approach, a matter of looking at the whole. A holistic view advocated by Goethe, von Schelling, Bradley, et.al.

The 'detail' hierarchy, presented as Figure 6.1 was developed from numerous sources identified in the temporal hierarchy paper (Eaton 1999). These sources created the nine layers to the hierarchy. These layers are also the micro-scales of the CAC macro-structure. This represents the 'detail' complexity of the model. The 'detail' complexity model identifies and absorbs many variables and these variables may be expressed as a multi-attribute function. (Eaton 1994 Risk and Uncertainty paper)

The dynamic complexity is reflected in the changes in CAC through time. It is therefore necessary to structure the sources of CAC in such a way as to indicate when they arise and when they cease to yield CAC.

> *At each stage there is found a material result: a sum of productive forces, an historically created relation of individuals to nature and to one another, which is handed down to each [epoch] from its predecessor; a mass of productive forces, capital funds and [factor] conditions, which on the one hand, is indeed modified by the new [epoch], but also on the other prescribes for it its conditions of life and gives it a definite development, a special character.*
>
> Karl Marx, The German Ideology,
> (Ed) CJ Arthur. London, 1974.p47.

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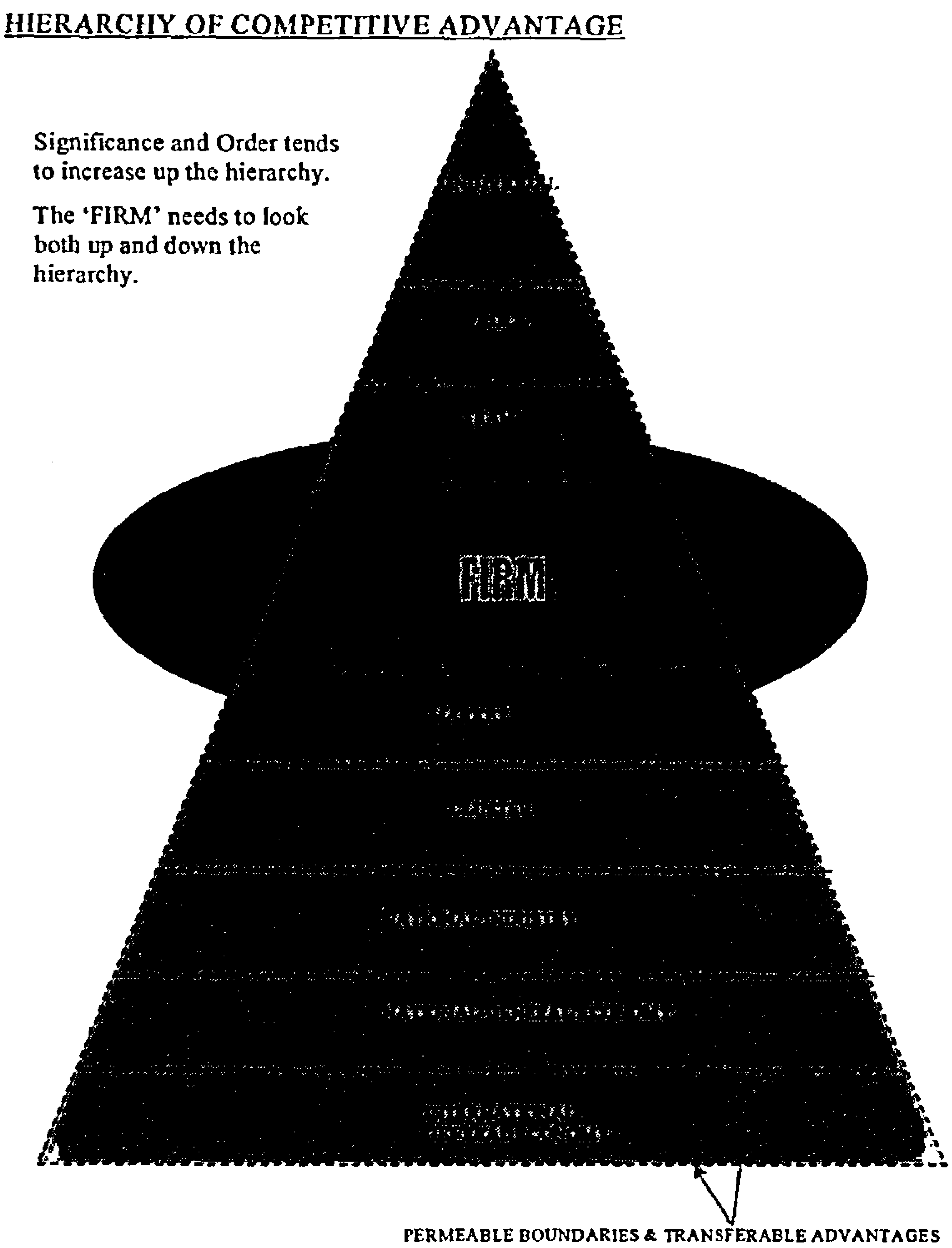
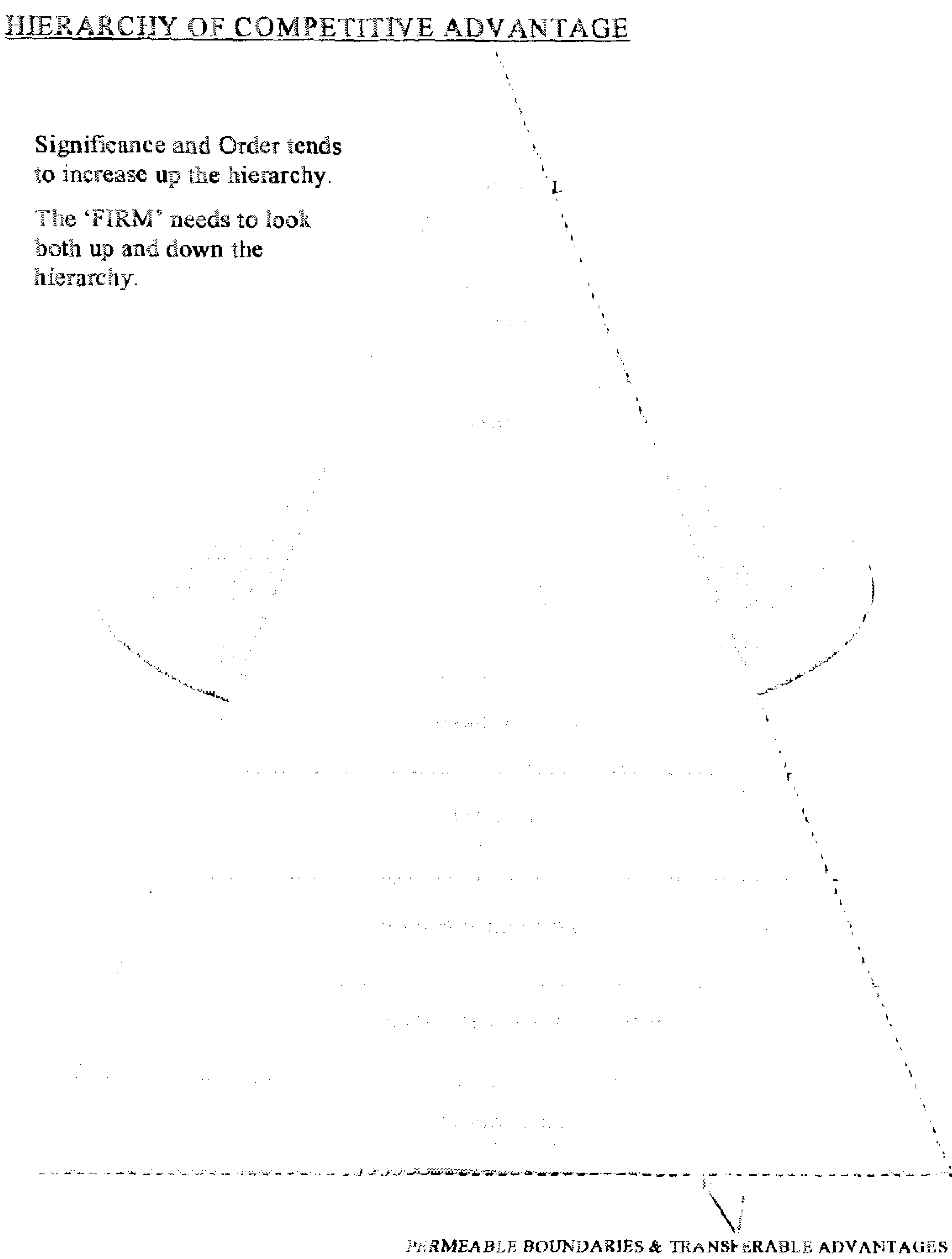


Hierarchy of Competitive Advantage. Fig. 6.1

The dynamic epochs identified in this research are those of Factor Condition, Investment Condition, Innovation Condition and Wealth Condition. Each epoch has been restructured using the Spinozarean geometry. Each conditions epoch is shown in the figures 6.2 – 6.5 respectively.



Hierarchy of Competitive Advantage. Fig. 6.1

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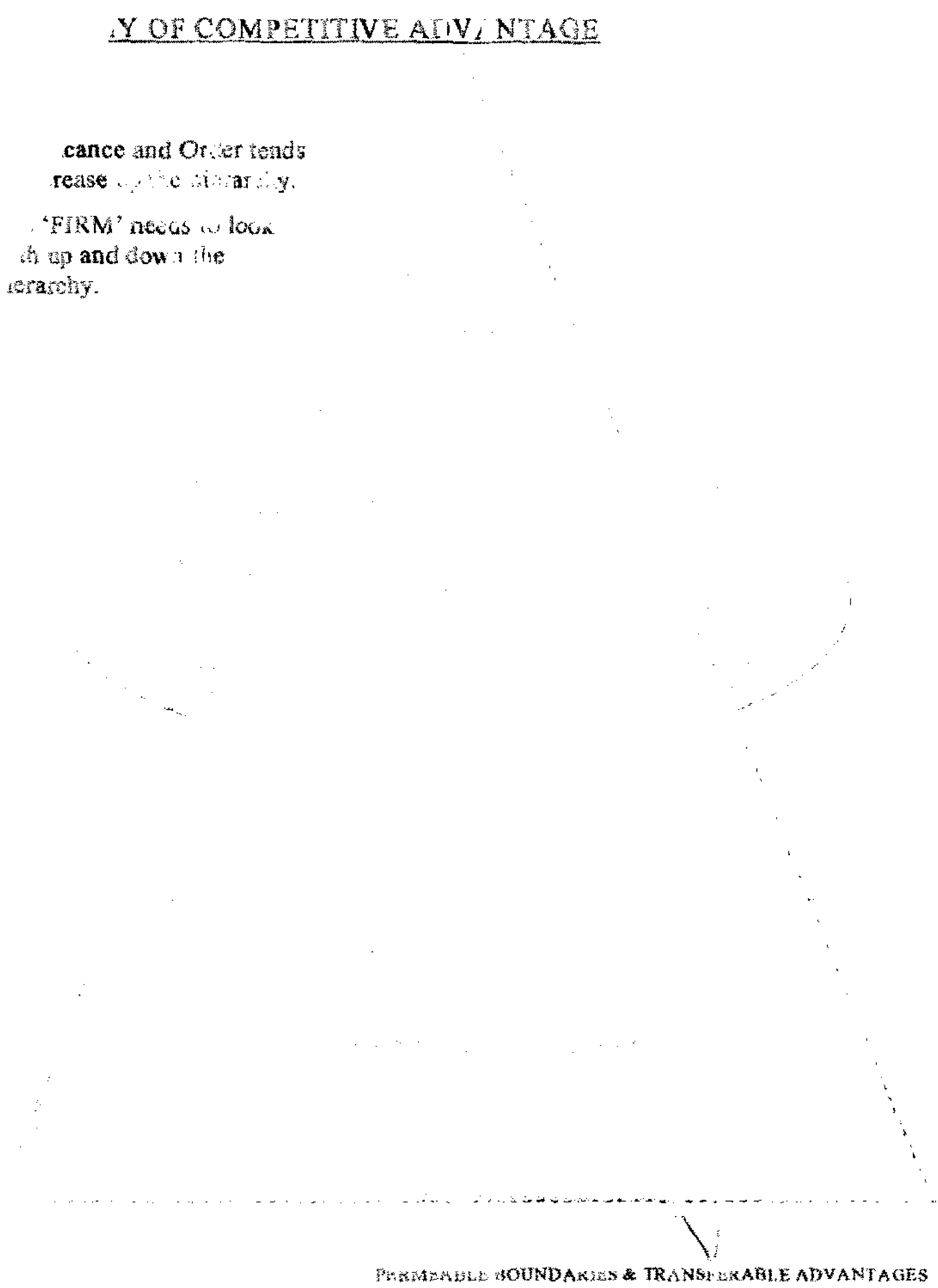

Hierarchy of Competitive Advantage. Fig. 6.1

The dynamic epochs identified in this research are those of Factor Condition, Investment Condition, Innovation Condition and Wealth Condition. Each epoch has been restructured using the Spinozarean geometry. Each conditions epoch is shown in the figures 6.2 – 6.5 respectively.

FACTOR CONDITIONS EPOCH Fig. 6.2

INVESTMENT CONDITIONS EPOCH Fig.6.3

INNOVATION CONDITIONS EPOCH Fig.6.4

WEALTH CONDITIONS EPOCH Fig.6.5

EPOCH TRANSITIONS SIMPLIFIED MODEL. Fig.6.6

The dynamic complexity of CAC has been modelled in a simplified Figure 6.6. Epoch transitions involve a kind of macroscopic behaviour that seems hard to predict by looking at the microscopic details.

Dynamic complexity occurs where cause and effect are subtle, and where the effects over time of interventions are not obvious.

The construction industry has made many unsuccessful attempts to introduce improvements. However the general perception still remains of a construction industry that produces poor products and services often of inappropriate quality that frequently fails to meet client demands for price certainty and guaranteed delivery. The 'Latham' Report (1995) and the Construction Task Force Report 1998 (commonly known as the 'Egan' Report) support this view.

> ***"Nonetheless, there is deep concern that the industry as a whole is under-achieving. It has low profitability and invests too little in capital research and development training. Too many of the industry's clients are dissatisfied with its overall performance."***

DETR.1998. Rethinking Construction. Executive Summary. Pp1.

Frequently the construction industry experiences unexpected 'side-effects' from improvement initiatives. When an action has one set of consequences locally and a very different set of consequences in another part of the system, this is an indication of the dynamic complexity.

When obvious interventions produce non-obvious consequences this also indicates dynamic complexity.

There is dynamic complexity in construction activity. It takes months to design a project, many weeks to obtain approval to construct, months to hire and train people to build the project, and years to develop new products, nurture management talent, and build a good reputation. And all of these processes interact continually. The real CAC leverage in most construction management situations lies in understanding dynamic complexity, not 'detail' complexity.

A deterministic system such as the construction industry can produce much more than just periodic [sic: epoch type] behaviour. A complex system can give rise to turbulence and coherence at the same time. There are classical models where everything is determined by initial conditions, and then there are quantum mechanical models where things are determined but you have to contend with a limit on how much initial information you can gather. Einstein's Theory of Relativity eliminated the Newtonian illusion of absolute space and time; Heisenburg's Quantum Theory eliminated the Newtonian dream of a controllable measurement process; and Chaos Theory eliminated the LaPlacian fantasy of deterministic predictability.

Coherence is the evolution of consistent shape in space and the evolution of shape in time. Coherence has been demonstrated by the dynamic epochs of figures 6.2 – 6.6. The initial testing of the representativeness of the dynamic epochs produced only one minor amendment to the factor conditions matrix, as indicated in case study A (Eaton (unabridged version) September 1999). Further case studies B and C demonstrated that the representativeness of the dynamic model appears acceptable for other sectors of the construction industry.

Figure 6.7 shows the Internal 'Detail' of CAC. Figure 6.8 the Distinctive Capabilities 'Detail' of the construction organisations' CAC, and Figure 6.9 the External 'Detail' of CAC. The 'Detail' models associated with the 'Detail' hierarchy demonstrates significant structural coherence. The four-sided polygonal shapes represent this structural coherence. They are a major feature of the 'Detail' Models. These four-sided polygonal shapes represent a 'Detail' equilibrium position.

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INTERNAL 'DETAIL' OF CAC Fig.6.7

INTERNAL 'DETAIL' OF CAC Fig.6.7

INTERNAL 'DETAIL' OF CAC Fig.6.7

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DISTINCTIVE CAPABILITIES 'DETAIL' MATRIX Fig.6.8

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EXTERNAL 'DETAIL' OF CAC Fig.6.9

EXTERNAL 'DETAIL' OF CAC Fig.6.9

EXTERNAL 'DETAIL' OF CAC Fig.6.9

'Detail' equilibrium occurs when the elements of an epoch combine in such a way so as to produce prototypical behaviour from the individual organisation. This prototypical behaviour is represented in this research by the 'Dynamic' and 'Detail' phase maps of figures 6.2 – 6.9. To use an atomic chemistry analogy, the individual organisations are the protons orbiting the epoch phase nucleus (of Factor Condition, Investment Condition, etc.)

The 'Dynamic' Complexity Models (Figs 6.2 –6.5) and the 'Detail' of CAC Models (Figs 6.7 – 6.9) for the construction industry of the United Kingdom show emerging and significant equilibrium.

However the construction industry 'system' is deterministic it demonstrates significant equilibrium yet you can't say what it's going to do next!

The research has carefully avoided philosophical discussion of cause, particularly the distinction between final cause and efficient, formal and material cause (Aristotle in Bekker et al. (1831)). In systems thinking it is an axiom that every influence is both cause and effect. Nothing is ever influence in just one direction. To see system wide interrelationships, a language of interrelationships is needed; a language made up of loops. Therefore the linkages between the variables of both the 'Dynamic' Complexity Model and the 'Detail' of CAC Models are shown as being both causal and effector. This is represented in the models by the twin headed linkages. This also demonstrates a cyclical feedback mechanism between the two attached variables. This linkage between variables is a significant feature of the mathematics of multi-attribute functions. This systematic anatomy provides the linkage between structure and system.

The holistic systems view is needed more than ever because society is becoming overwhelmed by complexity. Perhaps for the first time ever, humankind has the capacity to create far more information than anyone can absorb, to foster far greater interdependency than anyone can manage, and to accelerate change far faster than anyone's ability to keep pace. As a consequence of such societal changes the scale of the 'Dynamic' Complexity and 'Detail' of CAC is vast.

The global construction industry is large and complex. Stallworthy and Kharbanda (1985) estimate that it is the single most important industry in any national economy. Construction normally represents between 7 and 15% of gross domestic product (GDP).

Modern Cartesian economic theory relies heavily on the efficient market theory. Knowledge is assumed to flow freely from place to place. The people making important decisions are supposed to have access to more or less the same body of information. That is patently false in the competitive arena of the construction industry (Eaton. (June 1994). Interpretive & Modelling Problems of Risk & Uncertainty). The application of knowledge is a key feature of competition within the construction industry. Knowledge within the construction industry is imperfect. For example, construction estimators are biased by the customs of their disciplines and by the accidental paths of their own educations, coupled with individual perceptions and individual goals.

These imperfections contribute to the disorder exhibited by the construction industry. It is also a general description of what happens in a large variety of systems when things work on themselves again and again.

To create the conceptual patterns of CAC it was necessary to look for the scaling structures - how do big details relate to little details, complicated structures in which the complexity has come about by a persistent process. It's certainly not how a human being perceives those things, and it's not how an artist perceives them. It does however provide a method for modelling 'dynamic' and 'detail' complexity. The scaling structures have a philosophical and methodological pedigree identified in chapter two of this research. The scaling structure archetype adopted in presenting the research is the Spinozarean four-sided polygon.

This scaling structure archetype aids the identification of interrelationships rather than linear cause-effect chains. This highlights the processes of change rather than a single snapshot at a particular point in time. The reason that structural explanations are so important is that only they address the underlying causes of behaviour at a level that patterns of behaviour can be changed. Structure produces behaviour, and changing underlying structures can produce different patterns of behaviour (Eaton & Baldry 1999). Systematic structural solutions are inherently generative. Generative learning cannot be sustained in an organisation where 'detail' thinking, and therefore adaptive learning is the sole or predominant viewpoint.

The systems archetype (the four-sided polygon) reveals the elegant simplicity underlying the complexity of CAC. Where the archetype is absent or altered this indicates an area of turbulence, a failure to appropriate the CAC. What is this turbulence then? It is a mess of disorder at all scales, small disorders within large ones. This disorder is unstable. This instability will eventually transform to an equilibrium position. It is represented in the 'Detail' models by the polygonal structures that are not four-sided. Systemic structure is concerned with the key interrelationships that influence behaviour over time. It builds to learning to recognise types of structures that recur again and again; the recognition of the system archetype itself, or the recognition of missing elements of the system archetype. The simplest systems are now seen to create extraordinary difficult problems of predictability. Yet order arises spontaneously in those systems – disorder and order together. Equilibrium and dis-equilibrium archetypical examples are shown in Figures 6.10 and 6.11 below.

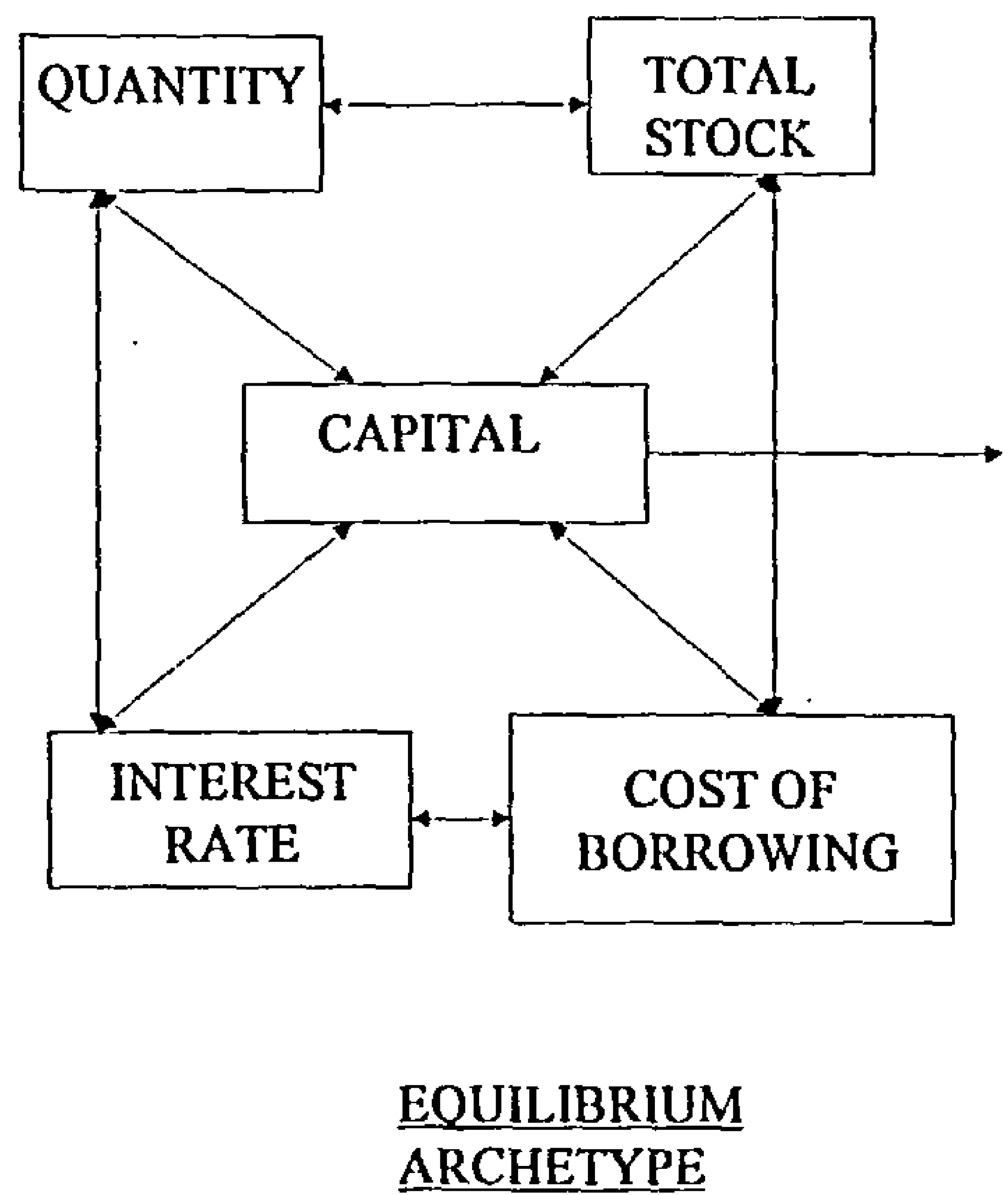
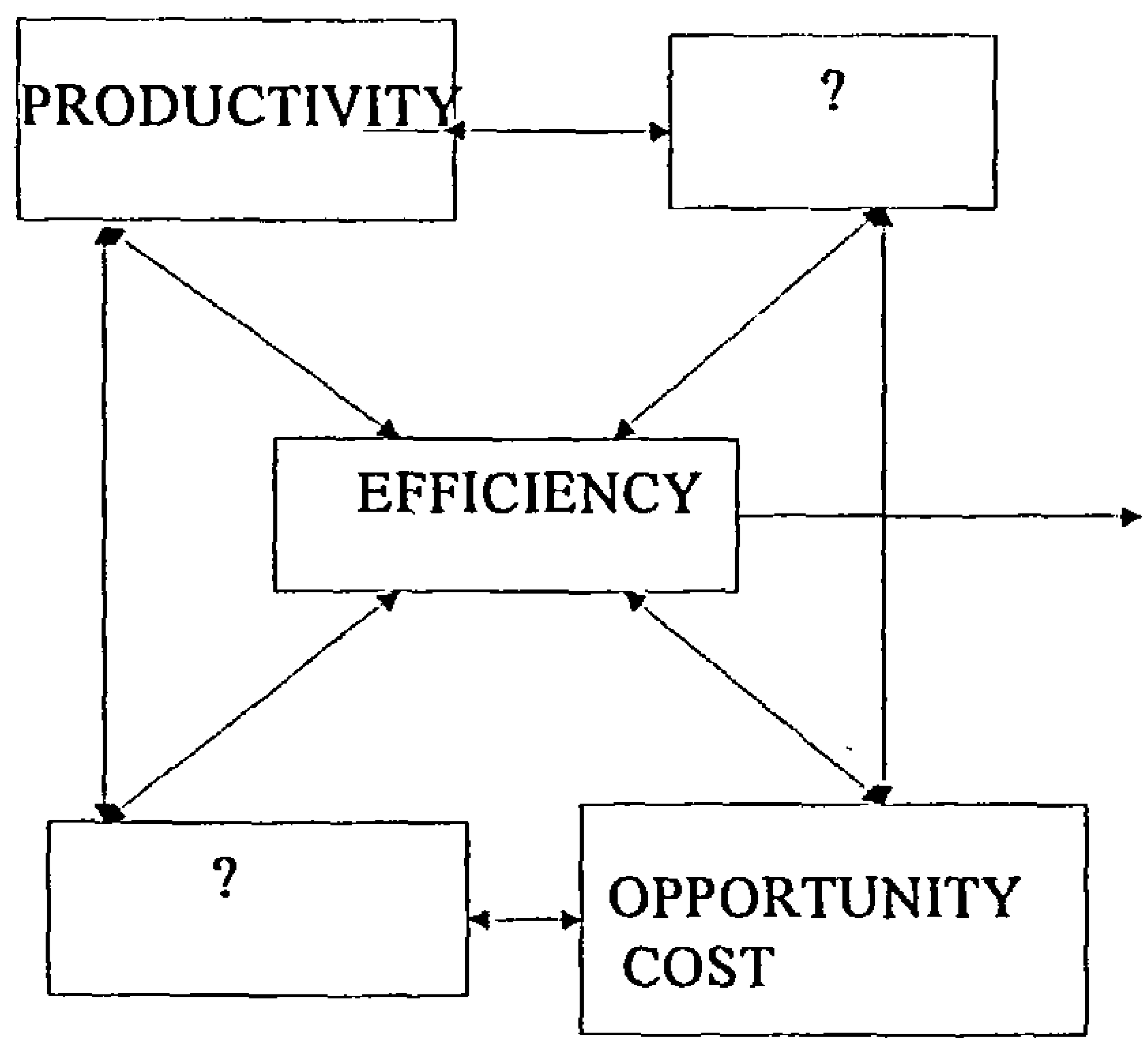


Fig. 6.10 Equilibrium Archetype.

The equilibrium archetype is complete. The identified factors form the complete four-sided polygon. Each factor is interconnected to its neighbour and to the factor at the next level in the micro scale. Thus the interest rate factor is connected to the cost of borrowing factor and the quantity factor within the same level of the hierarchy, and it is also connected to the capital factor at the next higher level in the hierarchy.

The dis-equilibrium archetype is incomplete. The productivity factor is unconnected at the same level in the hierarchy. It does however connect with the efficiency factor at the next higher level in the hierarchy. The efficiency factor is incomplete since many of the hierarchical connections are connected to empty factor locations.

Thus the dis-equilibrium archetypes can explicitly identify positions in a system archetype that need to be completed to move the system elements towards system equilibrium.



DIS-EQUILIBRIUM
ARCHETYPE

Fig. 6.11 Dis-Equilibrium Archetype.

The scaling system archetypes will assist in the implementation of generative learning.

Generative learning requires a conceptual framework of structural or systemic thinking, the ability to discover structural causes of behaviour. Thus 'dynamic' and 'detail' models are required concurrently. Since structure in human systems includes the operating policies of the decision-makers in the system, redesigning the decision-making redesigns the system structure. This requires a fundamental metanoia. Recognition of the interaction between an individual persons':

a. Thinking;
b. Internal models;
c. Perceptions;

and

d. Actions.

This then highlights a fundamental cognitive limitation: the human character is only capable of managing a very small number of separate variables simultaneously. Forcing the individual to invoke simplifying heuristics to solve dynamic problems, the recognition of 'Rules of Thumb'.

The individual does however, have an enormous capacity to deal with 'detail' complexity at the subconscious level that is not present at the conscious level, namely the recognition of intuitive behaviour.

Why are the explicit 'dynamic' and 'detail' models so powerful in affecting the appropriation of CAC? In part, because the models affect what an individual sees. Two people with different implicit mental models of CAC can observe the same event and describe it differently, because they've looked at different details. The problems with implicit mental models lie not in whether they are right or wrong - since by definition, all models are simplifications. The problems with implicit mental models arise when the models are tacit - when they exist below the level of awareness. Because the mental models are implicit they are unexamined, the models consequently remain unchanged. As the environmental supra-system changes, a gap can occur between the implicit mental model and reality, leading to incongruence and increasingly counterproductive actions.

Entire industries can develop chronic misfits (incongruence) between implicit mental models and reality. In some ways, insular industries, like the construction industry, are especially vulnerable because the member companies have a tendency to look to each other for standards of best practice.

The inertia of deeply entrenched mental models can overwhelm even the best systemic insights. But if implicit mental models can impede learning - freezing companies and industries in outmoded practices- why can't they also help accelerate learning?

That is the power of this explicit model. The fact that the model is made explicit encourages examination and challenge; this challenge can lead to an amendment as necessary, as identified in an early trial of the Factor Conditions Dynamic Matrix, (Eaton (September 1999). Unabridged version.)

To Build A Mapping Framework

The second objective of the research was the creation of explicit mental models [maps] that guide and shape our perception and action, bringing about the possibility of constant mutual participation between organisations and their environment.

One of the significant hurdles in building the mapping framework was the linearity of typical models. If all we have is linear language, then we think in linear ways, and we perceive the world linearly. CAC was not linear, the model needed feedback loops and scale reiteration. These have been inculcated into the explicit models as presented.

The great quantum theorist R P Feynman expressed this reservation:

> *"It always bothers me that, according to the laws as we understand them today, it takes a computing machine an infinite number of logical operations to figure out what goes on in a no matter how tiny a region of space, and no matter how tiny a region of time. How can all that be going on in that tiny space? Why should it take an infinite amount of logic to figure out what one tiny piece of space / time is going to do?"*

In the short term any point in space can stand for a possible behaviour of a dynamical system. In the long term the only possible behaviours are the fundamental attractors themselves. Phase transitions are movements in time or space (by an organisation) to a different fundamental attractor. Other kinds of motion are transient. By definition, attractors have the important property of stability - in a real system. The concepts of attractors and phase transitions are discussed later.

There was a compromise incorporated into the construction of the explicit models. A discrepancy so small that most researchers usually forgot it was there. The idiosyncrasy of individual definition of terms means that coherence could never be perfect. The models have not attained a static equilibrium. The variables placed on the model are really an average representation of the variable as observed within the construction industry. The models therefore incorporate aggregated features. The model structure is a composite of the average definition of all organisations within the construction industry. The features identified by previous researchers did contain a form of consistency, but the repetitions were never quite exact. There was a pattern, with disturbances. An orderly disorder. The complicated dynamical systems exhibit small-scale variability within the overall coherence of the model. Demonstrating a macro-scale dynamic equilibrium whilst exhibiting micro-scale dis-equilibrium. Some organisations could demonstrate points of instability - critical points where a small change could have large consequences. The difficulty in modelling such small-scale variability is evidenced by the character of the model equation...small-scale changes affect simultaneously all scales of 'dynamic' and 'detail' complexity in all relevant respects; both order and degree of change. Tiny differences in input can give rise to large discrepancies in output, a feature acquiring a technical name known as sensitive dependence on initial conditions or the 'Butterfly Effect'.

A further compromise within the 'dynamic' models of CAC is the failure to make allowance for deterministic non-periodic flow. The 'dynamic' models are constructed in a temporal sequence. Factor conditions lead to investment conditions, which then lead to investment conditions, etc. This sequence fails to acknowledge that the flow through these stages is not smooth. It should be considered as a turbulent flow. Using this analogy with hydro-mechanical sciences is useful. In the same way that hydro-dynamicists calculate smooth flow and use this as an empirical approximation of the real situation so too the dynamic model presents smooth flow as an empirical approximation of the turbulent phase transition in the temporal cycle. It is useful to note that despite many advances made in turbulent flow theory by incorporating chaos theory mathematics many of the turbulent flow differential equations are still insoluble, and the calculations are still approximated. An examination of the vast array of companies in the construction industry would suggest that it is improbable that all companies would follow this smooth dynamic phase transition. There will be individual examples of organisations that make paradigm shifts to unconnected phases and others that regress to an earlier phase by reversing the phase transition. The models however still reflect the average dynamic temporal flow.

A further reservation to the mapping was the explicit recognition of the Western cultural bias in the study. Eastern cultural approaches have been omitted from the study. It is however recognised that an examination of an Eastern cultures' approach to basic moral, ethical, and managerial issues, makes sense. A Western way of approaching these issues also makes sense. But the two can lead to opposite conclusions. This leads to discovering that there is more than one way to look at complex issues. The models as presented make explicit the cultural and ethical drivers of CAC. No judgement is made with regard to the effectiveness of alternative cultural philosophies.

The impact of the *explicit mapping framework* of mental models is profound - a recognition that all there ever is, are assumptions, never 'truths', that the world is seen through an idiosyncratic mental model and that all the mental models are always incomplete, and especially in Western culture, chronically non-systemic.

From the systems perspective, the human actor (in using these explicit models) is part of the feedback process, not standing apart from it. This represents a profound shift in awareness.

The feedback perspective suggests that everyone share responsibility for problems generated by a system. That doesn't necessarily imply that everyone involved can exert equal leverage in changing the system. The feedback concept illuminates the limitations of our current language and the difficulties of using everyday language to describe the multiple feedback processes in an organisation. This issue has not been pursued at this point in time.

In addition, the feedback concept complicates the ethical issue of responsibility. Again this issue has not been pursued.

There are two distinct types of feedback processes: reinforcing and balancing, which have been identified within the models, analogous to the Noah and Joseph effect described later. Within these types of feedback are both positive and negative forms. Positive reinforcement amplifies and ensures growth. Negative reinforcement can generate a decline in growth. Balancing operates when a goal seeking strategy exists. It acts as a countervailing force to reinforcement. (Newton's third law of motion!)

To understand how CAC operates within a construction organisation it is necessary to understand both the reinforcement and balancing processes. Those that are explicit and implicit! That is why the discipline of phenomenological imaginative variation in the mental models - horizonalising, reducing, clustering, organising, testing and improving our internal pictures of how CAC works - promises to be a major breakthrough for building competitive organisations.

A significant feature of the 'dynamic' complexity of the models is that the feedback loops may contain delays. 'Lags' in the flow of influence which make the consequences of actions occur gradually. This has been described in various management literatures as 'Vicious Circles' and 'Virtuous Circles' dependant upon being positive or negative feedback. There must be an expectation that lags may cause 'overshoot! One of the highest leverage points for improving system performance is minimising system delays. This could be considered to be a fundamental tenet of lean construction. (Eaton (1997). Productivity Improvements for Construction Professions.)

The systems viewpoint is generally oriented toward long-term views. That is why delays and feedback loops are so important. In the short term they can be ignored, they are inconsequential. They only become significant in the long term.

Therefore they can be disregarded in considering the 'Detail' complexity but they become a major factor in evaluating the 'Dynamic' complexity of CAC.

Senge states:

> *"Today, the primary threats to our survival, both of our organisations and of our societies, come not from sudden events but from slow, gradual processes."* Pp22.

The mapping framework will make explicit the emerging processes of epoch transition, and therefore will identify the slow gradual threats to the loss of CAC.

Senge also states:

> *"We learn best from experience but we never directly experience the consequences of many of our most important decisions."* Pp23.

O'Brien supports this:

> *"[What is required is]..organisational models that are more congruent with human nature. When the industrial age began, people worked 6 days a week to earn enough for food and shelter. Today, most people have handled that by Tuesday afternoon. Our traditional hierarchical organisations are not designed to provide for people's higher order needs, self-respect and self-actualisation. The ferment in management will continue until organisations begin to address these needs, for all employees."* (In Senge pp140.) *and "There is no fundamental trade off between the higher virtues in life and economic success."* (In Senge pp145.)

And Kazuo Inamori:

> *"Whether it is research and development, company management, or any other aspect of business, the active force is 'people'. And people have*

their own will, their own mind, and their own way of thinking. If the employees themselves are not sufficiently motivated to challenge the goals of growth and technological development [....]. there will simply be no growth, no gain in productivity, and no technological development. "(In Senge pp139-140)

And Max de Pre ex-CEO Herman Miller.

"A complete relationship needs a covenant... a covenantal relationship rests on a shared commitment to ideas, to issues, to values, to goals, and to management processes.... Covenantal relationships reflect unity and grace and poise. They are expressions of the sacred nature of relationships." (In Senge pp145.)

This covenantal relationship was identified in Eaton (October 1994). It generates a philosophical cornerstone to the research by identifying a fundamental archetype of: Ethics, Culture, Values and Humanities. As previously stated the philosophical discourse has been explicitly avoided.

It does however require recognition that the individual has larger aspirations for family, company, industry and society. Therefore if people do not share a common vision, and do not share common mental models about the business reality within which they operate, empowering people will only increase organisational stress and the burden of management to maintain coherence and direction.

An axiom that requires acknowledgement is,

'People don't resist change, they resist being changed'.

Thus to quote Robert Fritz:

"Structural conflict....[requires] strategies [for]: vision erosion, conflict manipulation, sheer willpower, and a new experience."

These structural conflict strategies will develop an archetype of four heuristics: Hunches, patterns, analogies and parallels. This will allow the individual to interpret the mental models and develop a coherent and consistent procedure for the appropriation of CAC

These heuristics will enable the non-linear closure of loops. This will explicitly permit continually discovering how apparent external forces are actually interrelated with an individuals' own actions within the organisation. It will allow the individual to see patterns of change and will foster generative learning. This explicit mapping exercise will allow multiple visions to coexist, it will assist in identifying the right course of action that transcends and unifies all individual visions.

The research has identified a management archetype of four issues: reflection, inquiry, trusting, and supporting that is required for successful appropriation of CAC within an organisation. The implementation of this archetype within a specific organisation is specifically excluded from this research. There is however significant published work, for example, *The Psychology of Behaviour at Work*, A. Furnham.1997, *Managing People at Work* J. Hunt, 1986, *Uncommon Sense about Organisations*, G. Hofstede, 1994., *An Introduction to Business Ethics*, Chryssides & Kaler, 1993, *Human Resources Management in Construction*, D Langford et al.1995. etc.

The research has also identified four elements of vision: clarity, enthusiasm, communication, and commitment. The implementation of this archetype within a specific organisation is specifically excluded from this research.

The research has identified that the organisational vision has four structural prerequisites: Alignment, harmony, coherency, and commonality. The implementation of this archetype within a specific organisation is specifically excluded from this research

The 'Detail' and 'Dynamic' maps will allow the explicit generation of insights about complex issues within the organisational environment. It will aid the identification of innovative, co-ordinated actions for the organisation to enhance the organisational ability to appropriate CAC.

The maps have identified models of 'Dynamic' and 'Detail' equilibrium. However the research has identified that there is a possibility of 'Dynamic Chaos', with instability at every point. Errors and uncertainties within the organisational environment may multiply, cascading upward through the chain of turbulent features. The occurrence of this feature is recognised in Chaos Theory as the 'Butterfly Effect'. There are however alternative theories emerging from Complexity Theory studies which present an alternative perspective.

The occurrence of 'Dynamic Chaos' at epoch transitions has been briefly considered. The four epochs, Factor, Investment, Innovation, and Wealth can be considered to be a 'periodic attractor'. A 'periodic attractor' attracts all other nearby deterministic possibilities. A phase transition between epochs occurs when the balance of equilibrium moves from one 'periodic attractor' to another. Thus an organisation will remain in the Factor epoch until the elements cannot remain in equilibrium around the Factor condition focus. At some point the 'Dynamic' turbulence creates a 'push', which propels the organisation towards the Investment epoch phase. If the 'push' is sufficiently strong the Investment 'periodic attractor' will 'capture' the organisation and move it on to the Investment epoch. If however the 'push' is not sufficient to allow 'capture' then the organisation could remain in 'dynamic chaos'. If the 'push' is very small, then the attraction from the Factor Condition 'periodic attractor' is not overcome and the organisation remains in the Factor epoch. Such a system is called intransitive. It can stay in only one steady state; only an outside force can change the equilibrium state.

> *"Raising the parameter [strength of push] meant raising the degree of non-linearity, and that changed not just the quantity of the outcome, but also its quality. It affected not just the final population [value of*

appropriable CAC] at equilibrium, but also whether the population would reach equilibrium at all. When the parameter was low, May's simple model settled on a steady state. When the parameter was high, the steady state would break apart, and the population would oscillate between two alternating values. When the parameter was very high, the system seemed to behave unpredictably." Gleick 1987.

This unpredictability had been evidenced in Chaos theory research. It had been defined as 'Almost intransitivity'. The behaviour of the 'almost intransitive' system depended sensitively, though, on the steepness - the degree of non-linearity, the boom-and-bustiness of the system. A concept familiar to those from a construction background.

These 'pushes can be represented by mathematical multi-attribute functions. Too shallow a function would produce extinction [return to original phase attractor] within a population [an individual construction organisation]. Increasing the steepness of the function eventually produced steady state epoch equilibrium. A further increase produces movement to another single point periodic attractor [via a phase transition]. Beyond a certain point, the mathematical function produces a bifurcation, an oscillating population [for example, reversing phase transitions - moving from innovation 'back' to an investment phase], then a further increase in the mathematical function caused further bifurcations and finally the population would refuse to settle down at all.

This final chaotic behaviour is a representation of the 'classical' historical behaviour of the construction industry.

These 'pushes' can be compared to the Noah and Joseph Effects as demonstrated in Chaos Theory. The 'pushes' are considered to be the Noah Effect - a discontinuity: such that when a quantity of a particular factor changes, it can change almost arbitrarily fast. Ample examples exist within the construction industry to demonstrate such an effect. Changes in Government policy, alterations to standard forms of contract, bankruptcy and retrenchment of major industry contractors. The Joseph Effect means persistence. The periodic attractors have a tendency to retain an organisation in a particular phase state. The Noah and Joseph Effects 'push' (and therefore 'pull') in different directions a further demonstration of Newton's Third Law.

Further research is required to establish the mathematics of 'dynamically chaotic systems' that never find an equilibrium state. Systems that fail to be 'captured' by the next phase attractor remain in the previous phase but in a format that almost repeats itself. It cannot be unchanged since some interaction of the phase has generated the 'push' towards the phase transition. This interaction will be mapped as a change in the linkages of a particular part of the phase map. The principal of sensitivity to initial conditions, as discussed previously, makes the prediction of the timing of a particular phase transition impossible.

From the research completed to date it would appear that such 'dynamically chaotic systems' are likely to demonstrate a form of 'complex aperiodicity'. (See Gleick 1987.)

Further research is also required to determine a link between aperiodicity and unpredictability.

Such research should be tempered with care, as HJ Gold quotes in Mathematical Modelling of Biological Systems:

> *" The result of a mathematical development should be continuously checked against one's own intuition about what constitutes reasonable [organisational] behaviour. When such a check reveals disagreement, then the following possibilities must be considered:*
>
> *a. A mistake has been made in the formal mathematical development;*
> *b. The starting assumptions are incorrect and / or constitute a too drastic oversimplification;*
> *c. One's own intuition about the [..] field is inadequately developed;*

d. *A penetrating new principle has been discovered."*

Having proposed a multi-attribute differential equation (in Eaton June 1994) further unpublished work since then leads to the conclusion that they may be inappropriate. Since they describe processes that change smoothly over time, and represent reality as a continuum, changing smoothly from place to place and from time to time, not broken into discrete grid points or time steps. Also, differential equations are hard to compute and most differential equations cannot be solved at all.

The differential equation proposed in Eaton (June 1994) did not display sensitive dependence on initial conditions.

Simpler equations - " difference equations" - may be appropriate in the examination of 'dynamically chaotic systems' that never find an equilibrium state since they can be used for processes that jump from state to state. A system such as a construction organisation is far too complex to be treated directly as a many body problem, but its dynamics have been mapped with the help of certain compromises.

They could be used to find a function that matches the crude realities of life- for example, competitive advantage within a construction organisation. They could lead to a solution to the abstract problems of stability and complexity, mathematical explanations of what enables competitors to co-exist. The creation of a foundation theory of CAC, capable of explicit solution of the simplest questions of how single organisations behave over time.

In the research conducted upon bidding behaviour of contracting organisations (Eaton June 1994) the possibility of option oriented and outcome oriented models was presented. Further unpublished research has identified that genetic algorithms could be used to represent multi-attribute functions in outcome oriented models, whilst fuzzy algorithms could be used to represent the same variables in option oriented models. In 1999 during the completion of this research a team from Harvard University have been experimenting with 'fuzzy genetic algorithms'. This is likely to be a fruitful area of further research.

The research concludes that there is disorder in the structure of sources of competitive advantage within a construction organisation. But construction organisations have to know about such disorder if they are going to deal with it. Periodicity is the most complicated orderly behaviour. Aperiodic behaviour is inherent in the phase transition of a construction organisation

The research also concludes that chaos is ubiquitous within any construction organisation; however the research also demonstrates that such chaos is stable; it is also structured. Therefore the models present a framework for managers within individual construction organisations to link strategy, structure, systems and behaviour.

The models mapped in this research are recognised to be caricatures of reality. They do however present an explicit framework for the creation of individualistic organisational maps. The choice is always the same. Make the model more complex and more faithful to reality, or make it simpler and easier to handle. When bifurcations occur, abrupt changes in behaviour, there is nothing in conventional linear models to account for that. That is one reason chaos experts believed that a new, global approach was necessary: the parts seem to be working but the whole fails. The mapping shown in this research is therefore a demonstration of this holistic approach.

To Show That This Is A Rational Reflection.

> " *Although people do not* [always] *behave congruently with their espoused theories* [what they say] *they do behave congruently with their theories in us*e [their mental models]. "
>
> C Argyris (Increasing Effective Leadership, 1976)

Strategic planning, which should be a bastion of long term thinking in corporations, is very often reactive and short term. According to Prahalad & Hamel 1985:

> *"Although strategic planning is billed as a way of becoming more future orientated, most managers, when pressed, will admit that their strategic plans reveal more about today's problems than tomorrow's opportunities."*

A number of management axioms (taken from Senge. 1990) can be used to illustrate the rationality of the explicit CAC framework for the models of this research:

> *"1.Today's problems come from yesterday's solutions. Solutions that merely shift problems from one part of the system to another often go undetected because those who solved the first problem are different from those who inherit the new problem.*
>
> *2. The harder you push the harder the system pushes back. Systems' thinking defines this as compensating feedback.*
>
> *3.Behaviour grows better before it grows worse. Compensating feedback usually involves a 'delay', a time lag between the short-term benefit and the long-term dis-benefit.*
>
> *4.The easy way out usually leads back in.*
>
> *5.The cure can be worse than the disease. We can shift the burden to 'others' who make the organisation dependent on them, instead of problem solving ourselves*
>
> *6. Faster is slower*

7.Cause and effect are not necessarily closely related in time and space. There is a fundamental mismatch between the nature of reality in complex systems and our predominant ways of thinking about that reality.

8. Small changes can produce big results- but the areas of highest leverage are often the least obvious. There are no simple rules for finding high leverage changes, but there are ways of thinking that makes it more likely.

9. You can have your cake and eat it too- but not at once.

10.Dividing an elephant in half does not produce two small elephants. Some issues can be understood only by looking at how major functions interact, but there are other 'detail' issues where critical systemic forces arise within an area; and others where the dynamics of an entire industry must be considered. The key principle, called the principle of the system boundary, is that the interactions that must be examined are those most important to the issue at hand regardless of parochial organisational boundaries.

11. There is no blame."

Systems theory concepts create leverage. Seeing where actions and changes in structures can lead to significant, sustainable improvements.

What managers in the construction industry most need are ways to know what is important and what is not important, what variables to focus on and which to pay less attention to - and they need ways to do this which can help groups or teams develop shared understanding.

The explicit organisational goal may not be congruency, (Eaton 1992) but the process leads to congruency when it works.

To Identify The Process, Chronologies And Connections Showing Temporal Development And Hierarchy.

Libchaber (In D'Humieres et al, 1982) had a feeling for the abstract, ill defined, ghostly thing called '**flow**'. Flow is shape plus change, motion plus form. In this research the temporal dynamic models represent the flow. Flow was a Platonic idea, assuming that change in systems reflected some reality independent of the particular instant.

Research has indicated that changes in the environment can be eliminated completely, by creating an organisational. 'Monad' (Eaton September 1994), or partially by considering the degree of boundary permeability (Eaton 1999). This allows the complexity within the construction environment to be simplified by uncoupling variables that are interlocked in reality and the creation of a single representative multi-attribute function rather than many dependant variables.

The explicit mental models create a self-referential discipline, a set of developable skills within the individual decision-maker, to be applied in specific instances, not as vague generalities and pieties about 'thinking more effectively'.

The explicit models of 'Detail' and 'Dynamic' complexity represent a symbiotic co-existence; construction organisations and markets jointly drive the process of creative destruction and continuous regeneration of sources of competitive advantage.

The process, chronologies and linkages have been presented in the conclusion to this research

To Bring Order To The Individual Experience Of CAC By Generating Reliable And Rich Pictures Of Potential Strategy Options.

The mental models as presented create a 'flavour' of organisational competitive advantage that could not be expressed by talking about mathematical averages. The significance of the models is in the representation of the qualitative nature of the sources of CAC, not in the generation of stochastic and deterministic data.

The explicit models represent abstract problems of stability and complexity for individual construction organisations, they represent mathematical explanations of what enables competitors to co-exist. They represent a model of the simplest question, of how a single construction organisation behaves over time. Of how the construction organisation must manage it structure, strategy, systems and behaviours to achieve the dynamic equilibrium of the fundamental system archetype: Culture, Ethics, Humanities and Espoused Values.

If construction managers believe their worldviews are facts rather than sets of assumptions, they will not be open to challenging those worldviews. The models represent a set of explicit assumptions, supported by significant observations and a comprehensive series of reservations. The construction managers must test their own idiosyncratic implicit model against the model presented here. They must challenge the 'detail' and 'dynamic' complexity, they must test the assumptions and observations, they must recognise the necessity of the reservations, and finally they must alter the model to suit the individual circumstances of the particular organisational need at the particular point in time.

The reader should not misperceive the purpose of this research. The models representing systems thinking should not be seen as drawing diagrams and building elaborate models of the construction industry. The models are a set of explicit tools and maps for improving an implicit, individual, idiosyncratic mental picture of the 'perceived reality' of competitive behaviour within the construction industry.

Ultimately, the payoff for the individual construction manager, from integrating systems thinking and mental models will be not only improving mental models (what we think) but altering ways of thinking: shifting from mental models dominated by events to mental models that recognise longer term patterns of change and the underlying structures producing those patterns.

Creativity and individual initiative are more important as sources of CAC than homogeneity and conformity.

This could lead to the construction manager developing a profitable mix of price, product, quality, design and availability that creates a strong sustainable market position. The difficulty is that the mix is dynamic, since the organisation will continue to alter and adapt in both its 'detail' and 'dynamic' complexity. This could then create long-term dynamic efficiency, enhancing, upgrading capabilities to create new value.

This would be an interactive, bottom-up/top-down process that was designed to engage managers at all levels within the construction organisation in a continual dialogue about how to build and defend long-term sustainable competitive advantage.

This could be interlinked with improvements in organisational effectiveness. The construction organisation becoming able to link dispersed initiatives and leverage distributed expertise from the entire organisation and not just from the higher levels of the organisational hierarchy.

Improvements in the organisational efficiency and effectiveness, creating the lean construction organisation provides the opportunity for the organisation to invest substantial resources in developing the expertise of people, to recruit the very best, to create structures and mechanisms that allow employees to continuously enhance, upgrade and broaden capabilities, (Eaton (September 1994), Ghoshal & Bartlett (1998)). Competitive advantage based upon an ability to capture, develop and apply scarce knowledge and expertise, recruiting and developing human assets are no longer a secondary function of the lean construction organisation. (Eaton, (January 1997)). This necessitates an ecdysis - casting off an old form to emerge in a new form. Thus creating the 'Individualised Lean Construction Organisation' a vertically integrated organisational system with clearly defined scale, scope, and existing capabilities. With all Strategy – Structure – System – Behaviour linkages exhibiting closed loop-in feedback.

Knowledge then replaces capital as the most valuable strategic asset within the organisation. Further emphasising the 'Individualised' significance of people. In the temporal hierarchy these individuals' appear at the apex of the construction organisational structure hierarchy.

A construction organisation capable of managing external forces, globalisation, technological demands, shortening product life-cycles, shifting technology platforms, converging industry boundaries, expanding alliance partnerships, structural realignment, deregulation, shifts in location of strategic assets, internal learning capabilities, knowledge intensive environments, information technology changes, etc.

Thus allowing the 'Individualised Lean Construction Organisation' to continuously improve quality, lower total costs, and satisfy customers in a sustainable manner.

Future Research.

In the course of this research various exclusions have been made. Usually the exclusions have been made because the particular issue was not central to the research objectives. However in some instances the exclusion has been made because it was recognised that the issue was too complicated or too vast to be fully investigated as an integral part of this research agenda.

The first reservation to this study was the exclusion of the consideration of the philosophical metaphysics of first cause. Metaphysics is the philosophy of being. What exists? What are the basic constituents of the world? Do properties exist independently of the individuals that possess them? Since CAC is considered to be a phenomenon demonstrated by the behaviour of individuals within organisations the philosophical question of whether CAC exists independently of the individuals has been ignored. It is recommended that the previous questions should be considered in detail.

The second reservation was that phenomenologically based philosophy required a perspective. This set the experiential boundaries that limited and constrained the study. It is recommended that another individual with a different perspective and background should repeat the mental mapping. Thus reducing some of the inherent cultural, ethical, professional and individual bias exhibited by the researcher.

The third reservation was the covert assumption that CAC could only be explained as a whole, not in terms of processes or parts. Further research is recommended to test the validity of this covert assumption.

The fourth reservation related to the covert assumption that for any construction company to remain viable it must make a profit. The study therefore adopted a cultural and political perspective that is of a classical Western European capitalist society. Alternative political perspectives, for example, communism, have been excluded. Alternative cultural perspectives based upon religious principals, such as Islamic nations have also been excluded. Classical European economic theory referred to as standard Cartesian economic theory has been assumed throughout the study. An examination of CAC from alternative cultural perspectives is recommended.

A fifth reservation was the assumption of rational economic behaviour. The mental models could be refined by the inclusion of alternative rational perspectives. For example, assuming that non-financial imperatives exist within the construction organisation that supplants the 'pure' economic behaviour. Some examples have been described within the construction industry, whereby avoiding redundancy amongst the workforce is the over-riding factor determining organisational behaviour. Other instances have been cited of construction organisations concentrating on maximising market share. These alternative rational perspectives could be examined.

Rogue trading behaviour and opportunistic profiteering (including monopolistic profits) whilst existing within the UK construction industry, have been excluded from the study. Incorporating such behaviour into the mental models could refine the study.

A further reservation is the implicit assumption of necessary or contingent truth. This includes reservations relating to the truth-value. Research to confirm the validity of this assumption is recommended.

There has been no consideration of the fuzzy approach, TV=□1-0□. Despite much research regarding the applicability of fuzzy systems (Zadeh (1965), Kosko (1994), and indeed genetic algorithms, (Mitchell (1996)) to the solution of construction problems. However fuzzy genetic algorithms' is likely to be a fruitful area of further research. Further research is required to establish the mathematics of 'dynamically chaotic systems' that never find an equilibrium state.

From the research completed to date it would appear that such 'dynamically chaotic systems' are likely to demonstrate a form of 'complex aperiodicity'. (See Gleick 1987.) Further research is recommended.

Further research is also required to determine a link between aperiodicity and unpredictability.

There has been no consideration of the statistical approaches to the management of risk. If the selected organisation cannot manage the risk and uncertainty of construction activity 'better' than any alternative organisation then it should not have an economic future within the construction industry. Further development of stochastic deterministic approaches to risk management is recommended, and in particular, the management of holistic whole life cycle risk management.

Further development of computer simulation capabilities, micro-worlds, soft systems tools, etc., is recommended because they deal with important non-quantifiable variables which are usually prominent in construction managers' mental models.

The research has identified a management archetype of four issues: reflection, inquiry, trusting, and supporting that is required for successful appropriation of CAC within an organisation. The implementation of this archetype within a specific organisation is specifically excluded from this research. There is however significant published work, for example, *The Psychology of Behaviour at Work*, A. Furnham.1997, *Managing People at Work* J. Hunt, 1986, *Uncommon Sense about Organisations*, G. Hofstede, 1994, *An Introduction to Business Ethics*, Chryssides & Kaler, 1993, *Human Resources Management in Construction*, D Langford et al.1995. etc. Further work in the implementation of the archetype is recommended.

The research has also identified four elements of vision: clarity, enthusiasm, communication, and commitment. There is however significant published work, for example, *Built to Last,* Collins & Porras, 1998, *The Individualised Corporation,* Ghoshal & Bartlett, 1998, *Customer Centred Growth,* Whiteley & Hessan, 1996. The implementation of this archetype within a specific organisation is specifically excluded from this research. Further work in the implementation of these four elements is recommended.

The research has identified that the organisational vision has four structural prerequisites: Alignment, harmony, coherency, and commonality. The implementation of this archetype within a specific organisation is specifically excluded from this research. Further work in the development of these four structural prerequisites is recommended.

Sensitive dependence on initial conditions, the 'Butterfly Effect' can now have an assigned quantitative value – the Lyapunov exponent. Research to define and quantify the Lyapunov exponent for a construction organisation is recommended.

A critical issue of construction 'organisational robustness' - how well can a construction organisational system withstand small 'pushes', has been excluded from the research findings. Further work to establish a measure of organisational robustness is recommended. Equally critical is construction 'organisational flexibility' - how well can a construction organisational system function over a range of environments. A locking-in to a single mode can be enslavement, preventing a construction organisation from adapting to change. Construction organisations must respond to circumstances that vary rapidly and unpredictably. Further work to establish a measure of organisational flexibility is recommended. Both measures could be invaluable tools in the benchmarking of construction organisations, both against industry competitors and, perhaps more importantly, against organisations from other sectors of industry. A major criticism of the construction industry has been its insularity.

These recommendations may alleviate some of that criticism.

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