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A STRATEGIC INDUSTRIAL ENGINEERING PHILOSOPHY

PIERRE LEONARD

A thesis submitted in partial fulfilment of the requirements for the degree

of

PHILOSOPHIAE DOCTOR (ENGINEERING)

in the

FACULTY OF ENGINEERING, BUILT ENVIRONMENT

AND INFORMATION TECHNOLOGY

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DEDICATION

To Ciska, my inspiration, my companion and my wife.

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THESIS SUMMARY

A STRATEGIC INDUSTRIAL ENGINEERING PHILOSOPHY

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KEYWORDS: Strategic Industrial Engineering Philosophy, Strategic Industrial Engineering, Strategic Industrial Engineering Process, Strategy, Industry, Industrial Engineering.

Economic and productive utilisation of natural resources are central to fundamental *Industrial Engineering* science, whereas capitalistic corporate *strategy* is aimed at growth of shareholders capital investments made into capitalistic systems of organisations and industries. In this thesis it is established that Industrial Engineering principles are applicable, as a strategic tool, in the economic and productive utilisation of corporate resources such as organisations within unrelated *industries* aimed at achieving the capitalistic corporate goal. In this expanded field of *Industrial Engineering,* termed *Strategic Industrial Engineering,* scientific engineering knowledge is therefore applied to capitalistic systems with the strategic aim of accumulating capital for the corporate shareholders.

The proposition of this thesis, termed *A Strategic Industrial Engineering Philosophy,* is primarily justified by applying the philosophical principle of sufficient reasoning. Secondary to this, scientific frameworks are proposed that support this expanded philosophy of *Industrial Engineering* by demonstrating the achievement of the capitalistic corporate goal. This is achieved through the following:

- Setting return on equity (ROE) as the scientific measure of capital accumulation;
- proposing a Strategic Industrial Engineering Process, aimed at achieving the capitalistic corporate goal, for further research. This process is based on the following:
  - The relationship between the fundamental strategy and engineering processes; and
  - fundamental corporate performance-regulating principles.
- demonstrating the validity of these performance-regulating principles through explorative statistical analyses.

The proposed *Strategic Industrial Engineering Process*, to be fully defined through further research, is illustrated in Figure 1:

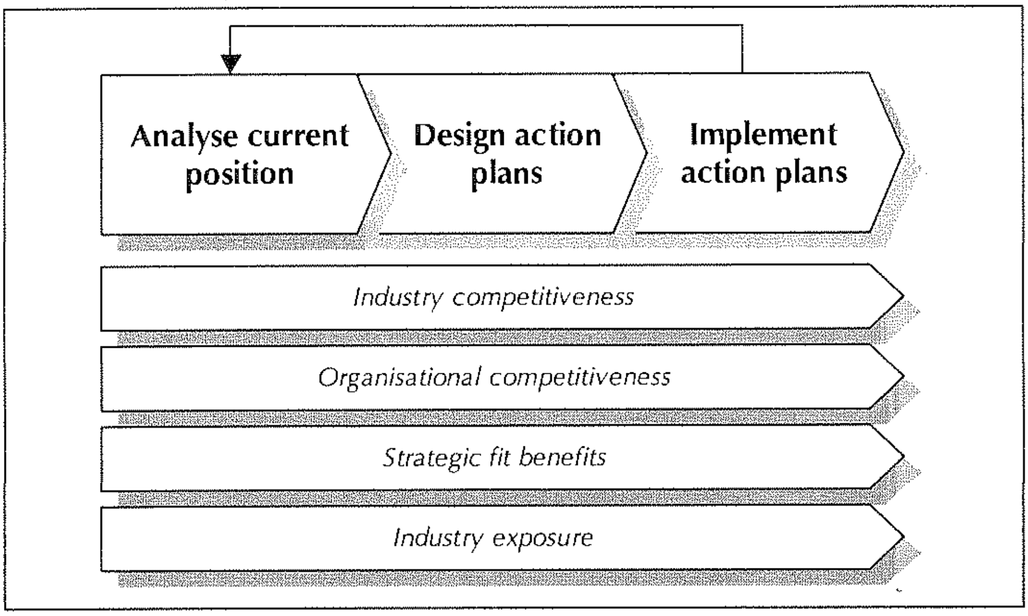

Figure 1: A strategic industrial engineering process

Fundamental corporate strategies are proposed based on applying the *Strategic Industrial Engineering Process* as a strategic tool. These corporate strategies are based on the following, as indicated in Figure 2:

- Organisational competitiveness;
- industry competitiveness; and
- cost of equity.

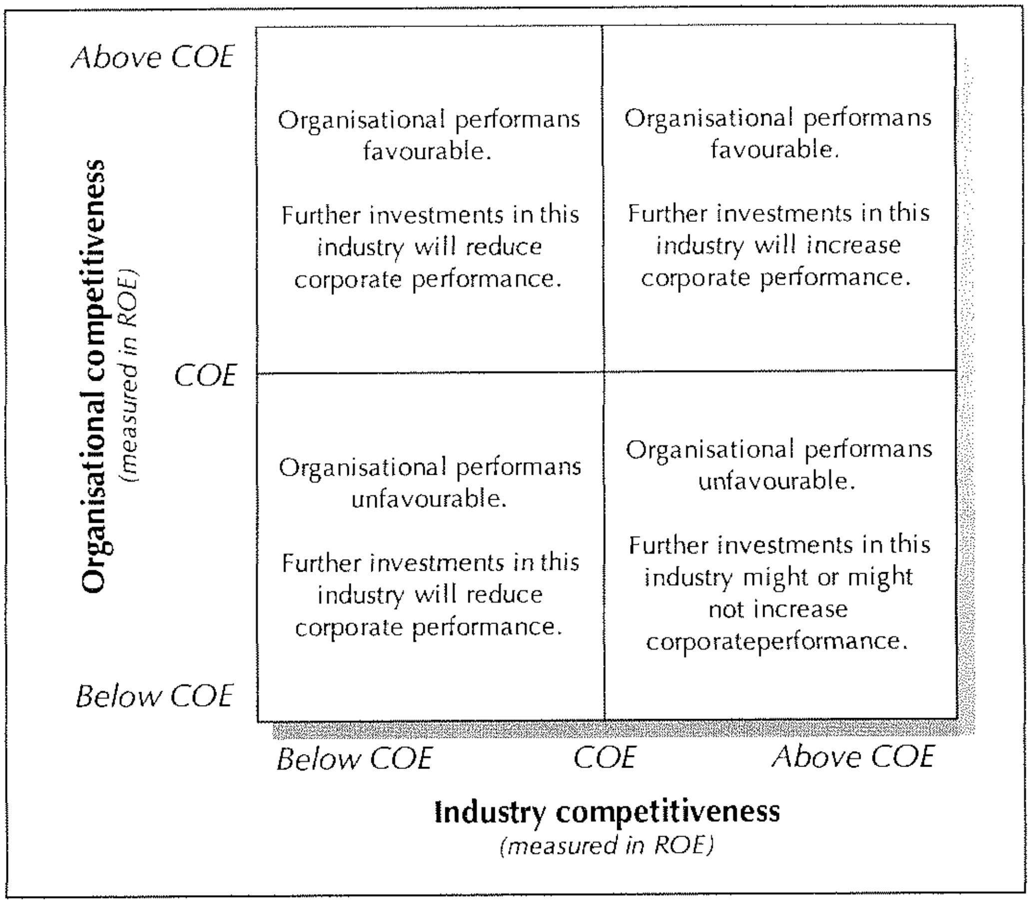

Figure 2: Base for corporate strategies

In Figure 3 it is illustrated that the following performance-regulating principles influence the accumulation of capital (ROE) for the benefit of capitalistic corporate shareholders:

- The competitiveness of its individual organisations;
- the individual organisations' accumulation of capital relative to the cost of equity;
- the competitiveness of the industry structures that the corporation is exposed to; and

- strategic fit benefits that improve the corporate performance too more than the average performance of its individual organisations.

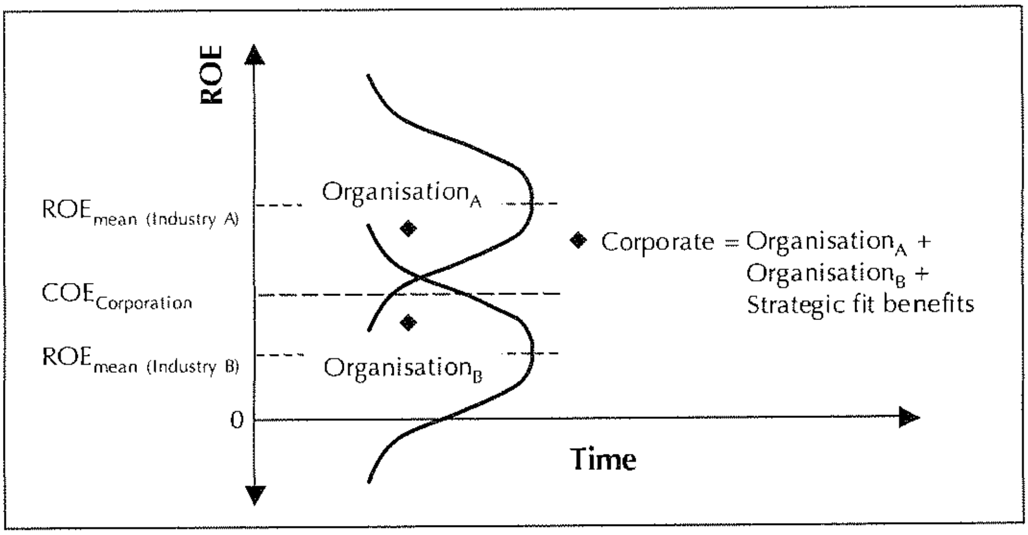

Figure 3: Corporate accumulation of capital

A corporation's accumulation of capital is influence by the positions of its individual organisations on the industry ROE life cycle. The proposed industry ROE life cycle is illustrated in Figure 4.

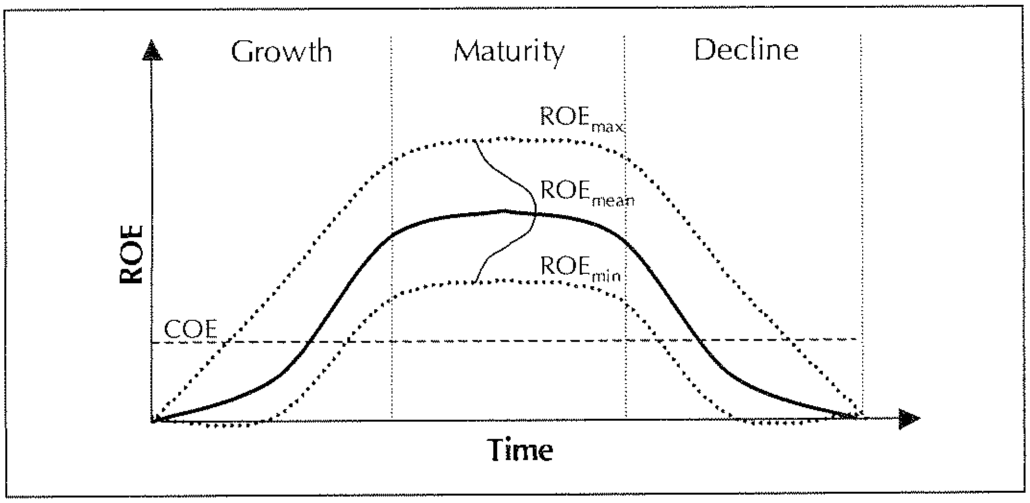

Figure 4: Industry ROE life cycle

Lastly, the foremost intent with this thesis is to establish and demonstrate a specific way of thinking about the role of *Industrial Engineering* in corporate *strategy*.

SAMEVATTING VAN PROEFSKRIF

'n STRATEGIESE BEDRYFSINGENIEURSWESE FILOSOFIE

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GRAAD:	Philosophiae Doctor (Ingenieurswese)

SLEUTELWOORDE: Strategiese bedryfsingenieurswese filosofie, Strategiese bedryfsingenieurswese; Strategiese bedryfsingenieurswese proses, Strategie, Bedryf, Bedryfsingenieurswese.

Die ekonomiese en produktiewe benutting van natuurlike hulpbronne is sentraal tot die wetenskaplike beginsels van bedryfsingenieurswese. 'n Kapitalistiese korporatiewe strategie het die groei van aandeelhouers se kapitaalbeleggings in kapitalistiese stelsels, soos organisasies en industrieë, ten doel. In die proefskrif word die volgende bevestig: *Bedryfsingenieurswese kan as 'n strategiese beginsel toegepas word om korporatiewe hulpbronne, soos organisasies in nie verwante industrieë,*

ekonomies en produktief te benut en sodoende die kapitalistiese korporatiewe doel te bereik. Die uitbreiding van die bedryfsingenieurswese veld word uitgedruk as *Strategiese bedryfsingenieurswese.* In Strategiese bedryfsingenieurswese word wetenskaplike ingenieurskennis toegepas op kapitalistiese stelsels met die strategiese doel om korporatiewe aandeelhouers se kapitaal te vermeerder.

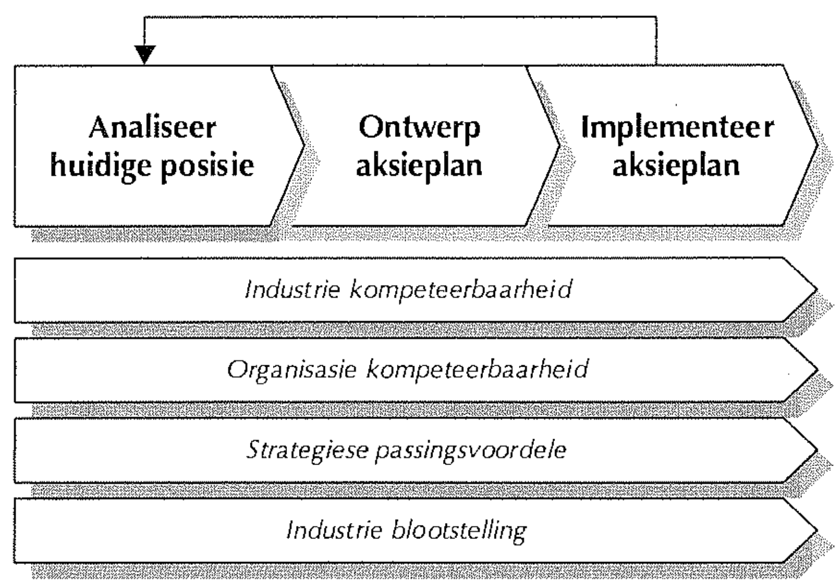
Die proefskrif se stelling, uitgedruk as; *'n Strategiese bedryfsingenieurswese filosofie,* word primêr geregverdig deur die toepassing van die filosofiese beginsel van genoegsame argumentering. Tweedens word hierdie uitgebreide veld van bedryfsingenieurswese ondersteun deur wetenskaplike raamwerke voortestel. Hierdie oplossing demonstreer die bereiking van die kapitalistiese korporatiewe doel. Dit word gedoen deur:

- Die wins op aandeelhouersbelang (ROE) te stel as die maatstaf waarteen die tempo van kapitaalvermeerdering gemeet word;
- 'n strategiese bedryfsingenieurswese proses, wat die strategiese bedryfsingenieurswese filosofie toepas om die kapitalistiese korporatiewe doel te bereik, voortestel vir verdere study. Hierdie proses is gebaseer op:
  - Die verwantskap tussen die fundamentele strategiese en ingenieurswese prosesse; en

- fundamentele korporatiewe prestasie-regulerings beginsels.

- die geldigheid van hierdie prestasie-regulerings beginsels word met behulp van eksploratiewe statistiek gedemonstreer.

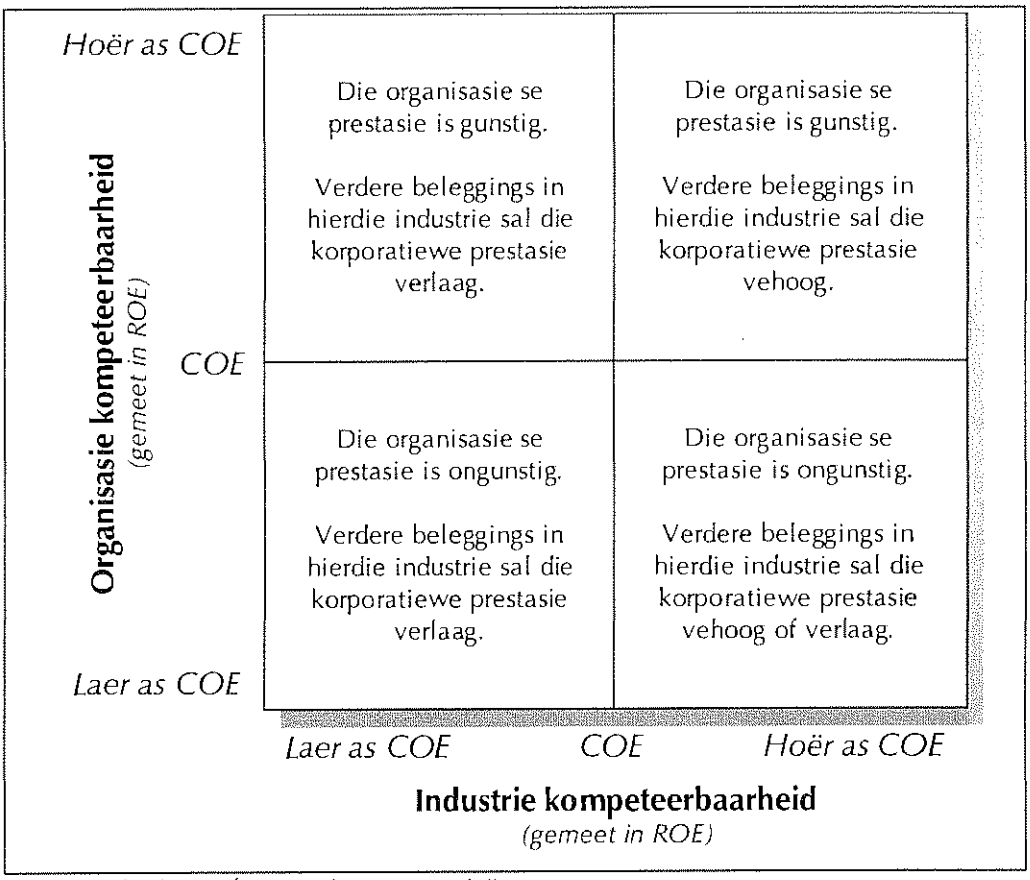
Die *Strategiese bedryfsingenieurswese proses* word voorgestel vir verdere studie in Figuur 1.



Figuur 1: Strategiese bedryfsingenieurswese proses

Fundamentele korporatiewe strategieë, wat gebaseer word op die aanwending van die strategiese bedryfsingenieurswese filosofie as 'n strategiese beginsel, word in die proefskrif gedefinieer. Soos voorgestel in Figuur 2 is hierdie strategieë gebaseer op:

- Organisasie kompeteerbaarheid;
- industrie kompeteerbaarheid; en
- die koste van kapitaal (COE).

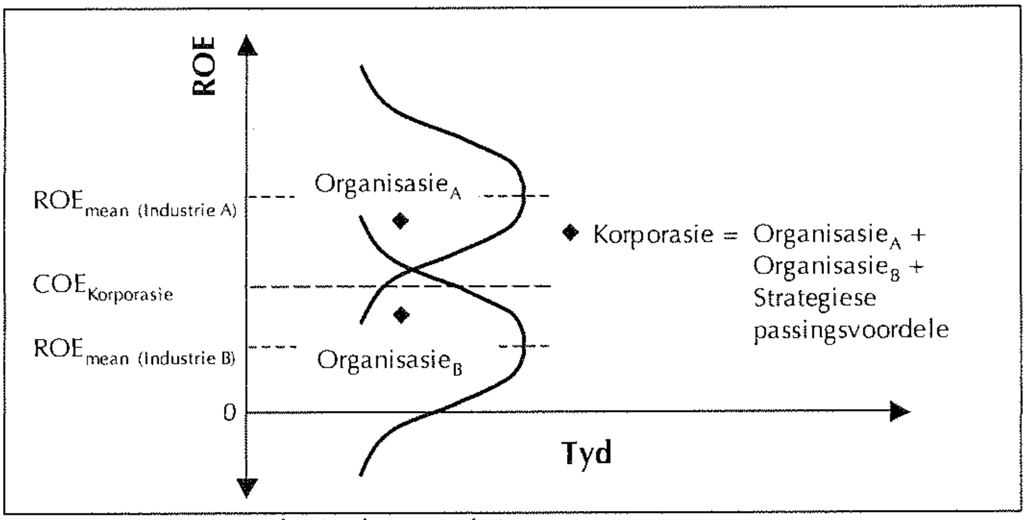


Figuur 2: Basis van korporatiewe strategieë

Figuur 3 illustreer die stelling dat die volgende prestasie-regulerende beginsels kapitaalvermeerdering (ROE), van die kapitalistiese korporatiewe aandeelhouers, beinvloed:

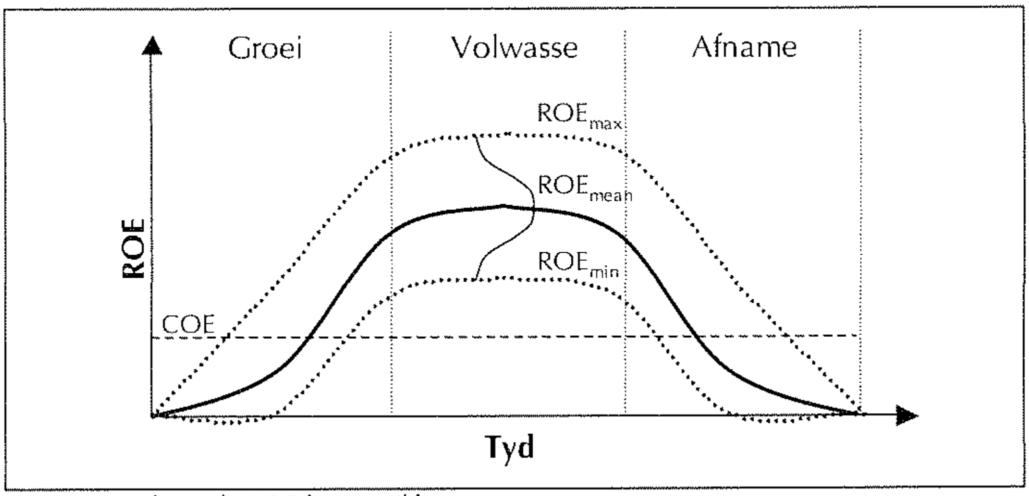
- Die kompeteerbaarheid van elke individuele organisasie van die korporasie;
- die kapitaalvermeerderingsvermoë van hierdie organisasie relatief tot die koste van kapitaal;
- die kompeteerbaarheid van die industriële strukture waaraan die korporasie blootgestel is; en

- strategiese passingsvoordele tussen die korporasie se organisasies wat die gemeenskaplike prestasie van die korporasie hoër maak as wat die som van die individuele organisasies se prestasies is.



Figuur 3: Korporatiewe kapitaalvermeerdering

Die korporatiewe kapitaalvermeerdering word verder beinvloed deur die posisie van die organisasies op die industriële ROE lewenssiklus. Die industriële ROE lewenssiklus word voorgestel in Figuur 4.



Figuur 4: Industriële ROE lewenssiklus

Laastens, die belangrikste bedoeling met hierdie proefskrif is om 'n spesifieke manier van denke, oor die rol van bedryfsingenieurswese in korporatiewe strategie, te vestig en te demonstreer.

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ACKNOWLEDGEMENTS

It is customary to acknowledge all sources in an academic writing by ending with an exhaustive bibliographic list and to provide up-front acknowledgement of its forbearers for their responsibility in the final result. In this, however, one fails to thank people appropriately for their contributions and it fails to mark the real sources of ideas so that readers may understand the origins of an academic manuscript. Perhaps our style is to revert to laundry lists because such origins are always difficult for the author to fully recognise. Although I will endeavour to personally thank those who in writing or in person have helped me to fashion this thesis, I would like to highlight the following contributions to the readers of this manuscript:

- Our Creator for making this possible;
- my wife and family, for their inspiration, support and sacrifices;
- professor Paul Kruger, for his guidance in fashioning this thesis;
- doctor Mellet Moll, for his contributions to this document and his mentorship in my personal development;
- professor Deon van Zyl and Mike van der Linde, Department of Statistics University of Pretoria, for the statistical analyses used in this thesis; and
- Bureau of Financial Analysis, for supplying the data used in this thesis.

PROLOGUE

"All men by nature desire to know."

Aristotle

For true academic scholars, life constitutes a journey in search of knowledge that is founded on unshakable truths. I believe this journey starts the day one opens one's eyes to the world. Seeing an unknown face to find that this is the face of one's mother, one's cornerstone for nourishment, security and comfort. Hordes of people might pass through life unaware of veiled mysteries and untold truths. They who do experience this realisation are the lucky few. This desire to know is the central theme throughout this thesis. My own desire to understand the inter-relationships between various spheres of life is to me, the foundation of this work.

In its existence mankind has, through the application of this knowledge, created various disciplines, each aimed at satisfying specific human needs. Viewed superficially, these disciplines might appear to be mutually exclusive. My perception is that unique people, with unique personal characteristics, exist within each of these disciplines. For example:

- Artists are primarily dreamers;
- theologists are primarily humanists;
- businessmen are primarily capitalists;
- medical practitioners are primarily philanthropists; and
- technologists are primarily intellectuals.

This observation, that these disciplines are mutually exclusive, is most likely exaggerated, as relationships and similarities between these disciplines do exist, although this is probably based on individual perception. Exploring the relationship between the disciplines of technology and business is the central idea of this thesis, as I am, in my professional capacity, involved in both the technical and business disciplines. The driving forces behind this desire to explore knowledge, and gain wisdom, within this specific intersect come from my experience and moulding through mentors, authors and role models.

Our existence consists of physical, emotional and intellectual activities. These intellectual activities are by and large involved in three spheres of knowledge that is aimed at satisfying mankind's curiosity with finding the truths of its existence. These three spheres of knowledge are:

- Mythology;
- philosophy; and
- science.

These spheres of knowledge are illustrated in Figure 5.

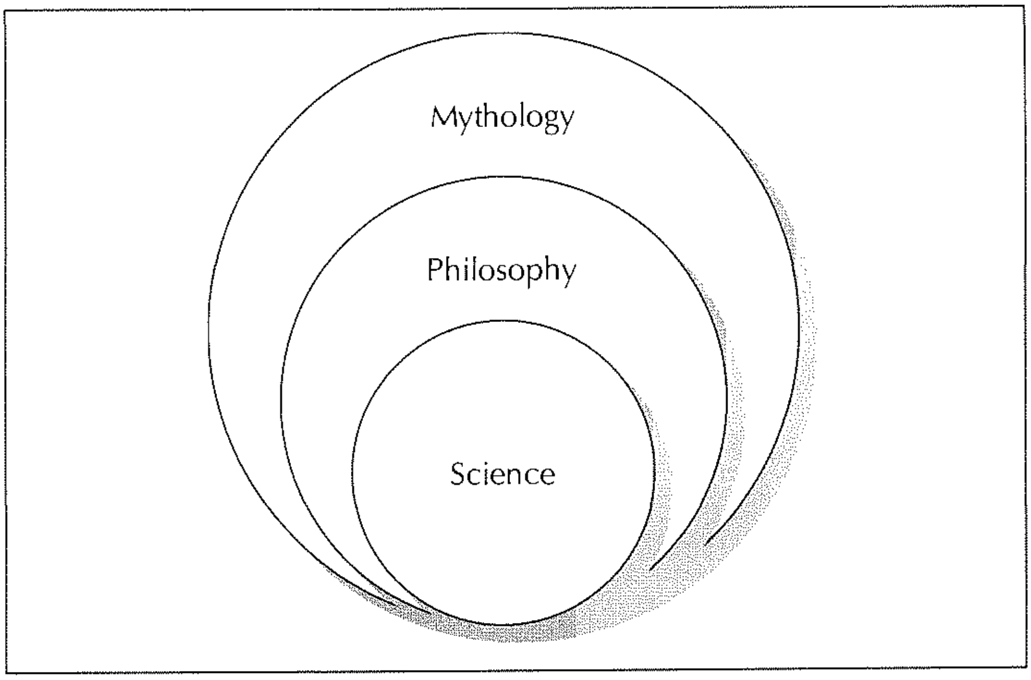

Figure 5: Spheres of knowledge

In this thesis, knowledge is primarily sought on a philosophical level, as opposed to mythology or science. As it is the foremost intent with this thesis to describe a specific way of thinking about the application of Industrial Engineering (technical) skills in corporate strategy (business) and by doing this expand our knowledge.

I hereby submit this thesis as my own original work.

Pierre Leonard

June 2003

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LIST OF EQUATIONS

CHAPTER 2 - IN SEARCH OF THE TRUTH

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CHAPTER 1 - OBSERVATION

"Humans, who are the servants and interpreters of nature, can act and understand no further than they have observed in either the operation or the contemplation of the method and order of nature."

Sir Francis Bacon

1 OBSERVING NATURE

The following observations, made in the subject areas of strategy (business) and Industrial Engineering (technical), lead to the inception of this thesis.

1.1 Strategy

The term *strategy* or its adjective *strategic*, was derived from the Greek word *stratos*, meaning *army* or *war*. The origins of the word *strategy* can also be traced to *strategos* referred to the role of a general in command of an army. Later it came to mean *the art of the general,* which is to say the psychological and behavioural skills with which *the general* occupies the role [Quinn: 64]. Military battles are won and wars are lost as a consequence of this *art of the general.* Therefore, these skills with which a general controls and manoeuvres his regiments or resources of war, influence the outcome of the battle [Griffith: 38].

By the time of Pericles (450 B.C.) the term *strategy* also came to mean managerial skill (administration, leadership, oration, power) [Quinn: 64], as competitive struggles between industry rivals are just as true for capitalistic organisations as it is for military regiments. Just as the general control the resources of war so too do the management control economic resources. The *art of the general* or *strategy* is employed by both to attain the spoils of rivalry [Grant: 36; Griffith: 38].

As much as society claims to be civilised, people will always engage in warfare, as the reason for warfare is the pursuit of a common goal by two or more opposing parties. Although the basis for warfare in the business environment is economic interaction between the organisation and its stakeholders, the philosophies around strategy remains the same as those proposed for warfare by the Chinese 2000BC [Griffith: 38].

The complexity of these behavioural skills required to control resources is escalating as capitalistic organisations find themselves in a transition from a physical to an intellectual economy [Grant: 36; Toffler: 96]. In modern corporations[1] the traditional definition of resources change as progressive corporations do not compete for their fortunes by merely operating and improving the means of production, but also by defining *corporate strategies* of [Grant: 36; Encarta: 61; Popenoe: 71]:

- Controlling the up- and downstream activities that influence their profitability;
- diversifying production to reduce the dependence on a single product or service in the marketplace; and
- acquiring industry competitors to reduce competition.

[1] *Conglomerate:* *Is a large company consisting of several unrelated organisations (firms) whose merger increases and diversifies company assets. [Hornby: 44; Encarta: 61]*

By observing these corporate strategies and related actions of mergers, consolidations and takeovers it is argued that *organisations* and *industries* can be defined as resources[2]. This statement is supported by the observation that progressive capitalistic corporations assess *organisations* and *industries* for investments in the same way as mining companies evaluate prospective mineral resources for potential investments.

1.2 Industrial Engineering

A posteriori[3] knowledge in scientific disciplines such as mechanics, electronics, chemistry and metallurgy is applied in fundamental engineering theory. This is done to develop ways of economically utilising natural resources for the benefit of mankind [Blanchard: 10].

These scientific, engineering, skills were extended to the mass production systems of the smokestack organisations of the industrial era through *Industrial Engineering*, which was conceived in the industrial revolution. The engineering emphasis shifted from economic utilisation to not only economic but also productive utilisation of natural resources (mass production systems) for the benefit of mankind [Smith: 87; Taylor: 93].

---

[2] *Resource:* *A supply of something that a country, an organisation or a person has and can use, especially to increase their wealth. [Hornby: 44]*

[3] *A Posteriori:* *Knowledge relating to that which is known through experience [paragraph 5.1.2, chapter 1] (Latin, "from what comes after"). [Hornby: 44; Encarta: 61]*

The fundamental aim of Smith's [87] *The Wealth of Nations* and Taylor's *The Principles of Scientific Management* [Davenport: 19; Taylor: 93], which laid the foundation for what is now termed *Industrial Engineering*, was to increase productivity by applying to human labour the same engineering principles that have proven so successful in solving the technical problems in the work environment [Blanchard: 10]. In the *Industrial Engineering* realm, these engineering skills are typically applied in the manufacturing environments on systems containing raw material input, machines, labourers and assembly or production lines. Industrial Engineering's association with the manufacturing environment stems from the inception of this discipline during the Industrial Age [paragraph 5.2.2, chapter 1] and hence the general association of the word industrial with manufacturing.

By observing Industrial Engineering it is argued that the development of this profession has been interrelated with the evolution of management and the approaches required by management to improve organisations. This observation leads to the following [Moll: 65]:

- Industrial Engineering is principally aimed at the improvement of industrial operations. Although it is often proclaimed to be applicable to other spheres as well, these opportunities have not yet been exploited to their full potential; and

- Industrial Engineering has grown from being aimed initially at the operational level to a strategic and corporate level, creating opportunities for greater impact.

1.3 Motivation

Integrating these observations made in the subject areas of strategy and Industrial Engineering is the motivation behind this thesis as it holds a further transition for Industrial Engineering to play a larger role in optimising and improving capital investments made by corporations into organisations and therefore industries. These observations lead to defining the proposition of this thesis in paragraph 2.2 of chapter 1.

2 PROPOSITION

2.1 Definition

In order to define the proposition, of this thesis, it is essential to begin by identifying what constitutes a *proposition,* as not all *sentences* constitute *propositions*. Sentences are linguistic items, as they either exist in natural languages such as English, or in artificial languages such as symbols or diagrams. However, the term *sentence* has two senses [IEP: 94]:

- *Sentence-tokens* are concrete objects existing in space and time. They are composed of ink marks on paper, sequences of sounds, patches of light on a computer monitor, etc [Dowden: 22]; and
- *sentence-types* cannot be located in space and time as they are abstract objects.

Propositions are abstract entities that do not exist in space and time and are sometimes said to be *timeless, eternal,* or *omnitemporal* entities [IEP: 94]. The essential point is that propositions are not concrete (material) objects, nor are they mental entities (*thoughts*) as Frege [Klement: 49] had suggested in the 19^{th} century. This notion can be argued by evaluating *truth* that which is to be derived from a proposition. Logicians have coined the term *truth-value* as a generic term for *truth or falsehood* [Dowden: 22]. To ask for the truth-value of P, is to ask whether

P is true or whether P is false. The theory that propositions are the bearers of truth-values has also been criticised, but as it is the more favoured theory that propositions, and not sentences, are the bearers of truth-values. This theory will be adopted in this thesis.

Declarative (indicative) sentences rather than interrogative or imperative sentences are used to express propositions. A proposition is customarily defined in modern logic as *what is asserted* when a sentence (an indicative or declarative sentence) is used to say something true or false, therefore to make a statement [Williamson: 43].

2.2 The proposition

The proposition, of this thesis, is: *The current philosophy of Industrial Engineering can be expanded beyond its current realm of engineering operational resources to incorporate the domain of strategic corporate resources, such as capitalistic organisations within unrelated industries.* This proposition is based on the observations and related motivation as defined in paragraph 1.3 of chapter 1.

This expanded philosophy of Industrial Engineering is termed *A Strategic Industrial Engineering Philosophy* and can be rationalised by contextually defining each of its fundamental elements as follows:

- *Strategy* meaning the psychological and behavioural skills with which capitalistic corporations control resources [paragraph 1.1, chapter 1];
- *industrial* refers to two principles:
  - *Industry* as a group of related capitalistic organisations competing for the same market demand, through the production or supplying of goods, services or other sources of income [paragraph 1.1, chapter 1]; and
  - *industrial* in the context of Industrial Engineering [paragraph 1.2, chapter 1];
- *Industrial Engineering* meaning the scientific, engineering, knowledge applied in the economic and productive utilisation of natural resources for the benefit of mankind [paragraph 1.2, chapter 1]; and
- a *philosophy* meaning a set of fundamental arguments, axioms and ideas that provides the primary context within which this thesis aims to expand the science of engineering by exploring the scientific boundaries of Industrial Engineering philosophy [Prologue].

The primary aim of this thesis is therefore to philosophically expand the application of Industrial Engineering, as a strategic skill, to the economic and productive utilisation of corporate resources such as capitalistic organisations within unrelated industries. A secondary aim is to explore potential scientific frameworks that support this expanded philosophy of Industrial Engineering.

A logical breakdown of the proposition into its fundamental elements is indicated in Figure 2-1.

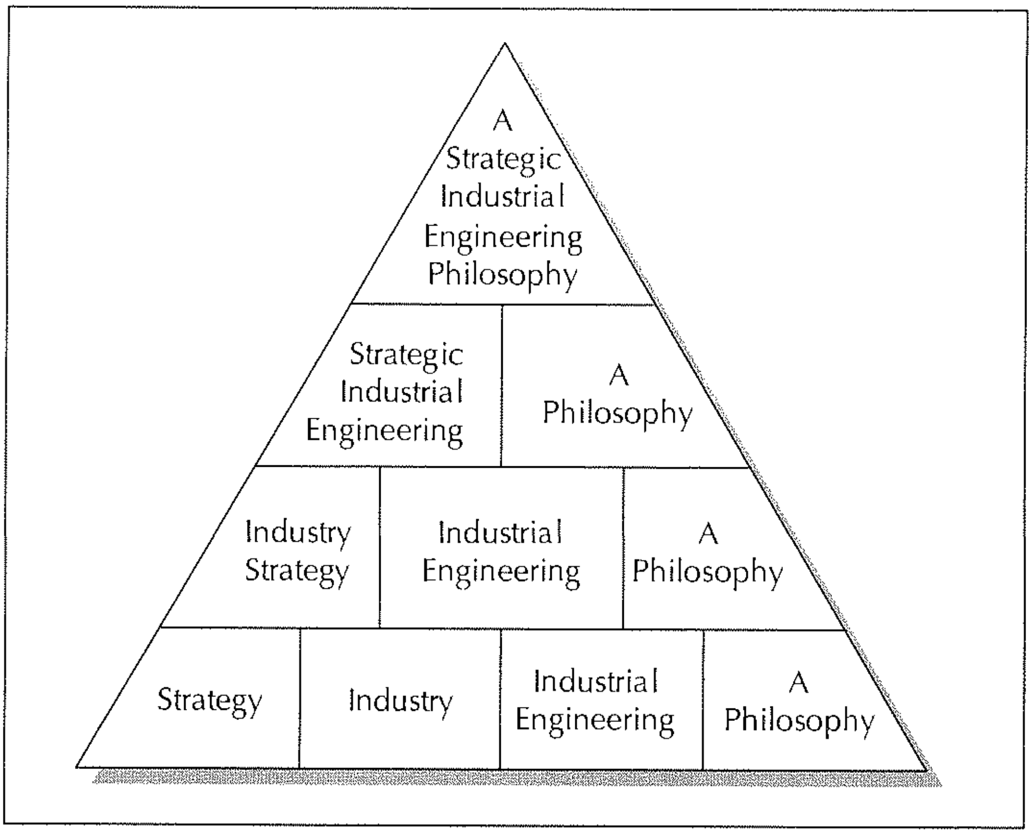

Figure 2-1: Fundamental elements of A Strategic Industrial Engineering Philosophy

3 RESEARCH

Cooper [16] describes research dimensions by classifying styles of thinking on two axes, illustrated in Figure 3-1. The horizontal axis ranges from a highly idealistic interpretation at the one end to empiricism at the other. The vertical axis ranges from rationalism at the one end to existentialism at the other. From this classification it is derived that research can be based on:

- Contradiction;
- case study or research;
- statistical analysis; and
- sufficient reasoning.

This thesis applies the following two approaches in researching the proposition:

- *Philosophical research* based on sufficient reasoning from existing truths, which is an integration of empiricism and rationalism; and
- *scientific research* based on a literature study and statistical analyses, which is an integration of empiricism and existentialism.

An adapted research classification matrix [Cooper: 16] is illustrated in Figure 3-1.

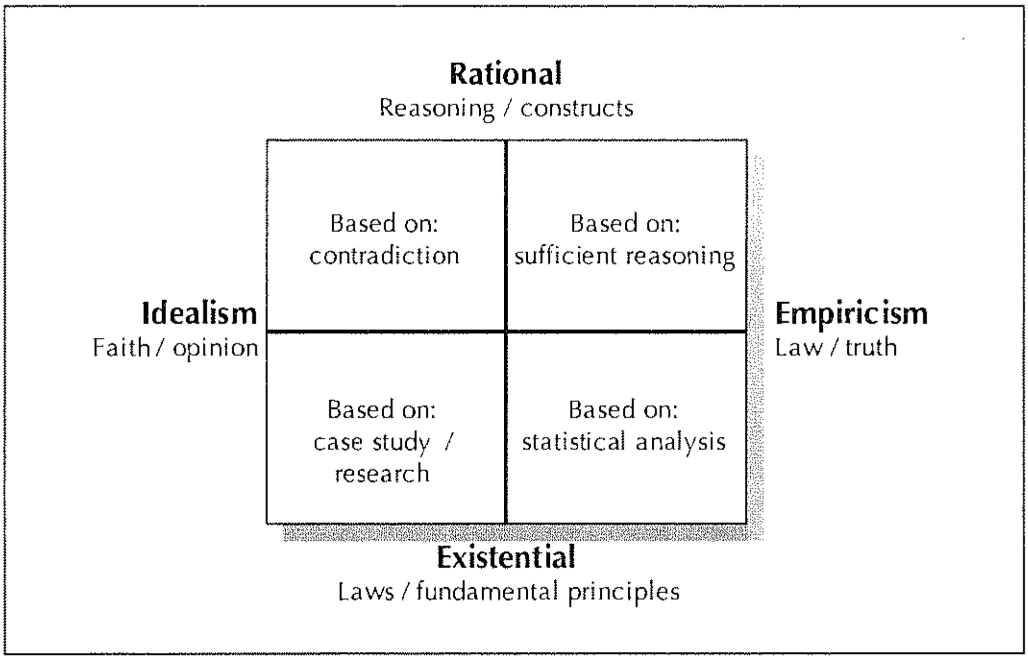

Figure 3-1: Research dimensions

3.1 Philosophical research

As sufficient reasoning is based on a process of reasoning conclusions from truths [Figure 3-1, chapter 1], it is essential to evaluate truth theories. This philosophical problem of truth has been with us for generations. In the 1st century AD, Pontius Pilate [John 18:38, The Bible] asked *"What is truth?"* but no answer was forthcoming. Considerable progress has been made in understanding the properties of truth in the last few centuries. The most important of these philosophical theories of truth are [Dowden: 22]:

- Correspondence theory;
- Semantic theory;
- Coherence theory;
- Pragmatic theory; and
- Deflationary theory.

3.1.1 Correspondence theory

Truth, according to the Correspondence Theory, is presumably what valid reasoning preserves. Historically correspondence theory was the most popular theory of truth. First proposed in a vague form by Plato in *The Republic* and by Aristotle in *Metaphysics*, this realist theory states that truth is what propositions have by corresponding to a way the world is, therefore a proposition is true provided there exits a fact corresponding to it [Dowden: 22; Rundle: 43]. In other words, proposition P is true if and only if P corresponds to a *fact*. According to this theory truth is a certain relationship that holds between a proposition and its corresponding fact.

3.1.2 Semantic theory

Tarski [92] captured what he considered to be the essence of the correspondence theory of truth by creating the Semantic Theory. It seeks to preserve the core concepts but without the problematic conceptual baggage of semantic paradoxes [Lowe: 43]. Tarski [92] wants his theory to reveal the logical structure within propositions that permits valid reasoning to preserve truth [Dowden: 22]. In other words the proposition A or B is true if and only if:

- Proposition A is true; or
- proposition B is true; or
- both proposition A and proposition B is true.

3.1.3 Coherence theory

The correspondence theory and the semantic theory account for the truth of a proposition as arising from a relationship between that proposition and features or events in the world. Coherence Theory, in contrast, accounts for the truth of a proposition as arising out of a relationship between that proposition and other propositions. A statement is therefore true if it coheres with other statements, false if it does not [Wolfram: 43]. Coherence theories help to explain how the truth was revealed and therefore knowledge derived [Dowden: 22]. Specifically, a Coherence Theory of truth will claim that a proposition is true if and only if it coheres with a *logical consistency*.

3.1.4 *Pragmatic theory*

A pragmatic theory of truth holds that a proposition is true if it is *useful to believe*. According to pragmatists [Dowden: 22], truth is what an ideally rational inquirer would in the long run come to believe. Truth is therefore the ideal outcome of a rational inquiry. The notion of truth as a relation of correspondence between belief and reality is not rejected but clarified by reference to actions, future experiences, etc. Each of the pragmatists, including Pierce, James and Dewey, has a distinctive way of carrying out this practical clarification [Hare: 43].

3.1.5 *Deflationary theory*

The deflationary theory, supported by Ramsey [Davidson: 43], denies the assumption, used by all the other mentioned theories, that a proposition is true if the proposition has some property like correspondence with the facts, satisfaction, coherence or utility [Dowden: 22]. Roughly it can be summarised that the deflationary theory advocates that:

- The concept of truth is redundant except as an indirect reference point; and
- ascribing truth to a proposition does not characterise the proposition, it is revealing something of the speaker's intentions.

3.1.6 Applied methodology

Philosophical discussions of truth have been bedevilled by the question, *"How could a proposition be true unless we know it to be true?"* For a proposition to be accepted, it must at least be a justified belief [Dowden: 22]. Justification, unlike truth itself, requires a special relationship among propositions. Foundationalism is a theory about the structure of justification that affirms that some beliefs are fundamental, i.e. justified without being based on other beliefs. Justified non-basic beliefs are based on these foundations through good inferences or reasoning [Goldman: 43]. Thus for a proposition to be justified it must at least cohere with other propositions that one has approved. On this account, coherence among propositions plays a critical role in the theory of knowledge. The principle of justification, thus foundationalism and coherence, is therefore applied in this thesis, as this logical principle will help to reveal how the thesis derives its truths and therefore creates knowledge.

Leibniz [Burnham: 11], a supporter of the coherence theory, identified truth as a proposition in which the predicate[4] is contained within the subject[5]. This idea of truth seems straightforward as it is now commonly

[4] *Predicate:* *That which is asserted. [Burnham: 11]*

[5] *Subject:* *That which is asserted about. [Burnham: 11]*

called *analytic propositions*, for example *P=P*, which is a basic logical truth, therefore a fact.

Leibniz further argued [Burnham: 11] that the predicate is not just contained in the subject it is the subject, being contained is implicitly or virtually the case with other truths. For example the statement *Jupiter is the sixth planet from the Sun* will usually be taken to be true only because it refers to a real world, in which Jupiter is, *in fact*, the sixth planet from the Sun. But Leibniz would analyse this as follows: If everything there was to know about Jupiter were known, that is, if a *complete concept* of Jupiter was known, it would also be known (among many other things) that Jupiter is the sixth planet from the Sun, at the moment. Therefore, the statement *Jupiter is the sixth planet from the Sun* is true not primarily because of some reference to the world, but because a *complete concept* of Jupiter is known, which is the subject of the proposition, and that *complete concept* contains (as a predicate) Jupiter being the sixth planet from the Sun. It may be the case that it happens to be known that *Jupiter is the sixth planet from the Sun* because reference was made to the world. But the fact that this discovery about Jupiter was made in this way does not make the statement that *Jupiter is the sixth planet from the Sun* true and therefore a piece of knowledge because of that reference.

Leibniz [Burnham: 11] also claimed that if a statement is true, it is true irrespective of time and space. Therefore, the statement *Jupiter is the sixth planet from the Sun*, made on 1 January 2002, was also true a million years ago and will be true a million years from now, even though Jupiter might not be there then. As any truth proposition is defined in the same way, the predicate is contained in the subject, it only takes a little thought to realise that for any subject, like *Jupiter*, the number of predicates that are true for *Jupiter* will be infinite or at least very large as they must include everything that did or will ever happen to *Jupiter*.

Leibniz [Burnham: 11] argued that one predicate or set of predicates explains another. Therefore many of the predicates that are true of a subject give the full picture (cohere) as a network of explanations. Leibniz [Burnham: 11] continued that for *every* predicate that is true of a subject, there would be a set of other true predicates, which constitute a *sufficient reason* for it being true. This principle holds that nothing is without a reason for it being and for being as it is [Grayling: 43]. This, he called *the principle of sufficient reason*. Unless this was true, Leibniz feels, the universe would not make any sense and science and philosophy both would be impossible [Remnant: 80].

The principle of *sufficient reason* must not only apply to each predicate in the complete concept of a subject, but also to the concept itself in its entirety as the concept of an *existing* thing. The totality of contingent things themselves does not explain themselves. There must be, Leibniz [Burnham: 11] insisted, something *outside the totality of contingent things* that explains them, something that is itself necessary and therefore requires no explanation other than itself [Grayling: 43]. Therefore to prove a proposition true by sufficient reasoning, it must be reasoned from an *existing truth*.

To summarise, Leibniz [Burnham: 11] argued that knowledge is based on the following two kinds of truths:

- Truth based on facts, therefore existing truths; and
- truth based on sufficient reason.

As virtually all theorists agree that a true proposition is a necessary condition for knowledge [Honderich: 43], this thesis applies the principle of sufficient reasoning from existing truths to create knowledge from its proposition.

4 THESIS FRAMEWORK

Kolb's [50] learning cycle is used as a model to the framework of this thesis. The learning cycle distinguishes between the following four phases in creating knowledge [Kolb: 50]:

- A question arises through reflection on the current reality of a situation (reflective observation);
- an abstract model or theory is constructed (abstract conceptualisation);
- the theory is tested (active experimentation); and
- the effects of the experiment are examined (concrete experience).

The phases of learning, according to Kolb [50], are shown in Figure 4-1.

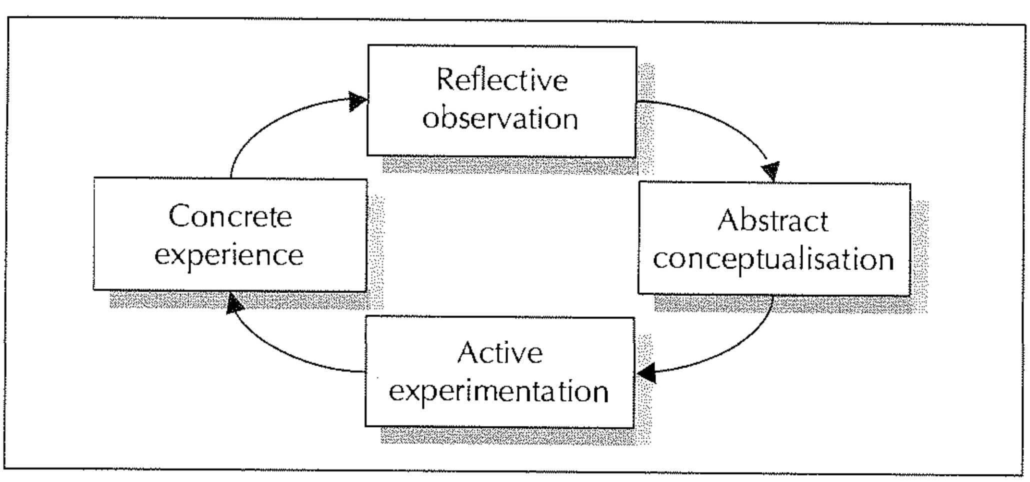

Figure 4-1: The learning cycle

This inductive, a posteriori, approach applies observation and experiences from *observation* to *reflection*. The framework also needs to support the primary research approach of *sufficient reasoning* based on *existing truths*. The framework of the thesis is therefore based on the integration of the learning cycle model and the primary research approach. This leads to the following four chapters with a prologue being added:

- Prologue;
- Chapter 1 – Observation;
- Chapter 2 – In search of the truth;
- Chapter 3 – Sufficient reasoning; and
- Chapter 4 – Reflection.

4.1 Observation

The first chapter is termed *Observation* and serves as introduction to the thesis. This term *observation* is derived from the first phase of the British Empiricists inductive, a posteriori, approach. Bacon [IEP: 94], hailed the primacy of experience, particularly the observation of nature, as the basis for acting and understanding. In general terms, by using the term *observation* in this thesis, one considers the circumstances, context and / or merits of a specific situation or current reality. It is in this sense that the term is used.

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4.2 In search of the truth

Chapter 2 is termed *In search of the truth* and independently researches the basic element of the proposition to define their existing truths. This chapter also serves as a literature study to the thesis. To establish the existing truths this chapter researches the basic elements of the proposition on the following two research levels:

- Philosophical level, termed *Academia* [paragraphs 5.3, chapter 1], philosophically researches the existing truths of the proposition's basic elements through the timeline of ages; and
- scientific level, termed *Principia* [paragraph 5.4, chapter 1], scientifically researches the existing truths of the capitalistic organisational goal to support its philosophical truths.

4.3 Sufficient reasoning

Chapter 3 is termed *Sufficient reasoning* and serves as the justification of the proposition of the thesis. The philosophical principle of sufficient reasoning is applied to argue the proposition, based on the existing truths within strategy, industry and Industrial Engineering that is defined in chapter 2. Knowledge is created by justification of the proposition through reasoning the proposition from its existing truths. The principle of sufficient reasoning will be applied on the following two levels:

- Philosophical level, termed *Academia* [paragraphs 5.3, chapter 1], applies the principle of sufficient reasoning on the existing truths, contained within each of its basic elements of the proposition [paragraph 2, chapter 2], to establish a true proposition; and
- scientific level, termed *Principia* [paragraph 5.4, chapter 1], applies science to support the philosophically justified proposition that Industrial Engineering can be used as a strategic skill to achieve the capitalistic organisational goal [paragraph 3, chapter 2].

4.4 Reflection

Chapter 4 is termed *Reflection* and serves as the conclusion to the thesis. The title is derived from the final phase of the British Empiricists inductive, a posteriori, approach [Bacon: 94].

4.5 Layout

The layout of this thesis is summarised as:

- In *Chapter 1 – Observation* (or introduction) the circumstances, context and/ or merits of the proposition of the thesis are defined;
- *Chapter 2 – In search of the truth* (or literature study) has two levels:
  - In *Level I – Academia* the existing truths of the basic elements of the proposition are defined; and

  - in *Level II – Principia* the existing truths of the capitalistic organisational goal are scientifically defined to support the findings in level I.

- *Chapter 3 – Sufficient reasoning* (or justification) has two levels:
  - In *Level I – Academia* the principle of sufficient reasoning is applied to justify the proposition and by doing this create new knowledge; and
  - in *Level II – Principia* the fundamental performance regulating principles contained within Strategic Industrial Engineering are statistically analysed to support the reasoning of level I.
- In *Chapter 4 – Reflection* (or conclusion) the findings of this thesis are summarised.

5 TERMINOLOGY

The following terms are referred to in the thesis and to ensure that they represent the required meaning their origins and/or definitions are elaborated upon. These terms or term categories are:

- Acquiring knowledge;
- timeline;
- Academia; and
- Principia.

5.1 Acquiring knowledge

There are three terms used to describe the ways in which philosophers argue that humans acquire knowledge [Encarta: 61; Lowe: 43; IEP: 94]:

- A priori;
- a posteriori; and
- synthetic a priori.

5.1.1 A priori

A priori (Latin, *from what comes before*) knowledge is acquired irrespective of experience, therefore by deductive reasoning alone [Encarta: 61]. Continental rationalists maintained that knowledge comes from foundational concepts known intuitively through reason, such as innate ideas [IEP: 94]. Other concepts are then deductively drawn from these. *A priori* is a term used to identify this type of knowledge that is obtained independently of experience [IEP: 94]. A proposition is accepted *a priori* if, when judged true or false, one does not refer to experience [Lowe: 43; IEP: 94]. *A priorism* is a philosophical position maintaining that our minds gain knowledge independently of experience through innate ideas or mental faculties. For Aristotle [IEP: 94] *a priori* referred to something, which was prior to something else. By prior he meant that something's existence was caused by the existence of another. Aristotle argued that to have knowledge of a prior thing was to have knowledge of a causal relationship.

5.1.2 A posteriori

A posteriori (Latin, *from what comes after*) knowledge relates to that which is known through experience [Encarta: 61; IEP: 94]. The 18th century philosophical movement in Great Britain, refers to as British Empiricism, maintained that all knowledge comes from experience

[IEP: 94]. British Empiricists staunchly rejected the theory of innate ideas and argued that knowledge is based on both sense experience and internal mental experiences, such as emotions and self-reflection. They, the British Empiricists, took their cue from Bacon who acclaims the superiority of experience, particularly the observation of nature. Bacon [Lowe: 43; IEP: 94] grounded the human understanding in observation and experience, which leads to a harsh rejection of the popular Aristotelian *a priori*, deductive method. The alternative that he proposed is an inductive approach – *a posteriori*. According to Bacon observations and experience should be collected and analysed to gain knowledge so as to act on the most reliable facts.

5.1.3 Synthetic a priori

A third type of knowledge is gained by reflecting on the nature of rational experience. It expresses the categories that the mind necessarily has to impose on its sensations in order to organise them into rational experience. Since the time of Kant, one of the most frequently argued questions in philosophy has been whether or not such a thing as synthetic a priori knowledge really exists [IEP: 94].

5.2 Timeline

As discussed in paragraph 3 of this chapter, knowledge is acquired through establishing a true proposition and therefore this thesis will justify its proposition through the principle of sufficient reasoning, which is founded on existing truths that is true irrespective of time and space. To ensure that the proposition is based on timeless (unchanged) truths, a timeline is included in the research framework.

According to Toffler [96,97], human history, although being complex and contradicting, can be seen to fit patterns. These patterns are evident throughout the evolution of humanity in concepts including society, culture, the media, organisations, science, computers, politics, economics etc. Toffler's wave theory is used as a base to establish a standard reference timeline within which this thesis could research timeless truths. The central premise of Toffler's [96,97] Wave Theory holds the pattern of three great advances or waves of change:

- Agricultural age (10th millennium BC to 18th century AD);
- Industrial age (18th century AD to 20th century AD); and
- Systems age (20th century AD to the present day).

5.2.1 Agricultural age

The first wave of transformation began when some prescient person about 10,000 years ago planted a seed and nurtured its growth. The significance of the age of agriculture (agricultural revolution) was that people moved away from nomadic wandering, hunting, gathering and foraging and began to cluster into villages to develop the culture of the great peasant societies of the past [Toffler: 96,97].

5.2.2 Industrial age

The Second Wave of change, triggered by the Industrial revolution some 300 years ago, gave rise to a new factory-centred civilisation, an expression of machine muscle and gathered steam after America's Civil War. People began to leave the peasant culture of farming to come to work in city factories. It is still spreading in some parts of the world as hundreds of millions of peasants, from Mexico to China, flood into the cities searching for minimal-skill jobs on factory assembly lines [Toffler: 96,97].

5.2.3 Systems age

Just as the machine seemed at its most invincible, countries started feeling the impact of a gathering third wave, based not on muscle but on mind. This is variously called the information or the knowledge age. The Third Wave Information Society is more than just technology and economics. It is not just *digital* and *networked.* Painful social, cultural, institutional, moral and political dislocations accompany this transition from a brute force to a brain force economy and a social demand worldwide for greater freedom and individuation. The *Third Wave* helps to explain why so many industrial age institutions, from giant corporations to governments, are dinosaurs gasping for their last breathe. *"This might be the reason why the United States of America is suffering from simultaneous crises in everything from education system, the health system, and the family system to the justice system, and the political system. They were designed to work in a mass industrial society"* [Toffler: 96,97].

5.3 Academia

Academia was originally a public garden or grove in the suburbs of Athens, named after Academus or Hecademus, who left it to the citizens for gymnastics [Encarta: 61; Griffin: 43; IEP: 94]. Few retreats could be more favourable to philosophers and the early thinkers. Within this enclosure Plato possessed, as part of his patrimony, a small garden, in which he opened a school for the reception of those inclined to attend his instructions. Hence arose the *Academic* sect and consequently the term *Academy* has descended to our times. The name *Academia* is frequently used in philosophical writings, especially in Cicero, as indicative of the Academic sect [IEP: 94]. This thesis refers to *Academia,* in its purest sense, as the context of philosophical facts and reasoning, as opposed to the popular, and often misdirected, use of the term as a collection of study material.

5.4 Principia

Newton's most famous publication *"Philosophiae Naturalis Principia Mathematica (Mathematical Principles of Natural Philosophy)",* commonly known as *Principia,* contains all his laws of motion and theories of tides and gravitation [Hall: 61; Rouse Ball: 82]. In this book Newton applied the theory of coherence by proving his theorems through reasoning from fundamental principles and therefore deriving laws of nature (knowledge). This thesis refers to *Principia* in context of scientific facts and reasoning.

CHAPTER 2 - IN SEARCH OF THE TRUTH

"I want to know how God created the world. I am not interested in this or that phenomenon, I want to know his thoughts. The rest are detail."

Albert Einstein

1 SEARCHING FOR THE TRUTH

1.1 Introduction

The first step in creating knowledge is to define existing truths, as these are the foundations for justifying a proposition [paragraph 3.1.6, chapter 1]. In this chapter, these existing truths contained within *A Strategic Industrial Engineering Philosophy* are examined by researching the proposition's fundamental elements [paragraph 2.2, chapter 1] on two levels:

In *Level I – Academia,* the existing truths of this thesis's proposition are philosophically researched through the evolution of its fundamental elements. Each element is philosophically researched according to a representative timeline in order to find the truth irrespective of time and space [paragraph 3.1.6, chapter 1], therefore to determine its existing truths. These fundamental elements are:

- Strategy;
- industry; and
- Industrial Engineering.

In *Level II – Principia,* the existing truths of the capitalistic organisational goal that support the philosophical truths, as defined in level I –

Academia, are scientifically researched. Therefore level II - Principia defines the scientific fundamentals of the capitalistic organisational goal.

1.2 Layout

The layout of this chapter is summarised as:

- In *Level I – Academia* the existing truths of the proposition are philosophically researched through the use of evolution timelines. The following two areas are researched:
  - In *Strategy,* the existing truths contained within strategy and industry are researched. *Strategy* is researched in the context of the capitalistic environment. The existing truths of *Industry,* in the context of capitalistic industries, are also identified. The existing truths of strategy are summarised in paragraph 2.4, of chapter 2; and
  - in *Industrial Engineering,* the existing truths contained within engineering and specifically Industrial Engineering are researched. The existing truths of Industrial Engineering are summarised in paragraph 2.8 of chapter 2.

- In *Level II – Principia* the achievement of the capitalistic organisational goal is scientifically analysed by researching the *measurement* of the capitalistic organisational goal and various capital accumulation ratios are evaluated. The peripheral concepts of weighted average cost of capital and capital structure that influence the measurement and its interpretation are also researched. The existing truths of *measuring* the capitalistic organisational goal are summarised in paragraph 3.5, chapter 2.

2 LEVEL I – ACADEMIA

2.1 Strategy

To set the term *strategy* in perspective of this thesis, its context is defined as; *strategy applied by the capitalistic corporation* [paragraph 2.2, chapter 1]. Defining the existing truth of *strategy* within this context requires a framework. Dimensions, for such a framework, are derived from the concept of cybernetics[1], as it is proposed that *strategy,* within the capitalistic organisational context, can be viewing as a cybernetic system.

This is based on the principle that cybernetics views goal orientated organisational systems as feedback control cycles [Weiner: 104]. *Strategy* is defined as [Oxford: 44]: *The art of formulating a series of manoeuvres to obtain a specific goal.* Strategy, in the capitalistic organisation, is aimed at achieving the capitalistic organisational goal and is therefore part of a goal orientated organisational system.

The existing truths of *Industry*, or its adjective *Industrial,* are researched in the context of capitalistic industries [paragraph 2.2, chapter 1]. These

[1] *Cybernetics:* *(Greek from kybernētēs meaning "steersman" or "governor"): Interdisciplinary science dealing with communication and control systems in living organisms, machines and organisations. [Hornby 44; Encarta 61]*

truths are derived from the research done on the context of strategy as defined above.

It is proposed that strategy, within this context, be viewed as a cybernetic system as illustrated in Figure 2-1.

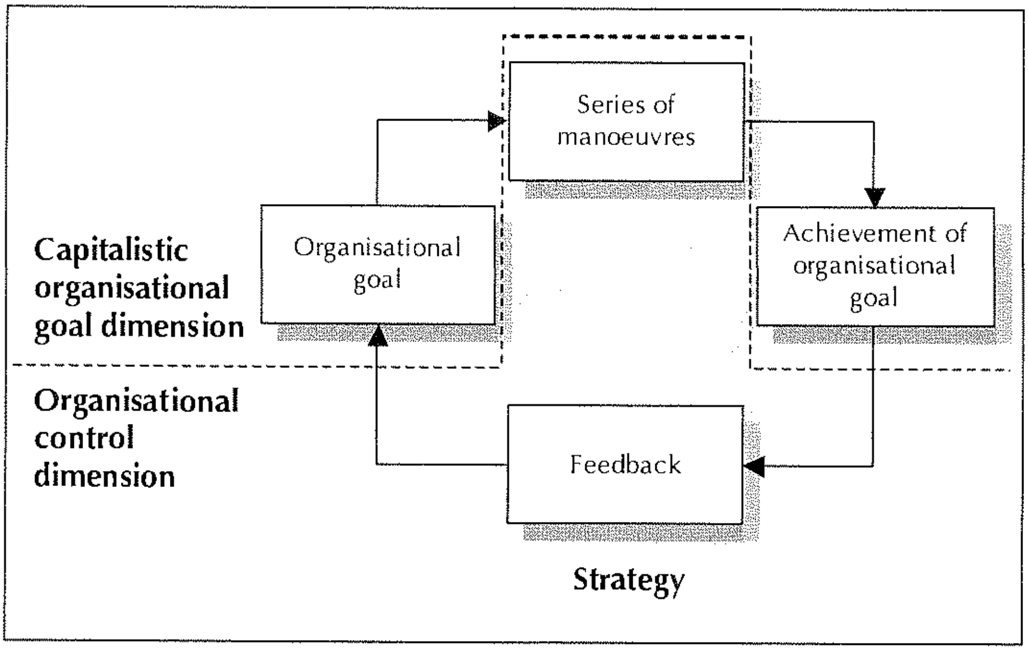

Figure 2-1: Cybernetic dimensions of strategy

The two dimensions that influence the existing truths of *strategy*, within the context of a capitalistic corporation, are derived from the cybernetic system. These two dimensions are:

- The concept of a capitalistic goal orientated organisation; and
- a series of manoeuvres and a feedback control cycle that controls the achievement of the organisational goal.

Based on this framework, the existing truths of the capitalistic organisational *strategy* are derived from the following:

- The existing truths of the *capitalistic organisational goal,* by researching the evolution of the organisation goal through economic systems in paragraph 2.2 of chapter 2; and
- the existing truths of *organisational control,* by researching the evolution of behavioural skill employed to control the achievement of the organisation goal in paragraph 2.3, chapter 2.

2.2 Capitalistic organisational goal

The term *economic system* (economy) is defined as the science of allocating or utilising scarce or limited resources [Stalin: 88; Toffler: 96]. These economic systems vary from being based on exchange or barter to sophisticated financial calculations. Every known society has some sort of economic institution, as the economy is one of the most important human cultural universals [Popenoe: 71]. Economic systems must solve a number of problems, as resources, both natural and human, are limited, by governing the allocation and utilisation thereof [Stalin: 88; Toffler: 96]. The evolution of economic systems, which are known to history, are defined as the following five main types [Popenoe: 71; Stalin: 88]:

- Primitive communal systems;
- slave systems;
- feudal systems;
- capitalist systems; and
- socialist systems.

An adapted version of the evolution of economic systems is used as the timeline through which the evolution of the *capitalistic organisational goal* is researched in order to define the existing truths contained within this dimension of strategy. The last two types of economic systems, namely capitalist systems and socialist systems, have developed as alternatives to one another. The framework that is applied to analyse the development of the *capitalistic organisational goal* and its relationship to the evolution of economic systems excludes socialist systems as the context of this thesis relates to capitalist systems. However, socialist systems are briefly discussed. The timeline is further adapted by including references to Toffler's [96,97] wave theory.

This adapted timeline of the evolution of economic systems is illustrated in Figure 2-2.

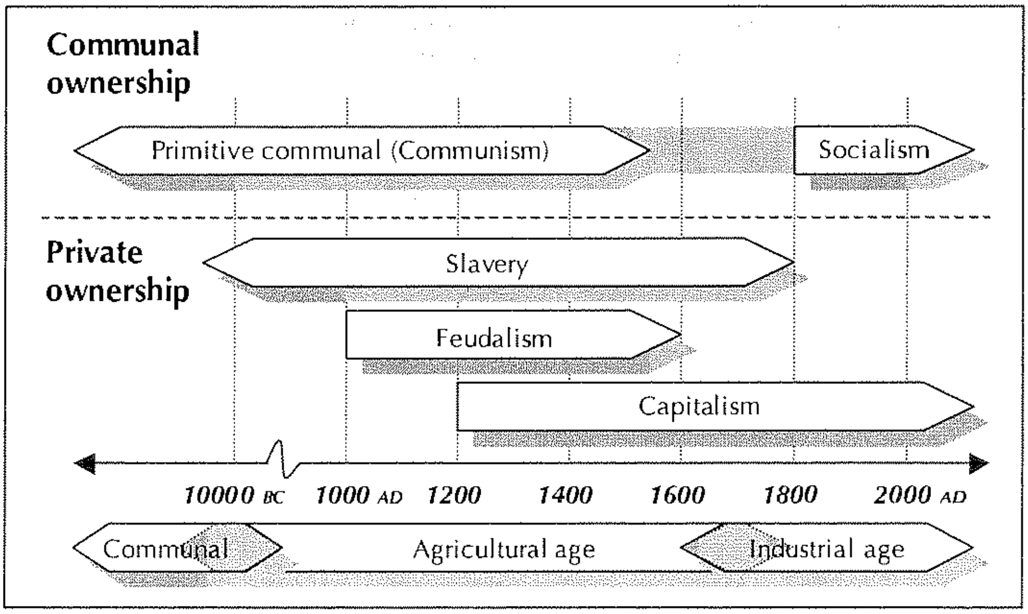

Figure 2-2:Timeline for the evolution of economic systems

2.2.1 *Primitive communal systems*

The primitive stone tools and later the elementary weapons of the ancient societies prohibited the possibility of men individually combating the forces of nature and beasts of prey [Stalin: 88]. In order to gather food or build some sort of habitation, men were obliged to work together if they did not want to die of starvation, fall victim to beasts of prey or neighbouring societies. These primary human requirements of food, shelter and security were the first common goals or special purposes around which groups formed, these special-purpose groups are called organisations [Etzioni: 71].

The economic system of the simplest historic societies rarely extended beyond the family. Labour was divided between the family members, who hunted, gathered, grew, harvested food and produced the basic necessities for survival. Little or no surplus of these commodities was left after their needs were met. In this subsistence economy, trade, marketing and taxation were non-existent. The basis of the relations of production under the *primitive communal system* is the notion that the means of production are socially owned [Sassoon: 61; Stalin: 88].

Organisations originated from the fundamental human requirement of survival. As human requirements transformed from an initial need to survive to more sophisticated needs [Maslow: 56] like growth, prosperity and regeneration so too did the special purposes change around which they rallied. As humans transform themselves in the pursuit of their needs, organisations transform themselves in order to reach new levels of achievement. The first fundamental goal that organisations pursue is therefore the ability to improve themselves, termed effectiveness [Moll: 65].

The relationship between organisational needs and effectiveness is illustrated in Figure 2-3 [Moll: 65]:

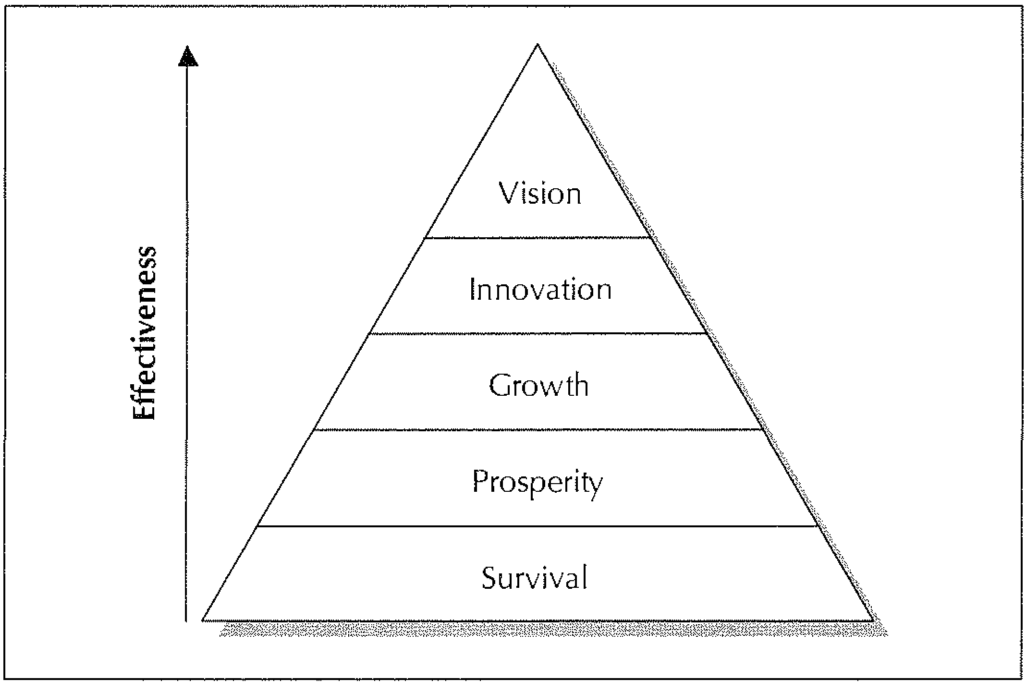

Figure 2-3: Organisational needs vs. effectiveness

2.2.2 *Slave systems*

The basis of the *slave system* is that slave-owners not only own the means of production, but also the workers in production *(slaves)* whom can be traded or killed as though they were objects [Stalin: 88]. Ethnic differences often occurred between slave-owners and slaves and slavery is often founded upon a strong racially prejudiced belief that the ethnic group to which the slave-owner belongs is *superior* to that of the slaves [Encarta: 61].

Society evolved from stone tools and the primitive husbandry of hunters to metal tools, pasturage, cultivation and handicrafts of the agricultural age. Land was exclusive and moderated wealth [Toffler: 96,97]. Farmers most probably began by noting which wild plants were edible or otherwise useful and learned to save the seed and to replant it in cleared land. Extended cultivation of the most prolific and hardiest plants yielded a stable strain. Herds of livestock were assembled from captured young wild animals and those with the most useful traits, such as small horns and high milk yield, were bred [Encarta: 61].

Domestication of plants and animals, in the agricultural revolution, increased the potential of producing surplus goods. Organisations (social groups) found that by focusing on certain crops, more could be produced and these surpluses of production lead to the exchange of products between individuals and societies. The first stage of a market economy was probably a regular, perhaps weekly, gathering for the exchange of these surplus goods [Popenoe: 71].

People began increasingly to devote themselves to particular tasks to earn a living by meeting the demands of the marketplace. In this way the division of labour was extended beyond the family and across villages or even an entire district. Religious functionaries, healers and metal workers were among the first few specialists who offered their services to the community at large [Popenoe: 71].

The ability of organisations to improve the way in which they satisfy their basic needs are therefore the second fundamental goal that organisations pursue, termed efficiency [Moll: 65].

The relationships between organisational needs, effectiveness and efficiency are illustrated in Figure 2-4 [Moll: 65]:

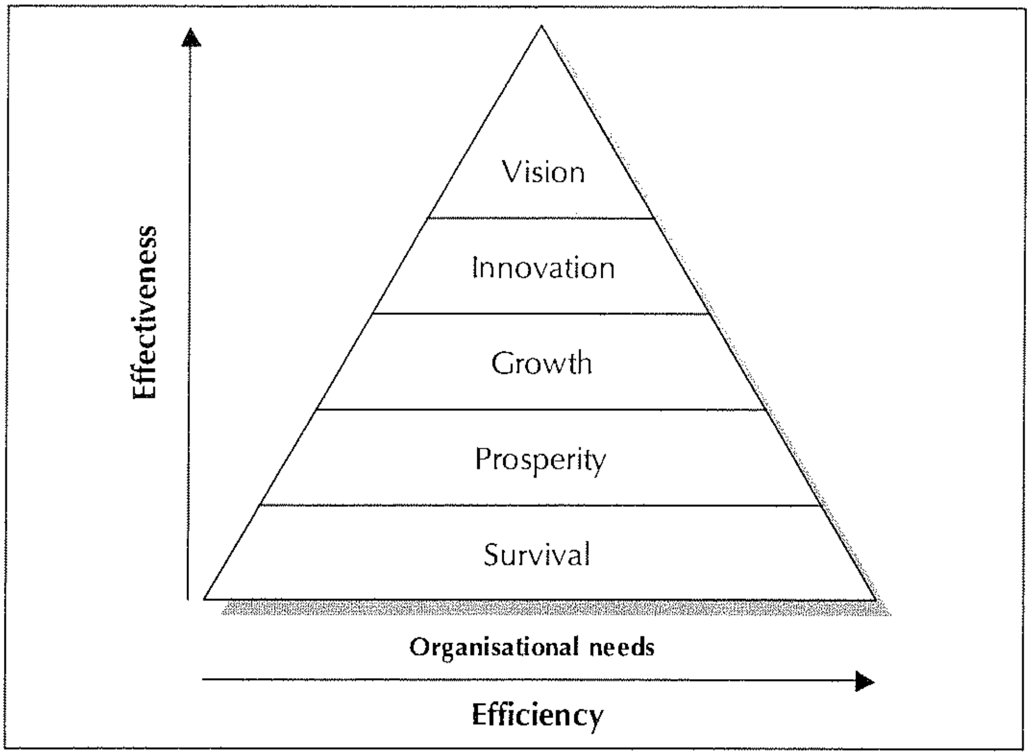

Figure 2-4: Organisational needs vs. effectiveness and efficiency

2.2.3 *Feudal systems*

The *feudal system* is based on the principle that the feudal lords own the means of production, but does not fully own the workers in production, *the serfs*, whom the feudal lords can no longer kill, but which can still be traded [Stalin: 88]. This period is characterised by two systems of relations [Encarta: 61]:

- Feudalism; a contractual system of political and military relationships existing among members of the nobility; and

- seignorialism; a system of political, economic and social relations between seigneurs, or lords, and their dependent farm labourers or peasants.

Feudalism was characterised by the granting of fiefs, mainly in the form of land and labour, in return for political and military services, a contract sealed by oaths of homage and fealty (fidelity). But lords and vassals were both free and social peers. Feudalism joined political and military service with landholding to preserve medieval Europe from disintegrating into innumerable independent seigneuries after the fall of the Carolingian Empire [Encarta: 61].

Alongside feudal ownership, there is individual ownership by the peasants and the handicraftsmen of their implements of production and his private enterprise based on personal labour. With the improvements in the utilisation of iron (i.e. the iron plough) and the developments in agriculture, horticulture, viniculture and dairy farming, factories appeared alongside the handicraft workshops.

These new productive forces demanded that labourers display some kind of initiative in production and an inclination or interest in work. The feudal lords therefore discarded slaves as labourers with no interest in work and entirely without initiative. They now preferred to deal with serfs, who have their own husbandry, implements of production and a certain interest in work essential for the cultivation of the land and for the payment in kind of a part of their harvest or labour to the feudal lords [Encarta: 61; Popenoe: 71].

This economic system evolved to a sophisticated economic order, which included landowners who rented space to craft-workers and luxury trade industries becoming a regular feature of the economy. Rulers levied taxes on trade to support professional armies that defended the increasingly complex societies from competing rulers and armies as wars and conquests were fought to satisfy the demands of ever more active markets [Popenoe: 71].

The increased influences of the environment on organisations and the ability of organisations to remain congruent with their environments is the driving force behind the third fundamental goal that organisations pursue, termed equilibrium [Moll: 65]. The relationships between organisational needs and the following three fundamental organisational goals are illustrated in Figure 2-5 [Moll: 65]:

- Effectiveness (the ability of organisations to improve themselves);
- efficiency (the ability of organisations to improve the way in which they satisfy their basic needs); and

- equilibrium (the ability of organisations to remain congruent with their environments).

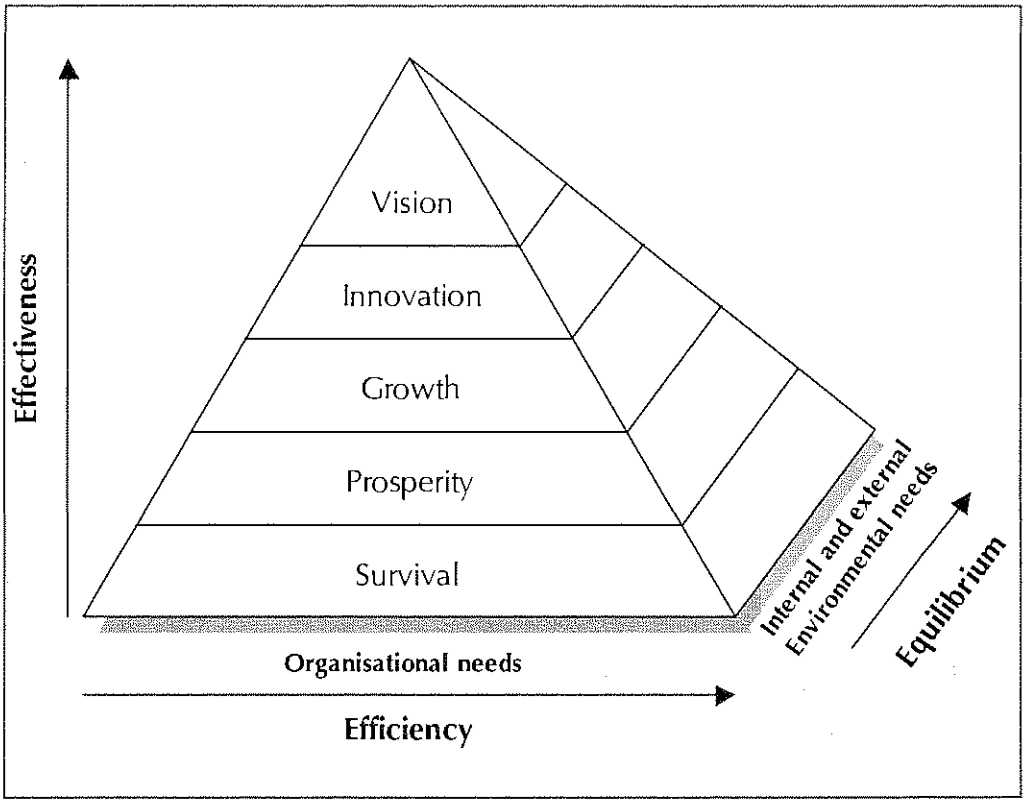

Figure 2-5: The fundamental organisational goal

2.2.4 *Capitalist systems*

The basis of the *capitalist system* [Stalin: 88] is that capitalists own the means of production, but not the workers in production, these workers can neither be traded nor killed, as they are personally free. In order for the wage labourers to survive they trade their labour to the capitalists, as they do not own the means of production.

Merchants and trade are as old as civilisation itself, but capitalism as a coherent economic system had its origins in Europe in the 13th century, towards the end of feudalism [Encarta: 61]. Human beings have always had a propensity to barter and exchange one thing for another [Smith: 87]. This inclination towards trade and exchange was rekindled and stimulated by the series of crusades that absorbed the energies of much of Europe from the 11th through the 13th centuries. A key element that emerged in capitalism was *the undertaking of activities in the expectation that it will yield gain in the future*. Because the future is unknown, both the risk of loss and the possibility of gain always exist.

The voyages of discovery in the 15th and 16th centuries gave further impetus to business and trade, especially following the vast flood of precious metals that poured into Europe after the discovery and conquest of the New World. The economic order that emerged from these events was essentially commercial or mercantile; therefore its central focus remained on the exchange of goods rather than on their production [Encarta: 61].

Forces of the renaissance and the *Reformation* furthered the thrust towards capitalism from the 13th century onward [Encarta: 61]. The Protestant *Reformation* started as people increasingly voiced their discontent with the current social system [Popenoe: 71]. The most important belief of Calvinism, a mainstream of Protestantism, which affected capitalism, was predestination [Proverbs 12:29; The Bible]. This belief puts an enormous strain on every individual, who wondered constantly if he was chosen. Intense human activity would develop and maintain self-confidence because it was obligatory for every individual to deem himself one of the chosen. This taught people to regard work as a form of prayer and the growth of possessions (accumulate capital) and not wasting it on worldly enjoyment, as evidence of a state of blessing, the result of a calling [Andreski: 6; Weber: 103].

The *capitalist system* grew out of a simple market economy and began taking form during the late middle ages [Wallerstein: 101]. Together with the new form of Christianity, namely Protestantism came a dramatically altered nature to the European society and by the 17^{th} century the trade and manufacturing economy was steadily growing. Although all the elements of capitalism were present at that time, commodities were still largely agricultural [Popenoe: 71].

Two developments, in the latter half of the 18^{th} century, paved the way for the emergence of modern capitalism [Encarta: 61]:

- The first was the appearance of the physiocrats[2] in France after 1750; and
- the second was the devastating impact that the ideas of Adam Smith had on the principles and practice of mercantilism[3].

Smith represented more than just the first systematic treatise on economics as he made a frontal attack on the doctrines of mercantilism. Like the physiocrats, Smith portrayed the existence of a *natural* economic order that would function most efficiently if the state played a highly limited role. Unlike the physiocrats, however, Smith did not believe that industry was unproductive or that only the agricultural sector was capable of producing a surplus above the subsistence needs of society, but saw in the division of labour and the extension of markets almost limitless possibilities for society to expand its wealth through manufacturing and trade [Encarta: 61; Smith: 87]. It was Smith that, far more than the physiocrats, opened the way for industrialisation and the emergence of modern capitalism in the 19th century.

The industrial form of capitalism came with the industrial revolution and the discovery of non-human sources of energy. Harnessing the power of

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[2] *Physiocracy:* *A school of economic thought that suggested the existence of a natural order in economics, one that does not require direction from the state for people to be prosperous. [Encarta: 61]*

[3] *Mercantilism:* *Economic policy, under which governmental control was exercised over industry and trade for the self-interest of the sovereign (the state) and not the self-interest of the individual owners of economic resources. [Encarta: 61]*

steam marked a highly significant step in technology and the introduction of the steam engine led to many new inventions in transport and industry [Encarta: 61]. The harnessing of steam was a significant turning point, as this made large-scale centralisation of manufacturing possible [Toffler: 96,97]. This also led to the creation of industrial industries that converts raw material into consumer goods. At the same time the tremendous population growth in the European countries provided a labour force that has turned to manufacturing for survival. The new productive forces require that the workers in production shall have higher education and more intelligence than the serfs, that they be able to understand machinery and operate it properly. Therefore, the capitalists prefer to deal with wageworkers, who are free from the bonds of serfdom and who are educated enough to be able to operate machinery properly.

Mass production of increasingly larger quantities of commodities intensified competition. Customer service and the principle of low prices and large turnover were introduced to the market. The result of this process was rationalisation. Those who would not follow suit had to go out of business. Respectable fortunes were made and not lent out at interest, but always reinvested in businesses [Weber: 103]. The effect of increased competition, enhanced by the advances in knowledge, skills, science and technology influenced the demands made by customers regarding the products that they required.

Throughout its history, but especially during its ascendancy in the 19th century, capitalism has had four key characteristics [Encarta: 61; Popenoe: 71]:

- Basic production facilities of land and capital are *privately owned*;
- owners of land and capital as well as the workers they employ are free to pursue their own self-interests in seeking *maximum gain* from the use of their resources and labour in production;
- economic activity is organised and coordinated through the interaction of buyers and sellers in markets; and
- under this system a minimum of government supervision is required (*laissez-faire*).

Private property is the cornerstone of the capitalist system. In capitalism, individuals or groups, as opposed to the societies as whole or political rulers, own almost all goods. By owning property, individuals or groups obtain the freedom to use it to their best advantage.

Profit is the goal of those who own and manage the means of production. In capitalist theory, owners are free to decide how they will use their profits. They may raise their own standard of living, expand their organisation or invest in other areas of the economy. In principle, a government does not restrict the amount of profit made.

Through *competition*, different producers of a particular commodity seek to appeal to the greatest possible number of buyers. Competitors constantly change their prices and the character of their goods to capture a greater portion of the market. Ideally, competition inspires technological progress as manufacturers try to outdo one another. Consumers are free to spend their incomes in ways that they believe will yield the greatest satisfaction. This principle, called consumer sovereignty, reflects the idea that under capitalism producers will be forced by competition to use their resources in ways that will best satisfy the wants of consumers. Self-interest and the pursuit of gain lead them to do this.

The French term *laissez-faire*, which roughly translated means *let (them) do (as they wish)*, summarises the common belief that capitalism functions best in those societies in which the government interferes the least in the marketplace. In this view, the forces of competition and customer demand, which are inherent in the capitalist system, are believed to be *natural controls* that will sufficiently regulate the economy's operation. Governments under this doctrine are only necessary to defend the rights of its citizens.

The basic unit of modern capitalism is the organisation, which derives its most suitable motivating force from the spirit of capitalism [Weber: 103]. The fundamental capitalistic organisational goal is to *accumulate capital.* The elements of the capitalistic goal of the *accumulation of capital* are illustrated in Figure 2-10.

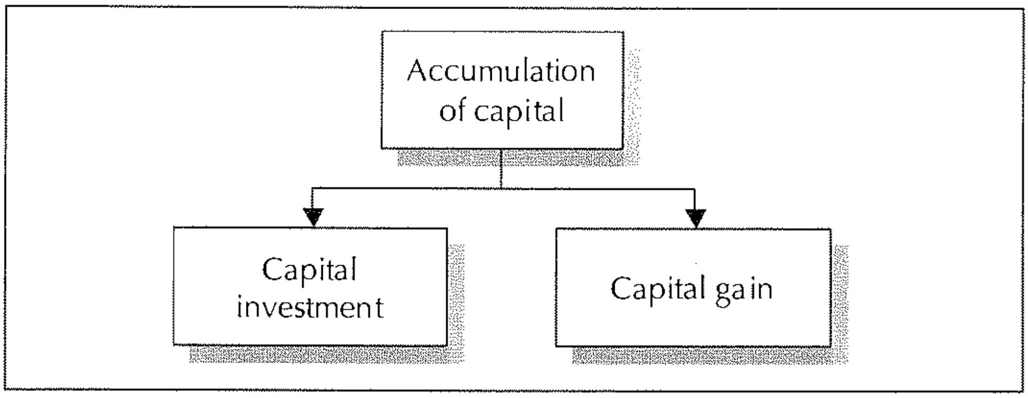

Figure 2-6: Accumulation of capital fundamentals

2.2.5 *Socialist systems*

The economic system most often considered, as an alternative to capitalism is *socialism.* While the final aim of socialism was a communist or classless society, it increasingly concentrated on social reforms within capitalism. The basis of the relations of production under the *socialist system* [Stalin; 88] is the social ownership of the means of production. The state is typically the collective owner, but in some forms of socialism the owner might be a small community or everyone who works for a particular enterprise.

Supporters of socialism object to capitalism on ethical and practical grounds. Capitalism is claimed to be unjust, as it exploits workers, degraded them by transforming them into beasts or machines and enables the rich to get richer while the workers face misery. Socialists also maintain that capitalism is an inefficient and irrational mechanism for the development of society's productive forces [Sassoon: 61].

In place of the market mechanics for setting prices, socialist theory calls for prices to be set collectively. The socialists believe that in economic (as in social and political) affairs, the important decisions should be made by representatives of all the people and should be co-ordinated to promote the broader social goals of the state, which then becomes the organisation that defends the interests of its citizens. The goods produced are distributed according to labour performed, on the principle: *He who does not work, neither shall he eat.* [Giddens: 32].

2.3 Organisational control

As defined in paragraph 1.1 of chapter 1, strategy relates to *the art of the general,* which is to say the psychological and behavioural skills with which *the general* occupies the role of commanding the army [Quinn: 36]. This will be taken as the context in which this paragraph explores the evolutions of *organisational control.* In this paragraph the evolution of *organisational control* is analysed from its military origins to its application in the industrial age capitalistic organisations.

A timeline, primarily based on Toffler's [96,97] wave theory, is used to explore the existing truths of *organisational control.* The wave theory is adapted by including references to Stalin's [88] development of economic systems.

This adapted timeline for the evolution of *organisational control* is illustrated in Figure 2-7:

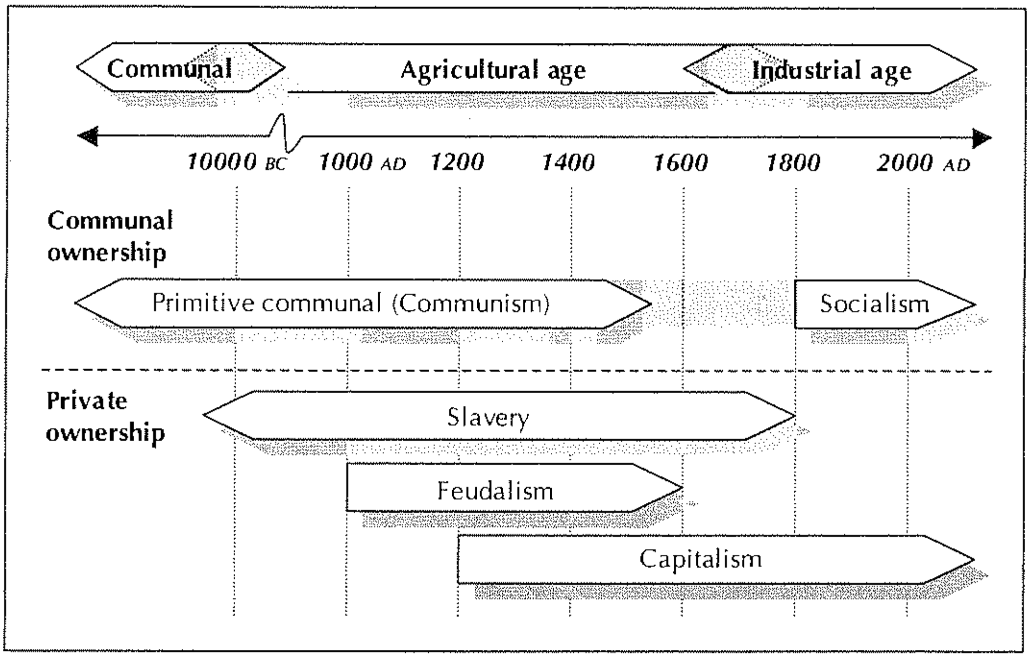

Figure 2-7: Timeline for the evolution of organisational control

2.3.1 *Communal age*

As discussed in paragraph 2.2.1 of this chapter, primary human requirements of survival, including food, shelter and security were the first common goals or special purposes around which organisations formed [Etzioni: 71]. In order not to fall victim to neighbouring societies these ancient organisations probably created military organisations to fight wars with prehistoric stone tools and uncomplicated weapons [Stalin: 88]. From these times engaging in warfare was a result of two or more parties pursuing a common goal [Griffith: 38].

Armies are purposeful organisations that are under the control of *generals*. *Organisational control*, within this context, is defined as [Oxford: 44]: *The ability to make somebody or something do what you* *want*. This definition illustrates the fundamental ability (psychological and behavioural skills) that enabled *the general* to control an army. An organisation's strategy is primarily concerned with the way in which it proposes to interact with its environment and how it proposes to influence what it can not control by using the resources over which it has control [Ansoff: 4].

2.3.2 *Agricultural age*

Probably the oldest treatise on controlling organisations comes from the Chinese societies (approximately 2000 BC) in their strategies for military forces. In order for a general to be victorious, he needs to [Griffith: 38]:

- Analyse his position as a whole, based on the factors governing the *art of war* (analysis);
- modifying his plans accordingly before entering into battle (design);
- giving the correct orders to allocate resources optimally (implementation).

Strategy gives military action meaning, which must be in accordance with the object of the war. In other words, strategy forms the plan of the war and in doing this, links together the series of acts that lead to the final decision. It therefore makes the plans for the separate campaigns and regulates the combats to be fought in each. These strategies or the plans, containing tactics aimed at misleading the enemy [Fredirick: 31; Griffith: 38], are devised prior to the battle and sets the course of actions to be taken during the battle depending on the outcome of the generals' analyses. Strategy must go with the army to the field in order to arrange particulars on the spot and to make the modifications in the general plan, as plans can turn out incorrect and others, relating to details, cannot be made beforehand. Strategy can therefore never take its hand from the activity. Strategy knows no other activity than regulating combat with the measures, which relates to it. It is the employment of the battle to gain the end of the war [Von Clausewitz: 100]. In a strategy, the thinking of the general is specified, it describes the proposed course of action of the different campaigns that compose the war and regulates the battles to be fought aimed at achieving the object of war [Von Clausewitz: 100]. Strategy is the overall plan for deploying resources to establish a favourable position and is concerned with winning the war. Strategy in warfare is the coordinated application of all these forces of a military organisation to achieve a common goal. Strategy's fundamental components are:

- A long-range view (vision);
- the preparation of resources; and
- planning for the use of those resources before, during, and after an action.

The relationships to war in the military organisations are based on the following principles [Griffith: 38; Von Clausewitz: 100]:

- Sovereign or state gives broad instructions, the objectives of war (*goal / purpose*);
- prince or general decides on and articulates the plan of battle or war (*strategy / control*); and
- troops execute a series of actions, the battle (*tactics / operations*).

As society and warfare have steadily grown more complex, military and non-military factors have become more and more inseparable and by the time of Pericles (450 BC) strategy also meant managerial skill (administration, leadership, oration, power) [paragraph 1.1, chapter 1]. An organisation is owned by a group of shareholders (capitalists) who protect their personal capital by legally limiting their liability for the organisation's debts [Encarta: 61; Popenoe: 71]. While the shareholders are entitled to a voice in the decision-making process, in practice most large organisations are characterised by a separation of ownership and control, the latter responsibility being given to management [Popenoe: 71]. This phenomenon correlates with the relationships in military organisations. Shareholders own organisations, they dictate the purpose and goals, but management control the organisation. The relationship between shareholders, managers and labourers, based on their function within the capitalistic organisation and relative to the means of production, can be defined as:

- Shareholders *own* the means of production, therefore defining the goals;
- managers *control* the means of production, aimed at achieving the goal; and
- labourers *operate* the means of production.

The relationships between resources in both military and capitalistic organisations are similar, as illustrated in Table 2-1.

	Military organisation	**Capitalistic organisation**
Setting the goal	Sovereigns or states	Capitalists or shareholders
Control	Princes or generals	Managers
Action / operation	Troops	Wage workers or labourers

Table 2-1: Correlation of relationships between military and capitalistic organisations

The following correlation of organisational control between the *art of the general* in military organisations and the *art of the manager* of capitalistic organisations can be made as illustrated as in Table 2-2.

	Purpose / goal	Environment	Resources
Generals	Object of war	Warfare	Military forces
Managers	Accumulation of capital	Competition	Means of production

Table 2-2: Correlation of control between generals and managers

2.3.3 *Industrial age*

During the industrial age, with the increase in competition between capitalistic organisations, the term strategy expanded far beyond its original military meaning to also include controlling of the capitalistic organisations' resources. Military strategy and organisational strategy share a number of common concepts and principles, the most basic being the distinction between strategy and tactics [Grant: 36]. *Strategy* is the overall plan for deploying resources to establish a favourable position. A *tactic* is a scheme for a specific action. Whereas tactics are concerned with the manoeuvres necessary to win battles, strategy is concerned with winning the war [Liddell Hart, 41].

Continual competition leads organisations to seek greater control over both the sources of raw materials and the outlets of their products. The organisation with the greatest competitive advantage commonly eliminates weaker organisation through acquiring them or leaving economic forces to terminate their activities. These large organisations use their profits to finance their own future development and growth [Popenoe: 71].

The relationship between ownership and control is depicted in Figure 2-8.

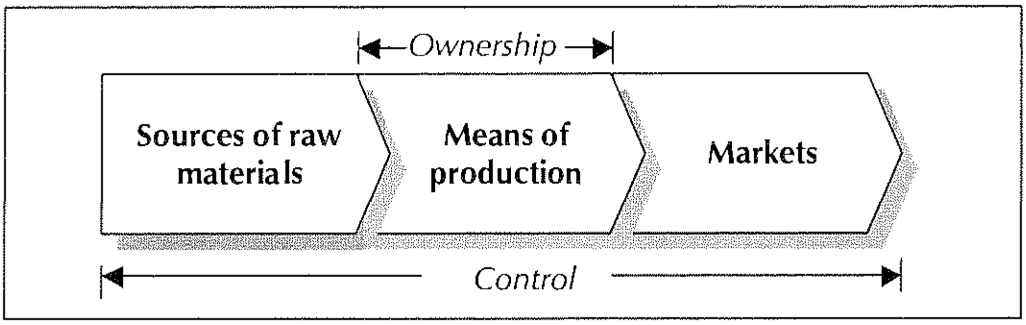

Figure 2-8: Organisational ownership and control

As a result of the related actions of mergers, consolidations and takeovers corporations are created. According to Porter [74] a corporation has two levels of strategy:

- Business strategy (or competitive strategy) concerns how to create competitive advantage in each of the organisations in which a corporation competes; and
- corporate strategy (or company-wide strategy) concerns two different questions:
  - What business the corporation should be in; and

- how the corporate office should manage the array of organisations.

Corporate strategy is what makes the corporate whole add up to more than the sum of its organisations. Grant [36] summarises the distinction as follows: *Corporate strategy is concerned with where a firm competes; business strategy is concerned with how a firm competes.* Andrews [7] describes corporate strategy as the pattern of decisions in a company that determines and reveals its objectives, purpose or goals. These decisions produce the principal policies and plans for achieving those goals and define the range of organisations the corporation is to pursue. This will also define the kind of economic and human organisation it is or intends to be, and the nature of the economic and non-economic contribution it intends to make to its shareholders, employees, customers and communities. Grant [36] describes corporate strategy as decisions over the scope of a firm's activities. He defines this scope as:

- Product scope – How specialised should the corporation be in terms of the range of products it supplies?
- Geographical scope – What is the optimal geographical spread of activities for the corporation?
- Vertical scope – What range of vertically linked activities should the corporation encompass?

As a corporation is a collection of individual organisations, corporate strategy making is a bigger picture exercise than crafting strategy for a single-organisation company. Corporate managers have to craft a multi-organisational, multi-industry strategic action plan for a number of different organisations competing in diverse industry environments. Managing a group of diverse organisations is usually so time consuming and complex that corporate level managers delegate lead responsibility for business strategy to the head of each organisation.

The subject area of corporate strategy concentrates on the following [Thompson: 95]:

- Making moves to position the corporation in the industries chosen for diversification. The basic strategy options are:
  - Acquire a organisation in the target industry;
  - form a joint venture with an organisation to enter the target industry; or
  - start a new organisation internally and try to grow it from the ground.
- taking action to improve the long-term performance of the corporation's portfolio of organisation's once diversification has been achieved:
  - Strengthening the competitive position of existing organisations;

   - divesting organisations that no longer fit into management's long-range plans; and
   - adding new organisations to the portfolio.
- trying to capture whatever strategic fit benefits exist within the portfolio of organisations and turn them into competitive advantage; and
- evaluating the profit prospects of each organisation and steering corporate resources into the most attractive strategic opportunities.

Although the great strategic thinkers of this period argue about the exact definition of strategy, the philosophy applied in controlling military forces has been adopted to control capitalistic organisations in their competitive environments. Strategy philosophers differ on the inclusion or exclusion of objectives or goals in the definition of strategy. A distinction can be made between those authors (models) that separate the goal formulation and strategy formulation tasks and those that combine them [Schendel and Hofer: 85].

The first group that separates the two tasks include authors like Ansoff [8], Cannon [12], McNichols [59], Paine and Naumes [68], Glueck [33], Hofer and Schendel [41]. This group consists for the most part of people, who write from a planning perspective. Therefore people predisposed to the planning approach are more likely to try to distinguish goals from strategies. Strategic planning as defined by Ansoff [8] refers to the formal process in the organisation of compiling and implementing long-term and short-term plans [Moll: 65].

The second group are subscribers to the strategic thinking school and combine the two tasks. These authors including Mintzberg [63], Andrews [7], Chandler [13], Learned et al. [51], Katz [46], Newman and Logan [67], Uyterhoeven et al [98]. Strategic thinking as defined by Mintzberg [63] refers to the skill associated with the strategic planning process [Moll: 65].

Strategic thinking ensures the effectiveness of the strategy process, therefore that the organisation is focused on the relevant issues. Strategic planning is concerned with the efficiency of the strategy process, therefore the level of success with the execution of the formal process. Mintzberg [63] argues that the core skill required in strategic thinking is innovation, while the core skill required in strategic planning is the application of the structured approach.

He explains this paradox as follows Mintzberg [63]: *"When strategic planning arrived on the scene in the mid 1960s, corporate leaders embraced it as the one best way to devise and implement strategies that would enhance the competitiveness of each business unit. True to the scientific management pioneered by Frederick Taylor, this one best way involved separating thinking from doing and creating a new function* *staffed by specialists: strategic business planners. Planning systems were expected to produce the best strategies as well as step-by-step instructions from carrying out those strategies so that the doers, the managers of businesses, could not get them wrong. As we now know, planning has not exactly worked out that way.*

Business planning is not strategic thinking. Indeed planning often spoils strategic thinking, causing managers to confuse real vision with the manipulation of numbers. And this confusion lies at the heart of the issue: the most successful strategies are visions, not plans."

2.4 Existing truths of strategy

The existing truths of strategy, within a capitalistic organisation, are summarised in this paragraph. The research was done over a representative timeline in order to identify the existing truths of strategy irrespective of time and space. As defined in paragraph 2.1 of this chapter, the existing truths of strategy, as applied by the capitalistic organisation, are based on the existing truths contained within the two cybernetic dimensions relating to:

- The concept of a capitalistic *goal* orientated *organisation*; and
- a series of manoeuvres and the behavioural skills that *control* the achievement of the organisational goal.

An organisation is a group of individuals with a common goal or purpose [Etzioni: 71]. The concept of purposefully organising originated from the primary human requirements of survival, such as food, shelter and security, and as these human requirements evolved to more sophisticated needs [Maslow: 56] like; prosperity, growth and regeneration so too do the purposes change around which organisations form. Although the purposes, around which groups rally, might change, it can be derived that organisations will always remain *purposeful*. An organisation is therefore defined based on its goal or purpose.

The relationships between organisational needs and the following three fundamental organisational goals are illustrated in Figure 2-5 [Moll: 65]:

- Effectiveness (the ability of organisations to improve themselves);
- efficiency (the ability of organisations to improve the way in which they satisfy their basic needs); and
- equilibrium (the ability of organisations to remain congruent with their environments).

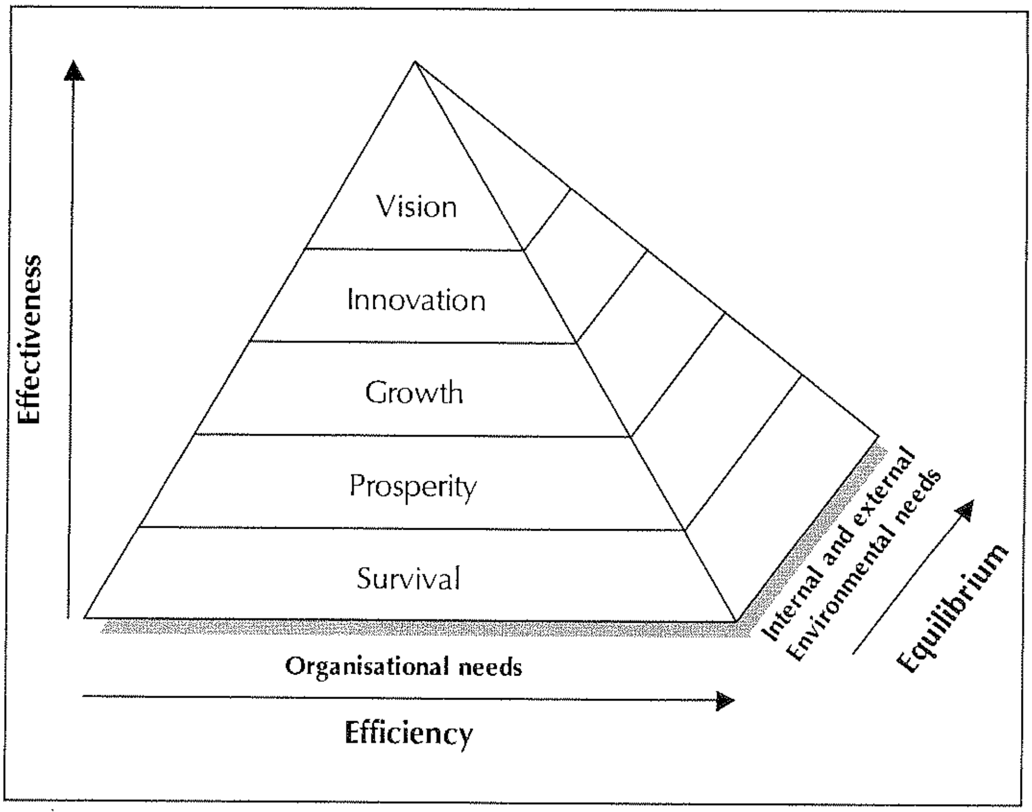

Figure 2-9: The hierarchy of basic needs of an organisation

The economic system of *capitalism* holds four fundamental characteristics [Encarta: 61; Popenoe: 71]. Groups uniting around this economic purpose of capitalism can therefore be defined as *capitalistic organisations* and are also similarly characterised by:

- Organisational means of production (capital) are *privately owned,* typically by shareholders;
- shareholders pursue their own self-interests in seeking *maximum gain* from the use of their *capital,* therefore *accumulation of capital.* Capital investments are exposed to both the risk of loss and the possibility of gain;
- economic activity is organised and coordinated through the *competitive* interaction in markets; and
- minimum government supervision is required *(laissez-faire).*

The elements of the fundamental capitalistic goal of the *accumulation of capital* are illustrated in Figure 2-10.

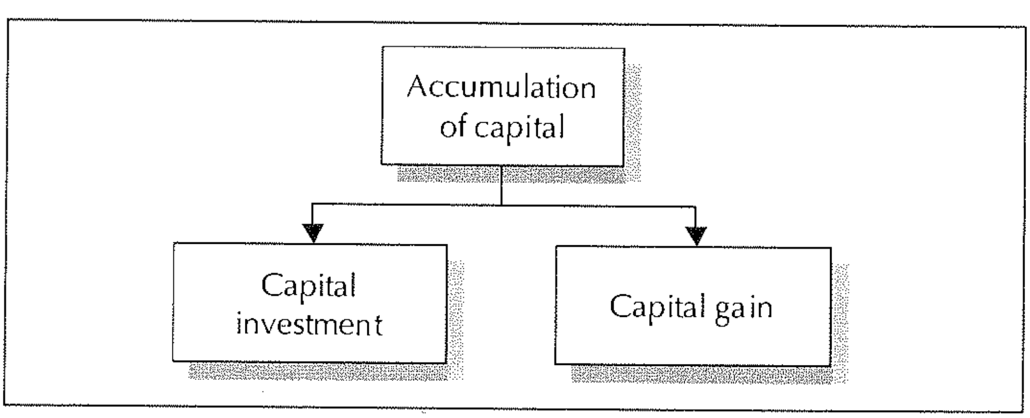

Figure 2-10: Accumulation of capital fundamentals

The evolution of organisational goals created larger and larger organisations and large organisations are characterised by the separation of ownership, control and labour. The following differentiations in the relationship to the means of production are made [Popenoe: 71]:

- Shareholders own the means of production;
- managers control the means of production; and
- labourers operate the means of production.

Two fundamental areas of control can be identified if linked to the objective of the capitalistic organisation:

- Control over the means of production (e.g. resources including capital and labour); and
- control over markets and sources of raw materials to achieve a competitive advantage.

The capitalistic organisational goal is pursued in an environment where two or more capitalistic organisations compete in meeting the demands of the market. A group of organisations that competes in meeting the same market demand, through production or supplying of goods, services or other sources of income, is defined as an *industry*. In the Oxford dictionary [44], the term industry is defined as: *The people and activities involved in producing a particular thing, or in providing a particular* *service.* Economic industries can customarily be classified as [Encyclopaedia Britannica: 24]:

- Primary or commodity[4] industries;
- secondary or manufacturing industries; and
- tertiary or service industries.

Strategy, in the economic environment, is the art or actions of the manager or leader to establish purposeful control over the organisation and the activities required for this can be derived as:

- Analysis of the current position;
- designing the plan of action to achieve the goal; and
- implementation of the plan of action by allocating and controlling resources.

The strategic process, based on these strategic activities, is illustrated in Figure 2-11.

[4] *Commodity:* *In general terms it is primary products (or raw materials) that is grown, such as coffee, tea, rubber, or cotton, or an extracted mineral resource, such as gold, copper, or tin; it may also be something that is (in effect) reared, such as wool. [Encyclopaedia Britannica: 24]*

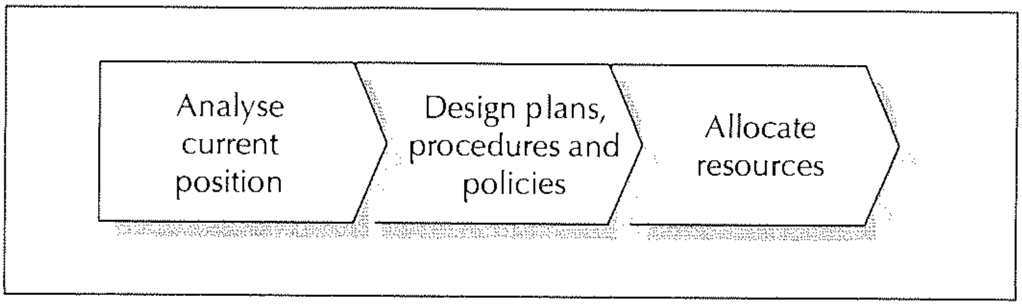

Figure 2-11: The strategy process

The term *strategy* is defined in the Oxford Dictionary [44] as: *The art of formulating a series of manoeuvres to obtain a specific goal.* The following fundamental elements defines the existing truths of strategy as applied by the capitalistic organisation:

- It is aimed at accumulating capital *(purposeful)*;
- a visionary course of action is set through plans, policies and procedures to compete in meeting customer demands *(action plan)*;
- resources are allocated in order to obtain control over *(resource allocation)*:
  - The means of production (resources that includes capital and labour); and
  - the sources of raw material and the markets in order to obtain a competitive advantage.
- a process of analysis, planning (design) and implementation is followed.

The subject area of corporate strategy has four fundamentals concerns:

- Positioning the corporation in the industries chosen for diversification;
- improving the long-term performance of the corporation's portfolio of organisation's;
- capturing whatever strategic fit benefits within the portfolio of organisations and turn them into competitive advantage; and
- evaluating the goal achievement prospects of each organisation and steering corporate resources into the most attractive strategic opportunities.

The term organisational *strategy*, in the context of this thesis, is therefore defined as: *A visionary plan of action by which resources are controlled in order to achieve the capitalistic organisational goal of accumulating capital.*

2.5 Industrial Engineering

Engineering is defined by The Accreditation Board of Engineering and Technology [Blanchard: 10] as: *The profession in which a knowledge of the mathematical and natural sciences gained by study, experience, and practise is applied with judgement to develop ways to utilise, economically, the materials and forces of nature for the benefit of mankind. Engineering is therefore the profession that strives towards the development of solutions for the satisfaction of human requirements by the application of the sciences.*

Maynard [58] and Salvendy [83] define Industrial Engineering as: *Industrial Engineering is concerned with the design, improvement and installation of integrated systems of people, materials, equipment and energy. It draws upon specialised knowledge and skills in the mathematical, physical and social sciences together with the principles and methods of engineering analysis and design to specify, predict and evaluate the results to be obtained from such systems.*

By comparing these definitions with the principles contained within the definition of technology [Encyclopaedia Britannica: 24], as: *The application of knowledge to the practical aims of human life or to changing and manipulating the human environment, including the use of materials, tools, techniques, and sources of power to make life easier or* *more pleasant and work more productive.* It can be derived that engineering is a profession that operates within the field of technology, with the specific emphasis on applying scientific (mathematical and natural sciences) knowledge.

The existing truths of *Industrial Engineering,* within this context of technology, are explored through a framework. Dimensions for such a framework are derived from the concept of cybernetics, as *Industrial Engineering,* being concerned with improvement, can be viewing as a cybernetic system. Cybernetics views Industrial Engineering as a feedback control system [Weiner: 104].

It is proposed that Industrial Engineering can be illustrated, as a cybernetic system, as in Figure 2-12.

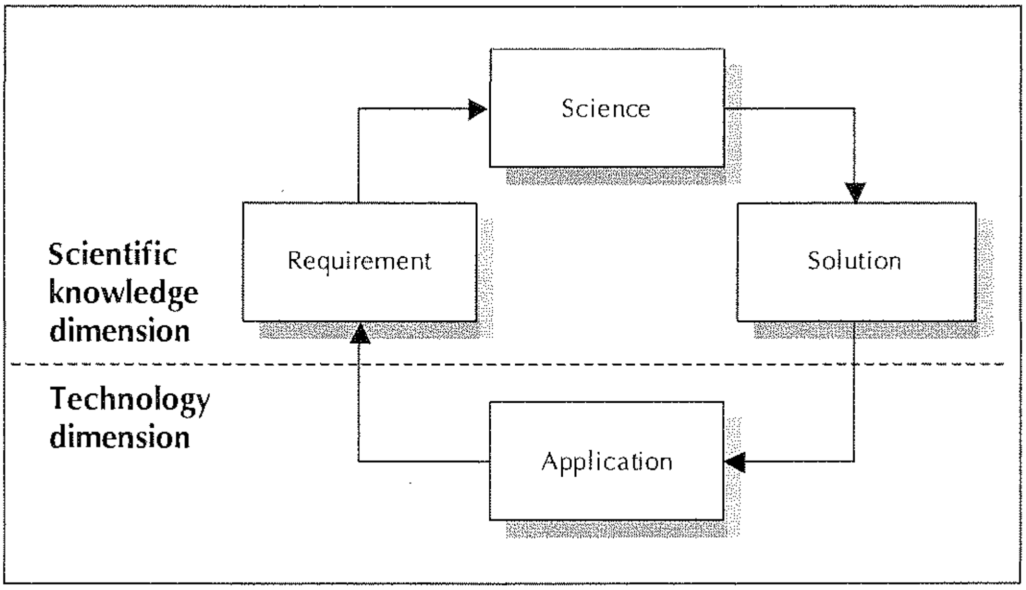

Figure 2-12: Cybernetic dimensions of Industrial Engineering

Based on this perspective the existing truths of Industrial Engineering can be defined by exploring:

- The evolution of *scientific knowledge*; and
- the development of *technology* over time.

2.6 Scientific knowledge [5]

A timeline of the evolution of scientific knowledge moving from *mythical* common sense, of ancient societies, to *philosophy of science,* of the early thinkers, to *scientific knowledge,* in the 17th Century, is proposed. This timeline is used to explore the evolution of scientific knowledge.

The timeline proposed to explore the evolution of scientific knowledge is illustrated in Figure 2-13.

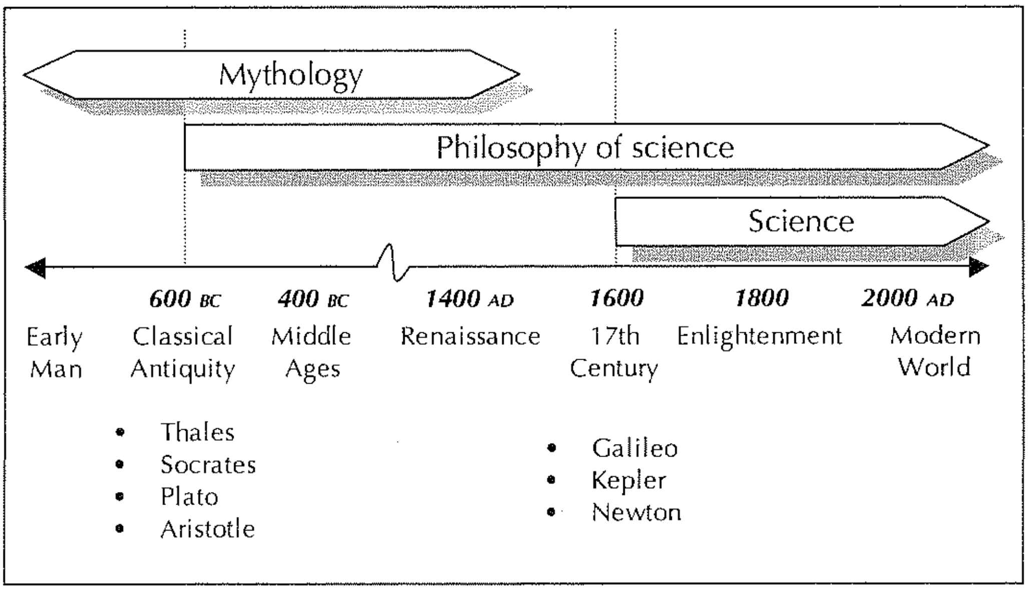

Figure 2-13: Timeline in the search for scientific knowledge

[5] *This section is adapted from selective writings of Blanchard [10], Delius [21], Encyclopedia Britannica [24], Honderich [43], Encarta [61] and Popenoe [71] accept where stated differently.*

2.6.1 *Mythology*

Ancient artisans, including navigators, farmers, architects, merchants, blacksmiths, shipbuilders, physicians and chroniclers were familiar with a great variety of materials, plants, animals, people and events. An enormous amount of information resided in the customs and common sense of the time.

Mythology is the study and interpretation of myths. Myth is a complex cultural phenomenon that describes and portrays in symbolic language the origin of the basic elements and assumptions of a culture [Encarta: 61]. Mythic narrative relates, for example to:

- How the world began;
- how humans and animals were created; and
- how certain customs, gestures or forms of human activities originated.

Myths differ from fairy tales in that they refer to a time before the conventional world came into being. As myths refer to an extraordinary time and place and to gods and other supernatural beings and processes, they are usually seen as aspects of religion. Myths are classified according to the dominant theme they portray [Encarta: 61]. Four main types of myths are defined:

- Cosmogonic myths;
- myths of culture heroes;
- myths of birth and rebirth; and
- foundation myths.

Cosmogonic myth is usually the most important myth in a culture and becomes the exemplary model for all other myths. It relates to how the entire world came into being. In some narratives, as in the first chapter of In The Bible the creation of the world proceeds from nothing (*creatio ex nihilo*). Egyptian, Australian, Greek, and Mayan myths also speak of creation from nothing. Other *cosmogonic myths* includes the following:

- Describe the creation as an emergence from the lower worlds, known in Navajo and Hopi cultures;
- symbolise creation through the various layers of emergence in a coconut shell or in the world egg, known in Africa, China, India, the South Pacific, Greece and Japan;
- creation stories of the world-parent myth, known to the Babylonian, Egyptians, Zuñi and Polynesians; and
- creation comes about through the agency of an earth diver, an animal, known in Romania and India.

Related to cosmogonic myths, but at the other extreme, are myths describing the end of the world (*eschatological myths*) or the coming of death into the world? The myths presuppose the creation of the world by a moral divine being, who in the end destroys the world. At this time human beings are judged and prepared for a paradisiacal existence or one of eternal torments. Such myths are present among Hebrews, Christians, Muslims and Zoroastrians. Other *eschatological myths* include the following:

- A universal conflagration and a final battle of the gods are part of Indo-European mythology;
- in Aztec mythology several worlds are created and destroyed by the gods before the creation of the human world; and
- death is not present in the world for a long period of time, but enters it through an accident or when human beings overstep the limits.

Myths of the *culture hero* describe the actions and character of beings that are responsible for the discovery of a particular cultural artefact or technological process. In Greek mythology Prometheus, who stole fire from the gods, is a prototype of this kind of figure. In the Dogon culture, the blacksmith who steals seeds for the human community from the granary of the gods is similar to Prometheus. In Seram, in Indonesia, Hainuwele is also such a figure; from the orifices of her body she provides the community with a host of necessary and luxury goods.

Usually related to initiation rituals, *myths of birth and rebirth* tell how life can be renewed, time reversed or humans transmuted into new beings. In myths about the coming of an ideal society (*millenarian* myths) or of a saviour (*messianic* myths), eschatological themes are combined with themes of *rebirth and renewal*. Millenarian and messianic myths are found in tribal cultures in Africa, South America and Malaysia, as well as in the world religions of Judaism, Christianity and Islam.

Since the beginnings of cities sometime in the 4th and 3rd millennia BC, some *creation myths* have recounted the founding of cities out of ceremonial centres, which were seen as extraordinary manifestations of sacred power.

2.6.2 *Philosophy of science*

Aiming at something more profound, some early thinkers restarted the search for knowledge. These early thinkers were called philosophers as they preferred words to things, speculation to experience, principles to the rule of thumb and they did not mind when their ideas conflicted with traditions and common phenomena of the most obvious kind. According to folklore Thales (approximately 600 BC) was the first true philosopher [Kirk; 48].

Philosophy, from the Greek word *philosophia* meaning *love of wisdom* (*philos*, meaning *love* and *sophia* meaning *wisdom*) [Pojman; 70], is the rational and critical inquiry into basic principles. Philosophy is often divided into four main branches:

- *Metaphysics*, the study of ultimate reality;
- *epistemology*, the study of the origins, validity and limits of knowledge;
- *ethics*, the study of morality and the good; and
- *aesthetics*, the study of the nature of beauty and art.

The two distinctive types of philosophical investigation are:

- *Analytic philosophy*, the logical study of concepts; and
- *synthetic philosophy*, the arrangement of concepts into a unified system.

Parmenides (approximately 480 BC) claimed that the world was one, that change and subdivision did not exist and that the lives of human beings that contained both were a fantasy. The proof that he presented is based on three, said to be self-evident, assumptions: That *being is*, that *not being is not* and that nothing is more fundamental than *being*. The argument follows that if change and difference exist, then there exists a transition from *being* to *not being*, which is the only alternative. *Not* *being* is not; therefore change and difference are not either. This is an early example of a type of philosophical reasoning that extended the domain of confirmable truths and separated it from intuition. This principle of *being (estin)* is the first explicit conservation law, by asserting the conservation of *being*. This premise guided laws such as the conservation of matter and the conservation of energy. The standardisation of *being* survived as the idea that basic laws must be independent of space, time and circumstance.

The philosophy of western science was greatly affected by the early *scientists*. They differed from philosophers by favouring specifics and from artisans by their theoretical bias. By the middle of the 5th century BC arithmetic, geometry, astronomy and harmonics were already dreaded subjects of teaching. The arguments between scientists, philosophers and artisans who explained and defended their enterprise in writing, as well as the more specific arguments between scientific, philosophical and practical schools, form an early *philosophy of science*. In many subjects of debate *scientific* assumptions were still closely intertwined with magical and religious ideas. *Philosophy of science* investigates the general nature of scientific practice [Lipton: 61]. The questions considered in the *philosophy of science* include:

- How scientific theories are developed, assessed and changed; and
- whether science is capable of revealing the truth about hidden entities and processes in nature.

Plato (427-347 BC), being opposed to these quarrels, tried to build a philosophy that combined technical excellence with religion and orderly politics. Plato distinguished between mere *opinion* and *science*. For him, science was the ideal of human knowledge and was seen as necessarily true and unchanging. In *The Republic* [Cushing: 16] Plato discussed the ideal state and the philosopher kings fit to rule it. According to Plato these philosophers are to desire knowledge of the truth and the reality, not just of superficialities, therefore true knowledge must be real, stable and unchanging. It must be of unique, immutable objects (forms), whereas belief has to do with appearances. Knowledge is infallible, while belief may be true or false.

Aristotle (384-322 BC) was Plato's most outstanding student. He favoured a procedure of taking experience at face value and tried to reconcile observation, common sense and abstract thought. He taught that all genuine knowledge is gained through logical demonstration proceeding from necessary first principles that are abstracted from sense, experience or observation. His paper on natural bodies was titled *Physica* (Physics) since the Greek word *physika* was originally derived from the adjective for *natural* and, as used by Aristotle, had the meaning of *natural science*

[Cushing, 16]. It was in this sense that scientists were once referred to as *natural philosophers*. Aristotle was the first *systematic philosopher* of western science.

Socrates (470-399 BC) (known through his dialogue and teaching of his most famous pupil, Plato), *Plato* and *Aristotle* are three of the earliest ancient Greeks that contributed greatly to the philosophical foundations of Western culture, by their systematic treatments of the nature of human knowledge. Philosophy of science is the branch of philosophy that attempts to clarify the nature of scientific inquiry (observational procedures, patterns of argument, methods of representation and calculation, metaphysical presuppositions) and evaluate the grounds of their validity from the points of view of epistemology, formal logic, scientific method and metaphysics.

2.6.3 Science

Through science the errors of mythical common sense are systematically corrected [Macdonald: 54]. The significant accumulation of scientific knowledge made it necessary to classify what was discovered in scientific disciplines. Science began its separation from philosophy in the 17th century with *physics* and *astronomy* the first to leave as they began to develop experimental techniques of their own [Pojman; 70]. Galileo added systematic verification, to the ancient methods of induction and deduction, through planned experiments by using newly invented scientific instruments such as the telescope, the microscope and the thermometer [Encarta: 61].

This exodus, led by *Galileo* (1564-1642 AC), *Kepler* (1571-1630 AC) and *Newton* (1642-1727 AC) was the first of many. Science proliferated into more than a hundred distinct disciplines; including *mathematical science* and *natural science*. *Science*, Latin for *scientia*, from *scire*, *to know*, is used in its broadest sense to denote systematised knowledge in any field, but usually applied to the organisation of objectively verifiable sense experience [Encarta: 61].

The Industrial Revolution brought about *mechanisation*, the substitution of people with machines as a source of physical work. This process affected the nature of work left for people to do. They no longer did all the things required to make a product, but repeatedly performed a simple operation in the production process. Consequently, the more machines were used as a substitute for people at work, the more workers were made to behave as machines. Two ideas have been dominant in the way we seek to understand the world around us during this machine age [Ackoff: 2,3]:

- Reductionism; and
- mechanism.

Reductionism (Plato) consists of the belief that everything can be reduced, decomposed or disassembled into simple indivisible parts. These individual parts are typically atoms in physics, simple substances in chemistry, cells in biology and monads, instincts, drives, motives and needs in psychology. Reductionism also gives rise to an analytical way of thinking about the world by seeking explanations and understanding. Analysis consists of taking apart what is to be explained, disassembling it, if possible, down to the independent and indivisible parts of which it is composed. Followed by explaining the behaviour of these parts. Finally aggregating these partial explanations into an explanation of the whole. Despite its successes, reductionism has been highly controversial, for it denies the claims of those (especially Marxists) who argue that the world is ordered hierarchal and that entities at upper levels can never be analysed entirely in terms of entities at lower levels. Reductionism is therefore preoccupied with analysis consisting of the following activities:

- Disassembling, what is to be explained, to the independent and indivisible parts of which it is composed;
- explaining the behaviour of these parts; and
- aggregating these partial explanations into an explanation of the whole.

Mechanism holds that all phenomena can supposedly be explained by using only one ultimate simple relation, *cause and effect*. According to this concept, the universe is completely explicable in terms of mechanical processes. Inasmuch as these mechanical processes are best understood in their movements, mechanism frequently involves the attempt to demonstrate that the universe is nothing more than a vast system of motions [Encarta: 61]. Therefore one thing or event was taken to be the cause of another (its effect) if it was both necessary and sufficient for the other. Because a cause was taken to be sufficient for its effect, nothing was required to explain the effect other than the cause. Consequently, the quest for causes was environment-free and employed what is now called *closed-system* thinking. Fundamental laws permitted no exceptions. Effects are completely determined by cause. Hence, the prevailing view of the world was deterministic. It was also mechanistic, because science found no need for teleological concepts, such as functions, goals, purposes, choice and free will, in explaining any natural phenomenon. They considered such concepts to be unnecessary, illusory or meaningless. The commitment to causal thinking yielded a conception of the world as a machine. It was taken to be like a hermetically sealed clock, a self-contained mechanism whose behaviour was completely determined by its own structure.

Although eras do not have precise beginnings and endings, the 1940's can be said to have contained the beginning of the end of the Machine Age and the beginning of the Systems Age. This systems age is the product of a new intellectual framework in which the doctrines of reductionism and mechanism and the analytical mode of thought are being supplemented by the doctrines of *expansionism*, teleology and a new synthetic (or system) mode of thought. Expansionism is a doctrine, which maintains that all objects and events, including all experience in them, are parts of larger wholes. It does not deny that they have parts, but it focuses on the wholes that they form part off. It provides another way of viewing things, a way that is different from, but compatible with, reductionism. It turns attention from ultimate elements to a whole with interrelated parts, to systems. Preoccupation with systems brings with it the synthetic mode of thought. In synthetic thinking, something to be explained is viewed as part of a larger system and is explained in terms of its role in that larger system.

The synthetic mode of thought, when applied to systems problems is called the *systems approach*. This way of thinking is based on the observation that, when each part of the system performs as well as possible, the system as a whole may not perform as well as possible. This follows from the fact that the sum of the functioning of the parts is seldom equal to the functioning of the whole. Accordingly, the synthetic mode seeks to overcome the tendency to perfect details and ignore system outcomes [Moll: 65].

Because the Systems Age is teleologically orientated, it is preoccupied with systems that are *goal seeking or purposeful*, that is, systems that can display choice of either means or ends, or both. It is interested in purely mechanical systems only insofar as they can be used as instruments of purposeful systems.

Systems exists in order to obey the rules set by a predetermined external purpose by initially pursuing the purpose and if it can in fact be reached, maintaining the properties of the purpose for the length of the useful life thereof, after which the system either seizes to exist or a new cycle is initiated. A system interacts with its environment (larger whole) from which the purpose is derived based on the requirements set by the environment. It subsequently processes these requirements and the resources given by the environment into something that satisfies the requirements. The concept of a system life cycle [Blanchard: 10] is derived from the point of view that life in general is cyclical and can be modelled as a system as shown in Figure 2-14.

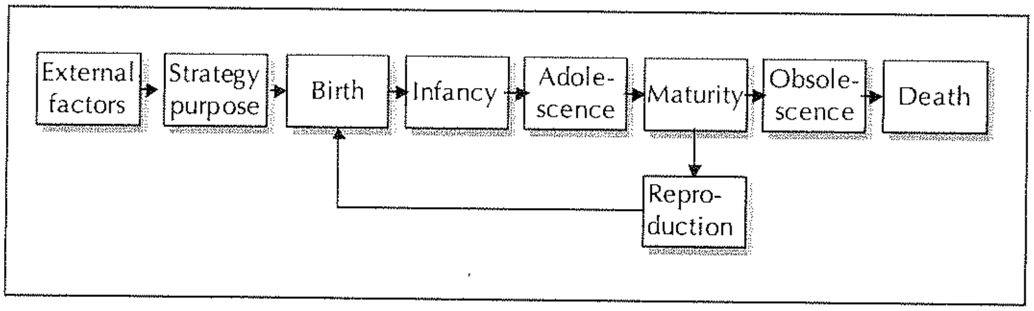

Figure 2-14: The life cycle of a system

The model is based on the life cycle of living beings. Entities are born into nature or society with the purpose of interacting with the larger system of which they are part (such as the ecosystem), and for as long as they are able to contribute towards the requirements of nature, sustain their own being, reproduce and eventually cease to exist.

The Systems Age is most concerned with purposeful systems, some of whose parts are purposeful, called social groups. The most important class of social groups is the one containing system whose parts perform different functions. These social groups are called *organisations*. In the Systems Age interest is focused on groups and organisations that are themselves parts of larger purposeful systems.

There is a correlation between the life cycle of man and that of man-made systems. The life cycle of man made systems begins with the identification of a need and extends through planning, research, design, production or construction, evaluation, consumer use, maintenance and support and ends with ultimate retirement / phase out. This process is generic in nature and represents the life cycle nature of large-scale systems.

A simplification of the customer-to-customer process or systems life cycle is illustrated in Figure 2-15.

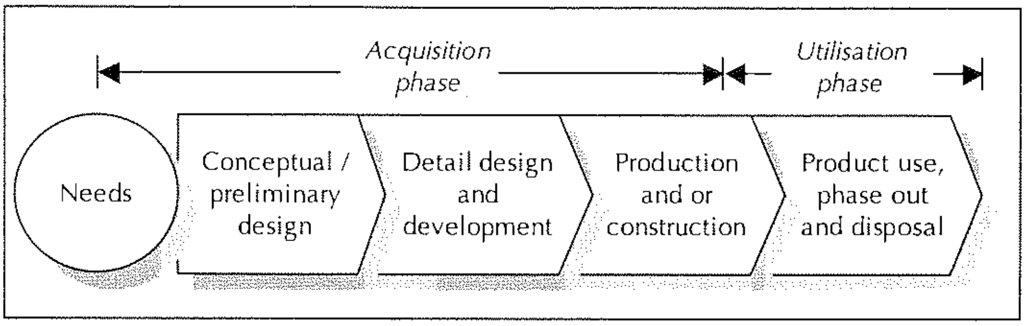

Figure 2-15: The s life cycle of man made systems

2.7 Technology

Technology is the discipline in which knowledge is applied to the use of materials, tools, techniques and sources of energy to make life easier or more pleasant and work more productive. As science is concerned with how and why things happen, technology focuses on making things happen [Encyclopaedia Britannica: 24].

An adaptation of Toffler's [96,97] wave theory is used to explore the evolution of technology. The wave theory is adapted by including a short reference to the primitive communal age.

This adapted timeline for the evolution of technology is indicated in Figure 2-16:

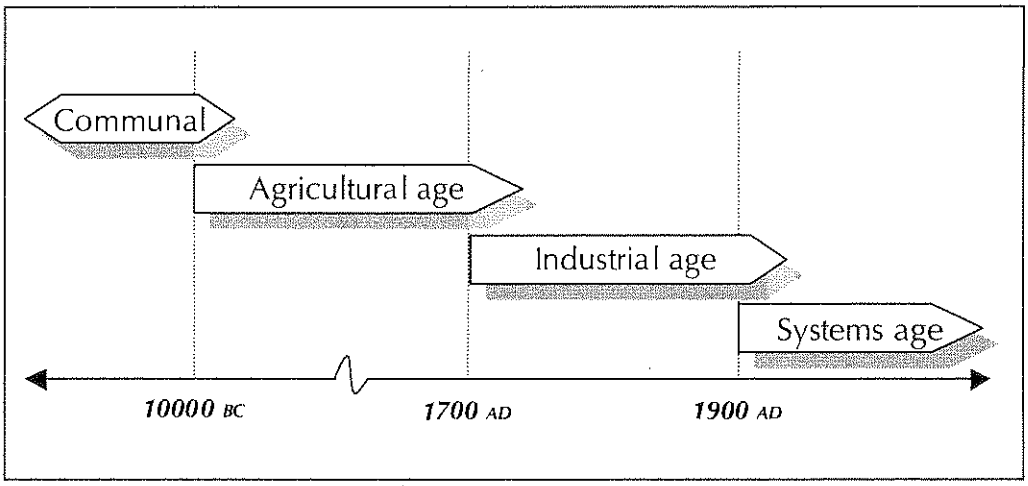

Figure 2-16: Timeline for the evolution of technology

2.7.1 *Primitive communal*

The first appearance of deliberately shaped tools produced by ancestors of human beings is found as far back as 2 600 000 BC. The earliest toolmakers' achievements such as stone axes, scrapers and control of fire were no more than the products of chance [Layton: 61]. Major technological activities can be traced back to ancient societies of which the inventions of the Incas, Egyptians and Chinese are probably the best know.

2.7.2 *Agricultural age*

Technological skills become sufficiently conscious and were passed from one generation to the next by accomplished practitioners. These craftsmen, however, had no systematic body of knowledge about their devices. This knowledge, resulting from analytical modes of thought associated with modern science, empowered people in a radically different way, from previously, to realise their technological goals [Layton: 61].

These technological advances originate predominantly from military requirements as the art and practice of designing, building and maintaining of military works, lines of military transport and communications. The pre-eminent military engineers of the ancient western world were the Romans, who maintained their supremacy by constructing forts, garrisons, roads, bridges, aqueducts, harbours and lighthouses [Encyclopaedia Britannica: 24].

Little technological advances were transferred from the military to the civilian economy. This was all changed by the invention of the line-of-battle or man-of-war ships, designed to carry heavy guns in addition to its crew and their provisions, as this invention was converted to transport substantial cargo instead of heavy guns and the first efficient sea freight transporters were created. It was one of the greatest technological breakthroughs that civilian economy ever experienced. It supported the commercial revolution of the late Middle Ages when international trade was established and Europeans started their economic penetration and dominance of the entire globe. The military economy and the civilian economy moved in parallel, mutually enriching each other [Drucker: 22; Encyclopaedia Britannica: 24]. Every advance in military technology provided new energy for the civilian economy and in turn the civilian technology was very rapidly applied to the military.

The first technical university (Ecole des Ponts et Chausseés, founded in 1747) was established to train Civil Engineers in the art of building roads primarily for the attempt of Louis XIV of France to become master of the European Continent [Lake: 61]. With this emerged the engineering profession and the systematic application of science and technology to the design and production of goods and services [Drucker: 22]. The engineering profession strives towards the development of solutions for the satisfaction of human requirements by the application of the sciences [Blanchard: 10]. The fundamental engineering approach is based on:

- An understanding of these requirements;
- the invention, conceptualisation and creation of solutions; and
- the development, application and maintenance thereof.

The classical approach to engineering is shown in the process model in Figure 2-17.

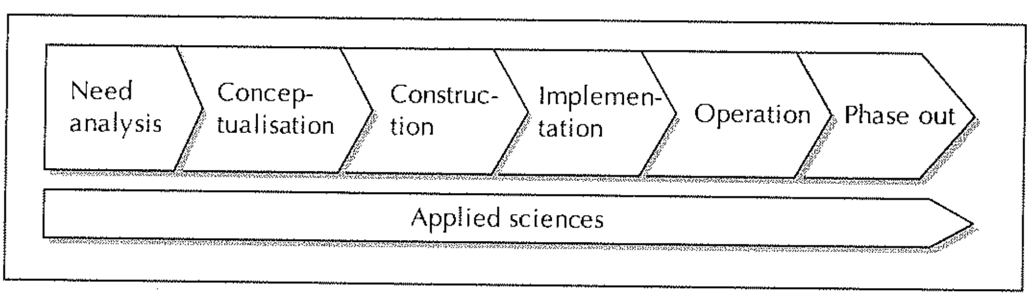

Figure 2-17: The classic approach to engineering

The three fundamental skills necessary for the delivery of an engineered solution are [Moll: 65]:

- Innovation;
- a structured and systematic approach; and
- the application of scientific methods.

2.7.3 Industrial age

Mumford [Layton: 61] grouped the development of technology in terms of three successive, but overlapping and interpenetrating, phases:

- *Eotechnic* (1000 AD – 1750) characterised by the use of raw materials such as wood, glass and water, with increased use of animal power and energy from wind and water;
- *palaeotechnic* (1750 – 1900) a period of *carboniferous capitalism* characterised by a coal and iron complex and the steam engine; and
- *neotechnic* (1900 onwards) characterised by prominent science and an electricity-alloy complex with new materials such as plastics coming into use. Electrical energy and diesel and petrol combustion engines replaced the steam engine.

Technological development accelerated with the Industrial Revolution and the substitution of machines for animal and human labour. A central theme of the industrial-era was centralisation and standardisation in the production process. This age provided highway systems, cars, telephones and mainframe computers linking remote outposts to central controls. The coming of the Industrial Revolution, spurred by technological advances such as steam power, changed working life profoundly. Factories divided the work once done by a single craftsman into a number of distinct, specialised tasks performed by unskilled or semiskilled workers. The idea that specialisation reduces cost, and thereby the price the consumer pays, is embedded in the principle of the capitalistic competitive advantage. *Technology* is the purposeful human activity, which involves designing and making products as diverse as clothing, foods, artefacts, machines, structures, electronic devices and computer systems, collectively often referred to as *the made world*. Such work often begins with a human need or an aspiration and technologists draw on resources of many kinds including visual imagination, technical skills, tools and scientific and other branches of knowledge [Layton: 61].

In *The Wealth of Nations,* Smith [38] recognised that the technologies of the industrial revolution have created unprecedented opportunities for manufacturers to increase worker productivity and therefore reduce the cost of goods, by what has become known as the division of labour. A number of specialised workers, each performing a single step in the manufacturing process, were more productive than generalised workers fully responsible for the manufacturing of one unit [Smith: 38]. The division of labour is the basic principle underlying the assembly line in mass-production systems. Modern mass-production methods have led to such improvements in the cost, quality, quantity and variety of goods available that the largest global population in history is now sustained at the highest general standard of living ever. The requirements for mass production of a particular product include [Encyclopaedia Britannica: 24]:

- The existence of a market large enough to justify a large investment;
- a product design that can use standardised parts and processes;
- a physical layout that minimises materials handling;
- division of labour into simple, short, repetitive steps;
- continuous flow of work; and
- tools designed specifically for the tasks to be performed.

Technology, in line with the context of this thesis, was further expanded by the various innovations of scientific approaches to management. Taylor [92] defined a set of principles that form the basis of the scientific approach towards the management and operation of human labour. The basic premise is that the world is concerned with the destruction of natural resources whilst the waste of the human resource goes by unnoticed. Waste of natural resources, including material is readily apparent whilst waste in human efficiency is less apparent and less understandable. Management was an aristocracy, a class consisting of the elite, those who own the industry. Taylor proposed that the basic aim of management should be the generation of maximum wealth for both the employer and the employees. The wealth of these stakeholders is interrelated. Underlying this argument is the principle that higher profits are generated by higher productivity and that these higher profits can contribute to higher wages and vice versa. The four principles to scientifically manage work are [Taylor: 92]:

- Development of scientifically based methods for every component of work in order to replace traditional approaches;
- scientific selection, training and development of workers;
- close co-operation between management and labour in order to ensure adequate application of the proposed methods; and
- an equal distribution of work between management and workers, specialising in administrative and technical work respectively.

Further pioneering included aspects such as demand forecasting, production planning, facilities layout and the economic aspects of labour division by Watt (1796) and Babbage (1832) [Kanawaty: 45]. Taylor [92] also pioneered the scientific measurement of work and the Gilbreths, Frank (1868-1924) and Lillian (1878-1972), refined it with time-and-motion studies. As a result, production processes were simplified, enabling workers to increase production. Gannt, defined Critical Path Methods used in planning and control systems [Kanawaty: 45]. Fayol [26] defined the fourteen principles of management and was also responsible for the view that business management's role consists of four basic elements namely planning, organisation, leading and control.

Reducing each job in the automotive assembly process to the installation of a single part in a predetermined manner made improvements on the concept of dividing work into simple, scientifically determined tasks [Ford: 28]. Initially, workers walked from one assembly stand to the next and the introduction of the moving assembly line brought the work to the worker. In breaking down the assembly process into a series of uncomplicated tasks Ford made the jobs infinitely simpler, but he made the management of the process from a product perspective infinitely more complex, especially when diversified products were introduced.

Alfred Sloan, succeeding Ford, created the prototype of the management system needed for the Ford production system. Initially the management system was based on ineffective departments unable to manage the product mix demanded. General Motors, being diversified and extremely bulky, was subsequently broken down into divisions for each model or subassembly, inherently applying the principles of Scientific Management on the management and organisational levels. Managers were assigned to oversee each of these divisions, the only difference being that, whereas workers needed technical skills, management was perceived to manage the financial output of the divisions.

Manufacturing firms grew larger in the 19th century as standardised parts and machine tools came into use and ever more specialised positions for managers, supervisors, accountants, engineers, technicians and salesmen were necessary. The trend toward specialisation continued through the 20th century and Scientific Management lead to the development of disciplines concerned with the management and design of work, including operations research, systems engineering, production management, industrial relations, personnel administration and linkages to the behavioural sciences.

Applying engineering principles and techniques of scientific management to maintaining high levels of productivity at optimum cost in industrial enterprises created the *Industrial Engineering* discipline. Industrial Engineering is concerned with the design, improvement and installation of integrated systems of people, materials, equipment and energy. It draws upon specialised knowledge and skills in the mathematical, physical and social sciences together with the principles and methods of engineering analysis and design to specify, predict and evaluate the results to be obtained from such systems [Maynard: 58; Salvendy: 82]. It is concerned with optimising systems by focusing on effectiveness, efficiency, productivity, profitability and quality, an approach termed productivity management [Sink: 86]. This field pertains to the efficient use of machinery, labour and raw materials in industrial production. It is particularly important from the viewpoint of cost and economics of production, safety of human operators and the most advantageous deployment of automatic machinery [Encarta: 61].

The optimisation elements that concerns Industrial Engineering are illustrated on the generic system [Sink: 86] in Figure 2-18:

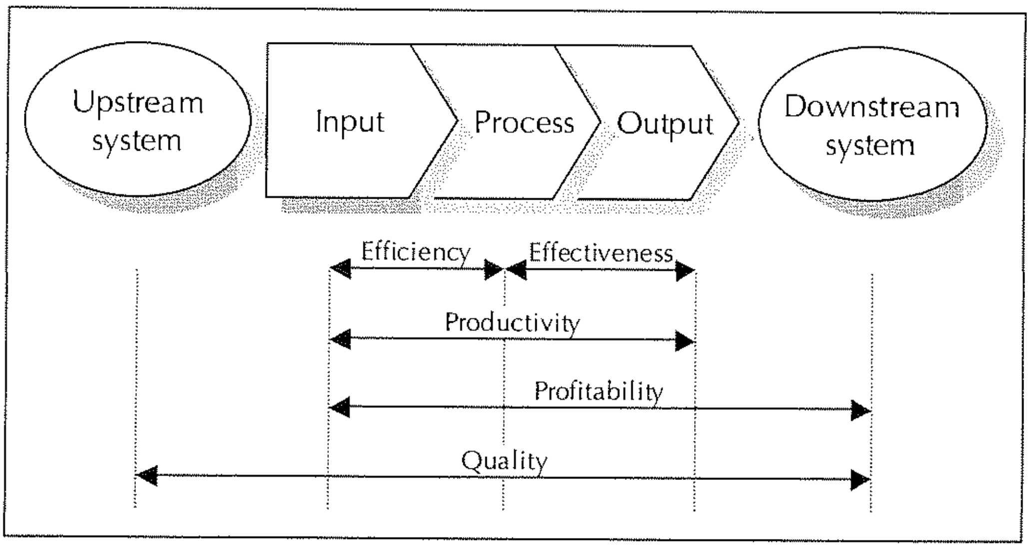

Figure 2-18: The principles of Industrial Engineering

The generic system can be viewed as a process that translates input received from upstream systems into output as required by downstream systems. Industrial Engineering is concerned with the generation of improved or optimal combinations of output and throughput in relation to input with respect to these systems [Moll: 65].

In order to optimise systems, Industrial Engineering focuses on effectiveness, efficiency, productivity, profitability and quality, an approach termed productivity management [Sink: 86]:

- Effectiveness is defined as the degree to which a system accomplishes what it is set out to accomplish (doing the right things). It is the strategic focus of productivity management.

- Efficiency is defined as the degree to which a system utilises its resources in correctly performing its function (doing things right). It is the operational focus of productivity management.
- Productivity is defined as the relationship between quantities of output (throughput) from a system and quantities of input into that same system.
- Quality is defined as the combination of the factors of conformance to technical requirements; fitness for purpose; conformance to financial and resource specifications and accordance to scheduling. Quality management is a process applied to the five major components of a system namely:
  - Selection and/or management of upstream systems;
  - management of incoming quality;
  - management of process quality;
  - management of outgoing quality; and
  - interaction with customer needs and expectations.
- Profitability is defined as the relationship between the cost of inputs and processing and revenues.

2.7.4 Systems age

Technology took a sharp turn away from standardisation and toward individualisation and diversity. The third wave of transformation began adapting massive second-wave-type enterprises to the third-wave appetite for differentiation. The third wave is not only concerned with human intelligence, [Toffler: 96, 97], but is also interested in where machine intelligence is imbedded and how smart products are created.

2.8 Existing truths of Industrial Engineering

The existing truths of Industrial Engineering are summarised in this paragraph. Research was done over a representative timeline in order to identify the existing truths [paragraph 3.4, chapter 1] of engineering and specifically Industrial Engineering irrespective of time and space. As defined in paragraph 2.5 of this chapter, the existing truths of Industrial Engineering are based on the truths contained within the two cybernetic dimensions of:

- Scientific knowledge; and
- technology.

As early as the ancient Greek civilisations did people search for understanding the world and events surrounding them and through this search for understanding did they gain knowledge. Knowledge is defined as [Oxford dictionary: 44]: *The understanding and skills that is gained through education or experience.*

Human knowledge has evolved from being based on *mythology* through *philosophy of science* to *scientific knowledge*. Plato defined science as true infallible knowledge that is real, stable and unchanging. In the Oxford dictionary [44] science is defined as: *The knowledge about the structure and behaviour of the natural and physical world, based on facts* *that you can prove.* Scientific knowledge are primarily gained through the following three methods:

- During the machine age:
  - Reductionism; and
  - mechanism.
- During the systems age:
  - Expansionism.

Expansionism is a doctrine, which maintains that all objects and events, including all experience in them, are parts of larger wholes or systems. Preoccupation with systems brings with it the synthetic mode of thinking, where something to be explained is viewed as part of a larger system and is explained in terms of its role in that larger system.

Purposeful systems exists in order to obey the rules set by some predetermined external purpose by initially pursuing the purpose and if it can in fact be reached, maintaining the properties of the purpose for the length of the useful life thereof, after which the system either seizes to exist or a new cycle is initiated. A simplification of the customer-to-customer process or systems life cycle is illustrated in Figure 2-15.

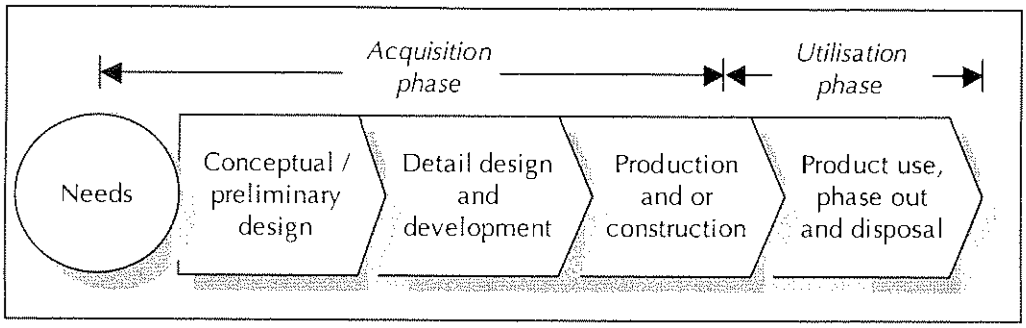

Figure 2-19: The life cycle of man made systems

The earliest forms of technology were found in the use of primitive tools and fire. Technological developments came mainly from the military environment and the advances in the military application of materials for their inherent qualities (e.g. strength). Machines of war, roads, bridges, forts and ships were constructed to supplement and strengthen the military forces. Technology is defined [Encyclopaedia Britannica: 24], as: *The application of knowledge to the practical aims of human life or to changing and manipulating the human environment, including the use of materials, tools, techniques, and sources of power to make life easier or more pleasant and work more productive.*

The engineering profession and the systematic application of science and technology to the design and production of goods and services [Drucker: 22] emerged with the transfer of technology to the civilian economy. With this came the division of the engineering profession into specialised fields with Civil Engineering being the first non-military engineering discipline. Subsequently engineering further divided into different disciplines, including mechanical, electronic, electrical, chemical and industrial.

The engineering profession strives towards the development of solutions for the satisfaction of human requirements by the application of the sciences [Blanchard: 10]. The fundamental engineering approach is based on:

- Obtaining an understanding of the specific requirements or needs;
- the invention, conceptualisation and creation of solutions to satisfy the specific requirement / need; and
- the development, application and maintenance of the solution in order to satisfy the requirement / need.

The classical approach to engineering is shown in the process model in Figure 2-17.

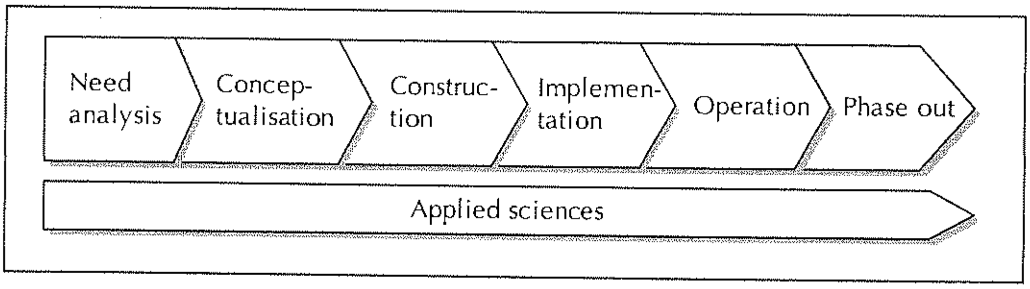

Figure 2-20: The classic approach to engineering

The three fundamental skills necessary for the delivery of an engineered solution are [Moll: 65]:

- Innovation;
- a structured and systematic approach; and
- the application of scientific methods.

The greatest technological force behind the industrial revolution came from harnessing non-human energy and with this the phenomenon of centralisation, mass urbanisation being evidence thereof. Later during this age the emphasis shifted towards improving the productive utilisation of human labour, which was initially focused on the unskilled and semi-skilled work force.

Industrial Engineering discipline originated in this industrial and manufacturing environment and is concerned with the design, improvement and installation of integrated systems of people, materials, equipment and energy in the industrial age. It draws upon specialised knowledge and skills in the mathematical, physical and social sciences together with the principles and methods of engineering analysis and design to specify, predict and evaluate the results to be obtained from such systems. It is concerned with optimising systems by focusing on effectiveness, efficiency, productivity, profitability and quality.

The optimisation elements that concerns Industrial Engineering are illustrated on the generic system [Sink: 86] in Figure 2-18:

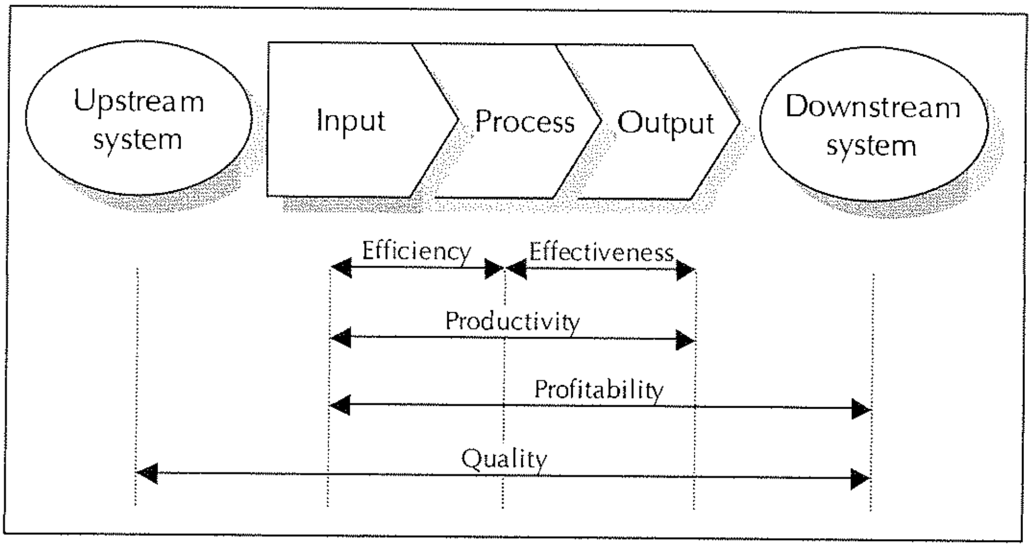

Figure 2-21: The principles of Industrial Engineering

3 LEVEL II – PRINCIPIA

3.1 The capitalistic organisational goal

During the primitive communal period success in achieving the organisational goal was measured by tangible measures like having sufficient food for survival or the size of property that was owned. In capitalism success is measured by the amount of capital accumulated [paragraph 2.4, chapter 2]. The capitalistic organisational goal of *accumulating capital* is a function of two fundamental elements [Figure 2-10, chapter 2]:

- Capital gain; and
- capital investment.

The relationship between *accumulation of capital, capital gain* and *capital investment* is defined in Equation 3-1.

$$
\begin{aligned}
\textit{Accumulation of capital} &= \textit{Capital investment} + \textit{Capital gain}\\
\therefore \quad \textit{Capital}_{t+1} &= \textit{Capital}_{t} + \Delta\,\textit{Capital}_{t+1}\\
\therefore \quad \textit{Capital}_{t+n} &= \textit{Capital}_{t} + \Delta\,\textit{Capital}_{t+n}
\end{aligned}
$$

Where: $t =$ *Base period*

$n =$ *Number op periods*

Equation 3-1: Accumulation of capital (Capital $_{t+n}$)

As defined in paragraph 2.4 of this chapter, shareholders pursue their own self-interests in seeking *maximum gain* from the use of their *capital*. The equation for capital gain can be derived as defined in Equation 3-2.

$$
\begin{aligned}
\textit{Capital}_{t+n} &= \textit{Capital}_{t} + \Delta\,\textit{Capital}_{t+n}\\
\therefore \quad \Delta\,\textit{Capital}_{t+n} &= \textit{Capital}_{t+n} - \textit{Capital}_{t}
\end{aligned}
$$

Where: $t =$ *Base period*

$n =$ *Number op periods*

Equation 3-2: Capital gain (Δ Capital $_{t+n}$)

The rate at which the capitalistic organisation achieves its goal is determined by calculating the rate of capital accumulation for a specific capital investment. This rate of accumulating capital is defined in Equation 3-3.

$$\textit{Capital accumulation rate} = \frac{\textit{Capital gain}}{\textit{Capital investment}}$$

$$\therefore \quad = \frac{\Delta\, Capital_{t+n}}{Capital_{t}}$$

$$\therefore \quad = \frac{Capital_{t+n} - Capital_{t}}{Capital_{t}}$$

Where: $t =$ *Base period*

$n =$ *Number op periods*

Equation 3-3: Capital accumulation rate

The following options exist to increase the rate of capital accumulation:

- Increase capital gain whilst maintaining capital investment levels;
- decrease capital investment whilst maintaining capital gain levels; and
- increasing capital gain and decreasing capital investment.

3.2 Capital accumulation ratios

As indicated in Equation 3-3, the rate of capital accumulation is measured by establishing relationships between the capital gain and the capital investment. In accounting[6] terms this is achieved by establishing a relationship between the income statements[7] and the balance sheet[8] of a

[6] *Accounting:* *The process of identifying, measuring, recording and communicating economic information about an organisation or other entity [61].*

[7] *Income statement:* *Summarises the organisation's revenues, expenses, gains, and losses [61].*

capitalistic organisation [Walsh: 102]. Various linkages or ratios between the income statements and the balance sheet can be made. These ratios measure in one way or another the ratio between *capital gain* and *capital investment*. The ratio between *capital gain* and *capital investment* is a central concept in the capitalistic system [Walsh: 102].

An organisation is owned by a group of shareholders (capitalists) who protect their personal capital by legally limiting their liability to the organisation's debts [paragraph 2.2.4, chapter 2]. It can therefore be derived that a relationship exists between an organisation's capital and the personal capital of its shareholders. An organisation obtains capital from its shareholders, which is termed shareholders equity[9]. A second means of obtaining capital is through debt[10], therefore borrowed funds from another (usually a financial) entity. This relationship between *organisational capital, shareholders equity* and *debt* is illustrated in Equation 3-4.

$$Organisational\ capital = Shareholders\ equity + debt$$

Equation 3-4: Organisational capital

[8] *Balance sheet:* *Provides information about an organisation's assets, liabilities, and owners' equity as of a particular date [61].*

[9] *Equity:* *The monitory investment of the owners or shareholders in an organisation [61].*

[10] *Debt:* *The monitory value that an organisation legally owes to another entity [61].*

Each monetary value of assets or organisational capital has to be matched by a corresponding monetary value of funds drawn from the financial market (shareholders and financial institutions). These funds have to be paid for at a market rate. Payment can only come from the operating surplus or gain derived from the efficient use of the assets or means of production. It is by relating this surplus or gain to the value of the underlying assets, funds, organisational capital or investments that the ratio between *gain* and *investment* is determined. Four ratios are explored in order to determine the most appropriate measure of the *rate of capital accumulation*. These ratios are:

- Return on total assets *(ROA)*;
- Return on net assets *(RONA)*;
- Return on equity *(ROE)*; and
- Economic value added *(EVA)*.

The cost of funds or capital will also be researched by analysing the:

- Cost of equity;
- cost of debt; and
- weighted average cost of capital *(WACC)*.

3.2.1 Return On Total Assets

Return on assets (ROA) is the ratio that links the *gain or profit* from the income statement with *total assets* from the balance sheet. This ratio measures how well management uses all the assets in the organisation to generate an operating surplus [Walsh: 102].

ROA is expressed as a percentage and is defined in Equation 3-5:

$$ROA = \frac{Profit}{Total\ assets}$$

Equation 3-5: Return on total assets

3.2.2 Return On Net Assets

Return on net assets (RONA) is the primary ratio that links the *gain* or *profit* from the income statement with *net assets (fixed assets + net working capital)* from the balance sheet. It therefore indicates the gain generated by the net assets used in the organisation. This ratio measures the operating performance of the organisation and integrates all elements at the operating level by linking profitability and activity. It is the primary test of operating performance [Price: 79].

RONA is expressed as a percentage and is defined as indicated in Equation 3-6:

$$RONA = \frac{Profit}{fixed\ assets + net\ working\ capital}$$

Equation 3-6: Return on net assets

3.2.3 Return On Equity

Return on equity (ROE) moves beyond RONA and operating issues to an examination of how the organisation is financed and how the financial strategy affects the organisational *capital accumulation rate* [Equation 3-3; chapter 2]. A key issue in financial strategy is the decision on the proportion of the organisation's assets to be financed by debt versus equity. Increasing the proportion of debt to equity in a profitable organisation can raise the shareholder's capital gains but simultaneously increases the risk of capital losses. The concept of leverage is crucial to managing the organisational *capital accumulation rate* and will be elaborated upon in paragraph 3.4, chapter 2.

Shareholders *gain* or *profit* is measured using profit after interest[11] and taxes have been paid, therefore ROE is influenced by:

---

[11] *Interest:* *Payments made for the use of borrowed funds (debt) [61].*

- Operating profits;
- the way in which the organisation is financed; and
- the proportion of its profits paid to tax[12].

This ratio is arguably one of the most important in organisational finance [Walsh: 102]. It measures the absolute return delivered to the shareholders. An adequate figure brings success to the organisation, as it results in a high share price and makes it easy to attract new funds. At the level of the individual organisation, a favourable ROE will keep in place the financial framework for a thriving, growing corporation. ROE is a critical feature of the overall modern market economy as well as of individual organisations [Walsh: 102], as it drives economic factors such as:

- Industrial investment;
- growth in gross domestic product;
- employment; and
- government tax receipts.

ROE is expressed as a percentage and is defined as indicated in Equation 3-7:

[12] *Taxation:* *The system of compulsory contributions levied by a government or other qualified public body on people, corporations and property, in order to fund public expenditure.*

$$ROE = \frac{Profit}{Shareholders\ equity}$$

Equation 3-7: Return on equity

3.2.4 *Economic Value Added*

Economic Value Added (EVA) is an estimate of an organisation's true economic profit after subtracting the cost of all capital employed. [Stewart: 91].

EVA is defined as illustrated in Equation 3-8:

$$EVA = Profit - Capital\ Charge^{13}$$

$$or \quad EVA = (ROTA - WACC^{14}) \times Invested\ capital$$

Equation 3-8: Economic value added

3.3 Weighted Average Cost of Capital

The weighted average cost of capital (WACC) is calculated as a weighted average of the cost of equity and cost of debt. This is the cost of capital for the organisation and it can be interpreted as the required market rate

[13] *Capital charge:* *Is equal to capital x Weighted Average Cost of Capital after tax (WACC)*

[14] *WACC:* *Defined in paragraph 3.3.*

for funds drawn from the financial market. The relationship between the *cost of capital*, *cost of equity* [paragraph 3.3.1, chapter 2] and *cost of debt* [paragraph 3.3.2, chapter 2] is illustrated in Equation 3-9.

$$\text{Weighted average cost of capital} = \text{Weighted average cost of (equity + debt)}$$

Equation 3-9: Weighted average cost of capital

Capital is a combination of equity and debt as defined in Equation 3-4. If both sides are divided by capital the percentages of total capital represented by equity and debt can be calculated, therefore termed *weighted average equity* and *weighted average debt*. These relationships of equity to capital and debt to capital are illustrate in Equation 3-10:

$$\begin{aligned} Capital &= equity + debt \\ \therefore \quad 1 &= \frac{Equity}{Capital} + \frac{Debt}{Capital} \end{aligned}$$

Equation 3-10: Capital relationship to equity and debt

By substituting Equation 3-10 into Equation 3-9 an equation for the weighted average cost of capital can be defined as illustrated in Equation 3-11.

$$WACC = \text{Weighted average cost of (equity + debt)}$$

$$\therefore WACC = \left[\frac{Equity}{Capital} \times \text{Cost of Equity}\right] + \left[\frac{Debt}{Capital} \times \text{Cost of Debt}\right]$$

Equation 3-11: Weighted average cost of capital

The cost of capital for a risk-free investment is the risk-free rate [Figure 3-1, chapter 2]. In the case of a risky investment, assuming that all the other information is unchanged, the required return is obviously higher, as risk requires a premium on the risk-free return. Therefore the cost of capital for a risky investment is greater than the risk-free rate. The cost of capital associated with an investment therefore depends on the risk of that investment. An investor can invest in an investment with a return equal to the risk free rate, with no risk. A premium is required to cover the potential risk of investing in higher risk industries and organisations. This is called the risk premium and can be illustrated on the risk map as defined by Stewart [91] in Figure 3-1.

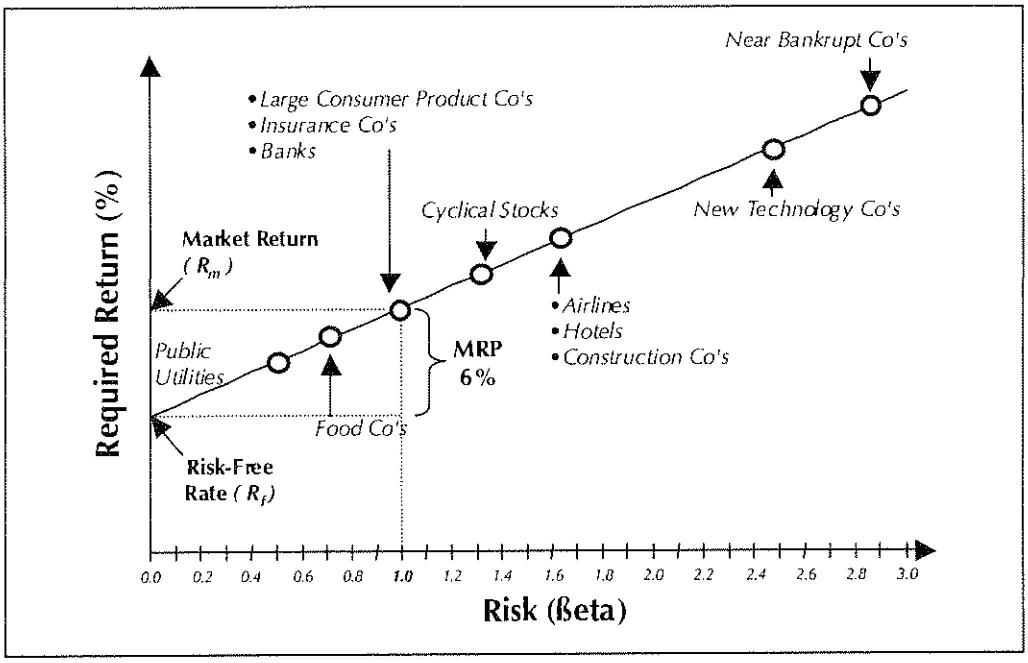

Figure 3-1: Risk map

The following clarifications, relating to the risk map [Figure 3-1], are made:

- Risk free rate (R_f) is based on a 12 months, daily average, of the long term government bond yields;
- market risk premium (MRP), (R_M – R_f) is based on large common stocks and is estimated at 6%; and
- beta coefficients (*ß*) for public trading companies are widely available.

As an organisation draws funds from both debt (banks and creditors) and equity (shareholders) the cost of capital will be a mixture of the surplus returns required to compensate its creditors and shareholders at market rate. The organisational risk premium depends on the industry and the financial risk *(solvency)*. The equity risk premium depends on the organisational risk level.

3.3.1 *Cost of equity*

The cost of equity can be defined as illustrated in Equation 3-12:

$$\text{Cost of Equity} = \text{Equity} \times (\text{risk-free rate} + \text{equity risk premium})$$

Equation 3-12: Cost of equity

The Cost of Equity can be calculated through two approaches [Ross: 81]:

- The dividend growth model; and
- the security market line (SML).

According to the SML approach, the required return on a risky investment is a function of three factors, illustrated in the risk map [Figure 3-1]. These factors are:

- The risk free rate (R_f).
- The market risk premium (MRP), ($R_M - R_f$).
- The systematic risk of the industry, called the ßeta coefficient ($ß$).

Based on this, Ross [81] defines the equation to calculate the required return on equity (R_E) or the cost of equity, as illustrated in Equation 3-13:

$$R_E = R_f + \beta_E \times (R_M - R_f)$$

Equation 3-13: Cost of equity

3.3.2 Cost of debt

The cost of debt can be defined as illustrated in Equation 3-14:

$$\text{Cost of Debt} = \text{Debt} \times (\text{risk-free rate} + \text{company risk premium})$$

Equation 3-14: Cost of debt

Unlike the organisation's cost of equity, its cost of debt (R_D) can normally be observed either directly or indirectly [Ross: 81], as the cost of debt is simply the average interest rate that the organisation must pay on new borrowings and these interest rates can be observed in the financial market. For example, if the organisation already has bonds outstanding, then the yield to maturity on those bonds is the market-required rate on the organisation's debt. Alternatively if the organisation's bonds were rated, say AA, then the cost of debt is equal to the interest rate on newly issued AA rated bonds. The rate on the organisation's outstanding debt is irrelevant, as this only indicates roughly what the organisation's cost of debt was when the bonds were issued and does not necessarily relate to the current cost of debt.

The interest paid by an organisation is deductible for tax purposes, but payments to shareholders, like dividends, are not. Therefore the after tax cost of debt needs to be calculated. In general, the after tax interest rate is equal to the pre-tax rate multiplied by one minus the tax rate (T_C). The after tax cost of debt is illustrated in Equation 3-15:

$$Cost\ of\ Debt = interest\ rate \times (1 - T_c)$$

Equation 3-15: After tax cost of debt

3.4 Capital structure

Capital structure or leverage is the portion of capital, which is financed by debt or equity. Leverage is measured as *capital / equity*, but it can also be measured as *debt / capital* or even *debt / equity*. Whichever way it is measured, higher levels of leverage imply higher levels of debt in the capital structure.

A change in an organisation's debt will result in a change to the organisation's cost of debt and subsequently the profits will change by this difference in the cost of debt. Therefore the change of profits is equal to the change in the cost of debt, as illustrated in Equation 3-16.

$$
\begin{aligned}
Profit_{t+1} &= Profit_{t} + \Delta\, Cost\ of\ debt_{t+1} \\
\therefore\quad \Delta\, Profit_{t+1} &= \Delta\, Cost\ of\ debt_{t+1}
\end{aligned}
$$

Where: $t =$ *Base period*

Equation 3-16: Change in headline earnings

From this equation it can be derived that ROE is similarly influenced. A change in ROE due to leverage is therefore calculated as illustrated in Equation 3-17.

$$
\begin{aligned}
\Delta\, ROE &= \frac{\Delta\, Cost\ of\ debt}{\Delta\, Equity} \\
\therefore\quad \Delta\, ROE &= \frac{\Delta\, Debt \times interest\ rate(1\text{-}Tax\ rate)}{\Delta\, Equity} \\
\therefore\quad \Delta\, ROE &= \Delta\, \frac{Debt}{Equity} \times interest\ rate(1\text{-}Tax\ rate)
\end{aligned}
$$

Equation 3-17: Influence of leverage on ROE

3.4.1 *The limit to leverage*

Leverage is a powerful concept. However, leverage acts to magnify gains, but also losses. As the interest rate on debt increases, the positive effect of leverage declines until a point is reached where leverage becomes negative. An organisation is then said to be in *negative leverage*, when the interest rate is larger than ROA. An organisation is in *positive leverage* when the interest rate is smaller than ROA. This relationship between ROE, ROA and the interest rate of debt is illustrated in Equation 3-18:

$$ROE = \frac{Profit}{Assets} \times \frac{Assets}{Equity}$$

$$ROE = \frac{Profit}{Assets} \times \left[1 + \frac{Debt}{Equity} \right]$$

$$ROE = ROA \times \left[1 + \frac{R \quad ROE}{Interest\ rate} \right]$$

$$ROE = ROA + \frac{ROA \times ROE}{Interest\ rate}$$

$$1 = \frac{ROA}{ROE} + \frac{ROA}{Interest\ rate}$$

$$\frac{ROA}{ROE} = 1 - \frac{ROA}{Interest\ rate}$$

$$ROE = ROA - Interest\ rate$$

$$For{:}\ Interest\ rate > ROA$$

$$\therefore \quad ROE < 0$$

$$And\ for{:}\ Interest\ rate < ROA$$

$$\therefore \quad ROE > 0$$

Equation 3-18: ROE, ROA and interest rate relationship

3.4.2 *Leverage and risk*

Risk, in this context, is defined as the probability of a deviation from an expected result. The higher the proportion of debt to equity the greater the leverage effect in a profitable organisation, but the greater the risk. The obvious risk is that the organisation might not be able to pay the interest or repay the loan in deteriorating business conditions. However, if interest rates rise above the rate of return, as illustrated in Equation 3-18, then even if the organisation is trading profitably the effect of negative leverage is just as powerful as the effect of positive leverage but in the opposite direction.

From this point onwards a downward spiral occurs and the effect of positive leverage turns to the tyranny of negative leverage as ROE falls below what it could have been had there been no borrowings at all. This erosion of equity can be insidious because the organisation may not notice it if it is only watching its apparently healthy profit situation. This is illustrated by comparing the risk of the three organisations in Table 3-1.

Organisation	Profitability ratio	x	Activity	=	RONA	x	Leverage	=	ROE
A	3		2		6		4		24
B	4		3		12		2		24
C	5		4		20		1.2		24

Table 3-1: Leverage and risk example

Each organisation produces the same ROE but at different rates of leverage. If these organisations were all in the same type of business, it can be derived that Organisation C has a better operating performance as measured by RONA as well as being the least risky of the three, as it has the lowest leverage. Two areas of risks are defined [Ross: 81]:

- Risk inherent in the organisation's operations or *business risk*; and
- risk that rises from the use of debt financing or *financing risk*.

Business risk depends on the organisation's assets and operations and is not affected by the capital structure. Given the organisation's business risk and cost of debt, the *financial risk* is completely determined by financial policy. Therefore, an organisation's cost of equity rises when it increases its use of financial leverage because the *financial risk* of the equity increases while the *business risk* remains the same.

Debt has two distinguishing features that should be taken into account [Ross: 81]. These two features are:

- Interest paid on debt is deductible from tax; and
- failure to meet debt obligations can result in bankruptcy.

The fact that interest paid on debt is deductible from tax is an added benefit to debt financing. The fact that interest is deductible from tax generates a tax saving equal to the interest multiplied by the corporate tax rate. This tax saving is called the *interest tax shield* [Ross: 81].

An added cost of debt financing is the risk of failure to meet debt obligations that can result in bankruptcy. As the debt / equity ratio rises, so too does the probability that the organisation will not be able to pay its bondholders what was promised to them. When this happens, ownership of the organisation's assets is ultimately transferred from the shareholders to the bondholders. The cost associated with bankruptcy may offset the tax-related gains from leverage. The term *financial distress cost* generally refers to the direct and indirect cost associated with going bankrupt and / or avoiding a bankruptcy filing. As the shareholders could loose money with bankruptcy, they have a very strong incentive to avoid bankruptcy filing. The bondholders on the other hand are concerned with protecting the assets value and will try to take control from the shareholders. This usually results in a long and potentially expensive legal battle. In conjunction with this the organisation lose additional value due to management focus being on saving the organisation and not on business, normal operations are disrupted and sales are lost, valuable employees leave, potentially fruitful programs are dropped and other profitable investments are not made.

3.4.3 *Optimal leverage*

The connection between capital structures, organisation value and cost of capital is illustrated in Figure 3-2 and Figure 3-3 [Modigliani and Miller: 79]. In Figure 3-2 the value of the firm (V_L) is plotted against the firms debt (*D*). In Figure 3-3 the weighted average cost of capital (*WACC*) is plotted against the debt to equity ratio (*D / E*).

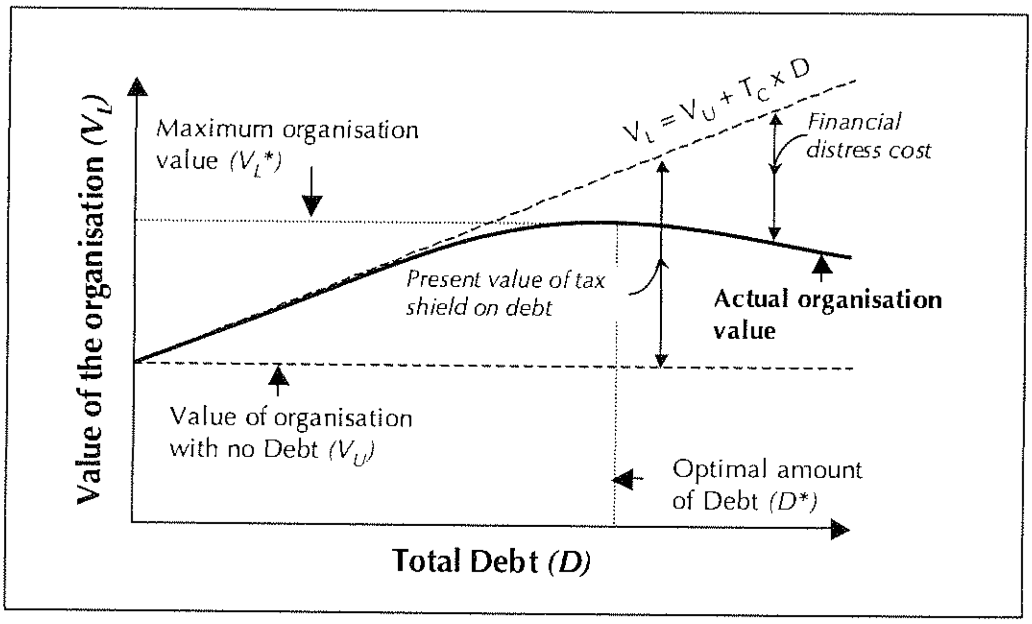

Figure 3-2: The value of the organisation vs. debt

When there are no taxes, bankruptcy cost or other real-world imperfections, the value of the organisation is not affected by its debt policy and V_L [Figure 3-2] stays constant. When taxes are included it can be seen that the organisation's value critically depends on its debt policy. The more the organisation borrows, the more it is worth. This happens because interest payments are tax deductible and the gain in value is equal to the present value of the tax shield.

When the impact of bankruptcy or financial distress cost is included the value of the organisation is not as large as indicated. The reason is that the organisation's value is reduced by the present value of the potential future bankruptcy cost. This cost grows as the organisation borrows more and eventually outweighs the tax advantage of debt financing. The optimal capital structure occurs at D^*, the point at which the tax savings from additional debt financing is exactly balanced by the increased bankruptcy cost associated with the additional borrowing [Modigliani and Miller: 79].

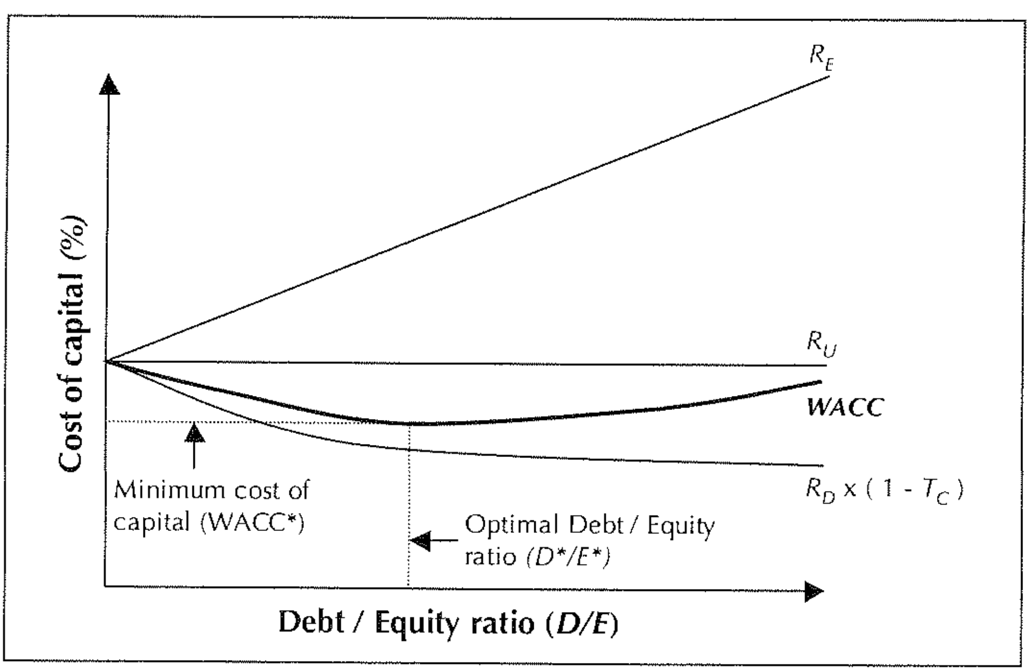

Figure 3-3: The relationship between WACC and Debt / Equity ratio

Referring to Figure 3-3 the same conclusions can be drawn based on the cost of capital. The weighted cost of capital (*WACC*) is not affected by the debt policy in the basic case, where there is no tax, bankruptcy cost or other real world imperfections, therefore the *WACC* is constant. *WACC* declines as the organisation uses more debt financing. As the organisation increases its financial leverage, the cost of equity does increase, but this increase is more than offset by the tax break associated with the debt financing. As a result the overall cost of capital declines. Corresponding to *D** in Figure 3-2, the optimal debt level, is the optimal debt to equity ratio (*D/E**). At this level of debt financing, the lowest possible cost of capital (*WACC*), occurs.

3.5 Fundamentals of the capitalistic organisational goal

ROE measures an organisation's capital accumulating rate and therefore the organisation's rate of success in achieving its goal, as it:

- Measures the rate of capital gain to the shareholder; and
- takes into account the organisation's capital structure.

Return on equity (ROE) is defined as illustrated in Equation 3-7:

$$ROE = \frac{Shareholders\ gain}{Shareholders\ equity}$$

Equation 3-19: Return on equity

ROE measures the *return on equity* and is sometimes also called *return on net worth*. The difference between ROE and other financial ratios is the use of debt financing or financial leverage as an additional tool to grow shareholders capital. This relationship between ROE and financial leverage is illustrated in Equation 3-20.

$$ROE = \frac{Profit}{Assets} \times \frac{Assets}{Equity}$$

Where:

$$ROA = \frac{Profit}{Assets}$$

and:

$$1 + \frac{Debt}{Equity} = \frac{Assets}{Equity}$$

Equation 3-20: ROE and financial leverage relationship

ROE can be decomposed further to end with the *Du Pont identity* [Price: 79]. The *Du Pont identity* indicates that three factors influence an organisation's ROE. These three factors are:

- Operating efficiency *(as measured by profit margin)*;
- asset use efficiency *(as measured by total asset turnover)*; and
- financial leverage *(as measured by the equity multiplier)*.

The *Du Pont identity* is illustrated in Equation 3-21.

$$ROE = \frac{Profit}{Sales} \times \frac{Sales}{Assets} \times \frac{Assets}{Equity}$$

Where: $$Profit\ margin = \frac{Profit}{Sales}$$

and: $$Total\ asset\ turnover = \frac{Sales}{Assets}$$

and: $$Equity\ multiplier = \frac{Assets}{Equity}$$

Equation 3-21: Du Pont identity

Weakness in either the operating or asset efficiency or both is visible in a diminished return on assets (ROA), which will translate into a lower ROE. From the Du Pont identity it can also be derived that increasing the amount of debt in the organisation could leverage the ROE. This is only true if the organisation's ROA exceeds its debt interest. An organisation is optimally leveraged when its tax savings from additional debt financing is equal to the increased bankruptcy cost associated with additional borrowings.

CHAPTER 3 - SUFFICIENT REASONING

"...there can be found no fact that is true or existent, or any true proposition, without there being a sufficient reason for its being so and not otherwise, although we cannot know these reasons in most cases."

Gottfried Wilhelm Leibniz

1 REASONING FOR KNOWLEDGE

1.1 Introduction

The proposition, of this thesis, is justified by reasoning from its existing truths and, by doing this, creating knowledge [paragraph 3.1.6, chapter 1]. In this chapter, the principle of sufficient reasoning is applied in order to justify the proposition *A Strategic Industrial Engineering Philosophy*. This is achieved by reasoning the proposition on two levels:

In *LEVEL I – Academia,* the proposition is academically justified. This is done by expanding the philosophy of Industrial Engineering beyond its current realm of production related resources, to incorporate the domain of strategic resources, such as capitalistic organisations within different industries. The proposition termed *A Strategic Industrial Engineering Philosophy* is proven true by reasoning from the following:

- Existing truths of strategy; and
- existing truths of Industrial Engineering.

The expanded Industrial Engineering philosophy is applied to define the relationship between improving the corporation's rate of achieving its goal (ROE) and the four corporate performance-regulating principles. These performance-regulating principles are:

- Industry competitiveness;
- organisational competitiveness;
- strategic fit benefits; and
- industry exposure.

In *LEVEL II – Principia,* the key findings of explorative statistical analyses are discussed. These analyses were performed to scientifically support the proposed fundamental performance-regulating principles as being part of *Strategic Industrial Engineering*.

1.2 Layout

The layout of this chapter is summarised as:

- In *Level I – Academia,* the proposition, of this thesis, is justified by reasoning from the existing truths defined in chapter 2. The proposition is justified by reasoning the following:
  - Achievement of the *capitalistic organisational goal* through a capitalistic organisational system in paragraph 2.1 of chapter 3];
  - *Strategic Industrial Engineering Philosophy* in paragraph 2.2 of chapter 3;
  - *Strategic Industrial Engineering* in paragraph 2.3 of chapter 3;

  - *Strategic Industrial Engineering Process* in paragraph 2.4 of chapter 3.

- In *Level II – Principia*, the key findings of explorative statistical analyses, to support the performance regulating principles, are summarised and discussed in paragraph 3.1.4 of chapter 3.

2 LEVEL I – ACADEMIA

2.1 Capitalistic organisational goal

The capitalistic organisational goal, which is based on capitalistic human needs, is defined as the *accumulation of capital* [paragraph 2.4, chapter 2]. Knowledge about how this goal is achieve is gained through applying the scientific doctrine of expansionism [paragraph 2.8, chapter 2] and the related synthetic mode of thinking, therefore by viewing the strategy of achieving the capitalistic organisational goal, as part of a larger system.

This proposed larger system, defined as the generic organisational system, is illustrated in Figure 2-1.

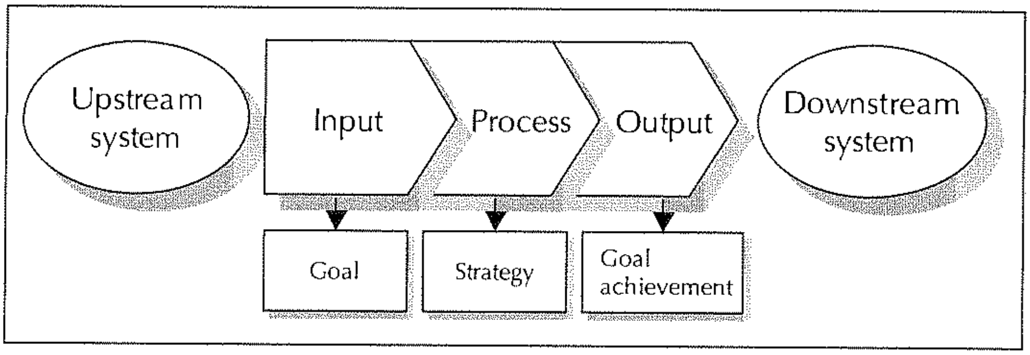

Figure 2-1: The generic organisational system

By including the transformation of capital investment to accumulated capital *(accumulated capital = capital investment + capital gain)* [paragraph 3, chapter 2] into the generic organisational system, knowledge is gained of how the capitalistic goal is achieved within this larger system. The capitalistic organisation is therefore a system that interacts with its environment by receiving input from that environment and providing output back to the environment. *Capital investment*, the input, is converted through a process of strategically controlling the means of production to an output of *accumulated capital*, which is in line with the objective of the capitalistic organisation [paragraph 2.4, chapter 2].

This capitalistic organisational system is defined and illustrated in Figure 2-2.

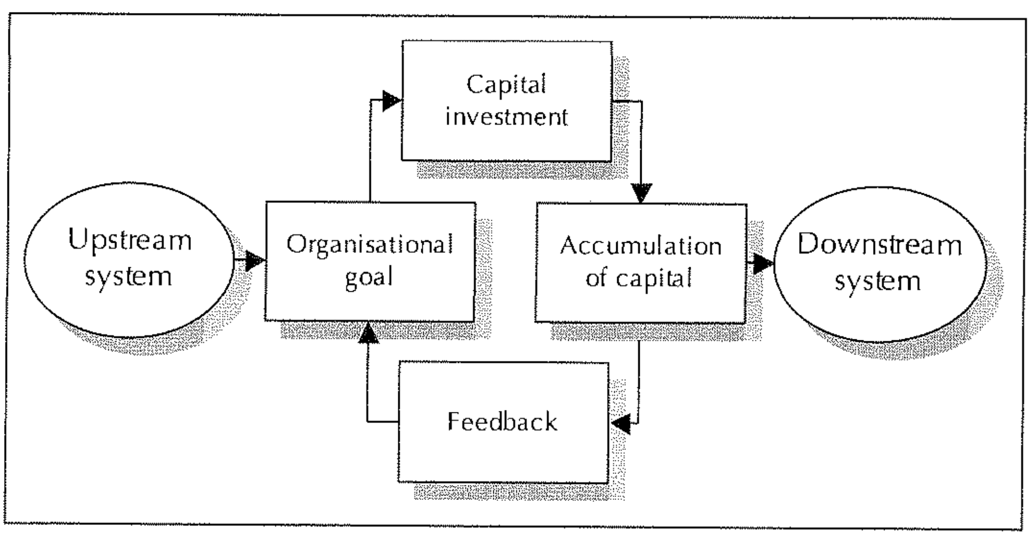

Figure 2-2: The capitalistic organisational system

Organisational strategy is the process of controlling the organisational means of production and is defined [paragraph 2.4, chapter 2] as: *A visionary plan of action by which resources are controlled in order to* *achieve the capitalistic organisational goal of accumulating capital.* The strategic activities [paragraph 2.4, chapter 2], with its generic elements of analysis, design and implementation (resource allocation), are therefore part of the expanded capitalistic organisational system aimed at achieving the capitalistic organisational goal. This expanded capitalistic organisational system is illustrated in Figure 2-3.

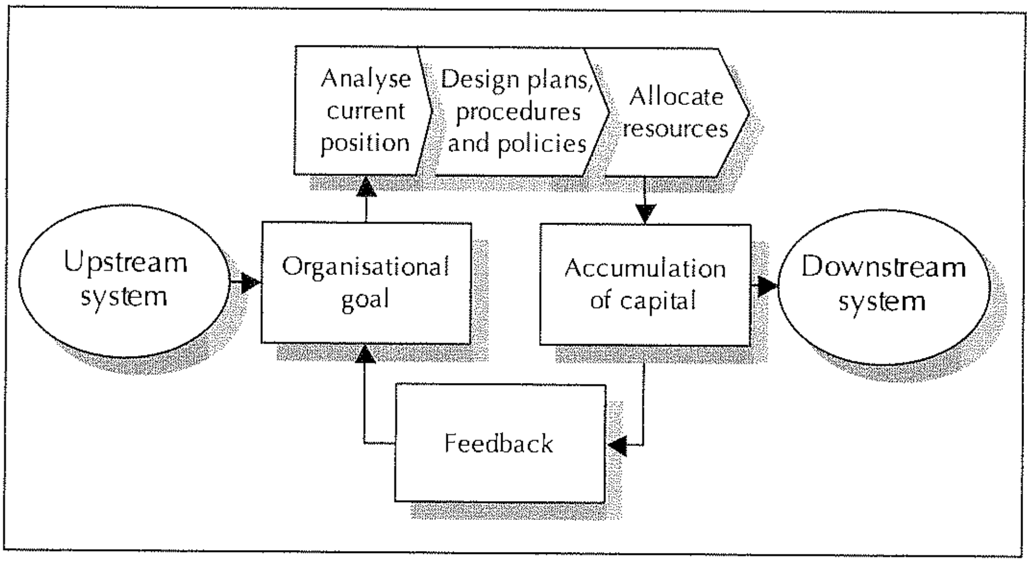

Figure 2-3: Expanded capitalistic organisational system

2.2 Strategic Industrial Engineering Philosophy

The two fundamental organisational goals of effectiveness and efficiency [paragraph 2.4, chapter 2], supported by the competitive nature of capitalism, are the motivating forces behind maintaining high levels of productivity of the organisational systems. Through the Industrial Engineering discipline the achievement of these goals are supported by drawing upon specialised scientific knowledge, skills and the analysis and design principles and methods of engineering to specify, predict and evaluate the results to be obtained from such systems [paragraph 2.8, chapter 2]. Productivity, which is a function of effectiveness and efficiency, is defined as: *The relationship between quantities of output from a system and quantities of input into that same system.* [Sink: 84].

It is reasoned that as the concept of maintaining high levels of productivity is applicable to systems, it is not only applicable to the manufacturing systems, but also to the capitalistic organisational system [paragraph 2.1, chapter 3]. Therefore the Industrial Engineering principles and skills that supports the achievement of high levels of productivity of the means of production of manufacturing related resources is also applicable to the capitalistic organisational system. Based on this reasoning the following adjustments to the productivity definition are proposed:

- *Quantities of input,* as per the definition of productivity [Sink: 84], can be expanded to include the *capital investment* into the capitalistic organisational system; and
- *quantities of output,* as per the definition of productivity [Sink: 84], can be expanded to include the *capital gain* from the capitalistic organisational system.

These expansions of the productivity definitions lead to defining productivity of capital as illustrated in Equation 2-1.

$$Productivity = \frac{Output}{Input}$$

$$Capital\ productivity = \frac{Capital\ gain}{Capital\ investment}$$

$$= \frac{Profit}{Investment}$$

Equation 2-1: Capital productivity

It is further reasoned that the financial measure of capital accumulation rate, defined as ROE, [paragraph 3.4, chapter 2] and the measure of capital productivity [Equation 2-1, chapter 3] measures the same outcome. This reasoning of setting ROE equal to capital productivity is illustrated in Equation 2-2.

$$Capital\ productivity = \frac{Profit}{Investment}$$

And: $$ROE = \frac{Profit}{Investment}$$

$\therefore$ $$Capital\ productivity = ROE$$

And: $$ROE = Capital\ accumulation$$

$\therefore$ $$Capital\ accumulation = ROE = Capital\ productivity$$

Equation 2-2: Capital productivity measures capital accumulation (ROE)

By applying specialised scientific knowledge, skills, principles and methods of the Industrial Engineering discipline to specify, predict and evaluate the results to be obtained from the capitalistic organisational system, will maintain high levels of capital accumulation or capital productivity, which satisfies the capitalistic organisational goal. This reasoning is further strengthened by the relationship between the fundamental principles of the strategy process and the classical engineering approach applied to achieve these improvements [paragraph 2.4 and 2.8, chapter 2]. The Strategic Industrial Engineering Process has the following steps:

- Current position analysis – obtaining an understanding of the specific requirements or needs;
- action plan design – creation of an innovative solutions to satisfy the specific requirement / need; and
- implementation of action plan through the allocation of resources – applying the solution in order to satisfy the requirement / need,

The proposition of this thesis, that the current philosophy of Industrial Engineering can be expanded beyond its current realm of industrial age resources to engineering economic industry resources, is therefore justified. This expanded philosophy of Industrial Engineering, termed *A Strategic Industrial Engineering Philosophy,* is therefore a strategic tool that is concerned with the means through which the capitalistic organisational system achieve high levels of capital accumulation within competitive industries.

2.3 Strategic Industrial Engineering

Strategic Industrial Engineering is defined as the utilisation of scientific (Industrial Engineering) knowledge to productively utilise capital investments made into industries as a means of increasing the rate of capital accumulation in capitalistic corporations. The elements of *Strategic Industrial Engineering,* in relation to achieving the organisational goal, are scientifically explored in this chapter. The process, derived from the relationship between the strategy and engineering processes [paragraph 2.2, chapter 3], has the following phases:

- Analysis of current position;
- design of an innovative action plan in order to satisfy the requirement or goal; and
- implementation of the action plan through the purposeful allocation of resources.

A generic *Strategic Industrial Engineering Process* is illustrated in Figure 2-4.

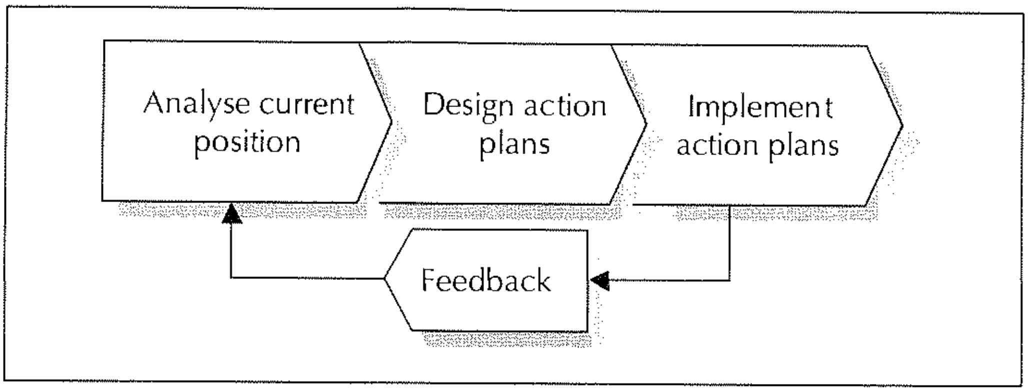

Figure 2-4: Generic strategic industrial engineering process

The third fundamental organisational goal of equilibrium is addressed in Strategic Industrial Engineering through the following performance-regulating principles:

- The ability (competitive advantage) of a corporation's independent organisations' to accumulate capital within their specific industries *(organisational competitiveness)*;
- competitive interactions within these individual industries *(industry competitiveness)*;
- the ability of the corporation to capture the strategic fit benefits of its portfolio of organisations *(strategic fit benefits)*; and
- the combination of independent organisations and therefore the exposure to multiple industries *(industry exposure)*.

These fundamental performance-regulating principles, aimed at achieving the capitalistic goal, are illustrated in Figure 2-5.

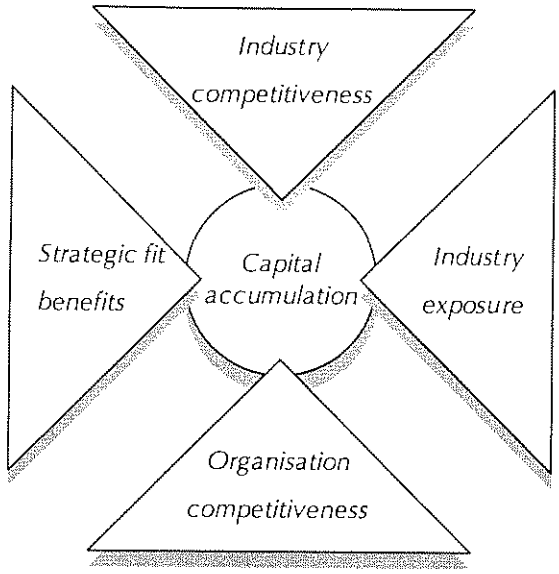

Figure 2-5: Performance regulating principles

2.3.1 *Organisational competitiveness*

It is proposed that organisational competitiveness (*ROE*), within an industry, is distributed as indicated in Figure 2-6. This distribution indicates the industry's average ROE performance and the standard deviation of competitive organisational performances within the industry. An organisation's competitiveness within an industry can be derived from its relative position to the average and standard deviation of this distribution.

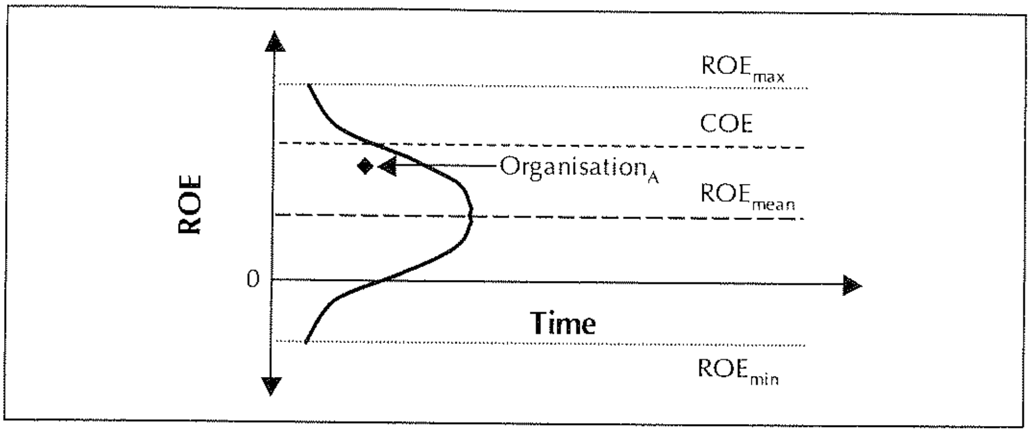

Figure 2-6: Industry ROE vs. organisational ROE

The symbol ROE_{mean} refers to the mean ROE performance of an industry. Any organisation within this industry performs relative to this average. This performance can be higher that the industry ROE_{mean}, with the best organisational performance indicated by ROE_{max}. An organisation can also perform lower than ROE_{mean} and the worst performing organisation in the industry will have a ROE that is indicated as ROE_{min}, which can even be lower than 0 therefore negative. The productivity of the organisation to accumulate shareholder capital (*ROE*) is also measured against its cost of equity (*COE*) to determine the positive or negative accumulation of capital contribution, based on the risk profile of the organisation. *Organisation$_A$* has a competitiveness (ROE) higher than the industry average *(ROE_{mean})*, although its performance is lower than the cost of equity. *Organisation$_A$* therefore has a negative contribution to the accumulation of shareholders capital, based on the risk profile of the organisation.

It is proposed that the distribution of organisations' competitiveness is a function of the three Du Pont identity elements [paragraph 3.5, chapter 2]. The competitiveness of an organisation, within an industry, is therefore the aggregate of the performance of the organisation on each of these elements measured against the competitors within the industry. The three Du Pont identity elements are:

- Operating efficiency *(as measured by profit margin)*;
- asset use efficiency *(as measured by total asset turnover)*; and
- financial leverage *(as measured by the equity multiplier)*.

2.3.1.1 <u>Operational efficiency</u>

The relative operating efficiency or operating competitiveness of the organisation is determined by the profit margin, which is a function of:

- Sales price[1], which is a function of the market forces and industry structure;
- units sold, also sales volume and relates to industry market share;

[1] *Sales price:* *Monetary value of things measured in terms of what the buyers in a market will give in exchange for them.*

- cost of sales[2], which includes all operating cost also called operating cash cost; and
- overhead cost[3], which is non-operating cost including interest and taxation.

The relationships between these elements of profit margin are indicated in Equation 2-3.

$$\textit{Profit margin} = \frac{\textit{Revenue} - \textit{cost of sales} - \textit{overhead cost}}{\textit{Sales price} \times \textit{units sold}}$$

Equation 2-3: Operating efficiency

Comparing operating efficiency of competitive organisations within an industry is achieved through the use of an industry cost curve. A generic industry cost curve, based on cost curves generated by AME [5], is illustrated in Figure 2-7.

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[2] *Cost of sales:* *Cost such as materials and wages that vary according to how much is produced.*

[3] *Overhead cost:* *Cost such as depreciation of the asset, interest on debt and taxation.*

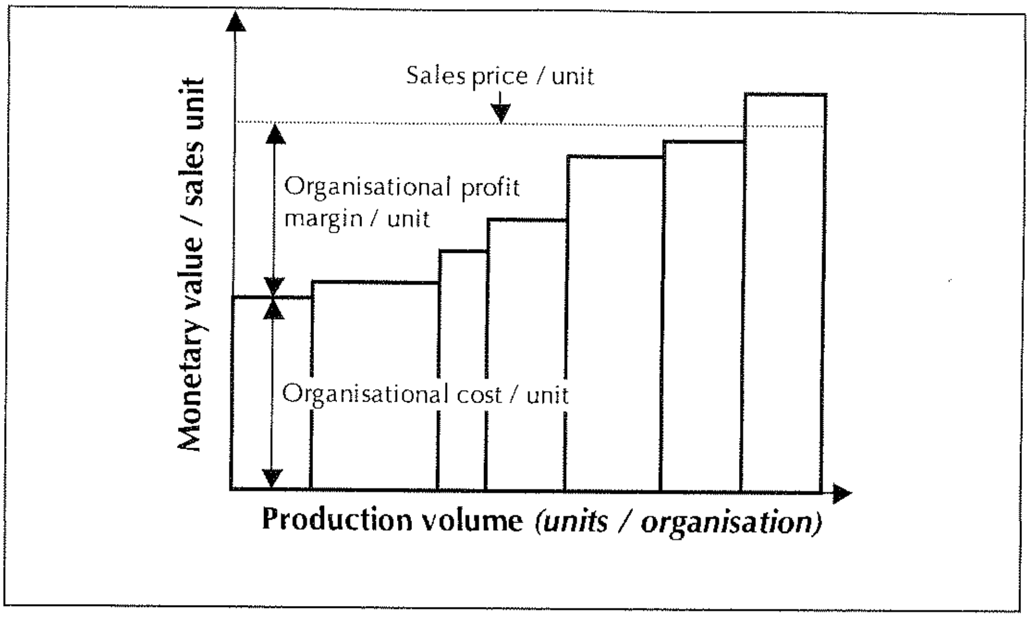

Figure 2-7: Generic industry cost curve

The curve illustrates the following:

- Supply or production volume (units / organisation) as independent variable; and
- monetary value / sales unit as dependent variable. The following are illustrated on this axis:
  - Organisational cost / unit;
  - organisational profit margin / unit; and
  - sales price per unit that is a function of demand.

The difference between the sales price / unit and the organisational cost / unit of the organisation multiplied with the production volume is equal to the organisation's profit. Organisations to the left-hand side of the curve will be more profitable based on lower cost per product. It is also indicated that the sales price / unit is lower than the organisation's cost / units to the far right of the curve. This indicates that the supply capacity is more than the demand.

The organisations with a production cost / unit above the sales price / unit line will therefore have to sell its product at a loss. The reason that a certain amount of product can still be sold beyond the demand level is that demand is influenced by price. If the price is low enough the product will most likely be sold, based on the principle that the user could now possible extract more value and therefore the product becomes useful. These high cost organisations will eventually close down if these low prices persist and they cannot reduce their cost to below the sales price / unit. In doing this they need to become more competitive and claim market share from another organisations in the industry. The sales price / unit will again increase when the demand exceeds the supply. The demand cycle in each industry is specific to the industry and is based on demand drivers. A relationship, as indicated in Figure 2-8, exists between the demand and supply curves of an industry.

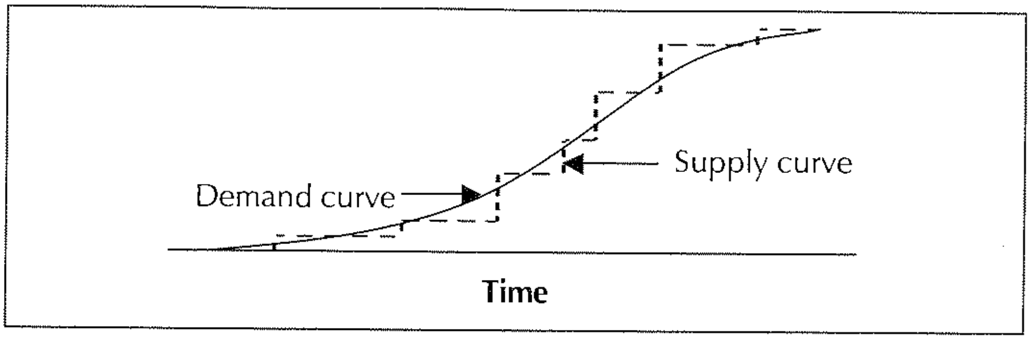

Figure 2-8: Demand / supply relationship

The demand curve will tend to follow a smooth curve, while the supply curve will typically follow a step curve. The reason for this is primarily the capacity developed to supply. Most organisations has a certain supply capacity, be it personnel in a consulting organisation or factory capacity in a steel organisation. These positive and negative gaps between demand and supply, also known as over and under supply, are the primary drivers for sales price / unit and also profit margin fluctuations.

An organisation's position on the cost curve therefore represents its relative operating efficiency within the industry. To improve operating efficiency the following need to be addressed:

- Revenue needs to increase, therefore:
    - Increase units sold; and / or
    - increase sales price.
- Total cost needs to be reduce, therefore:
    - Cost of sales needs to be reduced; and
    - overhead cost needs to be reduced.

The organisational profit margin can also be compared to the industry average, which is defined in paragraph 2.3.2.1 of chapter 3, to determine above or below industry average performance and subsequently the organisation's relative operational efficiency.

2.3.1.2 Asset use efficiency

Asset use efficiency is measured through asset turnover. The magnitude of required assets are typically industry specific, but the efficient utilisation of assets within the industry constraints is manageable. The efficient use of asset is a function of the following elements:

- Sales price;
- units sold;
- current assets[4];
- current liabilities[5]; and
- fixed assets[6].

---

[4] *Current assets:* *Those assets that management could reasonably be expected to convert into cash within one year; they include cash, receivables, goods in stock (or merchandise inventory) and short-term investments in stocks and bonds.*

[5] *Current liabilities:* *Monetary amounts that are expected to be paid within one year, including salaries and wages, taxes, short-term loans and money owed to suppliers of goods and services.*

[6] *Fixed assets:* *Encompass the physical plant—notably land, buildings, machinery, motor vehicles, computers, furniture and fixtures. They also include property being held for speculation and intangibles such as patents and trademarks.*

The relationships between these elements of asset turnover are indicated in Equation 2-4.

$$Total\ asset\ turnover = \frac{Sales\ price \times units\ sold}{Fixed\ assets + Current\ (assets - liabilities)}$$

Equation 2-4: Asset use efficiency

Increasing revenue and or reducing assets improve an organisation's efficient asset usage. Revenue is increased as discussed in paragraph 2.3.1.1 of chapter 3 and assets can be reduced by:

- Reducing current assets and fixed assets; and
- increasing the ratio between current liabilities and current assets.

The organisation's asset utilisation can be compared to the industry average, which is defined in paragraph 2.3.2.2, chapter 3, to determine above or below industry average performance.

2.3.1.3 <u>Financial leverage</u>

Equity multiplier measures an organisation's financial leverage and is a function of debt and equity. This relationship between debt and equity is illustrated in Equation 2-5.

$$Equity\ multiplier = \frac{Assets}{Equity} = 1 + \frac{Debt}{Equity}$$

Equation 2-5: Financial leverage

Financial leverage can therefore be improved by increasing debt or by reducing equity. However, *positive financial leverage* is limited to debt interest being less than the organisation's ROA [paragraph 3.3.1, chapter 2]. Financial leverage also exposes the organisation to the following risks [paragraph 3.3.2, chapter 2]:

- Business risk; and
- financial risk.

The optimal level of leverage, taking into account the above-mentioned risks, is achieved when taxation savings from additional debt financing is equal to the increased bankruptcy cost associated with additional borrowings [paragraph 3.3.3, chapter 2].

Debt / equity ratios or leverage can be compared to the industry averages [paragraph 2.3.2.3, chapter 3] to determine above or below industry average performance.

2.3.1.4 Cost of equity

The cost of equity is calculated based on the following factors [paragraph 3.2.1, chapter 2]:

- The risk free rate (R_f).
- The market risk premium (MRP), ($R_M - R_f$).
- The systematic risk of the industry, called the ßeta coefficient (*ß*).

Return on equity (R_E) or the cost of equity is illustrated in Equation 2-6:

$$R_E = R_f + ß_E \times (R_M - R_f)$$

Equation 2-6: Cost of equity

The importance of this as an internal organisational competitiveness benchmark is to determine if the contribution towards accumulation of shareholders capital (equity), as measured in ROE, is positive or negative in relation to the inherent risks of the organisation.

Theoretically, an organisation's long-term average ROE has the tendency to gravitate to the organisation's cost of equity, as the cost of equity defines the long-term expected ROE of the organisation based on its inherent risks and related market expectations. Philosophically it can be stated that the cost of equity is the shareholder's expected long-term return on capital investments made in a specific risk profile industry.

In the case where the organisation's ROE is higher than the cost of equity, the organisation has a positive accumulation of capital. An organisational ROE below the cost of equity indicates a negative accumulation of capital, based on the specific risk profile of the organisation.

2.3.2 *Industry competitiveness*

Value[7] creation requires that the sales price / unit that the customer is willing to pay for a product or service exceed the production cost / unit incurred by the organisation in producing the product or service. Value creation however, does not translate directly into *profit*, as the surplus value over the cost is distributed between customers and producers by the forces of competition [Grant: 36]. The stronger the competition between organisations, the lower the sales price / unit actually paid by the customer compared to the maximum sales price / unit that they would have been willing to pay. In other words, the greater the proportion of the surplus gained by the customer, the less is earned by

[7] *Value:* *The worth of a commodity or service measured against other commodities or services. The term generally refers to the total monetary revenue, or price, for which an item will sell.*

the organisations. The surplus earned by organisations over and above the minimum cost of production is not entirely captured in profit. Where an industry has powerful suppliers then these suppliers may appropriate a substantial part of the surplus.

The level of industry profitability is determined, in part, by the industry structure. The underlying theory of how industry structure drives competitive behaviour and determines industry profitability is provided by industrial organisation economics. The two reference points are the theory of monopoly and the theory of perfect competition, which represent the two ends of the industry structure spectrum.

A single organisation that is completely protected by barriers to entry of new organisations forms a monopoly. The profit that it creates is equal to the value it creates. By contrast, many organisations supplying identical products with no restrictions on entry or exit constitute perfect competition. In this case the rate of profit falls to a level that just covers the organisation's cost of capital. Typically industries' profits range between these two extremes [Grant; 36].

A summary of the industry structure spectrum is presented in Table 2-1.

	Perfect competition	Oligopoly	Duopoly	Monopoly
Concentration	Many organisations	A few organisations	Two organisations	One organisation
Entry and exit barriers	No barriers	Significant barriers		High barriers
Product differentiation	Homogeneous product	Potential for product differentiation		
Information	Perfect information flow	Imperfect availability of information		

Table 2-1: Industry structure spectrum

The effect of industry structure on industry value is illustrated in Figure 2-9.

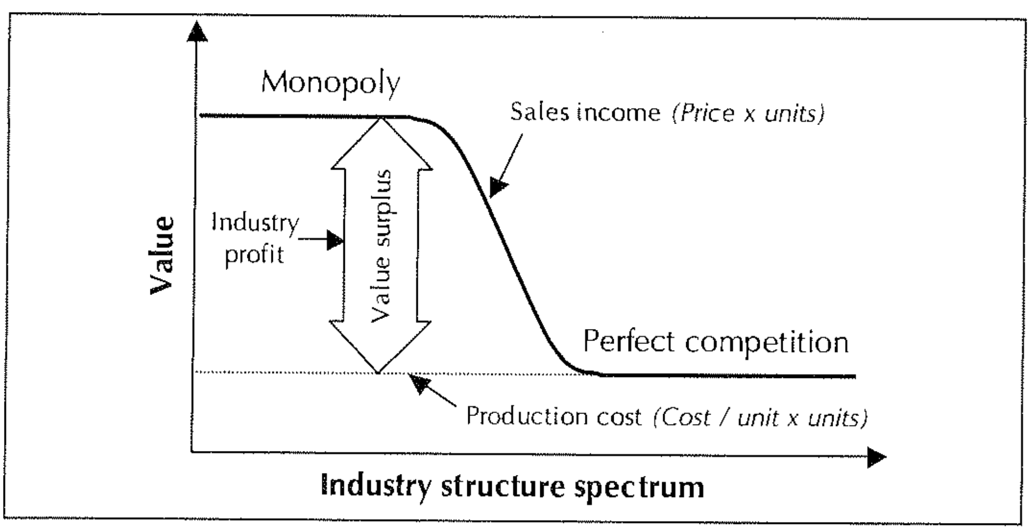

Figure 2-9: Industry value

Therefore competitive interaction within the industry determines an industry's profitability. Therefore profits earned in an industry are determined by three factors [Grant; 36]:

- The value of the product or service to customers;
- the intensity of competition; and
- the relative bargaining power at different levels in the production chain.

Competitive forces shape the playing field within an industry. Porter [65] suggests the *Five Forces model* as a means of understanding industry structure and competitive behaviour. The Five Forces model is shown in Figure 2-10.

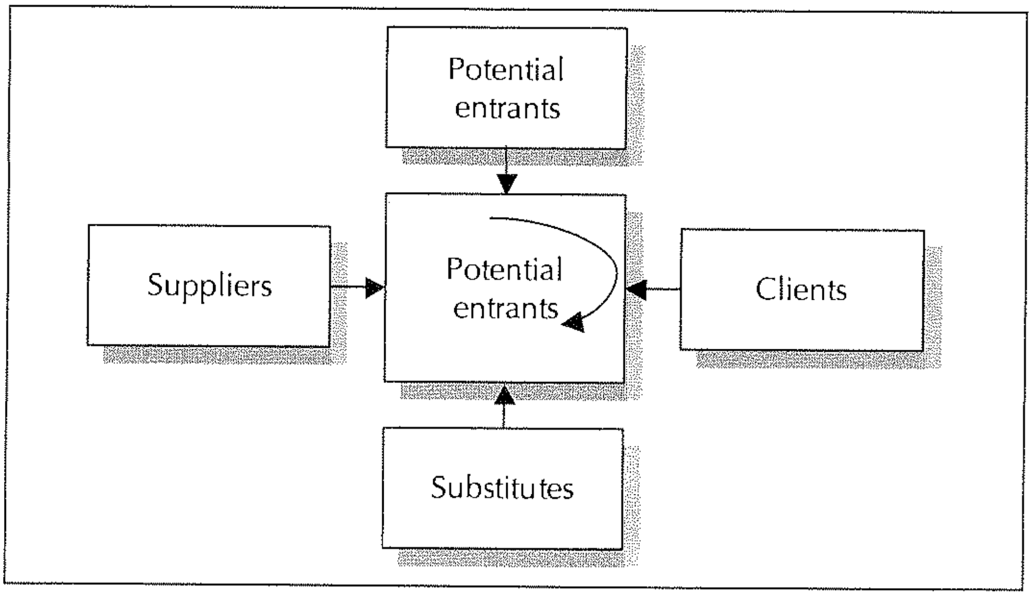

Figure 2-10: Five forces model

The five forces model requires an understanding of the following factors:

- The market needs that are being satisfied by a particular industry and the products on offer;

- existing competitors and the rivalry between them;
- potential competitive threats to the industry as a whole;
- potential substitutes to the industry as a whole;
- the nature of the customers (downstream system) of the industry with an emphasis on the collective power of the all the businesses in the industry to influence or expand the market;
- the nature of the supplier base (upstream system) of the industry; and
- barriers to entry into the existing business system set for/by an organisation.

One of best-known and most enduring marketing concepts is the product life cycle [Grant: 36]. Products are born, their sales grow, they reach maturity, they go into decline and they ultimately die. Blanchard's [10] life cycle concept is derived from the point of view that life in general is cyclical and can be modelled as a system as shown in Figure 2-11.

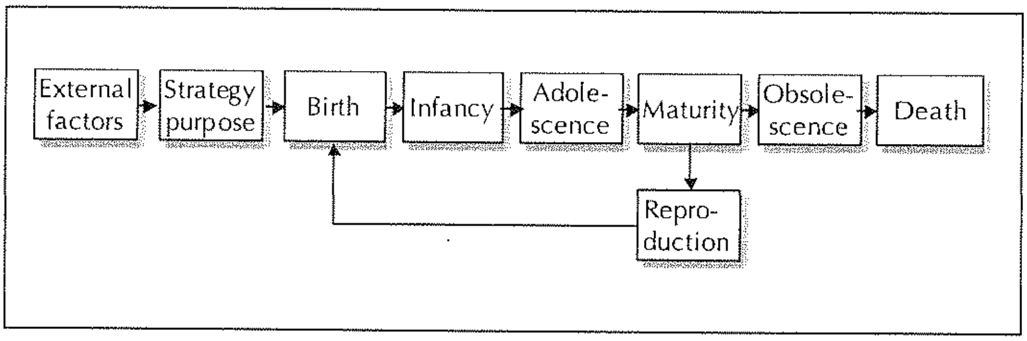

Figure 2-11: The life cycle of a system

If products have life cycles, so too do the industries that produce them. The extent to which industries conform to the life cycle is industry dependent [Grant; 36]. Therefore the duration and evolution patterns of life cycles may vary from industry to industry. Industries supplying basic necessities may never enter a decline phase because obsolescence is unlikely in such needs. Some industries may experience a rejuvenation of their life cycle. An industry is likely to be in different stages of the life cycle in different countries. Changes in demand growth and technology over the cycle have implications for industry structure, competition and sources of competitive advantage.

In the Oxford dictionary [44] industry is defined as: *The people and activities involved in producing a particular thing, or in providing a particular service*. This definition supports the statement that the life cycle of a particular thing or service *(the product life cycle)* and the corresponding *industry life cycle* are the same life cycle. It can further be derived that if a specific product is only produced by one organisation and this is also the only product that the organisation produces then the *organisation's life cycle* corresponds with that of the product and industry.

From the relationship between accumulation of capital (ROE) and revenue (sales), it is derived that an industry's accumulation of capital (ROE) is affected by the product life cycle. This relationship between accumulation of capital (ROE) and revenue is illustrated in Equation 2-7.

$$ROE = \frac{Net\ income}{Total\ equity}$$

$$= \frac{Profit}{Investment}$$

$$= \frac{Revenue \times Profit\ margin}{Investment}$$

Equation 2-7: Accumulation of capital and sales volume relationship

An industry's profitability, in relation to the industry's capital productivity, is therefore bound by a life cycle, illustrated in Figure 2-12. Industry profitability is a function of industry structure, therefore the competitive behaviour within the industry. The life cycle is therefore dependent on:

- The value of the product or service to customers;
- the intensity of competition; and
- the relative bargaining power at different levels in the production chain.

The sigmoid curve is often used to describe the life cycle of an organisation [Handy: 41], in this thesis it will describe the life cycle of an industry. It is therefore reasoned that an industry is subject to:

- An initial rapid *growth* phase;
- followed by a phase of *maturity* and relative stability; and
- lastly a phase of rapid *decline*.

The sigmoid curve is defined in Equation 2-8 [Handy: 41]:

$$\frac{1}{S} = K + MN_T$$

Where: T = *elapsed time*

S = *cumulative organisational ROE*

K, M and N are constants

Equation 2-8: Sigmoid curve

The following equations define the sigmoid curve phases:

- The growth phase is defined as $dS/dT > 0$;
- the maturity phase is defined as $dS/dT = 0$;
- the saturation or decline phase is defined where $dS/dT < 0$; and
- the points of inflection where $d^2S/dT^2 = 0$.

An industry's accumulation of capital (ROE) life cycle (*sigmoid curve*) is illustrated in Figure 2-12.

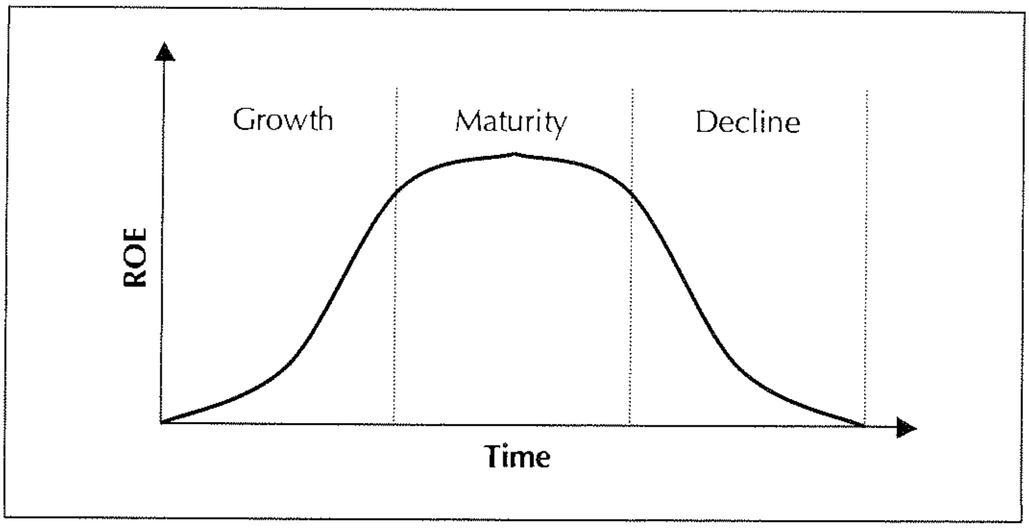

Figure 2-12: Accumulation of capital life cycle

The accumulation of capital life cycle represents the mean accumulation of capital (ROE_{mean}) of the industry over time. The distribution of organisational accumulation of capital within the specific industry, [paragraph 2.3.1, chapter 3], indicates the organisational competitiveness over the life cycle.

The proposed industry ROE life cycle that indicates the distribution of organisational competitiveness throughout the life cycle is indicated in Figure 2-13.

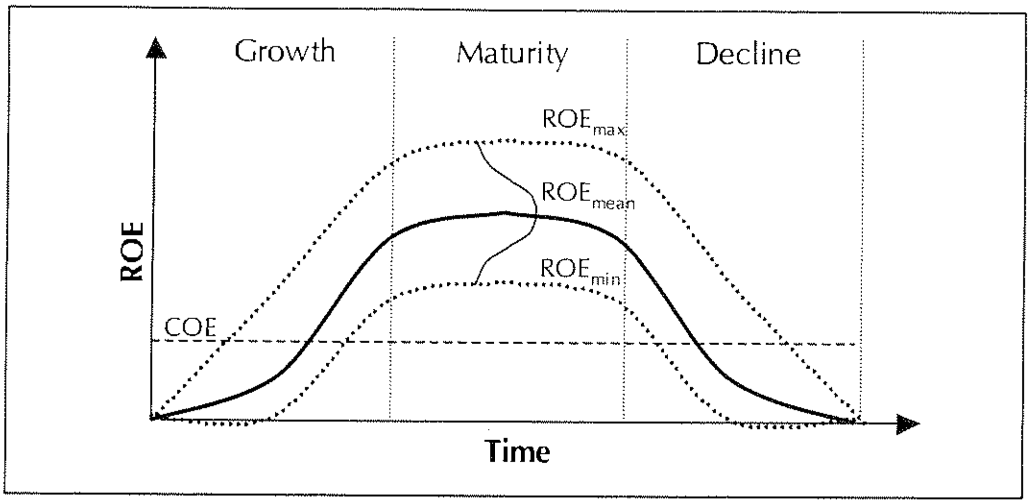

Figure 2-13: Industry ROE life cycle

The proposed industry ROE life cycle curve [Figure 2-13] depicts the following:

- The organisational competitiveness distribution as defined in paragraph 2.3.1 of chapter 3:
  - The industry's mean accumulation of capital (ROE_{mean});
  - the lowest organisational ROE in the industry (ROE_{min});
  - the highest organisational ROE in the industry (ROE_{max});
- the cost of equity [paragraph 2.3.1.4, chapter 3], included as reference point to indicate if accumulation of capital is higher or lower than the cost of equity (*COE*), therefore to determine the positive or negative accumulation of capital contribution, based on the risk profile of the organisation; and
- the three fundamental phases of a life cycle:
  - The growth phase;

- the maturity phase; and
- the decline phase.

The industry cycle, Figure 2-14, illustrates the proposed movement in *actual* ROE_{mean}, driven by industry competitiveness, versus the *average* ROE_{mean} over a 10 - 30 year period.

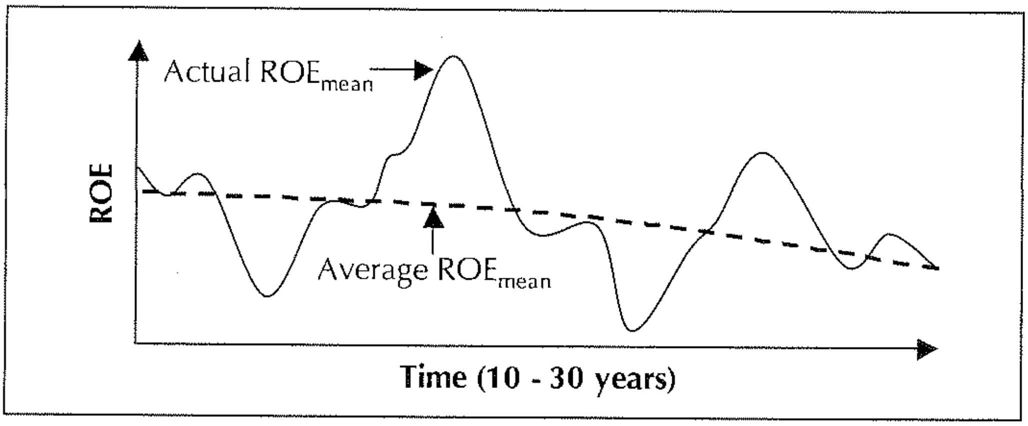

Figure 2-14: Industry cycle

In Figure 2-15 the proposed Industry ROE life cycle, which might span a period of hundreds of years, is illustrated with the industry cycle of 10 – 30 years superimposed on it.

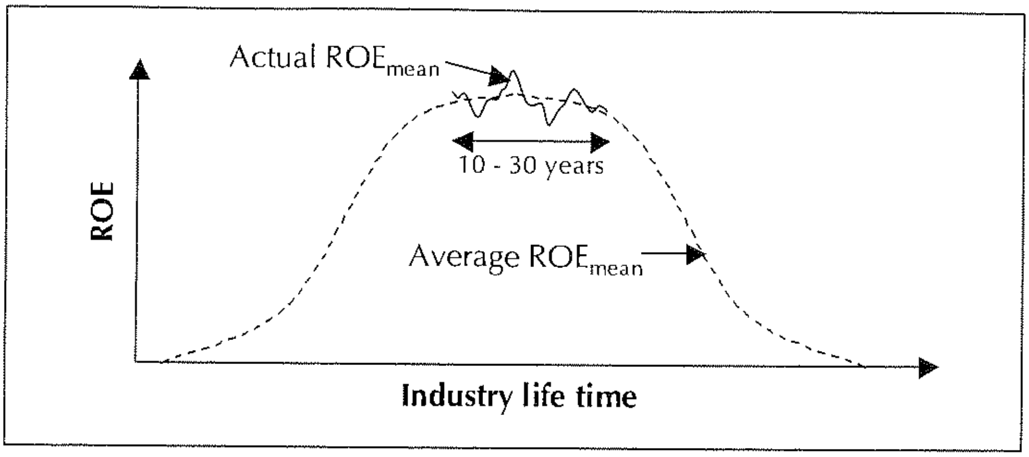

Figure 2-15: Industry cycle on the industry ROE life cycle

In Figure 2-15 it is illustrated that industry competitiveness influences the industry cycle and the industry cycle in turn follows the proposed industry ROE life cycle.

Often as one technology approaches its limits, another technology comes along that will eventually replace it. As technologies evolve industry life cycle discontinuities inevitable occurs. For example the glass bottle industry found much of their business replaced by steel cans and paper cartons. The steel can industry was succeeded by the aluminium can industry and paper cartons were replaced by plastic.

Technology driven industry life cycle discontinuities are illustrated in Figure 2-16.

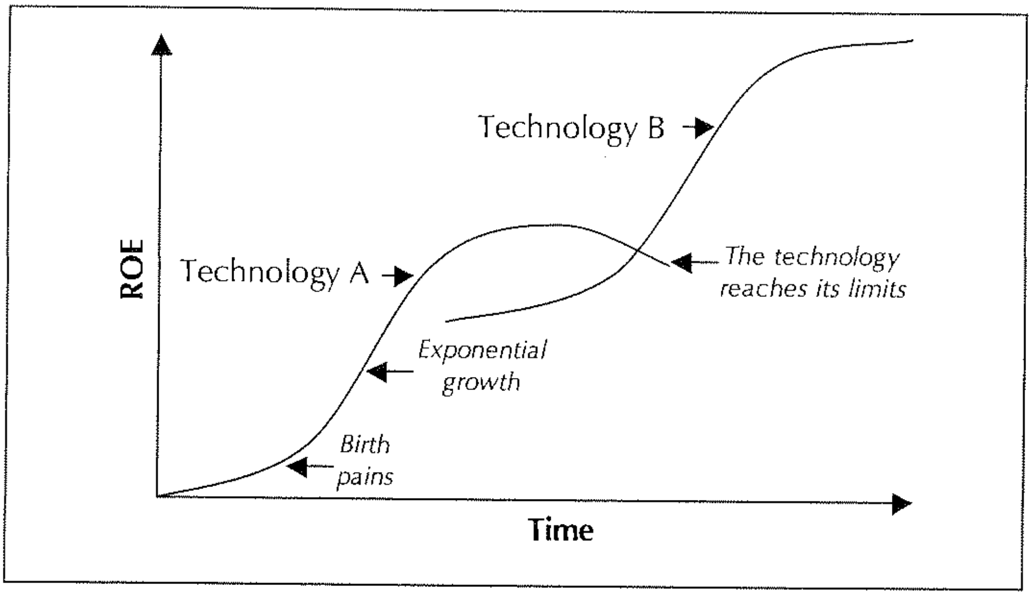

Figure 2-16: One technology or industry replaces another

Foster [17] studied such discontinuities and concludes that when they occur, corporate fortunes change dramatically. *"Leaders in the current technology rarely survived to become leaders in the new technology. Their losses can vary from gentle to total, from embarrassing to humiliating."* These leaders-to-losers stories can include entire industries.

Current industry profitability cannot be used to accurately predict industry profitability over time. However, the underling changes in the industry structure, based on competition within the industry, can be used to predict industry profitability with some accuracy. Scenarios of the potential changes in the underlying industry structure can be used to predict the probable change in an industry's operational efficiency. These structural changes are driven by [Grant: 36]:

- Current changes in production and process technology;
- current strategies of the leading competitors;
- changes in infrastructure and related industries; and
- government policies.

An industry's competitiveness is a function of:

- *Operating efficiency*, a function of industry structure over time and is measured by profit margin, which is a function of [paragraph 2.3.2.1, chapter 3]:
  - The value of the product or service to customers;
  - the intensity of competition;
  - the relative bargaining power at different levels in the production chain.
- *asset use efficiency*, measured by industry's total asset turnover; and
- *financial leverage*, as measured by the industry's equity multiplier.

2.3.2.1 Operating efficiency

The long-term mean profit margins of different industries vary as indicated in Table 2-2. This table was constructed using historical data (*ten-years*) of the JSE Securities Exchange, obtained from ABSA Economic Review [1].

Industry	**Profit margin** (*10 year Average*)
Retail	5.46
Building, Construction and Engineering	5.62
Clothing and textile	5.67
Information Technology	7.47
Services	7.88
Food	9.03
Transport	9.38
Electronics and Electrical	9.96
Steel	9.96
Beverage	11.81
Telecommunication	12.67
Diversified Industrial	14.73
Chemical, Oils and Plastics	19.67
Mining Holdings and Mining Houses	20.47
Property	28.77

Table 2-2: RSA industry vs. profit margin comparison

2.3.2.2 Asset use efficiency

Information obtained from ABSA Economic Review [1] was used to construct Table 2-3, which indicates the relationship between asset turnover and industries as measured over a ten-year period on the JSE Securities Exchange.

Industry	Asset turnover (10 year Average)
Retail	2.59
Information Technology	1.98
Building, Construction and Engineering	1.72
Electronics and Electrical	1.68
Services	1.61
Telecommunication	1.59
Food	1.54
Transport	1.34
Beverage	1.23
Clothing and textile	1.21
Chemical, Oils and Plastics	0.86
Steel	0.85
Diversified Industrial	0.77
Property	0.33
Mining Holdings and Mining Houses	0.31

Table 2-3: Industry and asset turnover comparison

2.3.2.3 Financial leverage

Information obtained from ABSA Economic Review [1] was used to construct Table 2-4 so as to indicate the relationship between the debt/equity ratio and various industries as measured over a ten-year period on the JSE Securities exchange.

Industry	**Debt / equity** *(10 year Average)*
Services	2.70
Telecommunication	1.70
Retail	1.58
Information Technology	1.41
Building, Construction and Engineering	1.36
Electronics and Electrical	0.94
Food	0.93
Transport	0.93
Beverage	0.80
Property	0.78
Clothing and textile	0.72
Chemical, Oils and Plastics	0.57
Steel	0.46
Diversified Industrial	0.37
Mining Holdings and Mining Houses	0.34

Table 2-4: Industry and debt/equity ratio comparison

2.3.2.4 Industry accumulation of capital

It is also suggested that these Du Pont elements have an interrelationship. For example – high profit margins with a high asset turnover will probable be more risky than a low profit with low asset turnover organisation. Risk is captured in leverage, therefore the first example will probable have a lower equity multiplier than the second example.

Information from ABSA Economic Review was used to construct Table 2-5 in order to demonstrate the potential interrelationship between the Du Pont identity elements. From this table it can be seen that industries with high profit margins typically have lower asset turnover. Debt / equity tends to follow this relationship, although it is not conclusive.

Industry	Profit margin (10 year Average)	Asset turnover (10 year Average)	Debt / equity (10 year Average)
Retail	5.46	2.59	1.58
Building, Construction and Engineering	5.62	1.72	1.36
Clothing and textile	5.67	1.21	0.72
Information Technology	7.47	1.98	1.41
Services	7.88	1.61	2.70
Food	9.03	1.54	0.93
Transport	9.38	1.34	0.93
Electronics and Electrical	9.96	1.68	0.94
Steel	9.96	0.85	0.46
Beverage	11.81	1.23	0.80
Telecommunication	12.67	1.59	1.70
Diversified Industrial	14.73	0.77	0.37
Chemical, Oils and Plastics	19.67	0.86	0.57
Mining Holdings and Mining Houses	20.47	0.31	0.34
Property	28.77	0.33	0.78

Table 2-5: Interrelationship between Du Pont identity elements

Industry accumulation of capital (ROE) is industry specific [paragraph 3.1.3.3, chapter 3], based on an industry's tendency toward unique Du Pont identity element values as illustrated above. Information from ABSA Economic Review was used to construct Table 2-5 in order to demonstrate the industry specific accumulation of capital, as measure in ROE. This represents the industry's competitiveness.

Industry	**ROE (%)** *(10 year Average)*
Services	34.25
Telecommunication	34.25
Retail	22.34
Information Technology	20.86
Building, Construction and Engineering	13.15
Electronics and Electrical	15.73
Food	12.93
Transport	9.97
Beverage	11.62
Property	7.40
Clothing and textile	4.94
Chemical, Oils and Plastics	9.64
Steel	3.89
Diversified Industrial	4.20
Mining Holdings and Mining Houses	2.16

Table 2-6: Industry specific ROE

2.3.3 Industry exposure

It is proposed that a corporation that is exposed to multiple organisations and therefore potentially multiple industries has a weighted average capital accumulation (ROE) based on the capital accumulation (ROE) of each independent organisation, within its specific industry, that it is exposed to. The current and future ROE of each industry will influence the current and future ROE of the corporation, as each organisation's ROE is influenced by its industry's competitiveness.

In Figure 2-17 the proposed influence of a corporation's exposure to multiple industries is illustrated. $Organisation_A$ is performing worse than its industry's ROE_{mean} although its ROE is higher than the corporate COE.

Organisation$_B$ is performing better than its industry's *ROE$_{mean}$*, but worse than the corporate COE.

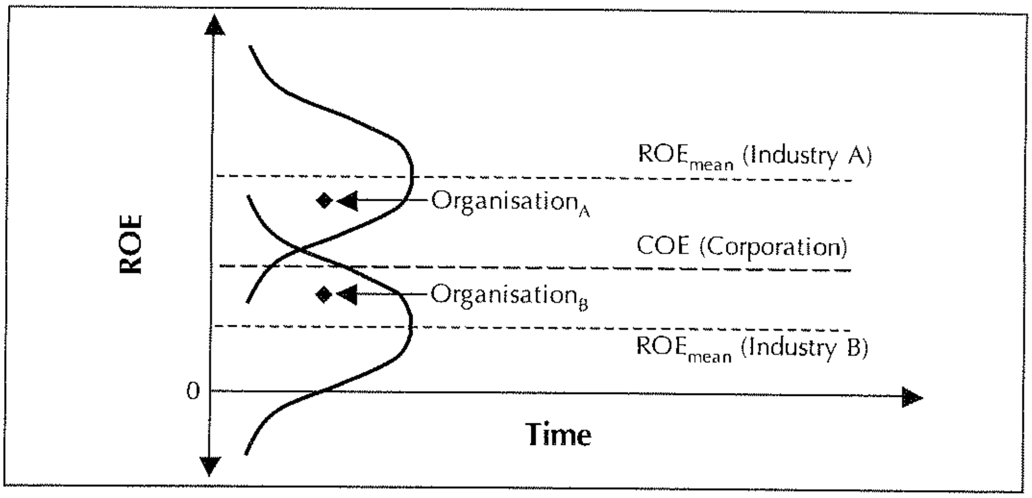

Figure 2-17: Corporate industry exposure

This relationship between the corporation and its individual organisation's accumulation of capital (*ROE*) [paragraph 2.2, chapter 3] is calculated as proposed in Equation 2-9.

$$ROE_{corporation} = \frac{((ROE \times Equity)_{organisation\ A} + (ROE \times Equity)_{organisation\ B}}{Equity_{organisation\ A} + Equity_{organisation\ B}}$$

Equation 2-9: Industry exposure

An organisation's industry exposure is dependent on the corporation's investment philosophy regarding the relationship between diversity of the grouping of organisations and shareholder accumulation of capital. In principle diversification does not create shareholder value unless a group of organisations perform better within a single corporation than they would perform operating as independent, stand alone organisations. It is proposed that the industry exposure is therefore dependent on:

- The investment philosophy of the corporation; and
- is defined by the organisational scope.

The corporation's investment philosophy depends on the relationship between ownership and control is illustrated in Figure 2-18.

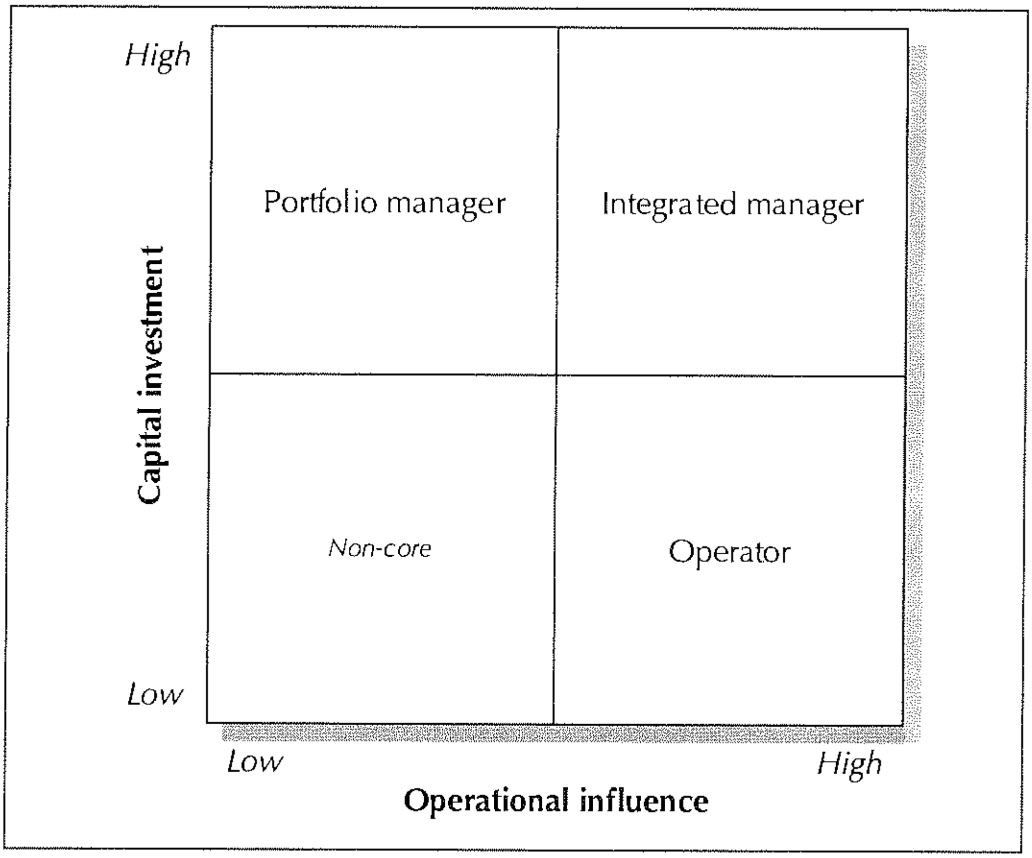

Figure 2-18: Capital investment philosophy model

From this model it is derived that three alternative philosophies exist:

- A *portfolio manager* philosophy with primary focus on ownership of investments. The core skills and processes are portfolio management related. A portfolio is managed in order to achieve accumulation of capital by managing industries life cycles and risk.
- An *operator* philosophy with primary focus on operations and ownership of certain organisational facilities as secondary. The core skills and processes are operational. A portfolio within this quadrant is managed with the aim of creating a competitive advantage above its competitors.
- An *integration manager* philosophy focuses on the synergies between individual assets. The core skills and processes are based on the integration of these organisations as assets. A portfolio will be managed in order to unlock synergies between the various organisations to accumulate capital.

The dynamics of the capital investment philosophy model are:

- In order to move from an *operator* to an *integration manager* approach, a corporation has to:
  - Increase its capital investment;
  - focus more on synergies than operations; and
  - develop its integration skills.

- In order to move from an *integration manager* to a *portfolio manager* approach, a corporation has to:
  - Focus more on capital investing than integration; and
  - develop its portfolio management skills.

The investment philosophy also relates to the strategic fit of the corporation's portfolio with its goals, values, resources, capabilities and core competencies. In other words, the investment philosophy of the corporation describes the diversification philosophy and fits this with the organisation's goals, values and ability.

A corporation's industry exposure is defined by the scope of the corporation. The corporation's scope axes define the diversity of a corporation in terms of the relationships between its organisations and industries, in which it competes [Grant: 36]. The corporation's scope axes are illustrated in Figure 2-19.

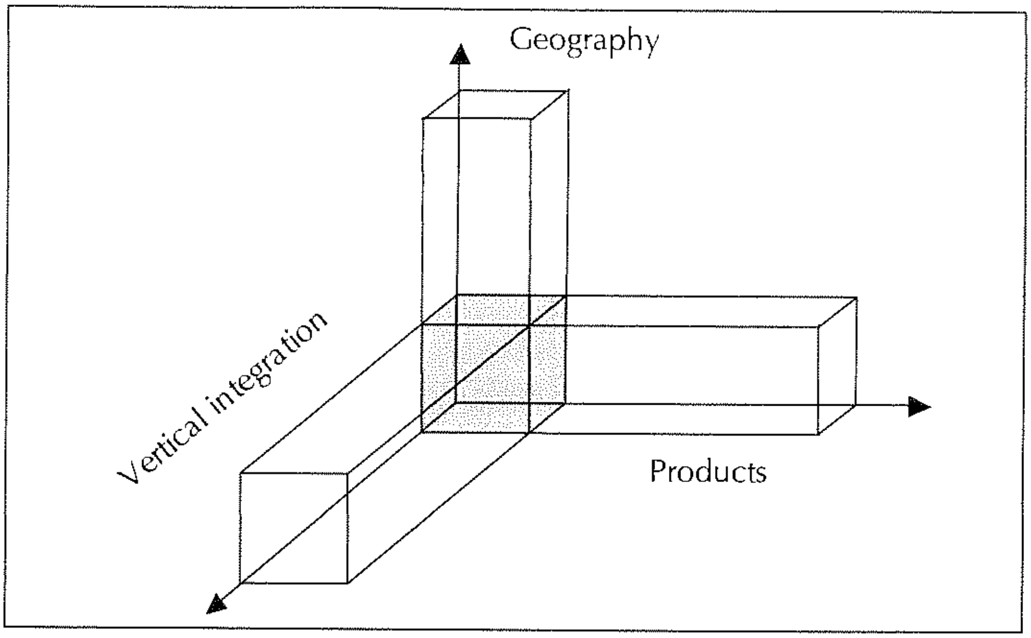

Figure 2-19: Corporation scope axes

The scope axis defines the following [paragraph 2.4, chapter 2]:

- Range of industries (products) that the organisation competes in;
- geographical distribution of the corporation (local, regional, national, global); and
- extent to which the corporation is integrated into downstream or upstream industries.

2.3.4 Strategic fit benefits

The purpose of corporate diversification is to build shareholder value. For diversification to enhance shareholder value, corporate strategy must do more than simply diversify the company's business risk by investing in more than one industry. Shareholders can achieve the same risk diversification on their own by purchasing stock in companies in different industries. Strictly speaking, diversification does not create shareholder value unless a group of organisations perform better under a single corporate umbrella than they would perform operating as independent, stand alone organisations. For example, if organisation A diversifies by purchasing organisation B and if A and B's consolidated profit in the years to come prove no greater than what each would have earned on its own, then A's diversification into organisation B has failed to provide shareholders with added value. Company A's shareholders could have achieved the same 2+2=4 result on their own by purchasing stock in organisation B. Shareholder value is not created by diversification unless it produces a 2+2=5 effect where sister organisations perform better together as part of the same corporation than they could perform as independent organisations. [Thompson: 95]

The problem with such a strict benchmark of whether diversification has enhanced shareholder value is that it requires speculative judgement about how well a diversified corporation's organisations would have performed on its own. Comparisons of actual performance against the hypothetical of what performance might have been under single organisation circumstances are never very satisfactory and they represent after-the-fact assessments. Managers have to base diversification decisions on future expectations. Determining whether a particular diversification strategy will increase shareholder value is based on three tests. Diversification strategies that satisfy all three tests have the greatest potential to build shareholder value over the long-term. The three tests for diversification are [Porter: 74]:

- *The attractiveness test*: The industry chosen for diversification must be attractive enough to produce consistently good returns on investment. The presence of favourable competitive conditions defines true industry attractiveness and long-term profitability. Such simple indicators as rapid growth of a product are unreliable proxies of attractiveness.
- *The cost of entry test*: The cost to enter the target industry must not be so high as to erode the potential for good profitability. However, the more attractive the industry, the more expensive it is to get into. Entry-barriers for new start-up organisations are nearly always high – where barriers are low, a rush of new entrants would soon erode the potential for high profitability. Buying an organisation already in the industry typically entails a high acquisition cost because of the industry's strong appeal. Costly entry undermines the potential for enhancing shareholder value.
- *Better off test*: The diversifying corporation must bring some potential for competitive advantage to the new organisation or the new organisation must offer some potential for added competitive advantage to the corporation's other organisations. The opportunity to create sustainable competitive advantage where none existed

before means there is also opportunity for adding profitability and shareholder value.

2.4 A Strategic Industrial Engineering Process

A *Strategic Industrial Engineering Process*, based on the integration of the fundamental strategic process, the fundamental engineering process and performance regulating principles, as discussed in paragraph 2.3 of this chapter, is illustrated in Figure 2-20.

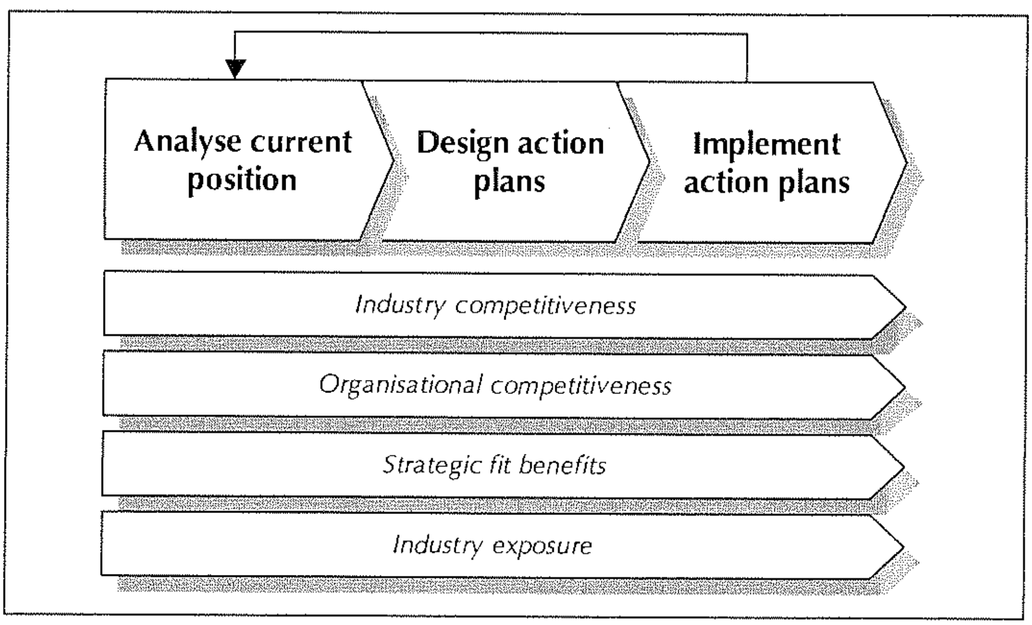

Figure 2-20:A Strategic Industrial Engineering Process

The action steps, of this proposed process, are briefly discussed in paragraphs 2.4.1 (Analyse current position), 2.4.2 (Design action plans) and 2.4.3 (Implement action plans). Defining this process in totality does not fall within the scope of this thesis, however the short discussions of each proposed process step demonstrates the applicability of such a process in support of a Strategic Industrial Engineering Philosophy. Defining the detail process is therefore left for further research.

2.4.1 *Analyse current position*

A corporation's current position is determined by aggregating the results from analysing the performance of each individual organisation and relating industry in achieving the capitalistic goal. The performance of these individual organisations and industries are analysed according to the four performance-regulating principles [paragraph 2.3, chapter 3]. The results of these analyses are plotted on the *current position matrix*, based on:

- *Industry competitiveness* (ROE_{mean}) as independent variable;
- *organisational competitiveness* (*ROE*) as dependent variable; and
- organisation's *cost of equity* (*COE*) as a threshold on both the independent and dependent variables, to determine the positive or negative accumulation of capital contribution, based on the risk profile of the organisation.

These analyses results are aggregated, by applying the *industry exposure* equation [Equation 2-9, chapter 3], to determine the corporation's overall capital accumulation performance. The corporation's capital accumulation (*ROE*) is benchmarked against its cost of equity (*COE*). Performance above the cost of equity indicates that the corporation's capital accumulation is above shareholders expectations. The inverse is also true, as a corporate ROE below the cost of equity indicates a performance below the shareholders expectations. Therefore a positive or negative ROE contribution to the corporation, based on the risk profile of the corporation.

The current position matrix is defined as illustrated in Figure 2-21.

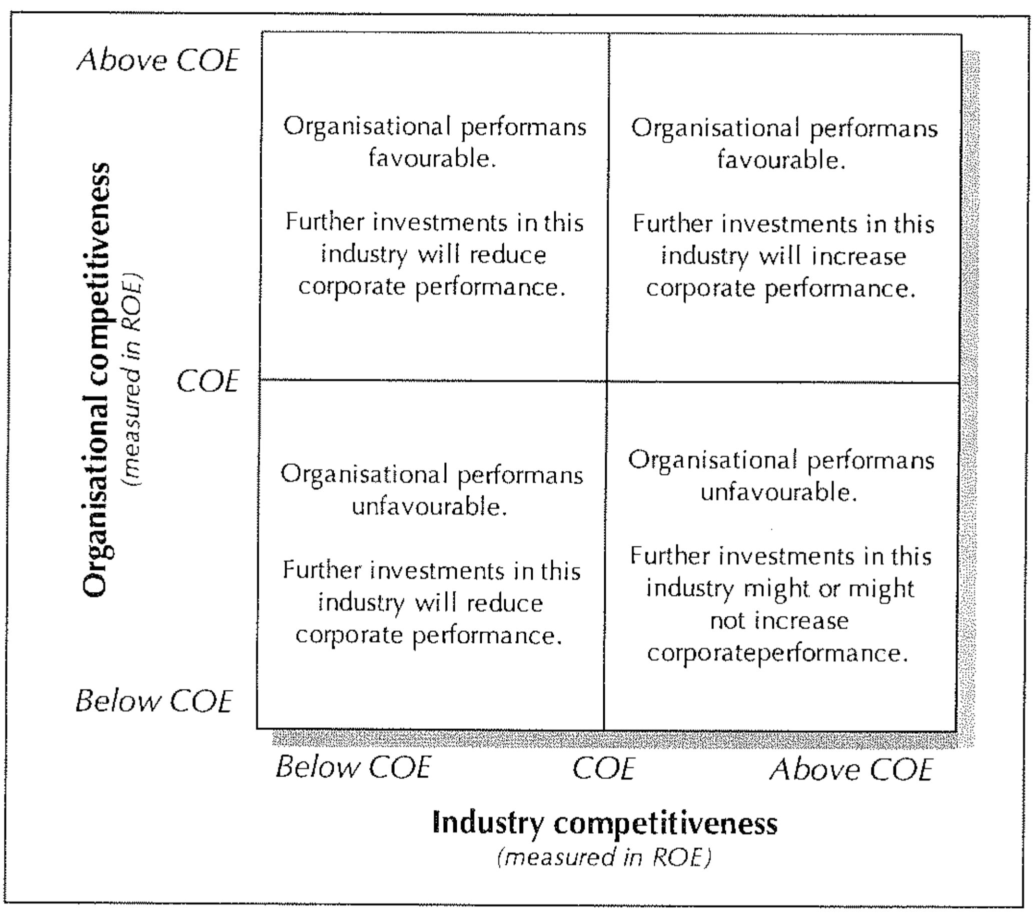

Figure 2-21: Current position matrix

2.4.2 Design action plans

Strategic actions for each individual organisation are defined, in relationship to its current and required goal achievements, taking into account the four performance-regulating principles. Aggregating these strategies defines the corporation's strategy.

Strategies of the individual organisations' are plotted on the *required position matrix*, based on:

- Future *industry competitiveness* (ROE_{mean}) as the independent variable;
- *organisational competitiveness* (*ROE*) as the dependent variable; and
- organisation's *cost of equity* (*COE*) as a threshold on both the independent and dependent variables, to determine the positive or negative accumulation of capital contribution, based on the risk profile of the organisation.

The strategic fit tests, as defined in paragraph 3.6.3 of chapter 2, needs to be performed in order to evaluate the ability of the corporation to capture the strategic fit benefits of the corporation's potential diversification actions. These three tests are:

- Attractiveness test;
- cost of entry test; and
- better off test.

The required position matrix is defined as illustrated in Figure 2-22.

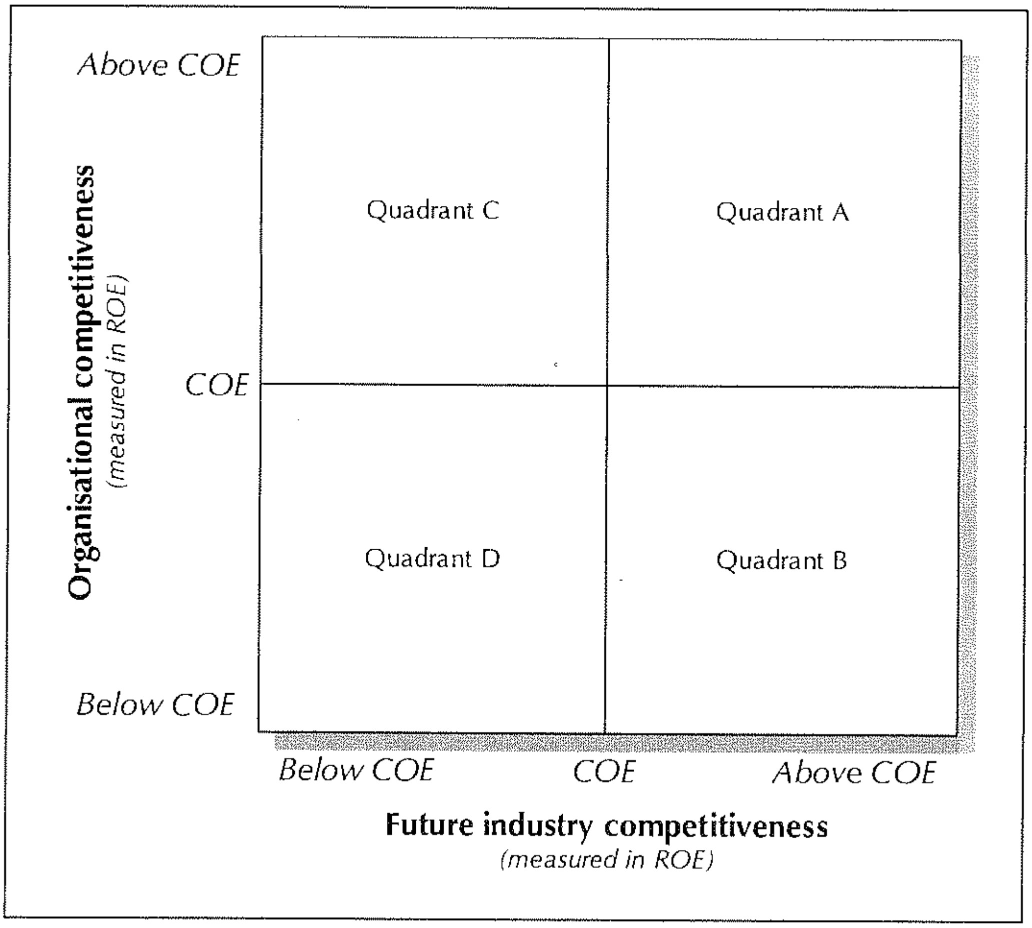

Figure 2-22: Required position matrix

It is proposed that strategic action for each organisation be defined, based on the following generic capital allocation strategies as defined for each quadrant of the required position matrix.

2.4.2.1 Quadrant A strategies

For organisations within this quadrant, both the *organisation's competitiveness* and the *industry competitiveness* exceed the *cost of equity* or shareholders' expectations. From this it is derived that:

- Additional capital investments in this industry will potentially generate returns that exceed the *cost of equity*; but
- care should be taken, as this quadrant can be misleading. Although the industry's competitiveness is higher than *COE* it can be that the corporation's exposure is in the worst performing organisation in the industry. In this case the organisation would also require improving.

An organisation within this quadrant can be rated as:

- *A+* if the organisational competitiveness is higher than the industry's competitiveness; and
- *A–* if the organisational competitiveness is lower than the industry's competitiveness.

Proposed capital investment strategies in this quadrant is based on:

- Increase capital investments in *A+* rated organisations, as *potential industry competitiveness* and *organisational competitiveness* are favourable; and
- two strategies are required for A– rated organisations:
  - Improve *organisational competitiveness*; and
  - increase capital allocation in this industry, as this is a profitable industry.

2.4.2.2 Quadrant B strategies

Industry competitiveness exceeds the *cost of equity* or shareholders expectations and the *organisational competitiveness* is lower than the *cost of equity*. From this it can be derived that:

- On average, additional investments in this industry will have returns that exceed the cost of equity; however
- the current organisation is this quadrant is under performing in this industry and would therefore require improvement before further investments are to be made.

Proposed capital investment strategies in this quadrant is based on:

- Improve organisational competitiveness in order to obtain capital accumulation that exceeds cost of equity. This is potentially possible in this industry as its competitiveness exceeds the cost of equity; and
- if this is not possible divestment should be considered.

2.4.2.3 Quadrant C strategies

Organisational competitiveness exceeds the cost of equity or shareholders expectations, although the *industry competitiveness* is lower than the *cost of equity*. From this it can be derived that:

- On average, additional investments in this industry will have returns that are lower than the cost of equity; however
- the organisation's competitiveness in this industry is above average and above the cost of equity. It is therefore important to identify the success factors within the organisation, therefore the competitive advantage, so as to determine if further investments will be successful; and
- the standard deviation of the industry's competitiveness is important as a high standard deviation combined with above average organisational competitiveness indicates a higher probability of success.

Proposed capital investment strategies in this quadrant is based on:

- If the superior organisational competitiveness is due to an identifiable competitive advantages that can be reproduced, then cautious capital allocation can be attempted; however
- if no competitive advantages can be identified and therefore not reproduced, then maximum capital accumulation should be captured without additional capital investments.

2.4.2.4 Quadrant D strategies

Both the *industry competitiveness* and the *organisational competitiveness* are lower than the *cost of equity* or shareholders expectation. From this it can be derived that:

- On average, additional investments in this industry will have returns that are lower than the cost of equity;
- improvement of the organisational competitiveness is required to above the cost of capital before further capital investments are to be made; and
- if no competitiveness improvements can be made to exceed the cost of equity, then this organisation should be divested.

An organisation within this quadrant can therefore be rated as:

- *D+* if the organisational competitiveness is higher than the industry's competitiveness; and
- *D–* if the organisational competitiveness is lower than the industry's competitiveness.

Proposed capital investment strategies in this quadrant is based on:

- Divestment should be considered in *D+* rated organisations, as improvement efforts to increase the organisational competitiveness would potentially be difficult and end in failure; and
- a *D–* rated organisation can improve its competitiveness to a *C* rate, if the positive standard deviation of the industry's competitiveness exceeds the cost of equity. This would potentially be difficult and could end in failure.

These analyses results are aggregated, by applying the *industry exposure* equation [Equation 3-23, chapter 2], to determine the corporation's required capital accumulation performance. The corporation's capital accumulation (ROE) is benchmarked against the cost of equity. Performance above the cost of equity indicates that the corporation's capital accumulation is above shareholders expectations. The inverse is also true, as a corporate ROE below the cost of equity indicates a performance below the shareholders expectations.

The *strategic fit benefit* tests should be applied to all potential diversification strategies. The results from this analysis should be considered in combination with the proposed capital investment strategies.

2.4.3 *Implement action plans*

In implementation, the administrative activities of continuously measuring and controlling organisational performance against set targets and the timely allocation of resources in order to support the achievement of the set targets are required. This includes adapting the strategies by making modifications, as action plans can turn out incorrect and others, relating to details, cannot be made in advance.

Putting strategies into effect and getting the organisation moving in the chosen direction call for a different set of managerial tasks and skills. Whereas crafting strategy is largely an entrepreneurial activity, implementing strategy is largely an internal administrative activity. Where successful strategy formulation depends on vision, market analysis and entrepreneurial judgement, successful implementation depends on working through others, organising, motivating, culture building and creating a strong fit between strategy and how the organisation does things. Ingrained behaviour does not change just because a new strategy has been announced. A performance management process aimed at the successful implementation of the desired strategies requires addressing the following main aspects:

- Defining an implementation plan supported by *target setting*;
- *tracking* performance against the plan;
- positive and negative *rewarding* for performance against targets; and
- creating a series of strategic *supportive fits*.

The proposed implementation cycle or performance management process is illustrated in Figure 2-23.

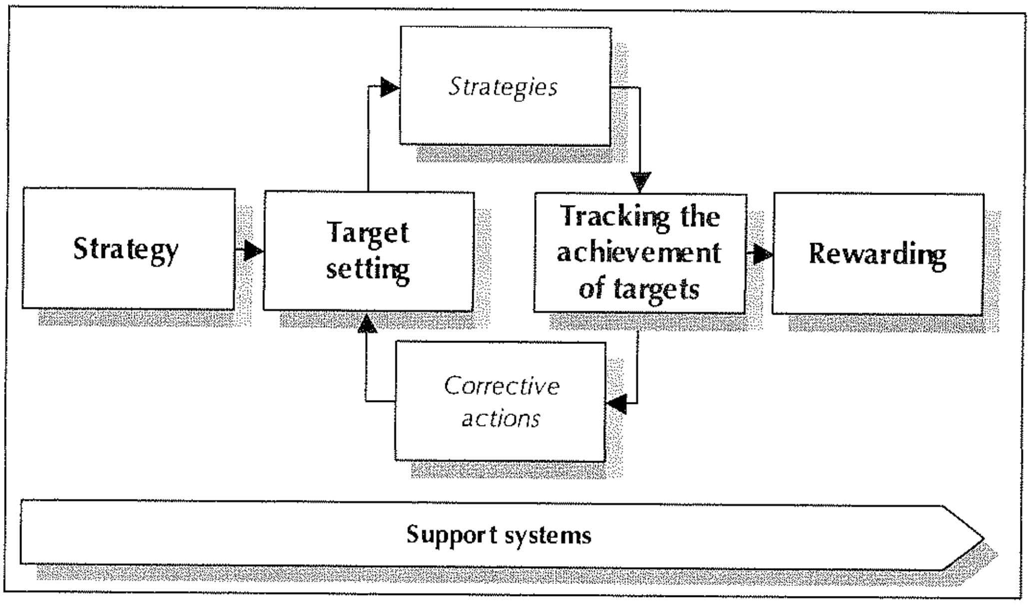

Figure 2-23: Implementation cycle

2.4.3.1 Target setting

Target setting is the process through which the corporation's strategic objectives are cascaded into detail targets for each organisation. This process consists of the following three target setting phases:

- Challenging *top-down* targets are set based on the shareholders expectations;
- *bottom-up* targets are determined based on the organisation's known and potential ability;
- a *reality check* is performed in order to deriving the final targets based on both the shareholders requirements and the organisation's ability. The final targets are typically a stretched improvement of the bottom-up targets based on detailed analyses of the performance drivers of organisation; and
- *final targets* are set and forms the bases of the organisation's budget.

The target setting process is illustrated in Figure 2-24.

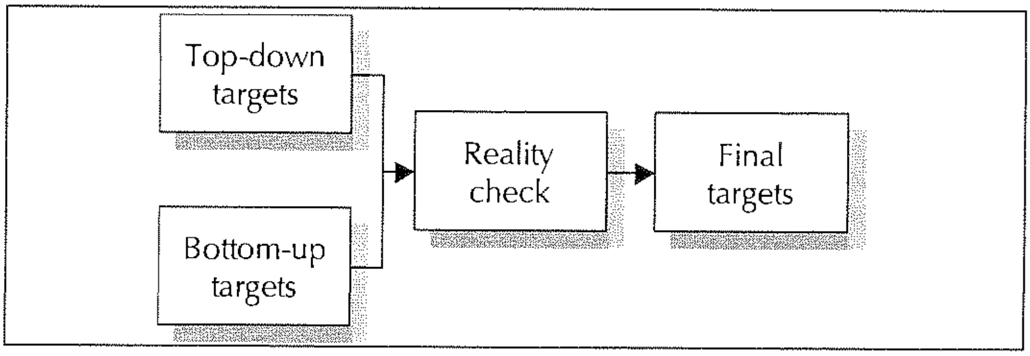

Figure 2-24: Target setting process

2.4.3.2 Tracking

Rigorous tracking of performance against set targets is required in order to implement suitable corrective actions. The tracking process consists of the following two phases:

- Constantly *measuring* the organisational performance against set targets; and
- appropriately *reporting* deviations in order to expedite possible corrective actions.

2.4.3.3 Rewarding

Rewarding of performance against set targets is determined by the organisation's rewarding philosophy. Rewarding can be positive if the set targets are achieved or negative if the targets are not achieved. The following entities are rewarded, based on the performance against targets:

- *Shareholders,* through the targets being achieved also through dividends;
- *employees,* as a motivational tool in order to achieve the set targets; and
- the *organisation* through retained earning for future growth.

2.4.3.4 Support systems

The motivational and inspirational challenge is to build enthusiasm throughout the corporation to carry out the strategy and meet performance targets. Along with enthusiasm and strategic commitment, must come unified managerial effort to create a series of strategic supportive fits. The stronger the strategic supportive fits created internally, the greater the chances of successful implementation. These supportive fits are summarised as [Thompson: 95]:

- The internal organisational structure must be matched to the strategy;
- the necessary organisational skills and capabilities must be developed;
- resource and budget allocation must support the strategy;
- the organisation's reward structures, policies, information systems and operating practices all need to reinforce the push for effective strategy execution, as opposed to having a passive role or even acting as obstacles; and
- managers must do things in a manner and style that creates and nurtures a strategic supportive work environment and corporate culture.

3 LEVEL II – PRINCIPIA

3.1 Research

The fundamental reasoning approach, as proposed by Plato [Cushing: 18], is used in conducting and concluding the research. This approach consists of the following discrete elements as indicated in Figure 3-1.

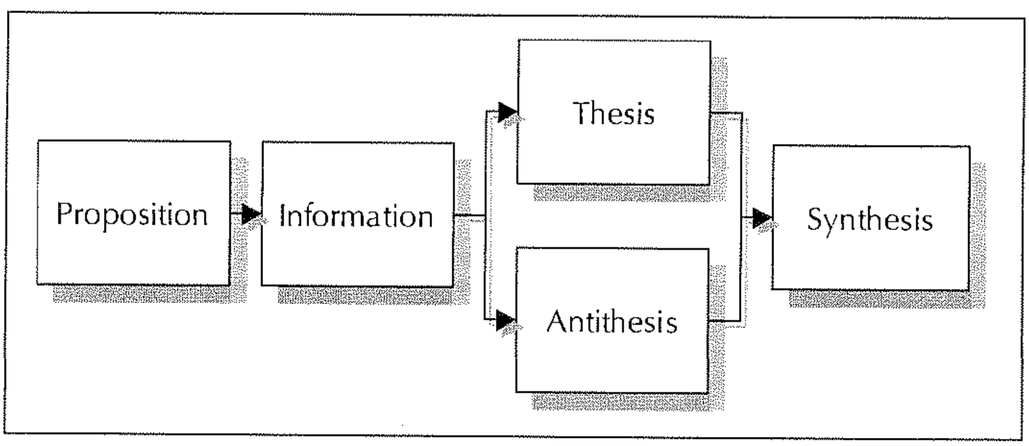

Figure 3-1: Fundamental reasoning approach

In this paragraph the key findings of explorative statistical analyses are summarised to scientifically support the fundamental performance-regulating principles proposed as being part of *Strategic Industrial Engineering* [paragraph 2.3, chapter 3]. The following three principles are analysed:

- Organisational competitiveness;
- industry competitiveness; and
- industry exposure.

3.1.1 Propositions

The following propositions are analysed:

- The distribution of organisational competitiveness, within a specific industry, is bell shaped, therefore the *ROE_{mean}* and *standard deviation* can be determined for that industry;
- industries conform to a life cycle shaped pattern; and
- *ROE_{mean}* is industry specific; therefore industries' structure and competitiveness influence an organisation's accumulation of capital.

3.1.2 Information

Financial information from listed organisation on the JSE Securities Exchange was obtained from the Bureau of Financial Analysis. Information relating to all the organisations within the following six sectors was obtained for the period 1971 to 1999:

- Building and Engineering;
- Information Technology and Electronics;
- Mining Holdings and Houses;
- Pharmaceutical;
- Motoring and transport; and
- Banking and financial.

The following information was obtained for each organisation within these six sectors:

- *Profit* defined as *Profit after Tax (PAT)*; and
- *equity* defined as *Total owners interest (OI)*.

The return on equity (*ROE*) of each organisation within the six sectors was calculated based on Equation 3-1.

$$ROE = \frac{Profit}{\left(\frac{Equity_{t-1} + equity_{t}}{2}\right)}$$

Equation 3-1: ROE calculation

The following information was excluded:

- All equity values < or = 0, as ROE can not be calculated for equity values that is < or = 0; and
- 38 data points, representing 1.03% of the total data, for ROE < -150% and ROE > 150%, as these points are extremes on the industries ROE distributions.

Information used in the statistical analyses is included in Appendix A.

3.1.3 Statistical analyses

Performing the explorative statistical analyses was supported by the Department of Statistics of the University of Pretoria. The source information has the following limitations:

- Data points are not independent, as the same organisations are present in consecutive years;
- tests for normality of the data indicated a significant deviation from normality;
- uncertainty regarding the available data being representative of the total population; and
- uncertainty regarding the available data time fame as representative of full industry life cycles.

3.1.3.1 Organisational competitiveness distribution

a. *Thesis*

The *Univariate procedure* was applied to statistically analyse the organisational ROE_{mean} per sector. The results indicate that the distribution of organisational ROE_{mean} per sector is bell shaped.

b. *Antithesis*

Tests for normality indicate significant deviations from a normal distribution. Closer evaluation of the data indicates that the main contributing factor seams to be a wide distribution of a few ROE_{mean} value.

3.1.3.2 Industry ROE life cycle

a. *Thesis*

Explorative statistical analyses of the various sectors' ROE_{mean} over time were performed to identify each sectors' ROE_{mean} s-shaped trend. Results from these analyses revealed that each sector's ROE_{mean} correlates to an s-shaped curve.

b. *Antithesis*

These analyses were inconclusive, but the antithesis was not proven.

3.1.3.3 Industry ROE_{mean}

a. *Thesis*

Results from the explorative statistical analyses, based on the *Global Linear Model*, indicate that ROE_{mean} of each sector varies significantly.

b. *Antithesis*

These analyses were inconclusive, but the antithesis was not proven.

3.1.4 Synthesis

Although the results are inconclusive, it is anticipated that further analyses in this field would confirm these results. Explorative statistical analysis indicates that the following propositions are true

3.1.4.1 <u>Organisational competitiveness distribution</u>

The distribution of organisational competitiveness, within a specific industry, is bell shaped, therefore the ROE_{mean} and *standard deviation* can be determined for industries. Results are included in Appendix B.

The ROE_{mean} and *standard deviation* results of each analysed sector are summarised in Table 3-1.

SECTOR	MEAN ROE	STANDARD DEVIATION
Building and engineering	15.13%	22.49%
Information technology and electronics	23.53%	25.70%
Mining Holdings and Houses	28.52%	27.34%
Pharmaceutical	22.07%	21.08%
Motoring and transport	13.74%	18.54%
Banking and financial	18.79%	26.41%

Table 3-1: Mean ROE and standard deviation per sector

3.1.4.2 Industry ROE life cycle

Each sectors' ROE_{mean} s-shaped trends conceptually indicate each sector's relative life cycle position. Therefore industries conform to a life cycle shaped pattern. Results are included in Appendix C. The six sectors' industry ROE_{mean} s-shaped curves are illustrated in Figure 3-2

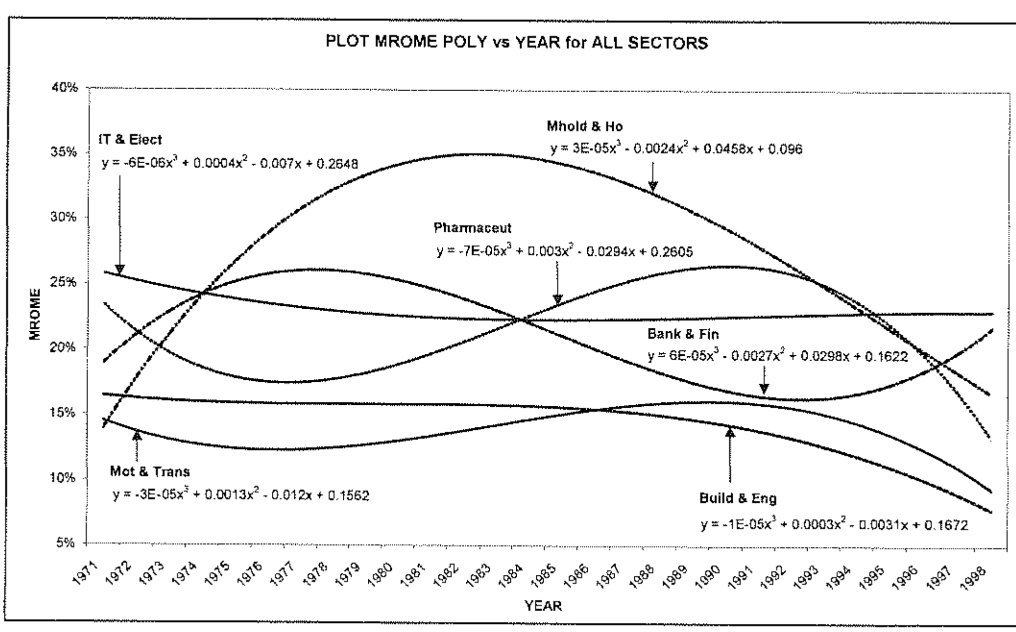

Figure 3-2: Industry ROE s-shaped curves

3.1.4.3 Industry ROE_{mean}

The ROE_{mean} of different sectors vary significantly. ROE_{mean} is industry specific; therefore industries' structure and competitiveness influence an organisation's accumulation of capital. Results are included in Appendix D.

CHAPTER 4 - REFLECTION

"The open mind never acts: when we have done our utmost to arrive at a reasonable conclusion, we still. . . must close our minds for the moment with a snap, and act dogmatically on our conclusions."

George Bernard Shaw

1 REFLECTING ON THE THESIS

1.1. Introduction

In this thesis, a true and justified philosophical proposition, termed *A Strategic Industrial Engineering Philosophy* [paragraph 2.2, chapter 1], is established that expands the application of Industrial Engineering, as a strategic tool, to include the economic and productive utilisation of capitalistic corporate resources such as organisations within unrelated industries. This is achieved through the following:

- Applying a philosophical research approach that utilises sufficient reasoning based on existing truths to justify the proposition;
- researching from existing truths contained within the fundamental elements of the proposition. These fundamental elements are the following:
  - Strategy;
  - industry; and
  - Industrial Engineering.
- justifying the *Strategic Industrial Engineering Philosophy*;
- defining *Strategic Industrial Engineering* that drives the achievement of the organisational goal through the following performance regulating principles:

  - Organisational competitiveness;
  - industry competitiveness;
  - industry exposure; and
  - strategic fit benefits.
- proposing a *Strategic Industrial Engineering Process* for further research. This process includes the following action steps:
  - Analyse current position;
  - design action plan; and
  - implement action plan.

Various subject areas are researched to define the existing truths contained within these fundamental elements and to justify the thesis's proposition. These subject areas are indicated in Figure 1-1.

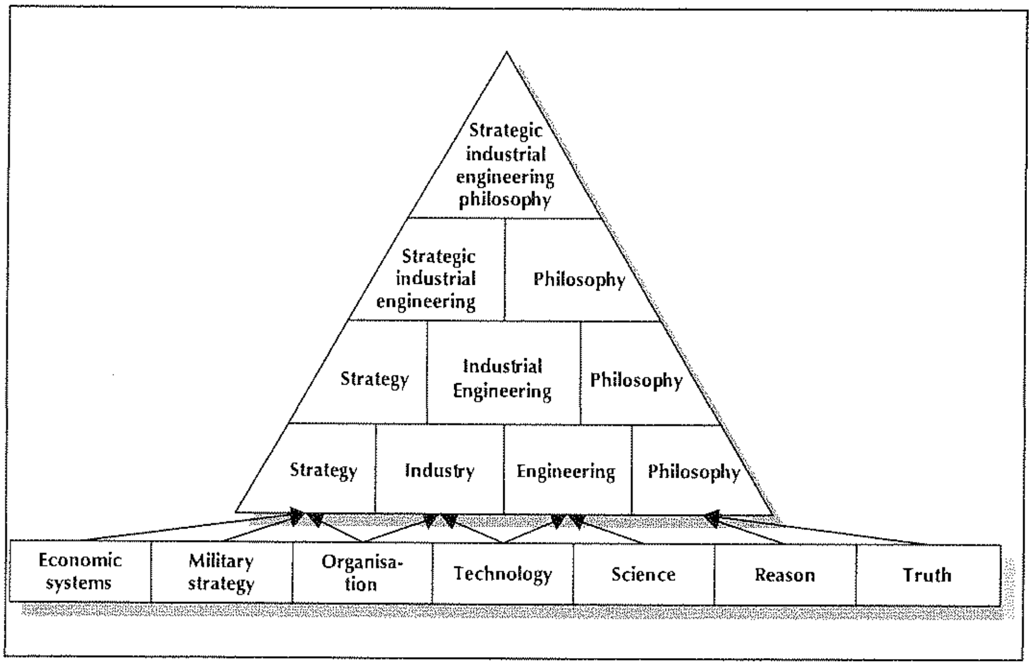

Figure 1-1: The researched subject areas of this thesis

Scientific frameworks are established that supports this expanded philosophy of *Industrial Engineering* by demonstrating the achievement of the capitalistic corporate goal. This is achieved through the following:

- Setting return on equity (ROE) as the scientific measure of capital accumulation;
- proposing a Strategic Industrial Engineering Process, aimed at achieving the capitalistic corporate goal, for further research. This process is based on the following:
  - The relationship between the fundamental strategy and engineering processes; and
  - fundamental corporate performance-regulating principles.
- demonstrating the validity of these performance-regulating principles through explorative statistical analyses.

This chapter concludes the thesis by addressing the following:

- Reflecting on the justified proposition;
- elaborating on the application of the proposition; and
- considering the contributions of *A Strategic Industrial Engineering Philosophy*.

1.2. Layout

The layout of this chapter is summarised as:

- The application of the specific *philosophical research* approach, used in this thesis, that utilises sufficient reasoning based on existing truths to justify the true proposition is reflected upon in paragraph 2 of this chapter;
- existing truths contained within the fundamental elements of the proposition are reflected on in paragraph 3 of this chapter. These existing truths, within the context of this thesis, are discussed in the following paragraphs:
  - Strategy in paragraph 3.1 of chapter 4;
  - industry in paragraph 3.2 of chapter 4; and
  - Industrial Engineering in paragraph 0 of chapter 4.
- *Strategic Industrial Engineering* is reflected on in three parts:
  - Philosophy in paragraph 4.1 of chapter 3;
  - framework in paragraph 4.2 of chapter 3; and
  - proposed process in paragraph 4.3 of chapter 3.
- the *application* of A Strategic Industrial Engineering Philosophy is elaborates on by in paragraph 5 of this chapter.
- the *contribution* of A Strategic Industrial Engineering Philosophy is reflected on in paragraph 6 of this chapter.

2 PHILOSOPHICAL RESEARCH

The proposition of this thesis is shown to be a true proposition, as it searches for the truth by applying the philosophical principle of justification, thus foundationalism and coherence [paragraph 3.1.6, chapter 1]. This logical principle helps to reveal how the thesis derives its truths and thus creates knowledge. The research method used in this thesis is based on the coherency theory and includes the following action steps:

- Observing nature in order to define the proposition [chapter 1];
- defining the existing truths contained within the observations and related proposition [paragraph 2, chapter 2];
- reasoning the truth of the proposition through the philosophical principle of sufficient reasoning so as to gain knowledge by justifying the proposition [paragraph 2, chapter 3]; and
- reflecting on the justified proposition [chapter 4].

3 EXISTING TRUTHS

The existing truths contained within the following three fundamental elements of the proposition are reflected upon in this paragraph:

- Strategy, including the scientific measurement of the capitalistic organisational goal;
- industry; and
- Industrial Engineering.

3.1. Strategy

The term organisational *strategy* is defined for this thesis as [paragraph 2.4, chapter 2]: *A visionary plan of action by which resources are controlled in order to achieve the capitalistic organisational goal of accumulating capital.* Strategy within the context of the capitalistic economic system is shown to contain the following existing truths:

- It is *purposeful,* as it reflects the fundamental organisational behaviour. In the context of the capitalistic economic system the purpose of strategy is to accumulate capital. The capitalistic organisational goal of accumulating capital is a function of capital gain and capital investment. This goal is pursued within an environment of:

  - Utilising privately owned means of production;
  - competitive interaction between rival organisations; and
  - minimum government interaction.

- it sets a *visionary action plan* through plans, policies and procedures to compete in meeting customer demands;
- it *allocates resources* to obtain control over the capitalistic resources (means of production). Continual competition leads organisations to seek greater control over both the sources of raw materials (*upstream activities*) and the outlets of their products (*downstream activities*). Investing capital into upstream, downstream and parallel systems extends the span of an organisation's control. These investments into more than one organisation, that may or may not be in the same industry, creates multi organisation conglomerates (corporations) that are exposed to multiple industries with different capital exposure profiles, strategies and capital accumulation potential. Subsequently capitalists are becoming shareholders of industries as opposed to the traditional view of capitalists being shareholders of organisational means of production.
- it utilises the *process* (art) of analysis, planning (design) and implementation.

3.1.1. Fundamentals of the capitalistic organisational goal

The achievement of the capitalistic organisational goal can be measured by the scientific measure of return on equity (ROE) [paragraph 3.5, chapter 2]. ROE measures an organisation's capital accumulating rate and thus the organisation's success in achieving its goal, as it:

- Measures the rate of capital gain to the shareholder; and
- takes into account the organisation's capital structure.

Three factors influence an organisation's ROE. These three factors are:

- Operating efficiency *(as measured by profit margin)*;
- asset use efficiency *(as measured by total asset turnover)*; and
- financial leverage *(as measured by the equity multiplier)*.

Return on equity (ROE) is defined as illustrated in Equation 3-1:

$$ROE = \frac{Shareholders\ gain}{Shareholders\ equity}$$

Equation 3-1: Return on equity

3.2. Industry

Industry is defined as [Hornby: 44]: *The people and activities involved in producing a particular thing, or in providing a particular service.* Industry in this context is shown to contain the following existing truths:

- It is a *purposeful* group of capitalistic organisations:
  - That compete in meeting the demands of the market;
  - through production or supplying of goods, services or other sources of income.

3.3. Industrial Engineering

Engineering is defined as [Blanchard: 10]: *The action of purposefully applying scientific knowledge to resources, including materials and energy. The engineering profession strives towards the development of solutions for the satisfaction of human requirements by the application of the sciences.* From the above it can thus be derived that engineering contains the following existing truths:

- Obtaining an understanding of the specific requirements or needs;
- creation of solutions to satisfy the specific requirement / need; and
- applying the solution in order to satisfy the requirement / need.

Industrial Engineering is termed industrial as a consequence of its origins in the industrial age and the general association of the words industrial and engineering with manufacturing. Industrial Engineering contains the following existing truths:

- It is concerned with the design, improvement and installation of integrated *systems* of people, materials, equipment and energy in the industrial and manufacturing environments;
- it draws upon specialised *knowledge* and skills in the mathematical, physical and social sciences together with the principles and methods of engineering analysis and design to specify, predict and evaluate the results to be obtained from such systems; and
- it is concerned with *optimising* systems by focusing on effectiveness, efficiency, productivity, profitability and quality.

4 STRATEGIC INDUSTRIAL ENGINEERING

4.1. Strategic Industrial Engineering Philosophy

The expanded field of Industrial Engineering, according to the Strategic Industrial Engineering Philosophy, is aimed at accumulating capital for the benefit of the capitalistic organisational shareholders. Thus Strategic Industrial Engineering applies scientific knowledge to capitalistic systems aimed at accumulating capital for the shareholders. Philosophical reasoning based on the existing truths of Strategy, industry and Industrial Engineering supports this expansion of the Industrial Engineering field.

Engineering is the application of scientific knowledge to purposefully utilise resources for the benefit of mankind [paragraph 2.8, chapter 2]. If considering the organisational entity as a resource and the scientific method of expansionism is applied to it, it can be derived that the capitalistic corporation is a purposeful system with capital as input and accumulated capital as output [paragraph 2.1, chapter 3]. The capital productivity measure of this system is equal to the accumulation of capital measure defined as return on equity [paragraph 2.2, chapter 3]. Thus improving the capital productivity of the system will improve the corporation's return on equity and subsequently improve the corporation's ability to achieve its capitalistic goal. Corporations can thus purposefully apply Industrial Engineering principles as a strategic tool to influence the rate of capital accumulation [paragraph 2.2, chapter 3].

Industrial Engineering aims to improve the productive use of capital in production related resources including machinery and human labour. If a corporation's strategy is to be supported by the Industrial Engineering profession, then Industrial Engineering should include into its list of resources the organisations and industries into which capital are invested, with the intent to achieve the capitalistic organisational goal. The semantic shift is towards improving the productivity of capital investments made in industries, thus managing the organisation as a resource.

The term industrial, relating to the discipline of Industrial Engineering, is in context of the industrial age or manufacturing and not as a reference to engineering industries. This latter concept of engineering industries reflects the intention of this thesis, as it is shown that Industrial Engineering principles can be applied to improve the productive use of capital investments made into industries and consequently a corporation's ability to accumulate capital.

A Strategic Industrial Engineering Philosophy is therefore a purposeful expansion of the Industrial Engineering profession, as a strategic tool, aimed at realising the capitalistic organisational goal by improving the rate of capital accumulation.

4.2. Strategic Industrial Engineering

The existing truth of the engineering process of analysing the needs, designing a solution and purposefully implementing this solution correlates with that of the strategy process in the capitalistic organisation. The proposed *Strategic Industrial Engineering Process*, derived from the relationship between the strategy and engineering processes [paragraph 2.2, chapter 3], has the following phases [paragraph 2.3, chapter 3]:

- Analysis of current position;
- design of a visionary action plan in order to satisfy the requirement or goal; and
- implementation of the action plan through the purposeful allocation of resources.

The accumulation of capital, defined as the goal of a capitalistic corporation, is based on controlling the relationship between the following fundamentals [paragraph 3.8, chapter 2]:

- *Organisational competitiveness,* defined as the ability of a corporation's independent organisations to accumulate capital within their specific industries;
- *industry exposure,* defined as the combination of independent organisations and thus the exposure to multiple industries;
- *strategic fit benefits,* defined as the ability of the corporation to capture the strategic fit benefits of its portfolio of organisations; and
- *industry profitability,* defined as the competitive differences between individual industries.

In Figure 4-1 it is illustrated that the following performance-regulating principles influence a corporation's goal achievement:

- The competitiveness of its individual organisations;
- the individual organisations accumulation of capital relative to the corporation's cost of equity; and
- the competitiveness of the industries, industry structure, that the corporation is exposed to; and
- strategic fit benefits that improve the corporate performance too more than the average performance of its individual organisations.

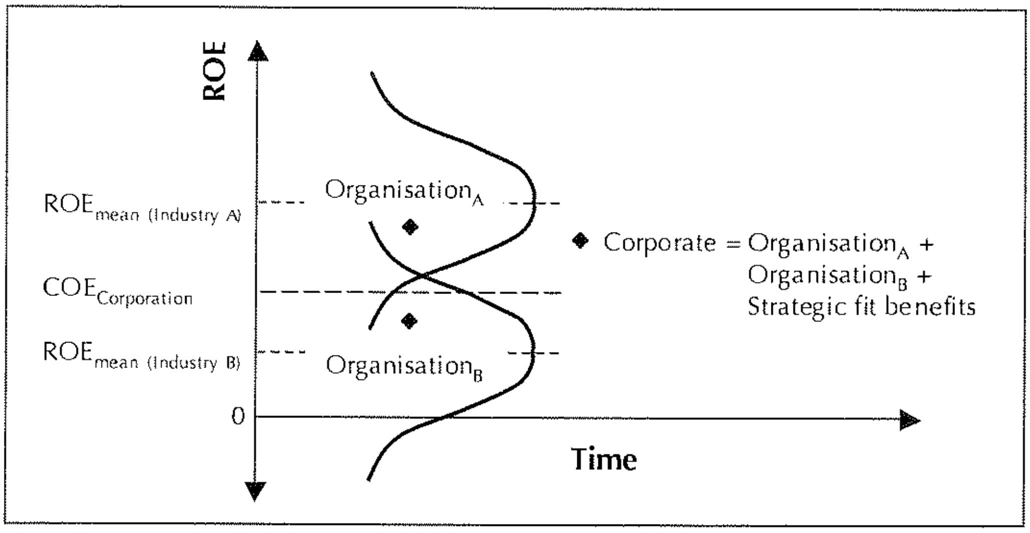

Figure 4-1: Corporate accumulation of capital

In Strategic Industrial Engineering it is proposed that controlling these performance-regulating principles is based on the industry ROE life cycle. The proposed industry ROE life cycle is illustrated in Figure 4-2.

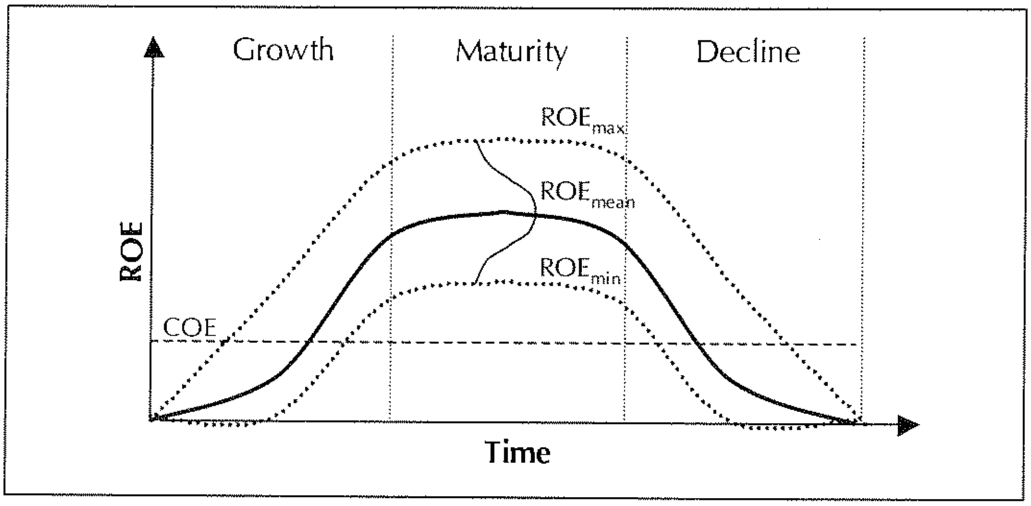

Figure 4-2: Industry ROE life cycle

The industry ROE life cycle curve [Figure 4-2] depicts the following:

- The organisational competitiveness distribution that includes:
  - The industry's mean accumulation of capital (ROE_{mean});
  - the lowest organisational ROE in the industry (ROE_{min});
  - the highest organisational ROE in the industry (ROE_{max});
- the cost of equity is included as reference point to indicate if accumulation of capital is higher or lower than the cost of equity (*COE*), thus to determine the positive or negative accumulation of capital contribution, based on the risk profile of the organisation; and
- the industry ROE life cycle that is a function of the industry structure. Changes in the industry structure, including discontinuities, will influence an organisation's ability to accumulate capital. The three fundamental phases of a life cycle are also shown:
  - The growth phase;
  - the maturity phase; and
  - the decline phase.

4.3. Strategic Industrial Engineering Process

A *Strategic Industrial Engineering Process,* aimed at achieving the capitalistic goal, proposed for further research is illustrated in Figure 4-3.

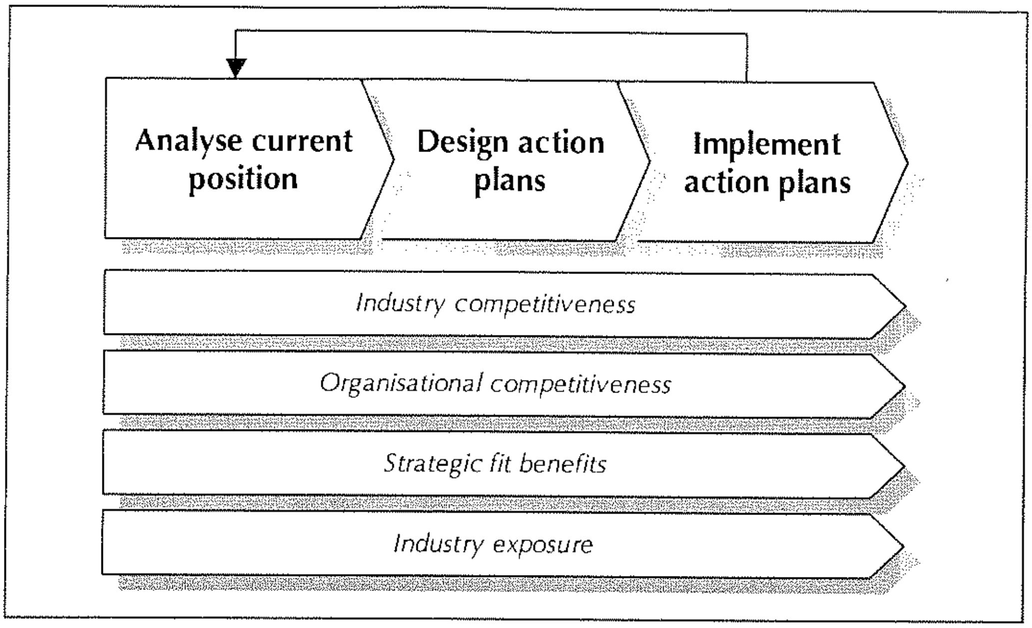

Figure 4-3: Strategic industrial engineering process

Corporate strategies are proposed based on applying the *Strategic Industrial Engineering Process* as a strategic tool. Corporate strategies are defined from the relationship between a corporation's individual organisations with the performance regulating principles. These strategies are based on the position of the individual organisations and relating industries performances as plotted on the matrix illustrated in Figure 4-4:

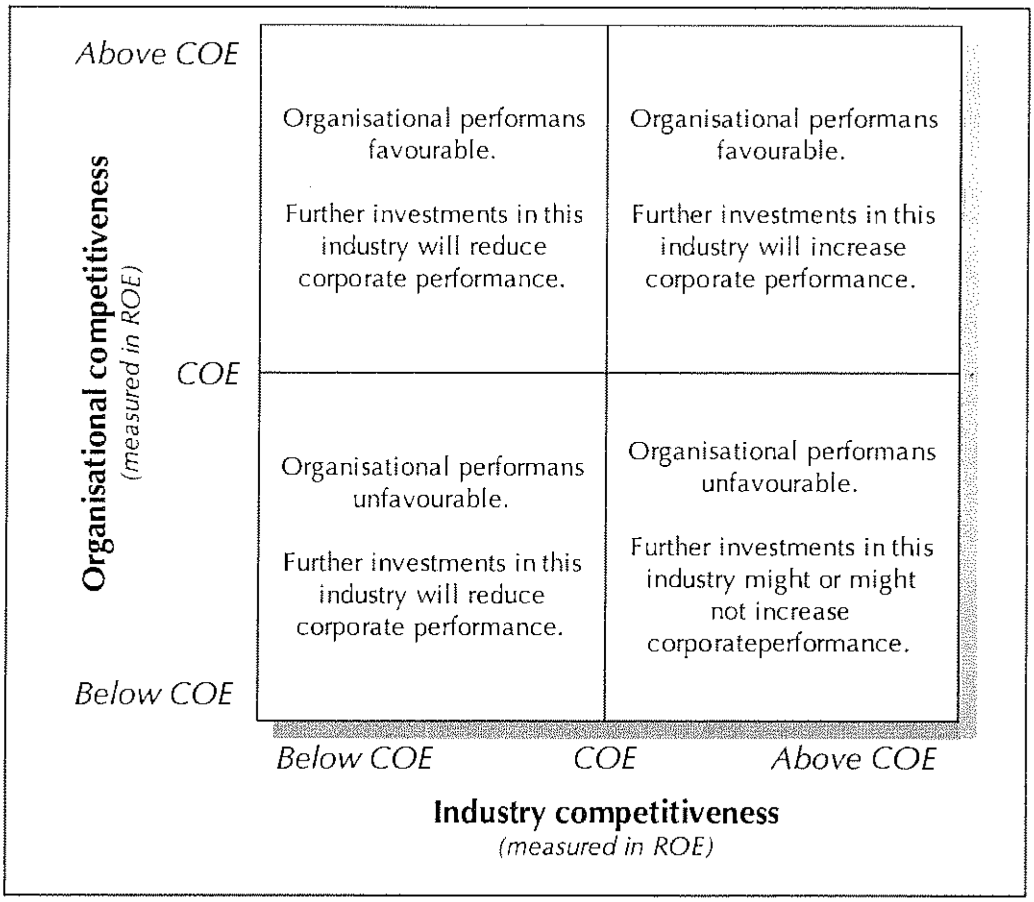

Figure 4-4: Base for corporate strategies

5 APPLICATION

The author has successfully applied the fundamentals of *Strategic Industrial Engineering* to develop and implement corporate strategies that is aimed at achieving the capitalistic goal. The following two applications are highlighted as reference:

- As part of the corporation's growth strategy an approach was developed and implemented to direct the corporation's industry investment and divestment strategies; and
- a performance management strategy was developed and successfully implemented in order to manage the corporation's improvement drive. The following elements of this strategy was integrated into a performance management process:
  - Corporate goals and strategic directives;
  - organisational target setting;
  - operations and operational improvement;
  - organisational performance tracking;
  - corrective actions; and
  - performance rewarding.

6 CONTRIBUTION

The thesis's primary contribution is a philosophy aimed at establishing and demonstrating a specific way of thinking about the role of Industrial Engineering in corporate strategy and secondary to this is the contextual elements elaborate upon. The author believes that *A Strategic Industrial Engineering Philosophy*, as developed in this thesis, contributes the following:

- Further extension of the Industrial Engineering profession into the domain of business; and
- establishing a philosophical avenue for future research and study.

Progressive organisations are increasingly utilising the engineering profession to solve problems in the business arena. The author extends this philosophy to the Industrial Engineers that take up this challenge.

"I have finished my task here."

Einstein

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APPENDIX A

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Obs	FIRM	SECTOR	RS	RE	ES	EE	ME	ROME	CYEAR	LISTED
1	FIELD	1	-3779	-1748	1662	377	1019.5	-1.7146	1984-1985	16
2	S&SHOLD	1	-73967	-411522	414167	65499	239833.0	-1.7159	1998-1999	11
3	SPICER	1	-209	1955	1231	915	1073.0	1.8220	1993-1994	3
4	STOCKS	1	-73967	-372080	376604	67378	221991.0	-1.6761	1998-1999	7
5	AUTOPGE	2	704	1988	1540	1092	1316.0	1.5106	1988-1989	1
6	AUTOPGE	2	1988	4732	1092	2986	2039.0	2.3207	1989-1990	2
7	ODMHOLD	2	-4190	-5851	4004	918	2461.0	-2.3775	1989-1990	3
8	PASDEC	2	-21185	-21185	1835	1835	1835.0	-11.5450	1998-1999	11
9	RAPTOR	2	1180	-25173	6984	1699	4341.5	-5.7982	1989-1990	2
10	SPICER	2	-14925	38840	15489	16766	16127.5	2.4083	1998-1999	7
11	CAM	3	-375	-8456	1279	8765	5022.0	-1.6838	1996-1997	1
12	CONSMNG	3	37163	22276	2790	4109	3449.5	6.4577	1994-1995	2
13	COROHLD	3	5595	7789	2381	3012	2696.5	2.8886	1973-1974	1
14	COROHLD	3	7789	4573	3012	3050	3031.0	1.5087	1974-1975	2
15	DUIKERS	3	9493	16125	7204	8035	7619.5	2.1163	1977-1978	7
16	DUIKERS	3	16125	13397	8035	7174	7604.5	1.7617	1978-1979	8
17	DUIKERS	3	13397	11571	7174	5841	6507.5	1.7781	1979-1980	9
18	FALCON	3	-924	5137	2010	2898	2454.0	2.0933	1993-1994	1
19	LONMIN	3	71000	188000	8000	39000	23500.0	8.0000	1998-1999	3
20	RANDMIN	3	17342	28534	16265	6010	11137.5	2.5620	1975-1976	7
21	RANDMIN	3	28534	52274	6010	6289	6149.5	8.5005	1976-1977	8
22	RANDMIN	3	139464	154700	41734	11259	26496.5	5.8385	1981-1982	9
23	RANDMIN	3	154700	196969	11259	103902	57580.5	3.4208	1982-1983	10
24	RANDMIN	3	196969	163134	103902	112874	108388.0	1.5051	1983-1984	11
25	RANDMIN	3	163134	264200	112874	158500	135687.0	1.9471	1984-1985	12
26	RANDMIN	3	264200	293100	158500	195500	177000.0	1.6559	1985-1986	13
27	TWEEFONTN	3	5839	8093	2836	3968	3402.0	2.3789	1973-1974	1
28	TWEEFONTN	3	2108	10084	4293	4297	4295.0	2.3478	1993-1994	21
29	TWEEFONTN	3	10084	7788	4297	4312	4304.5	1.8093	1994-1995	22
30	VOGELS	3	10518	216071	48957	228500	138728.5	1.5575	1998-1999	30
31	LANDMRK	5	-2394	-2854	1774	931	1352.5	-2.1102	1985-1986	17
32	PUTCO	5	277	422	103	242	172.5	2.4464	1971-1972	3
33	ADCORP	6	922	1757	889	664	776.5	2.2627	1988-1989	2
34	ADCORP	6	1757	1960	664	372	518.0	3.7838	1989-1990	3
35	ADCORP	6	1960	1401	372	1063	717.5	1.9526	1990-1991	4
36	ALEXFBS	6	-101253	214000	1881	89000	45440.5	4.7095	1998-1999	3
37	SFG	6	-3429	-3429	1071	1071	1071.0	-3.2017	1997-1998	1
38	SFG	6	-3429	-3429	1071	1071	1071.0	-3.2017	1998-1999	2

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The FREQ Procedure

FIRM	Frequency	Percent	Cumulative Frequency	Cumulative Percent
ADCORP	3	7.89	3	7.89
ALEXFBS	1	2.63	4	10.53
AUTOPGE	2	5.26	6	15.79
CAM	1	2.63	7	18.42
CONSMNG	1	2.63	8	21.05
COROHLD	2	5.26	10	26.32
DUIKERS	3	7.89	13	34.21
FALCON	1	2.63	14	36.84
FIELD	1	2.63	15	39.47
LANDMRK	1	2.63	16	42.11
LONMIN	1	2.63	17	44.74
ODMHOLD	1	2.63	18	47.37
PASDEC	1	2.63	19	50.00
PUTCO	1	2.63	20	52.63
RANDMIN	7	18.42	27	71.05
RAPTOR	1	2.63	28	73.68
S&SHOLD	1	2.63	29	76.32
SFG	2	5.26	31	81.58
SPICER	2	5.26	33	86.84
STOCKS	1	2.63	34	89.47
TWEEFONTN	3	7.89	37	97.37
VOGELS	1	2.63	38	100.00

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Obs	SECTOR	YEAR	N	MROME	STD
1	1	1971	88	0.13074	0.09967
2	1	1972	88	0.15700	0.11088
3	1	1973	91	0.22352	0.12612
4	1	1974	92	0.17888	0.11761
5	1	1975	60	0.15865	0.12905
6	1	1976	66	0.10487	0.20486
7	1	1977	67	0.09975	0.13945
8	1	1978	68	0.14255	0.17598
9	1	1979	68	0.20246	0.18530
10	1	1980	40	0.29128	0.24050
11	1	1981	46	0.22239	0.18752
12	1	1982	47	0.15013	0.21427
13	1	1983	47	0.05309	0.37401
14	1	1984	47	0.03335	0.28086
15	1	1985	38	0.11075	0.23254
16	1	1986	47	0.17497	0.21855
17	1	1987	60	0.16997	0.29646
18	1	1988	72	0.27786	0.20953
19	1	1989	71	0.18618	0.29079
20	1	1990	46	0.13604	0.14218
21	1	1991	49	0.06245	0.21273
22	1	1992	51	0.06492	0.29210
23	1	1993	51	0.12084	0.27145
24	1	1994	53	0.17942	0.24252
25	1	1995	24	0.15742	0.24903
26	1	1996	28	0.12053	0.27188
27	1	1997	30	0.06991	0.33979
28	1	1998	29	0.05171	0.36925
29	2	1971	6	0.23895	0.07690
30	2	1972	7	0.26955	0.09165
31	2	1973	7	0.25777	0.10862
32	2	1974	7	0.27918	0.09248
33	2	1975	7	0.24772	0.04289
34	2	1976	9	0.16886	0.05610
35	2	1977	9	0.21363	0.11401
36	2	1978	9	0.18458	0.07217
37	2	1979	10	0.27806	0.12796
38	2	1980	9	0.30317	0.14984
39	2	1981	11	0.26629	0.10207
40	2	1982	12	0.18052	0.13492
41	2	1983	12	0.18683	0.12496
42	2	1984	12	0.11593	0.18545
43	2	1985	11	0.16089	0.09338
44	2	1986	19	0.22973	0.15709
45	2	1987	28	0.36021	0.24173
46	2	1988	45	0.29180	0.25342
47	2	1989	42	0.20945	0.31626
48	2	1990	26	0.27460	0.18362
49	2	1991	28	0.20896	0.15047
50	2	1992	29	0.21864	0.34919
51	2	1993	29	0.20174	0.12823
52	2	1994	29	0.24598	0.21062
53	2	1995	20	0.20581	0.29439
54	2	1996	29	0.10031	0.36802
55	2	1997	30	0.26500	0.51796

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Obs	SECTOR	YEAR	N	MROME	STD
56	2	1998	36	0.29561	0.26909
57	3	1971	28	0.14768	0.08695
58	3	1972	27	0.17304	0.10921
59	3	1973	27	0.23366	0.12866
60	3	1974	29	0.29714	0.24950
61	3	1975	26	0.25422	0.20784
62	3	1976	27	0.21336	0.24080
63	3	1977	25	0.22530	0.19438
64	3	1978	25	0.28133	0.21010
65	3	1979	26	0.39649	0.26711
66	3	1980	26	0.46485	0.32081
67	3	1981	25	0.31140	0.21333
68	3	1982	25	0.34887	0.26148
69	3	1983	25	0.29595	0.21457
70	3	1984	25	0.33882	0.23475
71	3	1985	23	0.35312	0.28232
72	3	1986	26	0.38406	0.34466
73	3	1987	28	0.42520	0.40729
74	3	1988	28	0.31921	0.29330
75	3	1989	28	0.27783	0.33429
76	3	1990	16	0.27648	0.33878
77	3	1991	18	0.25457	0.35098
78	3	1992	18	0.19911	0.22504
79	3	1993	17	0.16343	0.25941
80	3	1994	19	0.30325	0.38402
81	3	1995	8	0.31429	0.30802
82	3	1996	12	0.20494	0.14099
83	3	1997	12	0.05252	0.27753
84	3	1998	11	0.24260	0.30496
85	4	1971	11	0.16561	0.23274
86	4	1972	11	0.21627	0.23911
87	4	1973	11	0.23627	0.19375
88	4	1974	11	0.20062	0.11890
89	4	1975	8	0.21293	0.11327
90	4	1976	9	0.16776	0.12213
91	4	1977	9	0.19302	0.17700
92	4	1978	9	0.22608	0.18187
93	4	1979	9	0.22191	0.16875
94	4	1980	5	0.14547	0.06524
95	4	1981	5	0.15282	0.05448
96	4	1982	5	0.31092	0.28498
97	4	1983	5	0.12749	0.04335
98	4	1984	5	0.12781	0.03928
99	4	1985	3	0.12895	0.05914
100	4	1986	4	0.15820	0.07079
101	4	1987	8	0.36703	0.48130
102	4	1988	11	0.34405	0.29103
103	4	1989	12	0.24455	0.41127
104	4	1990	8	0.33811	0.19302
105	4	1991	9	0.30731	0.21644
106	4	1992	9	0.27373	0.14154
107	4	1993	10	0.20558	0.12360
108	4	1994	11	0.26665	0.19819
109	4	1995	8	0.19838	0.07606
110	4	1996	8	0.17571	0.10561

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Obs	SECTOR	YEAR	N	MROME	STD
111	4	1997	11	0.12719	0.24454
112	4	1998	11	0.16210	0.08823
113	5	1971	28	0.10064	0.14082
114	5	1972	29	0.17332	0.23860
115	5	1973	30	0.14631	0.17138
116	5	1974	30	0.14783	0.10497
117	5	1975	23	0.13308	0.08912
118	5	1976	27	0.05319	0.13122
119	5	1977	27	0.09429	0.05869
120	5	1978	27	0.14072	0.16211
121	5	1979	27	0.17236	0.09785
122	5	1980	21	0.29200	0.17780
123	5	1981	24	0.16258	0.14484
124	5	1982	24	0.05978	0.20641
125	5	1983	24	0.04325	0.21404
126	5	1984	24	-0.09310	0.36282
127	5	1985	12	0.11434	0.07323
128	5	1986	16	0.27566	0.27138
129	5	1987	18	0.26414	0.13696
130	5	1988	28	0.31024	0.17214
131	5	1989	27	0.19197	0.12561
132	5	1990	14	0.12723	0.08120
133	5	1991	17	0.05219	0.17981
134	5	1992	18	0.10294	0.15117
135	5	1993	20	0.15824	0.08790
136	5	1994	20	0.16840	0.10942
137	5	1995	13	0.11819	0.15630
138	5	1996	25	0.17015	0.18023
139	5	1997	25	0.12799	0.10448
140	5	1998	27	0.06454	0.21852
141	6	1976	1	0.17707	.
142	6	1977	1	0.28076	.
143	6	1978	1	0.30220	.
144	6	1979	1	0.29905	.
145	6	1980	1	0.36795	.
146	6	1981	4	0.22752	0.12437
147	6	1982	4	0.22505	0.07282
148	6	1983	5	0.16611	0.05557
149	6	1984	6	0.13517	0.06499
150	6	1985	3	0.13881	0.00532
151	6	1986	9	0.18641	0.06903
152	6	1987	16	0.31716	0.32957
153	6	1988	22	0.19534	0.31188
154	6	1989	24	0.15367	0.36200
155	6	1990	15	0.21112	0.11496
156	6	1991	19	0.18859	0.28862
157	6	1992	19	0.13205	0.19379
158	6	1993	19	0.06355	0.40690
159	6	1994	20	0.22989	0.40454
160	6	1995	14	0.23795	0.27089
161	6	1996	27	0.16807	0.13431
162	6	1997	27	0.17977	0.25426
163	6	1998	30	0.21004	0.16414

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Obs	SECTOR	YEAR	N	MROME	STD
1	1	1971	88	0.13074	0.09967
2	1	1972	88	0.15700	0.11088
3	1	1973	91	0.22352	0.12612
4	1	1974	92	0.17888	0.11761
5	1	1975	60	0.15865	0.12905
6	1	1976	66	0.10487	0.20486
7	1	1977	67	0.09975	0.13945
8	1	1978	68	0.14255	0.17598
9	1	1979	68	0.20246	0.18530
10	1	1980	40	0.29128	0.24050
11	1	1981	46	0.22239	0.18752
12	1	1982	47	0.15013	0.21427
13	1	1983	47	0.05309	0.37401
14	1	1984	47	0.03335	0.28086
15	1	1985	38	0.11075	0.23254
16	1	1986	47	0.17497	0.21855
17	1	1987	60	0.16997	0.29646
18	1	1988	72	0.27786	0.20953
19	1	1989	71	0.18618	0.29079
20	1	1990	46	0.13604	0.14218
21	1	1991	49	0.06245	0.21273
22	1	1992	51	0.06492	0.29210
23	1	1993	51	0.12084	0.27145
24	1	1994	53	0.17942	0.24252
25	1	1995	24	0.15742	0.24903
26	1	1996	28	0.12053	0.27188
27	1	1997	30	0.06991	0.33979
28	1	1998	29	0.05171	0.36925
29	2	1971	6	0.23895	0.07690
30	2	1972	7	0.26955	0.09165
31	2	1973	7	0.25777	0.10862
32	2	1974	7	0.27918	0.09248
33	2	1975	7	0.24772	0.04289
34	2	1976	9	0.16886	0.05610
35	2	1977	9	0.21363	0.11401
36	2	1978	9	0.18458	0.07217
37	2	1979	10	0.27806	0.12796
38	2	1980	9	0.30317	0.14984
39	2	1981	11	0.26629	0.10207
40	2	1982	12	0.18052	0.13492
41	2	1983	12	0.18683	0.12496
42	2	1984	12	0.11593	0.18545
43	2	1985	11	0.16089	0.09338
44	2	1986	19	0.22973	0.15709
45	2	1987	28	0.36021	0.24173
46	2	1988	45	0.29180	0.25342
47	2	1989	42	0.20945	0.31626
48	2	1990	26	0.27460	0.18362
49	2	1991	28	0.20896	0.15047
50	2	1992	29	0.21864	0.34919
51	2	1993	29	0.20174	0.12823
52	2	1994	29	0.24598	0.21062
53	2	1995	20	0.20581	0.29439
54	2	1996	29	0.10031	0.36802
55	2	1997	30	0.26500	0.51796

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Obs	SECTOR	YEAR	N	MROME	STD
56	2	1998	36	0.29561	0.26909
57	3	1971	28	0.14768	0.08695
58	3	1972	27	0.17304	0.10921
59	3	1973	27	0.23366	0.12866
60	3	1974	29	0.29714	0.24950
61	3	1975	26	0.25422	0.20784
62	3	1976	27	0.21336	0.24080
63	3	1977	25	0.22530	0.19438
64	3	1978	25	0.28133	0.21010
65	3	1979	26	0.39649	0.26711
66	3	1980	26	0.46485	0.32081
67	3	1981	25	0.31140	0.21333
68	3	1982	25	0.34887	0.26148
69	3	1983	25	0.29595	0.21457
70	3	1984	25	0.33882	0.23475
71	3	1985	23	0.35312	0.28232
72	3	1986	26	0.38406	0.34466
73	3	1987	28	0.42520	0.40729
74	3	1988	28	0.31921	0.29330
75	3	1989	28	0.27783	0.33429
76	3	1990	16	0.27648	0.33878
77	3	1991	18	0.25457	0.35098
78	3	1992	18	0.19911	0.22504
79	3	1993	17	0.16343	0.25941
80	3	1994	19	0.30325	0.38402
81	3	1995	8	0.31429	0.30802
82	3	1996	12	0.20494	0.14099
83	3	1997	12	0.05252	0.27753
84	3	1998	11	0.24260	0.30496
85	4	1971	11	0.16561	0.23274
86	4	1972	11	0.21627	0.23911
87	4	1973	11	0.23627	0.19375
88	4	1974	11	0.20062	0.11890
89	4	1975	8	0.21293	0.11327
90	4	1976	9	0.16776	0.12213
91	4	1977	9	0.19302	0.17700
92	4	1978	9	0.22608	0.18187
93	4	1979	9	0.22191	0.16875
94	4	1980	5	0.14547	0.06524
95	4	1981	5	0.15282	0.05448
96	4	1982	5	0.31092	0.28498
97	4	1983	5	0.12749	0.04335
98	4	1984	5	0.12781	0.03928
99	4	1985	3	0.12895	0.05914
100	4	1986	4	0.15820	0.07079
101	4	1987	8	0.36703	0.48130
102	4	1988	11	0.34405	0.29103
103	4	1989	12	0.24455	0.41127
104	4	1990	8	0.33811	0.19302
105	4	1991	9	0.30731	0.21644
106	4	1992	9	0.27373	0.14154
107	4	1993	10	0.20558	0.12360
108	4	1994	11	0.26665	0.19819
109	4	1995	8	0.19838	0.07606
110	4	1996	8	0.17571	0.10561

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Obs	SECTOR	YEAR	N	MROME	STD
111	4	1997	11	0.12719	0.24454
112	4	1998	11	0.16210	0.08823
113	5	1971	28	0.10064	0.14082
114	5	1972	29	0.17332	0.23860
115	5	1973	30	0.14631	0.17138
116	5	1974	30	0.14783	0.10497
117	5	1975	23	0.13308	0.08912
118	5	1976	27	0.05319	0.13122
119	5	1977	27	0.09429	0.05869
120	5	1978	27	0.14072	0.16211
121	5	1979	27	0.17236	0.09785
122	5	1980	21	0.29200	0.17780
123	5	1981	24	0.16258	0.14484
124	5	1982	24	0.05978	0.20641
125	5	1983	24	0.04325	0.21404
126	5	1984	24	-0.09310	0.36282
127	5	1985	12	0.11434	0.07323
128	5	1986	16	0.27566	0.27138
129	5	1987	18	0.26414	0.13696
130	5	1988	28	0.31024	0.17214
131	5	1989	27	0.19197	0.12561
132	5	1990	14	0.12723	0.08120
133	5	1991	17	0.05219	0.17981
134	5	1992	18	0.10294	0.15117
135	5	1993	20	0.15824	0.08790
136	5	1994	20	0.16840	0.10942
137	5	1995	13	0.11819	0.15630
138	5	1996	25	0.17015	0.18023
139	5	1997	25	0.12799	0.10448
140	5	1998	27	0.06454	0.21852
141	6	1976	1	0.17707	.
142	6	1977	1	0.28076	.
143	6	1978	1	0.30220	.
144	6	1979	1	0.29905	.
145	6	1980	1	0.36795	.
146	6	1981	4	0.22752	0.12437
147	6	1982	4	0.22505	0.07282
148	6	1983	5	0.16611	0.05557
149	6	1984	6	0.13517	0.06499
150	6	1985	3	0.13881	0.00532
151	6	1986	9	0.18641	0.06903
152	6	1987	16	0.31716	0.32957
153	6	1988	22	0.19534	0.31188
154	6	1989	24	0.15367	0.36200
155	6	1990	15	0.21112	0.11496
156	6	1991	19	0.18859	0.28862
157	6	1992	19	0.13205	0.19379
158	6	1993	19	0.06355	0.40690
159	6	1994	20	0.22989	0.40454
160	6	1995	14	0.23795	0.27089
161	6	1996	27	0.16807	0.13431
162	6	1997	27	0.17977	0.25426
163	6	1998	30	0.21004	0.16414

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APPENDIX B

UNIVERSITEIT VAN PRETORIA
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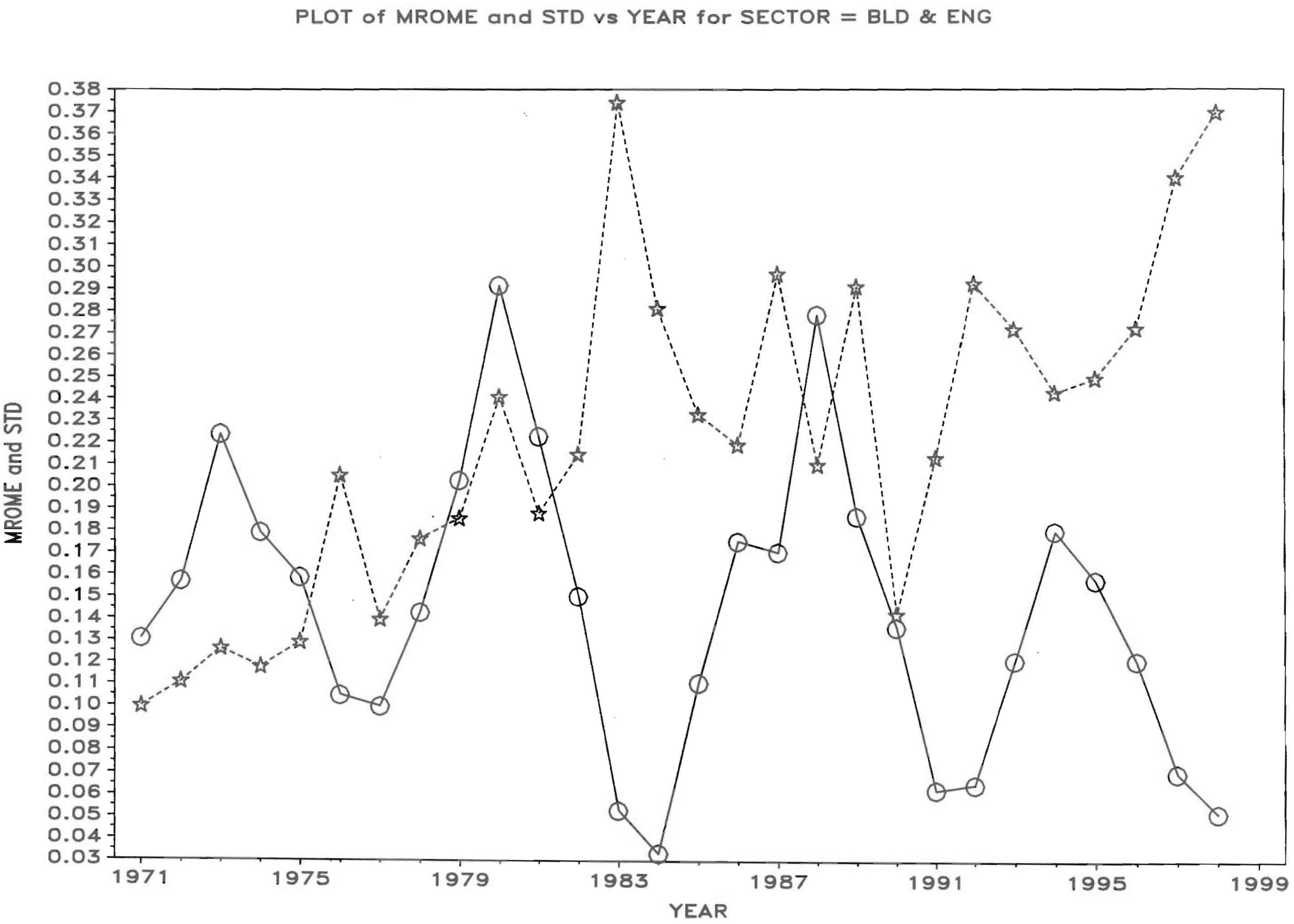

P06G01

UNIVERSITEIT VAN PRETORIA
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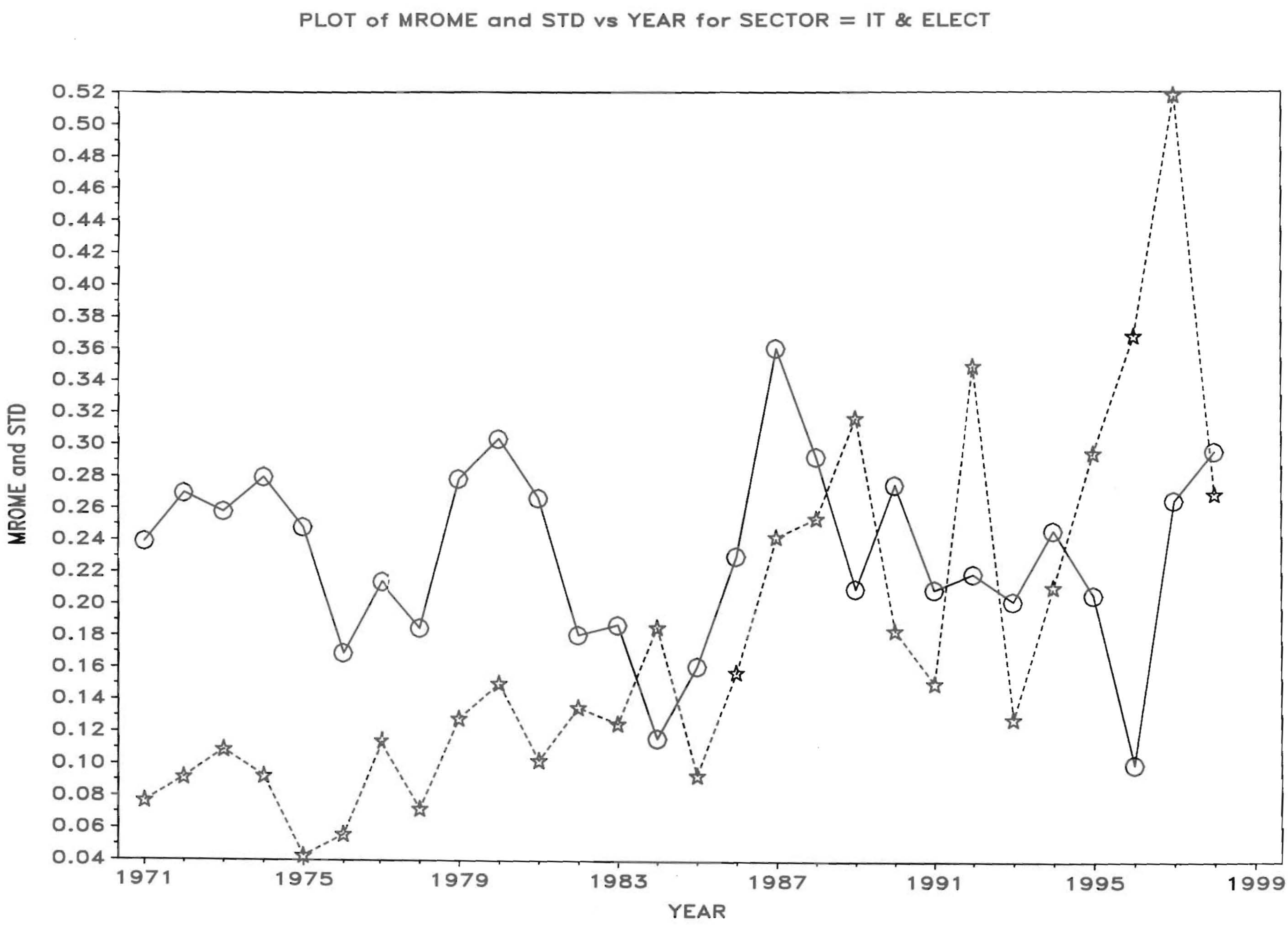
YUNIBESITHI YA PRETORIA



P06G02

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
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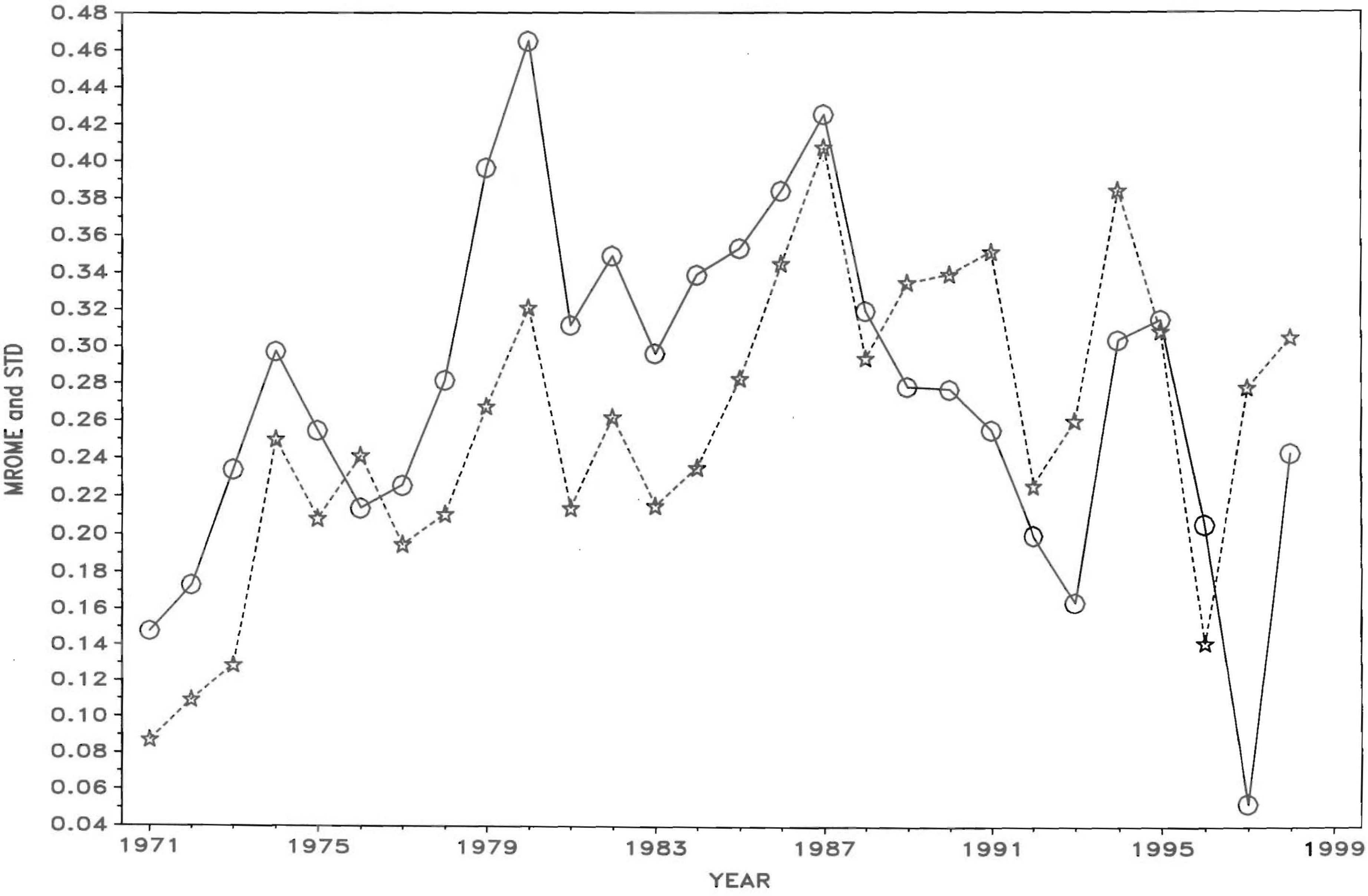
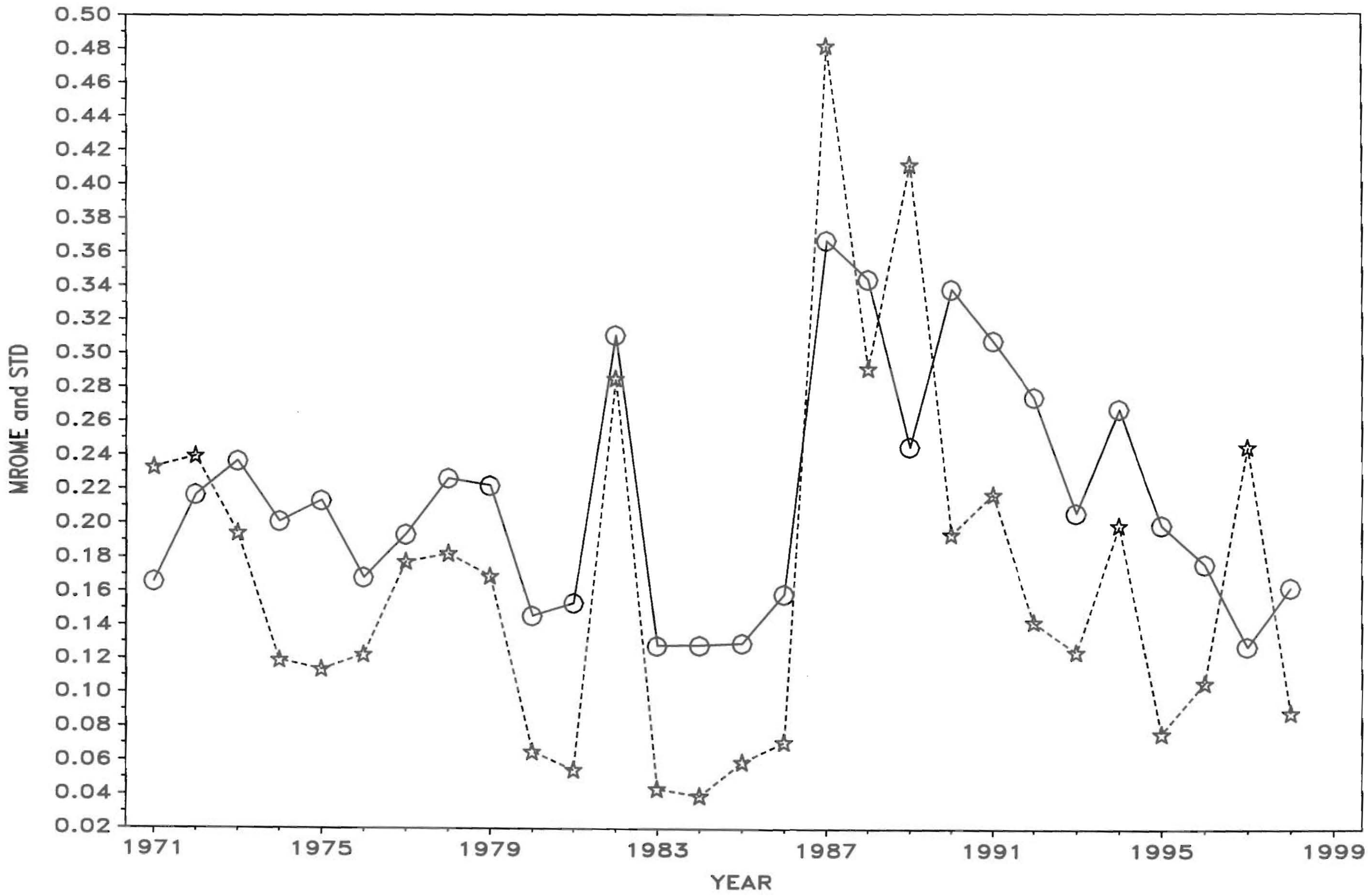
PLOT of MROME and STD vs YEAR for SECTOR = MHOLD & HO



P06G03

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

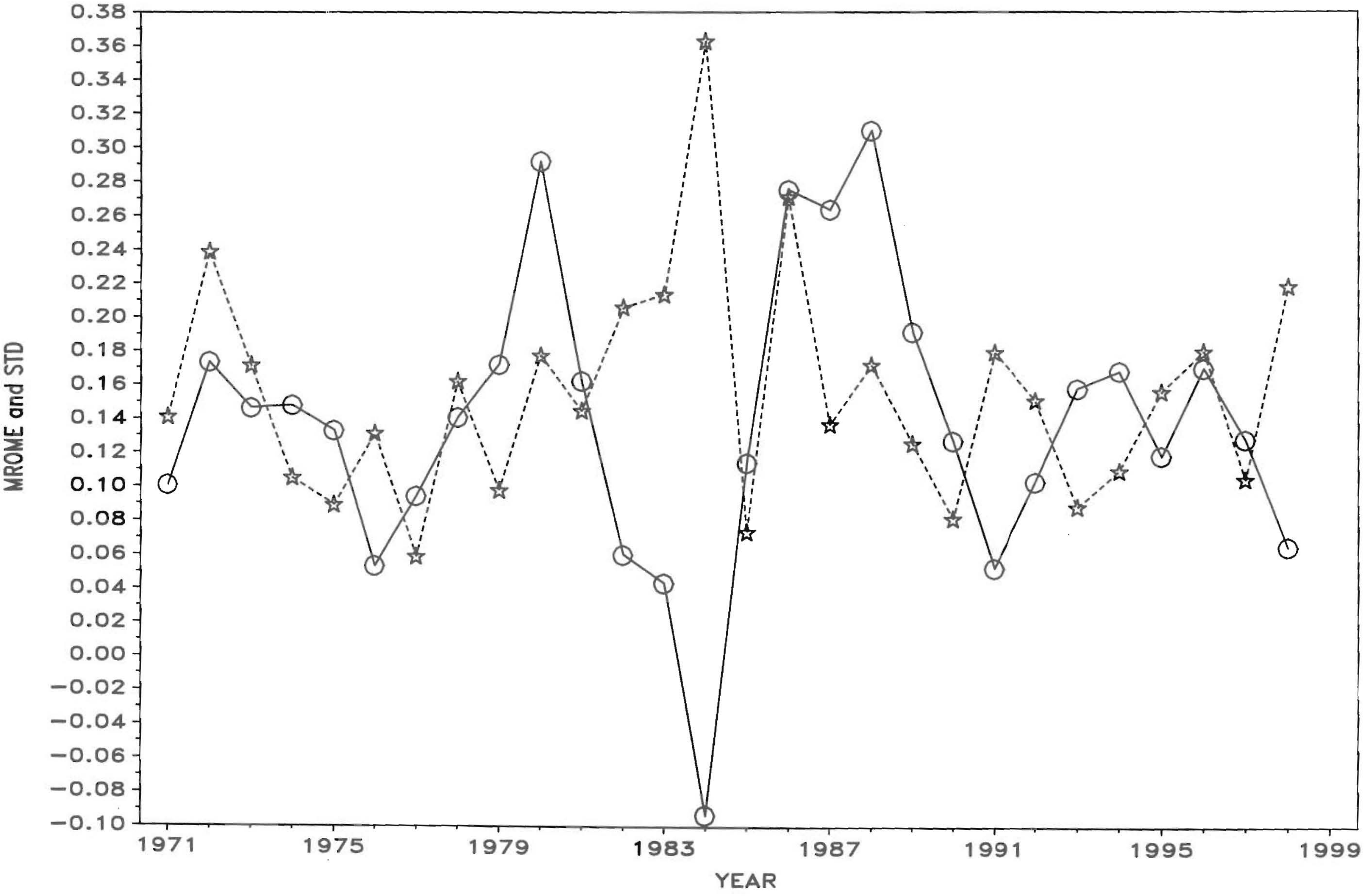
PLOT of MROME and STD vs YEAR for SECTOR = PHARMACEUT



P08G04

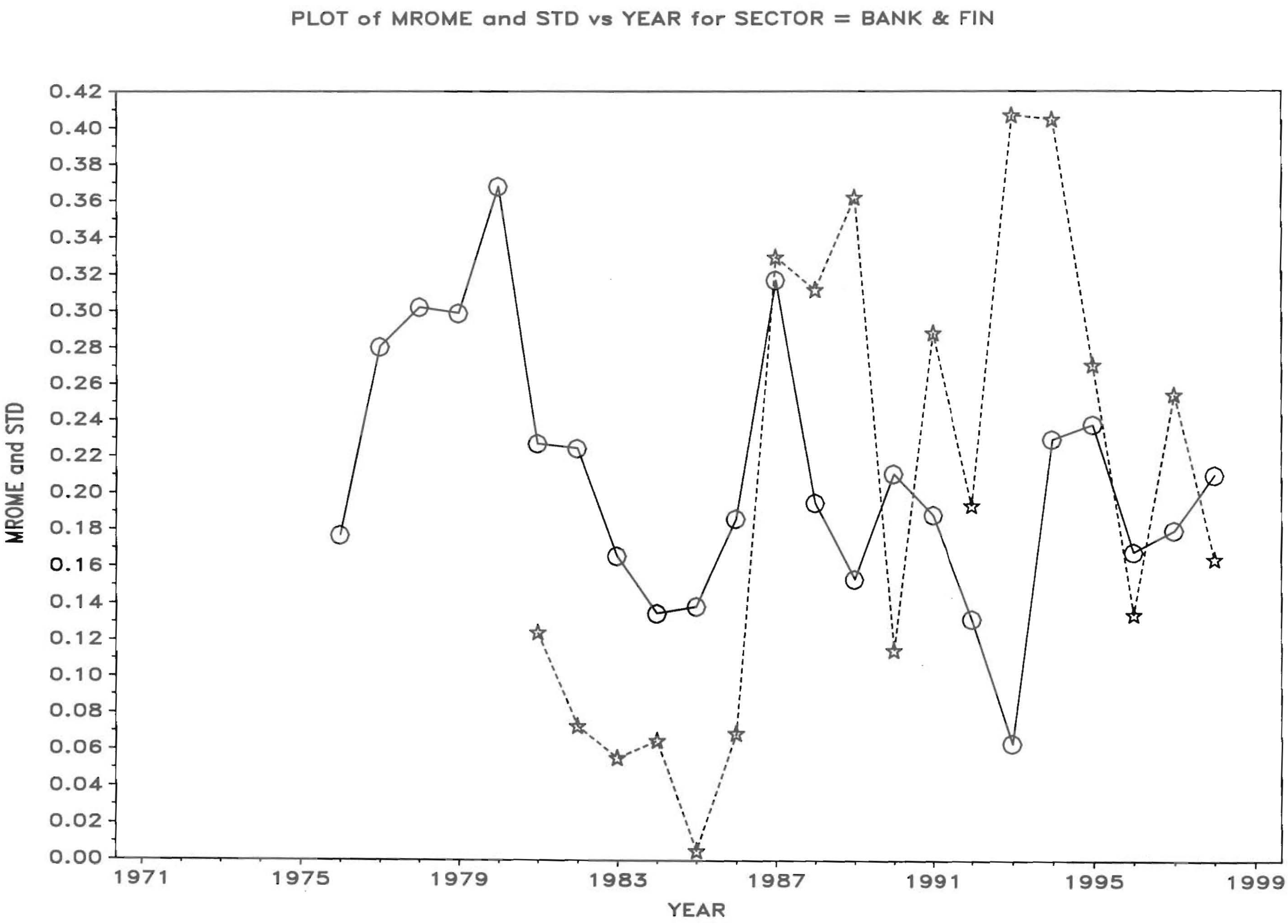
UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

PLOT of MROME and STD vs YEAR for SECTOR = MOT & TRAN



P06G05

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA



P06G06

UNIVERSITEIT VAN PRETORIA
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-- SECTOR=1 --

The UNIVARIATE Procedure
Variable: ROME

Moments

N	1564	Sum Weights	1564
Mean	0.15128471	Sum Observations	236.609294
Std Deviation	0.22489125	Variance	0.05057608
Skewness	-1.5491144	Kurtosis	14.2841517
Uncorrected SS	114.845776	Corrected SS	79.0504068
Coeff Variation	148.654313	Std Error Mean	0.00568662

Basic Statistical Measures

Location		Variability	
Mean	0.151285	Std Deviation	0.22489
Median	0.156667	Variance	0.05058
Mode	0.000000	Range	2.83619
		Interquartile Range	0.15350

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	26.60363	Pr > |t|	<.0001
Sign	M	626.5	Pr >= |M|	<.0001
Signed Rank	S	498504.5	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.779499	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.156674	Pr > D	<0.0100
Cramer-von Mises	W-Sq	14.12423	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	79.63207	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	1.3780328
99%	0.7910142
95%	0.4326985
90%	0.3291237
75% Q3	0.2361481
50% Median	0.1566672
25% Q1	0.0826485
10%	0.0000000
5%	-0.1364251

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-- SECTOR=1 --

The UNIVARIATE Procedure
Variable: ROME

Quantiles (Definition 5)

Quantile	Estimate
1%	-0.7845826
0% Min	-1.4581599

Extreme Observations

------Lowest-----		-----Highest-----	
Value	Obs	Value	Obs
-1.45816	414	1.10223	1118
-1.41618	278	1.15493	1119
-1.38602	125	1.23363	359
-1.28884	1517	1.23682	1117
-1.26980	124	1.37803	1336

Missing Values

Missing Value	Count	-----Percent Of----- All Obs	Missing Obs
.	4	0.26	100.00

```
                Histogram                           #   Boxplot                    Normal Probability Plot
 1.3+*                                              3      *           1.3+                                                         *
    .*                                              6      *              |                                                         *
    .*                                              6      *              |                                                        **
    .*                                             17      0              |                                                    ****++
    .****                                          61      0              |                                            +++*****
    .***********************                      451   +-----+           |                                       +***********
    .**********************************************  866   *--+--*         |                               *****************
-0.1+******                                        97      0          -0.1+                         *****+++++
    .**                                            28      0              |  +++*****++
    .*                                              9      *              |+  **
    .*                                              6      *              | ***
    .*                                              3      *              | *
    .*                                              4      *              |*
    .*                                              5      *              |*
-1.5+*                                              2      *          -1.5+*
     ----+----+----+----+----+----+----+----+----+-                        +----+----+----+----+----+----+----+----+----+----+
     * may represent up to 19 counts                                            -2        -1         0        +1        +2
```

SECTOR=2

The UNIVARIATE Procedure
Variable: ROME

Moments

N	528	Sum Weights	528
Mean	0.23529336	Sum Observations	124.234895
Std Deviation	0.25697668	Variance	0.06603702
Skewness	-1.0308379	Kurtosis	10.2210951
Uncorrected SS	64.0331532	Corrected SS	34.8015069
Coeff Variation	109.21544	Std Error Mean	0.01118347

Basic Statistical Measures

Location		Variability	
Mean	0.235293	Std Deviation	0.25698
Median	0.229147	Variance	0.06604
Mode	0.235238	Range	2.82353
		Interquartile Range	0.19351

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	21.03938	Pr > |t|	<.0001
Sign	M	226.5	Pr >= |M|	<.0001
Signed Rank	S	61479	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.828357	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.146555	Pr > D	<0.0100
Cramer-von Mises	W-Sq	3.673187	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	21.19054	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	1.3701092
99%	0.9494364
95%	0.6040653
90%	0.4880167
75% Q3	0.3336849
50% Median	0.2291473
25% Q1	0.1401785
10%	0.0430191
5%	-0.0609164

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-- SECTOR=2 --

The UNIVARIATE Procedure
Variable: ROME

Quantiles (Definition 5)

Quantile	Estimate
1%	-0.7735352
0% Min	-1.4534166

Extreme Observations

------Lowest------		------Highest-----	
Value	Obs	Value	Obs
-1.453417	367	0.967481	321
-1.217987	474	1.140125	458
-1.016677	178	1.299895	158
-0.963587	466	1.357360	175
-0.791339	266	1.370109	530

Missing Values

Missing Value	Count	-----Percent Of----- All Obs	Missing Obs
.	6	1.12	100.00

```
                 Histogram                          #      Boxplot                   Normal Probability Plot
 1.3+*                                              3         *           1.3+                                                     *
    .*                                              1         *              |                                                     *
    .**                                             9         0              |                                                *****+
    .***                                           14         0              |                                           +*****++
    .*************                                 61         |              |                                    +++*********
    .********************************************  219     +--+--+           |                             *************
    .*************************************         184     +-----+           |                *************
-0.1+****                                          20         0          -0.1+            ****++++
    .**                                             6         0              | +++++*++
    .*                                              1         0              |+    *
    .**                                             6         *              | ****
    .*                                              1         *              |*
    .*                                              1         *              |*
    .*                                              1         *              |*
-1.5+*                                              1         *          -1.5+*
     ----+----+----+----+----+----+----+----+----                             +----+----+----+----+----+----+----+----+----+----+
     * may represent up to 5 counts                                                -2        -1         0        +1        +2
```

------------------------------ SECTOR=3 ------------------------------

The UNIVARIATE Procedure
Variable: ROME

Moments

N	630	Sum Weights	630
Mean	0.28519451	Sum Observations	179.672538
Std Deviation	0.27343747	Variance	0.07476805
Skewness	1.65399572	Kurtosis	3.98230828
Uncorrected SS	98.2707232	Corrected SS	47.0291025
Coeff Variation	95.877537	Std Error Mean	0.01089401

Basic Statistical Measures

Location		Variability	
Mean	0.285195	Std Deviation	0.27344
Median	0.216631	Variance	0.07477
Mode	.	Range	1.99726
		Interquartile Range	0.22633

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	26.17902	Pr > |t|	<.0001
Sign	M	296	Pr >= |M|	<.0001
Signed Rank	S	95497.5	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.834842	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.160147	Pr > D	<0.0100
Cramer-von Mises	W-Sq	5.931161	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	33.45827	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	1.4601630
99%	1.2861921
95%	0.8863308
90%	0.6382920
75% Q3	0.3522808
50% Median	0.2166310
25% Q1	0.1259546
10%	0.0619316
5%	0.0290922

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-- SECTOR=3 --

The UNIVARIATE Procedure
Variable: ROME

Quantiles (Definition 5)

Quantile	Estimate
1%	-0.1821671
0% Min	-0.5370946

Extreme Observations

------Lowest------		-----Highest-----	
Value	Obs	Value	Obs
-0.537095	250	1.32141	225
-0.532181	427	1.38662	247
-0.457878	168	1.39558	477
-0.417621	516	1.39596	478
-0.303714	381	1.46016	203

Missing Values

Missing Value	Count	-----Percent Of----- All Obs	Missing Obs
.	20	3.08	100.00

```
------------------------------------------------------------ SECTOR=3 ------------------------------------------------------------

                                   The UNIVARIATE Procedure
                                       Variable:  ROME

                 Histogram                          #    Boxplot                    Normal Probability Plot
  1.45+*                                            1       *        1.45+                                                   *
      .**                                           5       *            |                                                  **
  1.25+**                                           7       *        1.25+                                               ***
      .*                                            4       *            |                                             **
  1.05+**                                           7       0        1.05+                                            **
      .**                                           5       0            |                                           **     +++
  0.85+***                                         10       0        0.85+                                        *** ++++
      .***                                         12       0            |                                         *+++
  0.65+*****                                       18       0        0.65+                                      ***+
      .****                                        15       |            |                                  +++**
  0.45+***********                                 43       |        0.45+                               +++****
      .*******************                         76    +-----+         |                            ++++****
  0.25+***********************************        137    *--+--*     0.25+                        ++*******
      .*********************************************  178    +-----+         |                  *********
  0.05+************************                    93       |        0.05+     ***********++
      .***                                         10       |            |  ****     ++++
 -0.15+*                                            3       |       -0.15+ **     +++
      .*                                            1       0            | *  ++++
 -0.35+*                                            1       0       -0.35++*++
      .*                                            2       0            |*
 -0.55+*                                            2       0       -0.55+*
       ----+----+----+----+----+----+----+----+----+                     +----+----+----+----+----+----+----+----+----+----+
       * may represent up to 4 counts                                          -2        -1         0        +1        +2
```

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SECTOR=4

The UNIVARIATE Procedure
Variable: ROME

Moments

N	236	Sum Weights	236
Mean	0.2206967	Sum Observations	52.0844214
Std Deviation	0.21080225	Variance	0.04443759
Skewness	1.84645372	Kurtosis	9.72004202
Uncorrected SS	21.9376935	Corrected SS	10.4428335
Coeff Variation	95.5167209	Std Error Mean	0.01372206

Basic Statistical Measures

Location		Variability	
Mean	0.220697	Std Deviation	0.21080
Median	0.182177	Variance	0.04444
Mode	.	Range	2.07983
		Interquartile Range	0.15623

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	16.08335	Pr > |t|	<.0001
Sign	M	110	Pr >= |M|	<.0001
Signed Rank	S	13320	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.790878	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.188899	Pr > D	<0.0100
Cramer-von Mises	W-Sq	2.610259	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	14.13481	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	1.4816248
99%	1.0501139
95%	0.5997947
90%	0.4212034
75% Q3	0.2686264
50% Median	0.1821775
25% Q1	0.1123975
10%	0.0647633
5%	0.0368014

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-- SECTOR=4 --

The UNIVARIATE Procedure
Variable: ROME

Quantiles (Definition 5)

Quantile	Estimate
1%	-0.2764356
0% Min	-0.5982011

Extreme Observations

-------Lowest------		------Highest-----	
Value	Obs	Value	Obs
-0.5982011	139	0.793535	82
-0.4909832	85	0.809567	220
-0.2764356	210	1.050114	34
-0.0759551	134	1.267239	35
-0.0405488	86	1.481625	33

```
               Histogram                     #          Boxplot
 1.45+*                                      1             *
     .
 1.25+*                                      1             *
     .
 1.05+*                                      1             *
     .
 0.85+*                                      1             *
     .**                                     4             *
 0.65+*                                      3             0
     .***                                    9             0
 0.45+**                                     5             |
     .********                              22             |
 0.25+****************                      47          +--+--+
     .*********************************     97          *-----*
 0.05+*************                         37             |
     .**                                     5             |
-0.15+
     .*                                      1             0
-0.35+
     .*                                      1             *
-0.55+*                                      1             *
      ----+----+----+----+----+----+---
     * may represent up to 3 counts
```

```
                       Normal Probability Plot
 1.45+                                                          *
     |
 1.25+                                                          *
     |
 1.05+                                                        *
     |
 0.85+                                                       *
     |                                                   **** +++
 0.65+                                                  **++++
     |                                               ****
 0.45+                                           +++++**
     |                                      +++++****
 0.25+                                  +++*******
     |                         *************
 0.05+                ***********+++
     |    *****   +++++
-0.15+       ++++
     | +*+++
-0.35++
     |*
-0.55+*
      +----+----+----+----+----+----+----+----+----+----+
           -2        -1         0        +1        +2
```

------------------------------ SECTOR=5 ------------------------------

The UNIVARIATE Procedure
Variable: ROME

Moments

N	645	Sum Weights	645
Mean	0.13741159	Sum Observations	88.6304751
Std Deviation	0.18537934	Variance	0.0343655
Skewness	-0.3954503	Kurtosis	14.1484091
Uncorrected SS	34.3102351	Corrected SS	22.1313806
Coeff Variation	134.908079	Std Error Mean	0.0072993

Basic Statistical Measures

Location		Variability	
Mean	0.137412	Std Deviation	0.18538
Median	0.131108	Variance	0.03437
Mode	.	Range	2.69488
		Interquartile Range	0.13360

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	18.8253	Pr > |t|	<.0001
Sign	M	264.5	Pr >= |M|	<.0001
Signed Rank	S	85308.5	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.813138	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.163193	Pr > D	<0.0100
Cramer-von Mises	W-Sq	4.962244	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	27.79366	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	1.3351499
99%	0.8131766
95%	0.3628006
90%	0.3078060
75% Q3	0.2052702
50% Median	0.1311076
25% Q1	0.0716653
10%	0.0108818
5%	-0.1267061

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-- SECTOR=5 --

The UNIVARIATE Procedure
Variable: ROME

Quantiles (Definition 5)

Quantile	Estimate
1%	-0.5135011
0% Min	-1.3597253

Extreme Observations

------Lowest------		------Highest-----	
Value	Obs	Value	Obs
-1.359725	335	0.855624	191
-0.802144	195	0.879137	380
-0.629061	568	0.898829	289
-0.595675	291	1.203513	465
-0.555039	569	1.335150	379

Missing Values

Missing Value	Count	-----Percent Of----- All Obs	Missing Obs
.	2	0.31	100.00

```
                 Histogram                          #  Boxplot                Normal Probability Plot
 1.3+*                                              2     *        1.3+                                                 *
    .                                                                 |
    .*                                              5     *           |                                               ***
    .*                                              1     *           |                                               * +
    .**                                            18     0           |                                      +++*****++
    .****************                             146  +-----+        |                                ++************
    .**********************************************415  *--+--*        |                  *******************
    .****                                          35     0           |             *****+++++
    .**                                            14     0           |+++*****
    .*                                              6     *           |****
    .*                                              1     *           |*
    .*                                              1     *           |*
    .                                                                 |
-1.3+*                                              1     *       -1.3+*
     ----+----+----+----+----+----+----+----+----+--                   +----+----+----+----+----+----+----+----+----+----+
     * may represent up to 9 counts                                        -2        -1         0        +1        +2
```

-- SECTOR=6 --

The UNIVARIATE Procedure
Variable: ROME

Moments

N	288	Sum Weights	288
Mean	0.18792267	Sum Observations	54.1217286
Std Deviation	0.26408006	Variance	0.06973828
Skewness	-1.0582662	Kurtosis	12.7733548
Uncorrected SS	30.1855859	Corrected SS	20.0148862
Coeff Variation	140.525922	Std Error Mean	0.01556107

Basic Statistical Measures

Location		Variability	
Mean	0.187923	Std Deviation	0.26408
Median	0.181675	Variance	0.06974
Mode	.	Range	2.80675
		Interquartile Range	0.12648

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	12.07646	Pr > |t|	<.0001
Sign	M	127	Pr >= |M|	<.0001
Signed Rank	S	17846	Pr >= |S|	<.0001

Tests for Normality

Test	--Statistic---		-----p Value------	
Shapiro-Wilk	W	0.707172	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.223087	Pr > D	<0.0100
Cramer-von Mises	W-Sq	4.845016	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	25.85939	Pr > A-Sq	<0.0050

Quantiles (Definition 5)

Quantile	Estimate
100% Max	1.4173713
99%	1.1416575
95%	0.5653895
90%	0.3570266
75% Q3	0.2518620
50% Median	0.1816753
25% Q1	0.1253862
10%	0.0556376
5%	-0.0812236

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-- SECTOR=6 --

The UNIVARIATE Procedure
Variable: ROME

Quantiles (Definition 5)

Quantile	Estimate
1%	-1.0793860
0% Min	-1.3893746

Extreme Observations

------Lowest------		------Highest-----	
Value	Obs	Value	Obs
-1.389375	187	0.895278	3
-1.108247	146	0.981895	20
-1.079386	197	1.141658	189
-0.994636	155	1.351892	188
-0.654989	54	1.417371	16

Missing Values

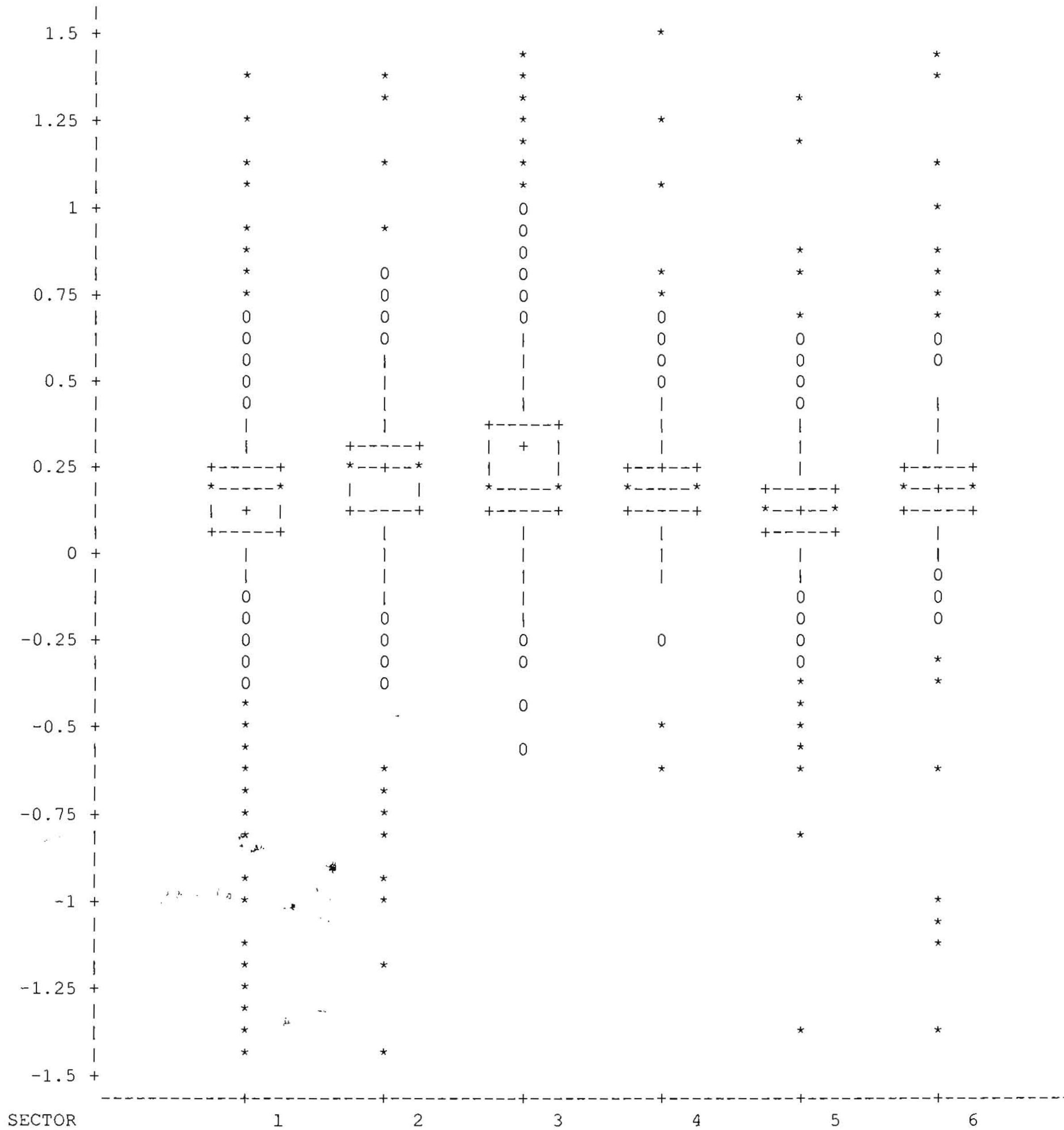
Missing Value	Count	-----Percent Of----- All Obs	Missing Obs
.	6	2.04	100.00

```
                  Histogram                    #       Boxplot                            Normal Probability Plot
 1.5+*                                         1          *             1.5+                                                   *
    .*                                         1          *                 |                                                  *
    .*                                         1          *                 |                                                 *
    .*                                         4          *                 |                                             *** ++
    .*                                         4          0                 |                                        ++**++++
    .***                                       9          0                 |                                 ++++++***
    .**************************              103       +-----+              |                         +*************
 0.1+*************************************   148       *--+--*          0.1+          *****************
    .**                                        7          0                 |      ***  +++++++
    .*                                         3          *                 |  +++**+++
    .                                                                       |+++
    .*                                         3          *                 |   **
    .*                                         1          *                 |  *
    .*                                         2          *                 |**
-1.3+*                                         1          *            -1.3+*
     ----+----+----+----+----+----+----+--                                  +----+----+----+----+----+----+----+----+----+----+
     * may represent up to 4 counts                                             -2        -1         0        +1        +2
```

(P06-R9) : PROC UNIVARITE of varb ROME by SECTOR from data set XXLISTED

The UNIVARIATE Procedure
Variable: ROME

Schematic Plots



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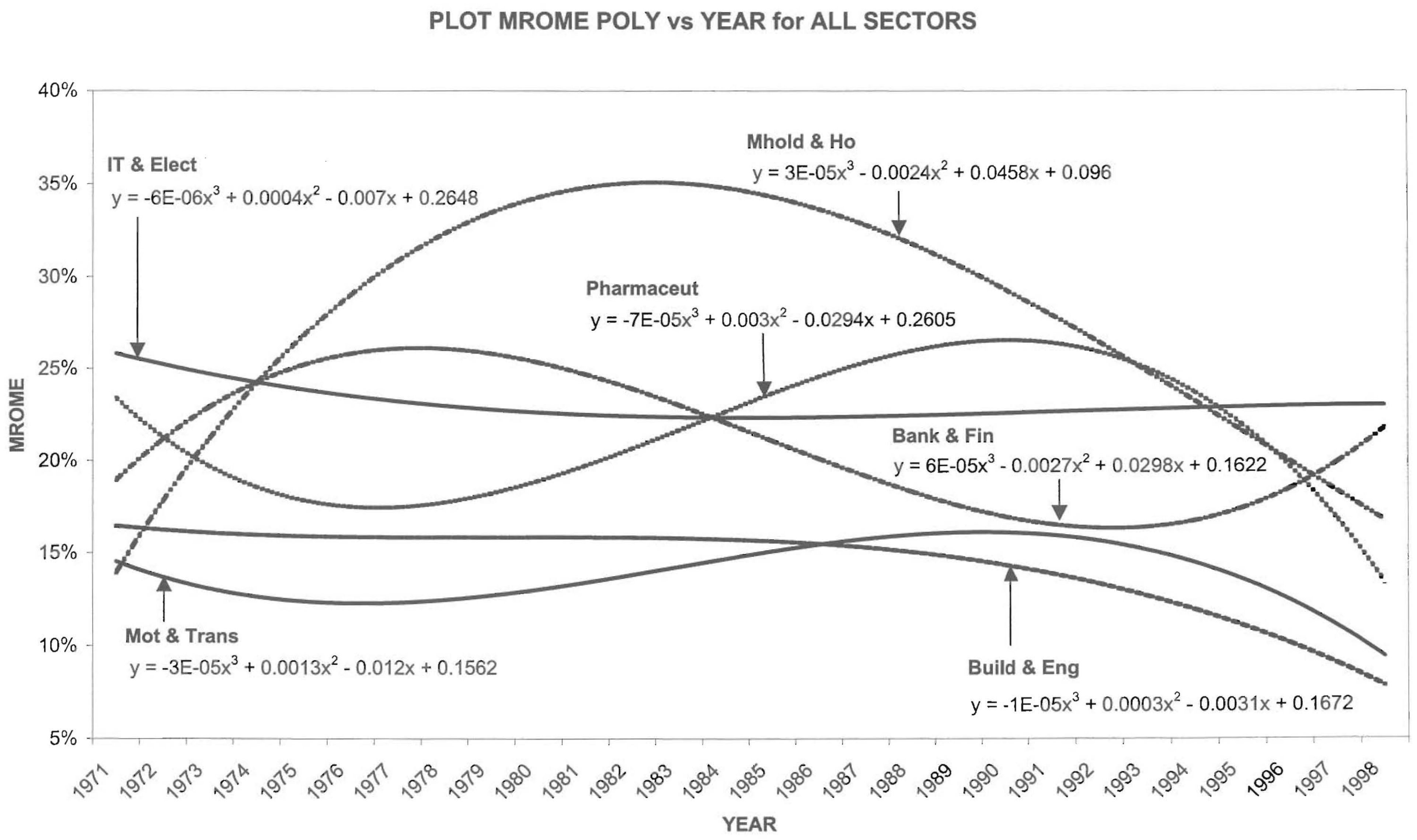
APPENDIX C



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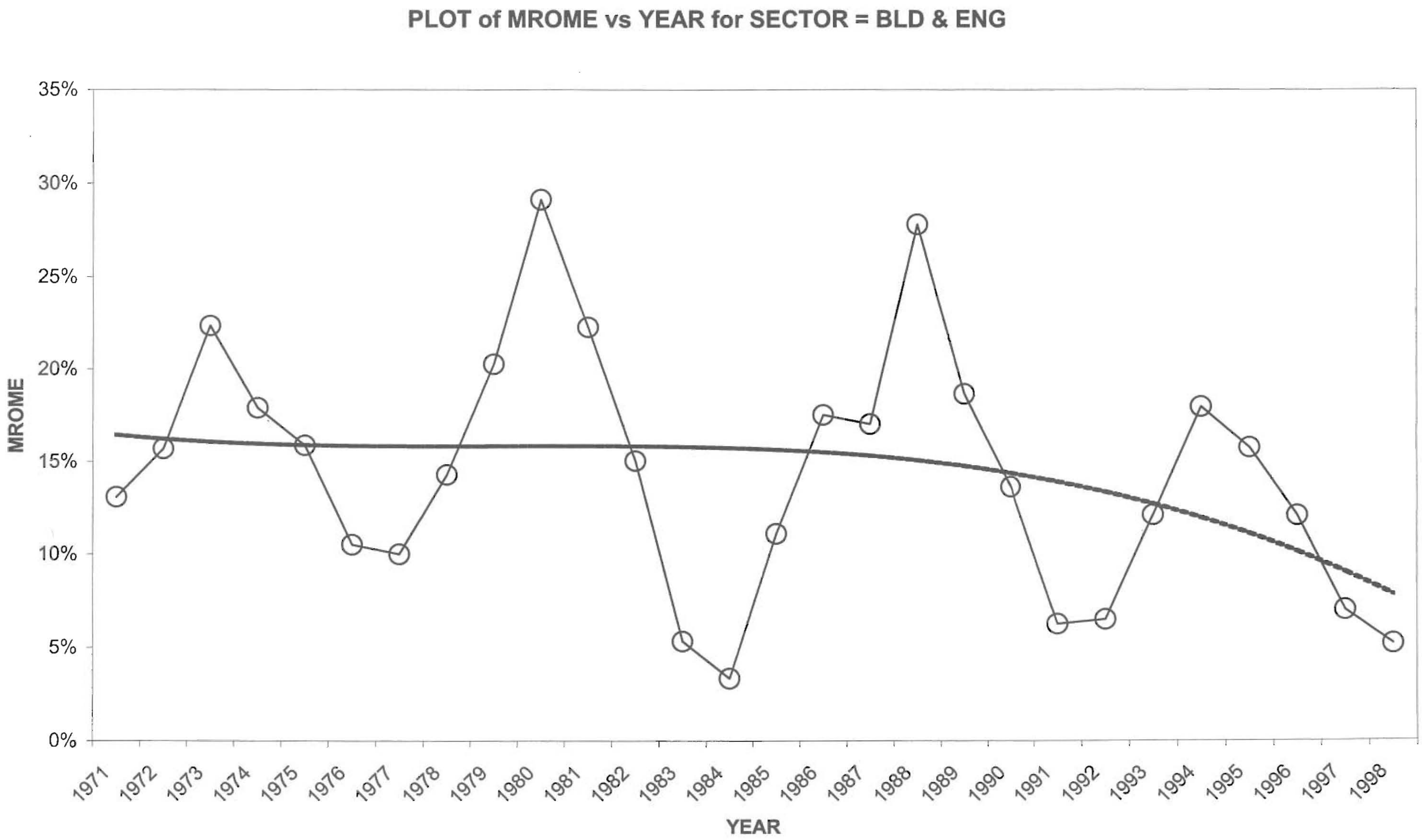

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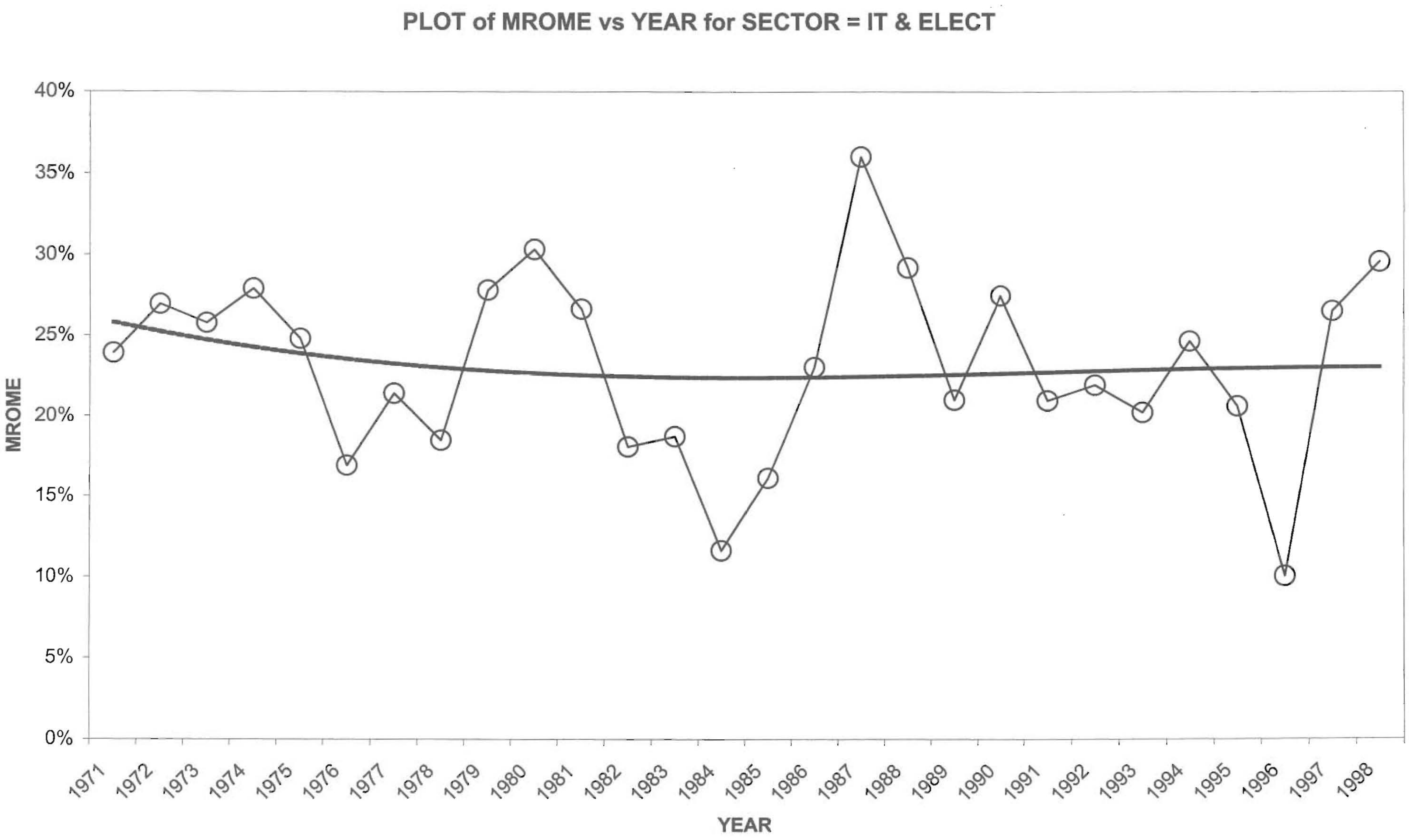

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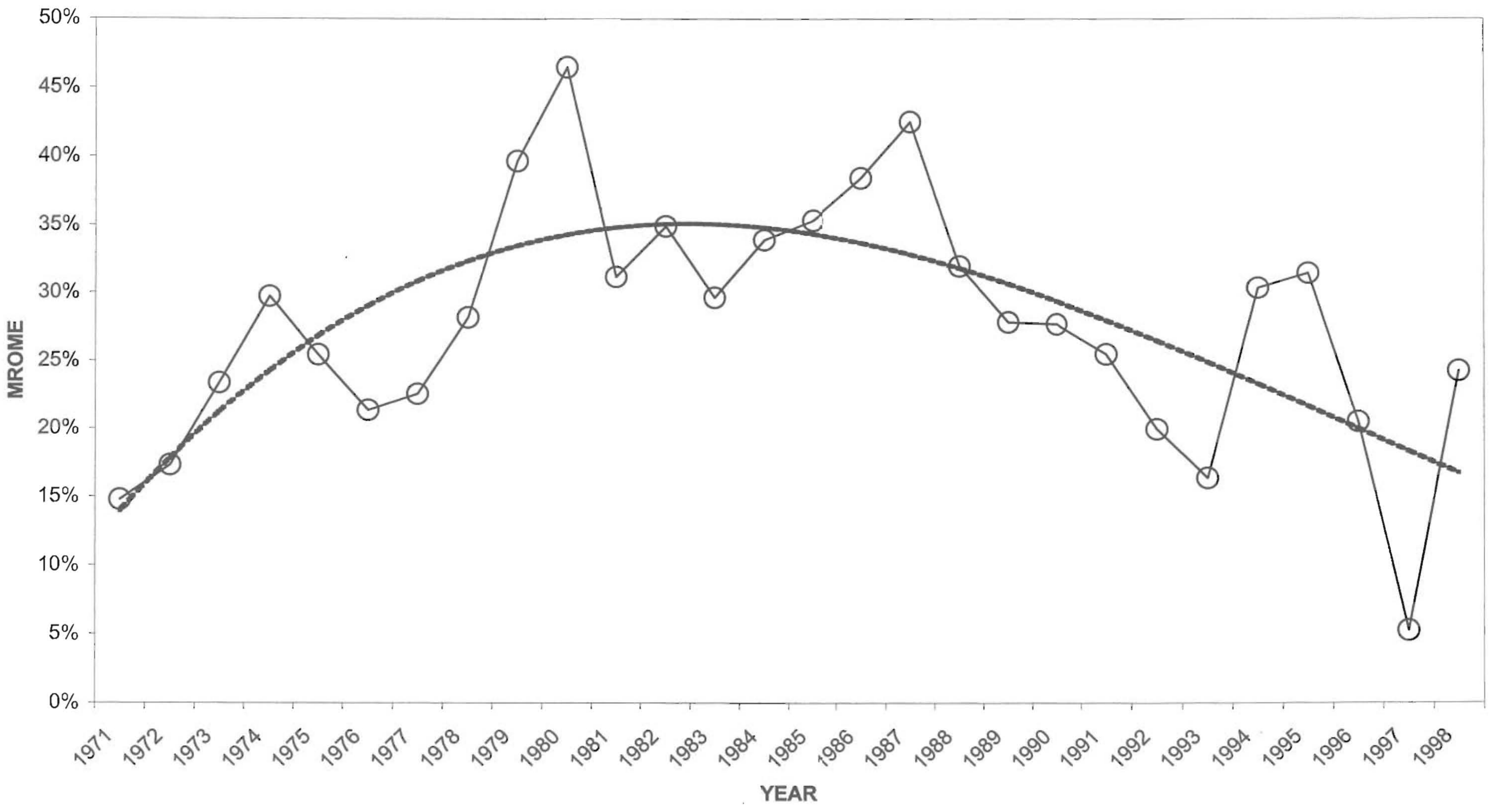
PLOT of MROME vs YEAR for SECTOR = MHOLD & HO



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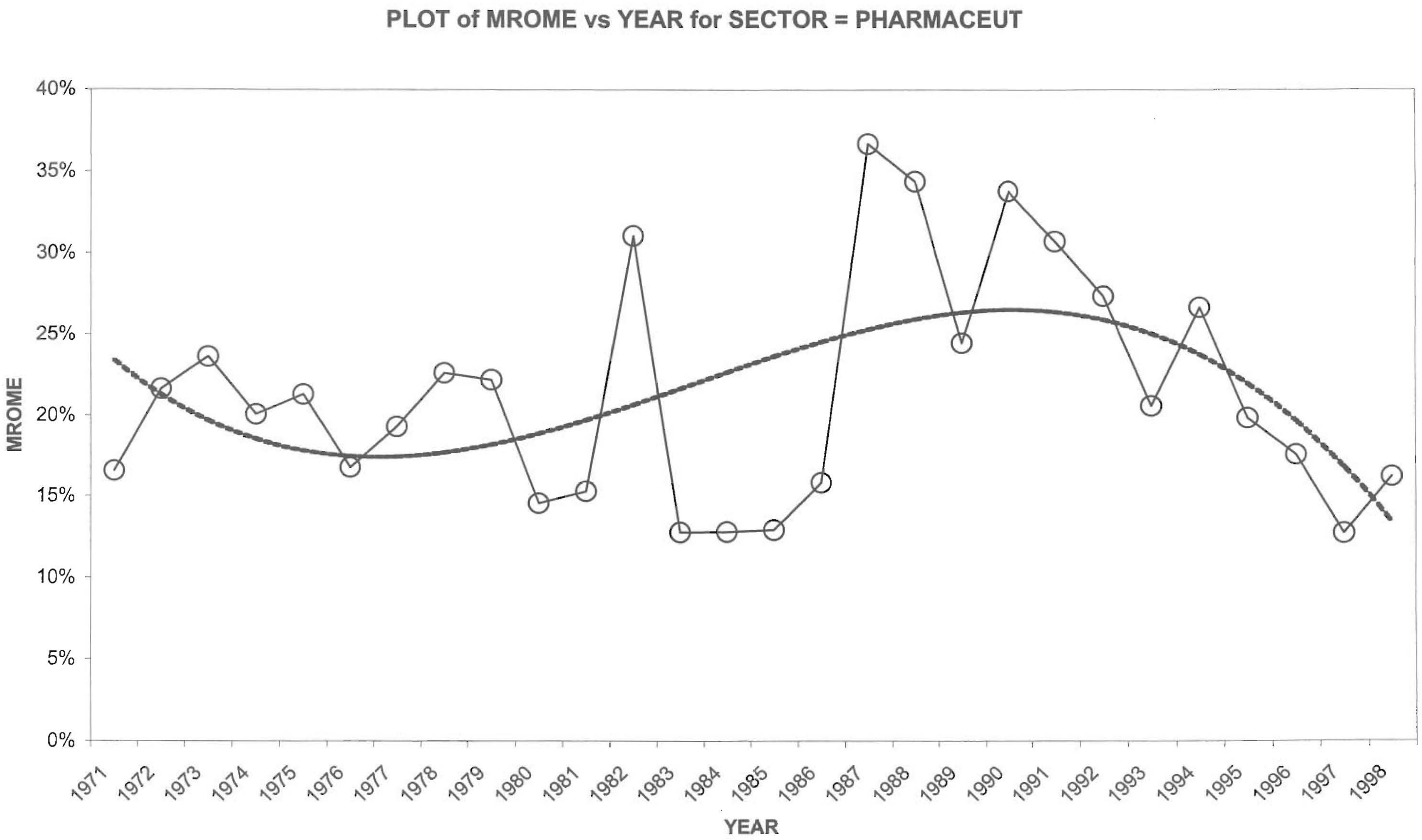

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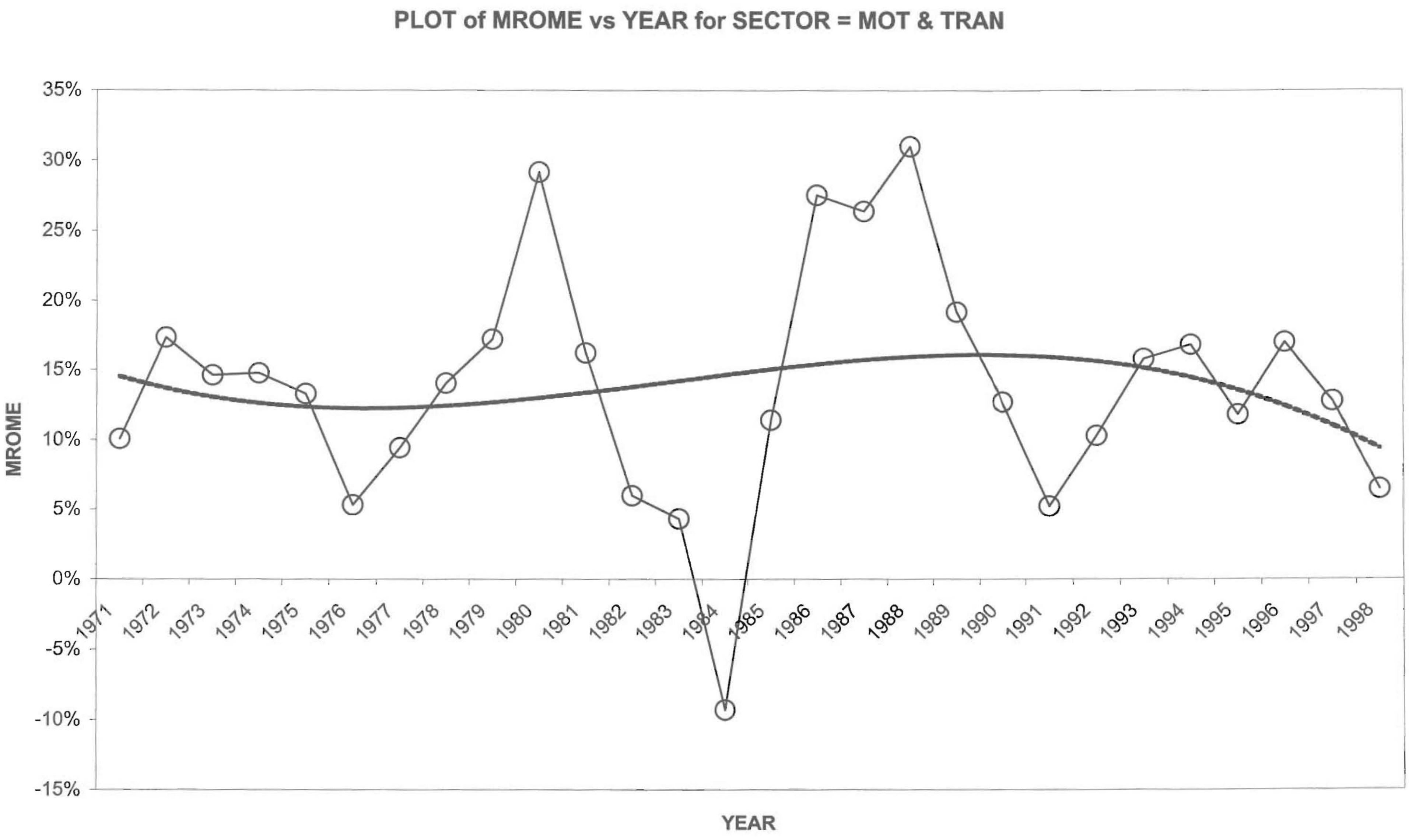

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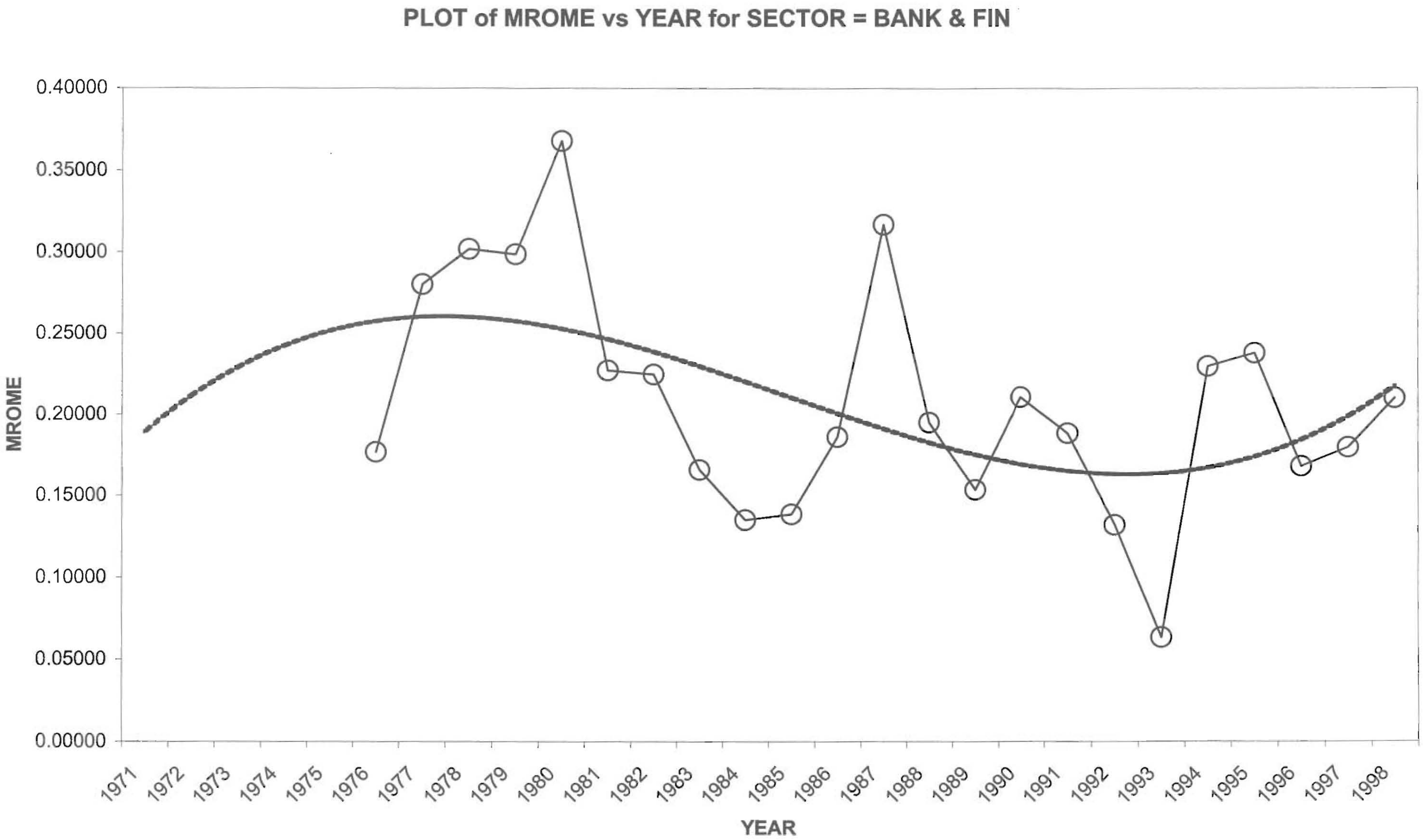

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APPENDIX D

UNIVERSITEIT VAN PRETORIA
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The GLM Procedure

Dependent Variable: ROME

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	11.1398937	2.2279787	40.55	<.0001
Error	3885	213.4701165	0.0549473		
Corrected Total	3890	224.6100103			

R-Square	Coeff Var	Root MSE	ROME Mean
0.049597	124.0333	0.234408	0.188988

Source	DF	Type I SS	Mean Square	F Value	Pr > F
SECTOR	5	11.13989373	2.22797875	40.55	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
SECTOR	5	11.13989373	2.22797875	40.55	<.0001

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The GLM Procedure
Least Squares Means

SECTOR	ROME LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
1	0.15128471	0.00592727	<.0001	1
2	0.23529336	0.01020131	<.0001	2
3	0.28519451	0.00933905	<.0001	3
4	0.22069670	0.01525868	<.0001	4
5	0.13741159	0.00922982	<.0001	5
6	0.18792267	0.01381264	<.0001	6

Least Squares Means for effect SECTOR
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: ROME

i/j	1	2	3	4	5	6
1		<.0001	<.0001	<.0001	0.2060	0.0148
2	<.0001		0.0003	0.4265	<.0001	0.0058
3	<.0001	0.0003		0.0003	<.0001	<.0001
4	<.0001	0.4265	0.0003		<.0001	0.1114
5	0.2060	<.0001	<.0001	<.0001		0.0024
6	0.0148	0.0058	<.0001	0.1114	0.0024	

NOTE: To ensure overall protection level, only probabilities associated with pre-planned comparisons should be used.

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