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**THE EFFECT OF THE IMPLEMENTATION OF LEAN
PRODUCTION PRINCIPLES ON THE FINANCIAL PERFORMANCE
OF A RAIL REFURBISHING PLANT OF A LARGE SOUTH
AFRICAN COMPANY**



Submitted by

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of the degree

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School of Management Studies
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DECLARATION

I, Allenby Charles Meiring, ID: 6606045009089, Student Number MRNALL002, hereby declare that the work contained in the dissertation titled "the effect of the implementation of Lean Production principles on the financial performance of a rail refurbishing plant of a large South African company", submitted for examination at The University of Cape Town, is original work researched and compiled by myself under guidance of Mr. Ian Hipkin of the Commerce Faculty.

Signed at Bloemfontein on the 10th October 2001.

A.C. Meiring

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ABSTRACT

The study emanated from the needs for (i) effective management systems in the currently changing South Africa, (ii) empirical, "real world" research in the operations management field as well as (iii) the requirement by local management to verify the effects of an implemented intervention. In terms of this background, the study investigates the effects of the implementation of Lean Production principles in a South African Government-owned Rail Refurbishing Plant with a Job production system on financial performance as measured by Return On Investment (ROI).

The research question formulated for the study investigates the possible differences in financial performance as measured by ROI between the Transwerk (Bloemfontein) Rail Refurbishing plant, which implemented Lean Production Principles, and three similar Transwerk Rail Refurbishing plants which had no Lean implementation initiatives.

The literature review discusses the constructs Lean Production and Return On Investment (ROI). Emphasis is placed on the elements and transferability of Lean Production, as well as the proven and potential effects of Lean Production principles on ROI. Despite cited criticism of Lean Production, the overall conclusion was reached (on the basis of case studies, research and postulations) that the implementation of Lean Production principles in a South African, Government owned, Rail Refurbishing plant with a job production system can improve ROI.

The research design (a case study) is reviewed next. Data sources are identified to be financial statements and questionnaires, while data collection methods are listed as the documentary approach and the survey approach. Sampling is non-random, and the generalisation of results is listed as a potential weakness of the study. The richness of in-depth descriptions of Lean Production principles as applied in the case study plant accompanied by descriptions of results and obstacles encountered, however, are listed as strong points of the study. A MANOVA is chosen as an appropriate statistical test to evaluate the collected data with $\alpha = 5\%$ to answer the research question of the study, while two χ^2 tests are performed to answer the secondary questions.

Various conclusions are made on the basis of results obtained from the statistical procedures:

- The ten Lean Practices considered most important by respondents for the success of Lean Production in the plant under investigation differ significantly from the practices considered most important by the literature and other researchers (see the first χ^2 test in the previous chapter). The Null hypothesis of the first test can thus not be rejected.
- A statistically significant proportion of Lean Practices could not be implemented in the plant under investigation. The Null hypothesis of the second test can thus not be rejected.
- Some of the practices referred to above could not be fully implemented due to restrictions brought about by the ownership and location of the plant under investigation, while other practices could not be implemented due to the industry and production system of the plant. In some instances practices were adapted to suit the environments under consideration.
- The balance of practices and elements not commented on above could be implemented. These include in-house lot size reduction, quality certificates from vendor et cetera.
- Various improvements were, however, reflected by items on the Income Statement and Balance Sheet of the plant under investigation – including improvements in ROI. The significant differences in ROI between similar plants over a period of time lead to the rejection of the Null Hypothesis for the third subquestion – i.e. the ROI of the plant with Lean Practices was better than that of plants without lean practices.

Based on the above findings, it is concluded that the application of Lean Production Principles to the South-African Government-owned Rail Refurbisher with a Job production system under investigation resulted in improved financial performance as measured by ROI.

Various recommendations are made:

- ◆ Recommendations based on literature issues focus on further investigation of workforce flexibility in jobshops, layout criteria for jobshops and possible MRP-kanban interfaces.
- ◆ Recommendations based on issues identified in the case study plant include suggested analyses of specific reasons for decreases in Stock, WIP and fixed

cost. Other suggestions focus on the feasibility of JIT purchasing in South Africa, the specific effect of labour relations in South Africa on Lean Production, and research on production in Rail environments.

- ◆ Recommendations based on limitations of the study include suggested surveys of South African Lean companies and South African Rail Refurbishers. A follow-up study is suggested to investigate medium term results of Lean practices in the plant under investigation. Studies regarding underlying reasons for the importance associated with individual practices by respondents are suggested.

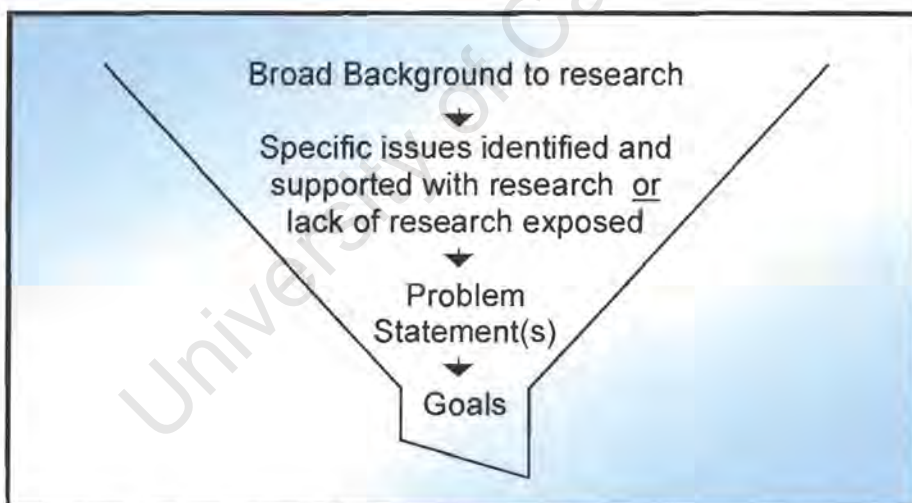
University of Cape Town

1. Problem Statement and Research Goals

1.1 Introduction

In this introductory chapter, a *funnelled approach* will be used to create the necessary background regarding the research question:

FIGURE 1.1
A “FUNNEL” APPROACH TO THE DESCRIPTION OF THE RESEARCH PROBLEM



A broad background to the research project proposal will be provided, and specific problems will be identified for research purposes. The need for research will be motivated by reference to supporting research or alternatively a lack of published research indicating a need for research in a particular area(s). The Chapter will be concluded with a short overview of the rest of the document (Jooste, Marx, Strydom & Van der Walt, 1996; Smit, 1991).

1.2 Broad perspective on the problem

1.2.1 Background

The changes brought about by the political transformation in South Africa since 1991 can be described as rapid, if not traumatic to the population of the country. More so are the effects of the *new struggle* for economic empowerment of millions of jobless and impoverished citizens. There is a need for everyday necessities that became associated with life in developed countries over many years - but they need them immediately! There is a demand for jobs, houses, medical services, education and food. However, the South African economy is not large enough and is not growing at an adequate rate to provide these items at the rate they are required. The only immediate solution seems to be government intervention (Christie, Lessem & Mbigi, 1993; Dornbusch & Fischer, 1998; Fourie & Mohr, 1997).

The newly elected ANC government consequently introduced its Growth, Employment and Redistribution (GEAR) strategy in 1996, with projections for economic growth in the period 1996-2000 projected to be in excess of 3% per annum. Privatisation was announced to be an important aspect of the GEAR strategy, and the process commenced in 1996 with the sale of minority stakes in domestic airline Sun Air and six SABC radio stations for R 516 million (Craig, 1998; Masithela & Van Huyssteen, 2001; Ryan, 1998; Van Huyssteen, 2001; Wackernagel, 1997).

The economic benefits of privatisation were however never more visibly demonstrated than when government banked the R 5.6 billion cheque from the sale of 30% of state-owned telecommunications operator Telkom to SBC and Telekom Malaysia. At the stroke of a pen, foreign reserves grew by a quarter, providing the cushion required to relax foreign exchange controls in July 1997. It has also been argued that the burgeoning foreign reserve account spooked currency speculators who might otherwise have attempted an Asian-style assault on the rand in late 1997 (Ryan, 1998).

Emboldened by the obvious success of the Telkom partial privatisation, the South African government planned a similar divestiture from 1998 onwards of other state-owned enterprises. A detailed analysis of all state-owned enterprises is well underway and work

has commenced on the restructuring of the subsidiaries at Transnet, the state-owned transport group (Ryan, 1998).

Although government is keen to privatise more assets, the problem is that the largest state owned companies will not fetch anything like that which government would like to achieve until their financial performance improves. A case in point is that Transnet, which embarked on a process of commercialisation to reduce its staggering debt burden and improve financial performance, is still (after nine years) a long way off the mark (Bidoli & Haffajee, 2000; Ryan, 1998).

Sikhakane (1998) however concludes that Transnet was beginning to “turn the corner” during 1998. One area in which Transnet showed a marked improvement since then was the group’s ability to generate cash. The success is attributed to greater focus on the management of working capital - encompassing more efficient credit control and stock reduction by the introduction of a *just-in-time* management concept (Bidoli & Haffajee, 2000; Sikhakane, 1998). In fact, by 1 December 2000, Transnet declared a dividend of R 1.8 billion after increasing profit from operations from R 1.1 billion in 1999 to R 3.3 billion in 2000 (Mkwanazi & Serobe, 2000).

Based on the Transnet *just-in-time* (JIT) management strategy, the local management of the Transwerk Coach Refurbishing Plant at Bloemfontein decided to implement broader Lean production principles to improve the financial performance of the plant, with emphasis on Return On Investment (or ROI). This measure of financial performance is currently used as one of a few critical factors to assess long term viability of plants in Transwerk (Greef, Malek, Meiring, Meiring & Van Loggerenberg, 1999).

- **Lean production:** Lean production is an expansion of the basic JIT philosophy. Lean production is “lean” because it uses less of everything (for example human effort, manufacturing space and engineering effort for product development) to produce more output than the competition. It requires lower inventory levels and provides fewer defects and a greater variety of products (Adendorf & De Wit, 1997).
- **Transwerk:** The figure below portrays the Divisions, Business Units, Service Centres and Subsidiaries of Transnet. Transwerk is a business unit of Transnet, and

consists of various product-focused businesses. The *Transwerk Coach Refurbishing Plant at Bloemfontein* is part of the Coach Business, one of the product-focused businesses of Transwerk (Hefers, 1992; Du Plessis, 1999).

TABLE 1.1
THE STRUCTURAL COMPOSITION OF TRANSNET LTD.

CLASSIFICATION	NAME	FOCUS
Divisions are transport operators representing Transnet's main areas of activity	<ul style="list-style-type: none"> • Spoornet • Portnet • Petronet • Autonet • South African Airways 	<ul style="list-style-type: none"> • Rail Transport • Harbours • Fuel pipelines • Road Transport • Airline
Business Units perform specialised functions in support of the transport operators	<ul style="list-style-type: none"> • Transwerk • Protekon • Connex • Transtel • Propnet 	<ul style="list-style-type: none"> • Rail Refurbishment and Manufacturing • Civil Engineering • Travel Agency • Internal Telephone Network • Property Portfolio Development
Service Centres offer support services to all Divisions, Business Units and employees	<ul style="list-style-type: none"> • Pensions • Housing • Transmed • Esselenpark Training College • Datavia • Promat 	<ul style="list-style-type: none"> • Pension Fund • Employee Housing Benefits • Medical Aid Scheme • Training and Development of Employees and the Community • Information Technology • Purchasing and Materials Handling
Subsidiaries represent separately registered companies owned by Transnet (Hefers, 1992)	<ul style="list-style-type: none"> • Transhold Properties • Viamax Logistics • V&A Waterfront • Transtrade • Preservation • Chemical Services 	<ul style="list-style-type: none"> • Transport Property Development • Transport Logistics • Property Development, Cape Town • International Marketing • Transnet Historical Heritage • Environmental Policy and Consultancy

(Hefers, 1992)

Due to

- the specific nature of the operations in a Rail refurbishing environment
- as well as the restrictions of the extensive rules and policy guidelines associated with large organisations,

- coupled with recent changes in Labour Law,

some elements of Lean production could either not be implemented, or were modified to suit the environment of the Transwerk Coach Refurbishing plant at Bloemfontein. As a result, questions regarding the effectiveness of the partially implemented, modified Lean Production system at the plant arose, and the need to validate the effect of the system on financial performance was expressed.

The need to validate the effect of Lean production principles on the financial performance of the Bloemfontein plant was underlined after changes in financial performance of the Bloemfontein plant over a number of months was observed. Plant management needed to establish whether the changes in financial performance were as a result of (a) an unidentified systematic variable across all Coach Refurbishing plants (e.g. price increases), or (b) the result of the Lean Production principles modified for implementation at the plant (Greef et al, 1999).

Within the context of the need to determine the effect of Lean production principles on the financial performance of the Transwerk Coach Refurbishing plant at Bloemfontein, the research question below was formulated according to the guidelines provided by Kerlinger (1964).

FIGURE 1.2

A COACH UNDER REPAIR AT THE TRANSWERK PLANT IN BLOEMFONTEIN



Photograph: the researcher

1.2.2 Research Question

Against the background of the conditions outlined above, the following research question was formulated:

Did the implementation of Lean Production Principles in a South-African Government-owned Rail Refurbishing Plant with a Job production system result in better financial performance (as measured in ROI)?

This question was subdivided into three sub questions:

- i. To what extent is it possible to apply Lean Production Principles to a South-African Government Enterprise?
- ii. To what extent is it possible to apply Lean Production Principles to a Job production system?
- iii. Did the application of Lean Production Principles to a South-African Government-owned Refurbisher with a Job production system result in improved financial performance?

1.2.3 The rationale for each sub problem

Smit (1991) states that a rationale and specification must be provided for each sub problem. The rationale for each sub problem, accompanied by supportive literature is provided accordingly in the following paragraphs.

1.2.3.1 Sub problem 1: To what extent is it possible to apply Lean Production Principles to a South-African Government Enterprise?

The rationale for this problem is based on the conditions below:

- Results of a study conducted by Spencer and Guide (1995) indicate that a number of components are of critical importance for the success of Lean programmes. Omission or customisation of such components because of **ownership and location** could thus potentially influence the financial results of the Transwerk Coach Refurbishing plant at Bloemfontein, and could in this context be regarded as potential sources of secondary variance for the study. One way to control secondary variance is to describe and measure the effects of sources of such variance (Smit, 1991).
- Case study research enables researchers to study and describe unique circumstances (Smit, 1991). A study of the literature (Campbell, 1987; Dale and Regan, 1999; Dawson, 1989; Jacoby, 1993; Liker, 1997; Sikhakane, 1998) reveals that Lean Production principles are applied in **various countries** (including South Africa), and that these principles can be applied in enterprises with **Government** ties. However, no evidence could be found regarding the implementation of Lean Production principles at South African Government-owned enterprises. An

investigation into *the extent to which is it possible to apply Lean Production Principles to a South-African Government enterprise* would thus enable the researcher to contribute to the body of knowledge surrounding Lean Production theory by describing unique circumstances.

- Case studies can serve as a source of techniques for other practitioners and researchers. A description and analysis of Lean Production elements customised for the Transwerk Coach Refurbishing plant at Bloemfontein could (depending on the effects described) thus be used by practitioners for the implementation of Lean Production principles *in South African Government-owned enterprises* (Smit, 1991).
- Case studies can be used for hypothesis verification. The hypothesis that Lean Production principles can be applied to *any* type of operation (ownership is not qualified) located *anywhere* in the world can potentially be contradicted or confirmed by investigating sub question 1 (Adendorf and De Wit, 1997; Hendry, 1998; Jones, 1997; Schonberger, 1982; Smit, 1991).
- Data gathered to answer this sub question will be used to generate explanations for results obtained in the answering of sub question 3.

1.2.3.2 Sub problem 2: To what extent is it possible to apply Lean Production Principles to a Job production system?

The rationale for this problem is basically the same as the rationale for sub problem 1 above:

- Results of a study conducted by Guide and Spencer (1995) indicate that a number of components are of critical importance for the success of Lean programmes. Omission or customisation of such components because of *production system type* could thus potentially influence the financial results of the Transwerk Coach Refurbishing plant at Bloemfontein, and could in this context be regarded as potential sources of secondary variance for the study. One way to control secondary variance is to describe and measure the effects of sources of such variance (Smit, 1991).
- Case study research enables researchers to study and describe unique circumstances (Smit, 1991). A study of the literature (Campbell, 1987; Cronje, Du Toit, Mol & Van Reenen, 1997; Dale and Regan, 1999; Dawson, 1989; Jacoby, 1993; Liker, 1997; Sikhakane, 1998) reveals that Lean Production principles are

applied in *various production environments*. However, no direct evidence could be found regarding the implementation of Lean Production principles in a Rail Refurbishing *Jobbing* production environment. An investigation into *the extent to which it is possible to apply Lean Production Principles to a Rail Refurbishing Jobbing Production environment* would thus enable the researcher to contribute to the body of knowledge surrounding Lean Production theory by describing unique circumstances.

- Case studies can serve as sources of techniques for other practitioners and researchers. A description and analysis of Lean Production elements customised for the Transwerk Coach Refurbishing plant at Bloemfontein could (depending on the effects described) thus be used by practitioners for the implementation of Lean Production principles *in (Rail Refurbishing), Jobbing Production environments* (Smit, 1991).
- Case studies can be used for hypothesis verification. The hypothesis that Lean Production principles can be applied to *any type of operation* (production systems are not qualified) anywhere in the world can potentially be falsified or confirmed by investigating sub question 1 (Adendorf and De Wit, 1997; Hendry, 1998; Jones, 1997; Schonberger, 1982; Smit, 1991).
- Data gathered to answer this sub question will be used to generate explanations for results obtained in the answering of sub question 3.

1.2.3.3 Sub problem 3: Did the application of Lean Production Principles to a South-African Government-owned Refurbisher with a Job production system result in improved financial performance?

The rationale for this problem is based on the conditions summarised below:

- Rasch (in Liker, 1997) conducted a statistical analysis of data from 249 US based small suppliers of automotive component parts and looked at the aggregate relationship among various facets of lean manufacturing and performance outcomes. His results show convincingly that each of the major aspects of Lean is associated with improvements in performance. This research confirms the claims by Liker (1997) and Sikhakane (1998) that the success by Japanese automotive manufacturers like Toyota and the recent cash-based success of Transnet can be

directly attributed to the application of the major principles of Lean production (such as *just-in-time* management). Although these findings could indicate a possibility that changed ROI figures observed at the Transwerk Coach Refurbishing plant at Bloemfontein could be the result of the implementation of Lean Production principles, it should be noted that information provided by Liker (1997) regarding ownership, location and production systems of the companies involved was insufficient to make a definite conclusion.

- Case study research enables researchers to study and describe unique circumstances (Smit, 1991). A study of the literature (Campbell, 1987; Cronje, Du Toit, Mol & Van Reenen, 1997; Dale and Regan, 1999; Dawson, 1989; Jacoby, 1993; Liker, 1997; Sikhakane, 1998) reveals several potential outcomes of Lean Production. None of the sources, however, contain an investigation into the changes in ROI as a result of Lean Production implementation. An investigation into *the changes in ROI as a result of the implementation of Lean Production principles* would thus enable the researcher to contribute to the body of knowledge surrounding Lean Production theory by describing unique circumstances.
- The answering of this sub question will provide the local Management of the Transwerk Coach Refurbishing plant at Bloemfontein with an evaluation regarding the changes in ROI as a possible result of the implementation of Lean Production principles

1.2.4 Research Goals

The following goals were identified for this research project:

1.2.4.1 Primary Goal

The primary goal of the study is to answer the research question as formulated in the previous paragraph, i.e.:

Did the implementation of Lean Production Principles in a South-African Government-owned Rail Refurbishing Plant with a Job production system result in better financial performance (as measured in ROI)?

1.2.4.2 Secondary Goals

Various secondary Goals were formulated:

- The description of unique problems, solutions, events and outcomes associated with the implementation of Lean Management principles in a South-African Government-owned enterprise with a Job production system to allow other researchers to understand the processes and environment.
- The description of unique problems, solutions, events and outcomes associated with the implementation of Lean Management principles in a South-African Government-owned enterprise with a Job production system to generate possible explanations for results obtained in the analysis of changes in ROI in Chapter 5.
- To report the observed effects of specific aspects of Lean Management on individual items in Financial statements of the plant under investigation to indicate possible needs for new research.

The research design (including data collection, analysis and interpretation) and the demarcation of the sample-entities used in this investigation will be described in more detail in Chapter 4.

1.3 Conclusion

In this chapter background information and circumstances leading to the research question were provided. The actuality and importance of the question were highlighted, and together with the tentative finding that insufficient research regarding Lean systems in South-African Government-owned Rail enterprises could be found, the conclusion was made that a research project in this sphere is necessary and of potential utility for managers in similar concerns.

In the next section, the independent variable of the study (i.e. Lean Production Systems) will be reviewed critically, while the following chapter will focus on the dependant variable (Financial performance). Relevant studies and documented Cases will be presented on a continuous basis to demonstrate the relevance and feasibility of this project.

2. Lean Production

2.1 Introduction

A literature review of the construct "Lean Production" is provided in this chapter. This review will form the basis for discussions regarding the extent to which Lean Production principles can be applied in Job Production environments, Rail environments, the South African environment and in Government Enterprise environments presented in chapter 3.

The literature review and description of Lean Production Practices in this chapter will be followed by an overview of critical comments regarding Lean Production as well as an overview of supportive research. The chapter concludes with a brief discussion on the preceding views and findings.

2.2 Lean Production Principles: an overview

2.2.1 Introduction

According to Storhagen (1995) the great progress of Japanese industry since the Second World War has been well noted. Expressed in production per man-hour the growth of Japanese productivity since the end of the 1950's has been almost three times that of the Western world. Furthermore, products from Japan generally show better quality and prove to be more reliable compared to products from other countries.

As the West woke up with a jolt to the remarkable performance of many Japanese manufacturers, Japanese management practices became the Holy Grail for many industrialists. Manufacturing methods excited particular interest and, during the 1980's, wide-scale implementations of practices such as just-in-time production, total quality control and team-based work organisation, were widely reported (Delbridge, Lowe and Oliver, 1998; Storhagen, 1995).

Delbridge et al. (1998) state that the strong Japanese identity of many of these practices ensured that issues of the feasibility and desirability of the transfer of these practices attracted widespread debate about the "Japanization" phenomenon. This debate has a number of strands to it. These include:

- Questions about the reality and coherence of "Japanese" management principles in Japan itself; the universality (or cultural specificity) of Japanese methods, and the implications of this for transfer to other contexts;
- Questions about the adoption of Japanese methods outside Japan and the impact of the methods on the various actors involved in the production process (such as workers, unions, supplier etc.)
- Leanness as a concept itself is questioned. A distinction should (according to critics of the system for example Bartezzaghi, 1999 and Stewart, 1998) be made between different types and forms of redundancy within an organisation. The emphasis in the Lean model represents a shift in functional redundancy from predominantly material (e.g. inventory) to essentially organisational (quality of people etc.)
- The changes in the competitive climate in Japan (after the crisis of the so-called bubble economy) demand a revision of Japanese production models
- Some critics claim that Lean Production has been surpassed
- Some Japanese academics suggest that the Lean system strategy should be adapted by "putting a little fat" on Lean Production, thus making it "unlean"
- The Lean Production approach to human organisation is considered by some as managerial strategy aimed at stripping labour out of production, controlling trade unions and undermining employee autonomy
- The kanban system could be a demon to vendors
(Bartezzaghi, 1999; Delbridge, Lowe and Oliver, 1998; Monden, 1998; Stewart, 1998).

The primary purpose of this research project is to investigate the effect of Lean Production principles on a given financial variable in a specific environment. Therefore:

- no efforts will be made to get involved in a *theoretical discussion* of issues in the broad "Japanization" debate from which most of the critical comments above were quoted
- no efforts will be made to validate Lean Production as a *globally applied system*.

Recent research regarding the *benefits* obtained and *limitations* encountered by employing the elements of Lean Production is, however, presented below. These results will be utilised for triangulation purposes (see the discussion under “Research Design” in chapter 5) as well as for the generation of explanations for results obtained during this study in chapter 6.

In the paragraphs below an overview of the Lean Production approach is provided, followed by a description and critical evaluation of practices associated with the approach.

2.2.2 Overview of the Lean Production approach

The Toyota production system arose from various efforts of the Japanese motor industry to catch up with the West after World War II, without the benefit of funds or splendid facilities. One of the most important goals of these efforts was increased productivity and reduced costs. To achieve this, emphasis was put on the notion of eliminating all kinds of unnecessary functions or *waste* in factories (Delbridge et al., 1998; Jones & Womack, 1997; Monden, 1998). Various kinds of waste were identified in the Toyota Production System and the Canon Production System, for example (Campbell & Dyer, 1987; Monden, 1994):

- excessive production resources (including workforce and facilities)
- overproduction
- more inventory than needed
- unnecessary capital investment

Several practices, such as the JIT (Just-in-time) approach to inventory management, were consequently introduced on a trial-and-error basis to reduce the wastes identified. The overall system of *Lean Production* is currently based on the application of these practices by all participants involved in the production sequence. Within every step of manufacturing, the production sequence can be viewed as a system of three major participants:

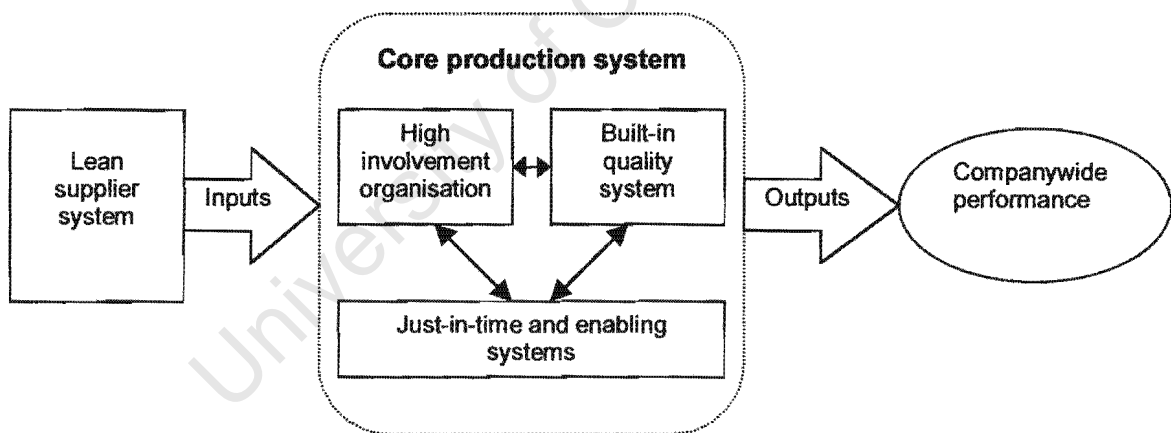
- suppliers
- the core production system
- customers

Within this context, the core production system is broken down into the following three components:

- material handling and transformation system
- quality system
- human organisation

Figure 2.1 represents the Lean Production process from a systems perspective, as proposed by Liker (1997). The double arrows connecting high involvement organisation, the built-in quality system and JIT and enabling systems suggest an interaction among the parts of the system. The general subsystems described in the figure are broken down into more specific sets of observable practices to serve as a basis for the discussion of individual elements of Lean Production.

FIGURE 2.1
LEAN PRODUCTION SYSTEM



(Source: Liker, 1997: 106)

2.2.3 The Core Production system

According to Liker (1997) the core production practices of any production system usually consist of the above mentioned three subsystems. The core practices of the Lean Production system and its subsystems are discussed below.

2.2.3.1 Material handling and transformation system

2.2.3.1.1 Elements of the Material handling and transformation subsystem in Lean Production systems

The material handling and transformation system of Lean Production is based on Just-in-time (JIT) Production and Autonomation. Just in time (as described earlier) basically means producing the necessary units in the necessary quantities at the necessary time. Autonomation or “Jidoka” may be loosely interpreted as autonomous defect control. It supports JIT by never allowing defective units from a preceding process to flow into and disrupt a subsequent process (Jones & Womack, 1997; Liker, 1997; Monden, 1998).

The following systems and methods were established to realise these concepts:

- At the core of JIT is the **Kanban**, a tag-like card on which the type and quantity of units needed are written and sent from workers of one process to workers of the preceding process. As a result, many processes in a plant are connected to each other. This connecting of processes in a factory allows for better control of quantities needed for various products. With the aid of the Kanban system, control of the production of the necessary products in the necessary quantities at the necessary time in every process of a factory and also among companies is achieved (Adendorf & De Wit, 1997; Gaither, 1990; Monden, 1998).
- **Smoothing** of the total production quantity in Lean Production is done to minimise variance in total outputs between two sequential periods. In short, the goal of production smoothing is to produce the same number of products every period – usually every day (Liker, 1997; Monden, 1998).
- Reduction in machine **set-up time** is required to accomplish the ideal lot size of one unit. In implementing JIT practices, machines have to be set up frequently for producing smaller lot sizes. Simplified and standardised set-up procedures must be developed (Meredith & Zhu, 1995). Through **small-lot production**, the production lead-time of various kinds of products can be shortened, and the company can adapt to customer orders and demand changes very promptly. From this viewpoint, too, the inventory of finished and intermediate products can be reduced (Liker, 1997; Monden, 1998).
- In Lean Production, machines are arranged in a **group technology layout** to smooth the production flow in contrast with the traditional process layout. In such a

layout dissimilar machines are grouped into work centres to work on products that have similar shapes and processing requirements. A single worker handles these machines one by one, and work at each process will proceed only when the worker completes his given jobs within a specified cycle time. Such production is called *one-piece flow* production and conveyance (Aquilano & Chase, 1989; Liker, 1997; Monden, 1998).

- **Standard operations** are aimed at the utilisation of a minimum number of workers for production on the basis of the achievement of three main goals: (i) high productivity through strenuous work (ii) line balancing among all processes in terms of production timing (iii) the minimum quantity work-in-process. To attain these three goals, standard operations are designed to consist of cycle time, standard operations routine, and standard quantity work-in-process. Standard operations are typically determined by the determination of above elements. Once standard operations sheets are ready, workers are thoroughly trained to perform the operations exactly according to the specifications on the sheet. The supervisor, who observes workers firsthand, ensures continuous adherence to the standard operations sheet. If standards are not being kept, he instructs the workers immediately in the proper instructions. If it is found that standards themselves are faulty, they are revised promptly (Gaither, 1990; Liker, 1997; Monden, 1998).
- Gaither (1990) defines **Preventive Maintenance** as inspections of buildings and all pieces of equipment. Machine adjustments, lubrication, cleaning, parts replacement, painting and any needed repairs or overhauls are done. These activities are performed *before* machines malfunction. Preventive maintenance is emphasised in Lean Production to ensure that a continuous workflow is not interrupted by machine downtime or as a result of poor quality from malfunctioning equipment. Much of this maintenance is carried out by operators, since they are responsible for the quality of products coming off the machine, and also because of their sensitivity to idiosyncrasies of the machine as a result of working on it day in and day out. Finally, the fact that the JIT philosophy favours many simple machines rather than a few complex ones enables the operator to handle routine maintenance activities (Aquilano & Chase, 1989).

2.2.3.1.2 Research on the Material handling and transformation subsystem in Lean Production systems

Various attempts have been made over the last two decades to validate the various elements or combinations of elements of the material handling and transformation system of Lean Production, as described above. More recent research is summarised below:

- Atwater and Chakravorty (1996) found in a comparative study that production lines designed according to the Theory of Constraints¹ performed better than traditionally balanced lines and lines designed according to JIT principles under high system variability and with low inventory. However, when inventory is added to the system, JIT-designed lines perform significantly better than other designs.
- Fazel (1997) determined an indifference point for annual demand at which Economic Order Quantity and JIT purchasing costs are equal. For demand levels above this point Economic Order Quantity purchasing is cheaper, while JIT purchasing is cheaper below the point. Results also indicated that JIT is the superior system for inventory items with higher prices, holding costs or ordering cost.
- Kadipas, Kadipasog, Khumawala and Peixoto (1999) found the following differences between organisations applying Lean practices and companies not applying Lean practices in an extensive survey of manufacturers in 13 countries:
 - The manufacturing units implementing JIT and TQM strategies had significant increases in quality and productivity levels, employee involvement, management commitment, suppliers' participation, and reduction in costs when compared to manufacturing units not implementing such strategies.
 - The manufacturing units implementing JIT and TQM strategies observe increased productivity level when compared to manufacturing units implementing only TQM strategies. The difference in productivity level improvements can be attributed to JIT core production strategies.
 - Results indicate that companies that implemented Lean practices observed significant improvements in quality and productivity without changing the production lot size. Specifically, companies observed significant improvements in lead time, delivery cycles and rejection rates. A substantial reduction in stocks of

¹ The Theory of Constraints basically proposes that, by focusing on its constraints and using simple and practical solutions, any organisation can realise similarly rapid improvements (Atwater & Chakravorty, 1996).

finished goods and WIP as well as a reduction in set-up time were also reported. These positive results are attributed to the use of work-cell concepts such as uniform workload, *kanban*, and group technology principles, which are very important for the successful implementation of Lean practices.

- Inventory cost, unit product cost, inspection cost and administrative cost have been indicated to reduce significantly after the implementation of Lean Production practices. Increase in in-bound cost may be associated with small and frequent deliveries. On the other hand, a substantial decrease in scrap/rework costs is directly related to a definite improvement in overall quality.
- Another interesting observation was made regarding access to and use of computer resources in purchasing and inventory management. This seems to indicate that computer technology is becoming more accessible and is being recognised as an important tool. Furthermore, based on the summary results, JIT companies seem to have an edge over the rest in the use of various computer tools.
- Das and Handfield (1997) conducted Case Study research regarding the effectiveness of JIT sourcing. They found significant differences in various performance areas in the favour of companies using JIT sourcing over companies not using JIT sourcing.:
 - JIT supplied firms derive the benefits of more frequent deliveries, smaller lot sizes and lower on-hand inventory levels compared to non-JIT firms
 - The researchers ascribe these benefits, in part, to the increased quality and degree of information sharing, trust and greater frequency of plant visits by buying manufacturing personnel among JIT firms relative to non-JIT firms.
- Bardi, Tan, Tracey and Vonderembse (1995) established empirically in a survey targeting 2000 US Purchasing Managers that JIT acts as a positive influence on the purchasing function

2.2.3.2 Quality system

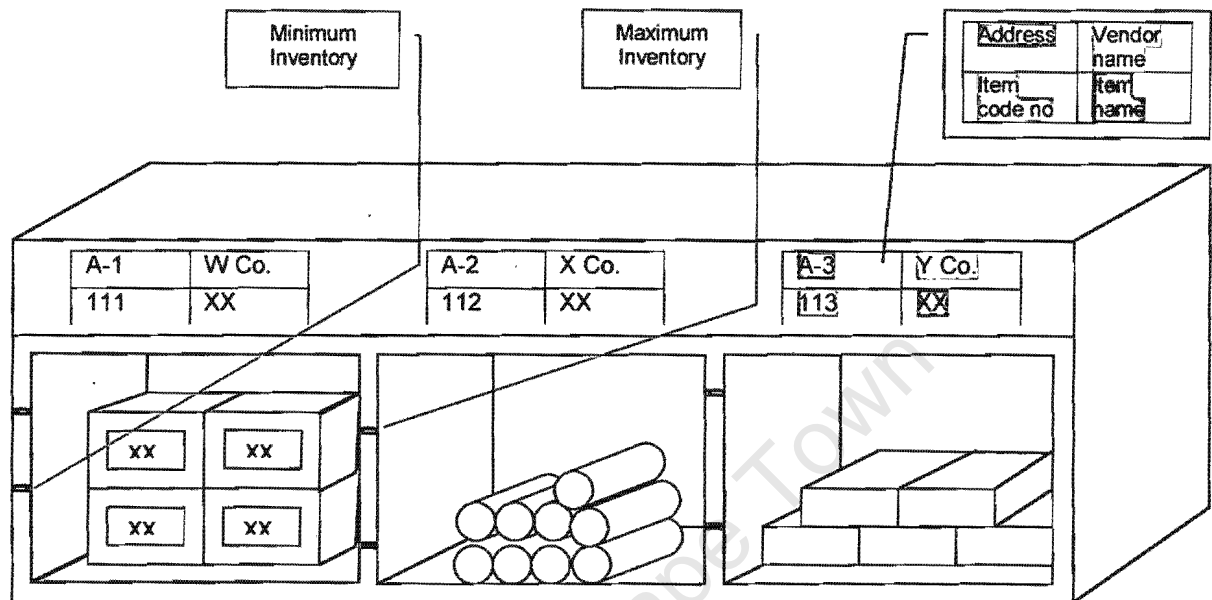
2.2.3.2.1 Elements of the Quality subsystem in Lean Production systems

Liker (1997) states that the quality system of Lean Production focuses on “building-in” quality rather than “inspecting-in” quality. The latter philosophy is based on improvement activities, the 5S system and autonomous defect control (Liker, 1997):

- Lean Production systems attempt to increase productivity and reduce manufacturing costs by initiating positive **improvement activities** at every workplace through small groups called **quality control circles**. The improvements are varied, and include *improvements of manual operations, reduction of the workforce, improvements in machinery, showing respect for Humanity (by giving workers meaningful jobs), suggestion systems and improvements via the kanban system.*
- **Kaizen, or "5S"** is a method used to eliminate the hidden slack in plants. 5S represent the Japanese words:
 - Seiri (to clearly distinguish between necessary items from unnecessary items and abandon the latter)
 - Seiton (to neatly arrange and identify items for ease of use)
 - Seiso (to always clean up; to maintain tidiness and cleanliness)
 - Seiketsu (to constantly maintain the 3S mentioned above)
 - Shitsuke (to ensure that workers make a habit of always conforming to rules)

Collectively these define a cleanup activity in the workplace. By implementing 5S, the levels of quality, lead-time, and cost reduction can be improved. These are the three main goals of production management in most Lean systems. Visual control of waste is essential for the establishment and maintenance of the consciousness amongst all employees to eliminate hidden wastes. A typical example of the visual control exercised in Seiton is the method to indicate maximum (lot size) and minimum (re-order point) quantities of inventories as depicted in figure 2.2.

FIGURE 2.2
INDICATION OF MAXIMUM AND MINIMUM QUANTITIES OF
INVENTORIES IN SHELVES



(Monden, 1998: 207)

- **Autonomous Defects Control** is an indispensable element of Lean Production, since continuous flow of production (synchronisation) is not possible without effective and efficient quality control. The evolution of the *Lean approach to quality control* evolved in *Japan* from inspection by independent inspectors and statistical sampling, to self-inspection by operators of all units produced, to company-wide quality control.

2.2.3.2.2 Research on the Quality subsystem in Lean Production systems

As in the case of the material handling and transformation system, elements of the Quality system of Lean Production were investigated continuously since the West noted the success of this production approach. Some recent research initiatives are given below:

- Kadipas et al. (1999) noted (in an extensive survey of manufacturers in 13 countries) the following differences between companies employing Lean practices and those companies not employing Lean practices:
 - The manufacturing units implementing JIT and quality related Lean strategies have increased quality standards when compared to manufacturing units

implementing only JIT strategies. The difference in quality standards improvements can be attributed to quality strategies.

- Multi-functional employees, quick implementation of an employee's suggestion on quality, production worker supports and recognition and awards were rated favourably, and contributed to significant improvements in quality and productivity. All these factors were attributed to the implementation of Lean quality strategies.
- Results from the analysis of the management-related section infer significance of quality strategies in the ultimate improvements in quality and productivity.
- Laszlo (1998) concluded from data obtained in a Case study of a Canadian manufacturer that ISO 9000 accreditation alone does not guarantee that companies desiring to compete globally will outperform competitors in product quality. ISO 9000 does however provide a foundation for the implementation of quality concepts used in world-class Lean Production systems.
- Min and Shin (1995) found that cost savings resulting from the line-stop strategy are greater than those using the off-line repair strategy.

2.2.3.3 Human Organisation in Lean Production

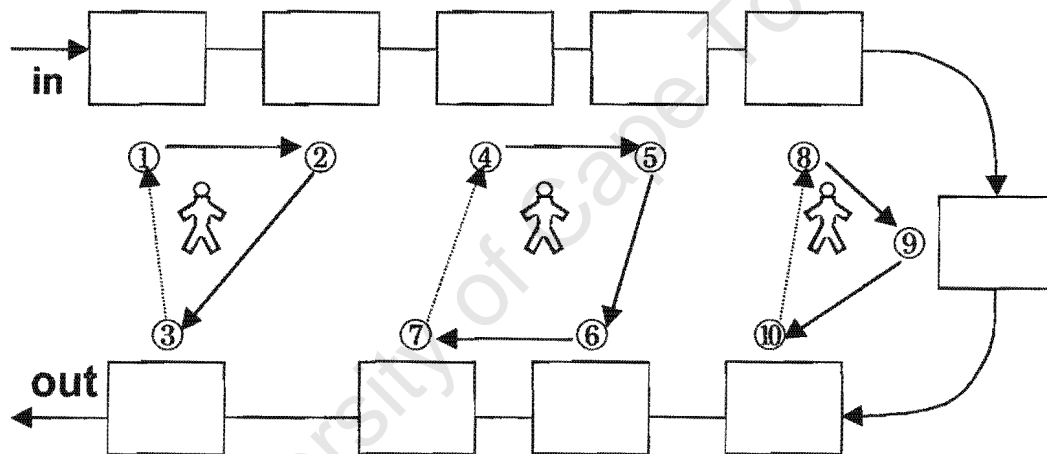
2.2.3.3.1 Elements of the Human Organisation subsystem in Lean Production systems

True to the primary goal of Lean Production (i.e. waste reduction), having a flexible workforce or "Shojinka" reduces waste in excessive workforce. Shojinka is attained by optimal application of ergonomics, multi-function or cross-trained workers and job rotation:

- The ***optimisation of ergonomics*** is essential for attaining a flexible workforce in Lean Production. The main focus of ergonomics in Lean Systems is the man-machine interaction, specifically around the placement of machines to operators to eliminate wasted motions e.g. excessive walking, thus improving workflow (see the paragraph "Improvement Activities" above for detail regarding value-added to non-value added work). Various machine-operator placement patterns or layouts (not to be confused with the earlier discussion of jobshops and flow systems!) may cause operators to waste motion and/or production time – even contribute to waste in Work-In-Process.

Planning the placement of machines in a U-turn layout eliminates the disadvantages of other types of layouts. Although the U-turn layout has several variations such as the concave and circle forms, the essence of the U-turn is that the entrance and exit of a line are at the same position. According to Monden (1998) the most remarkable and important advantage of this layout is the flexibility to increase or decrease the necessary number of workers when adapting to the changes in production quantities (changes in demand). This can be realised by adding or reducing the number of workers in the inner area of the U-shaped workplace (see figure 2.3 below).

FIGURE 2.3
U-FORM LAYOUT



(Source: Monden, 1998: 161)

The U-turn layout can be expanded to the linking of various processes to reduce time wastage at factory-level (Monden, 1998).

- **Workforce Flexibility** is attained through Multi-Function Workers. Although carefully designed machine layouts help develop flexibility in the workforce, the true meaning behind workforce flexibility is the ability to quickly alter the *number of workers* at each shop to adapt to changes in demand. This type of flexibility demands from an individual worker the ability to respond to changes in cycle time, operations routines, and in many cases, the duties of individual jobs. In order to meet these demands, workers must be trained to be skilled in many jobs and processes. A worker possessing many skills is called a Multi-function worker. Such workers are developed in various ways, but the *job rotation* technique used most frequently (Gaither, 1990;

Liker, 1997; Monden, 1998). Job rotation plans (like the one depicted in figure 2.4 directly below) is one tool used to achieve effective rotation:

FIGURE 2.4
JOB TRAINING PLAN SHEET

LINE NAME: <i>Line X</i>		YEAR: 1999								
PROCESSES WORKERS	1	2	3	4	5	6	7	8	9	
	A	○		○	●	●	●	●	●	○
B	○	●	●	○	○	○	○	○	○	
C	○	○	○	●	●	○	○	○	○	
D	●	○	●	○	○	○	○	○	○	
FOREMAN	●	●	●	●	●	●	●	●	●	

○ Planned to train ○ In training ● Trained

(Adapted from Monden, 1998)

2.2.3.3.2 Research on elements of the Human Organisation subsystem in Lean Production systems

Recent research initiatives focused on Human Organisation in Lean Production include:

- Boyer (1996) in a survey of 202 plants in the metalworking industries found that quality leadership on the part of management, small group problem solving, training and worker empowerment are all strongly correlated to managerial commitment.
- Brenner and Manders (1999) found in a comparative study that the shift to Lean production (with emphasis on sub-contracting) is causing an imbalance in income distribution. The strategy of large suppliers to concentrate production on core activities, leads to the redirection of work to highly remunerated (but decreasing)

employment in large enterprises and to poorly rewarded work in smaller subcontractors.

- Hutchinson, Kinnie and Purcell (1998) found that the downsizing associated with Lean Production is rarely "Lean", since it usually takes the form of quantitative changes in employment rather than in qualitative changes in the process of managing. Evidence also suggests that downsizing usually has an adverse effect on both employees who leave and those who remain with the organisation.
- Storhagen (1995) compared 52 Western and Japanese companies, and concluded that the implementation of Lean principles in the West has not achieved full potential, since the West has been using the wrong "set of tools" and that a reverse profile of competence is apparent. Where Western companies had strengths (structural factors), Japanese companies had weaknesses; where Japanese companies had strengths (process factors), Western companies had weaknesses. Storhagen (1995) concludes that an incorrect picture of what Lean Production really is about may have been a significant barrier to the success of Lean in the Western companies under investigation.
- Jackson, Mullarkey and Parker (1995) concluded that reductions in employee autonomy, increased production pressure and employee stress are not universal concomitants of Lean Production.

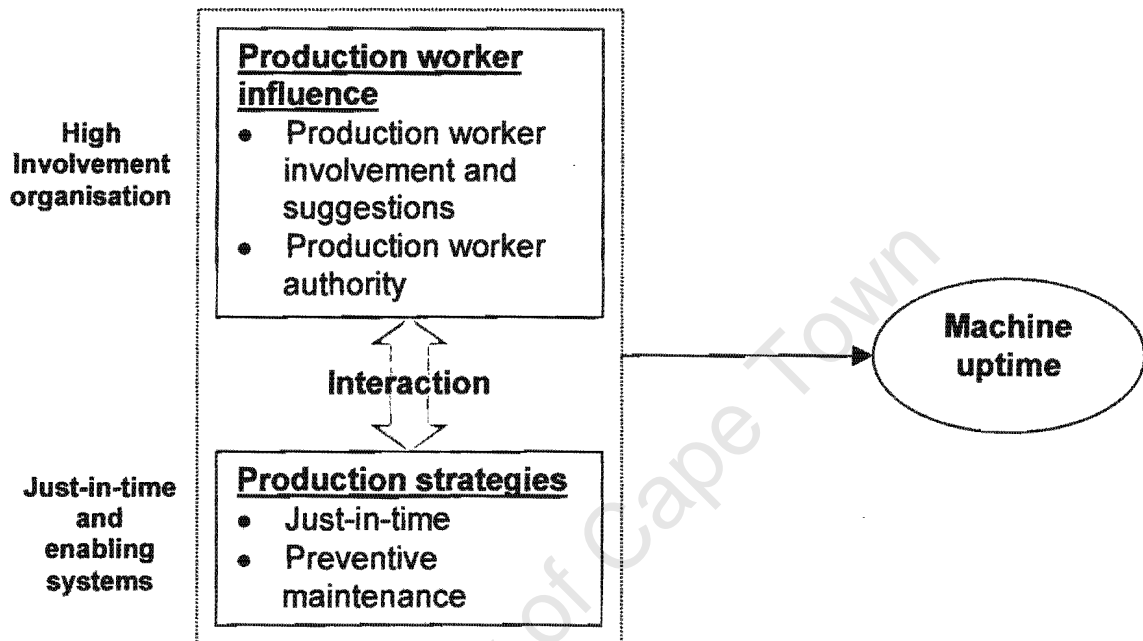
2.2.3.4 Interaction between the components of the Core Production System

2.2.3.4.1 Description of the interaction between the components of the Core Production System

Liker (1997) states that the interaction effect between two practices can be viewed as the *added benefit* gained from having the two practices working together. In line with systems thinking, this means that the total benefit obtained from having two practices working together is greater than the sum of the benefits of the practices working individually. The interaction between production worker influence and Lean Production strategies is of particular interest in that it illustrates the synergy that exists between human involvement and technology.

Figure 2.5 below highlights the interaction environment:

FIGURE 2.5
MODEL OF INTERACTIONS BETWEEN PRODUCTION WORKER
INFLUENCE AND PRODUCTION STRATEGIES



(Source: Liker, 1997)

2.2.3.4.2 Research on the interaction between the components of the Core Production System

Research on the Interaction between components of the Core Production system include:

- Kadipas et al. (1999) conducted an extensive survey of manufacturers in 13 countries to investigate differences between companies employing Lean practices and companies not employing Lean practices. The research results answered an important question: "Were there any significant differences between adopting only JIT or only TQM or both strategies simultaneously for a continual improvement in overall quality and productivity?" The researchers noted that for production-related practices, there was no significant difference between the firms that implemented only JIT and those that implemented both. For quality-, employee- and supplier-

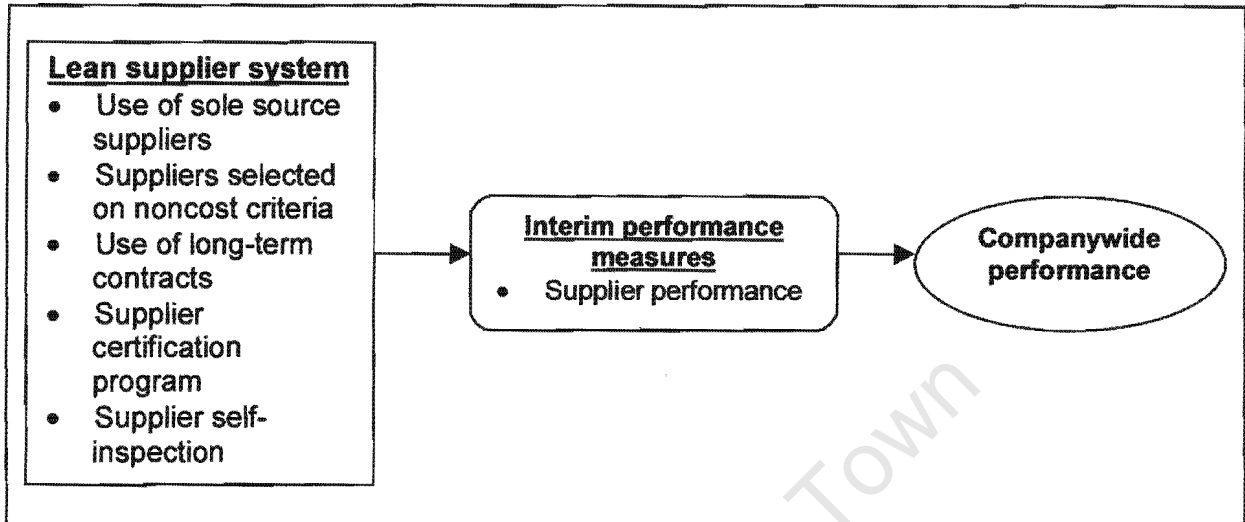
related practices, implementing only TQM or both made no difference. Management- and cost-related practices indicated no difference in any of the categories. This seems to indicate with respect to management- and quality-related practices, respondents were indifferent in identifying the actual source of these improvements. Adopting JIT or TQM or both programs showed significant differences (such as cost of manufacturing) in all the six manufacturing practices compared to the manufacturing firms not implementing any of these programs. The above discussion leads to an important conclusion that most production systems can benefit from certain aspects of JIT implementation without having TQM in place first, which is contrary to earlier findings. The results of the survey clearly indicate that factors identified under the production-related section can register significant improvements from the implementation of JIT even without TQM. The survey results also emphatically support that the remaining aspects as identified in the other five sections (employee, management, supplier, costs and quality) are found to be of significant value if a good TQM system is in place first, both at the company and at the supplier's end.

- Gupta and Sriparavastu (1997) found in a nation-wide survey of US companies that firms that use Lean Production principles such as JIT and a holistic quality approach reflect increased productivity and improved quality when compared to firms that did not implement the strategies.

2.2.4 The Lean Supplier system

In order for Lean Production to work efficiently, first-, second-, and third-tier suppliers must participate on an equal footing with company operations in the production flow. Much of the traditional oversight role of the company is transferred to the suppliers, and a system of mutual trust and respect is established. Typically, companies single-source orders and select suppliers on quality rather than cost criteria. Long-term contracts are established to ensure supplier dedication and commitment. Finally, suppliers are expected to maintain high quality standards commensurate with the company and inspect components before delivery. Consequently, decreased order lead times and low reject rates are indicators of supplier performance in Lean Production Systems. Figure 2.6 below represents such a Lean supplier system.

FIGURE 2.6
LEAN SUPPLIER SYSTEM SUBMODEL



(Source: Liker, 1997)

Elements of the system summarised above are discussed in the following paragraphs.

2.2.4.1 Supplier selection and certification

Lean enterprises commonly select sole suppliers on nonprice criteria, and establish mutual trust and respect with them. The criteria below are of critical importance when selecting sole suppliers to support JIT purchasing by Lean organisations (Badenhorst, Hugo & Van Rooyen, 1997; Lampbrecht & Stock, 1993; Meredith & Zhu, 1995):

- *Vendor lot size.* The willingness of the vendors to deliver small lots of raw materials and parts on a frequent basis is very important in implementation of the JIT purchasing practice.
- *Vendor lead-time.* Vendor lead-time is a key factor when selecting a vendor to establish a long-term co-producer relationship.
- *Quality certificates from vendor.* JIT emphasises quality starting at the source of supply. Unlike a traditional manufacturing system, JIT views inspection of incoming lots as an inefficient activity since it does not add value to products.
- *Vendor location.* In order to reduce the transportation cost associated with frequent small-lot deliveries, suppliers located in close proximity of a Lean organisation are chosen over distant suppliers.

- *Certified suppliers.* A JIT supplier is *certified* once it has been established, by means of an intensive investigation, that it supplies products or materials of constant high *quality* thus rendering routine inspections or tests of future consignments unnecessary.

Once a supplier supporting JIT practices of Lean organisations is chosen, a long-term contract is established. These contracts are usually characterised by

- Even, repetitive master production schedules
- Little paperwork
- Purchase orders which may specify overall quantities, although suppliers deliver on the basis of a *schedule* (see “Later Replenishment System” below) or on the basis of *daily production needs* (see “Sequenced Withdrawal” below)

(Lampbrecht & Stock, 1993).

2.2.4.2 Information provided to suppliers

Lean organisations must provide accurate information regularly to their suppliers to ensure optimum co-operation and performance. A point in case is that of Toyota. According to Monden (1998), Toyota provides two kinds of information to suppliers:

- the monthly production plan, and
- daily information which specifies the actual number of units to be supplied to the customer company, and may be in the form of a Kanban or a Sequence Schedule.

2.2.4.3 Withdrawal systems

- Lean enterprises may use various methods to withdraw the material ordered from suppliers. The Later Replenishment system (involving supplier kanban) and the Sequenced Withdrawal system (involving a material requirement schedule) are well-known systems in this regard (Monden, 1998).

2.2.4.4 Relationship with supplier

Meredith and Zhu (1995) underline the importance of good supplier relationships in a Lean Production environment. According to these authors, JIT production requires high quality, small lot sizes, and frequent delivery of raw materials. A good relationship with suppliers is crucial to achieve these requirements. For example, the Japanese make their vendors seem like the next level below the start of production.

Although numerous alternatives to foster supplier relations are possible, the following specific actions promote good relations with JIT suppliers (Badenhorst et al., 1997; Lampbrecht & Stock, 1993; Monden, 1998):

- complete and clear *communication* with the supplier on all aspects of products to be bought, including possible future changes
- mutual understanding of the *conditions and potential problems* arising out of JIT agreements
- mutual consideration and timeous communication of changes (e.g. in monthly production schedules)
- competitive bidding is limited to new parts suppliers
- buyer plants resist vertical integration and subsequent wipe-out of supplier business
- suppliers are encouraged to extend JIT to *their suppliers* to reap the benefits of Lean strategy themselves
- active use of analysis to enable desirable suppliers to become/stay price competitive
- minimal product specifications are imposed on suppliers
- suppliers are helped to meet quality requirements
- close co-operation between the quality departments of buyers and suppliers

2.2.4.5 Research on the Lean Supplier system

Research on Suppliers in Lean Systems include:

- Kadipas et al. (1999) conducted an extensive survey of manufacturers in 13 countries to investigate differences between companies employing Lean practices and companies not employing Lean practices. Results from the analysis of the supplier-related section are as follows: Long-term partnership relationship, supplier development, supplier performance, supplier certification, small frequent deliveries and blanket orders were rated to be substantially improved. A low score for periodic

review of supplier performance and inspection of incoming materials may be attributed to long-term partnership relationships with suppliers. The researchers considered the latter as an important aspect of successful implementation of JIT practices in Lean Production.

- Guide and Spencer (1995) conducted a survey among 250 members of the American Production and Inventory Control Society to establish the components viewed as important for the success of the JIT philosophy of Lean Production. They concluded that firms active in JIT practices do not view the purpose of JIT purchasing as an effort to push inventory to the stores of suppliers, thereby causing major financial problems to the latter.
- Frolick, Mehra and Ramarapu (1995) found in a survey that vendor/supplier participation is an element of critical importance for the success of Lean Production.
- Wafa and Yasin found in a survey (targeting 15 plants in the US mid-west region) that companies that recommend Lean practices such as JIT-rate communication and information exchange with suppliers as critically important for the success of Lean purchasing and inventory management. They also found that a lack of co-operation by suppliers in correctly supplying materials is considered a major cause of the failure of JIT purchasing.
- Meredith and Zhu (1995) concluded from survey results that Relationship with vendor, Vendor lot size, Vendor lead time, and Quality Certificates provided by vendors are considered as critical elements of Lean Production, while Sole sourcing is regarded as less important.

2.2.5 Customers in Lean Systems

As mentioned at the start of this chapter, Liker (1997) identified *Suppliers*, the *Core Production System* and the *Customer* as the major participants in production environments. The Core Production System and the Supplier system were handled in the previous sections. The interaction of the latter with the Customer system is described in the following paragraphs.

2.2.5.1 Takt time

According to Liker (1997) *takt time* is a critical element of Lean Production systems, originating in the Japanese automobile-manufacturing environment. *Takt* is the German

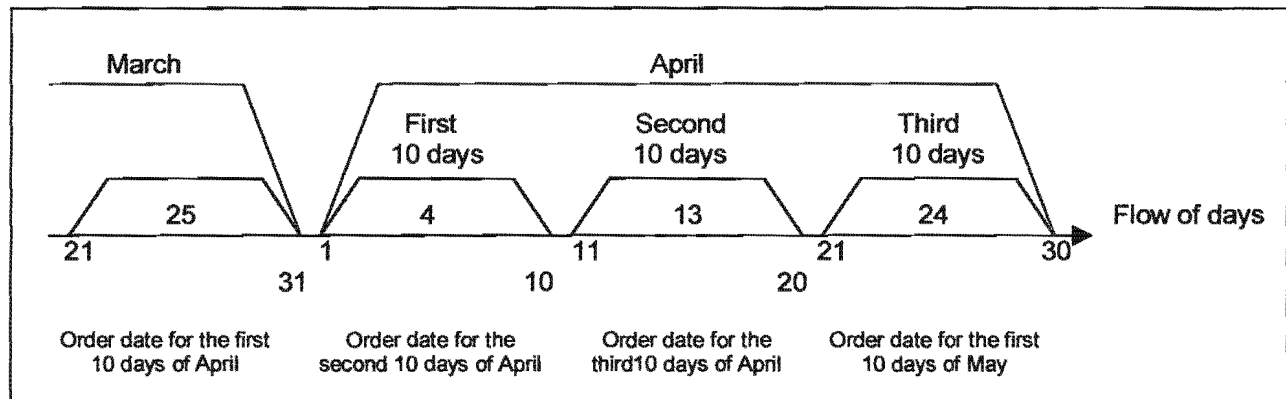
word for musical meter, which came to Japan in the 1930's whilst the Japanese were being taught aircraft production by German aerospace engineers. Takt time is the tool which links production to the customer by matching the pace of production to the pace of actual final sales. The way the concept is applied is that actual takt time is calculated for each product and part. The actual number of seconds required to produce each product and part is used to determine the number of seconds that should be allotted to each actual process in the entire production chain.

2.2.5.2 Information systems

The process of linking customer orders to production to part requirements is crucial for the effective management of Lean operations. This cannot be accomplished without an effective information system. The description of the information systems used in two Lean automotive manufacturers (Nissan and Toyota) by Monden (1998) demonstrates the synchronisation process of takt time selling and production clearly:

- The **Order Entry Information System** used by automotive manufacturers to plan production involves a two-step plan enabled by electronic communication:
 - A *monthly production schedule* and parts requirements forecast is compiled from sales plans submitted by domestic and foreign sales departments.
 - The *daily production system* is based on *product delivery schedule and sequence schedule* that is compiled from daily orders obtained from dealers. This process is depicted in figure 2.7 below.

**FIGURE 2.7
DAILY SALES AND PRODUCTION**



(Source: Monden, 1998)

- The *sequenced production schedule* determines the order of models to be assembled and is sent from the central computer to line-side printers. With this information, workers in the final assembly line know which type of vehicle they need to assemble.
- A dealer *on-line system* is used at the distribution stage to reduce the time lost in the ordering process and promptly respond to customer demands.
- The Information systems between automotive manufacturers and **Parts Manufacturers** involve various components, as described below:
 - The manufacturer distributes a *Parts Requirement Forecast Table* covering a three month period to its dealers. Information regarding actual parts supplied during the most recent month is provided together with a forecast for the two remaining months. In all likelihood, these estimates will be adjusted on a day to day basis by the utilisation of Kanban.
 - A *computer network system* exists between manufacturers and major *suppliers* to ensure accurate and immediate data exchange.
 - Parts Distribution Systems are comprehensive information networks enabling the dealers, manufacturing divisions and parts suppliers to respond to changes in market demand as whole synchronous organisations.

2.2.5.3 Research on Customers in Lean Systems

Austin and Peters (1995) found in a comparative study that Lean Production principles are usually implemented on the basis of economic considerations alone. Their experience with JIT led them to the conclusion that certain non-economic issues can arise, which affect the long-term profitability of the firm. They recommend that stakeholder theory must be used to ensure that customers are also considered.

2.3 Evaluation of Lean Production

The following observations can be made from the preceding paragraphs:

- Although more and more companies around the world are implementing Lean Production practices, extensive criticism regarding the *theory and concept* of Lean Production has been recorded over recent years (Ackroyd & Proctor, 1998,

Scarborough & Terry, 1998). Most of the published criticism encountered is however, not based on empirical research. For example:

- The objections offered by Stewart (1998) regarding the Japanization of Western industries are based on a literature review only
- Bartezzaghi (1999) uses a literature review to propose that Lean Production practices should make way for a new paradigm created by himself
- Some findings do not support *claims* made by Jones and Womack (1997), Lankford and Swanson (1998) Monden (1998) and Liker (1997) regarding the benefits of Lean Production. For example:
 - Total Quality concepts do not necessarily contribute to cost reduction
 - Production lines using Lean concepts do not necessarily perform better on delivery than other lines
 - Downsizing has an adverse effect on employees that leave a company as well as on the reduced workforce that remain in the company
- Research quoted above does however provide empirical support for *most* of the claims of Jones and Womack (1997), Lankford and Swanson (1998) Monden (1998) and Liker (1997) regarding the benefits obtained by employing Lean Production principles. For example:
 - Lean Production practices lead to improved productivity and better quality
 - Lean practices like Cellular layouts and JIT production lead to lower production costs
 - Good Supplier relations lead to co-operation and improvement of small frequent deliveries etc.
- It should be noted though, that many of the authors quoted above found that Lean principles are superior under *specific circumstances*, and not under *all* circumstances. For example:
 - Lines balanced according to JIT philosophy perform better than traditionally balanced lines and lines balanced to Theory of Constraints under conditions of system stability and sufficient inventory to ensure smooth running
 - JIT purchasing is superior in respect of items with higher prices, holding and carrying costs than EOQ purchasing
- Some practices were found to be more important for the success of Lean Production than others. For example:

- Relationship with vendor
- Vendor lot size
- Vendor lead time

These are considered as critical elements of Lean Production, while sole sourcing is regarded as less important.

2.4 Conclusion

Commonly found practices in Lean Production systems have been discussed in this chapter. Emphasis was placed on the application of these practices to the Toyota Motor Corporation in Japan, due to the fact that Lean Production, in its purest form, is manifested in this company (Delbridge et al., 1998).

The description of Lean practices was followed by the presentation of criticism as well as research supporting the benefits of Lean Production concepts, and the chapter concludes with a brief discussion on the research regarding Lean Production. During this discussion the conclusion was made that most of the claims regarding the benefits of Lean Production seem justified, because they could be supported by research results. Results, however, indicate that certain Lean Production practices are only beneficial under specific conditions.

The transferability of Lean Production practices to the environments that are the focus of the study is discussed in chapter 3.

3. The transferability of Lean Production

3.1 Introduction

A literature review of the construct “Lean Production” was provided in the preceding chapter. In this chapter, the transferability of Lean production to various environments will be investigated. The description of the environment(s) of the case study plant (Appendix A) is based on the framework provided in this chapter.

The specific environments, which were identified as factors influencing the application of Lean Production practices to the plant under investigation, include: Job production environments, Rail environments, the South African environment and Government Enterprise environments.

The discussions will include:

- descriptions of characteristics of the environments under discussion,
- research conducted and/or case studies regarding Lean Production in each environment

The chapter will be concluded by means of a summary of the application of Lean Production principles in the environments described in this study.

3.2 Issues in the implementation of Lean Production Practices

In the previous chapter, Delbridge et al. (1998) raised concerns regarding the transferability of Lean Production practices from Japanese companies to other environments. The discussion at the end of the chapter concluded that some Lean practices function well under specific conditions, while they fail under other conditions.

Based on these observations, a brief overview of implementation issues and factors critical for the success of Lean Production are provided in the subsequent paragraphs.

3.2.1 Lean Production elements

A study of the literature (Frolick et al., 1995; Guide & Spencer, 1995; Hendry, 1998; Mair, 1998; Meredith & Zhu, 1995; Wafa & Yasin, 1998) reveals an immense volume of contradictory data regarding the elements applicable to the implementation of Lean Production. Even the categorisation of these elements seems to be an area of disagreement.

The list of individual elements listed by Meredith and Zhu (1995) will be used as a starting point for the discussion of Lean Production elements. The list covers all major elements of Lean Production discussed in the previous chapter, as well as most of the elements identified and categorised by the other authors mentioned above. The list of elements proposed by Meredith and Zhu (1995) is presented in Table 3.1.

**TABLE 3.1
LEAN PRODUCTION ELEMENTS**

<input type="checkbox"/> Communication.	<input type="checkbox"/> Authority to stop lines.
<input type="checkbox"/> Co-worker relations.	<input type="checkbox"/> Outside consultant.
<input type="checkbox"/> Cross-training.	<input type="checkbox"/> Pilot project.
<input type="checkbox"/> Flatten bill of materials.	<input type="checkbox"/> Preventive maintenance.
<input type="checkbox"/> Flexibility.	<input type="checkbox"/> Quality certificates from vendor.
<input type="checkbox"/> Group technology.	<input type="checkbox"/> Quality circles.
<input type="checkbox"/> In-house lot size.	<input type="checkbox"/> Relationship with supplier.
<input type="checkbox"/> Investigate suggestions.	<input type="checkbox"/> Schedule stability.
<input type="checkbox"/> JIT champion.	<input type="checkbox"/> Set-up time reduction.
<input type="checkbox"/> JIT education.	<input type="checkbox"/> Sole sourcing.
<input type="checkbox"/> JIT team.	<input type="checkbox"/> Top management commitment.
<input type="checkbox"/> Vendor lot size.	<input type="checkbox"/> Vendor lead-time.

3.2.2 Critical Elements in Lean Production implementation

Given the disagreement between authors (Frolick et al., 1995; Guide & Spencer, 1995; Hendry, 1998; Meredith & Zhu, 1995; Wafa & Yasin, 1998) on the specific elements that should be considered as part of the Lean Production approach, it is understandable that the identification of factors critical for the successful implementation of Lean Production

will also lead to controversy. Research conducted by various authors will be used to identify critical elements of Lean Production:

- Meredith and Zhu (1995) requested academics and practitioners to identify (from the list above) elements they considered of critical importance for the success of Lean Production implementation, and compared their responses to data obtained from secondary (published) sources. A comparison of data obtained from the various sources is provided in the tabular format below:

TABLE 3.2
THE 10 MOST CRITICAL ELEMENTS PER DATA SOURCE FROM THE
RESEARCH OF MEREDITH AND ZHU (1995)

	Primary Data		Secondary Data		
	Academic	Practitioner	Survey	Case study	Discussion
Authority to stop lines.			X		
Communication.					X
Cross-training.	X	X	X	X	X
Flatten bill of materials.					
Flexibility.					
Group technology.	X	X	X	X	X
In-house lot size.	X	X			X
Investigate suggestions.					
JIT champion.					
JIT education.	X		X		X
JIT team.		X		X	X
Outside consultant.					
Pilot project.					
Preventive maintenance.		X		X	
Quality certificates from vendor.	X	X	X	X	X
Quality circles.	X	X	X	X	X
Relationship with supplier.	X	X	X	X	
Schedule stability.					
Set-up time reduction.	X	X	X	X	X
Sole sourcing.					
Top management commitment.					
Vendor lead-time.	X	X	X	X	X
Vendor lot size.	X		X	X	
Worker relations.					

- Wafa and Yasin (1998) categorised companies that implemented Lean practices based on their recommendation or non-recommendation of these practices to other companies. Once the data had been collected and compared, the following differences between the categories were identified:

TABLE 3.3
DIFFERENCES BETWEEN COMPANIES RECOMMENDING AND NOT
RECOMMENDING LEAN PRACTICES AFTER IMPLEMENTATION

Meredith & Zhu (1995) Elements	Description of specific manifestation of element of Wafa & Yasin (1998)	Companies that implemented Lean Practices	
		<i>Recommend Lean to other</i>	<i>Do not recommend Lean to other</i>
Top Management commitment	Formal Lean training for managers done	✓	X
	High levels of management support given	✓	X
Communication	Workers were trained in Lean philosophy	✓	X
Cross-training	Workers resist cross-training	✓	✓
Worker relations	High levels of unionised workers	✓	X
Communication	Communicate extensively with suppliers	✓	X
Relationship with supplier	Supplier co-operation viewed as crucial	✓	✓
Sole sourcing	Use sole suppliers	✓	✓

Note: a "✓" confirms that the statements in the left-hand columns are applicable to a company that did/did not recommend Lean Production to others, while a "X" means the opposite.

- Frolick et al. (1995) conclude from the results of a survey that the elimination of waste (including automaton) and production strategy (including reduced set-up time and group technology) are the most crucial categories of elements for Lean implementation, followed by quality control, quality improvement, management commitment, employee participation and supplier/vendor participation.
- Guide and Spencer (1995) use a categorisation approach similar to Frolick et al. (1995) above. They found the management of physical resources (including set-up reductions and preventive maintenance) to be imperative for the success of Lean implementation. Other important categories include: quality management in both the organisation and the supplier base, human resource management, and an overall understanding of the Lean Production philosophy towards inventory management (JIT) by all levels of the organisation.

- Hendry (1998) identified several elements applicable to Lean production and world class performance in a non-make-to-order/jobbing environment: workforce empowerment, design of products and processes, improved supplier relations, shopfloor simplification, capacity utilisation, quality and value improvement, up-to-date appropriate planning and control systems, performance measurement, benchmarking and continuous improvement

The attempts of the authors cited above (Frolick et al., 1995; Guide & Spencer, 1995; Hendry, 1998; Meredith & Zhu, 1995; Wafa & Yasin, 1998) to identify a *core number of elements* critical for the success of Lean Production implementation seem to be of little practical use. In fact, the contradictory results presented remind us of the claims of researchers such as Finch (in Frolick et al., 1995) that the elements of Lean production must be implemented as a total system and that implementation of any part of it without the rest will be unsuccessful. A piecemeal approach can create "islands of Lean" but can fall short of achieving company-wide improvements that increase the organisation's competitiveness.

Against the background presented above, it seems practical (for the purposes of this study) to focus on individual elements of Lean production instead of categories of elements.

3.2.3 Lean Production in Job-production environments

According to Delbridge et al. (1998) Womack et al., (1990) coined the phrase "Lean production" to describe a myriad of management practices found in their purest form among Toyota and its suppliers in Japan, but allegedly transferable anywhere in the world. In the following paragraphs, the transferability of Lean Production to other production systems (with the emphasis on Job-production) is investigated.

3.2.3.1 Characteristics of Job-production environments

Lean Production is a concept well known in production systems involving large scale manufacturing of identical products. However, little is known regarding the transferability of related principles related to other operational systems, especially Job-production systems. In fact, most of the published research in the operations management area has

tended to treat all companies the same – i.e. as if they were make-to-stock companies (implying repetitive manufacturing production systems). Using this approach, the needs of the make-to-order sector (such as companies with Job-production systems) have been neglected (Amaro, Hendry & Kingsman, 1999).

The starting point for this discussion of the characteristics of various production systems, will be to list some of the most common production systems according to an elementary taxonomy used by Adendorf and De Witt (1997) for the description of production systems. According to these authors, three pure systems and two hybrid systems exists:

- Continuous or repetitive systems
- Project systems
- Job systems
- Job-lot (hybrid) systems
- Limited-quantity large-scale (hybrid) systems

The systems listed above differ according to the type of product produced, the product flow, materials handling, raw materials inventory, work-in-process, production cost components, labour requirements and product strategy. The focus of this study falls on:

- Lean Production, which is found in its purest form in Toyota (Japan), a motor manufacturer with a repetitive production system as well as
- Job production, the system used by the plant which is the subject of this case study.

The discussion will thus be limited to a brief review of repetitive production and Job production. The characteristics of these systems are summarised in Table 3.4:

TABLE 3.4
REPETITIVE PRODUCTION VS. JOB-PRODUCTION SYSTEMS

Characteristic	Repetitive production	Job production
Product	Same product produced over and over, measured by physical count of units completed	The nature of work remains the same, but specific requirements differ from one task to the next
Production process strategy	Make-to-stock	Make-to-order
Material handling	Materials flow determinable, systemised and often automated	Handling depends on the product, therefore highly variable and cost high.
Raw material inventory	High Turnover	Low turnover
Work-in-process	Small quantities	Large quantities
Production cost components	Relatively high fixed cost; low variable cost per unit	Relatively low fixed cost; high variable cost per unit
Traditional Production planning mechanism	Master Production Plan adapted by Kanban; Pull strategy	MRP system; Push strategy
Labour requirements	Highly specialised routine tasks at a specific rate, performed by cross-skilled labour	Highly skilled artisans working without supervision and with moderate adaptability
Example	Motor car manufacturer	Motor mechanic

(Adapted from Adendorf & De Wit, 1997; Cronje, Du Toit, Mol & Van Reenen 1997)

A brief glance at the above table indicates that Job production systems differ from repetitive production in all the categorisation variables listed by Adendorf and De Wit (1997) and Cronje et al. (1997). These differences have serious implications for organisations that want to become "world class" by using Lean Production practices. The reason is that most operations models and research (like Lean Production research) are based on make-to-stock companies. Given the diversity of strategies and manufacturing types in organisations, however, it seems unlikely that one set of criteria will suit them all (Hendry, 1998).

3.2.3.2 Lean production in jobbing/make-to-order production environments: problems and suggestions from the literature

Hendry (1998) identified the following specific problems and solutions for make-to-order (the production process strategy used with Job-production) companies:

- **Workforce involvement.** Workforce requirements for jobshops are typically concerned with highly skilled artisans able to perform various tasks limited to their trades (Adendorf & De Wit, 1997; Gaither, 1990). The importance of a well-trained, flexible workforce, which has ownership of its work in Lean Production, was discussed extensively in the previous chapter. In the jobbing make-to-order sector, worker flexibility of well-trained, highly- skilled employees has been (according to Hendry, 1998) a traditional strength, often described as craftsmanship. Companies in this sector could still, however:
 - improve enthusiasm,
 - increase the co-operation from the shopfloor and
 - allow the workers to be more involved in problem solving and in ideas for improving products and processes.
- **Products** in jobshops are diverse and sometimes customer-designed or influenced. Much preproduction planning is necessary to establish routing, job instructions and processing plans (Gaither, 1990). Product development opportunities are thus restricted compared to mass-production make-to-stock companies. If designs could however be simplified with the co-operation of customers, production lead-time could be shortened, and if common parts could be used, both material cost and supplier relations could be improved because of large, homogeneous orders resulting in less logistical activities and higher revenue for suppliers (Hendry, 1998). *Takt-time selling* should be a traditional strength for jobshops, *since the finished goods policy* is based on *make-to-order*, resulting in low or no finished goods inventory waiting to be sold (Adendorf & De Wit, 1997; Gaither, 1990; Hendry, 1998; Liker, 1997).
- **Physical Shopfloor** designs in jobshops are mostly based on the *process layout*, where work centres are organised around particular types of equipment or operations such as drilling, forging, spinning, or assembly. Products flow through departments in batches corresponding to individual orders, which may be either stock orders or customer orders. Actions aimed at machine layout simplification and workforce reduction are common to Lean production environments. The lower volume and higher variety of parts produced in batches, which are common characteristics of the make-to-order sector companies, may warrant a strategic decision to retain a functional layout and reject a cellular layout. In this case, argues Hendry (1998), few published guidelines are available for the improvement of jobshop operations regarding shopfloor management and layout.

- **Capacity issues** in jobshops (according to Gaither, 1990) normally revolve around full capacity utilisation in workcentres with the aid of the MRP system. Aquilano and Chase (1989) describe the process as follows:

“MRP uses backward scheduling; having been fed a master production schedule, it schedules production through a bill of materials explosion in a backward manner- working backward in time from the desired completion date. As a secondary procedure, MRP, through its capacity resource-planning module, develops capacity utilisation profiles for work centres. When work centres are overloaded, either the master production schedule must be adjusted, or enough slack capacity must be left unscheduled in the system so that work can be smoothed at the local level (by work-centre supervisors or workers themselves).”

These authors conclude that attempts to *smooth capacity* (an important aspect of Lean Production) using MRP are often unsuccessful due to the complexity of such an exercise as well as the numerous computer runs required to complete the action. As a result, processing sequences for the product bill of material are usually not followed and the MRP schedule becomes invalid just days after creation. Hendry (1998) proposes (on the basis of the complexities of capacity management in jobshops) that:

- * Only once *full capacity utilisation* is achieved, should investment in new resources and automation be considered.
- * The bottleneck-issue in jobshops could be addressed by increasing parts commonality, while improved tool-storage planning (e.g. in standard tool storage containers on the shopfloor) could enhance set-up reduction.
- * Long-range planning using MRP master production schedules seems to be ineffective in jobbing environments. Capacity should thus be increased ahead of demand based on past capacity and short-term load projections.
- * Small, simple, movable machines are generally thought to be preferable.
- * Companies should develop skilled workers who are able to custom-build new machines as and when they are required.
- * Appropriate maintenance policies should (like in the case of Lean production) be in place to maximise the capacity available on machines (Hendry, 1998).

- **Quality and value for money** is more difficult to define, measure and improve in jobshops since the products vary more than in repetitive manufacturing. According to Hendry (1998) changes in *attitude to quality* could lead to less waste in rework, WIP and accidents. The relatively new concept of value for money is again more complex to measure and improve in jobshops than in other manufacturing systems. Furthermore, the traditional Western MRP system allows for rejects by producing larger batches than actually needed. A Lean Production system does not tolerate rejects. The MRP system may cause jobshops not to achieve the total amount of waste reduction (in e.g. WIP reduction) possible. Aquilano and Chase (1989) propose the “transfer batch” with a size of one unit as a way to ensure continuous workflow with high quality in batch production. Transfer batches refer to the movement of part of the process batch, a batch size large enough to be processed within a given time period. Rather than completing an entire batch before passing it on to the next workstation, individual units in the batch should be passed on as and when they have been completed by an operation. A transfer batch can be equal to or smaller than a process batch, but not larger.
- **Accurate, up-to-date planning and control systems** are crucial for success in all types of companies. In jobshops particularly, where “situational management” is difficult to achieve, some form of planning and control is essential. The systems may vary between companies, and may be computerised or not. The specific methods of control may thus be different for various situations, and authors disagree on the utility of various production planning and control tools in jobbing situations:
 - Aquilano and Chase (1989) argue that the complex and time consuming practices associated with MRP’s backward scheduling are impractical for jobbing environments, while the JIT concepts associated with Lean Production are limited to repetitive manufacturing. This method also requires a stable production schedule, which is almost impossible to achieve in jobshops. Furthermore, JIT does not allow much flexibility in products produced (the core feature of jobshops), and requires WIP when used with Kanban so there is “something to pull”. The authors conclude their argument by proposing synchronised manufacturing as a better alternative for jobshop environments.
 - Hendry (1998) states that various schools of thought exist regarding production planning in jobshops. Firstly, “Work-to” lists may be preferable in job shops to Kanban systems, although the latter might be better for that part of the

organisation where there is repetitive processing. Secondly: with optimum shopfloor visibility, long term planning is no longer essential. Thirdly: a chapter on MRP is included in jobshop planning systems to extend MRP capacity to infinite planning concepts.

- Adendorf and De Wit (1997) state that Kanban is an element of JIT. In contrast to MRP, which can be described as a push system, Kanban is a pull system. JIT itself is, broadly speaking, a pull system in which work is drawn by the consumer from the supplier in order to reconcile the use time with the delivery time. MRP on the other hand, is a system which uses bills of material, inventory, open order data, lead time, and master production schedules to calculate requirements for materials in job-lot manufacturing systems (Monden, 1998; Adendorf & De Wit, 1997). Schonberger (1982) concludes that the United States is most proficient in job-lot manufacturing because MRP was invented and nurtured here. Japan is most proficient in repetitive manufacturing management because the just-in-time system was developed there.
- Fowler (1999) argues that Kanban is actually a special case of generic feedback control principles, while pure MRP is a classic example of feedforward. In practice, the complexities of real world operations require combinations of these two approaches. Monden (1998) claims that, from the viewpoint of adapting production to demand changes during a month, MRP and the Kanban system both aim to realise JIT production. His conclusion that the Kanban system can be compatible with MRP supports the view stated by Fowler (1999) above.

Even though various views regarding the best planning practices for Lean jobshops exist, it is evident from the arguments presented above that:

- MRP alone cannot be utilised for optimum planning in jobshops wanting to apply Lean Production practices,
- Kanban alone seems inappropriate for jobshops
- MRP and Kanban can (and is recommended to) be used in combination, as in the case of Toyota, the company where Lean Production is found in its purest form.

Hendry (1998) stated (on the basis of the multiple views on planning for jobbing) that the appropriate choice of planning and scheduling for different company types is still acknowledged to be a matter for further research.

- **Performance measurement, benchmarking and continuous improvement** are issues relevant to all types of organisations. For the make-to-order/jobbing company, a different emphasis may be appropriate, for example with smaller reductions for measures like WIP inventory. Monitoring importance is however just as important in this environment as in others. Benchmarking may present the company using a jobbing production system with a problem, since it may be almost impossible to find a close enough match for the type of work performed. Kaizen principles could be applied equally to jobshops and mass-production (repetitive) systems (Hendry, 1998).

3.2.3.3 Cases Studies regarding Lean Production in jobbing environments

Various case studies regarding Lean production were found in the literature (Dale & Regan, 1999; Liker, 1997; Sohal, 1996), but none were from jobbing environments. The only case study evidence pertaining to Lean Production in jobshops was found in the form of a description of two make-to-order companies striving to become world class (Hendry, 1998). For confidentiality purposes, Hendry (1998) could not reveal the names of the companies described.

- **Case study A:**

“Evidence for the conclusion that changing from the job shop layout may only have a small impact on change can be found in a manufacturer of agricultural equipment. This company operates in a job shop manner for the production of components and for the required painting processes. An assembly line is used for the completion of one of the larger end products, (A). Some of the processes required by this product are also required by a second large end product manufactured by the company, product (B). Since all of the facilities for this process are located on the assembly line for product A, product B must be moved around the factory for these joint processes and then moved back again. This at first site appears wasteful of time. Of course, it is, but the company have made a strategic decision not to alter the layout because the volumes required for product B are extremely low and the costs of movement of the equipment involved are extremely high. Hence it was concluded that changing the layout would be a small impact change. Instead, they are concentrating on improving

the tidiness of the factory and then on improving their information flow and their planning. Data are currently being collected as the alterations are being made” (Hendry, 1998)

- **Case Study B:**

“A second precision engineering company, that chose to retain a functional layout, has achieved a remarkable increase in visibility of planning and in lead time reduction by rearranging and reducing its stocks and by addressing quality and set-up time reduction issues. In addition, this company has improved information flow and planning by producing its own in-house workload control software for planning customer inquiries and controlling job release. In particular, it kept the number of released jobs between 40 and 50 at any point in time, thereby reducing the WIP to a smaller, more manageable quantity. This company provides clear evidence that becoming cellular in layout is not a pre-requisite for major improvements in performance and practice” (Hendry, 1998).

3.2.4 Lean Production in Rail environments

The discussion below referring to Lean Production in *Rail environments*; describes the second variable influencing the implementation of Lean practices and is applicable to the plant which is the subject of this project. Consideration of the characteristics of Rail environments is followed by a short discussion about Lean Production in these environments. The discussion concludes with the presentation of case study evidence regarding the functioning of Lean practices in Rail environments.

3.2.4.1 Characteristics of Rail environments

3.2.4.1.1 Rail environments in general

Chan, Gaffney, Ip and Nealey (1998) identified the following characteristics of Rail environments:

- Railway operation (worldwide) is a traditionally less self-sufficient public utility, which requires substantial government subsidy to survive. As a result, privatisation of railway operation has become a popular trend in the industry. The success of pioneers in this arena, such as British Rail and the London Underground, has promoted other state-owned railway operators to emulate (Chan et al., 1998).

- The worldwide rail situation described above most certainly holds true for the South African rail environment as well. In a recent press release, the Minister of transport announced that some units of Transnet which are not of strategic importance to the government (according to GEAR) e.g. Transwerk, must be sold to OEM's (Kobokoane, 1999).
- Application of new management initiatives is slow in railway corporations. This is largely due to their traditional management style and paramount emphasis on operational safety (Chan et al., 1998; Chatterjee & Pearson, 1996).
- To adhere to safety, railway operators tend to adhere to many inherited rules and procedures, which are regarded as unquestioned wisdom. This conservative approach may contribute to the safeguarding of railway operations, but simply reinforcing existing rules and regulations is inadequate for the maintenance of an effective management system. These systems should equip the railway organisations to overcome operational challenges, particularly in today's volatile environment (Chan et al., 1998).

FIGURE 3.1

A FREIGHT TRAIN IN DANGEROUS CONDITIONS



Photograph: obtained from the Railfan website

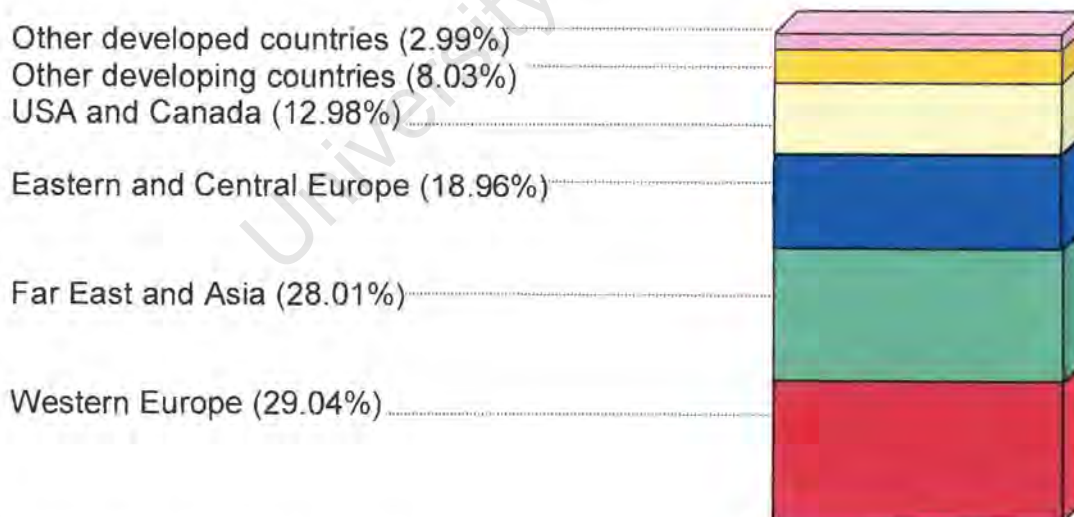
3.2.4.1.2 Rail manufacturing and refurbishing environments

While the previous paragraph provided some characteristics of the rail environment in general (including train operations etc.), information regarding rail manufacturing and refurbishing will be provided in this paragraph.

- The global market for Rail Manufacturing and Refurbishing Industry is dominated by ADtranz (21% market share), Breda (19%), Kawasaki (15.4%) and M-K (Amrail) (14% share). Some major UK contracts were recently placed with ADtranz by:
 - Connex Rail : £ 70m
 - Prism Rail: £ 200m

These contracts are, however, small in relation to the \$ 1 179 billion p.a. world rail market. See the projections for the Rail industry under “future prospects” below for other segments (by region) in the market.

FIGURE 3.2
WORLD RAIL MARKET PER GEOGRAPHICAL SEGMENT



(Adtranz, 1998: <http://www.adtranz.com>)

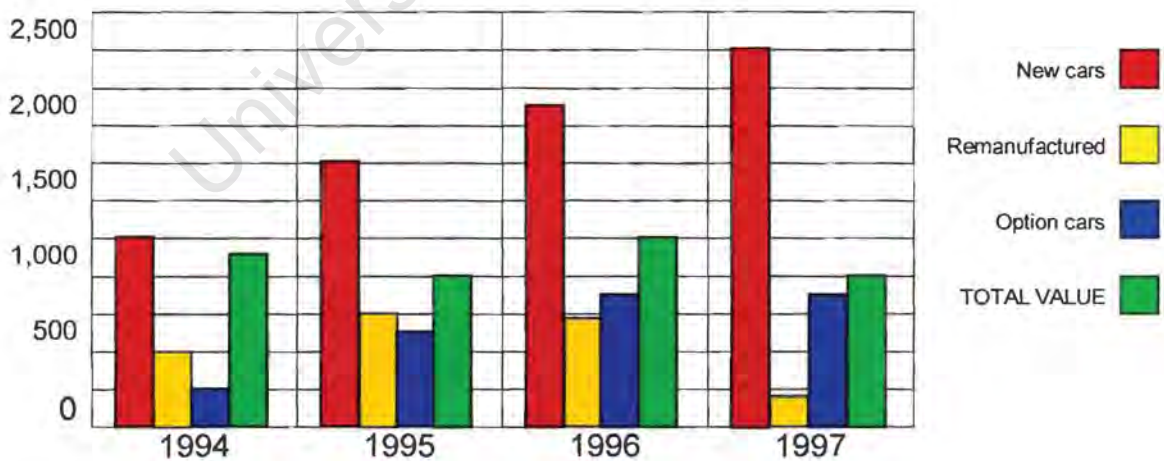
- Table 3.5 (below) represents the market shares of the main conglomerates dominating the world's rail industry (Totals are in \$ billions).

**TABLE 3.5
TRANSIT RAILCAR MARKET SHARE**

Company	LRV's	Heavy Rail	Comm. Rail	Locos	Total	% Market Share
ABB Daimler-Benz	18	220		13	251	21.3%
Bombardier			160	6	166	14.1%
Breda	152	74			226	19.2%
GM Elec. Loco.Div				33	33	2.8%
Gomaco					0	0.0%
Kawasaki			181		181	15.4%
M-K (Amerail)		13	156		169	14.3%
Mafersa					0	0.0%
Nippon-Sharyo	50				50	4.2%
Siemens-Duewag	103				103	8.7%
Sumitomo					0	0.0%
TOTAL	323	307	497	52	1179	100%

(Adtranz, 1998: <http://www.adtranz.com>)

**FIGURE 3.3
RAILCAR BACKLOG (1994-1997)**



(Adtranz, 1998: <http://www.adtranz.com>)

Figure 3.3 (directly above) should be read in conjunction with Figure 3.1, since this will provide an overview of both the market size (in \$) and the types of products/services produced and ordered:

- The graphs and tables above indicate the enormous size of the world rail market, as well as the different geographical market segments and categories of rail products manufactured and refurbished. Given the wide scope of *unique customer specifications* and relatively *limited quantities* of new railcars ordered (per batch) by individual operators as well as the traditional *jobbing nature of refurbishing work*, it is quite clear that the railway manufacturing and refurbishing environment is more similar by nature to make-to-order type jobbing organisations than to make-to-stock repetitive manufacturers (Greeff et al., 1999).
- The implication of this statement by Greeff et al. (1999) is that rail refurbishing and manufacturing environments display characteristics common to jobbing environments, such as customer provided specifications and high customer involvement with product design (Hendry, 1998).

3.2.4.2 Lean Production in Rail environments

The same hindering factors and suggestions applicable to general jobbing environments should be applicable to rail jobshops (Greeff et al., 1999; Hendry, 1998). Compare the discussion (above) regarding the characteristics of jobbing environments according to the following categories:

- Workforce involvement
- Products
- Physical Shopfloor design
- Capacity issues
- Quality and value for money
- Planning and control systems
- Performance measures, benchmarking and continuous improvement

3.2.4.3 Case studies of Lean Production in Rail environments and environments other than the automotive industry.

According to Delbridge et al. (1998), some critics of Lean production question the transferability of Lean practices to industries other than the motor manufacturing

industry. Some case studies regarding the application of Lean Production principles to environments other than the motor manufacturing industry were, however, found:

- *Canon*, a world-class photographic equipment manufacturer, as much as any other company illustrates the tremendous potential for achievement represented by the Lean approach. Fifteen years ago Canon was struggling to produce a camera that would appeal to the world market. The finest cameras were made almost exclusively in Germany. Canon revolutionised the industry, however, providing the latest in technological advances and precision at affordable prices (Campbell & Dyer, 1987).
- *Cedar works* is a small wood-processing company that makes mailboxes and bird feeders from aromatic Eastern Red Cedar. Cedar works is a classic American success story of a tiny grassroots company that has steadily grown and made the transition to employ world class Lean manufacturing practices (Liker, 1997).
- *Gelman Sciences* is a world leader in the rapidly expanding field of microfiltration and separations, with sales of more than \$ 1 billion in the fiscal year ending 1996. The company commenced with Lean implementation in one of their plants as a pilot project in 1993, and expanded the concept after 4.5 years with success throughout the whole corporation (Liker, 1997).
- Holmstrom and Lehtonen (1998) reported that the applications of JIT in the *paper industry* are scarce and conflicting. They used multiple case studies to demonstrate the benefits and potential benefits of JIT in this environment.

Case studies of the successful implementation of Lean Practices and/or published research regarding Lean Production in the Rail environment are (like in the case of the paper industry) scarce. One example of the implementation of Lean practices in the *general* Rail environment was found:

- Chan et al. (1998) describes the implementation of an integrated management system with Lean Practices such as Total Quality Management in the Mass Transit Railway Corporation of Hong Kong. These practices served to enhance the corporation's competitiveness by successfully addressing rapidly changing environmental needs via waste elimination.

A case where Lean was successfully implemented in the Rail Industry was found on the Internet in the form of an interview with Kaare Vagner, President and Chief Executive Officer of the ADtranz Group.

- Says Mr. Vagner:

"The international railway group ADtranz is the world's most complete provider of railway systems for main line and mass transit. We can already offer our customers throughout the world the entire range of rail technology and expect to grow more quickly than the market in the next few years and thereby consolidate our position further. Our 23,000 workforce is spread over 40 countries where we have production, marketing and design facilities. There are more than 50 countries in which ADtranz maintains a presence through branch offices and business partners. Despite this world-wide and customer-oriented presence, we have a very lean and efficient organisation - the ADtranz corporate centres in Berlin, Brussels and Zurich are staffed by just 55 employees from 14 nations."

(ADtranz, 1998 : <http://www.adtranz.com>)

3.2.5 Lean Production in South Africa

The discussion below about Lean Production in *the South African environment*, describes a third variable that influenced the implementation of Lean practices in the specific environment applicable to the plant which is the subject of this project. A discussion of the characteristics of the South African environment is followed by a short discussion about Lean Production in this environment. The discussion concludes with the presentation of case study evidence regarding the functioning of Lean practices in South Africa.

3.2.5.1 Some characteristics of the South African environment

Monden (1998) ascribes the success of the Lean Production practices in Toyota, Japan and other Lean Japanese companies to a so-called social production approach. This approach is based on (1) maker-supplier relationships, (2) management-labour relationships and the (3) Japanese educational system. Monden however considers the first two aspects as crucial for the implementation of Lean production in countries other than Japan. Since Delbridge et al. (1998) consider Lean Production to be found in its purest form in Toyota, Japan, the discussion below regarding the transferability of Lean production to other countries will be based on the views and methodology proposed from the viewpoint of Toyota.

3.2.5.1.1 Maker-supplier relationships

In a comparison between American and Japanese producer (maker) and supplier environments, Monden (1998) highlighted two major differences:

- A hierarchical subcontract organisation forms the primary step to each succeeding step in Japan, and this structure has not been constructed in American companies. For example, General Motors deals with more than 10 000 suppliers, while Japanese car manufacturers deal directly with only 100 to 300 subcontracted companies, who in turn deal directly with the next level of subcontractors/suppliers.
- Japanese subcontracted companies receive orders from one particular paternal company under long-term contract arrangements. Nearly 38% of all Japanese subcontractors generate 75% of their turnover from sales to one paternal company. Approximately 63% subcontracted companies rely on a paternal company for 50% of their sales.

According to Monden (1998) the above characteristics of the Japanese maker-supplier relationship are more conducive for the close co-operation and free information flow associated with Lean Production than other types of relationships with suppliers.

A study of the literature (Badenhorst et al., 1997; Cronje et al., 1997; Haffajee & Hazelhurst, 1999; Voordijk, 1999) on some aspects of purchasing and supplier relations in the South African environment, indicate that maker-supplier relationships in South Africa probably resemble the American model more closely than the Japanese model, and, *in addition*, experience problems unique to Africa. For example, although Hugo et al. (1997) recognised the potential benefits from selecting single suppliers, they express fears that

- single suppliers may become too complacent and unmotivated, thus no longer offering the service that they would if there were competition
- monopolies may arise.

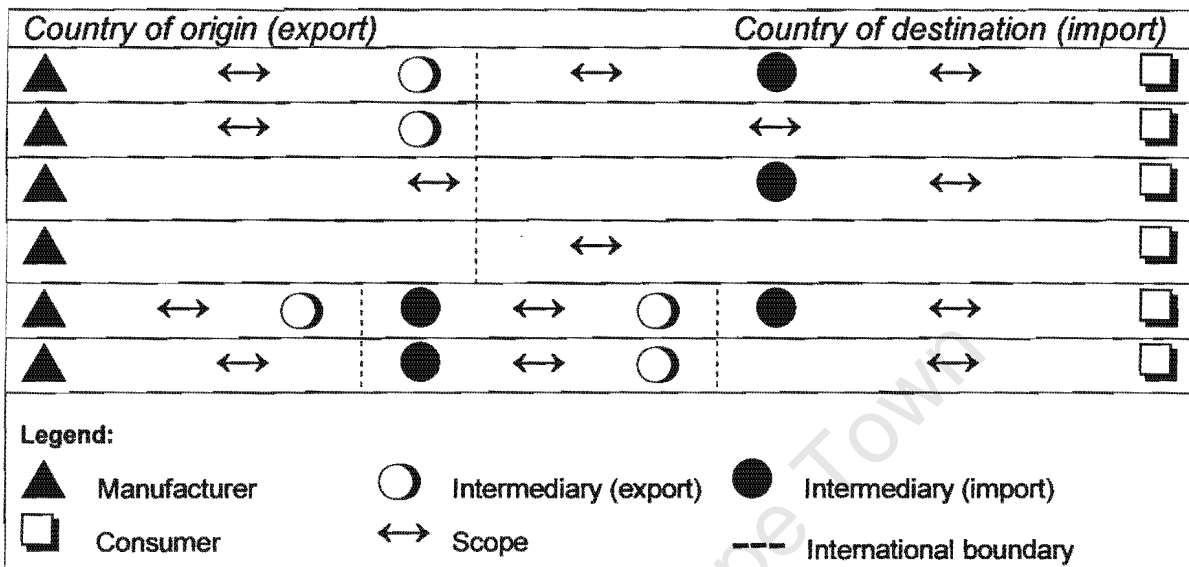
The above authors (Cronje et al. 1997; Haffajee & Hazelhurst, 1999 and Hugo et al. 1997) also provide comprehensive advantages of having more than one supplier. An aspect of crucial importance in the South African environment, i.e. Affirmative action purchasing, is highlighted by Hugo et al. (1997). Affirmative-action purchasing strategy is aimed at the contribution of purchasing organisations to Black Empowerment in South

Africa. This action should address imbalances caused by the specific political history of South Africa. The practical application of this strategy differs between organisations, but in essence:

- a certain percentage of total purchases, determined by management (in adherence to company policy), is to be purchased from affirmative-action suppliers
- government's tender rules require that the allocation of State contracts of R70bn per year are awarded with affirmative-action in mind
- companies should provide assistance to these suppliers if they cannot deliver their products on time/in the right quantities/of the right quality to ensure that they grow into fully fledged suppliers
- affirmative-action suppliers are allowed to be more expensive than competing suppliers
- affirmative-action suppliers are chosen to supply products/services according to their ability – e.g. it is unlikely that these suppliers would be able to supply complex, technologically advanced capital equipment.

Another phenomenon distinguishing the nature of maker-supplier relationships in South Africa, is the development phase of the South African Economy. Fourie et al. (1997) describe economic development through three phases, starting with primary sector growth which is agriculture and mining dominated, followed by growth in secondary sector activities which are concerned with production, followed by the tertiary phase growth concerned with the rendering of financial and government services. Mohr et al (1997) consider South Africa still to be heavily dependent on mineral resource exploitation, resulting in huge raw material exports and huge capital (e.g. machinery and advanced components) imports. The implication is that manufacturers/makers purchase imported material via a number of channels. Some of these channels, as described by Hugo et al. (1997) are represented schematically in Figure 3.4 below:

FIGURE 3.4
CHANNELS FOR INTERNATIONAL TRADE



(Source: Hugo et al., 1997: 310)

The situation of these multiple import channels could possibly complicate the nature of relationships between South African producers/makers and suppliers.

The above discussion demonstrates that the specific nature of South African maker-supplier relationships that could influence Lean Production

- resemble the American/Western model more than the Japanese model
- are complicated to some extent by Affirmative-action purchasing policies
- are possibly complicated by multiple import channels.

3.2.5.1.2 Management-labour relationships

In a comparison between American and Japanese industrial relations, Monden (1998) concludes that the predominantly hostile labour relations climate in America is an obstacle to Lean practices. These have implications for the transfers of workers within a plant, work-place improvements and flexible labour contracts which are aimed at achieving minimum waste in labour by having a flexible workforce. Monden (1998) however concludes that, despite these obstacles, the Lean Production system could still function in America.

The discussion below will focus on the issues listed by Monden (1998) as prerequisites as well as obstacles to Lean Production in the South African environment.

3.2.5.1.2.1 The fundamental nature of South African Labour relations

South Africa is perceived to have an over regulated labour market – to the extent that the labour system is observed as a disincentive for investment. After 1994 (when the ANC came into power), the Labour Department raced ahead of most other bureaucracies to overhaul the system it inherited. It crafted world-class legislation that was the pride of the International Labour Organisation. This body funded most of the research behind the four key South African labour laws: the Labour Relations Act (LRA), the Basic Conditions of Employment Act (BCEA) Employment Equity Act, and the Skills Development Act (Haffajee and Mabotja, 1999).

Bendix (1992) describes the effects of Government intervention with a combination of various factors, including interaction of Labour legislation, Union power, Management power and the health of the economy.

The effects of an over-regulated labour market are high union power, high social responsibility and a weakening economy. Some specific objectives of COSATU, the most powerful affiliation of labour in South Africa, which may influence the flexible workforce strategy of Lean Production in South Africa, are:

- a guaranteed annual income
- a living wage
- a 40-hour week without loss of pay
- job security
- specific (additional) paid holidays, bringing the number of paid holidays in South Africa to 16 per year
- retrenchment pay of one month's salary for every year of employment
- equal and increased technical and vocational training for females and youths
- the right to strike and picket
- job creation by banning overtime

These objectives will be quoted if and where they are applicable in the following discussion concerning flexible workforce strategies in a Lean Production system (Bendix, 1992).

3.2.5.1.2.2 *Achieving workforce flexibility by transferring workers within a plant*

One of the objectives of Lean Production is to banish waste in the form of excessive workforce. By creating flexible multi-function workers, they can be transferred to areas of need within a plant on a regular basis. This strategy poses no or, at least, insignificant problems in Japan, since workers are paid on seniority and other attributes. A change in job is thus not related to change in pay.

In the Western world (including South Africa), people are appointed to pre-evaluated jobs. In other words, they are paid according to the jobs that they do. A person that was appointed to perform highly paid artisan work can therefore not be transferred to do the work of semi-skilled workers, since semi-skilled workers would want the same pay as the Artisan for doing that job in future. This principle is sometimes called *job demarcation*. In some instances unions try to protect the classes of workers they represent by fending off attempts of management to *multiskill* workers over job-class boundaries in order to promote *job security* (Bendix, 1992; Cronje et al., 1997; Haffajee and Mabotja, 1999; Monden, 1998).

New labour laws make provision for labour to participate more in company decisions. This means that agreements must (like in the American environment) be reached when workers are transferred. A union wanting to achieve job creation goals could thus easily refuse to agree to transfers in an attempt to have extra workers employed, leaving some workers under-utilised (Bendix, 1992; Cronje et al. 1997; Monden, 1998).

3.2.5.1.2.3 *Achieving workforce flexibility by improvements*

The optimisation of machine layout, continuous improvement, longer and shorter shifts and automation are some of the strategies employed in Lean Japanese plants to reduce waste in excessive workforce. In the western world, however, unions must often be consulted where improvements may result in workforce reduction.

The strategy of Lean Production seems to be in conflict with COSATU objectives as well:

TABLE 3.6
LEAN STRATEGIES AND COSATU OBJECTIVES

LEAN STRATEGY	COSATU OBJECTIVE
Reduce workforce by improving machine layout and automation	Job security for workers; retrenchment pay of one month's salary for every year of employment; 6 months' maternity leave and a guarantee of re-employment
Adapt to demand changes by working shorter or longer hours	40 hour workweek without reduction in pay; guaranteed annual income; job creation by banning overtime

(Adapted from Bendix, 1992 and Monden, 1998)

This comparison shows that initiatives aimed at workforce flexibility and unions striving to achieve COSATU objectives may possibly obstruct reduction via workplace improvements in South Africa.

3.2.5.1.3 Education

Monden (1998) states that the Japanese school education system contributes to workforce utilisation in Japan, while the same may not be true of Western education. In fact, the general low educational level of the South African labour force (which is a result of past political practices) is a factor contributing to the country's extremely low productivity compared to developed Western countries.

Education and training of the labour force are, however, currently a high priority within the South African labour dispensation. Erasmus and Van Dyk (1996) perceive training and education to be the most important factors that will positively influence economic growth, political stability and social success in the country in future. The most important factors affecting education and training in South Africa are listed below:

- Population growth
- Low levels of education
- Unemployment
- Supply and demand for labour
- Technological acceleration

Erasmus and Van Dyk (1996) and Pritchard (2001) estimate from figures obtained by the South African National Training Board, that approximately 30% of the country's economically active people are illiterate, i.e. with a standard 3 or lower qualification, or without schooling. Approximately 55% of the total population are illiterate, which does not compare well with countries such as Japan (1%) and the USA (13%).

Given the above information, the low levels of literacy will pose a problem for the implementation of Lean Production practices in South Africa – e.g. having illiterate operators work to standard operations which specify cycle time, completion time per unit, method, WIP quantity etc. The situation may become even worse by job rotation, the one major strategy of ensuring workforce flexibility in Lean Production. To expect a worker who battles to write his name to read and adhere to the standard operation procedure of one task may be extremely difficult. To expect the worker to understand the same data for multiple processes (when rotated) could prove impossible.

3.2.5.2 Manifestations of Lean Production in South Africa

The possible effects of supplier-maker relationships, management-labour relationships and education in South Africa on Lean production were discussed in the previous paragraphs. Published research regarding Lean Production in South Africa is extremely scarce. Even the South African motor manufacturers listed as case studies provide little detail on Lean practices apart from plant tours and brochures, which focus mainly on Green Areas. For this reason, the discussions on the application of Lean Practices in South Africa and case studies on Lean Production in South Africa are combined in this section.

A comparison of information obtained during plant tours of the Toyota Manufacturing Division in Prospecton and Nissan's plant in Rosslyn, reveals that the following Lean practices are applied in the South African environment:

TABLE 3.7
MANIFESTATIONS OF LEAN PRACTICES IN TWO SOUTH AFRICAN
MOTOR CAR MANUFACTURERS

Lean practice	South African application
Just-in-time	3 days stock of local suppliers, 90 days of international suppliers are kept at Nissan
Kanban	Production Kanbans were viewed at Toyota during plant tour
Pokayoke	Some Pokayoke devices used during quality inspection were demonstrated during Toyota plant tour by the tour guide
Andon boards	Viewed at Nissan and Toyota during plant tours
Standard operations	Used at Nissan, but is called an AWM (Actual Work Method) sheet – published in plant-tour brochure and in a presentation at SAPICS by Waterson (1989). Supervisors check workers to ensure they work to AWM.
Job Rotation	Used at Nissan in Green Areas in the form of an "ILU" chart to demonstrate that a worker "I" is being trained to do a job, "L" can do the job exactly to standard operations sheet (AWM), and "U" can train another worker in the activity.
Suggestion scheme	Suggestion schemes functions at Nissan. Workers are paid up to R 10 000 for suggestions leading to better quality/lower cost. This was determined during a plant tour.
Statistical Quality Control	Quality trends are analysed in Green Areas at Toyota and Nissan
5S system	At Nissan and Toyota, evidence of the 5S system were evident in Green Areas. At Nissan, more emphasis is place on the first 3 aspects of 5S. At the Nissan plant, work areas are regularly inspected by an "auditor" to rate adherence to the cleanup principles emphasised by the company.

Green Areas are the infrastructure used to apply most Lean Practices in the South African environment. Green areas are, in essence, basic line-side meeting venues containing tables and chairs/benches, which are sheltered on three sides with walls. The walls are used to display various control charts, targets, procedures and information (Waterson, 1989). At Nissan SA, information is grouped under four categories:

- Quality targets and performance
- Cost targets and performance
- Delivery targets and performance
- People aspects

These categories correspond with goals in Lean Production as described by Monden (1998).

3.2.6 Lean Production and Government environments

The characteristics of Government environments are the final environment discussed as an influencing factor of the study.

3.2.6.1 Government environments

As indicated during the introductory chapter of the study, the Government is planning to sell state-owned businesses like Transnet – either wholly or partially in the near future as substrategy of GEAR. In fact, Public Enterprises Minister Jeff Radebe has promised to speed up the restructuring of state assets so they can play a profound and strategic role in the economic development of South Africa. Transport parastatal Transnet, is considered as a key priority by the Minister (Kobokoane, 1999; Ryan, 1998).

3.2.6.1.1 *Transnet History*

The Transnet organisation is (according to Krisch & Mathebula, 1999) as old and as complicated as the Union of South Africa. Railways and harbours developed in the four colonies and in the subsequent Union of SA mainly to support an agricultural and mining economy. As new modes of transport were commercially developed, they were added to the predecessors of Transnet, with SAA incorporated in 1934 and Petronet in 1962. Cash flows were healthy, and when they were not they could be hidden in the Department of Transport. In the early 1980's the South African Transport Service (SATS) was separated from government, preventing hidden subsidies. Even more important was the deregulation of the transport industry in 1988. Before deregulation, transport was an instrument of social policy. Road freight was strictly regulated and only 28-ton payloads were allowed on the roads. Deregulation introduced intense competition between road and rail as Transnet set off on a road of commercialisation (Krisch and Mathebula, 1999).

3.2.6.1.2 *Characteristics*

Being an enormous company (see Chapter 1 on the multitude of Divisions, Business units, Service Centres and Subsidiaries), it could be expected that Transnet, like other large companies, would have a mechanistic structure. These structures are characterised by high complexity (especially a great deal of horizontal differentiation), high formalisation, a limited information network (mostly downward communication), and

little participation by low-level members in decision making (Kreitner & Kinicki, 1992; Robbins, 1989).

Robbins (1989) describes the following specific characteristics of these designs:

- Division of labour – Each person's job is broken down into simple, routine, and well-defined tasks
- Well-defined hierarchy of authority – There is a multilevel formal structure, with a hierarchy of positions. Each lower position is under the control of a higher one
- High formalisation – To ensure uniformity and to regulate the behaviour of jobholders, there is heavy dependence on formal rules and procedures.
- Impersonal nature – Sanctions are applied uniformly and impersonally to avoid involvement with individual personalities and personal preferences of members
- Employment decisions based on merit – selection and promotion decisions are usually based on technical qualifications, competence, and performance of candidates.
- Career tracks for employees – Members are expected to pursue a career in the organisation. In return for this career commitment, employees are given permanent employment; that is, they are retained even if they "burn out" or their skills become obsolete
- Distinct separation of members' organisational and personal lives – To prevent the demands and interests of personal affairs interfering with the rational impersonal conduct of the organisation's activities.

Since the Government is currently the sole shareholder of Transnet, it can be expected that many of the characteristics (e.g. policy/rules/procedures) listed by Robbins (1989) above, will be flavoured in a way to support Government goals like Affirmative Action appointments and sourcing.

The influence of Government in Transnet decisions is still clearly seen in the daily management of Transnet. Consider for example the recent intervention by Government when Transnet planned to retrench employees:

"The alarm bells sounding now in government about the parlous state of the country's big transport parastatal, Transnet, have a hollow ring about them.

Transnet's managing director, former ANC MP Saki Macozoma, had his carefully laid plans to make 27 000 employees, mainly railway workers, redundant, squashed by President Thabo Mbeki four months ago.

At the time, the new Mbeki administration had run into a wall of union hostility over plans to cut the civil service. Fearful of this, government, in the form of new Public Enterprises Minister Jeff Radebe, cynically derailed Macozoma's plans. Now the chickens have come home to roost; Transnet is in terrible trouble, and the loss of the 27 000 jobs is more certain than ever. Those jobs were useful merely as political fodder for the politicians. With the civil service threat in abeyance, they are back on the line, with cries of concern for Transnet's future from government.

Well, better late than never. Transnet is actually paying staff to stay at home. According to Macozoma less than 5 000 of Transnet's 47 000 employees are producing profits. Where, to polish up a fashionable notion, is the national interest in that?

If Mbeki was prepared to stall the obvious so early into his presidency, we shudder to think how cautious he might become about privatisation and the cutting of State debt as the next election looms. Take the pain and the risks now, Mr President. Interventions like Minister Radebe's in Transnet sow gloom and despondency among valuable managers. Decisions, like the one this week to list Telkom in 2001, revitalise them. That is the way forward" (Bullard, 1999: 12)

Above citation clearly indicates how the interaction between the Government-labour alliance and the management of Transnet affects the running of the latter business.

3.2.6.1.3 Lean Production in companies with Government ties

As with Lean Production in South Africa, published research regarding Lean in Parastatals is scarce. For this reason, the discussion of the manifestations of Lean Production in Government Enterprises will be combined with the presentation of cases.

The following cases of Lean practices in companies with government ties were found:

- Sikakhane (1998) mentions that Transnet improved its management of working capital by adopting a just-in-time approach, but no further details are provided.

- A single case was found in the United Kingdom where a company with Government ties that successfully implemented Lean practices. RHP Bearings (UK), as a company, was formed in 1969 by the government of the day bringing together three of the UK's leading bearing manufacturers. The purpose of the formation was to protect the indigenous bearing industry, which was seen as of strategic importance to the UK, from overseas competition, in particular the Japanese. The RHP Bearings Blackburn plant was transformed by the implementation of Lean Management principles from potential closure to a successful business unit within the NSK-RHP European operation (Dale & Regan , 1999).

Descriptive case studies (e.g. the case of RHP Bearings, Blackburn) are usually not designed to test theories and generalise findings, but rather to describe events and outcomes to allow other researchers to understand the processes and environment investigated (McCutcheon & Meredith, 1993).

Although an extensive search on the Internet was launched to investigate generaliseable evidence of the effect of Lean Management Principles on the performance of Government-owned enterprises, no further sources were found.

From the discussions of Transnet's history and characteristics as well as the case study above, the following conclusions are made:

- Transnet's former role as instrument of (the previous government's) social policy, coupled with labour's power and hostility may possibly create an attitude problem (false sense of job security and unwillingness to change practices) with workers.
- Lean production's focus on workforce reduction may pose a problem in an environment in which the South African Government (which holds strong alliances with Labour) heavily influences company decisions on retrenchment.
- Excessive formalisation (rules and procedures) associated with large companies in general and influences by Government's goals such as Affirmative Action purchasing as well as Tender rules may restrict some actions associated with Lean Production. See section 3.2.5.1.1 on maker-supplier relationships above as well.
- Some Lean Production strategies however seem viable, such as just-in-time delivery of finished goods and just-in-time ordering and receiving of material.

3.3 Conclusion

In this chapter, the discussion has focused on the transferability of Lean Production to various environments. In the discussion unique factors influencing Lean practices in Jobbing environments, the Rail environment, the South African environment and Government-ownership environments were described.

The next chapter focuses on the dependant variable of the study, i.e. Return on Investment (ROI). The possible ways in which ROI can be affected by Lean practices will be indicated, and research findings of a similar nature will be reported.

University of Cape Town

4. Return on Investment

4.1 Introduction

In the previous two chapters, the independent variable of the study, i.e. the construct Lean Production and the transferability of this construct to various environments was discussed. In this chapter, the dependent variable of the study, i.e. Return on Investment (ROI) is discussed in some detail.

The discussion is introduced with a definition of the construct ROI, and the purpose and place of this analysis instrument in financial analysis are explained. This is followed by a description of the various elements used to calculate ROI, both from the Income Statement and the Balance Sheet. The chapter concludes with a discussion on the ways in which Lean practices can influence ROI, and supportive research is provided.

4.2 The nature of ROI

The measure ROI was chosen as the dependent variable for this study because of a practical need, and not because of theoretical considerations. The following discussion of the construct is therefore more descriptive by nature than evaluative. The advantages and limitations of this ratio will however be provided later in order to comment on the limitations to the study.

4.2.1 Ratio analysis

The nature of the concept Return on Investment (ROI) is probably best understood if described from the framework of financial ratio analysis. According to Gitman (1997) ratio analysis involves the methods of calculating and interpreting financial ratios to assess an organisation's performance and status. The balance sheet and income statement of the organisation are required for these computations.

Ratio analysis is not, however, merely the application of formulae to financial data to calculate ratios. The interpretation of such ratios is of greater importance. Interpretations are usually based on various comparisons:

- **Cross-sectional analysis** involves the comparison of the financial ratios of various companies at the same point in time. Typically, businesses are interested in how well they performed in relation to other businesses in their industry. Ratio values are frequently compared to those of key competitors or groups of competitors. This type of cross-sectional analysis, called benchmarking, has according to Gitman (1997) become popular in recent years, especially due to its diagnostic utility.
- **Time-series analysis** is applied when performance is analysed over time. A comparison of current to past performance, using ratio analysis, can assist organisations to establish whether they have progressed as planned. Gitman (1997) states that developing trends can be identified via multiyear comparisons. Knowledge of these trends should assist management in the planning of future operations. As with cross-sectional analysis, any significant year-on-year changes can be evaluated to assess whether they are symptomatic of larger problems.
- **Combined analysis** is according to Gitman (1997) probably the most informative approach to ratio analysis. In this approach, the cross-sectional analysis is combined with a time-series analysis. A combined view permits assessment of the trend in the behaviour of a ratio in relation to the trend in the industry.

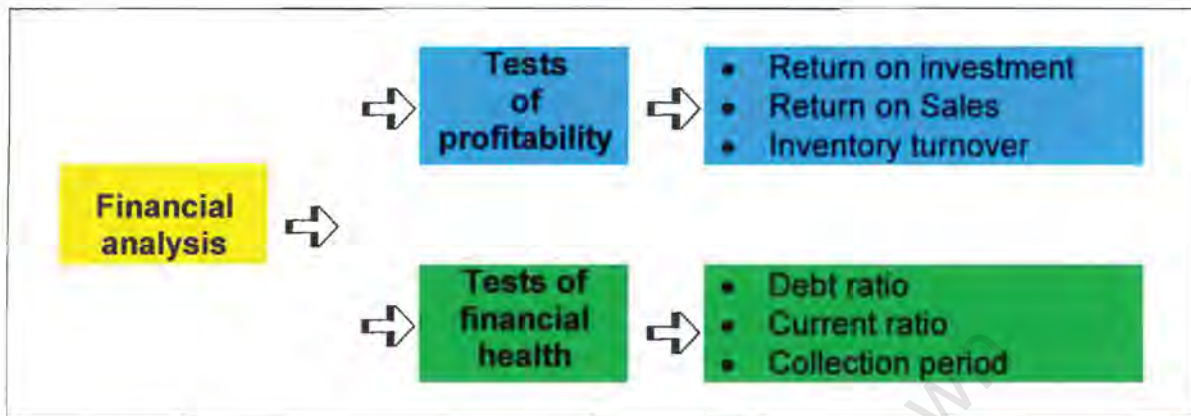
4.2.2 Groups of financial ratios

De Beer, Faul, Pistorius and Van Vuuren (1996) divide financial ratios into four groups:

- Profitability or rate of return
- Liquidity
- Solvency
- Financing structure

Gitman (1997) states that Liquidity, Solvency and Financing structure ratios primarily measure *risk*, while profitability measures measure *return*. Siropolis (1994) depicts these groupings in Figure 4.1.

FIGURE 4.1
SELECTED KEY RATIOS IN FINANCIAL ANALYSIS



(Source: Siropolis, 1994)

There are many measures of profitability, each relating the returns of the company with its sales, assets, equity or share value. As a group, these measures allow analysts to evaluate the firm's earnings with respect to a given level of sales, a certain level of assets, the owner's investment, or share value. Gitman (1997) states that, without profits, a firm could not attract outside capital. Moreover, present owners (the Government in Transwerk's case) and creditors would become concerned about the company's future and attempt to recover their funds. Owners, creditors, and management pay close attention to boosting profits due to the importance placed on earnings in the marketplace. In Transnet's case, returns must be large enough to attract buyers for units that must be sold (Sikakhane, 1998).

According to Siropolis (1994), the best yardstick for assessing return is called return on investment (ROI). It is computed by dividing net profit by investment. Siropolis (1994) explains the purpose of ROI calculations very simplistically:

"ROI tells entrepreneurs how many cents they earn in a year for each dollar of investment, in the same way that an interest rate tells savers how much they earn for each dollar savings at a bank".

Investment (according to Siropolis, 1994) can be defined in three different ways:

- Total assets
- Owner's equity
- Permanent capital

In other words, an investor may compute three different ROI's, depending on what he wants to measure:

- **Return on total assets** is computed by calculating profit before interest and taxation (operating profit) as a percentage of average total assets. This yardstick measures the overall effectiveness of management in generating profits with its available assets, irrespective of the sources of funds. In addition to shareholders, sources of money may include short-term creditors such as suppliers, and long-term creditors such as banks (Flynn & Weil, 1991; Gitman, 1997; Siropolis, 1994).
- **Return on owner's equity** measures the return earned on the owner's (both preferred and common stockholders') investment in the firm. The ratio is computed by calculating net profit after tax as a percentage of stockholders' equity (Gitman, 1997)
- **Return on permanent capital** is computed by calculating net profit after tax as a percentage of the sum of owner's equity and long-term liabilities (Gitman, 1997). In Transnet's case, operating profit is used instead of net operating profit, due to tax exemption (Greeff et al., 1999).

The particular measure used by Transnet, as determined from published Group results (Ernst & Young, 1997), is Return on permanent capital. The formula for the calculation of this ratio is provided below (Gitman, 1997; Siropolis, 1994; Flynn & Weil, 1991):

$$\text{ROI} = \frac{\text{Earnings Before Interest and Tax}}{\text{Fixed Assets} + \text{Net Working Capital}}$$

or

$$\text{ROI} = \frac{\text{Earnings Before Interest and Tax}}{\text{Owner's Equity} + \text{Long Term Loans}}$$

The reason that the same ROI can be calculated using Fixed Assets plus Net Working Capital or Owner's Equity plus Long Term Loans is found in the Accounting Equation. This equation is used to describe the financial position of an organisation, and postulates that

- assets equals liabilities plus owner's equity, or that
- net worth equals assets less liabilities and
- net worth equals owner's equity.

Thus, irrespective of which option is used, the same ROI can be calculated (Flynn et al., 1996). For the purposes of this study, the first option (using fixed assets and Net Working Capital) would be most beneficial to use as the basis for the discussion. The effects of Lean Production practices on the items associated with Net Working Capital (e.g. Stock) and Fixed Assets can be most clearly demonstrated in this way.

4.2.3 Information required for the calculation of ROI (return on permanent capital)

As indicated earlier, Gitman (1997) stated that the Income Statement and the Balance sheet of a company are needed to calculate ROI.

4.2.3.1 Income Statement

The Income Statement provides a financial summary of an organisation's operating results during a specified period. The construct "Operating Profit" or "Earnings Before Interest and Tax" (EBIT) is obtained from this statement (Gitman, 1997).

Faul et al. (1996) state that the income statements for various concerns (e.g. trading and manufacturing) follow similar patterns, but they differ to some extent to reflect the specific nature of each type of operation. In the case of a manufacturing concern, costs would for example include

- Raw material used for production, while trading concerns buy and sell finished products
- Direct and indirect labour
- Partially finished products

- Production overheads like indirect material, power consumption, plant maintenance, factory rental, factory insurance
- Cost of Finished Goods

An example of an income statement for a manufacturing concern is presented in Figure 4.2.

FIGURE 4.2
EXAMPLE OF AN INCOME STATEMENT FOR A MANUFACTURING CONCERN

XXX MANUFACTURERS		
INCOME STATEMENT FOR THE YEAR ENDED 31 MARCH 1999		
	<u>1998</u>	<u>1999</u>
Sales revenue	100 000	135 000
<i>Less: Cost of goods sold</i>		
Fixed cost	40 000	40 000
Factory rent	15 000	15 000
Electricity and Water	5 000	5 000
Maintenance to Factory	15 000	15 000
Insurance on Factory	5 000	5 000
Variable cost (.40 X Sales)	40 000	54 000
Labour	20 000	29 000
Material	20 000	25 000
Gross profits	20 000	41 000
<i>Less: Operating expenses</i>		
Fixed expense	5 000	5 000
Variable expense (.05 of Sales)	5 000	6 750
Operating profits (EBIT)	10 000	29 250
<i>Less: Interest expense (all fixed)</i>	1 000	1 000
Net profits after taxes	9 000	28 250
<i>Less: Taxes (.15 X net profits before taxes)</i>	1 350	4 238
Net profit after taxes	7 650	24 012

(Faul et al., 1996; Gitman, 1997)

Since this study is focused on production environments, the income statement discussion below will reflect the characteristics found typically in manufacturing concerns.

- **EBIT** is calculated by subtracting Costs from Income. Faul et al. (1996) categorises manufacturing costs as *material, labour and manufacturing overheads* like energy,

depreciation and bought-in services (see example above). Costs can (from a business management perspective) also be classified simplistically as either *Variable* or *Fixed Costs*. The allocation of costs to these categories may differ between firms – e.g. Labour may be a fixed cost for a large, traditional firm, while smaller firms using temporary workers may reflect it as variable cost (Gitman, 1997).

- Mohr (1997) defines **Variable Costs** from a microeconomic perspective as costs that can be altered in the short run (e.g. within one financial year). Cronje et al. (1997) define the same construct from an accounting perspective as costs that vary according to the volume of income generated – e.g. material costs normally increase if sales increase.
- Mohr (1997) and Gitman (1997) argue that **Fixed Costs** are a function of time, not sales volume, and state that it is normally contractual – rent is, for example, normally reflected as a fixed cost. Cronje et al. (1997) define the construct as the portion of total costs that remains unchanged – within the boundaries of a fixed production capacity – regardless of an increase in the quantity of goods produced.
- **Total costs** involved in the production of a specific number of products in a given period consist of the total fixed costs plus the total variable costs incurred during the period.

4.2.3.2 Balance Sheet

Faul et al. (1996) state that the balance sheet can be considered as an “instantaneous photograph” of the *financial position* of an enterprise in terms of:

- the **assets** belonging to the entity at that specific time
- the **liabilities** of the entity
- the difference between the assets and liabilities which represents **the net worth or owner's equity**

4.2.3.2.1 Assets

In an accounting sense the term asset is used to refer to something which has value, since value can be derived from it. The term also refers to any right to value. The term “asset” therefore refers to something that can be used or consumed in the future to generate value. Assets are classified, according to their nature, as either *fixed* or *current* assets (Faul et al., 1996).

- **Fixed Assets** are assets that have a lifespan longer than the normal operating cycle of an entity. Alternatively, where the operating cycle is less than a year, fixed assets have a lifespan of more than a year. The term *operating cycle* refers to the cycle which begins with the start of normal business activities (e.g. buying raw material) until the conclusion (cash is received for goods sold) thereof. Fixed assets are according to Faul et al. (1996) those possessions of an entity, which enable it to operate, e.g. land and buildings, machinery and equipment, and vehicles. Fixed assets are *depreciated*, and the depreciation costs are reflected in the income statement. This transaction is also recorded in an accumulated depreciation account on the balance sheet, and affects the cashflow of the organisation.
- **Current Assets** consist of cash and all other assets which can reasonably be expected to be realised into cash or to be consumed within the normal operating cycle of a business (Faul et al., 1996). Examples of items normally reflected as Current Assets include cash, stock (including raw materials, components and finished goods), work in progress (partially finished products) and debtors (amounts owing to the entity) (Gitman, 1997). The current or short-term assets listed above operate together in the organisation's business cycle or operating cycle:
 - Cash is converted through purchases into Stock followed by Work In Progress and again into saleable Finished Goods
 - Finished Goods are transferred into credit sales and then into debtors
 - Debtors are converted into cash when accounts are settled, completing the cycle

4.2.3.2.2 Liabilities

In an accounting sense the term *liability* is used to refer to the sources of funds used to finance assets. Faul et al. (1996) explain that, if an entity owns assets, they must have been obtained through the usage of funds obtained from a specific source – hence the term “sources of funds”. Sources of funds are thus basically parties having an interest in the entity's assets – owners to the extent of owner's equity and creditors to the extent of liabilities. This basic principle forms the basis for the **basic accounting equation** referred to earlier:

ASSETS = OWNER'S EQUITY + LIABILITIES
--

Gitman (1997) distinguishes between short-term (current) and long-term liabilities.

- **Current liabilities** are basically short-term liabilities which are expected to be converted into cash within one year or less (Gitman, 1997). Faul et al. (1996) list the following examples of current liabilities:
 - Trade creditors
 - Bills payable
 - VAT payable
 - Current portion of long-term liabilities
 - Arrear or accrued liabilities
 - Provisions (estimated obligations)
- **Long-term liabilities** or **fixed liabilities** differ from current liabilities in that they do not fall due within the current financial year (Faul et al., 1996; Gitman, 1997). Examples of long-term liabilities:
 - Loans and mortgages
 - Debentures
 - Suspensive sale creditors
 - Lease contracts
 - Inter-company loans

4.2.3.3 Net Working Capital

In the discussion above, it was demonstrated that the calculation of the Return On Investment (Return On Permanent Capital) of a business requires:

- **EBIT**, which is obtained from the Income Statement, and is calculated by subtracting variable and fixed costs from revenue
- **Fixed Assets**, which are obtained from the Asset portion of the balance sheet
- **Net Working Capital**, which is obtained by subtracting total Current Liabilities (Liability portion of the balance sheet) from total Current Assets (Asset portion of the balance sheet).

Net Working Capital is commonly used as measure of an entity's overall **liquidity**. When current assets exceed current liabilities, the entity has a positive net working capital. Under these (most common) circumstances, net working capital can also be defined as the portion of an organisation's current assets financed by long-term funds – i.e. the sum of long-term debt and stockholders' equity – that are in excess of financing requirements

of the firm's assets. Current (short-term) liabilities represent the entity's sources of short-term funds, therefore, as long as current assets exceed current liabilities, the amount of the excess must be financed with long-term funds (Gitman, 1997).

When current assets are less than current liabilities, an organisation has a negative net working capital. In this (less common) case, net working capital represents the portion of the entity's fixed assets financed by current liabilities. This conclusion is derived (according to Gitman, 1997) from the basic accounting equation provided earlier.

In general, entities are in a better position to pay their bills as they fall due when there are higher levels of current assets over current liabilities. This relationship stems from the conversion cycle in which cash is used to buy stock, representing the usage of cash. Cash outlays are commonly far easier to predict and anticipate than cash inflows. Because most organisations are unable to make an exact match of cash inflows to outflows, current assets that more than cover current liabilities are usually necessary. Stated in a different manner, some portion of current assets are usually financed by long-term funds (Gitman, 1997).

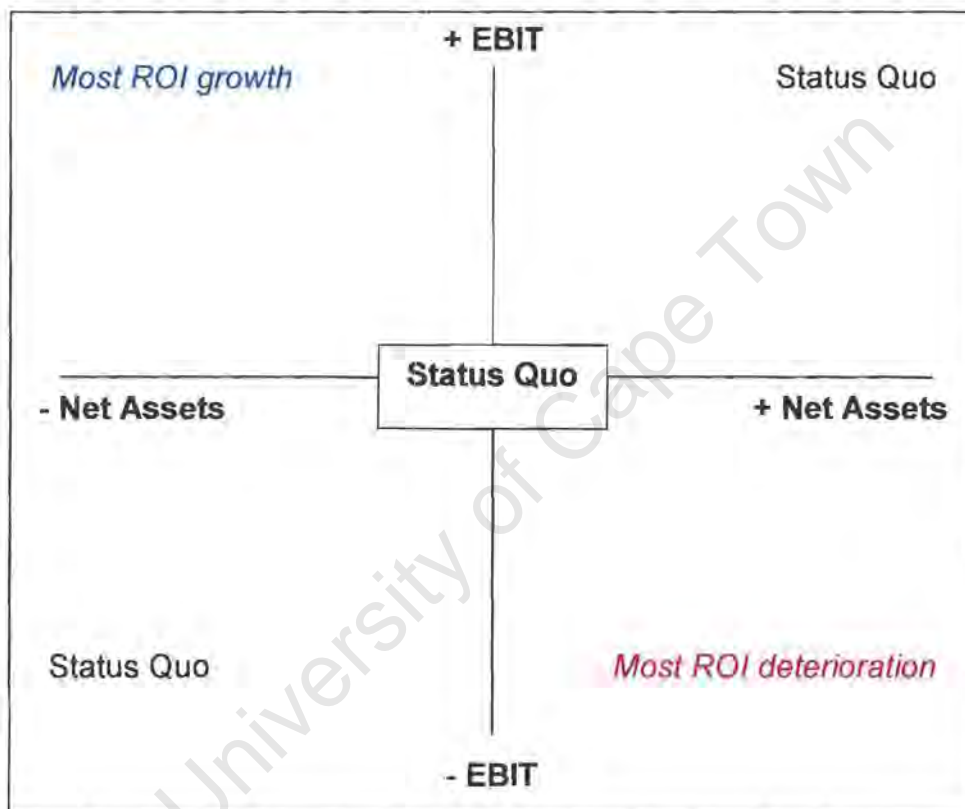
4.2.4 Improving ROI (return on permanent capital)

As indicated earlier, Government needs Parastatals to improve their performance – in the case of Transwerk specifically ROI. Adendorf and De Wit (1997) and Siropolis (1994) indicate that this can be achieved in various ways:

- The same Net Assets (Fixed Assets plus Net Working Capital) of a company can be utilised in a more productive way to generate a larger operating profit
- The same profit must be generated by a lower level of Net Assets (Fixed Assets plus Net Working Capital)
- The value of Net Assets (Fixed Assets plus Net Working Capital) can be increased to generate much more operating profit
- Less Net Assets (Fixed Assets plus Net Working Capital) can be utilised to produce more operating profit.

Figure 4.3 shows that in fact any combination of changes involving a larger proportion of EBIT to Net Assets will increase Return On Investment (Adendorf & De Wit, 1997; Gitman, 1997).

FIGURE 4.3
VARIOUS STRATEGIES TO INCREASE ROI



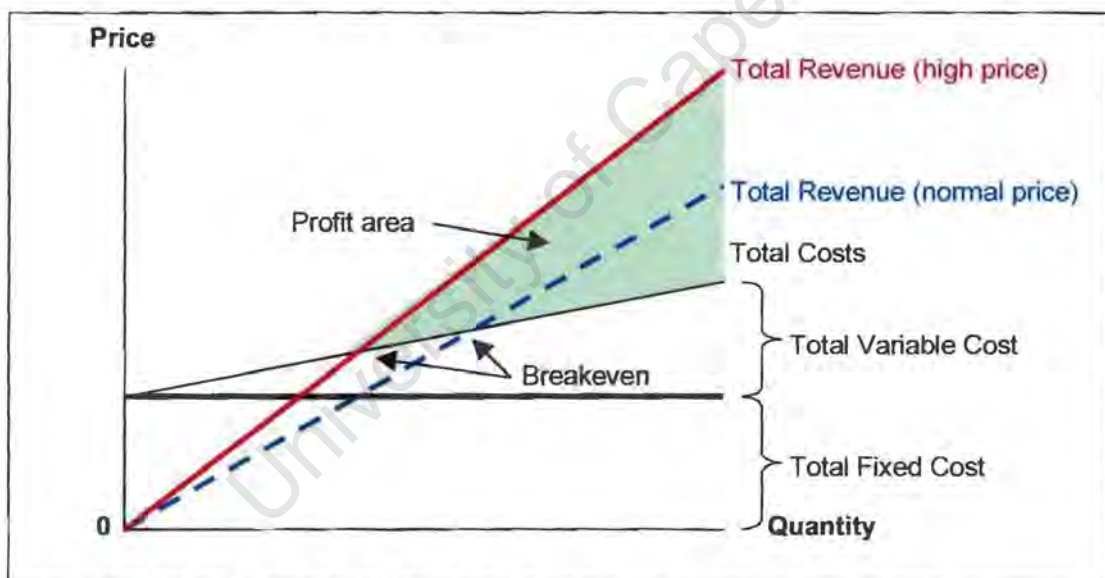
(Adapted from Adendorf & De Wit, 1997; Gitman, 1997)

Changes in ROI form the basis for changes in EBIT, Net Working Capital and Fixed Assets as was discussed above. The factors influencing changes in the last three constructs themselves were, however, not explained, and consequently receive attention now:

- **EBIT or Net Operating Profit** is calculated by subtracting Fixed and Variable costs from Income/Revenue/Sales. To increase EBIT, the following actions can be taken:

- Increase Sales by increasing prices. The assumptions of this strategy are that Price elasticity of demand = 0 (i.e. customers will buy a given quantity of the product irrespective of price), Fixed Costs and Variable Costs are kept exactly the same, while Revenue increases. As the difference between Revenue and Cost increase, EBIT increases as a result of a *shift* of the revenue curve. Figure 4.4 shows how the gradient of the Total Revenue curve increase as price increases. The same Quantity of goods is sold at a higher price, thus costs remain constant. The increase in profit is the difference between the Total Revenue at the normal price and the Total Revenue at the higher price (Adendorf & De Wit, 1997; Cronje et al., 1997; Mohr et al., 1997).

FIGURE 4.4
INCREASING PROFIT BY INCREASING PRICE

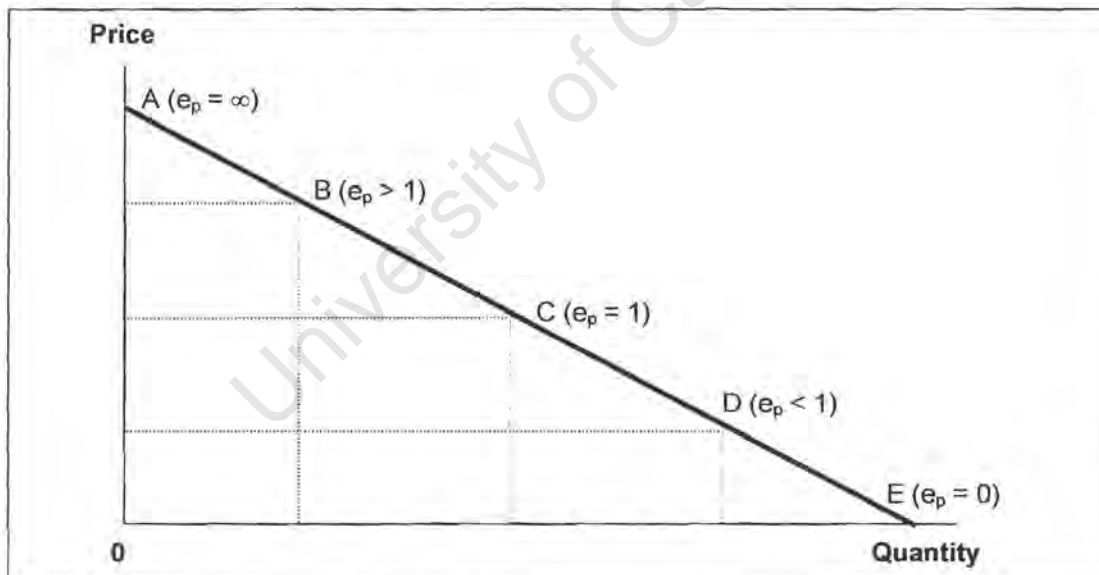


(Adapted from Cronje et al., 1997 and Mohr, 1997)

According to Mohr (1997), this approach is unlikely to succeed in practice, since customers are normally (depending on the product) sensitive to price changes, and merely buy similar products elsewhere at a cheaper price. Even in Monopolies, customers have limited resources, and would rather purchase less of a product than pay more for the same quantity of products as they bought at the lower price.

The interaction process between price, quantity and customer sensitivity to price described above is presented diagrammatically below. In a perfectly elastic market where price elasticity equals infinity ($e_p = \infty$) as at point A below, even the slightest change of price will cause customers to stop buying the product. At the other extreme, where price elasticity is equal to zero ($e_p = 0$) as at point E, customers will buy a fixed amount of the product irrespective of price. At point C, the percentage change in price will lead to an equal proportion change in demand in the opposite direction – e.g. 10% price increase leads to 10% less demand, while 10% price reduction leads to 10% more sales. At point B, elasticity is larger than one – i.e. if prices increase by 10%, demand decreases by more than 10%, while at point D, the percentage change in demand is less than the percentage change in price.

FIGURE 4.5
THE RELATIONSHIP BETWEEN PRICE, QUANTITY AND DEMAND



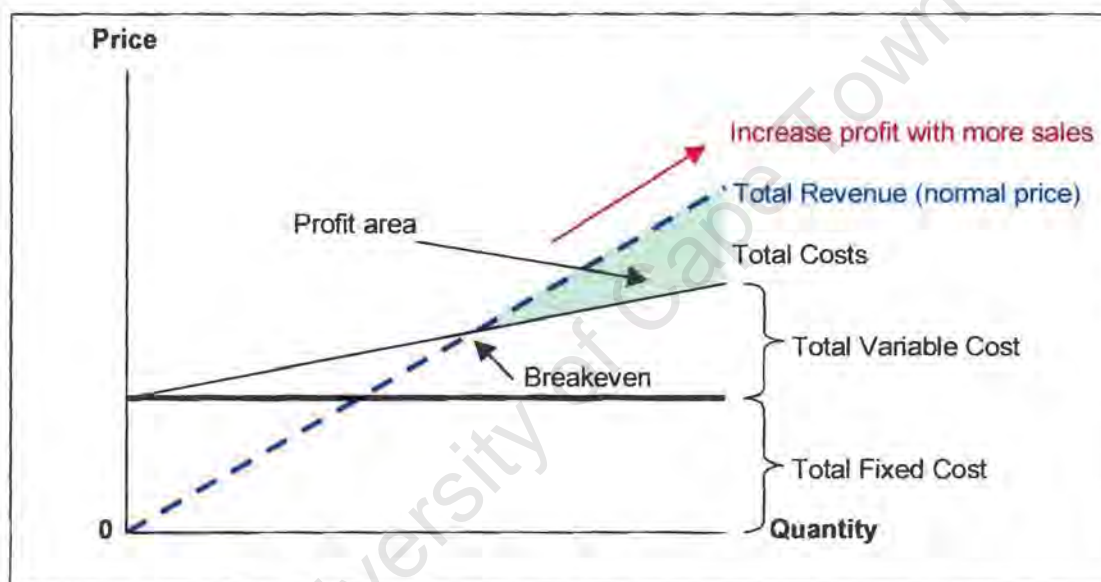
(Source: Mohr, 1997)

- A second approach to improvement of EBIT is to Increase Sales by trying to sell more of a given product at the same price, and benefit from economies of scale (Cronje et al., 1997). In the Cost-volume-profit figure described above, this strategy presents a **movement along** the revenue curve, and not a shift

in the curve as with the previous strategy. Although this strategy is more viable than the previous one, Mohr (1997) has reservations about the market circumstances ruling specific industries – especially where competition exists in a market. Aspects like brand loyalty, price wars by competitors, fluctuations in the interest rate and, of course, price elasticity of products and customer's budget constraints have unpredictable effects on this strategy.

FIGURE 4.6

PROFIT IMPROVEMENT WITH A MOVE ALONG THE REVENUE CURVE



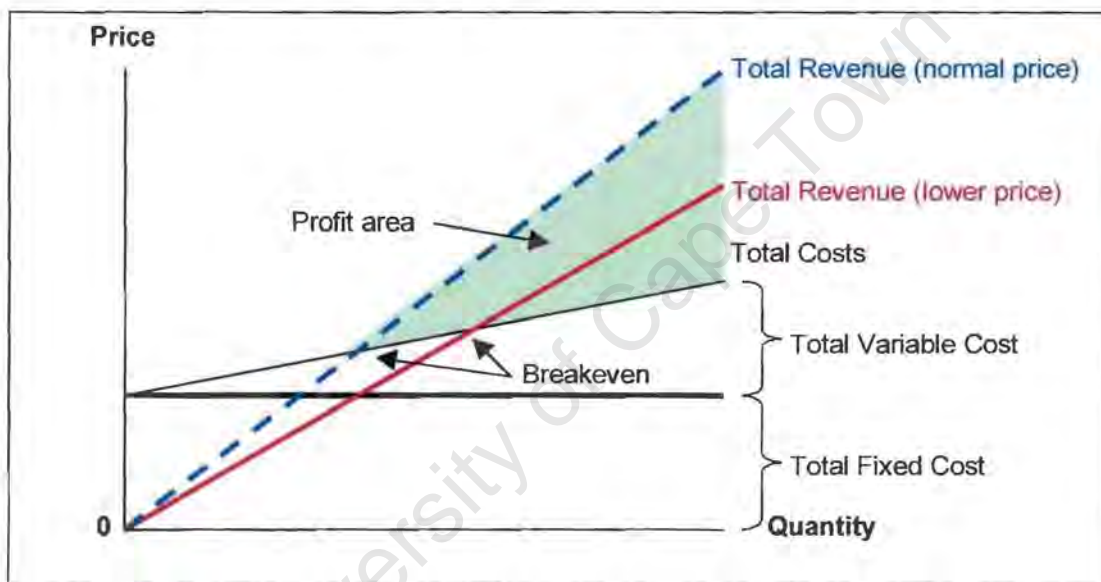
(Adapted from Cronje et al., 1997 and Mohr, 1997)

In Figure 4.6 above, a movement from breakeven point right and upward along the revenue curve will result in the increase in profit.

- Another profit improvement via Sales-increase strategy is to lower prices and benefit from economies of scale. This strategy (like the first strategy discussed above) assumes some degree of elasticity – mainly unitary elasticity ($e_p < 0$) or elastic demand ($e_p < 1$). This strategy also represents a shift in the Total Revenue curve, since prices are lower, and the slope of the curve is thus reduced. The shift in the revenue curve referred to above is depicted in Figure 4.7 by the difference between the solid revenue line labelled normal price, and the broken revenue line labelled lower price. The

smaller profit obtained by selling larger quantities should in this instance be compared to the benefit of possibly obtaining the same profit with higher prices and less units sold. A decision to lower prices to attract more revenue should thus be based on a thorough knowledge of the price elasticity of demand as well as other factors influencing buying behaviour (Cronje et al., 1997; Mohr, 1997).

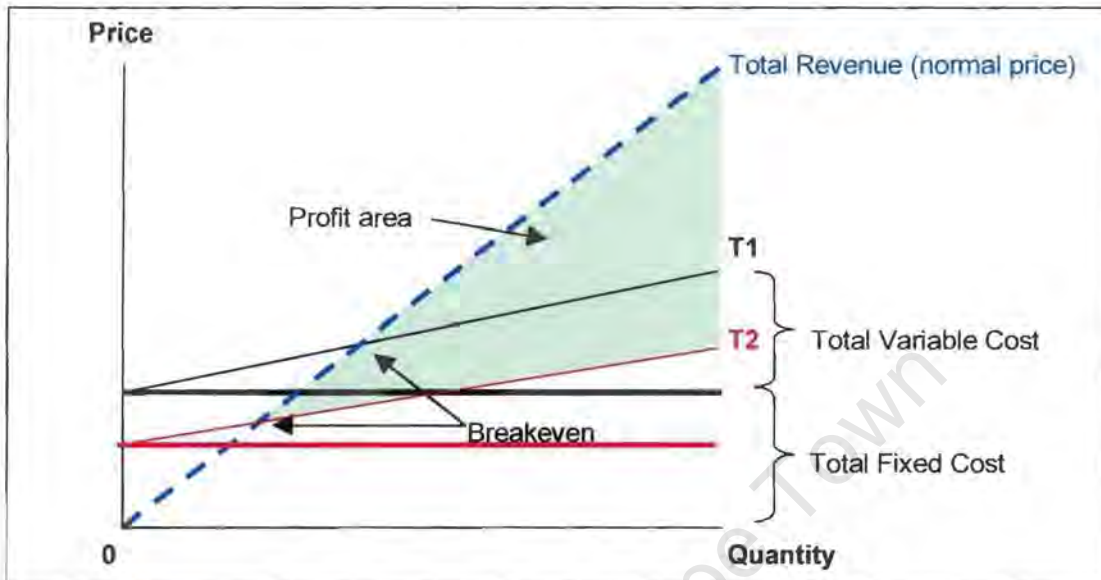
FIGURE 4.7
OBTAINING HIGHER TOTAL REVENUE AND PROFIT WITH LOWER PRICES



(Adapted from Cronje et al., 1997 and Mohr, 1997)

- Profit Increase via Cost Reduction is the strategy pursued by Lean organisations. According to this strategy, profit is increased mainly via the elimination of waste that contributes to superfluous operating costs.

FIGURE 4.8
PROFIT INCREASE BY COST REDUCTION



(Adapted from Cronje et al., 1997 and Mohr, 1997)

The effect of the reduction in cost on profit is represented by the shift of the cost curve from T1 to T2 in the figure above (Adendorf and De Wit, 1997 and Monden, 1998). The cost reduction goal and the effect thereof on ROI are discussed in more detail in the next section.

- **Net Working Capital** can (like EBIT) be changed in a multitude of ways. To improve ROI (return on Permanent Capital), Net Working Capital (N.W.C.) must be reduced. The reduction of N.W.C. can either be achieved by the reduction of Current Assets while Current Liabilities remain the same, an increase in Current Liabilities while Current Assets remain the same, or a simultaneous reduction or increase of both elements in the explained proportions. Since the purpose of this discussion is only to list some elementary strategies to reduce Net Working Capital, the complex field of Working Capital Management will not be discussed in its entirety.

Some of these elementary options are portrayed in Table 4.1:

TABLE 4.1
WAYS TO REDUCE NET WORKING CAPITAL

CURRENT ASSETS	CURRENT LIABILITIES	EFFECT ON NWC	EFFECT ON ROI
↓	⇒	↓	↑
↓↓	↓	↓	↑↑
⇒	↑	↓	?
↑	↑↑	↓	?
↓	↓↓	↓	↑

Legend:

↓ : Decrease
 ↓↓ : Large decrease
 ⇒ : Little/no change
 ↑ : Increase
 ↑↑ : Large Increase
 ? : Effects uncertain.

(Source: Adapted from Adendorf & De Wit, 1997; Cronje et al., 1997; Gitman, 1997)

The specific approach chosen should however be linked to company objectives, since e.g. reductions in Current Assets to Current liabilities may be contrary to liquidity goals set by stakeholders (Cronje et al., 1997; Gitman, 1997)

- Reductions in Current Assets can be achieved by reducing the balance sheet elements listed as Current Assets, e.g. Stock, WIP, Finished Goods, Cash and Debtors
- Changes to Current Liabilities can likewise be achieved by the manipulation of items listed as Current Liabilities, e.g. Accounts Payable, Provisions, Accrued Liabilities etc.

As stated earlier, the listing of the above strategies is no attempt to describe activities like short-term financing or investment decisions normally associated with Working Capital Management. The discussion merely provides a basis for the discussion below regarding the effect of Lean Production practices on ROI.

TABLE 4.3
LEAN PRACTICES AND ROI SUMMARY

Subsystem	EBIT	N.W.C.	Assets	ROI
Material handling	More	Less	Less	More
Quality	More	-	-	More
Human	More	-	-	More
Suppliers	-	Less	-	More
Customer	-	Less	-	More

The overall effects of practices summarised above are verified by an extensive study by Rasch (in Liker, 1997). This researcher conducted a statistical analysis of data from 249 US based small suppliers of automotive component parts and looked at the aggregate relationship among various facets of lean manufacturing and performance outcomes. His results show convincingly that each of the major aspects of Lean is associated with improvements in performance. This research by Rasch (in Liker, 1997) supports the claims by Liker (1997) and Sihakane (1998) that the success by Japanese automotive manufacturers like Toyota and the recent cash-based success of Transnet can directly be attributed to the application of the major principles of Lean production (such as *just-in-time* management).

Also refer to the research summarised in the chapter on Lean Production, where various other research findings support claims that Lean Production practices lead to financial improvements.

4.4 Conclusion

In this chapter the ratio ROI was defined, and various strategies to improve ROI were listed. The Lean Production goal of profit improvement by waste reduction was described, and supportive research was provided. In the next chapter, the research methodology of the study is described, followed by a chapter in which results are interpreted and conclusions made regarding the effects of Lean practices by the case study plant on ROI.

5. Research Design

5.1 Introduction

In the previous chapters, the research problems and goals, as well as the independent (Lean production systems) and the dependent (financial performance as measured by ROI) variables of the research project were provided. In the current chapter, the research design for the project is briefly described.

5.2 The formulation of a hypothesis

Smit (1991) stated that scientific research begins with problem identification and formulation, followed by the formulation of a hypothesis. Since the theory of Lean Production and the operational measure (ROI) of constructs under investigation could be defined sufficiently, hypothesis testing was possible for the study (McCutcheon and Meredith, 1993: 239).

The problem statement was described in detail in Chapter 1, hence only the hypothesis formulation is dealt with in the current chapter.

The hypothesis formulated below, originated in:

- the postulations of Adendorf & De Wit (1997), Liker (1997) and Schonberger (1983) regarding the transferability of Lean production principles
- the research of Rasch (in Liker, 1997) on the relationship between Lean principles and financial performance
- various cases studies of businesses that experienced improvement in financial performance after the implementation of Lean principles (Campbell & Dyer, 1984; Dale & Regan, 1999; Liker, 1997; Monden, 1994)

Considering the background provided by the research and postulations above, the following null and alternative hypotheses were formulated in respect of this study:

For subquestion 1 and 2 (see paragraphs 1.2.3.1 and 1.2.3.2), two sets of hypotheses apply:

- The first test will be performed to determine whether the top ten practices identified by Transwerk respondents as important to a *South African Government owned Rail Refurbishing plant with a job production system* are similar to the most important Lean practices identified by other researchers (Meredith & Zhu, 1995).

H₀: The Lean production practices considered most important are not the same for respondents of the Transwerk Coach Repair plant at Bloemfontein and respondents in other studies.

H₁: The Lean production practices considered most important are the same for respondents of the Transwerk Coach Repair plant at Bloemfontein and respondents in other studies.

- A second test will be performed to establish whether a statistically significant proportion of the practices deemed as most important by respondents in the study of Meredith and Zhu (1995) can be implemented in a *South African Government owned Rail Refurbishing plant with a job production system*.

H₀: A significant proportion of Lean production principles as applied to repetitive manufacturing systems could not be implemented in the Transwerk Coach Refurbishing plant at Bloemfontein

H₁: A significant proportion of Lean production principles as applied to repetitive manufacturing systems could be implemented in the Transwerk Coach Refurbishing plant at Bloemfontein

For subquestion 3 (see paragraph 1.2.3.3):

H₀: Lean production principles applied to Job production systems do not lead to improved ROI

H₁: Lean production principles applied to Job production systems lead to improved ROI

The strategy and method of research is described next. During the discussion explanations on how the above hypotheses will be tested are provided.

5.3 Strategy and method of research

5.3.1 General

Whenever survey data is to be collected, there must be a decision as to the specific pattern or design which the data collecting will follow. Every scientist attempts to arrange the conditions of his research so that the data which are forthcoming will bear most effectively on the hypothesis he is attempting to test or to the information needs he is trying to fulfill (Festinger and Katz, 1966).

The activities involved in the preparation of the research design for this project are discussed in the next paragraphs.

5.3.2 Type of design

5.3.2.1 Design characteristics

Recently, there have been numerous calls for more empirical field-based research to be conducted in operations management. Knowledge of how operations systems work can be enhanced significantly through contact with the "real world" conditions that operations management models seek to describe. Case study research is a primary means of exploring field conditions (Flynn, Sakakibara, Schroeder, Bates and Flynn, 1990; McCutcheon & Meredith, 1993).

The *single case study* documents, in detail, the operations of a single plant. Contrary to the familiar anecdotal "success story" article, it provides a careful and detailed documentation of practices to be used as the basis for research. This may be used in conjunction with survey research, or some other type of comprehensive data gathering effort, to develop explanations for some of the findings on a more comprehensive basis.

In *multiple case studies*, detailed information is gathered at each of several sites, although the same information may not necessarily be gathered at each. Whatever is available at each site is documented, in as much detail as possible. In analyzing the

data, similarities and differences between the sites are noted and documented, to the extent possible. If enough cases are examined, limited statistical testing can be done. When the purpose of the multiple case study is theory building, confirmatory statistical analysis is not expected or desired. Multiple case studies can also be used for theory verification. Large samples are not necessarily required; in theory verification, one case can falsify a hypothesis. If there are enough cases, however, some forms of inferential statistical analysis are possible (Flynn et al., 1990).

In this study, the following apply:

- Comprehensive data were gathered for a single plant – i.e. the Transwerk Coach refurbishing plant at Bloemfontein
- Data collection included qualitative and quantitative data
- The performance of the plant (as measured by ROI) before, during and after the implementation of Lean Production principles was statistically analysed
- Using the same accounting measurements, the performance (ROI) of similar Transwerk plants in other cities (that did not implement Lean Production principles) was compared with the performance of the Bloemfontein plant over the same period (i.e. before, during and after the implementation of Lean Principles at Bloemfontein).
- Qualitative data was used to develop explanations for some of the findings on a more comprehensive basis
- Advocates of Lean Production theory claim that the principles of the theory can be applied successfully anywhere in the world and in any production environment. The statistical analysis of this study provided an answer to the question whether the implementation of Lean Production principles affected the ROI of a South-African Government owned Rail refurbishing plant (theory verification).

The design chosen for the project can thus be described as:

- A Single Case study. Although the study might be described as a Field study due to its size and design, the intensive investigation techniques used and the search for influencing factors are characteristic of case studies.
- Quantitative and controlled. The quantitative data collected for similar Transwerk plants in cities other than Bloemfontein were used for the control of secondary variance (see paragraph 4.3.6.3 below). No detailed comparison of *practices* between plants was involved. The departure point of the study is that the Lean

Production practices that are described and implemented are new to Transwerk's plant in Bloemfontein, and that no similar program was implemented in one of the other three plants chosen for statistical control (Flynn et al, 1990; McCutcheon & Meredith, 1993).

- Longitudinal: Data regarding the effect of an intervention was compared to historical performance on a month-by-month basis (Van der Walt et al, 1997: 150).
- Explanatory and descriptive: A hypothesis is tested and events and outcomes were described to allow other researchers to understand the process and environment.
- Deductive: The general theory of Lean Production was used as the departure point for an investigation into the effectiveness of the theory in a very specific environment – i.e. a South-African Government-owned Rail Refurbishing Plant with a Job production system. Furthermore, only one dependent variable (Return On Investment) was chosen for the study. The main purpose of the study was thus not to induce theory from one or multiple cases, but to investigate the application of an existing theory in a specific setting (Eisenhardt, 1989).

5.3.2.2 Evaluation of Case Study research

The lack of controlled conditions, carefully obtained objective measures and scientific rigor have limited the case study as a research tool. Yet the naturalistic and controlled characteristics have also made the case study a unique source of information that complements experimental research.

Figure 5.1 below contains a summary of the major advantages and disadvantages associated with Case Study research:

FIGURE 5.1

MAJOR ADVANTAGES AND DISADVANTAGES OF CASE STUDY RESEARCH

ADVANTAGES	DISADVANTAGES
<ul style="list-style-type: none">• Exploratory depth: Case study research is a primary means of exploring field conditions, and thus serves as a valuable link between operations theory and practice• One case can falsify a hypothesis• Phenomena can be studied in their natural setting and meaningful, relevant theory can be generated from the understanding gained through observing actual practise• Case studies serve as sources of techniques that can be used• Understanding: Rare occurrences can be studied using Case Study research methods• Case studies have motivational and persuasive value	<ul style="list-style-type: none">• Alternative explanations may be available for events in a specific case• Lack of controls: Case Studies may be contaminated with the subjectivity of a given researcher or a group of researchers• Conclusions from Case Studies cannot be generalised• Access and time constraints• Triangulation requirements• Unfamiliarity with procedures

(Flynn et al., 1990; McCutcheon & Meredith, 1993; Meredith, 1998; Smit, 1991)

In the context of

- the small sample used for this study, the opportunity exists to directly observe processes and use logic to deduce and infer relationships that could be overlooked when using more traditional rationalist research methods aimed at larger samples
- the numerous calls recently expressed for more empirical field-based research to be conducted in the Operations Management field (like in the “real world settings” of Case Studies),
- the potential of the triangulation approach to increase the accuracy of data via multiple data collection and comparison

the advantages of using the Case Study approach for this research project outweighed potential disadvantages listed in the table above (Eisenhardt, 1989; McCutcheon & Meredith, 1993; Meredith, 1998).

5.3.2.3 Role of the Researcher

According to Smit (1991), Case Study research can be grouped together with Field Studies and Field Experiments in the category *Naturalistic Observation*. Traditionally the roles of Researchers in Naturalistic Observation vary from (a) *pure observation and recording of events* in the one extreme to (b) *participation and observation* to (c) *manipulation and control of variables* at the other extreme.

In this study, the researcher is also the manager in charge of the plant under investigation, and thus technically manipulated variables that could influence the outcome of the study. The role of the researcher could thus best be described as that of *Observer Participant*. The following are advantages and disadvantages of researchers in the role of *Observer Participant*:

FIGURE 5.2

ADVANTAGES AND DISADVANTAGES OF RESEARCHERS IN THE ROLE OF OBSERVER PARTICIPANT

ADVANTAGES	DISADVANTAGES
<ul style="list-style-type: none"> • Realistic, practical and in-depth documentation of variables is possible based on the knowledge of the observer of the environment in which a study is conducted • No effects caused by the entry of an unknown researcher • No difficulty with the acceptance of an unknown researcher resulting in "Hawthorne-effects" and resistance • Observer has access to important information resources (e.g. reports, computer databases, minutes of meetings and Strategic Plans of the company) that "outsiders" cannot obtain 	<ul style="list-style-type: none"> • Since studies are usually conducted over long periods, researchers may leave the field they are studying before a given study is completed • Researchers may experience difficulty in retaining a theoretical perspective while working • Researchers may experience role confusion • Researchers are sometimes faced with ethical issues – e.g. if their research results may be disadvantageous to their teams/employers etc. • Workers interviewed may feel they are obliged to say what their manager wants to hear

(Adapted from Smit, 1991)

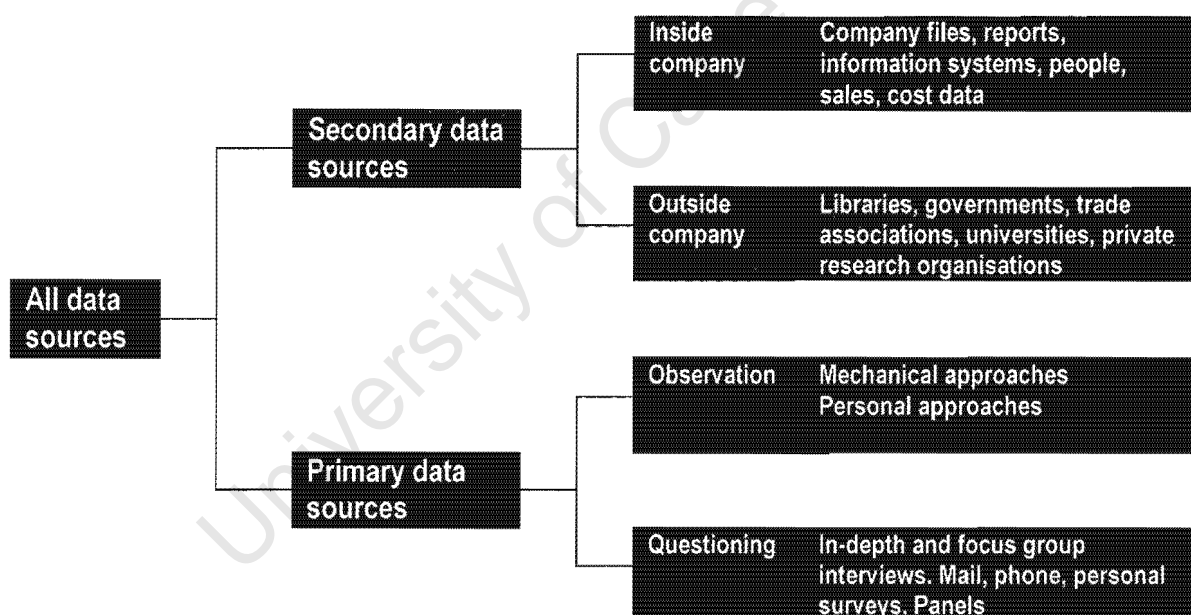
Since the *central question* of the study was answered after the statistical analysis of data obtained from *financial statements*, the validity and reliability of the study were not

affected by the *role* of the researcher as Observer Participant (see paragraphs 5.3.5.1.3, 5.3.5.2.3 and 5.3.5.3.3 below). It is only the explanatory comments obtained by interviews that could be biased to some extent due to workers being sensitive to the answers they provide. The normal restrictions applicable to Case Study research are, therefore, applicable to the data obtained from interviews.

5.3.3 Data Sources

True to the nature of Case Study research, data is collected from a multitude of sources. The figure below demonstrates potential sources of primary and secondary data:

FIGURE 5.3
SOURCES OF SECONDARY AND PRIMARY DATA



(McCarthy and Perrealt, 1996)

5.3.3.1 Primary Data

Primary data sources are generally used to collect information specifically needed to describe events and offer explanations in respect of statistical findings (McCutcheon & Meredith, 1993; Van der Walt et al, 1997). For the purposes of this study, primary data

was collected by means of a questioning technique (described below) used to generate explanations for statistical findings.

5.3.3.2 Secondary Data

Secondary data exist as historical data which have been collected before, either by the enterprise or by outsiders (McCutcheon & Meredith, 1993; Van der Walt et al, 1997). In this study, secondary data were collected from the following "Inside Company" sources:

- Financial statements were the source of data needed to compare ROI per plant *and* to explain possible reasons for differences between ROI in plants
- Monthly Management reports were used as sources for comments on possible factors influencing results per plant
- The Strategic Plans for the four Coach Refurbishing plants of Transwerk (from 1997 onwards) were used to (a) show that only the Bloemfontein plant embarked on the Lean Production route and (b) to identify systematic sources of variance influencing all plants
- The Tactical Plans of the Bloemfontein plant were used to perform a monthly comparison of ROI. The comparison was then used to explain the possible effects of elements of Lean Production as implemented during a given month on the ROI for that month (and onwards)
- Audit reports were used to highlight sources of waste (in Lean terminology) in the Bloemfontein plant
- Company Tender Rules were used to describe the specific conditions regulating purchasing in a Government-owned business
- Agreements with Labour were used to describe the conditions regarding workforce utilisation in a South-African Government-owned business
- Company policy on Outsourcing, Redundant Stock, Capital Investment, Asset Rationalisation, Risk (Loss Control and Safety), Data Equipment and Remuneration served as further sources for the description of conditions in a Government-owned business

Naturally, some sources contain confidential and even restricted information, and were only quoted to confirm statements made by the researcher.

5.3.4 Data Collection Method

As stated earlier, Case Study researchers typically combine multiple data collection methods. The rationale is that the triangulation made possible by multiple data collection methods provides stronger substantiation of constructs and hypotheses (Eisenhardt, 1989). In this study, two methods of data collection, i.e. the *Survey Approach* and the *Documentary Method* were combined to collect data on the constructs being studied.

5.3.4.1 The Survey Approach

The *Survey Approach* was utilised to collect the primary data for the project. A Survey approach involves the collection of problem-specific data from selected individuals (respondents) by way of direct or indirect questioning. This approach makes use of structured questions and response categories that allow the results to be quantified (Smit, 1991; Van der Walt et al, 1997).

An evaluation of the approach by Smit (1991) is summarised in Figure 5.4:

FIGURE 5.4

ADVANTAGES AND DISADVANTAGES OF THE SURVEY APPROACH

ADVANTAGES	DISADVANTAGES
<ul style="list-style-type: none">• Respondents are usually willing to cooperate with the researcher, and valuable information can thus be obtained with this approach• Information obtained in this way is normally relatively reliable. Aspects requiring clarification can be addressed during the interview with follow-up questions• Additional sources can be consulted to cross-check interview information• Spontaneous reactions can be observed directly• Delicate/sensitive questions (which are not suited to questionnaires) can be asked in a tactful way during the interview	<ul style="list-style-type: none">• Researchers must normally travel extensively to interview respondents, resulting in high cost• The method is time-consuming• Personal Bias and subjectivity by the interviewer may influence respondents• Supervision is required where a team of researchers is involved, since faulty and/or incomplete records are potential problems in team settings

(Smit, 1991)

For this study, the advantages depicted above seem to outweigh the disadvantages, since no travelling and no teamwork are involved during interviews. Furthermore, financial statements are normally expected to be reliable data sources.

5.3.4.2 The Documentary Method

The *Documentary Method* was utilised to collect the secondary data needed for the project. This method involves the analysis of written materials that contain information about phenomena being studied. The Documentary Method enables researchers to perform qualitative and/or quantitative data analysis. An evaluation of the approach by Smit (1991) is summarised in Figure 5.5 below:

FIGURE 5.5
ADVANTAGES AND DISADVANTAGES OF THE DOCUMENTARY APPROACH

ADVANTAGES	DISADVANTAGES
<ul style="list-style-type: none"> • Non-reactivity, which implies that respondents do not react to the research situation • Longitudinal analysis is possible • Large amounts of data can be scrutinised • Relatively low cost • Trends and patterns across cases can be identified 	<ul style="list-style-type: none"> • Subjectivity • Selective data capturing • Incompleteness • Availability • Sample bias • Codification problems • Lack of availability of uniform data • Inaccuracy

(Smit, 1991)

For this study, the following advantages apply:

- A longitudinal analysis was possible (ROI is measured on a month-to-month basis over a number of years)
- Large amounts of data could be scrutinised (compare all the sources of secondary data being used)
- Relatively low cost was involved, since all the data needed was at the disposal of the researcher for normal work activities

- Trends and patterns across cases could be identified (published case studies of other plants with Lean practices were used to explain events in conjunction with data obtained from primary sources).

Few (if any) of the disadvantages apply to this study. For example, Financial Statements are audited annually for completeness and accuracy, thus the Inaccuracy disadvantage is minimised.

5.3.5 Data Collection instruments

The questionnaire is the most common instrument for the collection of primary data (Van der Walt et al, 1997: 153). Primary data on the independent variable of the study (Lean Production) was collected by means of a self-designed questionnaire (Appendix B). Secondary data on the dependent variable (financial performance as measured by ROI) was obtained from financial statements of the plant under investigation. Several sources of qualitative data were employed to provide explanations and detail about findings, as well as for triangulation purposes (McCutcheon & Meredith, 1993). The instruments are discussed below.

5.3.5.1 Questionnaire on the perceived results of the implementation of Lean Production Principles

5.3.5.1.1 Composition of the instrument

This questionnaire (see Appendix B) consists of 24 items in Likert-scale format. Respondents were however encouraged to provide additional commentary where they felt necessary. They were assured of the confidentiality of responses.

5.3.5.1.2 Rationale for the inclusion of the instrument

The purpose of the survey was to understand and interpret the specific and concrete quantitative data through a qualitative assessment. Eisenhardt (1989: 538) comments on combining qualitative and quantitative evidence:

“the qualitative data are useful for understanding the relationships revealed in the quantitative data or may suggest directly theory which can then be strengthened by quantitative support”. With reference to theory building, she refers to

Mintzberg's (1979: 587) view that data may create the foundation for theories, but anecdotal data enable us to do the actual building, as the richness comes from the anecdote.

Some questionnaires of previous studies (e.g. the study of Wafa and Yasin, 1998) regarding the validation of Lean Production principles were available, but they were found to be only partially useable for this study due to the grouping and categorisation of variables.

Against the background of the partial usefulness of existing instruments for the investigation of a jobbing environment, the researcher adapted a questionnaire of Meredith and Zhu (1995) to enable respondents to evaluate the importance of practices on a Likert-scale format, instead of in pure categorical mode. The questionnaire was based on work of Guide and Spencer (1998) and Meredith and Zhu (1995), and included the 24 categories that these researchers found to be important for the success of Lean Production implementation in question format.

Data collected with the aid of this instrument was used to supplement and explain findings from the statistical analysis described below. This instrument thus enabled the researcher to answer the first two research questions of the study and to cross-validate the information used to answer the third research question of the study (Eisenhardt, 1989).

5.3.5.1.3 Reliability and Validity of the instrument

No statistical information regarding the reliability and validity of the instrument is available. It is, however, based on the research of Guide and Spencer (1998) and Meredith and Zhu (1995), and the validity of the questionnaire should be acceptable (see paragraphs 3.2.1 and 3.2.2). Although the face validity of the initial instrument was satisfactory in the opinion of the researcher, the methodology of Guide and Spencer (1995) was followed to increase face validity further.

These researchers used the following steps to compile their instrument on critical JIT components:

- a literature study was completed to identify theoretical JIT constructs to be measured

- the questionnaire was developed based on JIT constructs identified
 - the questionnaire was modified based on the experiences from a JIT case study
 - the modified questionnaire was presented to academics and practitioners involved with JIT so that face validity could be improved
 - the questionnaire was modified once more, and mailed to practitioners in plants
 - returns were analysed for use in the final statistical analysis
- (Guide & Spencer, 1995; Huysamen, 1988).

The researcher followed the same process as the above academics, and the final, modified questionnaire was used for this study.

5.3.5.2 Financial Statements

5.3.5.2.1 Composition

The financial statements used for this study included an Income Statement, a Balance Sheet, a Value-Add statement, a Profit Plan and a Returns summary. The information was presented on a month-by-month basis from April to March (the beginning and end of the Transnet financial year) for the financial periods 1996 to 1999. Budgets were available in exactly the same format.

5.3.5.2.2 Rationale for inclusion

Financial statements were basically the only data source from which longitudinal, quantitative information on Return On Investment (the dependent variable of the study) for the plants under investigation could be obtained. This information was used to perform the statistical analysis necessary to answer the third research question of the study. Data available on the statements was also used to explain some of the findings of the study in greater detail.

5.3.5.2.3 Reliability and Validity

Financial statements cannot be considered as data collection instruments, since they are compiled for other purposes. As documentary sources of quantitative information, however, their validity and reliability should be high. Financial statements are compiled according to universally accepted, standard principles. Furthermore, audits are performed regularly to verify results as reflected in statements. Findings and conclusions

based on a statistical analysis of information derived from Financial statements should thus (generally speaking) not be subject to serious objections regarding reliability and validity (Cronje, Du Toit, Mol and Van Reenen, 1997; Flynn and Weil, 1995; Smit, 1991).

5.3.5.3 Qualitative data

5.3.5.3.1 Composition

The various sources of qualitative data described in paragraph 4.3.3.2 above (Monthly Management Reports, Strategic and Tactical Plans, Audit Reports, Agreements and Company Policy) cannot be regarded as data collection instruments. They are however listed, since they served as sources of triangulation and explanation for events and findings that could not be explained from the survey and financial statements.

Since Monthly Management Reports form an important source of qualitative information in this study, a brief description is provided:

- Transwerk's Monthly Management Reports consist of financial statements and statistics provided by the Personnel-, Purchasing-, Risk- and Marketing departments. All statistics are obtained from the SAP system, an enterprise resources management computerised system. This means that information is standardised, for example: Purchasing statistics regarding material purchased from Affirmative Action Vendors and Stock purchased as reflected in financial statements are obtained from the same database.
- These reports are submitted by all Transwerk plants on a monthly basis for corporate reporting purposes, and explain deviations from targets and budgets. Planned corrective actions (for example reductions of material usage) are included if required.
- The managers in charge of plants write executive comments included in these reports. In the case study plant, the researcher thus writes these comments.
- Where executive comments fail to provide satisfactory explanations for deviations from targets and budgets, further investigations are conducted by higher level management, or by auditors.

In short, the mentioned reports are standardised and higher level management and auditors verify them. They should therefore provide trustworthy explanations with regards to events influencing figures.

5.3.5.3.2 Rationale for inclusion

As mentioned above, the qualitative data listed was used for triangulation purposes. Furthermore, these sources were needed to provide data for answering the first two research questions of this study.

5.3.5.3.3 Reliability and Validity

Although the face validity of the qualitative data used for the study is good, the concepts "validity" and "reliability" are more applicable to quantitative measurement instruments than to sources of qualitative data (Huysamen, 1995; Smit, 1991). See the elaboration on "Management Reports" in paragraph 5.3.5.3.1.

5.3.6 Sampling plan

5.3.6.1 Populations

In hypothesis-testing research, the concept of a population is crucial, because the population defines the set of entities from which the research sample is to be drawn. Also, selection of an appropriate population controls extraneous variation and helps define the limits for generalising the findings (Eisenhardt, 1989).

Two populations were involved in the current study:

- the population from which the case itself was chosen
- the population respondents that were interviewed regarding the perceived effects of Lean Production principles

The two populations are defined below.

5.3.6.1.1 Population of Cases

The population under scrutiny was South-African Government-owned enterprises in the Rail Refurbishing Industry with Job production systems. In South Africa, only one company (Transwerk, a Business Unit of Transnet) satisfies these criteria. Several units (distributed over 8 locations in South Africa) of Transwerk have Job production systems:

- Coach Refurbishing
- Locomotive Refurbishing
- Wagon Repair

- Maintenance units in all plants

Other units of Transwerk such as *Wagon Build* and *Manufacturing* have Job-lot and other systems, while Rail Refurbishing units such as *Union Carriage and Wagon*, *VICTRA*, *Dorbyl* and *Ubuntu* are not Government-owned. It is however possible that some of the results of this study may benefit all the above-mentioned parties to some extent.

5.3.6.1.2 Population Respondents

Populations targeted for questioning in similar studies were investigated before a population potential respondents were defined for the current study. A summary of the populations targeted in 5 studies is provided in Figure 5.6:

FIGURE 5.6
POPULATIONS TARGETED IN FIVE STUDIES REGARDING ASPECTS OF LEAN PRODUCTION PRINCIPLES

Researcher(s)	Study Focus	Target Population
Gupta and Sriparavastu, 1997	An empirical study of just-in-time and total quality management principles implementation in manufacturing firms in the USA	154 respondents from Top management, Plant Management and Middle Management
Das and Handfield, 1997	Just-in-time and logistics in global sourcing: an empirical study	108 American-based Purchasing managers
Guide and Spencer, 1995	An exploration of the components of JIT Case study and survey results	10 key managers from two factories
Bardi, Tan, Tracey and Vonderembse, 1995	Current purchasing practices and JIT: some of the effects on inbound logistics	268 purchasing managers who are members of NAPM
Boyer, 1996	An assessment of managerial commitment to lean production	202 managers from plants with memberships of FMA and CASA/SME

Based on the sample and population descriptions by the researchers summarised in the table above, the population potential respondents at the Transwerk Coach Repair plant at Bloemfontein were defined as employees involved in managerial activities. In this case, five individuals were identified from the functions Customer Service, Purchasing, Production (Coach section), Production (Paint section) and Engineering.

5.3.6.2 Sampling

5.3.6.2.1 Case Sampling

The researcher selected the case of the Transwerk Coach Repair plant at Bloemfontein mainly for practical reasons:

- information regarding the Production System of the plant was available to the researcher
- it was known to the researcher that the plant adopted a Lean Production strategy

5.3.6.2.2 Respondent Sampling

The emphasis in this study was to seek opinions and acquire insight into the perceptions of respondents. As Linz (1988: 179) has pointed out, in such situations:

“sample size is less important than are experience, competency and objectivity of participants ... the testimony of even a single expert informant on a particular topic is still valuable if treated with caution”.

The sampling procedure used for the study involved the *non-random* identification of all Managers at the Bloemfontein Coach repair plant of Transwerk. The group consisted of 5 individuals, who were all interviewed by the researcher. This type of sampling methodology is commonly used in the Operations environment, for example in the assessment of Quality Management Systems (Det Norske Veritas, 1994). The Hypothesis testing results were however not affected by sampling procedure, since the hypothesis was tested with data obtained from another source (financial statements).

5.3.6.3 Control

5.3.6.3.1 Secondary variance

In scientific research, control means several things. The researcher tries systematically to rule out variables that are possible *causes* of the effects he is studying other than the variables that he has hypothesised to be the *causes*.

Sources of *secondary variance* as a result of poor control, can be countered by the planning of research in the following ways:

- the elimination of factors causing variance

- the distribution of the effects of such factors
- the measurement of the effect of such factors

5.3.6.3.2 Secondary variance in the selected Case

The following sources of secondary variance could possibly contaminate the results of the study:

FIGURE 5.7
POTENTIAL SOURCES OF MAJOR SECONDARY VARIANCE IN THE SELECTED CASE

Variable	Effect
Some elements considered as "critical" for the success of Lean Production could not be implemented, while others had to be customised	Unknown.
Unprecedented high or low salary increases between different financial years	High increase: reduced ROI; Low increase: inflated ROI
Labour Law increasing the overtime rate	Artificially Reduced ROI
Extreme Depreciation of the Rand, leading to huge increases of imported material costs	Reduced ROI
Forced disposal of Slow-moving or Dead stock by Transnet EXCO	Reduced ROI
Price increases between Financial years differ	Huge increase: inflated ROI; Small increase: understated ROI

The elimination of the sources of secondary variance depicted in Figure 5.7 above, was an impossible task, since all of the factors listed are beyond the control of the researcher. Omission of elements affected was also not feasible, since all potentially affected figures on Financial statements are needed to calculate ROI.

The effect of the omission and customisation of Lean elements was measured in a qualitative way, and will be triangulated with data from various sources in the next chapter. The effects of the other variables could also be measured, but in a situation where various grades of workers receive differentiated pay increases, and where prices of thousands of material items are adjusted annually on an individual basis, the option was not practically possible.

The remaining alternative for control purposes was thus to distribute the effect of variables other than *the omission and customisation of Lean elements* by way of counterbalancing. In this study the effects of the sources of variance were counterbalanced by the selection of three similar plants to the plant selected for the case. The assumption was then made that the effects of for example high salary increases would affect all four plants equally. A comparison of changes in ROI between the plants will thus not be biased towards the results of one plant because of e.g. labour cost. If the past performance of the Bloemfontein plant was used as the only control measure to evaluate ROI improvement, results would be biased after, say, a huge pay increase between any two consecutive years (Smit, 1991).

Counterbalancing was therefore used to control the effects of the secondary variance for this study.

5.3.6.3.3 Secondary variance for Respondents

The constraints listed in the Figure 5.2 above containing disadvantages of researchers in the role of Observer Participant could also serve as sources of secondary variance in the case of respondents. This type of variance was controlled via the triangulation made possible by multiple data collection instruments. (Eisenhardt, 1989: 532-550; Guide and Spencer, 1995).

Figure 5.8 below contains a summary of the qualitative data used for the minimisation of secondary variance in survey results:

FIGURE 5.8

TRIANGULATION OF SURVEY DATA WITH QUALITATIVE DATA OBTAINED FROM VARIOUS SOURCES

SURVEY CATEGORY	TRIANGULATION SOURCES
Management of Physical Resources	<ul style="list-style-type: none"> Data on NOSA Star ratings, Housekeeping audits (obtained from Management Reports) as well as a comparison of "Bought-in" costs on Financial statements (of which Maintenance Costs are a major portion) between plants and years were used supplementary to survey questions regarding this aspect
Quality Management	<ul style="list-style-type: none"> ISO-audit reports and Management Reports were used to substantiate opinions regarding quality
Human Resources Management	<ul style="list-style-type: none"> Management reports (containing comments on Affirmative Action Training) and agreements regarding Job Demarcation were used to triangulate opinions regarding the importance of cross-skilling "Value-Added" statements (obtained from Financial Statements) and comments in Management Reports were used to cross-check opinions regarding capacity utilisation
The influence of JIT on Inventory Management	<ul style="list-style-type: none"> "Current Asset" levels in Financial Statements were compared with Marketing Comments in Management reports to determine whether Finished Goods were sold to clients in "takt time" Changes in Stock levels (obtained from Financial Statements) due to JIT awareness were compared to changes in the levels of stock in similar plants and Executive Comments in Management reports regarding Purchasing and Materials Management

(Eisenhardt, 1989; Guide & Spencer, 1995)

The commonly used Triangulation Method, therefore, served as a control for the effects of secondary variance for the survey data of this study. If respondents, for example, indicated that the *elimination of waste in capacity* contributed to higher ROI, the responses were compared to the "Value-Added" part of financial statements to verify improvements in capacity utilisation.

5.3.7 Processing, Tabulation and Analysis

5.3.7.1 Processing

Data from questionnaires as well as Financial Statements were computerised. Raw data was captured in Microsoft Excel. This served as the basis for the descriptive and

inferential statistical techniques that were applied in the Tabulation and Analysis steps below.

5.3.7.2 Tabulation

Data was summarised and grouped in various tables and graphs to include (broadly):

FIGURE 5.9
DESCRIPTIVE STATISTICS USED IN THIS STUDY

CONTENTS	PURPOSE
Table and Graph containing rates of change in ROI between plants over time	<ul style="list-style-type: none"> • To present a simple summary of <i>ROI changes*</i> between the Bloemfontein plant and control plants • To show trends over plants for the identification of possible sources of secondary variance
Tables and Graphs containing the rates of change in factors contributing to Operating Profit between plants over time	<ul style="list-style-type: none"> • Used for the generate explanations for inferential results obtained for this study in the context of changes in Operating Profit • To show trends over plants for the identification of possible sources of secondary variance
Tables and Graphs containing the rates of change in factors contributing to Net Assets between plants over time	<ul style="list-style-type: none"> • Used for the generation of explanations for inferential results obtained for this study in the context of changes in Net Assets • To show trends over plants for the identification of possible sources of secondary variance
Tables and Graphs containing Survey responses	<ul style="list-style-type: none"> • Used for the generation of explanations for inferential results obtained for this study in the context of changes in ROI • To <i>identify</i> components of Lean Production applicable to a Jobbing production environment • To show the <i>extent to which respondents agree</i> on the components of Lean Production applicable to a Jobbing production environment
Tables and Graphs containing data obtained from qualitative sources, survey data as well as Financial data	<ul style="list-style-type: none"> • Used to generate explanations in respect of inferential results obtained for this study in the context of changes in ROI • To identify components of Lean Production applicable to a Jobbing production environment • To triangulate results

* Note: Statistics are presented in "percentage changed from base year" format, because levels of indicators like ROI are currently a confidential issue for Transwerk (Greiff et al., 1999; Smit, 1991).

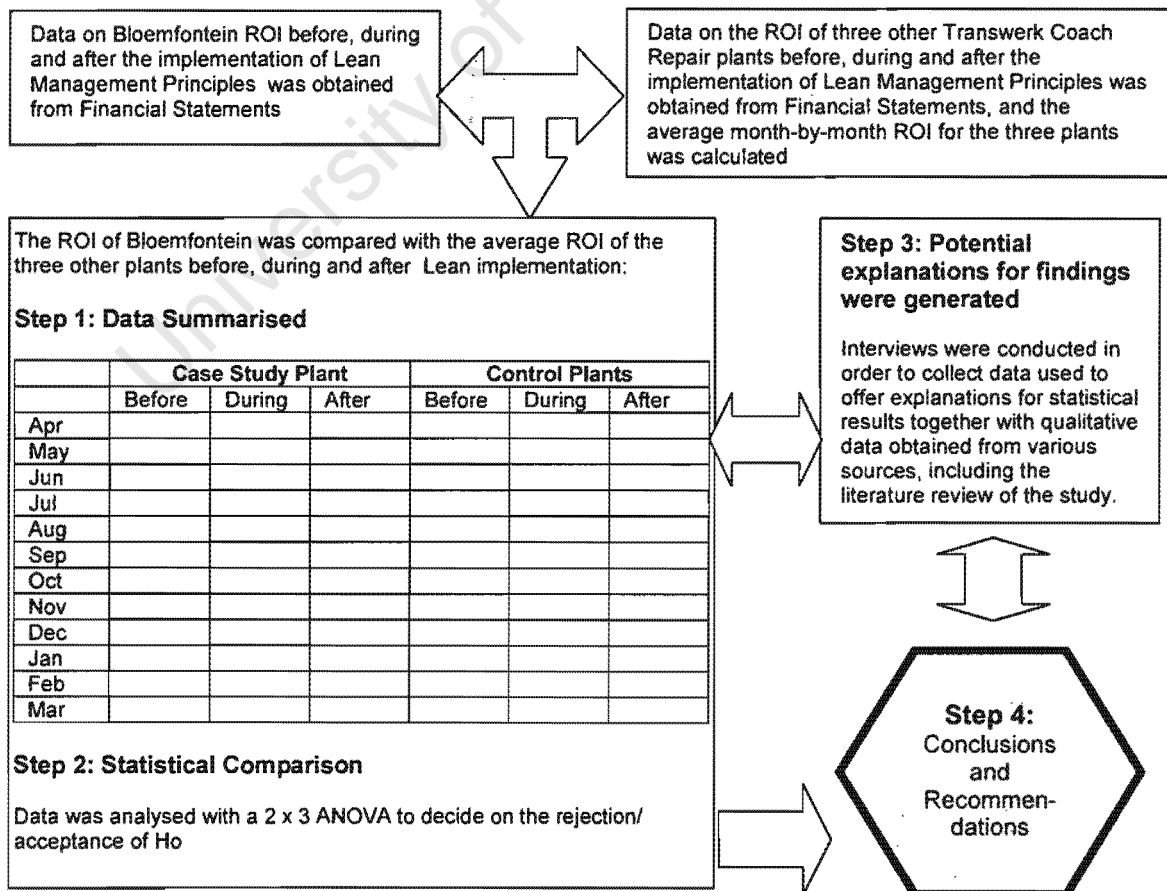
5.3.7.3 Analysis

The changes in *financial performance* (as measured by ROI) as a result of the implementation of the Lean production system were the core interest of this study. The tool chosen to analyse the problem is a 2 x 3 ANOVA, since the changes in ROI of the Bloemfontein plant were compared with the average ROI of three other plants before, during and after the implementation of Lean Management principles at Bloemfontein. A statistical significant difference on the $\alpha = 0.05$ level would lead to the rejection of the Null hypotheses, i.e. that the implementation of Lean production principles leads to an improvement of ROI in the Bloemfontein plant. The χ^2 test was chosen to evaluate questionnaire data regarding the transferability of Lean production.

5.3.8 Research process summary

The research process followed during the study is summarised in the flowchart below:

FIGURE 5.10
RESEARCH PROCESS SUMMARY



5.4 Conclusion

In Chapter 5 the research design of the study, as well as data collection approaches and instruments were described. The processing, tabulation, analysis and control procedures were provided next, while the chapter was concluded with the conditions that would lead to the rejection of the null hypothesis of the study.

The next chapter contains the statistical results obtained for the study, as well as possible explanations for results. The explanations were generated from the various qualitative sources described in Chapter 5 as well as the literature review of the study.

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6. Results and interpretation

6.1 Introduction

In this chapter, the results obtained for the study are presented and interpreted. The research questions posed for the study are answered, and the hypothesis formulated in Chapter 5 is tested according to the methodology described in this Chapter. Relevant findings are reported with the aid of various tables and graphs, and research reported during the literature study is used to make comparisons and generate potential explanations.

Results are presented according to the various constructs described during the literature study:

- Lean Practices as implemented at the Transwerk Coach Repair plant at Bloemfontein, as influenced by environmental factors (job production-, railway-, South African- and Government ownership environments)
- Financial outcomes (changes in EBIT, NWC, Fixed Assets and ROI) of the practices implemented

6.2 Lean Production in the Transwerk Coach Refurbishing plant at Bloemfontein

The gathering and analysis of data regarding Lean Production as (a) applied in the Case Study plant and (b) as influenced by the specific environments described during the literature study are aimed at answering the first two research questions of the study. Data presentation referring to the specific practices of importance to the plant under investigation is the starting point of the discussion, followed by a summary of factors

influencing the practices. The section on Lean Practices will conclude with the presentation of test results and the interpretation thereof.

6.2.1. Descriptive Statistics

Table 6.1 reflects the computed percentile ranks of Lean practices in the plant under investigation, according to perceived importance and from the list of practices by Meredith and Zhu (1995).

TABLE 6.1
PERCENTILE RANKS DENOTING THE RELATIVE IMPORTANCE
ASSOCIATED BY RESPONDENTS WITH THE LISTED LEAN PRACTICES IN
THE CASE STUDY PLANT

Element	Total Raw Score	Mean	σ	Lowest score	Highest score	Percentile ranks
Communication.	40	6.67	0.52	6.00	7.00	100%
Quality certificates from vendor.	39	6.50	0.55	6.00	7.00	96%
Relationship with supplier.	38	6.33	0.52	6.00	7.00	91%
In-house lot size.	37	6.17	0.75	5.00	7.00	87%
Vendor lead-time.	36	6.00	0.89	5.00	7.00	78%
JIT education.	36	6.00	1.26	4.00	7.00	78%
JIT champion.	35	5.83	1.47	4.00	7.00	74%
Flexibility.	34	5.67	1.03	4.00	7.00	70%
Sole sourcing.	33	5.50	0.55	5.00	6.00	61%
Schedule stability.	33	5.50	1.22	4.00	7.00	61%
Vendor lot size.	32	5.33	1.03	4.00	6.00	48%
Co-worker relations.	32	5.33	0.82	4.00	6.00	48%
Cross-training.	32	5.33	0.82	4.00	6.00	48%
Outside consultant.	28	4.67	0.52	4.00	5.00	35%
Flatten bill of materials.	28	4.67	2.25	2.00	7.00	35%
Investigate suggestions.	28	4.67	1.03	3.00	6.00	35%
Pilot project.	25	4.17	0.41	4.00	5.00	30%
Preventive Maintenance.	24	4.00	1.26	3.00	6.00	22%
Authority to stop lines.	24	4.00	2.45	1.00	7.00	22%
Top management commitment.	23	3.83	1.33	2.00	5.00	17%
Quality circles.	18	3.00	0.89	2.00	4.00	13%
JIT team.	9	1.50	0.55	1.00	2.00	9%
Group technology.	8	1.33	0.52	1.00	2.00	0%
Set-up time reduction.	8	1.33	0.52	1.00	2.00	0%

Table 6.1 was compiled by the statistical manipulation of questionnaires (see Appendix B), consisting of 24 Lean practices identified by Meredith and Zhu (1995). Respondents (see Chapter 5 for sample particulars) rated the importance of each practice for the success of Lean Production objectives in the case study plant on a 7-point Likert scale. Responses per question were summed, and various measures of central tendency and variability were used to analyse responses.

Next, approximating the methodology of Meredith and Zhu (1995), the ten items considered as most important by respondents from the Transwerk Coach Refurbishing plant at Bloemfontein were compared with the top ten items listed as most important from various sources by Meredith and Zhu (1995). Summary results are presented categorically in Table 6.2.

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TABLE 6.2

THE 10 MOST CRITICAL ELEMENTS PER DATA SOURCE FROM THE RESEARCH OF MEREDITH AND ZHU (1995) COMPARED TO DATA OBTAINED FOR THIS CASE STUDY

	<i>CR plant</i>	<i>Academic</i>	<i>Practitioner</i>	<i>Survey</i>	<i>Case study</i>	<i>Discussion</i>
Authority to stop lines.				X		
Communication.	X					X
Cross-training.		X	X	X	X	X
Flatten bill of materials.						
Flexibility.	X					
Group technology.		X	X	X	X	X
In-house lot size.	X	X	X			X
Investigate suggestions.						
JIT champion.	X					
JIT education.	X	X		X		X
JIT team.			X		X	X
Outside consultant.						
Pilot project.						
Preventive Maintenance.			X		X	
Quality certificates from vendor.	X	X	X	X	X	X
Quality circles.		X	X	X	X	X
Relationship with supplier.	X	X	X	X	X	
Schedule stability.	X					
Set-up time reduction.		X	X	X	X	X
Sole sourcing.	X					
Top management commitment.						
Vendor lead-time.	X	X	X	X	X	X
Vendor lot size.		X		X	X	
Worker relations.						

Table 6.3 contains a comparison of data gathered from the questionnaires (Appendix B) to data obtained from management reports and situational analyses in plans. The focus of Table 6.3 is to reconfirm (from alternative sources) the significance of practices listed as important by respondents.

TABLE 6.3

THE MOST CRITICAL LEAN ELEMENTS FROM THE RESEARCH OF MEREDITH AND ZHU (1995) COMPARED TO DATA OBTAINED FOR THIS CASE STUDY

Lean Practices	Questionnaires and literature		Reports and plans	
	Listed as most important by respondents in CR plant	Listed as most important in the research of Meredith & Zhu (1995)	Indicated as practical for CR environment	Not indicated as practical for CR environment
Authority to stop lines.		X		X
Communication.	X	X	X	
Cross-training.		X		X
Flatten bill of materials.				X
Flexibility.	X		X	
Group technology.		X		X
In-house lot size.	X	X	X	
Investigate suggestions.			X	
JIT champion.	X	X	X	
JIT education.	X	X	X	
JIT team.		X		X
Outside consultant.			X	
Pilot project.				X
Preventive Maintenance.		X	X	
Quality certificates from vendor.	X	X	X	
Quality circles.		X		X
Relationship with supplier.	X	X	X	
Schedule stability.	X		X	
Set-up time reduction.		X		X
Sole sourcing.	X		X	
Top management commitment.			X	
Vendor lead-time.	X	X	X	
Vendor lot size.		X		X
Worker relations.			X	

Data from Table 6.3 was used to perform calculations in the χ^2 tests below.

6.2.2 Inferential statistics

Two χ^2 tests were performed to answer the question about the transferability of Lean Production practices to the case study plant:

- The first test was performed to determine whether the top ten practices identified by respondents as important to a *South African Government owned Rail Refurbishing*

plant with a job production system are similar to the most important Lean practices identified by other researchers (Meredith & Zhu, 1995).

- The second test was performed to establish whether a statistically significant proportion of the practices deemed as most important by respondents in the study of Meredith and Zhu (1995) could be implemented in a *South African Government owned Rail Refurbishing plant with a job production system*.

The results for the first test are provided directly below in Table 6.4 which contains the raw data regarding the practices rated important in this study as well as the study of Meredith and Zhu (1995). Table 6.5 contains data regarding the expected frequencies for the test, and Table 6.6 contains the actual test results for the question.

TABLE 6.4
OBSERVED DISTRIBUTION

	<i>Bloemfontein</i>	<i>Literature</i>	
Most Important	6	15	21
Less Important	18	9	27
	24	24	48

TABLE 6.5
EXPECTED DISTRIBUTION

	<i>Bloemfontein</i>	<i>Literature</i>	
Most Important	10	15	25
Less Important	14	9	23
	24	24	48

TABLE 6.6
RESULTS

	<i>Bloemfontein</i>	<i>Literature</i>	
Most Important	1.60	0.00	1.60
Less Important	1.14	0.00	1.14
			2.74

χ^2 critical: 3.84 for $\alpha = 0.05$

The second test was (as indicated) performed to establish whether a statistically significant proportion of the combined range of 15 items listed by Meredith and Zhu (1995) could be implemented at the Transwerk Coach Refurbishing plant at Bloemfontein. Table 6.7 contains the raw data regarding the practices rated important in the study of Meredith and Zhu (1995) versus practices that could not be implemented. Table 6.8 contains data regarding the expected frequencies for the test, and Table 6.9 contains the actual test results for the question.

TABLE 6.7
OBSERVED DISTRIBUTION

	<i>Useful</i> <i>(Implemented)</i>	<i>Not useful</i> <i>(Abandoned)</i>	
Most Important	8	7	15
Less Important	7	2	9
	15	9	24

TABLE 6.8
EXPECTED DISTRIBUTION

	<i>Useful (Implemented)</i>	<i>Not useful (Abandoned)</i>	
Most Important	10	5	15
Less Important	6	3	9
	16	8	24

TABLE 6.9
RESULTS

	<i>Useful (Implemented)</i>	<i>Not useful (Abandoned)</i>	
Most Important	0.40	0.80	1.20
Less Important	0.17	0.33	0.50
			1.70

χ^2 critical: 3.84 for $\alpha = 0.05$

The expected frequency distribution for this test was not calculated using the marginal totals approach, but was determined according to the unequal expected frequency approach. It was assumed that (if asked to list the 10 most important Lean Practices), the practices of the Transwerk plant would fall within the range of the 15 items from the study of Meredith and Zhu (1995), and that it was possible to implement these practices.

6.2.3 Interpretation

Interpretations of the various figures and tables are presented below:

- The information contained in Table 6.1 indicates that the management of the Transwerk Coach Refurbishing plant at Bloemfontein considered communication, quality certificates by vendor, relationship with supplier, in-house lot size, vendor lead time, JIT education, JIT champion, flexibility, sole sourcing and schedule stability as the most important for their circumstances. The variability between the

responses of various respondents seems to be relatively low. Consider, for example, the minimum scores of 6 and 7 awarded to the top three items. The standard deviation for items seems to be low at between 0.52 and 1.47, while standard deviations of 1.37 are considered to be acceptable for behavioural sciences instruments (Hetherington, Smith & Stewart, 1984). This may be indicative of a great deal of consensus amongst respondents regarding the items which are of most importance in the Transwerk Rail Refurbishment plant at Bloemfontein.

- The information presented in Table 6.2 indicates that 6 of the 10 items considered to be important for the Transwerk plant coincide with data gathered by Meredith and Zhu (1995), i.e. communication, in-house lot size, JIT education, quality certificates from vendor, relationship with supplier, and vendor lead time. Some items considered as very important by respondents from the Transwerk plant (flexibility, JIT champion, schedule stability and sole sourcing) were not found to be critical by any of the sources used by Meredith and Zhu (1995). Furthermore, 6 items found to be of critical importance in their study were considered by respondents of the Transwerk plant as of peripheral importance to their situation. Examples include the authority to stop lines, cross training, group technology, Preventive Maintenance, set-up reduction, and vendor lot size.

Possible explanations for this situation can be found in the specific environments affecting the Transwerk Coach Refurbishing plant at Bloemfontein. These explanations were generated from management reports, audit reports and plans:

- Flexibility is considered to be of great importance for the plant under investigation due to the variety of models and purpose-made trains required by clients. Since annual sales are based on orders and/or contracts with customers, flexibility is essential. Work that cannot be done in one plant is offered to other plants, resulting in under-utilisation of capacity and redundancy.
- A JIT champion is considered to be of great importance for the plant under investigation, because it deals with resistance from managers, foremen, workers and suppliers.
- Schedule stability is important for the improvement of the accuracy of materials ordered. Currently the plant management has no influence on quantities and types of jobs delivered for refurbishing - despite an agreed-upon schedule. Since the MRP functions on a forecast, unnecessary material is often ordered if the

client does not send in coaches according to schedule. This material may remain in stock for long periods, and contributes to high Net Working Capital and low ROI.

- Sole sourcing is considered important for specific items, such as paint. In this case, the application of primers and topcoats from various suppliers on the same coach pose guarantee problems, since supplier A is not willing to guarantee his topcoat if applied with supplier B's primer. If many suppliers are used, varying quantities of paint in many colours multiplied by many suppliers accumulate in inventory, resulting in superfluous stock.
- Authority to stop lines is basically not applicable in this jobbing environment since independent artisans and their helpers perform manual operations on coaches dispersed over a large plant. A sudden stoppage on one coach or in one process such as Electroplating does not affect all other stations immediately, as in repetitive manufacturing. Furthermore, the goal of this approach (preventing mass production of scrap) is not applicable for jobbing, since little repetitive work (wherein the same mistake is repeated over and over) is performed.
- Cross training is a major obstacle under the job-class system applied in South Africa as in many Western countries, and although it could be very useful if implemented, could not be changed at plant level.
- Group technology (optimum machine arrangement aimed at workforce reduction) is basically not applicable to the Transwerk Coach Refurbishing plant at Bloemfontein. One or two large machines are used, while the majority of the work is performed manually with small air-driven handtools.
- Preventive Maintenance was not perceived to be of critical importance for the successful implementation of Lean Production practices at the Transwerk plant. With the exception of a few large items such as cranes and coach jacks, handtools are generally used, and new tools could be bought regularly for close to the cumulative amounts charged for PM's by the plant's maintenance section. The job-class system prevents operators from performing PM's to their own tools.
- Set-up reduction is, like some of the previously mentioned items, basically of no significant importance in the Transwerk plant under investigation, since artisans and helpers use small handtools requiring virtually no set-up to perform the majority of work during Coach repairs.

- Vendor lot-size is generally speaking of no significant importance in the Transwerk plant under investigation, since custom purpose items are only ordered as needed. In isolated cases, suppliers attach minimum order quantities, but this is the exception, not the rule.

The discussion above is summarised in Table 6.10. Problems are described briefly, and the origins of problems (environmental influence) are indicated.

TABLE 6.10
ORIGINS OF PROBLEMS THAT INFLUENCED THE IMPLEMENTATION OF
LEAN PRODUCTION PRACTICES IN THE CASE STUDY PLANT

LEAN PRACTICES	DESCRIPTION OF INFLUENCING FACTORS	ORIGIN OF PROBLEM	
		Location & owner	Production system & industry
Authority to stop lines.	Many independent workstations where manual tasks are performed by artisans & helpers.		X
Communication.	Multitude of jobs in various phases of production dispersed in huge plant complicates control and problem solving. To focus on same goals, all teams must be updated regularly; problems must be communicated timeously.		X
Cross-training.	Unions power and resistance. Wide scope of tasks from many rail-trades.	X	X
Flexibility.	Job-class system upheld by unions. Various rail-specific trades.	X	X
Group technology.	Many independent workstations exist where manual tasks are performed with small handtools. GT based on machine grouping.		X
Preventive Maintenance.	Job-class system upheld by unions, operators thus not allowed to PM machines. Small inexpensive tools with basically no set-up are used.	X	X
Schedule stability.	Unpredictable send-in rate unlike manufacturing where build-schedule can be predetermined.		X
Set-up time reduction.	N/A, since small handtools are used.		X
Sole sourcing.	Tender procedures in large companies.	X	
Vendor lot size.	Unpredictable number(s) of components complicates contracts and material usage forecasts. Vendors reluctant to pre-manufacture parts due to tender procedures.	X	X

- Table 6.10 shows that the Lean Production practices deemed "most important" by respondents, were also **implemented** in the environment of the Transwerk Coach Refurbishing plant at Bloemfontein – this is according to Management reports and situational analyses in business plans.
- The first Chi-square test (Tables 6.4 to 6.6 above) did not yield a statistically significant result, since the obtained χ^2 was 2.74 and the critical χ^2 value is 3.84 for $\alpha = 0.05$. The null hypothesis (assuming **different** sample proportions) is thus upheld.

The implication of this finding is that the proportion of Lean Practices **considered to be important** for the Transwerk Coach Refurbishing plant at Bloemfontein is statistically significantly different from the practices considered important in typical repetitive manufacturing environments.

- The second Chi-square test (Tables 6.7 to 6.9 above) did not yield a statistically significant result, since the obtained χ^2 was 1.70 and the critical χ^2 value is 3.84 for $\alpha = 0.05$. The null hypothesis (assuming **different** sample proportions) is thus upheld. The implication of this finding is that the proportion of Lean Practices that could be **implemented** at the Transwerk Coach Refurbishing plant at Bloemfontein is statistically significantly different from the practices considered important in typical repetitive manufacturing environments.

6.2.4 Previous Research and Literature

The discussion below will focus on the 24 elements of Meredith and Zhu (1995). Elements will not be discussed according to the systems model of Liker (1997), but rather according to the categories reported:

- Practices listed as important by both respondents to this study and the study of Meredith and Zhu (1995)
- Practices listed as important by respondents to this study but viewed as less important in the study of Meredith and Zhu (1995)
- Practices listed as less important by both respondents to this study and the study of Meredith and Zhu (1995)
- Practices listed as less important by respondents to this study but viewed as important in the study of Meredith and Zhu (1995)

References are made to the literature and appropriate research where applicable.

6.2.4.1 Practices listed as important by both respondents of this study and the study of Meredith and Zhu (1995)

The factors discussed below were found to be important by respondents of this study, as well as by Meredith and Zhu (1995).

6.2.4.1.1 Communication

- **Literature:** Liker (1997) and Monden (1998) have emphasised the importance of excellent communication in *Lean Production systems* in general. They emphasised (a) the communication of quantities of products to be produced between sales and production departments, (b) the communication of quantities of components (per production kanban) to be manufactured/assembled between processes in a plant, and (c) communication (electronic and per kanban) regarding materials to be delivered by suppliers to plants. Communication is thus perceived as an important aspect of Lean Production in the literature.
- **Research:** The work of Liker (1997) and Monden (1998) was reconfirmed by:
 - A study conducted by Meredith and Zhu (1995), during which Communication was denoted as extremely important for the success of Lean Production.
 - Wafa and Yasin (1998), who found in a survey of 15 plants that companies recommending Lean Production rate communication and information exchange with suppliers as critically important for the success of Lean purchasing and inventory management.
- **Conclusion:** Hendry (1998) states that communication in the form of up-to-date planning and control systems is crucial for the success of all types of companies. Her opinion (that this is especially true for jobshops, where “situational management” is difficult to achieve), is supported by the high importance given by respondents as reflected by the high scoring (Table 6.1 above) of this aspect. The kanban system used to communicate quantities required between processes and between suppliers and producers is however not always deemed practical in jobshops due to high variability and low quantities of materials used. Practices like visible communication on the shopfloor, combinations of MRP and production kanbans, Green Areas and “Work-to” lists as well as electronic data exchange, however, could enhance communication in jobshops (Adendorf & De Wit, 1997; Aquilano & Chase, 1989; Follower, 1999; Hugo et al., 1997).

6.2.4.1.2 Quality certificates by vendor

- **Literature:** A review of the literature (Hugo et al., 1997; Lampbrecht & Stock, 1993; Liker, 1997; Meredith & Zhu, 1995; Monden, 1998) indicated that high quality, defect-free production is extremely important for continuous workflow in Lean Production. Since defective components lead to production interruptions in repetitive

manufacturing, excellent quality (one defect in a million) is often expected from suppliers. For this reason, suppliers are often certified before being chosen as sole suppliers of products. Where parts cannot be bought in large quantities due to small, infrequent orders (e.g. in jobshops), supplier certification may not be a cost-effective exercise. In such cases the high quality problem can be addressed by the issuing of quality certificates by vendors. In addition, in some industries, such as the Rail industry, quality certificates are required for some components in adherence to strict safety measures. The concept of quality certificates issued by vendors is thus recognised as important in the literature.

- **Research:** The importance of the issuing of quality certificates by vendors is reconfirmed by the research of Meredith and Zhu (1998). Their results indicated that academics, practitioners and secondary sources agreed on the importance of the matter for the success of Lean Production
- **Conclusion:** The high importance attached by respondents in this study to Quality Certificates supplied by vendors supports the research of Meredith and Zhu (1995) regarding the importance of the aspect. From the description of the circumstances of the Coach Refurbishing plant at Bloemfontein in Appendix A, and the literature (Hugo et al., 1997; Lampbrecht & Stock, 1993; Liker, 1997; Meredith & Zhu, 1995; Monden, 1998), the conclusion is drawn that quality certificates from vendors are especially important for jobshops (due to high variability and low volumes of orders) in the rail environment (where emphasis is placed on safety, for example through approved parts).

6.2.4.1.3 Relationship with supplier

- **Literature:** Liker (1977) considers the supplier subsystem an integral part of the Lean Production system. This production system functions well due to the co-operation of all levels of suppliers (Monden 1998). The co-operation is obtained by establishing and maintaining *excellent supplier relations* (Hugo et al., 1997; Lampbrecht & Stock, 1993). Hendry (1998) considers the latter as crucial in make-to-order environments, where small, infrequent orders are usually placed due to the batches of dissimilar products manufactured (requiring dissimilar parts).
- **Research:** The work of these authors was confirmed by:

- A survey by Kadipas et al. (1999), who found that manufacturers with Lean Production systems had better supplier relations and higher productivity than manufacturers without Lean Production systems
- A study of Meredith and Zhu (1995) wherein respondents indicated supplier relations are important for Lean Production success
- **Conclusion:** The respondents in this case study rated the relationship with suppliers as the third most important Lean Production practice. This highly assigned importance corresponds well with the study of Kadipas et al. (1999) above and the study of Meredith and Zhu (1995). Good supplier relations are essential in jobshops for quick response to unique orders (typical of Rail industry) that may delay production. Data from management reports (see the description of Lean practices in this case study) however show that supplier relations (in the case study), although rated important, are complicated by tender rules and infrequent, small custom orders placed with suppliers by make-to-order jobshops. This description of supplier relation related problems in jobshops corresponds with the discussion by Hendry (1998), who proposes that parts commonality should be increased to reduce the variety of orders placed and to increase volumes.

6.2.4.1.4 In-house lot size

- **Literature:** The ultimate lot-size of one unit denotes one-piece flow situations in Lean Production. This strategy results in lower WIP and ultimately in lower Finished Goods and workforce. One-piece flow is one of the core strategies supporting the JIT philosophy, which with automation, forms the pillars on which Lean Production rest (Liker, 1997; Monden, 1998).
- **Research:** The following research supports the literature quoted above:
 - Atwater and Chakravorty (1996) found that JIT balanced lines (functioning under one-piece flow) perform better than traditionally balanced lines and TOC lines under system certainty
 - Meredith and Zhu (1995) found that practitioners from Lean Production environments rated in-house lot size as an extremely important practice for the success of Lean Production.
- **Conclusion:** The high importance associated with in-house lot size by respondents from the Coach Refurbishing plant at Bloemfontein is underlined by management reports in respect of the case study plant, wherein the rapid accumulation of WIP due

to coaches waiting for parts is described. These findings correlate with the importance which the literature (Liker, 1997; Monden, 1998) associates with in-house lot size, and underline research findings of Meredith and Zhu (1995) regarding the value attached by practitioners in Lean plants to this construct.

6.2.4.1.5 JIT education

- **Literature:** Liker (1997) and Monden (1998) emphasise the role of company-wide education on Lean practices with emphasis on JIT in the successful implementation of Lean production.
- **Research:** The findings below serve as reconfirmation of the importance attached by Liker (1997) and Monden (1998) to JIT education:
 - Wafa and Yasin (1998) found that companies recommending Lean Production as strategy provided formal Lean Production training to Management.
 - Guide and Spencer (1995) found that the overall Lean Production philosophy towards inventory management must be understood by all levels of employees for Lean Production to be successful.
 - Meredith and Zhu (1995) determined that most of the sources investigated by them indicated that JIT education is critical to the success of Lean Production practices.
- **Conclusion:** The high importance (cumulative 78% relative to other constructs) attached by respondents to this aspect corresponds with the literature (Liker, 1997; Monden, 1998) and with the high importance most sources in the study of Meredith and Zhu (1995) assigned to the construct. Management reports (see Chapter 5 for a description of this data source) show that JIT education actually formed a crucial part of Lean implementation at the Transwerk plant. According to this source, JIT education:
 - indicated to personnel what was expected of them to make a success of JIT
 - contributed to a positive attitude amongst personnel since fears and concerns regarding Lean production could be discussed openly

6.2.4.1.6 Vendor lead time

- **Literature:** Monden (1998) describes how, in the Lean Toyota Production System, suppliers are provided with annual, monthly and daily quantities of material required.

Material is then withdrawn either by kanban or per schedule. Material is thus provided as needed, since suppliers have ample time to produce components. It thus seems as if the literature consulted does not attach too much importance to vendor lead time in JIT settings, since certified, sole suppliers have ample warning of schedules and schedule changes. Hugo et al. (1997) however emphasise the importance of supplier lead time for production in general, while Aquilano and Chase (1989) describe how (in make-to-order jobshops) the MRP system generates purchase orders based on Bills of Material, production Forecasts, standard prices and vendor lead time. Thus, in *jobshops*, production lead-time may be an issue if continuous flow is desired.

- **Research:** In the study conducted by Meredith and Zhu (1995), all sources researched indicated that vendor lead time is an extremely important element of Lean production's success.
- **Conclusion:** Respondents in this study associated a high degree of importance (tied with JIT education at 78% cumulative) with this element. This finding is in line with the research findings of Meredith and Zhu (1995) regarding Vendor lead time, and in support of the postulations of Hugo et al. (1997) and Aquilano and Chase (1989) about the importance of vendor lead time in MRP jobshop settings.

6.2.4.2 Practices listed as important by respondents of this study but viewed as less important in the study of Meredith and Zhu (1995)

Flexibility, a JIT champion, schedule stability and sole sourcing were considered important by respondents in this study, while results from the study of Meredith and Zhu (1995) indicated that these items were deemed of peripheral importance. Possible explanations for the importance associated with these items were provided earlier. In this section, brief literature and research references are compared to the findings of the current study.

6.2.4.2.1 Flexibility

- **Literature:** Gaither (1990) considers flexibility as a competitive strategy in production management. Hendry (1998) views the highly skilled workers (artisans) in jobshops as a traditional strength of these types of operations, since these workers can

perform a wide variety of tasks. The job-class systems in typical Western plants and grade representation by South African Unions however often result in job demarcation and specialisation. These circumstances may be obstacles to flexibility strategies of Lean Production.

- **Research:** The following findings add to the literature cited above:
 - Meredith and Zhu (1995) found that flexibility was not considered in any of their sources as one of the top ten crucial elements of Lean Production.
 - Wafa and Yasin (1998) found that both in plants recommending Lean Production and in plants not recommending Lean Production workers resisted cross training.
- **Conclusion:** The respondents in the current study considered flexibility important because of the limited rail market in South Africa (this aspect was explained and interpreted earlier). To cover costs, viable Rail Refurbishing plants in South Africa should be able to switch to any purpose-made train or Coach model in the short term to accommodate client orders. Failure to do so may result in losses and closure. The discrepancy between this finding and the literature as well as research cited above is thus caused by the specific location and industry of the plant under investigation. Despite the importance attached by respondent managers to flexibility, monthly reports and strategic plans indicate resistance to cross training and flexible workforce utilisation by workers in support of union objectives.

6.2.4.2.2 JIT champion

- **Literature:** Liker (1997) and Monden (1998) mention the importance of a JIT team, while Meredith and Zhu (1995) specify the role of a JIT champion. A JIT champion is a person who initiates JIT implementation. Usually, the JIT champion will be responsible for and takes a leadership role in the entire implementation process.
- **Research:** The research of Meredith and Zhu (1995) indicated that neither practitioners in Lean plants, nor academics or surveys indicated that a JIT champion is of crucial importance for the success of Lean Production.
- **Conclusion:** The importance associated with a JIT champion by respondents from the case study plant could possibly be understood from the perspective of the traditional slow acceptance of and even resistance to new management initiatives in rail industries (Chan et al., 1998). One respondent (who wants to remain anonymous for private reasons) elaborated:

“These people (denoting workers in the case study plant) have a typical railway attitude. If they are not threatened, begged or forced to change their ways, they will keep on doing their jobs in the 1960’s way till they retire. They need someone to feed them Lean principles day in and day out.”

6.2.4.2.3 Schedule stability

- **Literature:** Liker (1997) states that smoothed production schedules as described by Monden (1998) are sometimes wrongly perceived as “frozen” schedules. Monden considers production smoothing to be a crucial factor for the functioning of JIT production and material ordering. Hendry (1998) however indicates that jobshops wanting to apply Lean Production practices may experience difficulties with achieving schedule stability (smoothing) due to low-volume high-variety orders from clients.
- **Research:** The studies below reflect contrasting findings on the importance of schedule stability in Lean production:
 - Atwater and Chakravorty (1996) found that JIT balanced lines are superior to other lines under stable schedules.
 - The research of Meredith and Zhu (1995) indicated that neither practitioners in Lean plants, nor academics or surveys indicated that stable schedules are of crucial importance for the success of Lean Production.
- **Conclusion:** Schedule stability is (contrary to some literature and research above) deemed important by respondents from the Coach Refurbishing plant. This finding however supports the views of Hendry (1998) on jobshop product variability and planning accuracy, and underlines the finding of Atwater and Chakravorty (1996) regarding stability as precondition to JIT-line success.

6.2.4.2.4 Sole Sourcing

- **Literature:** A survey of the literature (Hugo et al., 1997; Lampbrecht & Stock, 1993; Liker, 1997; Meredith & Zhu, 1997; Monden, 1998) highlighted the importance of supplier certification and the choice of sole suppliers in JIT purchasing. Sole suppliers are developed and assisted by Lean OEM’s, and long-term contracts and good supplier relations ensure good service and prices from suppliers.
- **Research:** The following conflicting research results were found:

- Kadipas et al. (1999) established in a survey of 13 Manufacturers that supplier certification, long-term relations with suppliers and small frequent deliveries are crucial to the importance of JIT in Lean Production
- Meredith and Zhu (1995) found, in a study involving the analysis of primary and secondary data, that sole sourcing is considered as less important to the success of Lean Production.
- **Conclusion:** The specific circumstances of the Coach plant at Bloemfontein could possibly serve as an explanation for the high importance respondent managers attached to sole sourcing (see the explanation regarding this aspect earlier). One respondent (who is responsible for purchasing) wrote:

“In our line of business, most spare parts are especially made by suppliers to our specifications and drawings. It is cheaper, faster and more convenient for me as a purchaser to deal with one trusted supplier who has already developed patterns and jigs for our parts than with a multitude of unknown suppliers.”

This finding is consistent with the literature (Hugo et al., 1997; Lampbrecht & Stock, 1993; Liker, 1997; Meredith & Zhu, 1997; Monden, 1998) and the research of Kadipas et al. (1999).

6.2.4.3 Practices listed as less important by both respondents of this study and the study of Meredith and Zhu (1995)

The five items below (flatten BOM's, involving an outside consultant, a Pilot Project, Top Management commitment and co-worker relations, suggestion investigation) were deemed less important by both the respondents in the current study, and in the study by Meredith and Zhu (1995).

6.2.4.3.1 Flatten Bill of Materials

- **Literature:** According to Meredith and Zhu (1995) and Monden (1998), JIT tends to flatten out the bill of materials and eliminate levels of subassembly by redesigning product structures so that the pre-assembled components are used to make a large number of end items to customer orders. A two-level bill of materials may be created by treating a customer order as an end item and manufacturing items from standard

materials and parts to a level below the end item. Monden (1998) however indicated that the hierarchical supplier structure found in Japanese plants (where various tiers of suppliers support each other to produce subassemblies delivered to the OEM) does not exist in the West – sometimes not even in Lean organisations. Hendry (1998) recognised a similar problem in make-to-order jobshops, and suggests that parts commonality must be increased to partially address the problem.

- **Research:** Meredith and Zhu (1995) found that the flattening of Bills of Material is considered as *less important* to the success of Lean Production in a study involving the analysis of primary and secondary data.
- **Conclusion:** The respondent managers from the Bloemfontein Coach Repair plant rated the flattening of Bills of Material less important. The Logistics Manager elaborated on this item:

“We replace or repair damaged or missing individual items like bogey springs on Coaches. We do not manufacture complete Coaches. For this reason it is not practical or cost effective to buy subassemblies like complete bogies to flatten our Bills of Material.”

This finding underlines the study of Meredith and Zhu (1995) above. The explanation offered by Monden (1998) regarding the supplier structure of Western manufacturers provides one possible explanation for the finding of the study of Meredith and Zhu (1995) as well as for the plant under investigation. The view offered by Hendry (1998) regarding suppliers and parts in jobshops, however, is probably a better explanation of the weight associated with the construct by respondents from the Transwerk plant. Management reports indicate that this aspect is also deemed less practical to implement in the Transwerk Coach plant.

6.2.4.3.2 Outside consultant

- **Literature:** Since many Lean Production practices are not programmable, a traditional approach to adoption of new technology is not applicable to a JIT implementation process, such as the use of a vendor. Companies, especially small companies, therefore seek outside consultants as their primary sources for guiding their JIT implementation (Frolick et al., 1995; Liker, 1997; Meredith and Zhu, 1995; Monden, 1998).

- **Research:** Meredith and Zhu (1995) established in their study that this aspect is not considered crucial by any of the primary or secondary sources investigated by them.
- **Conclusion:** Although management reports indicate that the plant under investigation actually used a consultant to assist with implementation, respondent managers regarded this aspect as less important than other practices associated with the implementation of Lean Production. This finding is consistent with the results of the study cited above.

6.2.4.3.3 Pilot Project

- **Literature:** Pilot projects are considered a popular manner in which to begin the implementation of a new system which requires many changes in an organisational structure. Should the pilot project results prove to be successful, the experience gained from the pilot project will guide a company-wide JIT implementation.
- **Research:** Contrasting findings regarding the importance of Pilot projects for the implementation of JIT (as part of Lean Production strategy) are provided below :
 - Vora et al (1990) found that 10 of the 14 plants they studied used pilot projects before large-scale JIT implementation began. The advantages of a pilot project are the lower cost of failure and less production disruption during an implementation process when comparing a small-scale to a large-scale implementation.
 - Meredith and Zhu (1995) found that none of the sources they studied considered pilot projects as crucial to Lean Production success.
- **Conclusion:** The low importance associated by respondents from the Transwerk plant corresponds with the findings of the study by Meredith and Zhu (1995). The finding is not totally inconsistent with the findings of Vora et al. (1990), since the latter researchers found that not all plants (10 out of 14) used pilot projects. Reasons offered for a decision not to implement a pilot project in the Transwerk plant in management reports relate to the specific rail and jobshop environment of the latter plant:
 - Inter-relatedness of the low volume, labour intensive production process
 - Union resistance

6.2.4.3.4 Top Management commitment

- **Literature:** Monden (1998) considers top management commitment as a prerequisite for the implementation of Lean Production, since capital outlays, involvement with suggestion schemes, contracts with vendors etc. cannot take place without their approval.
- **Research:** Contrasting research findings are reflected below:
 - Wafa and Yasin (1998) established in a study comparing practices of firms that recommend Lean production to practices of firms not recommending Lean production that recommending firms displayed high levels of management involvement in Lean Production.
 - Meredith and Zhu (1995) found that (although the construct “Top Management” was rated important in the literature) it was not considered one of the most crucial elements of Lean implementation.
- **Conclusion:** Respondents from the Transwerk plant did not rate *Top Management involvement* as a crucial element of Lean Production. When asked to clarify their response, respondents indicated that plant management had sufficient delegated authority to employ capital, and make changes necessary for the implementation of Lean Production (within company policy boundaries). The lower importance assigned to this aspect correlates with the findings of Meredith and Zhu (1995). The high involvement of local management (in the context of delegated authority) corresponds with the findings of Wafa and Yasin (1998) regarding this aspect.

6.2.4.3.5 Co-worker relations

- **Literature:** Liker (1997), Meredith and Zhu (1995) and Monden (1998) emphasise the interdependence among co-workers in Lean Production, since several JIT practices, such as group technology and authority to stop production lines require employees to work together. According to these authors it is imperative to create a congenial environment among the co-workers.
- **Research:** The following research covers co-worker relations:
 - Frolick et al. (1995) reported from survey results that employee participation is crucially important for Lean Production's success.

- Meredith and Zhu (1995) found that co-worker relations (though listed as a significant Lean element in literature studies) were not identified as one of the 10 most important practices by any source consulted by them.
- **Conclusion:** Respondents from the Transwerk plant did not consider co-worker relations of crucial importance for Lean production. In elaborate comments, respondents identified the long production lead-time and low volume of work, as well as the layout of operations as reasons for their ratings. Operations in a Coach Refurbishing plant are, according to respondents, not as “tight” as in repetitive manufacturing and worker-interdependence is thus lower than in the situation described by the literature above. With lower interdependence, co-worker relations become less important. The finding corresponds with the finding of Meredith and Zhu (1995) regarding the lower importance associated with this aspect.

6.2.4.3.6 Investigate suggestions

- **Literature:** Monden (1998) considers the respect paid to the humanity of workers as well as the benefits obtained by organisations from the investigation of suggestions as extremely important to continuous improvement in Lean Production. Meredith and Zhu (1995) state that, because JIT implementation involves significant organisational change, employee commitment is crucial to its success. Employee suggestions should in the opinion of these authors be encouraged and rewarded while keeping both formal and informal lines of communication open. Hendry (1998) stated that the involvement of workers in jobshops could in general be increased in the interests of workers and organisations.
- **Research:** The following research relates to the investigation of suggestions:
 - Coster, Cilliers and Watkins (1987) reported various studies showing that opportunities offered to employees to be creative contribute to job satisfaction, which correlating negatively with absence, fatigue, labour turnover, cardiac arrest, stress, and pro-unionism. Job satisfaction correlates positively with commitment, performance, life satisfaction and mental health.
 - Meredith and Zhu (1995) reported that no source investigated by them considered the investigation of suggestions as one of the top ten most crucial practices for Lean Production.
- **Conclusion:** The evaluation by Transwerk respondents of the *investigation of suggestions* as not as important as the ten practices rated most important, supports

the research of Meredith and Zhu (1995). Respondents explained during interviews that, although consultation with and involvement of labour is considered important in the South African labour relations sphere, and although the recording and investigation of suggestions is required in ISO 9002 audits of the plant, no system was in place to reward workers for suggestions. This practice was observed by shopstewards of the Transwerk plant during plant tours at Nissan, where workers are rewarded in cash for suggestions. The expectation consequently exists that workers should be paid for suggestions. Respondents however assume that this element could be valuable to the plant if a way could be found to implement it in current constraints. This assumption supports the high priority assigned to worker suggestions by Hendry (1998) and Monden (1998).

6.2.4.4 Practices listed as less important by respondents of this study but viewed as important in the study of Meredith and Zhu (1995)

The aspects listed below were rated important in the study of Meredith and Zhu (1995), but respondents of this study rated them as *less important*. The interpretation of these findings (based on the qualitative comments of respondents) were provided earlier. The aspects listed in the section were co-incidentally also *not implemented* at the case study plant. Respondents were, however, of the opinion that even if these aspects were implemented, they would contribute little or nothing to the reduction of waste in the plant. In this section, findings are tested against the literature and previous research.

6.2.4.4.1 Authority to stop lines

- **Literature:** According to the literature (Liker, 1997; Meredith & Zhu, 1995; Monden, 1998) Taiichi Ohno initiated *Jidoka* (a component of autonomous defect control) which means stopping everything when something goes wrong. The implementation of this idea suggests that every individual is responsible for the quality of products or components that he or she produces. If anything goes wrong, the operator has the right to stop the production line. This will ensure that mass production of defective parts does not occur. While the entire line is stopped, the other workers will do their machine maintenance work and housekeeping.
- **Research:** The following research supports the literature cited above:

- Min and Shin (1995) found that cost savings resulting from line-stop strategy are greater than those using off-line repair strategy.
- Meredith and Zhu (1995) found that survey data indicated the authority to stop lines as a critically important issue for Lean Production.
- **Conclusion:** Respondents from the Transwerk plant rated this construct low in importance, since (due to layout and production technology employed) the concept of line-stopping is not practically applicable in the plant (as established in clarifying questions to respondents). One respondent explained that, even if line-stopping was introduced, no significant cost saving (based on the prevention of the mass-production of defective products like in a repetitive production environment) would occur. Cost savings such as those highlighted by Min and Shin (1995) are thus not possible in jobshops due to the more or less independent nature of tasks compared to that of other tasks.

6.2.4.4.2 Cross-training

- **Literature:** Monden (1998) sees multi-function workers, cross-trained by (mostly) rotation between jobs, as one of the core strategies for waste reduction in Lean plants. This strategy is aimed at the reduction of excessive workers, and leads to a higher output per person, less idle time and a lower salary bill. Hendry (1998) states that this strategy would probably not lead to immediate, drastic cost reductions in jobshops, since highly skilled artisans performing a wide variety of tasks is a traditional strength of jobshops. Monden (1998), however, sees the job-class system (where job demarcation and job evaluation are used as a basis for resistance to cross training), which is used frequently in the West, as a problem to workforce flexibility. One artisan (a painter) can for example not do the work of another artisan (a welder) since remuneration may differ.
- **Research:** The following research pertains to workforce flexibility and cross-training:
 - Jackson et al. (1995) found that reductions in employee autonomy, increased production pressure and employee stress are not universal concomitants of the Lean Production flexible workforce strategy.
 - Meredith and Zhu (1995) established from both primary and secondary data sources that cross training is considered crucial for the implementation and functioning of Lean Production.

- Wafa and Yasin (1998) found workforce resistance to cross training in plants recommending and in plants not recommending Lean implementation.
- **Conclusion:** In contrast to some of the research above, respondents from the Transwerk plant did not consider cross-training as a crucial element for Lean implementation in the plant. Reasons offered by respondents pertained mostly to union resistance to the concept, as is the case in many other Western Countries (Monden, 1998; Wafa & Yasin, 1998). Some respondents commented that half the workforce consists of artisans, which are cross-trained in many processes anyway. Further cross-training would (in their opinion) reduce no cost. This finding is to some extent consistent with the opinion of Hendry (1998) namely that cross-training is expected not to be a major cause of improvements in jobshops due to the nature of the traditional workforce characteristics of jobshops. The reason that the aspect is not considered crucial (resistance), however, corresponds with the findings of Wafa and Yasin (1998).

6.2.4.4.3 Group technology

- **Literature:** Group technology is the technique of grouping machines which perform different tasks, in into one work cell, thus allowing these tasks to be performed without moving a large number of work-in-process inventories between departments. Such cells are often designed in such a way that one worker can operate all the machines simultaneously (Meredith & Zhu, 1995). Monden (1998) views this approach to workforce utilisation and machine layout as a major way to reduce excess workers and wastage in WIP, Finished Goods Inventory, Material and Capital investment in new assets. Hendry (1998) however feels that, in jobshops, functional layouts may sometimes be retained for strategic purposes. Jobshops can thus not gain as many cost reductions from group technology layouts as repetitive manufacturing concerns.
- **Research:** The research below pertains to group technology in Lean Production:
 - Kadipas et al. (1999) found that respondents attributed reductions in stock, finished goods and WIP to the use of work-cell concepts such as uniform workload, kanban and group technology principles.
 - Meredith and Zhu (1995) found that group technology was rated one of the most critical aspects of Lean production by all sources consulted.

- **Conclusion:** Transwerk respondents did not rate group technology as one of the ten most important Lean Production practices for their circumstances. This finding is inconsistent with the findings of Meredith and Zhu (1995) and Kadipas et al. (1999). Explanations offered by Transwerk respondents (see the interpretation of findings earlier) centred on the nature of operations in their Rail-industry jobbing plant. This finding is consistent with the opinion of Hendry (1998) above, regarding the smaller potential benefit for jobshops in the implementation of group technology principles than for repetitive manufacturers. Although little information on the nature of operations from which Meredith and Zhu (1995) and Kadipas et al. (1999) drew their respondents is offered, it is possible that they were sampled from repetitive manufacturing environments where group technology can be beneficial.

6.2.4.4.4 JIT Team

- **Literature:** According to Meredith and Zhu (1995) a JIT team is a group of experts who are specialised in different functional areas within an organisation and work together as a team during a JIT implementation process. These authors state that many JIT users use JIT teams during the JIT implementation process. Liker (1997) suggests strongly that those plants wanting to implement Lean Production should embark on this route.
- **Research:** Meredith and Zhu (1995) found in their study that the majority of sources consulted by them considered a JIT team as one of the ten most important aspects of the implementation of Lean Production.
- **Conclusion:** Transwerk respondents did not consider a JIT team as one of the ten most important aspects of Lean implementation and functioning in the Coach Repair plant. Policy and budgetary constraints were offered as reasons. In the Transwerk plant, a knowledgeable person trained managers of the Coach Business. They consequently implemented and maintained practices by themselves as part of their duties and long-term planning. The advice of an outside consultant and the involvement of the local plant manager provided sufficient direction and support for the implementation without a JIT team. This finding is not in total contradiction with the findings of Meredith and Zhu (1995), since they reported a minority of plants (in their study) that implemented Lean Production without a JIT team.

6.2.4.4.5 Preventive Maintenance

- **Literature:** Aquilano and Chase (1989) and Gaither (1990) consider Preventive Maintenance as important to continuous workflow in Lean Production. Because Lean Production's JIT philosophy allows little work-in-process inventory, machine breakdowns can be disruptive. Maintenance and minor repairs are often considered a part of line workers' job requirements in Lean plants (Meredith & Zhu, 1995).
- **Research:** In the study of Meredith and Zhu (1995), two sources (practitioners in Lean plants as well as case study research) indicated that Preventive Maintenance should be considered as one of the most important Lean Production elements.
- **Conclusion:** During the interpretation of results earlier in this chapter, explanations were offered regarding the lower importance associated with this element by Transwerk respondents. The explanations basically focused on the jobshop nature of operations at the Transwerk Coach Refurbishing plant. Although considered lower in importance (in contradiction with the findings of Meredith and Zhu, 1995 above), Preventive Maintenance is being performed in the Transwerk plant. The reason however, is not the same as the motivation (uninterrupted workflow) offered by the literature (Aquilano and Chase, 1989; Gaither, 1990) above. The actual reason (as indicated by respondents) for Preventive Maintenance is the pre-occupation in rail operations with safety. Equipment like Overhead Cranes and Coach Jacks that must be checked regularly as prescribed in safety regulations. This equipment, however, receives Preventive Maintenance during each regular inspection. The maintenance is recorded in a register to ensure that should an accident occur, proof can be given that the employer made a concerted effort to ensure the safety of workers. This explanation corresponds with the description of the preoccupation with safety by rail industries by Chan et al. (1998).

6.2.4.4.6 Set-up time reduction

- **Literature:** Liker (1997), Monden (1998) and Womack (1997) consider the reduction and possible elimination of set-up as extremely important in an environment where products are scheduled in Takt-time and are to be synchronised with sales. Simplified and standardised set-up procedures should therefore be developed (Meredith and Zhu, 1995).

- **Research:** Meredith and Zhu (1995) found that all of the following sources investigated by them indicated set-up reduction as one of the top ten most important practices of Lean Production:
 - Academics
 - Practitioners
 - Survey data
 - Case study data
 - Data gathered in discussions
- **Conclusion:** Respondents from the Transwerk plant assigned the lowest importance to set-up reduction of all elements considered (see table 6.1). Reasons offered (see the interpretation of results) relate to the nature of equipment used. One respondent explained that little or no set-up operations are involved when hand-tools like hammers, chisels and hand-drills are used. This finding is in contrast to the literature (Liker, 1997; Monden, 1998; Womack, 1997) and research (Meredith & Zhu, 1995) above, since set-up reduction is basically non-applicable to the specific Rail-industry jobbing environment under investigation in this study.

6.2.4.4.7 Vendor lot-size

- **Literature:** Liker (1997), Meredith and Zhu (1995) and Monden (1998) consider the willingness of the vendors to deliver small lots of raw materials and parts on a frequent basis as very important in the implementation of the JIT purchasing practice of Lean Production. JIT purchasing and line balancing requires that deliveries are made as and when there is a need for the purchased raw materials in respect of the next operation in the exact quantity needed.
- **Research:** The following research is applicable:
 - Some researchers (Wafa & Yasin, 1998; Frolick et al., 1995; Guide & Spencer, 1995) found supplier participation in general is important for the success of the JIT strategy in Lean Production.
 - Only Meredith and Zhu (1995) concentrated specifically on vendor lot-size. They found that academics and survey data indicated this element as one of the top ten most important elements of Lean Production.
- **Conclusion:** Transwerk respondents associated a lower value with this element, a contradiction to the literature (Liker, 1997; Meredith & Zhu, 1995; Monden, 1998) and

research (Meredith & Zhu, 1995) above. The make-to-order character of the plant's operations was offered as an explanation earlier in this chapter.

6.3 Lean Production and ROI in the Transwerk Coach Refurbishing plant at Bloemfontein

Statistics, interpretation of statistics as well as previous research and literature regarding the implementation of Lean Production practices at the Transwerk plant were provided in the section above. In this section, the same statistics and discussions will be provided with respect to the financial outcomes of the above practices as measured by ROI.

6.3.1 Descriptive Statistics

The statistics below were obtained by comparing financial statements of various plants. Descriptive statistics will be presented according to the various financial statements used for the calculation of ROI as described in Chapter 4:

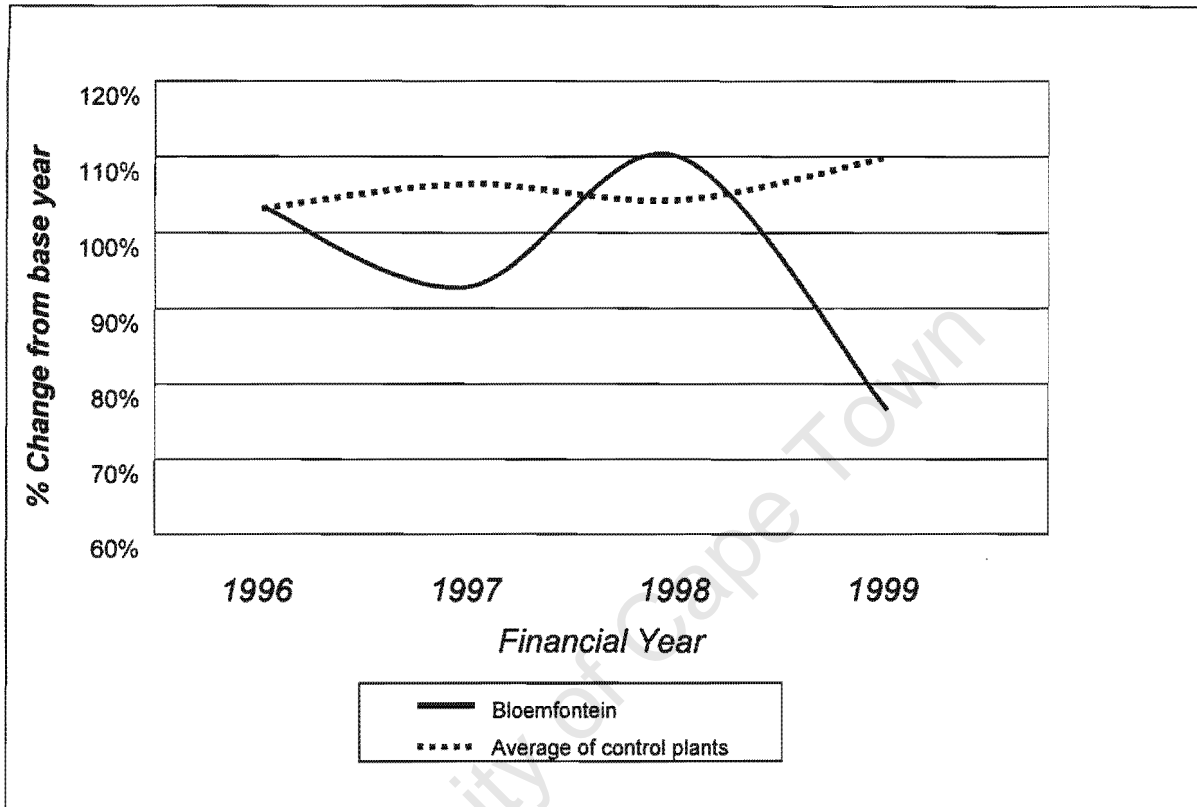
- Income Statement (Variable and Fixed Costs as well as Operating Profit or EBIT)
- Balance Sheet (Current asset items WIP and Stock, Current liability item Accounts Receivable, NWC and Fixed Assets)

6.3.1.1 Income Statement results

Figure 6.1 covers the *percentage changes in levels of* elements measured for all plants from base years indicated. An 88% EBIT in 1997 does not for example, show that plant X had an 88% profit margin. It actually shows that the plant fell 12% in EBIT relative to the base year of measurement. Since the Income Statement reflects (for the calculation of ROI) how EBIT was obtained by subtracting variable and fixed costs from sales, changes in all the latter items as proportions of sales are shown further on.

The first graph below (Figure 6.1) provides an indication of changes in fixed cost as proportions of Sales (mainly labour and overheads) from the given base year between plants:

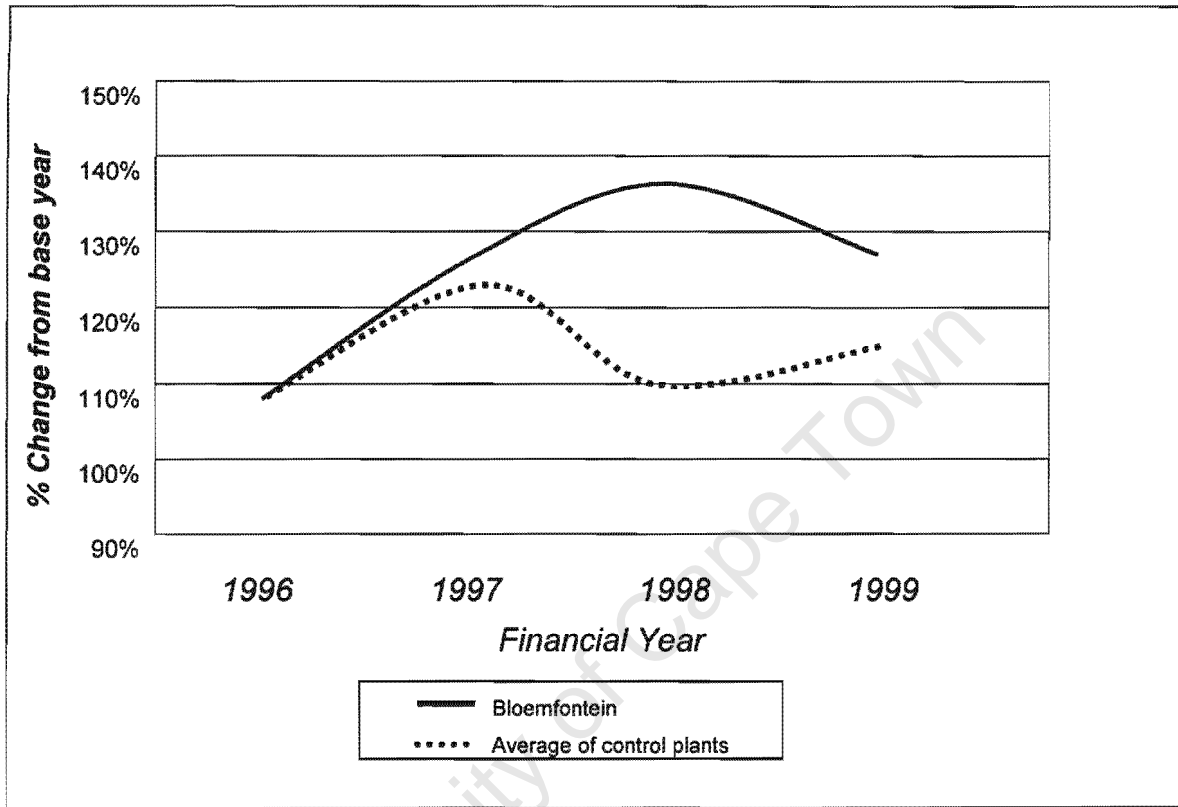
FIGURE 6.1
FIXED COST AS A PERCENTAGE OF SALES: % CHANGE FROM 1996
BASELINE PER PLANT



The next graph below (Figure 6.2) provides an indication of changes in variable cost (consisting of material and overtime) as proportions of Sales (mainly material) from the given base year between plants:

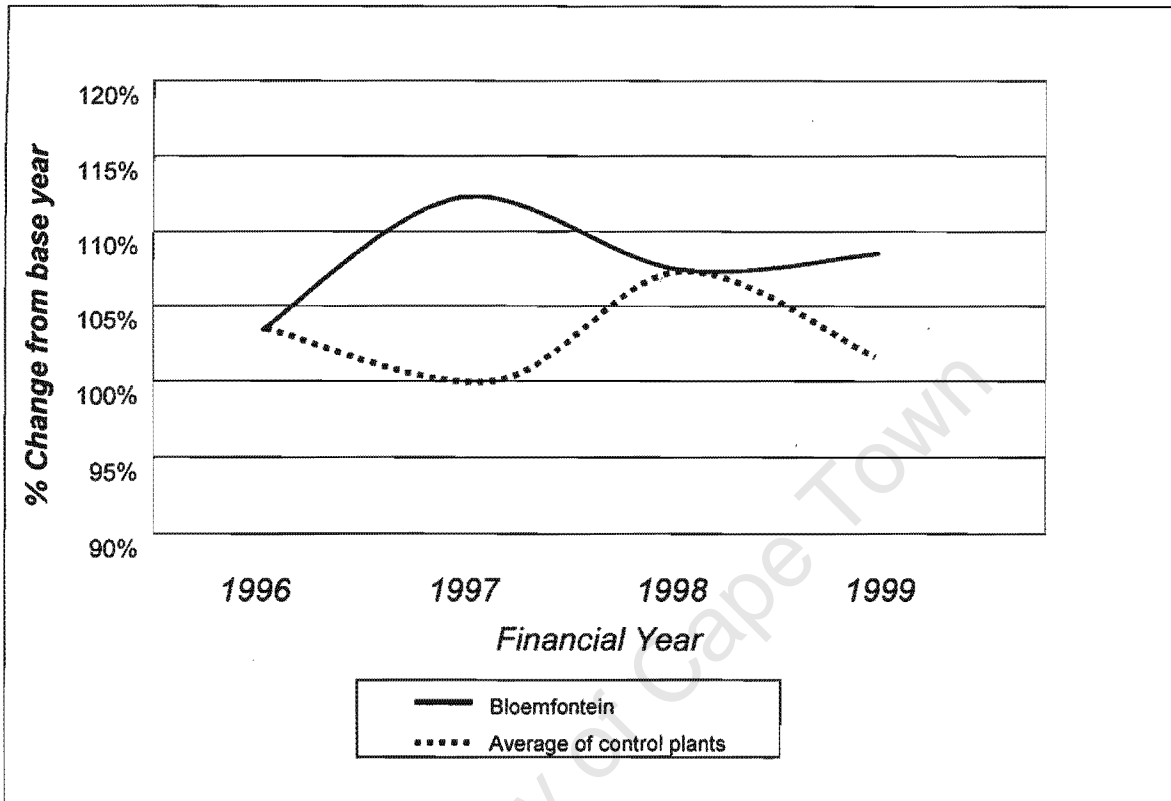
FIGURE 6.2

**VARIABLE COST AS A PERCENTAGE OF SALES: % CHANGE FROM 1996
BASELINE PER PLANT**



The next graph in Figure 6.3 focuses on the changes in Operating Profit (EBIT), over a period, as a percentage of Sales and is compared between plants.

FIGURE 6.3
CHANGES IN OPERATING PROFIT AS PERCENTAGE OF SALES SINCE
BASE YEAR



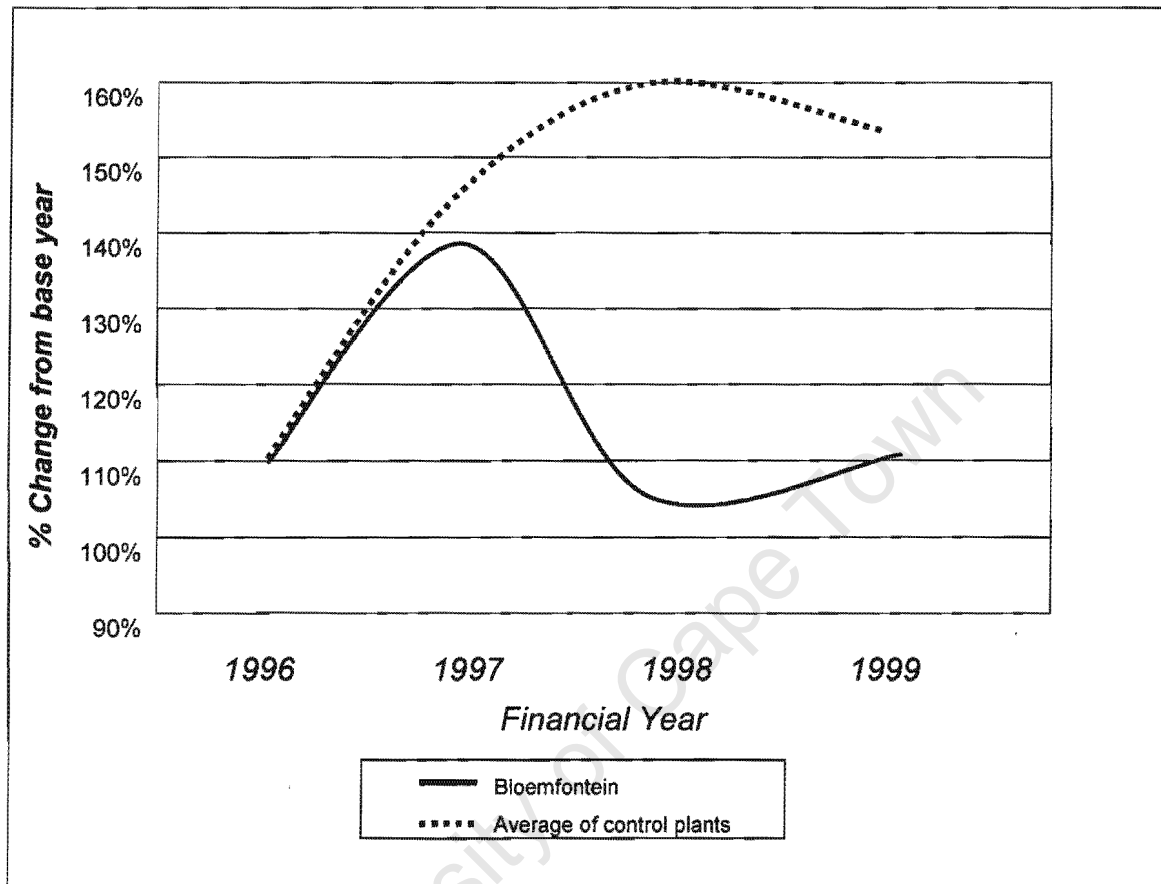
Respondents to this study proudly commented on Figure 6.3: “The cumulative Operating Profit of the Bloemfontein plant since 1996 grew to **twice** the cumulative profit of the other three plants **combined** because of our Lean strategy!”

The last three graphs reflected changes on Income statement items. The next graphs will focus on both the Asset and Liability portions of the Balance Sheet, with special reference to Net Working Capital and Fixed Assets, forming part of the calculation of ROI.

6.3.1.2 Balance Sheet items

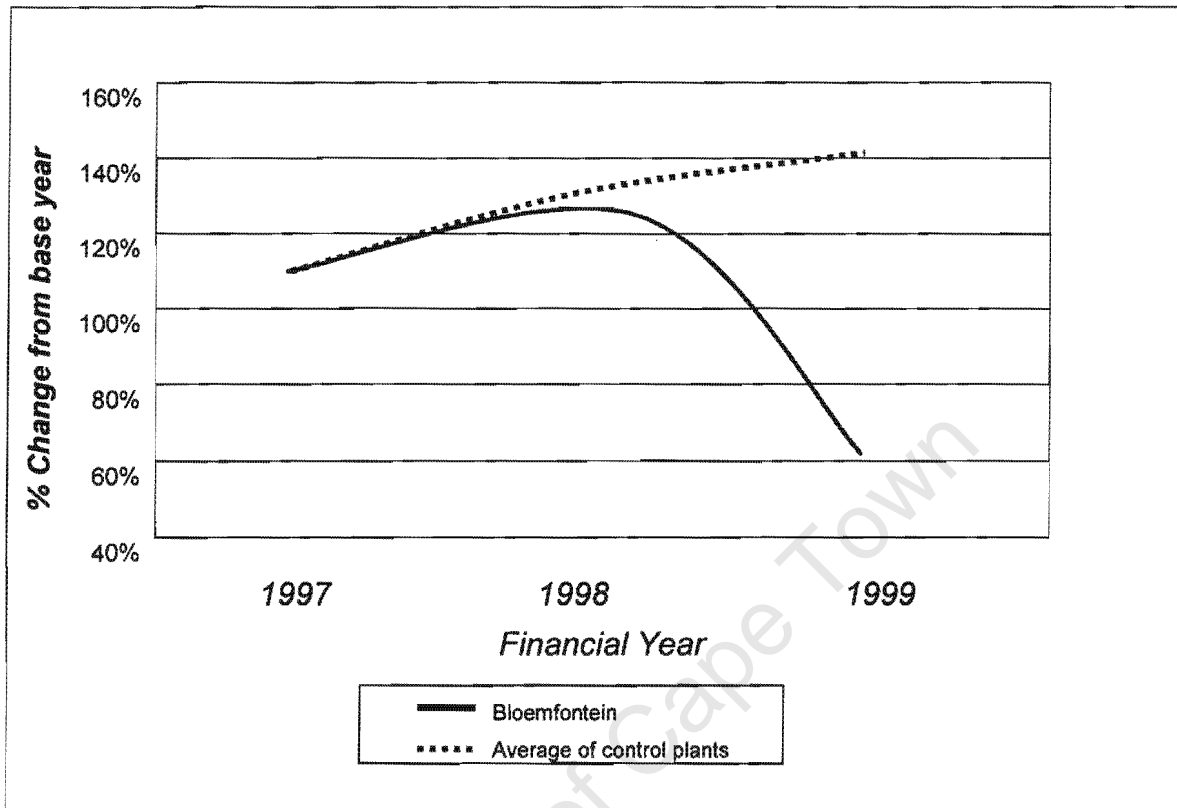
Figures 6.4 and 6.5 below (stock and WIP) represent items often referred in the preceding literature study. The graph immediately below reflects the percentage change in stock levels over a period of time and as compared between plants.

FIGURE 6.4
PERCENT CHANGES IN STOCK LEVELS SINCE BASE YEAR



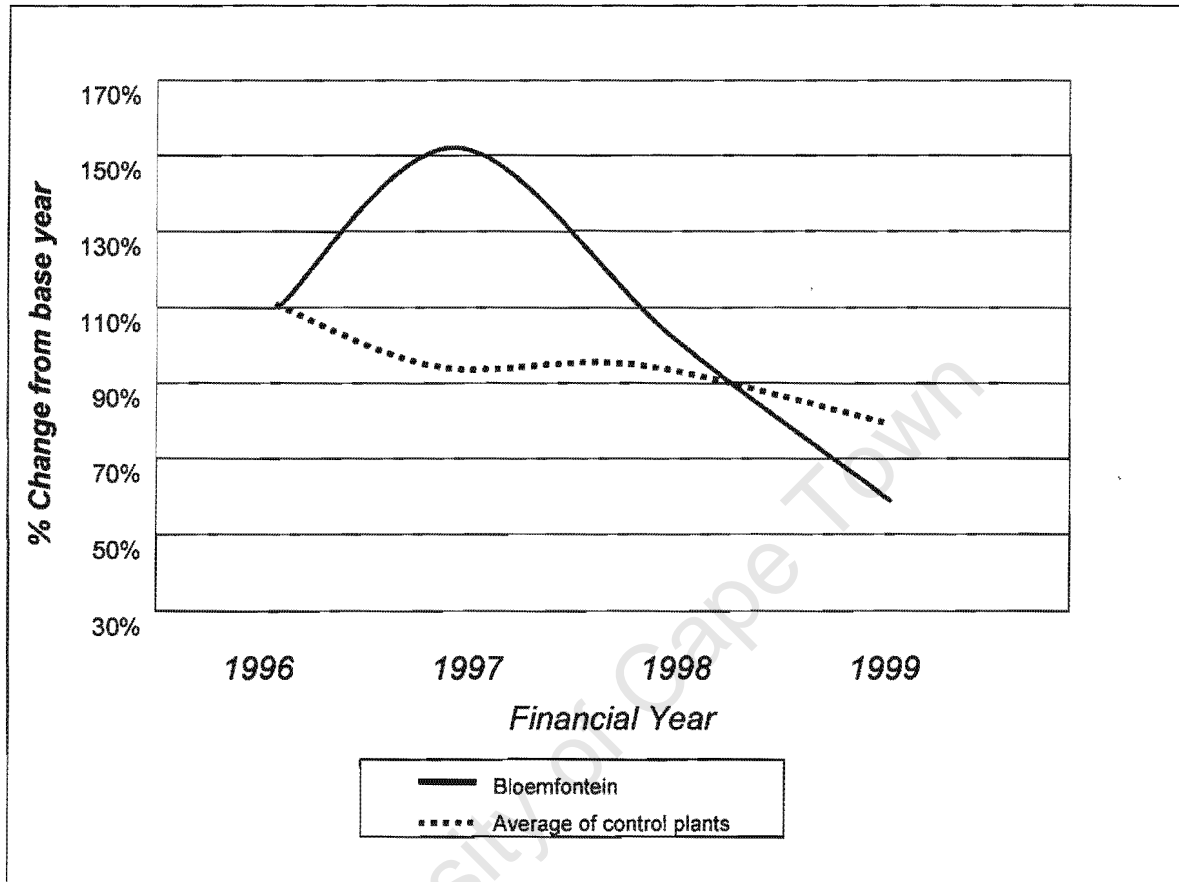
The following graph (Figure 6.5) indicates the percentage change, since the base year, in Work In Progress (consisting of material issued and productive hours worked multiplied by cost centre tariff) and is compared between plants.

FIGURE 6.5
PERCENTAGE CHANGES IN WIP LEVEL SINCE BASE YEAR



Keeping to the short term, the next graph (Figure 6.6) depicts changes in Accounts receivable, a Short-term asset.

FIGURE 6.6
CHANGES IN ACCOUNTS RECEIVABLE SINCE BASE YEAR



The following graph (Figure 6.7) represents Net Working Capital, i.e. the difference between short-term (current) assets and liabilities. This construct is one of the three major constructs (EBIT, NWC and Fixed Assets) used to compute ROI.

FIGURE 6.7
CHANGES IN NET WORKING CAPITAL BETWEEN PLANTS SINCE BASE
YEAR

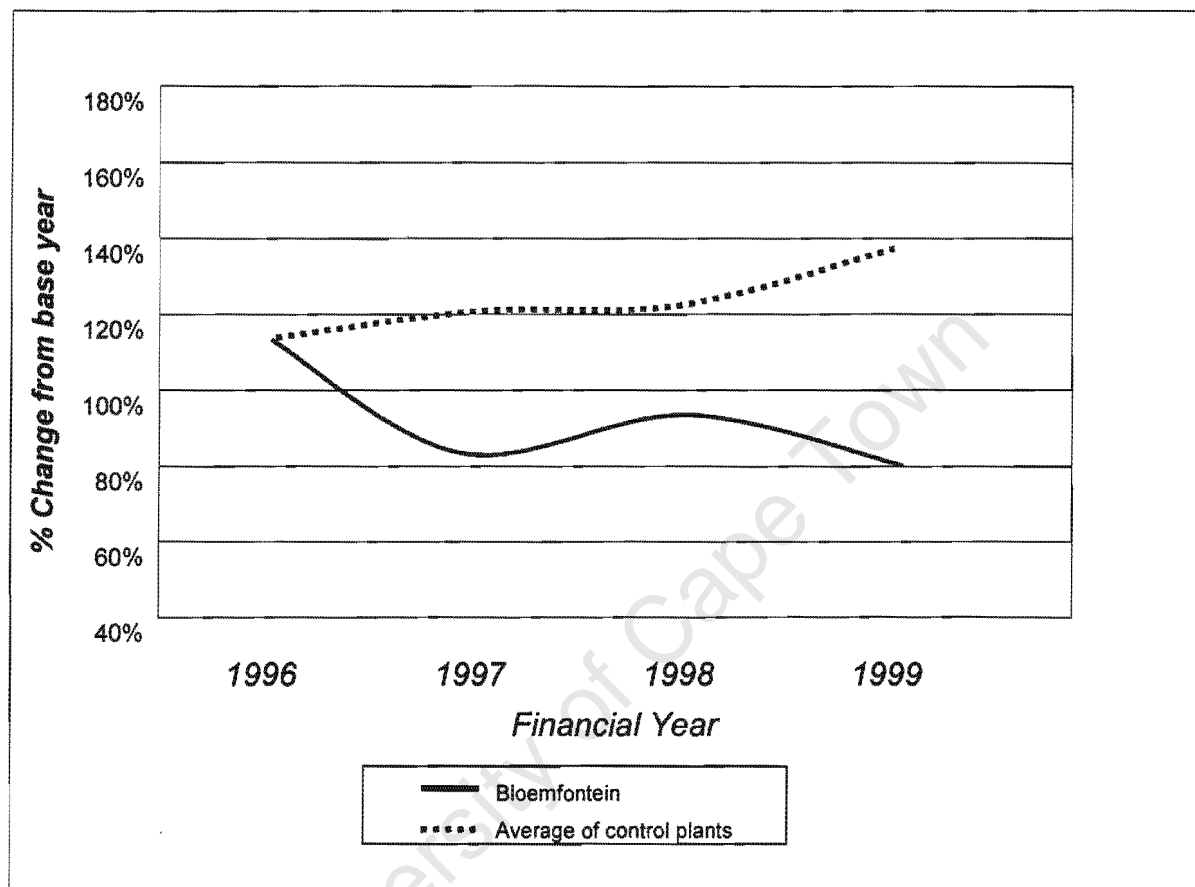
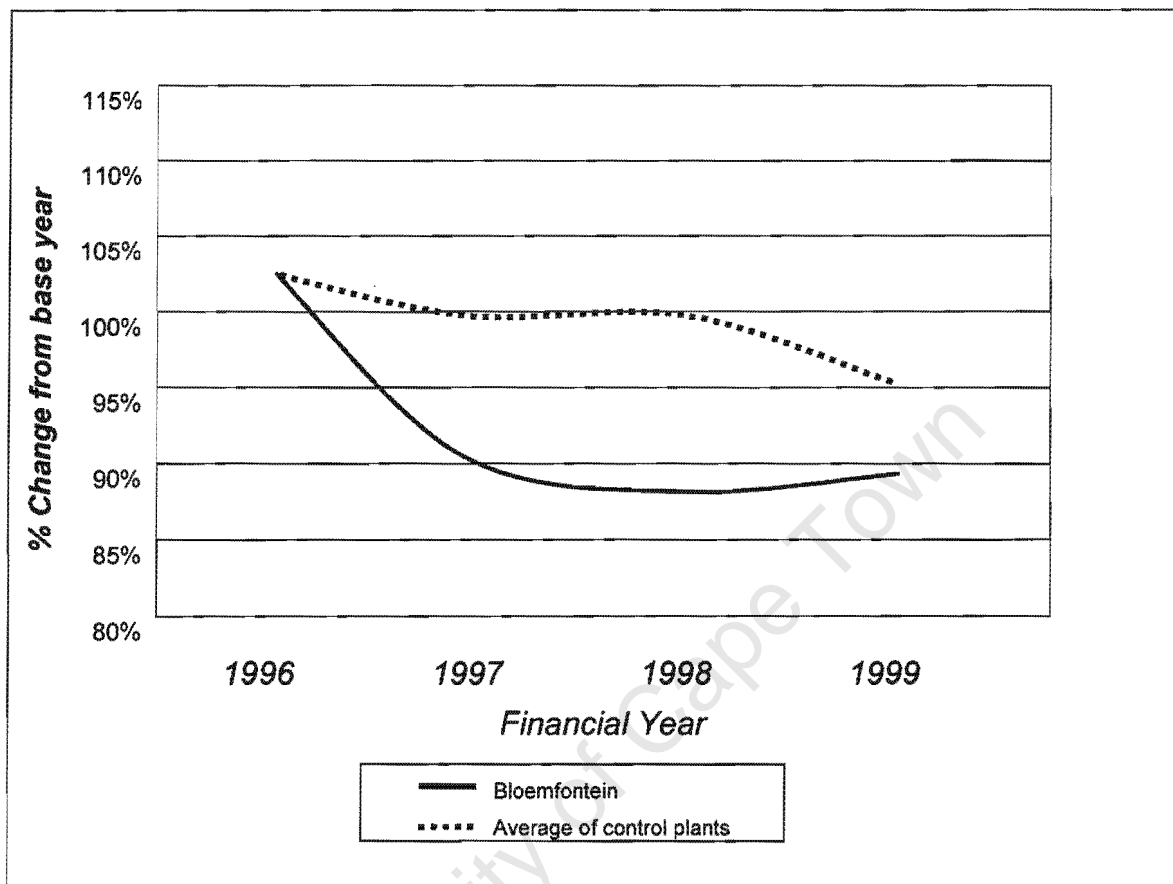


Figure 6.8 below portrays the changes in Fixed Assets (consisting mainly of land and buildings, machinery and equipment) as compared between plants and over time. Note that changes in fixed assets (as described during the literature study) can be caused by the buying, selling and writing off of fixed assets as well as depreciation.

FIGURE 6.8

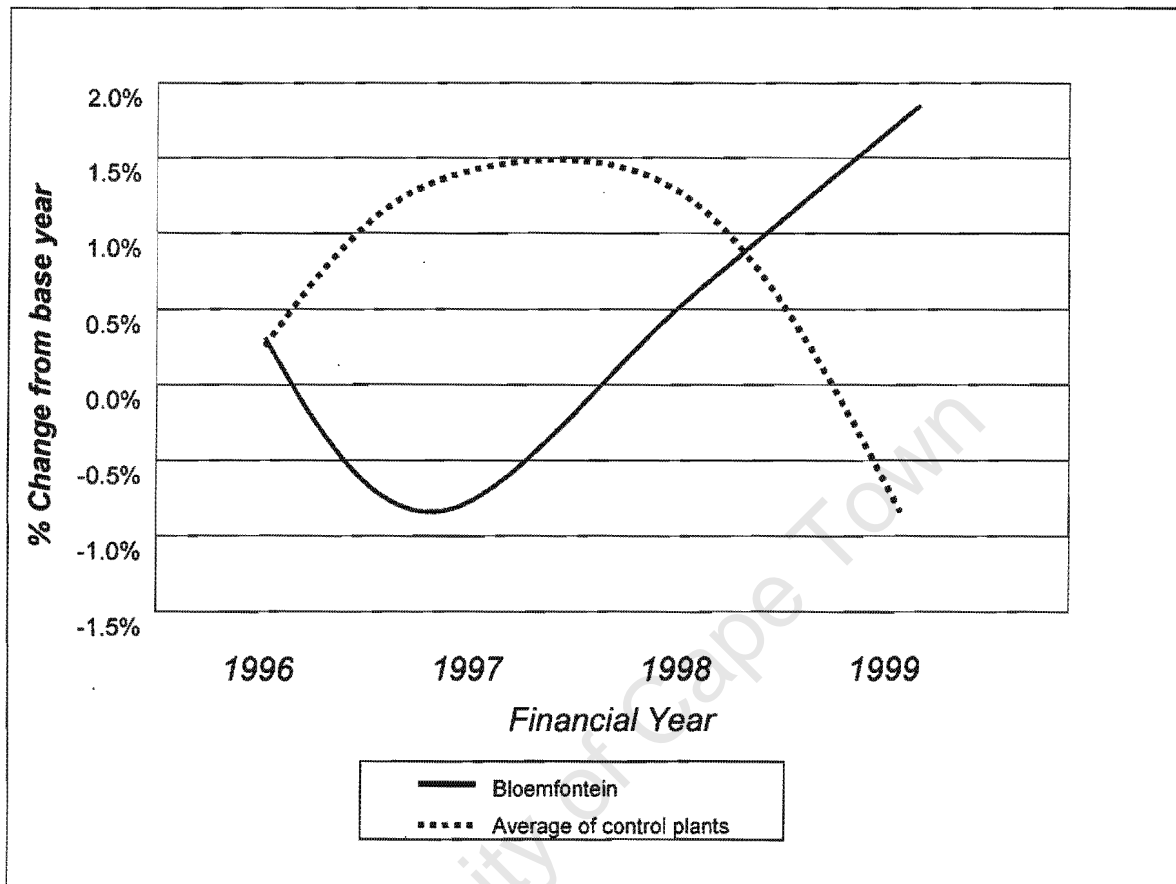
PERCENTAGE CHANGES IN FIXED ASSETS SINCE BASE YEAR



The final graph (Figure 6.9) contains descriptive statistics regarding the dependent variable (ROI) of the study. The percentage change in ROI is compared between plants over a period of time in the graph.

FIGURE 6.9

PERCENTAGE CHANGE IN ROI BETWEEN PLANTS SINCE BASE YEAR



The trends in graphs presented above are discussed in the next section, followed by a discussion of findings against the background of previous research as well as literature.

6.3.2 Inferential statistics

A Multiple Analysis of Variance (MANOVA) was performed to determine whether a statistically significant difference in the ROI of plants developed in the periods before, during and after the implementation of Lean production at Bloemfontein. The quarterly results of plants over three years (i.e. 12 observations for Bloemfontein and 12 observations for the Mean of other plants) were used for the calculation.

TABLE 6.11
MANOVA SUMMARY TABLE FOR A 2 X 3 ANALYSIS OF DIFFERENCES IN
RETURN ON INVESTMENT

Source	df	SS	MS	F	F-krit
Plants	1	0.21	0.21	0.117897	4.41
Time	2	2.50	1.25	0.718805	3.55
Plants x Time	2	157.76	78.88	45.2719	3.55
Error	18	31.36	1.74	1	
Total	23	191.8372			

$\alpha = 0.05$

An interpretation of the above results is provided in the next paragraph, followed by a comparative discussion on the results of this study to previous research and literature.

6.3.3 Interpretation

Interpretations of the various graphs and tables are provided below:

6.3.3.1 Income Statement Items

Three graphs from the Income Statement were provided:

- Percentage change in **Fixed Cost** (Figure 6.1 above) as a proportion of Sales indicates that the Bloemfontein plant started off with a faster rate of reduction in Fixed Cost in comparison to other plants, followed by a slight increase, and finally a large reduction during 1999, the year in which most Lean Practices were implemented. Management's reports offered slight decreases in labour cost and decreases in Other Operating Expenses as a result of workforce sensitisation from visual display (of budgeted to actual costs and production performance) on the shopfloor as reasons for reductions in Fixed Cost. However, bought-in services (e.g. maintenance) increased during the last year.
- Bloemfontein's **Variable Cost** (mainly material) as a percentage of Sales (Figure 6.2) increased at a faster rate than other plants during 1997 and 1998 (before and during Lean implementation), but started decreasing in 1999 while other plants

started increasing. Reasons for this tendency were explained by management reports as:

- Differences in pricing strategy between Bloemfontein (working only on Intercity Coaches) and the other plants (working in most instances, only on Metro Coaches). The Metro plants (according to this report) plot their annual price increases against their competition during a tender process. In the 1997 to 1998 period the general price increases by both these plants and their competitors were higher than that of the Bloemfontein plant. The Bloemfontein plant negotiated small increases with its sole customer due to severe financial constraints and poor market conditions in the intercity rail commuter market (in which the customer operates). The financial constraints in the intercity market are partially caused by a lack of government subsidy opposed to ample subsidies for the metro market.
- The decreasing rate in 1999 is ascribed to better control by implementation of Lean practices involving the display of material usage per Foreman in Green Areas and on the shopfloor.
- Bloemfontein's **Operating Profit** (Figure 6.3) follows a similar pattern to the Fixed Cost pattern. Management reports ascribe improvements (better than other plants) in 1999 to:
 - Higher monthly Sales, because MLPS (the plant's sole customer) negotiated a larger Coach repair budget (to take advantage of small price increases) with the Spoornet executive management team. The small overall price increases were based on savings in Fixed Costs in 1997 and 1998 (see the previous paragraph), which were passed on to the customer.
 - Higher customer loyalty due to better prices
 - Faster throughput time,
 - Better communication (planning schedule, material ordering and two-way radios).
 - Cost reduction by Lean Practices

6.3.3.2 Balance Sheet Items

Six graphs from the Balance Sheet were provided:

- Percentage Changes in **Stock** levels since the base year show that the Bloemfontein plant's Stock is more or less on the same level as the base year (1996), while the

average of the other plants is on more than 150% of the base-year level. This represents a real-terms reduction in stock level according to management reports, since the PPI for producers should (according to latter reports) be used to discount stock value to 1996 prices before comparisons regarding Stock levels can be made. The postulated real-terms reduction in stock is attributed to some high-value items being purchased in JIT fashion.

- Percentage Changes in **WIP** levels (material and labour) since the base year show that the Bloemfontein plant's Work In Process levels dropped to around 50% of WIP levels in the base year, while the WIP levels in other plants grew to about 130% of the base year level. This dramatic reduction in WIP is ascribed in management reports to the following Lean Production practices:
 - attempts to balance the number of production days per workstation to reduce bottlenecks
 - better communication between operations and purchasing, resulting in fewer delays due to stockouts
 - better production planning and control ("pull" strategy used to schedule jobs, which are plotted on Gant chart and displayed on the shopfloor after all foremen agreed on schedule)
 - attempts to synchronise monthly sales with monthly production schedules
- Percentage Changes in **Accounts Receivable** levels since the base year indicate dramatic reductions in all plants. Bloemfontein is, however, currently on less than 50% of the base year level, while other plants are on approximately 60%. Management reports ascribe this situation to:
 - better co-operation by customer based on improved relationship (due to better prices – as described earlier)
 - better logistics (software) systems implemented in Transwerk in 1997
 - better control of debtors
- Percentage Changes in **Net Working Capital** levels since the base year indicate substantial reductions in the case of Bloemfontein (60% of base year level in 1999), while control plants exceeded base year (increased to 130% - i.e. 30% up). Management reports ascribed this reduction to:
 - reductions in WIP
 - reductions in Accounts Receivable

7. Conclusions and Recommendations

7.1 Introduction

In this chapter, conclusions are drawn from the results obtained from this study, and recommendations are presented. Conclusions will focus on answering the research question and sub questions of the study. Limitations to the study are discussed under "recommendations" together with opportunities identified for future research.

7.2 Conclusions

In chapter 1, the research question was broken down into three sub questions. The rationale for each question was presented, and it was argued that the answering of these questions would provide background and support for answering of the research question. Conclusions based on findings for the sub questions will thus be provided before conclusions regarding the overall question are presented.

7.2.1 Conclusions regarding sub question (i)

Sub-question (i) read: "To what extent is it possible to apply Lean Production Principles to a South-African Government Enterprise?"

The following conclusions are made regarding this question:

- It is not possible to fully implement **Cross-training** in the South African Government owned plant under investigation due to restrictions associated with this environment. Restrictions are mainly attributed to unique management-labour relations in comparison with other companies and countries. Since Cross-training is considered by the literature and researchers (see previous chapter) as crucial for the successful implementation of Lean Production, the conclusion that this practice cannot be implemented fully in the plant under consideration is reported as an important finding.

- Practices associated with **Flexibility** could not be fully implemented in the South African Government owned plant under investigation. Managers offered unique management-labour relations in comparison with other countries as explanation. Since Flexibility is considered by the literature and researchers (see previous chapter) as crucial for the successful implementation of Lean Production, the conclusion that practices associated with this element of Lean Production cannot be implemented fully in the plant under consideration is reported as an important finding.
- **Preventive Maintenance** practices in the South African Government owned plant under investigation could not be fully implemented due to restrictions associated with this environment. Respondents listed unique management-labour relations as well as the production system of the plant as restrictions. Since Preventive Maintenance is considered by the literature and researchers (see previous chapter) as crucial for the successful implementation of Lean Production, the conclusion that this practice cannot be implemented fully in the plant under consideration is reported as an important finding.
- Full implementation of **Sole sourcing** practices in the South African Government owned plant under investigation was not possible. Unique company policy (ownership) of the plant was listed as a restricting factor. Since Sole Sourcing is considered by the literature and researchers (see previous chapter) as crucial for the successful implementation of Lean Production, the conclusion that this practice cannot be implemented fully in the plant under consideration is reported as an important finding.
- It is not possible to fully implement **Vendor lot size** practices in the South African Government owned plant under investigation due to restrictions associated with this environment. Restrictions are mainly attributed to unique management-labour relations as well as the production system of the plant. Since Vendor lot size is considered by the literature and researchers (see previous chapter) as crucial for the successful implementation of Lean Production, the conclusion that this practice cannot be implemented fully in the plant under consideration is reported as an important finding.
- **Quality Circles** could not be fully implemented in the South African Government owned plant under investigation. Restrictions are mainly attributed to unique management-labour relations as well as the production system of the plant. Since Quality Circles is considered by the literature and researchers (see previous chapter) as crucial for the successful implementation of Lean Production, the

conclusion that this practice cannot be implemented fully in the plant under consideration is reported as an important finding.

Based on the above conclusions, the overall conclusion is made that it is not possible to implement a significant proportion of Lean Production practices considered as important by the literature and researchers in the South African Government owned plant under investigation. Similar concerns could thus expect similar restrictions when attempting to implement Lean Production practices.

7.2.2 Conclusions regarding sub question (ii)

Sub-question (ii) read: "To what extent is it possible to apply Lean Production Principles to a plant with a Job production system in the Rail refurbishing industry?"

The following conclusions are made regarding this question:

- **Line-stop** practices could not be implemented in the Rail Refurbishing plant with a job production system under investigation due to unique production system of the plant. Since Line-stop practices are considered by the literature and researchers (see previous chapter) as crucial for the successful implementation of Lean Production, the conclusion that this practice cannot be implemented fully in the plant under consideration is reported as an important finding.
- It is not possible to fully implement all **Communication** practices such as kanbans and EDI in the Rail Refurbishing plant with a job production system under investigation due to restrictions associated with this environment. Alternative communication practices such as Visual Management, shopfloor display and two-way radios could be implemented. Restrictions are thus mainly attributed to unique production systems of the plant. Since Communication practices such as kanbans and EDI practices are considered by the literature and researchers (see previous chapter) as crucial for the successful implementation of Lean Production, the conclusion that these practice cannot be implemented fully in the plant under consideration is reported as an important finding.
- Full implementation of **Cross-training** practices were not possible in the Rail Refurbishing plant with a job production system under investigation due to restrictions associated with this environment. These restrictions are mainly attributed to both labour relations (see previous paragraph) and the unique production system of the plant. Since Cross-training practices are considered by the literature and researchers (see previous chapter) as crucial for the successful

implementation of Lean Production, the conclusion that these practices cannot be implemented fully in the plant under consideration is reported as an important finding.

- Attainment of **Schedule Stability** in the Rail Refurbishing plant with a job production system under investigation was problematic due to the unique industry of the plant. Since Schedule Stability is considered by the literature and researchers (see previous chapter) as crucial for the successful implementation of Lean Production, the conclusion that this practice cannot be implemented fully in the plant under consideration is reported as an important finding.
- **Set-up reduction** could not be attained in the Rail Refurbishing plant with a job production system under investigation due to restrictions associated with this environment. Restrictions are mainly attributed to both the unique industry and the production system of the plant. Since Set-up reduction is considered by the literature and researchers (see previous chapter) as crucial for the successful implementation of Lean Production, the conclusion that this practice cannot be implemented fully in the plant under consideration is reported as an important finding.
- It is not possible to attain **Vendor lot size** reductions for most purchased items in the Rail Refurbishing plant with a job production system under investigation due to restrictions associated with this environment. Restrictions are mainly attributed to both the unique industry of and the production system of the plant. Since Vendor lot size reduction is considered by the literature and researchers (see previous chapter) as crucial for the successful implementation of Lean Production, the conclusion that this practice cannot be implemented fully in the plant under consideration is reported as an important finding.
- It is not practical to implement **Group Technology** practices in the Rail Refurbishing plant with a job production system under investigation due to restrictions associated with this environment. Restrictions are mainly attributed to the production system of the plant. Since Group Technology is considered by the literature and researchers (see previous chapter) as crucial for the successful implementation of Lean Production, the conclusion that this practice cannot be implemented fully in the plant under consideration is reported as an important finding.

Based on the above conclusions, the overall conclusion is made that it is not possible to implement a significant proportion of Lean Production practices considered as

important by the literature and researchers in the Rail Refurbishing plant with a job production system under investigation. Similar concerns could thus expect similar restrictions when attempting to implement Lean Production practices.

7.2.3 Conclusions regarding sub-question (iii)

Sub-question (iii) read: "Did the application of Lean Production Principles to a South African Government-owned Refurbisher with a Job production system result in improved performance?"

The plant under investigation was a South African Government owned Rail Refurbishing plant with a job production system. The following conclusions were made regarding this question:

- It was possible to reduce **Fixed Costs** in the plant under investigation. The reduction of costs is considered by both the literature and researchers (see previous chapter) as an important outcome of Lean Production. Despite the fact that certain key Lean Production practices were not implemented, the plant was able to obtain this benefit. This is reported as an important finding.
- **Variable cost** reduction was also achieved by the investigation plant. Once again, cost reduction is considered to be a significant result of the implementation of Lean Production practices by the literature and researchers (see previous chapter) consulted. Consequently, the important finding noted was that the investigation plant was able to achieve a reduction in variable costs even though certain key Lean Production practices were not implemented.
- The investigation plant was able to increase its **Operating Profits**. According to the literature and researchers (see previous chapter), Lean Production practices should result in a growth in Profit. Even though the investigation plant was unable to implement all significant Lean Production practices, it was able to achieve this result, hence the importance of reporting this fact as a finding.
- Literature and researchers (see previous chapter) consulted state that a **reduction in stock levels** is a direct result of the implementation of Lean Production practices. The investigation plant was able to reduce stock levels without implementing all key Lean Production practices. This finding was, therefore, reported as relevant.
- Without implementing all key Lean Production practices, it was possible for the plant under investigation to **reduce the levels of Work-in-process**. This is an important outcome of the implementation of Lean production practices, in

accordance with the literature and researchers (see previous chapter) consulted. The achievement of this benefit despite all the restrictions faced by the plant, is significant as a finding.

- **Accounts Receivable** could be reduced in the investigation plant. The literature and researchers (see previous chapter) consider Waste Reduction, in general, as a relevant outcome of Lean Production but little reference is made to reductions in Accounts Receivable due to Lean Practices. It is important to report the fact that the plant was able to reduce this item even though it was unable to implement certain key Lean Practices, as a finding.
- **Waste reduction** is, in general, considered by the literature and researchers (see previous chapter) as an important result of the implementation of Lean Practices. Although little reference is made to the reduction of Net Working Capital due to Lean Practices, the plant under investigation was able to achieve this benefit. The ability of the plant to do this without implementing all key Lean Practices is regarded as an important finding.
- It was possible to reduce **Fixed Assets** in the plant under investigation. Both the literature and researchers (see previous chapter) stated the importance of Asset reduction and/or containment as a result of Lean Practices. In this instance, the important finding noted was that the investigation plant was able to achieve this benefit despite the fact that they did not implement certain key Lean Practices.
- Little is reported by the literature and researchers (see previous chapter) on the improvement of ROI as a direct result of the implementation of Lean Practices. The investigation plant was, however, able to achieve an increased **Return on Investment** by implementing limited Lean practices. This is significant to report as a finding.

Based on the above findings, it is concluded that the application of Lean Production Principles to the South African Government-owned Rail Refurbisher with a Job production system under investigation resulted in improved financial performance.

7.2.4 Conclusions regarding the research question of the study

The research question of the study read: "Did the implementation of Lean Production Principles in a South-African Government-owned Rail Refurbishing Plant with a Job production system result in better financial performance (as measured by ROI)?"

The following information serves as a background to the conclusion in respect of this question:

- The ten Lean Practices considered most important, by respondents, for the success of Lean Production in the plant under investigation differ significantly from the practices considered most important by the literature and other researchers (see the first χ^2 test in the previous chapter). The Null hypothesis of the first test could thus not be rejected.
- A statistically significant proportion of Lean Practices could not be implemented in the plant under investigation (see the second χ^2 test in the previous chapter). The Null hypothesis of the second test could thus not be rejected.
- Some of the practices referred to above could not be fully implemented due to restrictions brought about by the ownership and location of the plant under investigation, while other practices could not be implemented due to the industry and production system of the plant. In some instances practices were adapted to suit the environments under consideration.
- The balance of practices and elements not commented on above (as identified in the research of Meredith and Zhu, 1995) could be implemented. These include in-house lot size reduction, quality certificates from vendor etc. (see table 6.3 above).
- Various improvements were, however, reflected by items on the Income Statement and Balance Sheet of the plant under investigation – including improvements in ROI. The significant differences in ROI between similar plants over a period of time lead to the rejection of the Null Hypothesis for the third subquestion – i.e. the plant with Lean Practices had better ROI than the plants without Lean Practices.

Based on the above findings, it is concluded that the application of Lean Production Principles to the South-African Government-owned Rail Refurbisher with a Job production system under investigation resulted in improved financial performance as measured by ROI.

7.3 Recommendations

Various recommendations result from the study. These recommendations are largely based on issues identified in the literature, the study itself as well as limitations of the study.

7.3.1 Recommendations based on issues identified in the literature

Hendry (1998) stated that the largest proportion of research in the Operations/Production Management field is conducted and intended for make-to-stock environments. This Production Process Strategy is mainly associated with repetitive manufacturing (Adendorf & De Wit, 1997). Given the diversity of production systems and circumstances in practice, it is however unlikely that findings from the make-to-stock repetitive manufacturing environment will apply to all production systems in the same manner (Hendry, 1998). Based on this statement and the lack of published research found on jobbing production systems in general, the following recommendations are made:

- Issues, methods and impacts of workforce flexibility improvement in jobshop environments should be investigated. This suggestion is based on the high importance associated with this element of Lean Production by respondents in the study of Meredith and Zhu (1995) as well as the description of the unique characteristics of jobshop workforces by Hendry (1998).
- Monden (1998) has identified several ineffective designs in a repetitive manufacturing environment. Hendry (1998) however indicated that changes in layout may sometimes not be feasible in jobshops. No guidance is provided regarding the criteria or process involved when considering alternative layouts with a view to Lean Production (Group Technology) by respondents in the study of Meredith and Zhu (1995) and the lack of published research about this aspect, it is suggested that models should be developed to aid managers of jobshops in decision making regarding layout design.
- Liker (1997) Monden (1998) state that MRP can be used in conjunction with kanbans. Although Louis (1997) provides an elaborate description of the possible ways in which the two systems can be combined (e.g. by "automated kanban"), little is published in the form of research regarding the feasibility of such a system in jobshops. Based on
 - this observation
 - as well as the statement by Hendry (1998) that planning and control systems in jobshops are admittedly an area requiring more research

- and the high importance attached by Meredith and Zhu (1995) in their research regarding Lean elements to schedule stability, vendor lead time, vendor lot size and communication

it is recommended that the combination of MRP and kanbans in jobshops should be investigated.

7.3.2 Recommendations based on issues identified in the case study plant

In the section above conclusions were made regarding the information gathered for this study. Specific explanations regarding some conclusions (e.g. increases or decreases in some financial items) were not provided, since the study was not intended to elaborate on all observations made. In many instances findings were explained against broad literature or general research observations. Using this as a background, the following recommendations are made:

- An analysis should be made to determine the specific causes of decreases in Stock in the context of the environments described during this study. Although Liker (1997) and Monden (1998) state that Stock is reduced in Lean systems based on JIT supplier kanban practices, this practice could not be fully implemented in the plant under investigation.
- Specific causes of decreases in WIP in the context of the environments described during this study should be analysed. Although Liker (1997) and Monden (1998) state that WIP is reduced in Lean systems based on production kanban practices, the latter practice could not be fully implemented in the plant under investigation.
- An analysis should be made to determine the specific causes of decreases in Fixed cost in the context of the environments described during this study. Although Liker (1997) and Monden (1998) state that costs like Labour cost, Maintenance cost and Depreciation are reduced in Lean systems based on various practices such as flexible workforce reduction/Preventive Maintenance/Continuous Improvement, these practices could not be fully implemented in the plant under investigation.
- An investigation into the extent to which it is possible to attain JIT production and purchasing in South Africa is necessary. Apart from the cases of motor manufacturers in South Africa, little is known about these practices in the South African environment.

- An investigation into the extent to which South African Labour Relations affect Lean Production practices is suggested. Although information regarding industrial action and motivation seems to be plentiful in South African research, little could be found regarding this interface between Industrial Relations and Production Management.
- Little could be found regarding the description and research of production and refurbishing in Rail environments. Research in this sphere is scarce, and efforts of researchers should be directed towards the improvement of this multi-billion industry.

7.3.3 Recommendations based on limitations of this study

In the sections above, recommendations were made based on areas not sufficiently covered by research and literature. The recommendations below are based on the inherent limitations of the study itself.

7.3.3.1 Limitations of the study

- Smit (1991) stated that alternative explanations may be available for events in a specific case. It is thus possible that in the case of Transwerk Bloemfontein, an aspect like pricing policy (the effects of which were not measured) for jobs unique to the plant and thus uncommon to other plants could influence results.
- The literature (Flynn et al., 1990; McCutcheon & Meredith, 1993; Smit, 1991) indicates that case study results cannot always be generalised. The findings of this study could be used as a basis for further investigation by other researchers and practitioners, but results can for example not be generalised for all jobshops.
- The scope of the study was extremely broad, and some aspects such as the effect of COSATU objectives on Lean practices, could not be described and measured in depth. Certain findings, therefore deserve a more in-depth study, since significant influences on Lean Production may have been underestimated in the process.
- Kadipas et al. (1999) found that Lean Production practices in general only show real benefits approximately two years after implementation. In the case of the Transwerk Coach Refurbishing plant at Bloemfontein, some practices were only implemented a few months before the study was conducted. Results may thus have been affected by this factor.

7.3.3.2 Recommendations flowing from limitations of the study

- Although it might be an almost impossible task in the South African environment, it is recommended that a *survey* covering various companies is conducted regarding Lean Production in the South African environment, is concluded.
- A similar survey of South African Rail concerns (e.g. Union Carriage and Wagon, Dorbyl, Transwerk, Victra etc.) is suggested.
- A follow-up study should take place two years or more after the implementation of Lean Production practices in the plant under investigation.
- Aspects considered by respondents from the Transwerk plant as crucial for the success of Lean Production in the plant should be examined in greater detail.
- Aspects *not* considered by respondents from the Transwerk plant as crucial for the success of Lean Production in the plant should be examined in greater detail. It may be possible to propose alternative ways of achieving the benefits of the Lean elements considered less important by respondents based on practical considerations.

7.4 Conclusion

In the preceding chapter, various conclusions were made about the extent to which Lean Production practices can be implemented in the specific environment of a South African Government owned Rail Refurbishing plant with a job production system. The conclusions focused on aspects contradicting general expectations regarding the transferability of Lean Production practices.

Various recommendations were made regarding further research. Recommendations were based on issues identified in the literature, issues identified during the study, and finally on the basis of the shortcomings of the study.

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APPENDIX A

Lean practices as applied in the case of the Transwerk Coach Repair Plant at Bloemfontein

The discussion below will be introduced with a description of the products and systems of the Transwerk Coach Repair plant in Bloemfontein (hereafter referred to as CR), followed by a description of the way in which Lean Practices were implemented at the plant. This discussion is structured according to the subsystems identified by Liker (1997), i.e. Core Production system, suppliers and customers.

1. Background

The Coach Repair (CR) plant of Transwerk, Bloemfontein specialises in the refurbishment of Intercity Passenger Coaching stock. Strictly speaking, a *service* is thus rendered by the plant.

FIGURE A1

THE TRANSWERK COACH REFURBISHING PLANT AT BLOEMFONTEIN



Photograph: the researcher

1.1 Product characteristics

The coaches being refurbished belong (mainly) to Mainline Passenger Services (MLPS), a division of Spoornet, although work for some of Africa's railways and an Australian Railway has been carried out in the past. Repair work is conducted strictly according to elaborate specifications and designs provided by the client, and may include:

- Basic repainting (both diesel locomotives and Coaches are painted at the plant)
- Light repair work involving elementary maintenance of e.g. broken windows
- Major repair work involving the stripping, inspection and replacement of numerous components per job.
- Repairing wrecks and collision damage
- Rebuilding of existing coaches for special purposes, e.g. converting an ordinary job into a Blue-Train luggage carrier

FIGURE A2
A MAINLINE WRECK



Photograph: the researcher

The repair process is complicated by the wide variety of models, sub-models, purpose-made vehicles and other variables in the MLPS fleet, e.g.:

- Sleeper coaches contain compartments with sleep bunks. Submodels vary according to the inclusion/exclusion of showers, toilets, wash basins etc
- Sitter coaches contain seating only
- Kitchen Cars and Dining cars
- Power Cars
- Steam Cars
- The Phelophepha mobile health clinic, the Blue Train and the Kitchen/Dining cars converted for use by BJ's Fast Foods are examples of purpose-made vehicles and trains.

FIGURE A3
THE BLUE TRAIN



Photograph: obtained from the official Blue Train website

- Spoornet changes specifications on a continuous basis – for example the paint scheme has been changed three times since 1990 (Phungula, 2001):

FIGURE A4

THREE DIFFERENT MLPS PAINT-SCHEMES BETWEEN 1990 AND 2001



Photographs: the researcher

In summary, the nature of the work remains the same, but specific requirements between jobs differ. This is typical of jobbing production systems, as described by Adendorf and De Wit (1997).

1.2 Production planning

Work is normally negotiated with clients per contract, and loose send-in and delivery schedules are compiled. Coaches are actually received, however, according to availability – major variations from the schedules therefore occur.

This situation complicates the ordering and purchasing of material, since an MRP forecast is used as the basis for material ordering and purchasing. If for example the client promised to send in 8 sleepers and actually sends 6 sitters, the wrong material was ordered and received, causing short term stockouts and long term surplus or “dead” stock. The latter is identified periodically on the basis of Corporate inquiries regarding stock not utilised over periods of 12 months and longer. Eventually this stock is scrapped, but only after extensive procedures regarding the disposal of surplus stock have been followed.

The situation described above reflects some of the typical make-to-order problems described by Hendry (1998).

1.3 Materials Management

As indicated above, the material utilised during the repair process is ordered based on an MRP list. The MRP is based on estimations of material and hours necessary to perform specific repairs. Estimates may however be far off, since the condition of

coaches differ immensely – depending on their last repair date, the region where they are used (e.g. coastal units rust) and whether they were out of service and vandalised by squatters. Thus the actual and planned MRP quantities differ greatly between jobs, even between models which are exactly the same.

For example:

- The MRP calculation for the replacement of brass doorlocks is based on an average of 2 locks per coach, and this operation could be performed in, say 30 minutes per lock. If 2 coaches are expected in April, 4 locks are ordered, and the load for this operation is computed to be 120 minutes.
- Coach number X arrives. This Coach was in regular use between Cape Town and Bloemfontein, and only one lock must be replaced.
- Coach number Y was stored on a siding near Braamfontein railyard, and all 4 locks were stolen and sold as scrap metal.
- The result is that an absolute variance of 3 locks is recorded, and the net result is that 1 lock more than the planned number of locks was used.

**FIGURE A5
COACHES IN STORE**



Photo obtained from David Forsyth's unofficial SAR page

Being part of Transnet, a large corporation, extensive rules and regulations regarding purchasing and Tender Rules must be followed. Various role players e.g. the Engineering section of the Bloemfontein plant as well as Promat, a Transnet Service

Centre (see Table 1.1), are involved in the purchasing and receiving cycle. The process is elaborately described and controlled by the application of various financial controls. Annual and ad hoc audits are conducted to ensure adherence to the process. Deviations are viewed in a serious light, and officials and managers involved may be disciplined and dismissed, depending on the circumstances.

The broad material ordering and receiving process involves:

- an MRP run
- a meeting between logistics and operational staff of CR to do a rationality check of quantities ordered
- approval of the final list by the manager in charge of CR
- presentation of the list to Engineering
- the Engineering official “flags” the list to Promat, who obtains tenders for items being ordered
- tenders are presented to the Engineering section for recommendation
- large price variances are presented to the manager of CR first before the order is placed
- orders are placed by Promat after the recommendation by Engineering
- suppliers receive orders, and produce the item ordered
- finished items are delivered to Promat, who provides the supplier with a proof that goods were received
- Promat forwards the material to the Engineering department’s stock receiving office
- the Engineering section conducts a superficial quality inspection to check quantities and enter material into the CR store in a restricted status
- while the material is actually moved to the CR store, documentation for invoice payment is prepared, and the Financial section pays the supplier
- the storeman at CR receives stock, has it placed on shelves, and records the stock quantities on computer
- stock status changes to active, and material can be issued if a picklist (based on a Bill Of Material and pre-inspection of a specific job) is presented
- faulty material is returned to the store, and moves in the opposite direction along the receiving chain, back to the supplier

FIGURE A6
A TYPICAL RAIL REFURBISHING STORE



Photograph: the researcher

Production scheduling is supposed to be performed according to MRP dates, but due to the complexity of the operation, the lack of sufficient PC's and the high variability of actual operations, production management compiles a simple Gantt-chart to schedule jobs.

This situation is in accordance with descriptions of high formalisation in large companies, the restrictions of the South African environment and problems associated with production planning in jobshops (Bullars, 1999; Gaither, 1990; Hendry, 1998; Robbins, 1989).

1.4 Production Process

The stations involved in the major repair of a sleeper coach demonstrate the production process at CR best:

- send-in schedules are agreed with the client
- material is ordered well in advance for more or less standard operations
- when a coach arrives, it must be inspected by a group of foremen (including the client's quality inspector who works on-site)
- a list of damaged components is compiled, and bills and routings are compiled

- work on a coach commences when an MRP order is assigned
- jobs are scheduled in Gantt-chart format
- once scheduled, coaches are stripped of components such as windows, toilets, wash basins etc. and components which were removed are distributed by trolley to the Electroplating shop, the Electrician shop, the Shotblast and paint shop and other processes while the Coach itself is shunted to the shotblast booth and thereafter to various repair, painting and finishing sections

FIGURE A7

BODY FILL, BODY REPAIR, COMPONENT REPAIR AND MASKING AT THE TRANSWERK COACH REPAIR PLANT IN BLOEMFONTEIN



Photographs: the researcher

- some processes, such as sub-processes of underframe and bogie repair, involve subcontracting to other units in the Bloemfontein Transwerk plant such as Wheel/Axle/Bearing testing and repair

FIGURE A8

BOGIES SEPARATED FROM COACHES AT THE TRANSWERK PLANT IN BLOEMFONTEIN



Photograph: the researcher

- once completed and tested, coaches are shunted out to the railway station where they are collected by the client for use on trains

The production lead-time for a job of this nature is long in comparison with the manufacturing of new products, and few units are under repair at any given time. Work-in-process can (like in repetitive manufacturing) accumulate if stations are not synchronised.

The production process described above approximates descriptions of jobshop operations in the literature (Adendorf & De Wit, 1997; Hendry, 1998; Gaither, 1990).

1.5 Quality Control

The quality system used in the CR plant is ISO 9002. Although no formal TQM initiative was launched in the plant, the ISO quality procedure utilised in CR was written to cover a wide range of aspects, ranging from customer satisfaction to

training to supplier certification to continuous improvement. 100% inspection of the product is required by the client, and non-conformance reports are compiled by the client's representative if major defects were not rectified to specification.

Faults are not measured as defects per 100 units as in statistical sampling, but as an average number of faults per unit. Quality Certificates, important for safety, are required by the client for certain components such as couplers and springs. Some materials, such as paint, may only be purchased from vendors approved by the client. The client accepts no job unless the quality inspector assigned to the plant has inspected each job, and all faults are rectified to specifications. Hereafter a quality certificate is issued, and the job may be invoiced.

A number of years ago, before Transnet was registered as a company, under the SATS, quality circles functioned in the organisation, and workers were kept rigorously to routing times and standard operation sheets – all under the so-called “Bonus” incentive scheme. When the scheme was abolished due to costs and the administrative burden associated with the recording of individual performance, these practices were abolished.

The unique situation of defect measurement and continuous improvement described above supports the views of Hendry (1998) on the nature of quality improvements in make-to-order companies.

1.6 Finished Goods inventory

Unlike repetitive manufacturing, the CR plant's production process strategy is make-to-order. No jobs are repaired without orders placed by the client. This means that jobs are sold as soon as they are finished, and waste in finished goods is basically non-existent. The only conditions under which excessive finished goods may accumulate are when the client is forced to freeze all maintenance work due to cost savings imposed by Corporate office, or when a job is finished, but of such poor quality that the client will not accept it.

Hendry (1998) stated that reductions in finished goods inventory would not cause major waste reduction and benefits in jobshops. The description above supports her views.

1.7 Workforce

The following characteristics distinguish the CR workforce:

- work is performed by artisans of various specialised trades unique to the rail industry such as Vehicle builders and Wagon fitters, and apart from certain fixed equipment such as jacks, cranes and acid-baths, the majority of the work is performed with hand-held tools such as drills, air impact wrenches and grinders
- artisans are “direct” workers, and their helpers are “indirect” workers
- several unions represent various grades of workers – e.g. in the broader Transnet, one union represents traindrivers, another represents artisans and technical personnel, while a different union represents clerical personnel and again another union represents semi-skilled and unskilled workers
- like in the USA, the job-class system exists, accompanied with demarcation of duties etc.
- all major decisions and business plans must be negotiated and agreed with labour
- affirmative action and training are important goals for the plant

In short, the CR plant is similar to most western and South African companies as far as human organisation is concerned (Liker, 1998).

2. Lean Practices at CR

The Core Production system consists of the Material Handling system, Quality system and Human Organisation (see Chapter 2).

2.1 Material Handling in CR

As explained in paragraph 1.3 headed “Materials Management” above, Material ordering was (before Lean Production was implemented) mainly restricted to the mechanistic operation of the SAP-driven MRP 2 system. Though many efforts were made to correct the “Item Master”, lead time, standard prices and other significant aspects of the system, the results were unsatisfactory. Stock-outs, dead-and-slow moving stock and major price variances were common problems encountered on a continuous basis. Work-in-progress and production planning (before Lean Production was Implemented) was done by the same mechanism as other materials – the MRP 2. Similar problems were experienced, but in other manifestations. On paper, this system should work wonderfully, due to the fact that every reconditioned part could be planned and allocated to workstations to perfection. In practise, this system never worked, because the costs in engineering input and the frequency of re-scheduling

required to keep abreast of day-to-day disruptions made it impractical. Late deliveries and wasted capacity were common problems encountered on a continuous basis when this system was employed. The following Lean production practices were consequently implemented:

- **Kanban system.**

- **Supplier Kanban**

- More than 3000 items are used in the CR plant in sporadic batch sizes (independent of work volume), rendering manual kanbans basically impossible
- Tender rules complicate sole sourcing and paperless, low-specification purchasing
- Contracts specifying approximate monthly usage could however be signed for high-volume items such as paint; especially where the client specifies approved suppliers.
- These restrictions are consistent with the opinion of Hendry (1998) that the Kanban system may be impractical for a jobbing environment

- **Production kanban**

- Production Kanban was found to be possible for CR, but was abolished due to resistance by Foremen, Production Managers and staff.
- A compromise was reached in the form of a Gantt Chart prepared in "pull" fashion, where the MRP finish date is used as starting point, and the foreman involved in the final process specifies dates in which coaches must reach him from preceding processes in a "backschedule" format. In this way, foremen are involved in planning, while jobs are pulled Kanban style towards selling dates
- Schedules are displayed in Green Areas allowing staff to be informed about production schedules and priorities.
- Hendry (1998) stated that "Work-to" lists and schedules as well as improved visibility on the shopfloor may be preferable in jobbing environments. Monden (1998) furthermore recommends a combination of MRP and Kanban. The situation described for CR above supports the viewpoints of both authors.

2.2 Production Smoothing

- Production smoothing at the CR plant (before Lean Production was Implemented) was complicated by the variability in send-in rate by the customer as well as the differing conditions of incoming jobs, thus causing forecasts of load to be inaccurate
- With the co-operation of the plant's clients, it was however found to be possible to schedule coaches in takt-time fashion
- Line balancing could be achieved by adding or removing workers from stations to achieve a target turnaround time per station. Before Lean Production were implemented, load in the case plant was calculated according to available capacity as compared to the workload. Thus:
 - Station X has 2 direct workers, each able to work 7 hours per day, while Station Y has 2 direct workers, able to work 7 hours per day. This is so because it always worked like this in the past.
 - The capacity for station X is thus $2 \times 7 = 14$ hours per day, and the capacity for station Y is also 14 hours per day
 - A job with 42 hours for station X and 14 hours for station Y will thus spend 3 days at station X and 1 day at station Y
 - WIP may therefore accumulate between slow and fast stations

Applying Lean flow principles, the situation was redefined:

- To ensure that no job spends more than two days at a station, average workload is divided by 2 days, resulting in 21 hours at station X and 7 hours at station Y
- Workers are reassigned: 3 to station X (i.e. capacity of 21 hours per day) and 1 to station Y (i.e. 7 hours per day)
- Stations are now balanced, and fluctuations are absorbed via overtime
- The advice offered by Hendry (1998) focuses on parts commonality, full capacity utilisation and maintenance policy, and seems to be inappropriate for these circumstances.

2.3 Set-up reduction

- Lot production using machines requiring set-up changes are not applicable to the CR plant, since artisans use small, standard handtools.

- The implication is that set-up reduction could not contribute to any waste reduction in the CR plant.

2.4 Process Layout for shortened Lead Times

- The local management at the CR plant decided to retain a process layout due to the limited demand, the labour-intensive nature of the work, the expected resistance from labour if people were to be retrenched due to mechanisation and due to the unavailability of capital.
- This decision is in accordance with the case studies presented by Hendry (1998) to demonstrate that make-to-order companies may sometimes decide to retain process layouts and reject cellular layouts for strategic reasons.

2.5 Standardisation of operations

- Standard Operations, called "Job Procedure Cards" or "J.P. Cards", were used during the 1980's when the CR plant was part of the SATS. These practices were abolished with the Bonus incentive scheme in the late 1980's.
- After these "J.P. Cards" were abolished and before Lean Production practices were implemented, workers were allowed to use their own discretion regarding work method and time taken. Foremen found it basically impossible to control production pace and quality, since everything became debatable due to a lack of standards.
- Local management decided to involve Transnet's training service centre at Esselenpark to compile and register datasheets for the most critical operations performed on coaches, and to train workers according to these sheets. The decision was based on the perceived weaknesses of traditional trade training and the need for affirmative action artisans from the current workforce. This system was partially implemented at the time of this study.
- Hendry (1998) considers the flexibility and expertise of artisans in jobshops as a traditional advantage of these operations. This is partially true for the CR plant.

2.6 Preventive Maintenance

- Preventive Maintenance (PM) was performed on machinery before the implementation of Lean Practices in the CR plant.

- The benefit of the practice is however questioned, since hand-held equipment could possibly be replaced once or more times per year instead of paying an internal Transwerk subcontractor to perform regular maintenance.
- The job demarcation system associated with job-class representation by unions is an obstacle to operators performing PM themselves.
- The opinion of Hendry (1998) regarding the expected positive effect of regular preventive maintenance on capacity utilisation in jobshops may thus not be true for the CR plant.

2.6 Quality at CR

- As mentioned above, the CR plant used the ISO quality management system before and after Lean Production practices were implemented. The procedure manual used in the plant within the above system was written to cover inter alia the following aspects:
 - Contract review
 - Purchasing and Sub-contracting
 - Process Control
 - Inspection and testing
 - Training, Human Resources management and communication
 - Statistical techniques
- Continuous improvement activities are a standard requirement for the retention of ISO certification, thus these activities (as measured in the recording of x-number of suggestions per 100 employees per year) are performed in the CR plant.
- Re-introduction of Quality Circles (with some modifications) was found to be a possibility in the CR environment, but with some modifications to the Japanese model. Workers are for example offered a tin of cold drink and a meat pie to encourage them to attend quality circles during lunch hour. Limited monetary payments for cost-reduction and quality improvement ideas were possible. Some problems regarding internal financial controls and expectations of all workers to be paid for any contribution in the context of cash payment were however foreseen.
- Aspects listed above resemble the organisation-wide Total Quality approach described by Gaither (1990).
- Before Lean Production practices were implemented at the CR plant, ISO certification auditors pointed out that process control, training and statistical

techniques were inadequately addressed. During the most recent audits, auditors were surprised, and commended management on the major improvements made regarding the issues listed as problems during their previous visits. The standardisation of operations and training by means of datasheets, statistical control and customer satisfaction reports made the biggest impression.

2.7 Human Organisation at CR

- Workforce reduction and flexibility were experienced as problems at the CR plant, since workers cannot be moved freely between processes due to the traditional job-class system, union involvement and Government interference with initiatives to retrench Transnet employees as described by Monden (1998) and Bullard (1999).
- Some compromises could however be reached in this specific environment; e.g. artisans are paid on higher levels to supervise semi-skilled workers performing traditional artisan duties, and to provide formal on-job training (using datasheets with a view to Article 28 Trade tests). This activity contributes to Transnet's goals of Affirmative Action, while capacity is enlarged.
- Waste reduction initiatives, such as improvements of workflow by elimination of unnecessary motions, were redefined to concentrate on multiple activity analysis as described by Currie (1992). According to this method, tasks of artisans and their helpers are plotted to indicate activities versus waiting time. Reassigning workers amongst tasks consequently eliminates idle time. The figure below is an example of such an analysis:

**FIGURE A9
MULTIPLE ACTIVITY CHART**

Time	Artisan A	Helper A	Artisan B	Helper B
07h00	Task A	WAIT	Task D	Help with D
07h30	Task B	Help with B	Task E	WAIT
08h00	WAIT	CLEAN	Task F	WAIT
08h30	Task C	WAIT	WAIT	CLEAN
09h00	WAIT	CLEAN	Task D	Help with D
09h30	Task A	WAIT	Task E	WAIT
10h00	Task B	Help with B	Task F	WAIT
10h30	WAIT	CLEAN	WAIT	CLEAN
11h00	Task C	WAIT	Task D	Help with D
11h30	WAIT	CLEAN	Task E	WAIT
12h00	LUNCH	LUNCH	LUNCH	LUNCH
WORKED	180 MIN	180 MIN	240 MIN	150 MIN
WAITED	120 MIN	120 MIN	60 MIN	150 MIN
UTILISATION	60%	60%	80%	50%

- The situation and applications above confirm the restrictions associated with the lower volumes and higher variety of operations in jobshops as described by Hendry (1998).

3. Implementation timeframe

The implementation process consisted of the following major phases:

Phase I: 1997

This phase consisted mainly of analysis, planning and consultation:

- A new manager (the researcher) was appointed in the case study plant in June 1997.
- The plant's situation was analysed from various perspectives and with the inputs of various parties, such as unions, foremen and external parties such as the NPI
- The analysis indicated that, due to the plant's limited market opportunities and restrictive company policy, profit increase could more likely be realised by cost reduction than from increased sales.
- Lean Production was identified by management as the preferred cost reduction strategy.

Phase II: 1998 to 1999

This phase consisted mainly of sensitisation and implementation:

- To learn how Lean plants operate, management, foremen and shopstewards visited Nissan and Toyota's plants in respectively Rosslyn and Prospecton. During these visits, valuable information was gathered, and important contacts were established. Management was referred to an outside consultant for in-depth advice.

- The consultant provided training to management, foremen and unions on various occasions. In addition, the consultant visited the plant and made recommendations.
- Stockholding was addressed during this phase. Slow moving stock was identified and sold. Negotiations with suppliers of the highest value inventory items were initiated and, after a tender process, medium-term contracts were awarded. The contracts were modified to allow for delivery of items as needed on short notice – a move towards JIT within company constraints. Huge savings were made with paint: before contracts were awarded, paint was bought from various approved suppliers. Once an order was placed, the cheapest quote had to be accepted – irrespective of the remaining products of other suppliers in the store. This used to be a complex matter, since the products of various suppliers may not be used together. The blue paint of supplier “X” may for example not be used with the red paint of supplier “Y” in case a chemical reaction may occur.
- WIP and production planning was planned and controlled in Gantt chart format – in offices and on the shopfloor. In-house lot size was monitored this way.
- Communication was improved by the purchasing of two-way radios (foremen) and “toolbox talks” (workers).
- The first steps were taken to standardise work procedures in 1998, when the Transnet training College (Esselenpark) wrote the first “Datasheets” containing standard work procedures, time allowed and safety hints. Since the first datasheets were available, workers were trained and certified competent by a trainer appointed specifically for this purpose. Negotiations with unions to get around their rigid “job-class” demarcation of duties stance started in 1998, and resistance was still evident by the time the study was published.
- Workers were moved between work centres to achieve line balancing, and weekly (continuous) production time analysis was implemented to ensure that balancing remained in tact.
- The plant’s client was asked to co-operate with the stabilisation of the production schedule, but no formal agreements were reached.
- Elementary statistical quality control techniques were implemented, but with little perceived gain thus far. Supervision tended to leave the setting of targets and the updating in this regard to management, despite attempts to “get them on board”. Only once a firm stance was taken by management did the targets and progress appear on the shopfloor (in “green areas” such as those at Nissan and Toyota as suggested by the consultant).

Phase III: 1999 onwards

This phase was characterised by “fine-tuning” and improvements to aspects implemented in the previous phase:

- The contracts with suppliers were expanded to include high-value items not covered during the first round of tendering. Logistics personnell attempted to improve relations with suppliers by frequent communication and feedback as well as projections of stock requirements.
- More workers received training.
- By the time this dissertation was published, a “Learnership” (the first in the company) was registered. This step was made possible by the groundwork done with the writing of “datasheets” aimed at standard operations.
- “Datasheets” were systematically positioned to form the basis of routings (and thus quotations, capacity planning and so forth).
- The plant’s client was rewarded with discounts for co-operation in schedule stabilisation and higher volumes.

- By the time this document was published, a cheap “andon” system in the form of a personal computer linked to several televisions in strategic places on the shopfloor was underway.
- Wastage (mainly: wasted production capacity) was a fixed item on management meetings.

The table below portrays the sequence in which practices were implemented, as well as the lag between implementation and results.

	1997 Analysis, planning and consultation	1998 Sensitisation and implemen- tation	1999 “Fine tuning”
Fixed Cost	8% less	11% more	25% less
Variable Cost	25% more	35% more	25% more
Operating profit	12% more	5% more	8% more
Stock level	35% more	5% less	0% more
WIP	0% more	25% more	40% less
Accounts receivable	55% more	0% more	40% less
Net Working Capital	18% less	8% less	20% less
Fixed Assets	10% less	15% less	12% less
ROI	0.7% less	0.7% more	2% more

Note: all % changes relate to 1996 base-year

4. Conclusion

Management concluded that the implementation of Lean Production practices was a worthwhile exercise, and further “fine-tuning” will take place.

APPENDIX B

Critical elements for Lean Production at Transwerk Coaches

Nu	Element	Insignificant			Critical				COMMENTS
		1	2	3	4	5	6	7	
1	Vendor lead time.								
2	Outside consultant.								
3	Relationship with supplier.								
4	Top management commitment.								
5	Vendor lot size.								
6	JIT education.								
7	Flexibility.								
8	Sole sourcing.								
9	JIT team.								
10	Schedule stability.								
11	Communication.								
12	Co-worker relations.								
13	Cross-training.								
14	Flatten bill of materials.								
15	Quality certificates from vendor.								
16	JIT champion.								
17	Preventive maintenance.								
18	Investigate suggestions.								
19	Quality circles.								
20	Pilot project.								
21	Authority to stop lines.								
22	Group technology.								
23	In-house lot size.								
24	Set-up time reduction.								

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