THE IMPACT OF TECHNOLOGICAL AND ORGANISATIONAL DIMENSIONS ON OPERATIONAL PERFORMANCE OF MANUFACTURING COMPANIES

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DECLARATION

I declare that this research report is my own, unaided work. It is being submitted for the Degree of Master of Science in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.

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ABSTRACT

Despite the adoption of Advanced Manufacturing Technologies (AMT) by manufacturing firms, the literature reports disappointing performance of manufacturing, attributed to an imbalance between the dimensions of technology (i.e. AMT) and organisation. The central research problem of this study was:

To analyse the effect of development along organisational and technological dimensions on operational performance of manufacturing firms in South Africa.

The investigation into the central research problem was guided by a primary research question:

Does a balanced development of organisational and technological dimensions result in optimum levels of operational performance of manufacturing?

Structural Equation Modelling was employed to assess the central research problem and the primary research question by evaluating the relationship between three latent variables: Technology, Organisation and Operational Performance.

Data was collected by means of a self-administered online web questionnaire. A total of 104 responses were received from a target sample of 604 Managing Directors of manufacturing firms. The sample was not representative of the population of manufacturing firms in South Africa.

It was shown that the correlation between Technology and Organisation was fairly strongly positive. The direct impact of Technology on Operational Performance was unexpectedly non-significant, whereas Organisation's direct impact on Operational Performance was strongly positive.

These results did not support the primary research question. In fact, organisational dimensions were more important than technological dimensions in obtaining optimum levels of operational performance of manufacturing.

The implication was that firms should strongly emphasise the development of its organisation as part of a technology strategy.

ACKNOWLEDGEMENTS

Firstly, I would like to thank my wife and children for their support and patience to complete this research project. To use the analogy of building a house, they were the foundation upon which I could build.

Secondly, I would also like to thank my first research supervisor – Prof. D.R. Snaddon – for giving the initial guidance on the topic and content of this study. The house was built up to floor level.

Finally, I would like to thank my second research supervisor – Dr. H. Campbell – for his guidance, support, patience and inspiration to complete this research project. Without his help, I would probably still be wandering in the wealth of research methods, statistics, and even the English language. The walls and roof were built, the house was completed.

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LIST OF ABBREVIATIONS

ADF	Asymptotically Distribution Free
AGV	Automatic Guided Vehicle
AMT	Advanced Manufacturing Technology
AS/RS	Automatic Storage / Retrieval System
BOM	Bill Of Material
CAD	Computer Aided Design
CAD/CAM	Computer Aided Design / Computer Aided Manufacturing
CAE	Computer Aided Engineering
CAPP	Computer Aided Process Planning
CEO	Chief Executive Officer
CFA	Confirmatory Factor Analysis
CIM	Computer Integrated Manufacturing
CM	Cellular Manufacturing
CNC	Computer Numerically Controlled
CRM	Customer Relationship Management
DFMA	Design For Manufacture and Assembly
E-commerce	Electronic commerce
ERP	Enterprise Resource Planning
FMC	Flexible Manufacturing Cell
FMS	Flexible Manufacturing System
JIT	Just-In-Time
MCFMS	Multi-Cell Flexible Manufacturing System
MD	Managing Director
MES	Manufacturing Execution System
MMFMS	Multi-Machine Flexible Manufacturing System
MPS	Master Production Scheduling
MRP	Material Requirements Planning
MRPII	Manufacturing Resource Planning
SCM	Supply Chain Management
SEM	Structural Equation Modelling
SFM	Single Flexible Machine
TQM	Total Quality Management
WIM	Web-Integrated Manufacturing
WLS	Weighted Least Squares

1 INTRODUCTION

1.1 Background

Manufacturing companies adopted various forms of Advanced Manufacturing Technology (AMT) over the past three decades for improving their performance and competitive position. Cost reduction, higher efficiency and better quality of the products were initially the major drivers for performance improvement, but later also flexibility and agility (Upton, 1995: 74; Gunasekaran and Yusuf, 2002: 1375-1378). In short, the adoption of AMT was a strategic response to a highly competitive and rapidly changing market environment: customers no longer demanded lower prices and superior quality alone, but also a high product variety, better service and faster delivery (Bessant, 1991: 34-37; Burcher and Lee, 2000: 341-343).

Despite the promise of AMT, the literature also reveals that the expected benefits were generally disappointing. This phenomenon is attributed not just to technological but also to organisational problems suggesting some relationship between the dimensions of technology, organisation and performance. The following sections provide a brief discussion of these elements and their relationship.

1.1.1 The technological dimension

AMT[1] refers to a group of technologies of equipment, systems and methods that are used for automation and integration of design, manufacturing and coordination or administrative systems (Jonsson, 2000: 1447-1448; Challis, Samson and Lawson, 2002: 1948). These technologies can be plotted along a continuum of independent or standalone systems on the one end, and highly integrated systems on the other end (Bessant, 1991: 53-57). The continuum suggests a framework for measuring different adoption levels of AMT, referred to by this study as the

[1] This report interchangeably refers to AMT as ‘manufacturing technology’ or just ‘technology’.

technological dimension. By emphasising the degree of integration among processes or systems, this framework is more universal than other, more prescriptive frameworks.

Some examples of independent or limited integrated systems are Computer Aided Design (CAD), Computer Aided Engineering (CAE), Computer Numerically Controlled (CNC) machines, industrial robots, Automatic Guided Vehicles (AGV), Automatic Storage and Retrieval Systems (AS/RS), Cellular Manufacturing (CM) and Flexible Manufacturing Systems (FMS) (Rehg and Kraebber, 2001).

More integrated systems include Material Requirements Planning (MRP), in which coordination and manufacturing functions are linked, and Computer Aided Design and Manufacturing (CAD/CAM) for integration of design and manufacturing functions (McMahon and Browne, 1998).

Further integration of AMT systems results in Manufacturing Resource Planning (MRPII), Computer Integrated Manufacturing (CIM) and Enterprise Resource Planning (ERP). These systems are intended for integration of all internal functional areas such as planning, manufacturing, engineering, marketing, finance and management information functions (Schonberger and Knod, 1997: 372).

The highest form of integration links all internal functional areas as well as external up- and downstream elements of the value chain. Examples are extensions of ERP and Web Integrated Manufacturing (WIM) systems (Huang and Mak, 2001; Ndede-Amadi 2004: 191-193).

1.1.2 The organisational dimension

Various authors discuss issues of the organisational dimension that contribute to success, or failure, of adopted AMT. Bessant (1991: 307-332) argues that the development of skills, work organisation, functional integration, control, inter-organisational relationships and culture are critical for exploiting AMT successfully. Mintzberg (1993: 25-119) discuss which organisational design parameters build the effective organisation. These are related to training, job specialisation, behaviour formalisation, unit grouping and size, liaison devices, decentralisation of decision-making and ideology.

Cook and Cook (1994: 49-50) suggest similar factors and introduced the 'organic bi-modal' organisation, underscoring the importance of a mutual relationship between management and employees to facilitate shared management responsibilities. Tidd, Bessant and Pavitt (1999: 303-337) discuss various factors for building the innovative organisation ranging from individual skills to 'learning organisation' concepts.

Although the literature reveals many common characteristics, a generally accepted framework for the organisational dimension does not seem to exist. In addition, many authors seem to view the relevant organisational issues from different perspectives. Rather than selecting one literature source, this study proposes a consolidated framework to accommodate similarities, to facilitate simplification and to use a more balanced approach across the reviewed literature.

1.1.3 Performance

Performance of manufacturing companies comprises operational and business performance (Skinner, 1985: 53; Slack, 1991: 3; Small, 1998: 130). It is therefore important that both performance measures are discussed including their linkage.

Measures for business performance are typically profit, market share and monetary return on investment ratios, but can also include supplier performance as well as customer and employee satisfaction (Neely, 1998: 5-30). The many aspects of business performance have led to the development of frameworks that integrate a set of critical indicators for measuring business performance and alignment with corporate strategy (Gomes, Yasin and Lisboa, 2004). A most notable example is the Balanced Scorecard integrating performance aspects of finance, customer satisfaction, internal business processes and innovation (Kaplan and Norton, 1992).

A shortcoming of this framework is that it may deceptively indicate satisfactory business performance due to, for example, high financial performance but only

average internal business process performance. For this reason, an appropriate measure of the performance of the manufacturing function is operational performance and not overall business performance (Challis *et al.*, 2002: 1951). In the Balanced Scorecard's terms, operational performance is regarded by this study as a combination of internal business process performance and innovation.
The literature reveals different indicators to measure operational performance. Traditional measures revolve around cost and efficiency. But, as Skinner (1985: 33) and Kaplan (1990: 35) point out, these alone are no longer adequate in fast changing and highly competitive market environments. Operational performance indicators should rather be closely linked to the requirements of the customer: low prices, high quality, high variety of products as well as fast and on-time delivery (Slack, 1991: 7-8; Small, 1999: 268).

1.1.4 Relationship of technology, organisation and performance

Ettlie (1988: 15-17) and Bessant (1991: 344-345) argue that technology and the organisation need to evolve in parallel in order to gain the benefits of AMT. More recent literature supports this view. Tidd *et al.* (1999: 261-267) as well as Sonntag (2003: 319) point out that AMT is a form of process innovation requiring specific attention to organisational change management within the firm. Based on similar principles, Ghani and Jayabalan (2000) propose an AMT implementation framework taking both technological and organisational factors into account.

Empirical research confirms various aspects of the technology, organisation and performance relationship, but only a few include all three variables. For example, Small (1999: 266-267) found that operational performance generally increased with the level of adopted AMT but excluded organisational issues as a suggestion for further study. Boyer's (1999) longitudinal research reveals a positive correlation between AMT and business performance but only included some organisational issues that were related to AMT investment decision-making.

Two other empirical studies are of particular interest to this study. Both examine the relationship of all three variables, but from different perspectives. Frick, Gertsen, Hansen, Riis and Sun (1998) assess AMT and organisation against business performance, while Challis *et al.* (2002) assess AMT, Total Quality Management (TQM) and Just-in-time (JIT) manufacturing against employee and operational performance.

Although Frick *et al.*'s (1998) study show the significance of a strategic framework for developing technological and organisational dimensions so as to reach optimum performance levels, the main shortcoming is that performance measures are focused on overall business performance, which may obscure true performance of manufacturing (*cf.* Section 1.1.3). On the other hand, Challis *et al.* (2002) assess technological and organisational aspects against operational performance, but focus on rather limited 'best practice' concepts such as TQM and JIT.

Nevertheless, it is clear that some relationship between the dimensions of technology, organisation and performance exists. Moreover, Frick *et al.* (1998) and Challis *et al.* (2002) show that performance is the highest when firms maintain an appropriate balance between the development of technological and organisational dimensions. The next section indicates where this study positions itself in relation to the reviewed literature and presents the central research problem as well as the primary research question.

1.2 Statement of the problem

Table 1.1 provides an overview of which aspects of the suggested technology, organisation and performance relationship are covered by the empirical literature discussed in Section 1.1.4.

Challis *et al.* (2002) investigated the dimensions of technology, organisation and operational performance but focused on 'best practices' only, which may not be generally applicable for manufacturing companies that did not adopt such practices. Other studies include only two variables (Boyer, 1999; Small, 1999), while Frick *et al.* (1998) include both technological and organisational dimensions but assessed them against business performance as opposed to operational performance.

Table 1.1 Research on technology, organisation and performance relationships

	Frick *et al.* (1998)	**Boyer (1999)**	**Small (1999)**	**Challis *et al.* (2002)**	**This study**
Technological dimension	●	●	●	●	●
Organisational dimension	●			●	●
Business performance	●	●			
Operational performance			●	●	●

Unlike Challis *et al.* (2002), this study proposes a broader model for investigating technology and organisation against operational performance, independent of limited ‘best practice’ concepts. Therefore, the central research problem of this study is:

To analyse the effect of development along organisational and technological dimensions on operational performance of manufacturing firms in South Africa.

Because of the multifaceted nature of the research problem, this study is guided by the following primary research question based on Frick *et al.*’s (1998) work:

Does a balanced development of organisational and technological dimensions result in optimum levels of operational performance of manufacturing?

1.3 Research questions

Three research questions are posed to resolve the central research problem and to answer the primary research question by deduction. Figure 1.1 presents a structural model of the hypothesised relationship between the dimensions of technology, organisation and operational performance. Figure 1.1 also places the research questions within the context of the model, which will be further developed when the research methodology is discussed in chapter 3.

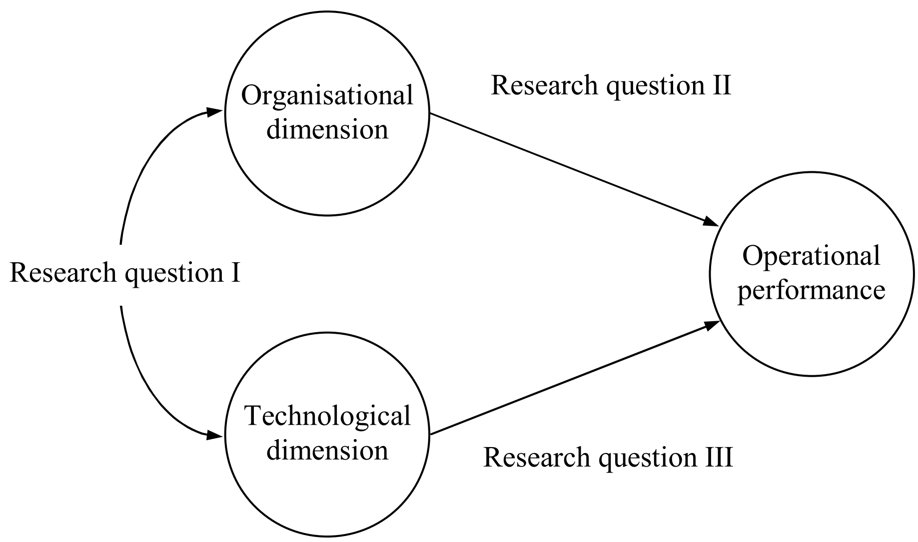


Figure 1.1 Proposed structural model

1.3.1 Research question I

How are technological and organisational dimensions of manufacturing firms related with each other? The curved double-headed arrow hypothesises that they are correlated. The question here is to what extent?

1.3.2 Research question II

How is development along the organisational dimension affecting operational performance of manufacturing firms?

The straight-headed arrow hypothesises a direct causal relationship between organisation and operational performance. Guided by this question, the present study attempts to investigate the existence and strength of this link.

1.3.3 Research question III

How is development along the technological dimension affecting operational performance of manufacturing firms?

The straight-headed arrow hypothesises a direct causal relationship between technology and operational performance. But is there such a link? If so, how strong is this relationship?

1.4 Research hypotheses

Three hypotheses are raised to answer the three secondary research questions. As mentioned in the beginning of Section 1.3, these will be used to answer the primary research question and to assess the central research problem of this study.

1.4.1 Research hypothesis I

Firms who initially developed along the technological dimension need to develop along the organisational dimension to gain the benefits of AMT (Frick *et al.*, 1998: 359; Colombo and Delmastro, 2002: 624). Conversely, firms who initially developed along the organisational dimension used their skills, structure and culture to improve manufacturing practices and processes, but realise that development along the technological dimension is necessary to maximise operational performance (Mohanty and Deshmukh, 1999: 310-312). This relationship is asserted in the first hypothesis:

Development along one dimension (technology or organisation) correlates with development along the other dimension.

1.4.2 Research hypothesis II

Although Challis *et al.* (2002: 1956) found a positive correlation between organisational aspects and operational performance, this study contends that such correlation is relatively weak when a firm does not develop along the technological dimension (*cf.* Section 1.4.1). The second hypothesis therefore asserts that:

Development along the organisational dimension alone results in marginal operational performance.

1.4.3 Research hypothesis III

Boyer (1999) found a positive relationship between the implementation of AMT and business performance, while Small (1999: 272-277) reports a similar relationship with operational performance. However, new technology requires not only learning how to use it effectively, but also unlearning old ways of working (Frick *et al.*, 1998: 359; Sonntag, 2003: 319). Thus, the success of new technology in terms of performance also depends on developing and changing organisational aspects such as skills, structure and culture. The third hypothesis therefore asserts that:

Development along the technological dimension alone results in marginal operational performance.

1.5 Research objectives

This study has two objectives as set out below.

1. To gain knowledge of the current state of affairs in South Africa in terms of the central research problem and primary research question of this study.

2. To contribute to knowledge on the subject of improving a firm's operational performance by adopting AMT. Insight into this subject may increase the probability of a firm gaining the benefits of this technology.

1.6 Research context

The decision to conduct this study was inspired by the author's experience of ten years with a repetitive manufacturing firm in the light metal industry. Despite extensive adoption of AMT, this firm failed to gain a substantial competitive advantage after more than a decade. The underlying problem intrigued the author of this study: Why could a modern plant with sophisticated manufacturing technology not compete in world markets? Based on own experience and a brief literature survey, it became clear that research on the relationship between technology, organisation and operational performance might give insight into the underlying problem. For this study to be of value to academics and industry, it was decided to investigate a large sample of the repetitive manufacturing industry on these aspects.

1.7 Definition of terms

A brief explanation of terminology used in the research problem, questions and hypotheses is given in the next sections.

1.7.1 Technological dimension

The technological dimension refers to Advanced Manufacturing Technology (AMT) that constitutes equipment, systems and methods used by manufacturing firms for automation and integration of design, manufacturing and coordination or administrative functions (Jonsson, 2000: 1447-1448; Challis *et al.*, 2002: 1948).

1.7.2 Organisational dimension

The organisational dimension constitutes human and structural aspects of a firm including skills, team design, organisation design, inter-organisational relationships and corporate culture (Tidd *et al.* 1999: 303-337).

1.7.3 Operational performance

Operational performance is a measure of how well inputs are transformed to outputs in terms of quality, speed, dependability of processes, flexibility and cost (Slack, 1991; Small, 1999: 268).

1.7.4 Repetitive manufacturing

Repetitive manufacturing is a mode of operation in which outputs constitute discrete units usually in high volumes and with relatively low variety (Schonberger and Knod, 1997: 434).

1.8 Delimitations

1.8.1 Scope

The scope of this study is limited to the repetitive manufacturing industry in South Africa. However, the scope of the literature review is not limited to South Africa only. It is therefore assumed that the reviewed literature is also applicable to the South African manufacturing context. Additionally, operating modes such as project, job, batch and continuous processing are not considered due to varying characteristics.

1.8.2 Survey method

A self-administered web-based questionnaire will be used for collecting cross-sectional, quantitative data from a target sample. The data will be subjected to statistical analysis and inference with the purpose of testing the hypotheses. The results will be used to answer research questions and to resolve the central research problem.

1.9 Benefits of this study

The envisaged benefits of this study are twofold:

1. Firms who wish to embark on AMT to improve operational performance of their manufacturing function may use the results of this study as an important input for planning technological and organisational change to increase the probability of AMT implementation success.

2. Firms who already have adopted AMT but did not gain substantial improvement in operational performance may use the results of this study to analyse the underlying problem, and to take appropriate action to resolve it.

1.10 Organisation of this research report

The background, research problem, research questions, hypotheses, and the overall research setting of this study are discussed in chapter one.

Chapter two presents a review of the relevant literature which comprises four main issues. Firstly, the technological dimension is explored by discussing a framework for conceptualising and measuring the level of a firm's adopted AMT. Secondly, a framework is proposed for conceptualising and measuring how well a firm has developed along the organisational dimension. Thirdly, business and operational performance are discussed including its relationship and how to measure it. Fourthly, some empirical research on the relationship of technology, organisation and operational performance is reviewed and how it relates to this study.

The research methodology will be dealt with in chapter three. A measurement and a structural model will be developed for conceptualising, measuring and analysing the hypothesised relationship between technology, organisation and operational performance. Furthermore, chapter three will also discuss the sampling frame, target sample, questionnaire design and administration method, statistical analysis method with The SAS System, as well as reliability and validity measures.

Chapter four presents the results of this study including questionnaire response, demographics of respondents and an assessment of non-response bias. Additionally, some distributional assumptions of the actual sample data will be assessed and its internal consistency. Lastly, the measurement and structural model will be evaluated by using The SAS System's CALIS procedure.

Chapter five provides a discussion and interpretation of the results including hypotheses tests and an assessment of the primary research question and the central research problem of this study. The questionnaire response and some methodological issues of Structural Equation Modelling will also be discussed.

Chapter six provides a conclusion of the results of this study and recommendations for future research.

Appendices provide details of the questionnaire, pilot study results, cover and reminder letters which were sent to the target sample, raw response data, and statistical output data from The SAS System (release 8.02). Finally, references and a bibliography of relevant literature are given at the end of this report.

2 LITERATURE REVIEW

This chapter presents a literature review of the dimensions of technology, organisation, performance and its relationship. Section 2.1 and 2.2 discuss frameworks for measuring technological and organisational dimensions respectively. Section 2.3 presents a discussion of business and operational performance. The hypothesised triangular relationship between technology, organisation and performance is discussed in Section 2.4. Finally, Section 2.5 presents a summary of this chapter.

2.1 The technological dimension

2.1.1 Existing frameworks

In order to measure the level of adopted AMT and thus to position a firm along the technological dimension, it is imperative to identify or to develop an appropriate framework. The literature reveals however that there is no generally accepted framework and that definitions, interpretations and classifications of AMT vary among industry and research practitioners (Boaden and Dale, 1986: 30-37; Singh, 1990: 17-18). Existing frameworks of AMT were reviewed, but not all of them are suitable for this study.

Groover's (1987: 1-5, 720-722) framework for example comprises three levels of AMT. The first level is the stand-alone automation of physical factory operations. The next level represents integration of design and manufacturing systems into CAD/CAM. The third and highest level is the all-inclusive scope of CIM in which all functional areas of the firm are integrated. The limitation of this framework is its broad definition of only three levels, which makes precise measurement of the level of adopted AMT difficult.

An improvement is Meredith and Hill's (1987) framework, which uses four levels ranging from basic or stand-alone automation up to full integration. However, a shortcoming is that the basic level is defined as '… stand-alone hardware …' like

CNC-machines or industrial robots (Meredith and Hill, 1987: 52). If the definition is strictly adhered to then CAD for example, which is a software-based system, does not fit at this level. This causes inconsistencies higher up in the hierarchy of the framework. Nevertheless, Ghani and Jayabalan (2000) use it for proposing an AMT implementation framework, but this has not been empirically tested.

Bessant (1991: 53-57) on the other hand, takes a different approach based on Kaplinsky's (1984: 19-35) work. His framework emphasises the degree of integration among processes or systems as opposed to the predominantly prescriptive nature of the two previous frameworks. This makes it more universal and applicable for this study. Frick *et al.* (1998: 347), Small (1999: 266), Jonsson (2000: 1447-1448) and Challis *et al.* (2002: 1948) use comparable frameworks for measuring the level of AMT adoption, thus supporting its use for this study. The next section explains Bessant's framework in more detail.

2.1.2 The selected framework for the technological dimension

Bessant's (1991: 53-57) framework constitutes four levels emphasising the degree of integration among design, manufacturing and coordination processes or systems. The four levels are, in order of increasing technological integration:

1. Integration within systems
2. Integration between systems
3. Integration of all systems
4. Integration beyond the firm's boundaries

Figure 2.1 illustrates the principles of Bessant's framework. A particular level represents technological integration of lower level systems. For example, integration of design and manufacturing systems (level 1) becomes CAD/CAM in level 2. Each level will be discussed in the following subsections. Although the discussion is somewhat descriptive, it is necessary for understanding the selected framework.

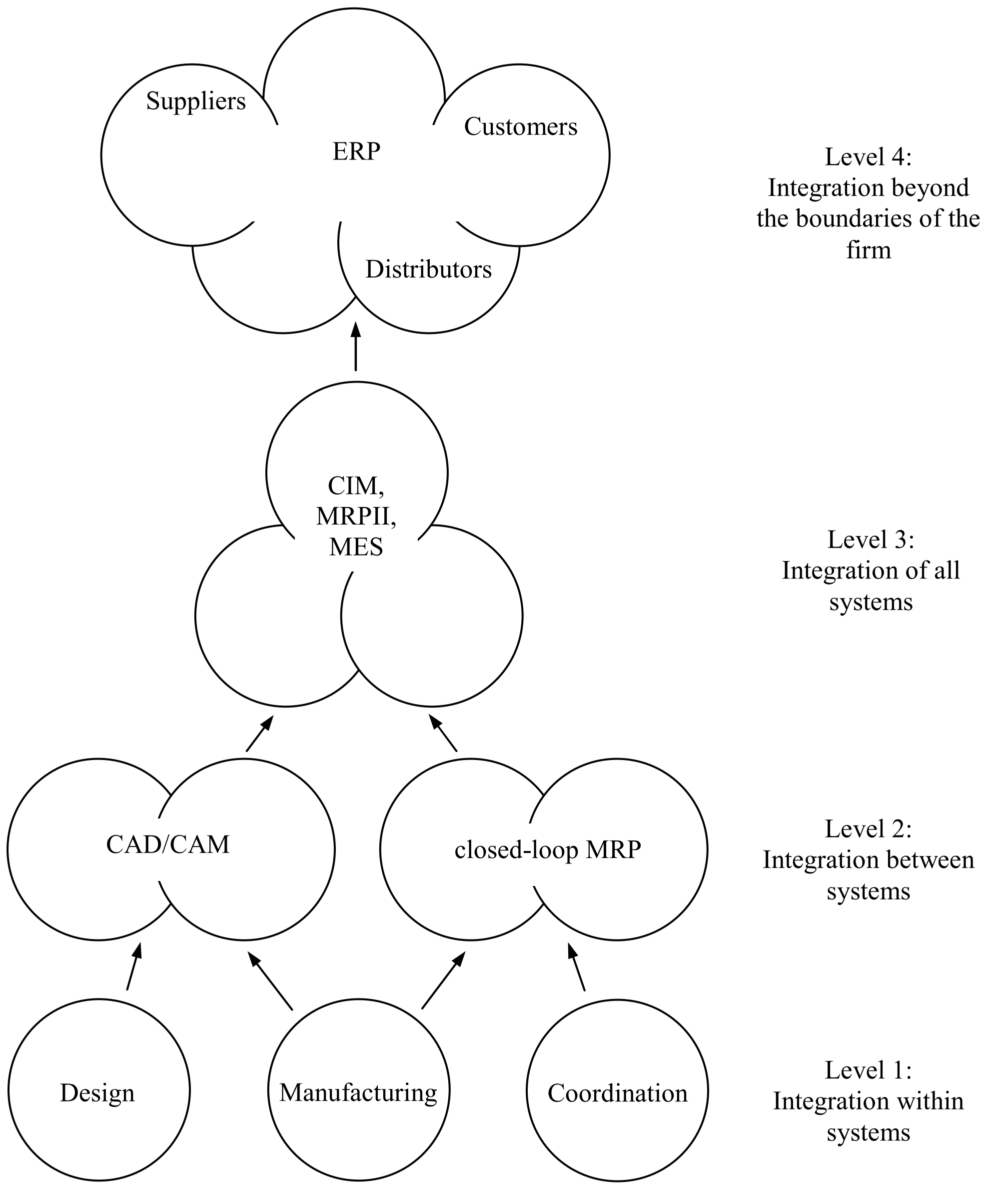


Figure 2.1 AMT framework (adapted from Bessant, 1991: 55)[2]

[2] Circles do not denote latent variables. Here, they only illustrate the concept of the framework.

2.1.2.1 Integration within systems

Integration at the lowest level of the framework only exists locally within design, manufacturing or coordination systems. Although functional linkages among these basic systems may exist, they are manual in nature. For example, production schedules are manually submitted from the planning department (a coordination system) to the factory floor (a manufacturing system). There is however no technological link at that level between the basic systems such as provided by a shared computer system for example. The following three subsections provide a more detailed description of the three basic systems: design, manufacturing and coordination.

<u>The design system</u>

Computer-Aided Design (CAD) and Computer-Aided Engineering (CAE) are typical examples of design systems. Basic CAD systems are merely computerised tools for drawing the graphic representation of the product and for generating part lists. More advanced CAD systems assist with automated three-dimensional modelling and could involve more than one CAD workstation linked with each other (McMahon and Browne, 1998: 3-15). CAE systems are used for advanced engineering analysis of designs including finite-element and mass property analysis (Rehg and Kraebber, 2001: 145).

<u>The manufacturing system</u>

A lot of technological development has been focused on the manufacturing system. The literature reveals that the most prominent technologies are:

1. Computer Numerically Controlled (CNC) machines
2. Industrial robots
3. Automatic Guided Vehicles (AGVs)
4. Automatic storage systems
5. Cellular Manufacturing (CM)
6. Flexible Manufacturing Systems (FMS)

Local computer control of machinery is the common element for technology at this level of the framework. Although the technology in itself could be highly sophisticated, they are not integrated with design or coordination systems. Integration within the manufacturing system manifests itself as combinations of the above listed technologies.

Automatic storage systems for example, are computer-controlled unmanned stores, in the literature commonly referred to as Automatic Storage and Retrieval System (AS/RS). These are often used in conjunction with AGVs for handling material as shown in Figure 2.2, but can also be linked with conventional conveyor systems (Groover, 1987: 404-428).

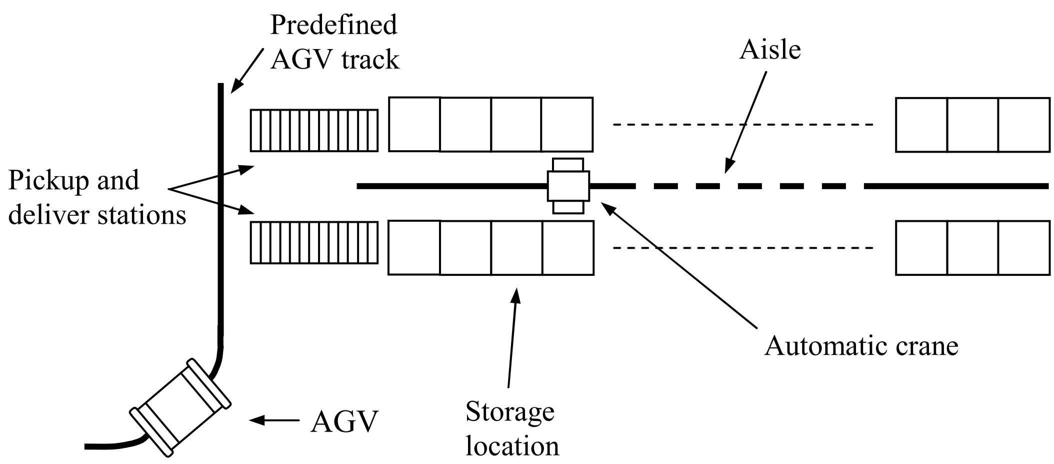


Figure 2.2 Automatic storage system integrated with an AGV system

Another example of integration within the manufacturing system is Cellular Manufacturing (CM). The underlying principle is that parts are grouped into families based on attributes including material type, machining operations, tolerance specifications and surface finish. The literature refers to this concept as Group Technology (Rehg and Kraebber, 2001: 160-166). Production equipment like conventional lathes, drills or mills traditionally arranged in a functional layout, are then rearranged into manufacturing cells such that each cell completely processes a part family in the most efficient way in terms of shorter change-over and material movement times. Figure 2.3 illustrates this concept (adapted from Frazier and Spriggs, 1996).

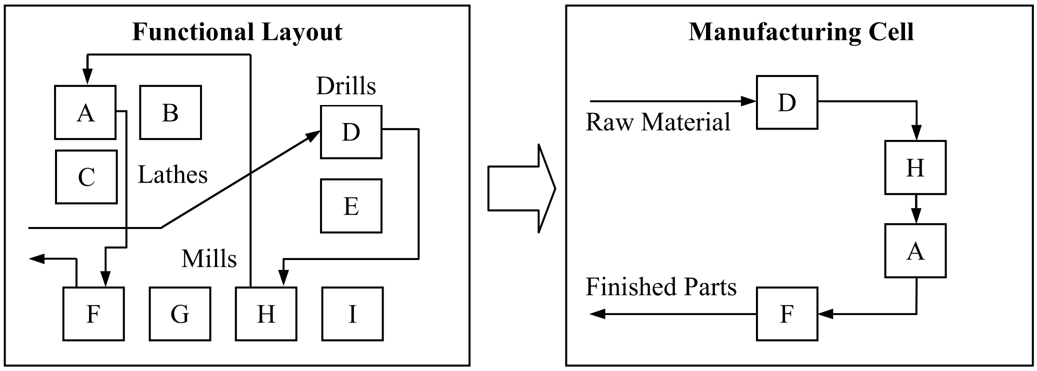


Figure 2.3 Cellular Manufacturing concept (Frazier and Spriggs, 1996)

In contrast to CM which predominantly comprises conventional machinery, Flexible Manufacturing Systems (FMS) primarily use CNC-machines or automated machining centres in a cellular layout under central computer control. Industrial robots and automatic transport devices such as AGVs often perform material movements inside and outside the cell (Rehg and Kraebber, 2001: 368). Although Bessant (1991: 55) uses FMS as an example of integration between systems (the next level), this study proposes to place it at this level because most FMSs are technologically integrated only within the manufacturing system.

Figure 2.4 illustrates some FMS configurations based on MacCarthy and Liu's (1993) classification scheme. The Single Flexible Machine (SFM) is the basic unit, typically consisting of a CNC-machine and a local storage system for parts or tools. Combining several SFM systems into a single cell forms the Flexible Manufacturing Cell (FMC). Both SFMs and FMCs are used for building multi-machine and multi-cell FMSs.

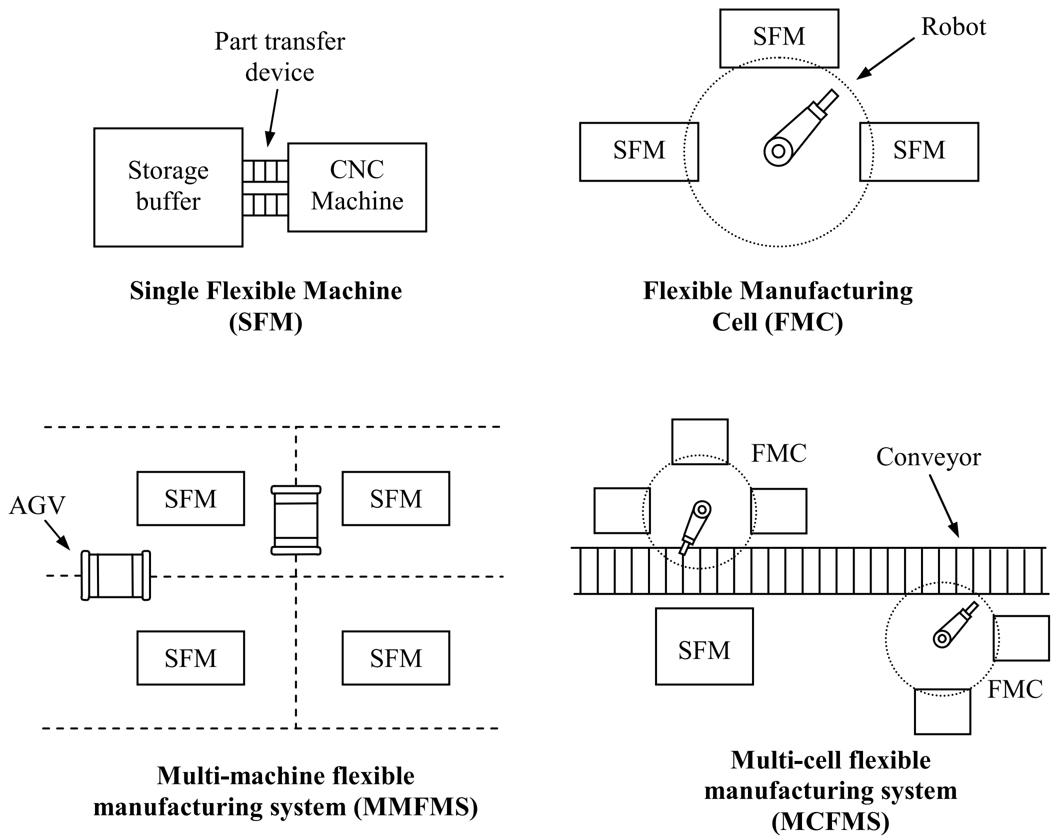


Figure 2.4 Examples of four FMS configurations (MacCarthy and Liu, 1993)

<u>The coordination system</u>

The purpose of the coordination system is the generation, manipulation and provisioning of information for management and control of the activities of an organisation (Kaplinsky, 1984: 77).

From a financial perspective, the use of standalone accounting packages and spreadsheets are examples of non-integrated coordination processes.

An example of coordination for the manufacturing operation is Material Requirements Planning (MRP). In its basic form, MRP calculates detailed production plans based on an aggregate Master Production Schedule (MPS), machining lead times, the Bill of Material (BOM) and current inventory levels

(Schonberger and Knod, 1997: 361-371). The production plan as generated by MRP, is then used to purchase raw materials, to manufacture according to the quantities and due dates, and to despatch end-items. At the lowest level of integration, MRP plans are manually submitted to the responsible departments.

2.1.2.2 Integration between systems

The second level of the framework encompasses technological integration of lower level systems. A common element here is the limited or clustered use of shared information systems and computer networks. Two examples will be discussed in this section: CAD/CAM (integration of design and manufacture) and closed-loop MRP (integration of manufacture and coordination).

<u>CAD/CAM</u>

McMahon and Browne (1998: 295-303) consider CAD/CAM as a two-stage process in which Computer-Aided Process Planning (CAPP) provides a link between CAD and CAM technologies. This is illustrated in Figure 2.5. CAPP encompasses two major activities, namely Product-Process Analysis and Process Planning. The CAD function interfaces with the Product-Process Analysis function for optimising designs taking Design for Manufacture and Assembly (DFMA) principles into consideration. The Process Planning function then generates instructions describing how and in what sequence parts or products must be manufactured by CAM technologies such as CNC-machines, machining centres and FMSs.

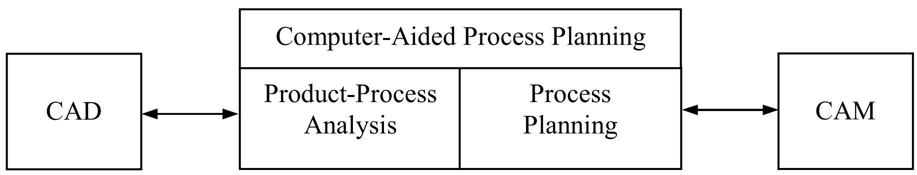


Figure 2.5 Conceptual CAD/CAM architecture (McMahon and Browne, 1998)

Closed-loop MRP

The basic MRP system described earlier evolved into closed-loop MRP in which automatic feedback takes place of plant performance relative to the production plan. The success of an MRP system depends on timely and accurate data of raw material orders, inventory levels, production outputs, actual lead times and BOMs. Closed-loop MRP addresses this requirement and is illustrated in Figure 2.6. Purchasing and Production Activity Control represents the execution and control of the production plans (Arnold, 1996: 15-23) as part of the manufacturing process.

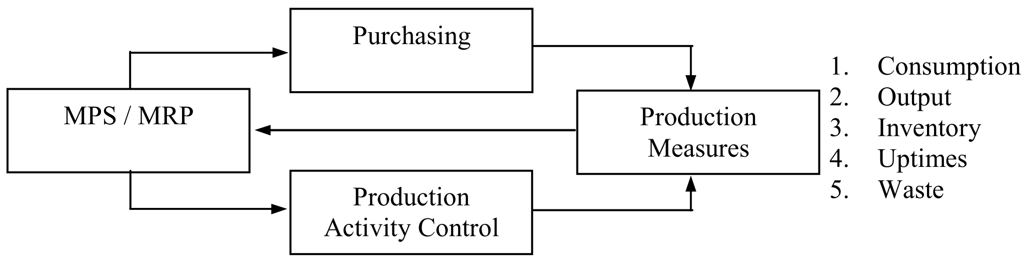


Figure 2.6 Principles of closed-loop MRP (adapted from Arnold, 1996: 23)

2.1.2.3 Integration of all systems

Increased requirements for shorter product life cycles, higher quality, greater reliability, and an overall drive for better efficiency has led to a trend towards integration of all resources utilised in manufacturing (Groover, 1987: 776-789; Bessant, 1991: 56). Three major technologies fit at this level of the framework: Manufacturing Resource Planning (MRPII), CIM and Enterprise Resource Planning (ERP). Although the literature reveals that the differences between them are somewhat vague, the following subsections present some clarification.

MRPII

Closed-loop MRP evolved into a modular system integrating planning, manufacturing, engineering, marketing, finance and management information functions, commonly referred to as MRPII. Schonberger and Knod (1997: 372) point out that the exact definition and configuration of MRPII is not clear, but that it is at least 'intended to incorporate all resources'. Vendors of such systems added modules to the MRPII concept ranging from maintenance management up to simulation modules. Yusuf and Little (1998: 66 - 71) discuss an 'extended' MRPII system in which further integration with CAD/CAM technology is proposed. This implies that MRPII has not evolved yet towards full integration. However, the extent of technological integration of MRPII systems justifies it to position it at this level of the framework.

<u>CIM</u>

Boaden and Dale (1986: 34-37) point out that CIM ties all aspects of the manufacturing organisation into an integrated system in which all information is shared. This view correlates with Bessant's (1991: 54) definition:

> 'The integration of computer-based monitoring and control of all aspects of the manufacturing process, drawing on a common database and communicating via some form of computer network.'

Based on this definition, CIM integrates all previously discussed design, manufacturing and coordination processes and systems, similar as with MRPII but with a broader scope. It is often complemented with manufacturing strategies such as JIT and innovative managerial and organisational concepts including Total Quality Management (TQM), continuous improvement and customer satisfaction (Rehg and Kraebber, 2001: 22-26). Related to this are Manufacturing Execution Systems (MES) which tie in with CIM and MRPII systems but more on an operational level (Ndede-Amadi, 2004).

<u>ERP</u>

Closely linked with the functionality and description of MRPII, CIM and MES, are ERP systems. Although no exact definition was found in the literature, Schonberger and Knod (1997: 373) as well as Rehg and Kraebber (2001: 319) regard ERP systems as an extension of MRPII. It appears however that MRPII, CIM and MES systems have a strong manufacturing focus, while ERP systems are more focused on overall business management. The lack of clear definition and the apparent confusion of ERP in relation to MRPII, CIM and MES might well be attributed to an intense 'technology push' by software vendors and system integrators in favour of ERP over the last decade or so.

2.1.2.4 Integration beyond a firm's boundaries

The highest level of the framework integrates MRPII, CIM, MES, or ERP systems with external up- and downstream elements of the value chain (suppliers and customers). The rapid advancement in computer and communications technology is driving much of the current developments of extending beyond a firm's boundaries. Examples are Internet-based procurement, Supply Chain Management (SCM), Customer Relationship Management (CRM), and E-commerce (Rehg and Kraebber, 2001: 319-344; Ndede-Amadi 2004: 191-193).

Huang and Mak (2001) discuss how the Internet and web-technology can be utilised for collaboration in product design and manufacturing across the globe. Web-Integrated Manufacturing (WIM), as they term it, could even go as far as involving remote lead-users in the design process, group decision-making, customer requirements analysis, customer service management, rapid prototyping and SCM.

2.2 The organisational dimension

2.2.1 A consolidated framework

For measuring a firm's position along the organisational dimension a framework is required to conceptualise the relevant issues. Various authors discuss aspects of the organisational dimension for gaining the benefits of AMT or for developing the effective organisation in general. Most notable are Bessant (1991: 307-332), Mintzberg (1993: 25-119), Cook and Cook (1994: 49-53) and Tidd *et al.* (1999: 303-337). Although the referenced literature reveals many common characteristics, a generally accepted framework for conceptualising the organisational dimension does not seem to exist. In addition, many authors seem to view the relevant organisational issues from different perspectives. Rather than selecting one literature source, this study proposes a consolidated framework to accommodate similarities, to facilitate simplification and to use a more balanced approach across the reviewed literature as is shown in Table 2.1.

Table 2.1 Proposed consolidated framework in relation to reviewed literature

<table>
<tr><th>Consolidated framework</th><th>Bessant (1991)</th><th>Mintzberg (1993)</th><th>Cook and Cook (1994)</th><th>Tidd et al. (1999)</th></tr>
<tr><td>Individual skills</td><td>Skills</td><td>Training[1]</td><td>Education and training</td><td>Skills</td></tr>
<tr><td>Team design</td><td>Work organisation</td><td>Unit grouping and size[2]</td><td>Team design</td><td>Team design</td></tr>
<tr><td rowspan="6">Organisation design</td><td rowspan="3">Functional integration</td><td>Job specialisation</td><td rowspan="3">Organisation structure</td><td rowspan="6">Organisation structure</td></tr>
<tr><td>Behaviour formalisation</td></tr>
<tr><td>Unit grouping and size[2]</td></tr>
<tr><td rowspan="3">Control</td><td>Liaison Devices</td><td rowspan="3">Levels of management</td></tr>
<tr><td>Vertical decentralisation</td></tr>
<tr><td>Horizontal decentralisation</td></tr>
<tr><td>Inter-organisational relationships</td><td>Inter-organisational relationships</td><td>-</td><td>Inter-organisational relationships</td><td>External focus</td></tr>
<tr><td rowspan="4">Corporate culture</td><td rowspan="4">Culture</td><td rowspan="2">Indoctrination[1]</td><td>Trust and cooperation</td><td rowspan="2">Vision and leadership</td></tr>
<tr><td>Empowerment of people</td></tr>
<tr><td rowspan="2">Ideology</td><td>Learning</td><td rowspan="2">Learning organisation</td></tr>
<tr><td>Reward systems</td></tr>
</table>

1. Mintzberg discuss training and indoctrination as one organisational design parameter, but this study rather splits it because indoctrination seems more related to corporate culture than to individual skills.
2. Unit grouping and size are relevant at both team and organisation levels.

Challis *et al.*'s (2002: 1951) construct of the organisational dimension (*cf.* Section 2.4.2) includes skills, productivity, some aspects of culture and labour relationships but is too limited when compared to the referenced literature and the proposed framework of Table 2.1. A similar argument holds for Frick *et al.*'s (1998: 348) measurement of the organisational dimension (*cf.* Section 2.4.1).

The next section will elaborate further on the consolidated framework by discussing each element.

2.2.2 Elements of the consolidated framework

2.2.2.1 Individual skills

Depending on the degree of AMT in an organisation, a higher level of the average skill-set of an employee is required to exploit the full benefits of the technology. Although operational factory staff (e.g. operators and supervisors) do not need to know the technical intricacies of AMT, they need to understand its functionality, limitations and impact on plant operations in terms of operational performance criteria. In addition, they need to adapt to new ways of team working, as will be discussed in the next section. This not only requires higher skills, but also a shift from single-skilled towards multi-skilled staff. Lowe (1995: 158-159) point out in this regard that the 'range and depth' of skills need to be developed.

The complexity of technology also brings along that specialised engineering companies are often contracted for designing and implementing new systems and for maintenance of existing systems. The result is that systems are increasingly experienced as 'black-boxes' by operational and in-house engineering staff. System faultfinding and diagnostic skills are therefore often more important than detailed repair skills (Bessant, 1991: 311-312).
Within a South African context of an apparent shortage of skilled labour (Gerber, Nel and Van Dyk, 1997: 535, 546), it is also important for firms to know where to

obtain required skills from external sources, either on a permanent or on a contract basis, when they are not available in-house (Tidd *et al.*, 1999: 250). The decision to utilise external sources should be based on a trade-off between the risk of not having the skills immediately available and the cost of hiring highly skilled contractors or consultants.

2.2.2.2 Team design

Bessant (1991: 315-317) argues that teams must change to more flexible ways of working in order to cope with the complexities of AMT as well as with competitive pressures. Such new ways of working are characterised by team working, self-organisation and a degree of local authority and autonomy. Rehg and Kraebber (2001: 483) point out that the supervisor's role for example, has shifted from being a 'master craftsperson' to a 'resource provider and coach' for his team of machine centre operators. The synergistic effect is a more motivated and skilled workforce that responds effectively and efficiently to operational contingencies and that excels in continuous improvement at shop floor level.

Bateman and Snell (1996: 408-409) refer to it as 'self-managed teams' that are typically more productive, cost-conscious, customer-oriented (internal as well as external customers) and have a strong quality focus.

Mintzberg (1993: 47) warns however, that the negative aspect of strong teams is that they tend to separate themselves from the rest of the organisation. This means that teams, no matter how effective, cannot operate in isolation but should rather be part of, and supported by, an appropriate organisational structure, which will be discussed in Section 2.2.2.3.

Wageman (1997: 49-61) reports seven critical success factors for highly effective self-managing teams. Her research shows that these factors are more important than just good coaching by management. In short, good self-managing teams have:

1. a clear understanding and ownership of its mission
2. tasks designed for a team
3. team rather than individual rewards
4. access to physical resources (equipment, meeting space etc.)
5. appropriate decision-making authority
6. goals that link in with company objectives
7. the ability to think strategically

This implies that the success of self-managing teams depends to a large extent on the skill-set of its members and the organisational setting. Such skills however not only refer to theoretical, but also to practical skills. In an empirical study of successful continuous improvement projects for a highly automated production facility in Belgium, Lapré and Van Wassenhove (2002: 108-111) for example, argue that a balance of theoretical and practical skills within the team is absolutely essential. On the other hand, clear communication and cooperation is sometimes difficult between theoretically and practically inclined people, simply because they do not always understand each other.

2.2.2.3 Organisation design

The integrated nature of AMT brings along that decisions made in one department or team may have a great impact on other parts of the organisation. Similarly, top-management cannot always make sound operational decisions due to the vast amount of information made available by highly integrated and complex AMT systems such as CIM for example (albeit that this also suggests a poorly designed information system).

Nevertheless, closer cooperation is required among management, departments and teams, which requires specific attention to organisation design and structure (Bessant, 1991: 317-318). Organisation design can be defined by three main components (Robbins, 1991: 460-462):

1. **Complexity** refers to the degree of differentiation within the company. It encompasses the number of different jobs (horizontal differentiation), the number of organisational levels (vertical differentiation), and the geographic dispersion of the physical facilities of a multi-site firm (spatial differentiation).

2. **Formalisation** refers to the standardisation of job outputs by means of fixed procedures and work instructions.

3. **Centralisation** refers to the locus of decision-making and control within the organisation. Decisions are predominantly made at top-management level in highly centralised firms.

Burns and Stalker (1961:5) introduce a well-known and often used notion of ‘mechanistic’ and ‘organic’ organisations when they studied the relationship between management systems and product innovation in the United Kingdom’s electronics manufacturing industry. Robbins (1991: 487-488) concisely summarises the differences between these two endpoints of the organisation design continuum by using the three components discussed earlier and the way information flows (Table 2.2).

Table 2.2 Mechanistic versus organic organisation designs

	Mechanistic	**Organic**
Complexity	High	Low
Formalisation	High	Low
Centralisation	High	Low
Information flow	Downward	Up, down and lateral

The table suggests that mechanistic organisations are 'rigid', while organic organisations are 'fluid'. The literature is not clear about what organisation design is best suited for AMT environments. Zammuto and O'Connor (1992: 705, 709) as well as Cook and Cook (1994: 49) suggest that successful adopters of AMT have moved more towards the organic organisation. Agrawal and Hurriyet (2004) argue that only proactive, organic manufacturing organisations can survive in a rapidly changing business environment. On the other hand, Dean, Yoon and Susman (1992: 221) conclude that AMT did not have a significant impact on the level of differentiation (complexity), which is an indication that firms do not necessarily need to change to the organic organisation. Tidd *et al.* (1999: 309-315) rather suggest an appropriate balance between the two extremes of mechanistic and organic organisations. Tidd *et al.*'s view seems more likely given the widespread drive towards ISO 9000 certification for example, which in fact encourages higher levels of formalisation.

2.2.2.4 Inter-organisational relationships

The concept of cooperation among firms, or inter-organisational relationships, receives much attention in the literature. The general theme is about reducing risk, cost and time of *product* innovation for gaining a competitive advantage under uncertain and dynamic environmental conditions (see for example Bessant, 1991: 267-289; Tidd *et al.*, 1999: 197-238). This study however, considers inter-organisational relationships in light of gaining the benefits of AMT by learning *process* innovation, i.e. new ways of making products by using technology such as discussed in Section 2.1.

Formal and informal relationships within and across industrial sectors, government and universities, are important sources of information and learning. Robertson, Swan and Newell's (1996) empirical research on the diffusion of technological innovation in the United Kingdom's manufacturing sector suggest the following inter-organisational networks for companies:

1. Professional associations
2. Academic institutions
3. Other firms
4. Technology suppliers
5. Informal professional relationships

Marri, Gunasekaran, Kobu and Grieve (2002: 111) researched the 'triangular cooperation' between government, industry and universities. They recommend that government should support and motivate firms to implement AMT by providing financially attractive funding. Inter-organisational networking among industry would help firms with technological assistance, probably at relatively low cost. They further recommend that universities collaborate in providing short-term employee training, seminars, workshops and knowledge transfer.

Firms that utilise such networks not only learn about new technologies, but also learn about positive and negative aspects of particular technologies. However, the ability of an organisation to critically evaluate the various forms of AMT remains important to ensure that the real needs of the firm are addressed.

2.2.2.5 Corporate culture

An important factor for success or failure of AMT is corporate culture. Bessant (1991: 321) points out that technological innovation will not succeed in an 'old-established and unchallenged culture' whose primary way of working is merely to cope with advanced systems. Likewise, a workforce that lacks creativity, initiative and skills may even hinder organisations that adopted advanced technologies (Upton, 1995: 78).

In contrast, the literature suggests that the success rate of AMT is generally higher when corporate culture reflects organisational learning linked with continuous improvement and optimisation initiatives. Aimed at closing the gap between actual and potential performance of AMT systems, such firms do not hesitate to challenge technology and underlying manufacturing principles (Gerwin and Kolodny, 1992: 277; Tidd *et al.*, 1999: 329; Sun and Scott, 2003: 204-211). The literature refers to companies with such culture as ‘learning organisations’, which typically demonstrate five main characteristics (Garvin, 1993: 81-89):

1. **Systematic problem solving**: using scientific methods, statistical tools and root-cause analysis.
2. **Experimentation**: creating and acquiring new knowledge for continuous improvement and for expanding an organisation’s capability.
3. **Learning from past experience**: reflecting on past successes as well as on failures.
4. **Learning from others**: benchmarking against high-performance organisations and customer needs.
5. **Transferring knowledge**: disseminating broadly shared ideas and knowledge at all levels of the organisation.

These activities need to be supported by an open climate, formal learning processes, shared vision and leadership. It essentially reflects that it is people who make technology work.

2.3 Measuring performance

2.3.1 Business performance

Business performance measures are typically profit, market share and monetary return on investment ratios, but can also include supplier performance as well as customer and employee satisfaction (Neely, 1998: 5-30). The many aspects of business performance have led to the development of frameworks that integrate a set of critical indicators for measuring business performance and alignment with corporate strategy (Gomes *et al.*, 2004). A most notable example of such a framework is the Balanced Scorecard (Kaplan and Norton, 1992) integrating performance aspects of finance, customer satisfaction, internal business processes and innovation. An overview of this framework is given in Figure 2.7.

A shortcoming of this model is that it may deceptively indicate satisfactory business performance due to, for example, high financial performance but only average internal business process performance. This problem is amplified if managers tend to look only at the end result (i.e. overall business performance) without examining underlying factors. For this reason, an appropriate measure of the performance of the manufacturing function is operational performance and not overall business performance (Challis *et al.*, 2002: 1951). As shown in Figure 2.7, this study regards the internal business process and innovation components (e.g. product and process flexibility, *cf.* Section 2.3.2) of the Balanced Scorecard similar to operational performance.

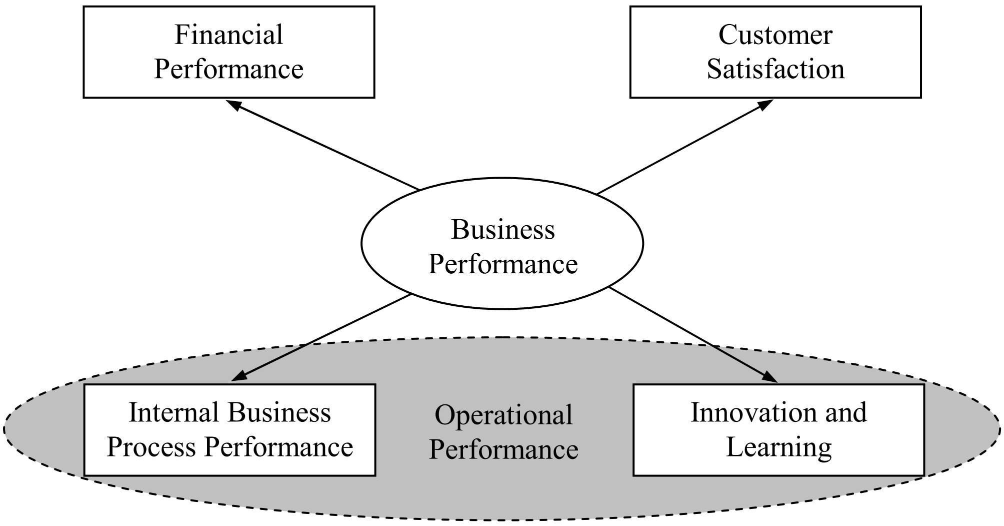


Figure 2.7 The Balanced Scorecard framework

(adapted from Kaplan and Norton, 1992)

2.3.2 Operational performance

Traditional measures of operational performance revolve around cost and efficiency. But, as Skinner (1985: 33) and Kaplan (1990: 35) point out, these alone were no longer adequate in fast changing and highly competitive market environments. Manufacturing at low cost and with high efficiency required firms to operate with long production runs and few product changes. But customer requirements have changed over the last two decades. Operational performance indicators should therefore reflect and measure these new requirements: low prices, high quality, high variety of products as well as fast and on-time delivery (Slack, 1991: 7-8; Small, 1999: 268).

Although White (1996: 50) lists over one hundred indicators for measuring operational performance, the literature and empirical research reveal that they can be classified according to five main indicators (Slack, 1991: 7-8; White, 1996: 45; Small, 1998: 133; Sohal, Schroder, Uliana and Maguire, 2001: 27; Challis *et al.*, 2002: 1951; Maier, Hammer and Zentis, 2004: 16-18):

1. **Quality**: making products right and according to specification
2. **Speed**: making products in the shortest possible time
3. **Dependability**: delivering products on schedule as promised
4. **Flexibility**: ability to change product and processes efficiently
5. **Cost**: making products at the lowest possible cost

Depending on a company's competitive position and environment, the operational performance indicators may have different priorities and importance (Noori and Gillen, 1995). Nevertheless, the five indicators should accurately represent true performance of the manufacturing function.

2.4 Relationship of technology, organisation and performance

The notion that the dimensions of technology and organisation are related to performance is not new. Both dimensions complement each other and should therefore evolve in parallel in order to reach optimum levels of performance. Ettlie (1988: 15-17) refers to this process as 'synchronous innovation', while Bessant (1991: 344-345) calls for 'simultaneous innovation'.

More recent literature supports this view. Tidd *et al.* (1999: 261-267) and Sonntag (2003: 319) argue that one of the critical success factors of AMT is organisational change management. Based on such principles, Ghani and Jayabalan (2000) propose an AMT implementation framework incorporating both technological and organisational factors.

Empirical research confirms various aspects of the technology, organisation and performance relationship, but only a few include all three variables. For example, Small (1999: 266-267) concludes that operational performance generally increases with the level of adopted AMT but excluded organisational issues as a suggestion for further study. Boyer's (1999) longitudinal research reveals a positive correlation between AMT and business performance but only included some organisational issues that are related to AMT investment decision-making.

Two other empirical studies are of particular interest to this study. Both examine the relationship of all three variables, but from different perspectives. Frick *et al.* (1998) assess AMT and organisation against business performance, while Challis *et al.* (2002) assess AMT, TQM and JIT against employee and operational performance. Both empirical studies are briefly discussed in the following sections.

2.4.1 Frick *et al.*'s (1998) study

Frick *et al.* (1998: 346) use the Organisation-Technology (O-T) map to analyse business performance of Northern Europe's manufacturing industry. Shown in Figure 2.8, this two-dimensional diagram represents an evolutionary path that organisations follow, either intentionally or unintentionally, to develop along organisational and technological dimensions. An example is given in the diagram showing the changing relationship between the two dimensions over time (hypothetically measured at time t_1, t_2 and t_3).

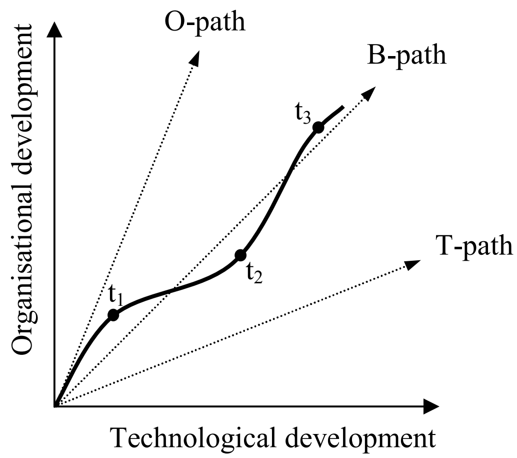


Figure 2.8 Evolutionary Organisation-Technology (O-T) map

(adapted from Frick *et al.*, 1998: 347)

Frick *et al.* (1998: 347-348) operationalise the constructs of technological and organisational development and business performance as follows:

Technological development

A firm's position along the technological dimension is measured by the extent of automation and integration of conventional machines, machining centres and manufacturing systems. The scale is from stand-alone to fully integrated and automated.

Organisational development

A firm's position along the organisational dimension is measured by job specialisation, formalisation and standardisation, decentralisation of decision-making, organisation configuration and flexibility of the workforce.

Business performance

Overall business performance of a firm is measured by market share, revenue, profit and adaptability.

Based on the O-T map of Figure 2.8, they identify three main evolutionary paths:

1. The **organisation-oriented** or O-path: the organisational dimension receives significantly more attention than the technological dimension. These firms view organisational development as more important than adopting technology such as AMT.
2. The **technology-oriented** or T-path: the technological dimension receives significantly more attention than the organisational dimension. Firms following the T-path view technology as the main solution to manufacturing and competitive problems.
3. The **balanced** or B-path: both dimensions are on average equally developed over time with only slight variation along the B-path. Firms following this path gradually develop both dimensions in order to maintain a balance.

Frick *et al.*'s (1998: 359) key findings are that the lowest business performance was seen with technology-oriented firms. Balanced firms have the highest business performance, whereas none of the sample includes organisation-oriented firms. Although they demonstrate the significance of a strategic framework for developing technological and organisational dimensions so as to reach optimum performance levels, there are a few shortcomings:

1. The small sample size of only 28 firms resulted in rather postulated conclusions.
2. Organisation-oriented firms are not reflected in the sample.
3. Performance measures are focused on overall business performance, which may obscure true performance of manufacturing (*cf.* Section 2.3.1).

2.4.2 Challis *et al.*'s (2002) study

Their study uses a large sample of 1024 firms in the Australian and New Zealand manufacturing industry. Challis *et al.* (2002: 1945-1947) investigate the relationship between, what they call, 'Integrated Manufacturing' (AMT, TQM and JIT), employee performance and operational performance. More specifically, Figure 2.9 shows a model of the investigated correlations.

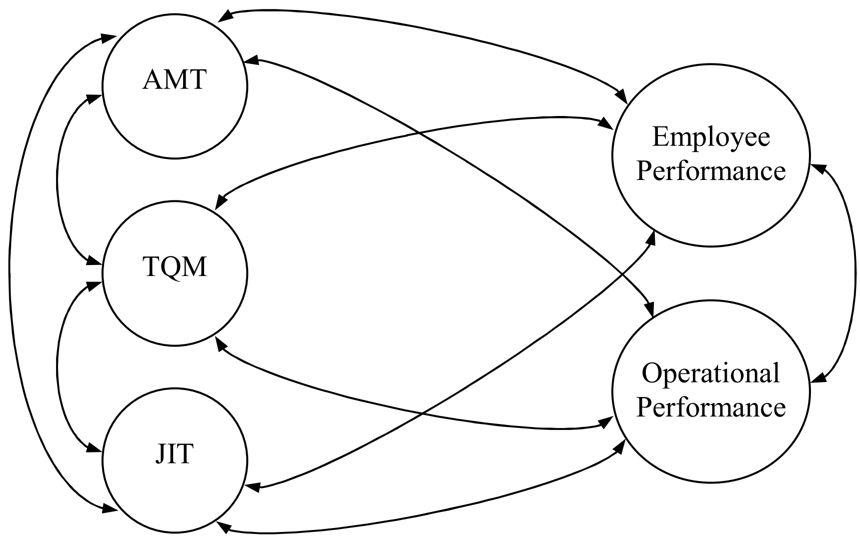


Figure 2.9 Challis *et al.*'s (2002) model

Briefly, the constructs shown in Figure 2.9 are operationalised as follows (Challis *et al.*, 2002: 1948-1951):

<u>AMT</u>

The extent of using design, manufacturing and administrative (coordination) technologies including its perceived contribution to competitiveness.

TQM

The adoption of practices such as continuous improvement, customer satisfaction and quality management including its perceived contribution to competitiveness.

JIT

Supplier cooperation for improving raw material supply processes, manufacturing cycle time, machine set-up and materials management including its perceived contribution to competitiveness.

Employee Performance

Morale, productivity, time lost due to industrial disputes, skills and attitude towards customer service.

Operational Performance

Cost, quality, delivery and flexibility of products and processes.

Table 2.3 shows how their study compares to this study's framework for technology, organisation and performance. Note that the operationalisation of JIT compares in part to this study's technological dimension (integration with suppliers, *cf.* Section 2.1.2.4) and in part to operational performance (speed and flexibility, *cf.* Section 2.3.2).

Table 2.3 Comparison of this study's and Challis *et al.*'s constructs

This study	Challis *et al.*
Technological dimension (Section 2.1)	AMT, partly JIT
Organisational dimension (Section 2.2)	TQM, Employee Performance
Operational Performance (Section 2.3)	Operational Performance, partly JIT

Despite the similarities as shown in Table 2.3, Challis *et al.* focus on 'best practice' concepts such as TQM and JIT. This study however, proposes to use a broader model for investigation of technology, organisation and performance relationships, independent of 'best practices' that may not be generally adopted by manufacturing companies. This broader model is based on the literature review presented in this chapter and will be discussed further in chapter 3 dealing with the research methodology.

Nevertheless, the key findings of Challis *et al.* (2002: 1956-1958) are:

1. A strong correlation exists between employee performance and operational performance. Although not statistically proven, they argue that high performing employees cause higher operational performance.
2. TQM as well as JIT have moderate positive correlation with employee and operational performance. AMT has low positive correlation with employee performance and no correlation with operational performance.
3. AMT has strong positive correlation with operational performance only in a strong TQM environment.

By using the comparison of Table 2.3, Challis *et al.*'s findings roughly mean in terms of this study that:

1. Organisational development positively correlates with operational performance.
2. Technological development alone does not correlate with operational performance.
3. Development along both technological and organisational dimensions positively correlates with operational performance.

2.5 Summary

2.5.1 The technological dimension

AMT refers to a group of technologies of equipment, systems and methods that are used for automation and integration of design, manufacturing and coordination functions (Jonsson, 2000: 1447-1448; Challis *et al.*, 2002). These technologies can be plotted along a continuum of independent and highly integrated systems providing a framework for measuring the level of adopted AMT (Bessant, 1991: 53-57), referred to by this study as the technological dimension. This framework is more universally applicable than others, which are either not sufficiently precise, or may cause inconsistencies in the framework.

The lowest level of the framework constitutes local automation and integration within design (CAD; CAE), manufacturing (CNC machines; industrial robots; AGVs; AS/RS; CM and FMS) or coordination (stand-alone accounting packages; spreadsheets; basic MRP) systems.

The second level of the framework constitutes technological integration of systems and processes of the first level. Closed-loop MRP for example, represents integration of coordination and manufacturing functions, while CAD/CAM represents integration of design and manufacturing functions.

At the third level of the framework, further integration results in MRPII, CIM, MES and ERP. These systems integrate all internal functional areas such as planning, manufacturing, engineering, marketing, finance and management information functions (Schonberger and Knod, 1997: 372-373; Ndede-Amadi, 2004).

At the fourth level, all internal functional areas as well as external up- and downstream elements of the value chain are integrated. Examples are Internet-based procurement, SCM, CRM, online catalogues on the Internet, E-commerce and WIM systems (Rehg and Kraebber, 2001: 319-344; Huang and Mak, 2001).

2.5.2 The organisational dimension

Based on similarities as well as different perspectives found in the literature, a consolidated and simplified organisational framework is proposed comprising of five critical elements: individual skills, team design, organisation design, inter-organisational relationships and corporate culture (Bessant, 1991: 307-332; Mintzberg, 1993: 25-119; Cook and Cook, 1994: 49-53; Tidd *et al.*, 1999: 303-337).

Depending on the degree of implemented AMT, the 'range and depth' of skills need to be increased for both operational and in-house engineering staff (Lowe, 1995: 158-159). It is also important that firms know where to obtain required skills from external sources when they are not available in-house (Tidd *et al.*, 1999: 250).

The complexity of AMT as well as turbulent market conditions requires new team structures and roles built upon skills and flexible ways of working. The literature refers to such teams as self-managing teams who typically have the necessary resources and decision-making authority for effectively and efficiently improving plant operations and for coping with operational contingencies (Rehg and Kraebber, 2001: 483; Wageman, 1997: 49-61).

Higher skills and self-managing teams are building blocks for moving towards more organic or 'fluid' organisational structures as opposed to mechanistic or 'rigid' structures, although an appropriate balance between these endpoints is important (Tidd *et al.*, 1999: 309-315).

To keep abreast of developments in AMT, it is also important to maintain inter-organisational relationships. These revolve around networking with industry, government and universities (Marri *et al.*, 2002: 111). But the ability to critically evaluate new technology remains important to ensure that the real needs of the company are addressed.

Corporate culture is an important factor for success or failure of AMT systems. A well-developed culture encourages to challenge technology and underlying manufacturing principles for closing the gap between actual and potential performance. Such culture is demonstrated in so-called 'learning organisations' that continuously increase and utilise skills and knowledge for continuous improvement and optimisation initiatives. This requires an open climate, formal learning processes, shared vision and leadership (Tidd *et al.*, 1999: 329; Sun and Scott, 2003: 204-211).

2.5.3 Measuring performance

A shortcoming of using a framework such as the Balanced Scorecard for measuring overall business performance is that it may obscure true performance of the manufacturing function. This problem is amplified if managers tend to look only at the end result (i.e. overall business performance) without examining underlying factors. An appropriate measure of the performance of the manufacturing function is therefore operational performance and not overall business performance (Challis *et al.*, 2002: 1951).

The literature reveals that quality, speed, dependability, flexibility and cost are the most important indicators for measuring operational performance of manufacturing (White, 1996: 45; Sohal *et al.*, 2001: 27; Challis *et al.*, 2002: 1951).

2.5.4 Technology, organisation and operational performance relationship

One of the critical success factors of AMT is organisational change management, which indicates that technology and organisation both need to be developed in order to increase performance (Sonntag, 2003: 319). Empirical research confirms this relationship, but some of them only assessed technology-performance relationships (Small, 1999: 266-267; Boyer, 1999). Two studies included all three variables and are therefore of particular interest to this study.

Frick *et al.* (1998: 359) investigated technological and organisational development against overall business performance. They conclude that a balanced development of technology and organisation results in the highest performance, but only assessed a small sample of 28 firms. Additionally, by using overall business performance indicators, Frick *et al.*'s study may not reflect true performance of manufacturing (*cf*. Section 2.3.1).

In contrast, Challis *et al.* (2002: 1945-1947) assessed 'Integrated Manufacturing' (AMT, TQM and JIT) against employee and operational performance on a large sample of 1024 firms, but might be limited by focusing on 'best practices'. By translating Challis *et al.*'s constructs to this study's terminology, their findings roughly mean that: 1) Organisational development positively correlates with operational performance; 2) Technological development alone does not correlate with operational performance and 3) Development along both technological and organisational dimensions positively correlates with operational performance.

The next chapter presents the research methodology that will be employed to investigate this study's hypothesised relationship between the dimensions of technology, organisation and operational performance.

3 RESEARCH METHODOLOGY

This chapter presents the research methodology that will be employed by this study. Section 3.1 and 3.2 discuss the central research problem, primary research question and the hypotheses to be tested. A measurement and structural model will be developed in Section 3.3. The sampling frame and target sample is discussed in Section 3.4 and 3.5 respectively. Section 3.6 presents the questionnaire design, while Section 3.7 explains the data collection method. Data preparation and screening of raw response data is discussed in Section 3.8. The evaluation of measurement and structural models with SAS PROC CALIS (The SAS System release 8.02) is discussed in Section 3.9. Measures to demonstrate reliability and validity will be outlined in Section 3.10. Finally, Section 3.11 provides a short summary of this chapter.

3.1 Research problem

Presented in chapter 1, the central research problem of this study is (*cf.* Section 1.2):

To analyse the effect of development along organisational and technological dimensions on operational performance of manufacturing firms in South Africa.

As discussed in the literature review, only two other studies analysed the relationship between organisation, technology and performance (*cf.* Section 2.4). In short, Frick *et al.* (1998) examined the relationship between technological and organisational dimensions against business performance. Their key finding is that business performance is high when companies maintain an appropriate balance between technological and organisational dimensions (*cf.* Section 2.4.1). But, as pointed out in Section 2.3, business and operational performance are two related yet distinct metrics. More specifically, high levels of business performance might not necessarily mean high levels of operational performance.

The other study was done by Challis *et al.* (2002), who analysed relationships between, what they called, 'Integrated Manufacturing' (AMT, TQM and JIT), employee performance and operational performance. Their key finding, among others, is that AMT correlates positively with operational performance only in a strong TQM environment (*cf.* Section 2.4.2). A shortcoming however, is that Challis *et al.* (2002) focus on 'best practices' such as TQM and JIT. It therefore remains unanswered what the impact of technology and organisation is on operational performance of manufacturing companies, regardless of 'best practices'.

Nevertheless, it appears reasonable to expect high levels of operational performance for manufacturing firms that equally maintain technological and organisational dimensions. Stated differently, the primary research question of this study is:

Does a balanced development of organisational and technological dimensions result in optimum levels of operational performance of manufacturing?

The research problem and primary research question captures a hypothesised triangular relationship between organisation, technology and operational performance. This raises three research hypotheses which are presented in the following section.

3.2 Research hypotheses

3.2.1 Research hypothesis I

$H1_0$:

Development along one dimension (technology or organisation) does not correlate with development along the other dimension.

$H1_a$:

Development along one dimension (technology or organisation) correlates with development along the other dimension.

3.2.2 Research hypothesis II

$H2_0$:

Development along the organisational dimension alone does not result in marginal operational performance.

$H2_a$:

Development along the organisational dimension alone results in marginal operational performance.

3.2.3 Research hypothesis III

$H3_0$:

Development along the technological dimension alone does not result in marginal operational performance.

$H3_a$:

Development along the technological dimension alone results in marginal operational performance.

3.3 Research model

The research problem and hypotheses presented in the previous two sections, suggest simultaneous and causal relationships among the constructs of technology, organisation and operational performance. For this reason, Structural Equation Modelling (SEM) techniques seem to be most appropriate for statistical analysis and inference. Anderson and Gerbing (1988) proposed a two-step approach for SEM:

1. Specify a measurement model and assess its goodness-of-fit to the sample data.
2. Specify and assess the structural model

The main purpose of the first step is to assess with Confirmatory Factor Analysis (CFA) how well the observed variables measure the latent constructs. The second step involves the structural model in which the relationships among latent constructs are assessed (Jöreskog, 1993: 296). The following two subsections elaborate on this approach in terms of this study.

3.3.1 The measurement model

Figure 3.1 shows how the three latent constructs (technology, organisation and operational performance) are measured by multiple indicator variables in accordance with the literature review presented in chapter 2. Since it is a measurement model, only unanalysed associations between the latent constructs are modelled, i.e. they are assumed to covary with each other as indicated by curved double-headed arrows (Kline, 1998: 190).

The relationship between latent and indicator variables of the measurement model is specified by a set of linear equations for each latent construct:

<u>Linear equations for the Operational Performance construct (F_1):</u>

$$V_{01} = L_{v01f1} * F_1 + E_{01} \tag{1}$$
$$V_{02} = L_{v02f1} * F_1 + E_{02} \tag{2}$$
$$V_{03} = L_{v03f1} * F_1 + E_{03} \tag{3}$$
$$V_{04} = L_{v04f1} * F_1 + E_{04} \tag{4}$$
$$V_{05} = L_{v05f1} * F_1 + E_{05} \tag{5}$$

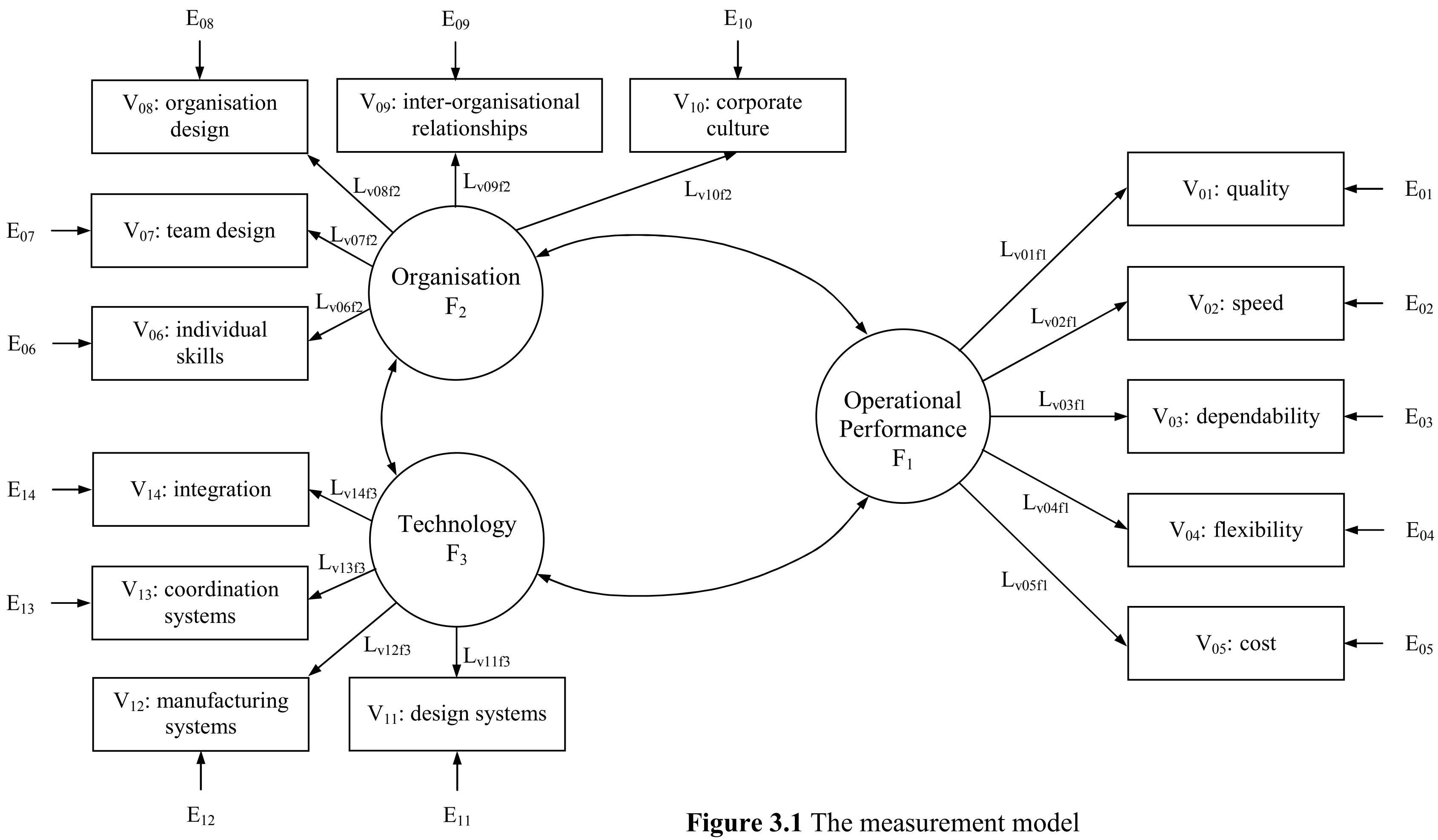


Figure 3.1 The measurement model

Linear equations for the Organisation construct (F_2):

$$V_{06} = L_{v06f2} * F_2 + E_{06} \quad (6)$$
$$V_{07} = L_{v07f2} * F_2 + E_{07} \quad (7)$$
$$V_{08} = L_{v08f2} * F_2 + E_{08} \quad (8)$$
$$V_{09} = L_{v09f2} * F_2 + E_{09} \quad (9)$$
$$V_{10} = L_{v10f2} * F_2 + E_{10} \quad (10)$$

Linear equations for the Technology construct (F_3):

$$V_{11} = L_{v11f3} * F_3 + E_{11} \quad (11)$$
$$V_{12} = L_{v12f3} * F_3 + E_{12} \quad (12)$$
$$V_{13} = L_{v13f3} * F_3 + E_{13} \quad (13)$$
$$V_{14} = L_{v14f3} * F_3 + E_{14} \quad (14)$$

where:

V_{xx} = indicator variable xx (the subscript xx ranges from 01 to 14)
F_y = latent construct y (the subscript y ranges from 1 to 3)
L_{vxxfy} = factor loading of latent construct F_y on variable V_{xx}
E_{xx} = measurement error for indicator variable xx

In accordance with Jöreskog's (1993: 297) recommendations for cross-sectional studies, it is assumed that measurement errors for the indicator variables are independent and that each indicator loads on only one latent variable (unidimensionality).

In order to assess the measurement model's identification, it is necessary to calculate the number of observations and parameters. The number of observations is given by (Kline, 1998: 204):

$$observations = \frac{v(v+1)}{2} \tag{15}$$

where v is the number of observed indicator variables. This results in 14(14+1)/2 = 105 observations.

The number of parameters is determined by the number of variances and covariances (unanalysed associations) of latent variables, measurement error terms and factor loadings (Kline, 1998: 204). This results in 31 parameters.
Since the number of observations (105) is more than the number of parameters (31), the measurement model of Figure 3.1 is identified (over-identified). This is a necessary condition for parameter estimation and model fitting (Hatcher, 2003: 159-160, 272).

3.3.2 The structural model

The relationship between the latent variables is assessed with the structural model shown in Figure 3.2. The Organisation (F_2) and Technology (F_3) constructs are exogenous latent variables that have direct causal effects (weighted by path coefficients P_{f1f2} and P_{f1f3}) on the endogenous latent variable Operational Performance (F_1). The disturbance term (D_1) models unknown exogenous omitted causes that may have a causal effect on the endogenous variable. The curved double-headed arrow represents covariance (C_{f2f3}) between the two exogenous variables. The structural relationship is given by:

$$F_1 = P_{f1f2} * F_2 + P_{f1f3} * F_3 + D_1 \tag{16}$$

where:

F_1 = Endogenous latent variable Operational Performance

F_2 = Exogenous latent variable Organisation

F_3 = Exogenous latent variable Technology

P_{f1f2} = Path coefficient of F_2 on F_1

P_{f1f3} = Path coefficient of F_3 on F_1

C_{f2f3} = Covariance between the exogenous latent variables F_2 and F_3

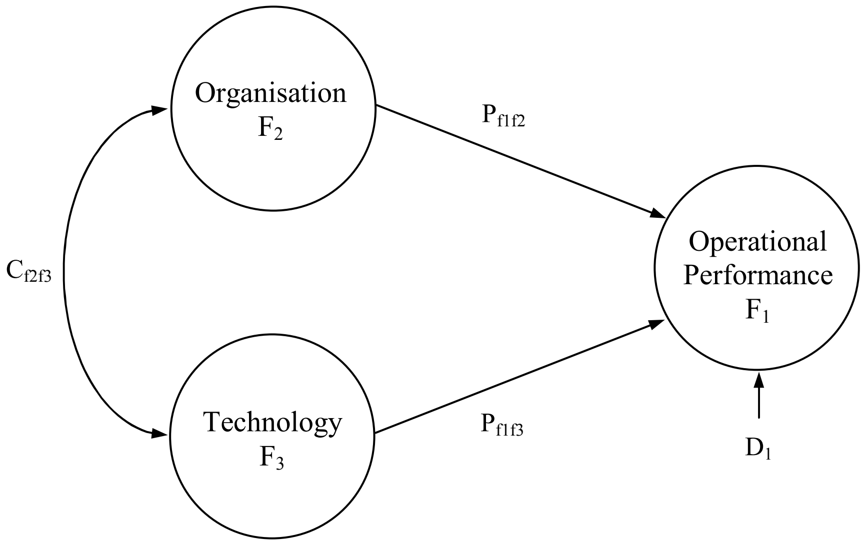


Figure 3.2 The structural model

The evaluation of the structural model will be used to support or reject the hypotheses of Section 3.2, and consequently to answer primary and secondary research questions and to resolve the central research problem (*cf.* Sections 1.2, 1.3, 1.4 and 3.1).

3.4 Sampling frame

The units of analysis in the sampling frame are repetitive manufacturing firms in South Africa. Small (1999: 268) reports that repetitive manufacturers are the most likely adopters of the technology discussed in Section 2.1 of the literature review.

The Department of Trade and Industry (DTI) as well as Statistics SA were contacted for detailed information on the population of manufacturing firms in South Africa. The DTI could not provide such information. Probably due to non-disclosure agreements, Statistics SA could only provide summary information of the geographic distribution of manufacturing firms based on a census of the manufacturing industry conducted in 1996. Unfortunately, this information did not contain details whether a firm is a repetitive manufacturer or not. Table 3.1 summarises the distribution of manufacturing firms per province (Statistics SA, 1998: 6-34). As shown in the table, the majority of manufacturing firms in South Africa (over 80%) reside in the Gauteng, KwaZulu Natal and Western Cape provinces.

Table 3.1 Geographic distribution of manufacturing firms in South Africa

Province	Population Distribution	
	Frequency	**Percentage**
Gauteng	10915	42.97%
KwaZulu Natal	4915	19.35%
Western Cape	4701	18.51%
Eastern Cape	1500	5.91%
Free State	972	3.83%
Mpumalanga	813	3.20%
North West	663	2.61%
Limpopo	581	2.29%
Northern Cape	339	1.33%
Total	**25399**	**100%**

Because the data is from 1996 (Census of Manufacturing), it is likely that the population distribution has changed significantly over the last eight years. Contributing factors to a changed population are, for example, government-supported industrial development programmes such as the DTI's Integrated Manufacturing Strategy (DTI, 2002) and the Growth, Employment and Redistribution strategy (GEAR, 1996). Statistics SA did not have updated information of the population of manufacturing firms at the time of this study.

3.5 Target sample

Because the DTI and Statistics SA could not provide detailed information of the sampling frame, websites of three online business directory services were consulted for the target sample:

1. The websites of two online business directories (www.mbendi.co.za and www.brabys.co.za) did not include e-mail addresses. Additionally, the information from these websites were categorised per industry sector and not per manufacturing operating mode (e.g. repetitive or continuous).

2. Another online business directory, the 'Decision Makers Database' (www.decisionmakers.co.za), included e-mail addresses of senior management of manufacturing firms. The information was also not categorised per manufacturing operating mode, but per geographical area (province).

Of the three online business directories, the 'Decision Makers Database' (DMD) seems the most appropriate to use because e-mail addresses were included (see Section 3.7 for reasons why that information is necessary). A director of DMD was informally interviewed to establish the currency and accuracy of their database. DMD stated that the information is regularly maintained (approximately twice a year) by reviewing advertisements and articles in professional magazines, trade journals and other directories. A sample of 718 firms including details such as company name, e-mail address and name of the Managing Director, industry sector and geographical location was purchased from DMD.

The representativity of the target sample is evaluated against Statistics SA's geographical population distribution by using a χ^2 goodness-of-fit test. The null and alternative hypotheses for this test are:

H_0: *The sample distribution conforms to the population distribution.*

H_a: *The sample distribution does not conform to the population distribution.*

The expected sample size for each province is obtained by multiplying the population's percentage per province from Table 3.1 with the total sample size of 718. The details of the test are summarised in Table 3.2, while Figure 3.3 gives a graphical representation of the expected and observed sample distributions.

Table 3.2 χ^2 goodness-of-fit test of the target sample and the population

Province	**Population distribution (Table 3.1)**	**Observed sample size (O)**	**Expected sample size (E)**	$\frac{(O - E)^2}{E}$
Gauteng	42.97%	480	309	94.63
KwaZulu Natal	19.35%	59	139	46.04
Western Cape	18.51%	133	133	0
Eastern Cape	5.91%	21	42	10.50
Free State	3.83%	5	27	17.93
Mpumalanga	3.20%	4	23	15.70
North West	2.61%	5	19	10.32
Limpopo	2.29%	5	16	7.56
Northern Cape	1.33%	6	10	1.60
Totals	**100%**	**718**	**718**	**204.28**

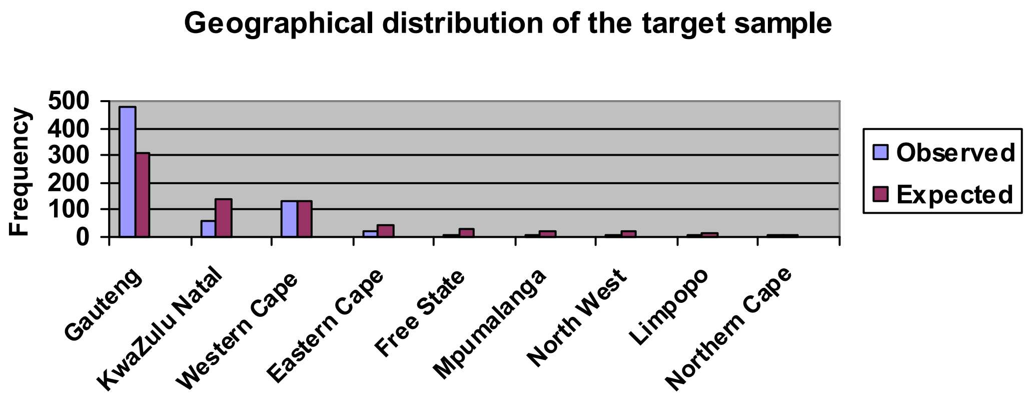


Figure 3.3 Observed and expected sample distributions per province

From Table 3.2 and a standard statistical table for the χ^2 critical value (degrees of freedom, df = 9 – 1, p = 0.05), it follows that $\chi^2 = 204.28$ and $\chi^2_{(0.05,\ df = 8)} = 15.51$. Since $\chi^2 > \chi^2_{(0.05,\ df = 8)}$, the null hypothesis is rejected. In other words, the sample distribution is not representative of the population of manufacturing firms in South Africa at a 95% confidence level. Two main factors could contribute to the statistically significant difference between observed and expected sample distributions:

1. As shown in Figure 3.3 and Table 3.2, the Gauteng and KwaZulu Natal provinces are the highest contributors to the difference in observed and expected sample sizes. The difference may decrease with updated population data (*cf.* Section 3.4).
2. The way DMD maintains the accuracy and currency of its database means that a bias exists towards actively advertising manufacturing firms. It is unknown by this study what the extent is of non-advertising manufacturing firms.

As mentioned in Section 3.4, repetitive manufacturers are the most likely adopters of the technology that is discussed in the literature review. By manually reviewing a firm's industry sector of the address list of 718 cases, 114 cases were excluded that are unlikely to be repetitive manufacturers. The excluded cases are operating in industry sectors such as food and beverages, chemicals and other continuous manufacturing sectors. This resulted in a sample size of 604 cases.

According to Saunders, Lewis and Thornhill (2003: 284), a likely response rate for online surveys ranges between 10% and 30%, which translates to between 60 and 181 responses.

The literature about CFA and SEM recommend using a 'large' sample size. But different authors have different views of what is 'large' and what the minimum sample size should be. For example, Byrd and Turner (2000: 178) recommend a sample size of at least 100, with 200 being a 'good' sample size. Kline (1998: 112) on the other hand, suggests a minimum sample size of five times the number of parameters, else model evaluation may be doubtful. For the measurement model of this study (*cf.* Section 3.3.1), it means that a minimum sample size of 155 (5 times 31) is required. Because the number of responses for this study is expected to be between 60 and 181, sample size may become an issue for this study.

3.6 Questionnaire design

The design of the questionnaire is based on the measurement model of Figure 3.1. Five items in the form of statements have been compiled for each indicator variable. This resulted in a total of 70 items. The statements were drawn from the literature that was reviewed as presented in chapter 2. Each item is anchored on a five-point measurement scale of 'strongly disagree', 'disagree', 'not sure', 'agree' and 'strongly agree'. The total score of an indicator variable is the average of the five item scores for each case.

Additional demographic questions have been included such as industry sector, management level, management area, annual revenue, number of employees and type of production system (i.e. manufacturing operating mode). These were similar to what was used by Sohal *et al.* (2001) who investigated the adoption of AMT in the South African manufacturing industry.

The full questionnaire is presented in Appendix A. The application of suggested questionnaire design principles that have been applied for this study are summarised below (DeVellis, 1991: 57-60; Burgess, 2001: 1-17; Saunders *et al.*, 2003: 280-316; Synodinos, 2003: 221-233):

1. The first two pages of the questionnaire are used to briefly describe the study, confidentiality of respondents and how to fill in the questionnaire.

2. Positive and negative statements for each indicator variable have been mixed to minimise acquiescence bias. Positive statements have been internally coded (not visible to the respondent) from one (‘strongly disagree’) to five (‘strongly agree’). Negative statements have been reverse coded from five (‘strongly disagree’) to one (‘strongly agree’).

3. The statements were such that the respondents should be able to readily select an appropriate response option, without the need for detailed calculations or for information searching.

4. The wording of the statements was carefully selected to prevent double negatives, leading statements, ambiguousness and lengthy sentences.

5. The statements are grouped per indicator variable, and the indicator variables are grouped per construct (technology, organisation and operational performance) to maintain a logical flow of the questionnaire.

6. Demographic questions are asked last.

Table 3.3 gives an overview of the questionnaire design including a brief outline of the statements for each indicator variable and references to the literature review of chapter 2.

Table 3.3 Overview of questionnaire statements

Latent construct	Indicator variable	Outline of statements	Item numbers	Reference (section)
Technology	Design systems	Relative use of Computer Aided Design (CAD) and Engineering (CAE) systems for design and analysis.	1 to 5	2.1.2.1
	Manufacturing systems	The extent of using computer controlled machinery, robots, AGVs, automatic storage systems and manufacturing cells.	6 to 10	2.1.2.1
	Coordination systems	Use of non-integrated coordination systems such as spreadsheets, basic MRP and locally stored data.	11 to 15	2.1.2.1
	Integration	The extent of integration between design, manufacturing and coordination systems; integration with the value chain.	16 to 20	2.1.2.2, 2.1.2.3, 2.1.2.4
Organisation	Individual skills	Functional understanding of AMT; level of multi-skills; use of external contractors.	21 to 25	2.2.2.1
	Team design	Degree of autonomous decision-making; response to contingencies; ownership of its purpose; team composition; use of resources.	26 to 30	2.2.2.2
	Organisation design	The extent of specialised jobs, levels of management, job output standardisation, decision making, information flow.	31 to 35	2.2.2.3
	Inter-organisational relationships	Utilisation of relationships with other companies, institutions and government; attendance of seminars.	36 to 40	2.2.2.4
	Corporate culture	Way of problem solving; continuous improvement practices; learning from past experience; benchmarking; knowledge sharing.	41 to 45	2.2.2.5

Table 3.3 Overview of questionnaire statements (continued)

Latent variable	Indicator variable	Outline of statements	Item numbers	Reference (section)
Operational performance	Quality	Conformance to customer specifications; variability of product attributes; overall quality compared to competitors.	46 to 50	2.3.2
	Speed	Relative magnitude of development and manufacturing cycle times; total lead time; value-added vs. non-value added time; WIP.	51 to 55	2.3.2
	Dependability	Use of spare capacity; production schedule adherence; planned vs. actual dispatch dates; reliability of equipment;	56 to 60	2.3.2
	Flexibility	Efficiency of introducing new products; product-mix; ability to efficiently adapt systems; response to market	61 to 65	2.3.2
	Cost	The relative level of direct material, labour and overhead cost; competitive pricing; relative cost of manufacturing technology.	66 to 70	2.3.2

The draft questionnaire has been subjected to a pilot study with nine participants (senior managers in the repetitive manufacturing industry). The purpose of the pilot study was to assess the average total time to complete the questionnaire, clarity of instructions, identification of unclear or ambiguous statements, major topic omissions and overall appearance of the questionnaire (Saunders *et al.*, 2003: 308-309).

One participant did not respond. Signed copies of the evaluation forms that were used by the participants are presented in Appendix B. Table 3.4 summarises the main comments of the participants and the actions taken to improve the questionnaire. The first column, labelled 'Reference', refers to the section of the corresponding evaluation form in Appendix B. The pilot study indicated that the total time to fill in the questionnaire is approximately 15 minutes.

Table 3.4 Main results from the pilot study and actions taken

Reference	Comment	Action
B.1	Not sure of the meaning of questions 2 and 10.	Questions 2 and 10 rephrased to increase clarity.
B.2	No comments.	No action.
B.3	Motivational issues caused by automation not included.	These are already implicitly addressed by corporate culture. A highly motivated workforce would be reflected in high scores for culture. No action was taken.
B.4	Some technical abbreviations not clear.	Ensured that abbreviations were written in full when used the first time.
B.5	What specific model or standard was used to model technology?	That has been addressed in the literature review. No action taken.
B.6	No industry standard for measuring cost.	Only recent statistics for North America was available for this study, which may be inappropriate for South Africa. The questions for manufacturing cost have been based on general principles including direct labour, direct material and factory overhead cost. Additionally, it may reduce response rate if too detailed information or calculations are requested. No action taken.
B.7	Question 6 inconsistent with the example question of the questionnaire.	Rephrased question 6.
B.8	Maybe better to give detailed definitions of technological terms.	Rephrased some questions related to technology to ensure clarity. No detailed definitions included as it would make the questionnaire too wordy.

3.7 Data collection method

To increase the probability of a relatively high response rate (between 20% and 30%), targeted respondents will be invited by e-mail to participate in the research. E-mail is not only faster and cheaper compared to postal invitations, but also more convenient for the targeted respondents (Managing Directors). The possibility that this may cause a bias towards respondents who use e-mail messaging systems is probably negligible because of the pervasive adoption of it by companies over recent years. Figure 3.4 gives an overview of the administration process. A cover letter (see Appendix C.1) will be e-mailed to the target respondents inviting them to participate in this study. The cover letter includes an Internet link to the self-administered online web questionnaire. By pressing the SUBMIT button at the end of the questionnaire, the raw response data is e-mailed back.

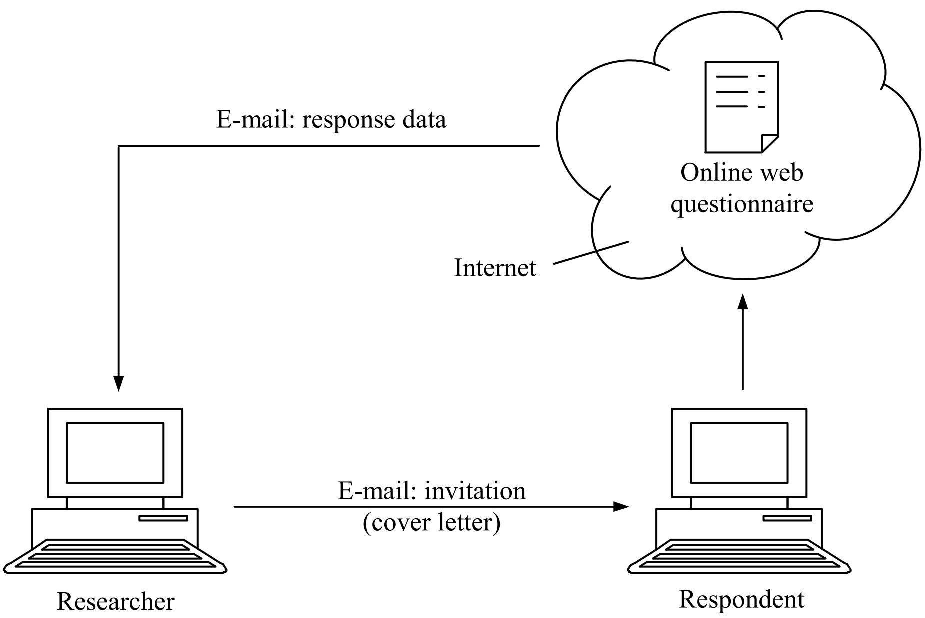


Figure 3.4 Questionnaire administration process

3.8 Data preparation and screening

The sample needs to be subjected to several preparation and screening steps for the following reasons (Kline, 1998: 67-91):

1. Problems related to data might cause that estimation procedures for the measurement and structural models fail to generate a solution.
2. The Maximum Likelihood method requires that the data is univariate and multivariate normally distributed.

The data preparation and screening steps will be detailed in the following subsections.

3.8.1 Missing data

The questionnaire is designed to test that all statements and demographic questions are filled in. If respondents do not select a response option for an item, the online questionnaire will generate an appropriate error message including an indication of which data is missing. Only when all data is filled in, it will be submitted by e-mail. This prevents responses with missing data.

3.8.2 Multicollinearity

Potential bivariate multicollinearity will be checked by visual inspection of the correlation matrix. If any combination of two indicator variables has a correlation coefficient of more than 0.85, the variables will either be deleted or combined into one indicator variable to eliminate multicollinearity (Kline, 1998: 78).

3.8.3 Univariate outliers

If the average score for a particular indicator variable is beyond calculated limits of the mean ± 3 standard deviations, it will be regarded as a univariate outlier. Cases with such extreme scores will be listwise deleted from the dataset.

3.8.4 Univariate and multivariate normality

The Maximum Likelihood estimation procedure requires that the data is normally distributed on both univariate and multivariate levels. Additionally, Nunnally (1978: 141-142) points out that correlation coefficients will be biased if the distribution of one variable is markedly different than the distribution of the other variable. It is therefore important that all variables are from normal distributions.

Univariate normality of the data will be assessed with skewness and kurtosis indexes. Various standard statistical textbooks were consulted for generally accepted maximum absolute values for skewness and kurtosis to label a distribution as approximately normal. Most of them explain quite clearly what both indexes measure but none of them provided adequate guidelines, except for stating that both indexes will be zero for a perfect normal distribution. Therefore, this study selected somewhat arbitrarily univariate skewness and kurtosis limits of ± 1.0 for an approximate normal distribution.

Mardia's (1970) statistic, calculated by the KURTOSIS option of PROC CALIS, will be used to assess multivariate normality of the data. If the statistic is between ±2.0, multivariate normality will be assumed.

3.8.5 Internal consistency

The average scores of the composite indicator variables will be evaluated for internal consistency with Cronbach's coefficient alpha method (Cronbach, 1951). This study adopted Nunnally's (1978: 245) recommendation that alpha should exceed 0.7 for hypothesised measures of a construct[3]. If alpha is below 0.7, indicators that have the highest contribution to unreliability will be deleted until coefficient alpha is above the minimum.

[3] Although the measures are drawn from the literature review presented in chapter 2, no generally accepted and established measures exist; hence the measures used in this study are hypothesised.

3.8.6 Non-response bias

The distribution of actual responses needs to be compared against the target sample distribution. If there is a statistically significant difference, then the results of this study may not generalise to the target sample. Note that the actual response distribution will in any case not generalise to the population because the target sample is not representative of the population as shown in Section 3.5. The χ^2 goodness-of-fit test will be used to compare the geographical distribution of the actual responses against the target sample distribution.

3.9 Model evaluation

The measurement and structural models will be evaluated with SAS PROC CALIS (The SAS System release 8.02) according to an approach recommended by Hatcher (2003: 249-437) and Jöreskog (1993, 294-314). Their recommendations are based on Anderson and Gerbing's (1988) two-step modelling process: the structural model is only tested after an acceptable goodness-of-fit between the measurement model and the sample data has been obtained.

3.9.1 Evaluating the measurement model

The general principle employed to evaluate the measurement model of Figure 3.1 is that each construct is separately subjected to CFA before the entire measurement model is evaluated. In other words, once each construct adequately accounts for variances and covariances in the sample data, the analysis will proceed with evaluating all three constructs simultaneously for overall goodness-of-fit.

Hatcher (2003: 280-340) points out how to evaluate CFA models with SAS PROC CALIS:

1. Review the log file to verify that PROC CALIS completed without errors.
2. The χ^2 value should be relatively small in relation to the degrees of freedom (df). An acceptable value is $\chi^2/\text{df} < 2.0$ and that the p-value is greater than 0.05.
3. The Comparative Fit Index (CFI) and the Non-Normed Fit Index (NNFI) should be at least 0.9.
4. Absolute t-values, representing a t-test of the null hypothesis that the factor loading is equal to zero in the population, should exceed 1.96 ($p < 0.05$). Additionally, standardised factor loadings should be at least moderate and standard errors should not be excessively small.
5. The distribution of normalised residuals should be symmetrical around zero with only a few residuals exceeding 2.0 in absolute value.
6. Composite reliabilities (see Section 3.10) for latent factors should be at least 0.60.
7. Estimated variance extracted for latent factors should exceed 0.50 (see Section 3.10).
8. Discriminant validity should be evaluated. This study will use the χ^2 difference test to demonstrate discriminant validity (see Section 3.10).
9. The Wald and Lagrange multiplier tests could be used to improve goodness-of-fit by deleting or adding parameters respectively.

As stated in Section 3.5, sample size may become an issue for this study. More specifically, Bentler and Bonett (1980: 591) discuss that the probability of the χ^2 significance test rejecting a false model increases with sample size. Conversely, for a small sample size, the test is more likely not to reject a false model. Similar arguments hold for the χ^2/df ratio. The χ^2 and the χ^2/df ratio tests will therefore be used only as general indicators of model fit.

For this reason, Hatcher (2003: 191-192, 291) recommends using additional fit indexes (CFI and NNFI) that are relatively insensitive to sample size. Gerbing and Anderson (1993: 59) show in a Monte Carlo simulation that the CFI is only slightly biased by sample size. For the NNFI, Marsh, Balla and McDonald (1988:

407) demonstrate that this index (referred to as the Tucker-Lewis Index in their study) is relatively insensitive for sample sizes ranging from 25 to 1600. Overall, the combination of using χ^2, the χ^2/df ratio, the CFI and the NNFI as goodness-of-fit indicators should result in a meaningful evaluation.

If the measurement model does not adequately account for the sample data, several options are available that may be guided by the Wald and Lagrange multiplier tests. Anderson and Gerbing (1988: 417) discuss four steps that could be used to respecify an unacceptable measurement model:

1. assign a suspicious indicator to a different factor
2. delete the suspicious indicator from the model
3. assign a suspicious indicator to multiple factors
4. correlate measurement errors of suspicious indicators

The first two options are preferred because they maintain unidimensionality of the model. The last two options will not be used because that would make interpretability of the estimated underlying constructs difficult and may take advantage of chance due to measurement and sampling error. Additionally, MacCallum, Roznowski and Necowitz (1992: 501-503) warn that 'data-driven modifications' of a model to obtain a better fit to the sample data may result in a model that does not generalise to other samples or the population, especially when sample size is small. In light of this, model modifications will be minimised, while data filtering (removing univariate and multivariate outliers for example) will be emphasised to maximise data quality.

3.9.2 Evaluating the structural model

The structural model of Figure 3.2 is a modified measurement model in which causal relationships are specified between exogenous and endogenous variables. Although indicator variables are not shown in Figure 3.2, the model is a combination of the measurement and structural components. Kline (1998: 245-252) refers to it as 'hybrid models'. As such, evaluation includes performing a simultaneous test of both components for model fit and evaluation of just the structural part.

Analogous to the previous section, Hatcher (2003: 343-437) points out how to evaluate hybrid models, i.e. how to do path analysis with latent variables using SAS PROC CALIS:

1. In specifying the model in SAS, scale latent factors by fixing its indicator with the highest standardised loading (from the CFA described in the previous section) at one.
2. Review the log file to ensure that PROC CALIS completed without errors.
3. The χ^2 value should be relatively small in relation to the degrees of freedom (df). An acceptable value is χ^2/df < 2.0 and that the p-value is greater than 0.05.
4. The Comparative Fit Index (CFI) and the Non-Normed Fit Index (NNFI) should be at least 0.9.
5. Absolute t-values, representing a t-test of the null hypothesis that factor loadings and path coefficients are equal to zero in the population, should exceed 1.96 ($p < 0.05$). Additionally, standardised factor loadings and path coefficients should be at least moderate without excessively small standard errors.
6. Review R^2 for latent endogenous variables (for this study: Operational Performance F_1) to see how much variance is accounted for.
7. The distribution of normalised residuals should be symmetrical around zero with only a few residuals exceeding 2.0 in absolute value.
8. Calculate the Parsimony Ratio (PR) defined as the ratio between the degrees of freedom of the model and the null model. The PR should be as close to 1.0 as possible.

9. Review the Parsimonious Normed Fit Index (PNFI). The PNFI should be at least 0.50.
10. Calculate the Relative Normed Fit Index (RNFI). The RNFI reflects goodness-of-fit of just the structural part of the model and should be at least 0.9.
11. Calculate the Relative Parsimony Ratio (RPR) and the Relative Parsimonious Fit Index (RPFI). Both may be used to evaluate different models.
12. Evaluate the fit of the hybrid model compared to the measurement model with a χ^2 difference test. If there is a significant difference, the hybrid model may need to be modified.

Hatcher (2003: 394-410) discusses how a hybrid model could be modified if necessary. The steps involve using Wald and Lagrange multiplier tests to see which parameter could be deleted or added respectively (one at a time). Each successive model modification is evaluated for improvement in fit with a χ^2 difference test. The (revised) hybrid model may be accepted if it fits the sample data as good as the measurement model. This will also be assessed with a χ^2 difference test.

3.10 Reliability and validity

Reliability is demonstrated when a measure is consistent, accurate and repeatable. Validity on the other hand, is demonstrated when an indicator measures the intended underlying latent variable and not something else (Kline, 1998: 192-198). Reliability and validity for this study will be assessed by following Hatcher's (2003: 325-339) recommendations. Reliability measures include internal consistency, indicator reliability, composite reliability and variance extracted estimates. Validity measures include convergent, discriminant and content validity, which are a subset of overall construct validity. These are briefly discussed in the following subsections.

3.10.1 Reliability measures

3.10.1.1 Internal consistency

Section 3.8.5 briefly discussed the internal consistency measure (Cronbach's alpha) that will be used to assess the overall reliability of the measurement scales. This measure is merely a basic test of the internal consistency of all variables, i.e. how variances of the 14 indicator variables relate to the covariances among them, regardless to which latent variable they are assigned. As pointed out in Section 3.8.5, a value of 0.7 will be used as the minimum for reliable data.

3.10.1.2 Indicator reliability

Once an acceptable measurement model has been obtained, the reliability of the indicators will be assessed by the square of its standardised factor loading (R^2). This value represents the percentage variation in the indicator explained by its underlying latent variable. Similar to the previous section, a value of 0.7 or higher means that the indicator reliably measures the underlying latent variable.

3.10.1.3 Composite reliability

The reliability of a latent variable is demonstrated with the composite reliability (CR) measure exceeding 0.6. It is calculated for each latent variable with the following formula (Fornell and Larcker, 1981: 45; Hatcher, 2003: 326):

$$CR_j = \frac{\left(\sum L_i\right)^2}{\left(\sum L_i\right)^2 + \sum \mathrm{Var}(E_i)} \tag{17}$$

where:

CR_j = composite reliability of latent variable j

L_i = standardised factor loading of latent variable j on indicator i

E_i = the error variance of indicator i measuring latent variable j

3.10.1.4 Variance extracted estimate

The variance extracted (VE) estimate indicates how much variance in relation to the total variance (which includes measurement error) is captured by the latent variable. It is calculated for each construct by (Fornell and Larcker, 1981: 46; Hatcher, 2003: 331):

$$VE_j = \frac{\sum L_i^{\ 2}}{\sum L_i^{\ 2} + \sum \mathrm{Var}(E_i)} \tag{18}$$

where:

VE_j = variance extracted by latent variable j

L_i = standardised factor loading of latent variable j on indicator i

E_i = the error variance of indicator i measuring latent variable j

3.10.2 Validity measures

3.10.2.1 Convergent validity

Convergent validity is demonstrated if the indicator variables of a particular latent variable are strongly correlated. This would indicate that they are measuring the same underlying latent variable. Convergent validity will be assessed with the *t*-test of the null hypothesis that the factor loadings are zero for each indicator variable measuring the same underlying latent variable. If the *t*-values are significant, the indicators demonstrate convergent validity.

3.10.2.2 Discriminant validity

If correlations between the indicators of a particular latent variable and the indicators of another latent variable are weak, it will provide evidence of discriminant validity. Also, if two latent variables are highly correlated it will suggest low discriminant validity. This will be assessed between two latent variables with a χ^2 difference test between an unconstrained and a constrained measurement model Hatcher (2003: 332-339).

3.10.2.3 Content validity

The pilot study was used as an instrument to demonstrate content validity. Only minor modifications have been made to the questionnaire items (see Table 3.4), thus supporting the validity of its content.

3.11 Summary

This chapter presented the research methodology that will be employed for this study. The central research problem is:

To analyse the effect of development along organisational and technological dimensions on operational performance of manufacturing firms in South Africa.

Based on two other studies (Frick *et al.*, 1998 and Challis *et al.*, 2002), it appears reasonable to expect high levels of operational performance when firms maintain a balance between technological and organisational dimensions. This expectation is captured by the primary research question:

Does a balanced development of organisational and technological dimensions result in optimum levels of operational performance of manufacturing?

Three hypotheses were presented which will be used to answer the primary research question and to resolve the central research problem. Structural Equation Modelling will be used to test the hypotheses. The exogenous latent variables are Organisation and Technology. The endogenous latent variable is Operational Performance.

The sampling frame consists of repetitive manufacturers in South Africa. A target sample of 718 cases was purchased from a business directory service provider. The sample is not representative of the population according to a χ^2 significance test. By manually reviewing the sample, 114 cases were excluded that were unlikely to be repetitive manufacturers. The final target sample size was therefore 604 cases.

A 70-item online self-administered questionnaire was developed to measure 14 indicator variables. The score for an indicator is the average of its five items. The items are presented as statements for which a respondent selects an option on a five-point measurement scale from ‘Strongly Disagree’ to ‘Strongly Agree’. A pilot study with nine participants provided comments that have been used to improve the questionnaire, thus demonstrating content validity. Targeted respondents will be invited to participate in the research by e-mailing a cover letter that includes an Internet link to the online questionnaire. Raw response data will be e-mailed back to the researcher for analysis.

Data preparation and screening of raw response data includes checking for missing data, multicollinearity, univariate outliers, univariate and multivariate normal distributions, internal consistency and non-response bias.

The measurement and structural models will be evaluated with SAS PROC CALIS. Once an acceptable fit of the measurement model to the sample data has been obtained, the structural model will be tested. Measures to demonstrate reliability includes an assessment of indicator and composite reliability as well as variance extracted estimates. Validity will be demonstrated by assessing convergent and discriminant validity of the latent variables.

The next chapter presents the results of this study based on the methodology that has been outlined in this chapter.

4 RESULTS

This chapter presents the results of the study that was conducted based on the research methodology discussed in the previous chapter. Section 4.1 presents the questionnaire response including the demographics of the respondents and an assessment of non-response bias. This is followed by a discussion of preparation and screening of the response data in Section 4.2. The evaluation of the measurement and structural models are presented in Section 4.3 and 4.4 respectively. Finally, the last section provides a short summary of this chapter.

4.1 Questionnaire response

4.1.1 Response statistics

A total of 604 cover letters were e-mailed to Managing Directors of manufacturing firms inviting them to participate in this study. Shortly thereafter, 32 e-mails were returned as undeliverable due to unknown e-mail addresses or full e-mailboxes. Two automatic e-mail replies indicated that the invitations were discarded as unsolicited e-mail. A total of 49 separate e-mails were received from non-respondents, who wished not to participate in the study.

Figure 4.1 shows a trend of the number of returned questionnaires per week. A total of 22 responses were received two weeks after the initial invitation was sent. A reminder was subsequently e-mailed (see Appendix C.2), which resulted in a total of 45 responses received during the following two weeks. A second and last reminder was sent next (see Appendix C.3), which resulted in another 38 responses. Time constraints did not allow for sending a third reminder.

Three responses were duplicates based on the e-mail field at the end of the online questionnaire that respondents were required to fill in. These have been removed from the dataset. Two respondents faxed a copy of the filled in questionnaire because they encountered technical problems with submitting the data online. These have been manually processed. Thus, the total number of responses was 22 + 45 + 38 – 3 + 2 = 104. The raw response data have been copied into a Microsoft Excel 2000 file. A copy of the content of this file is presented in Appendix D.

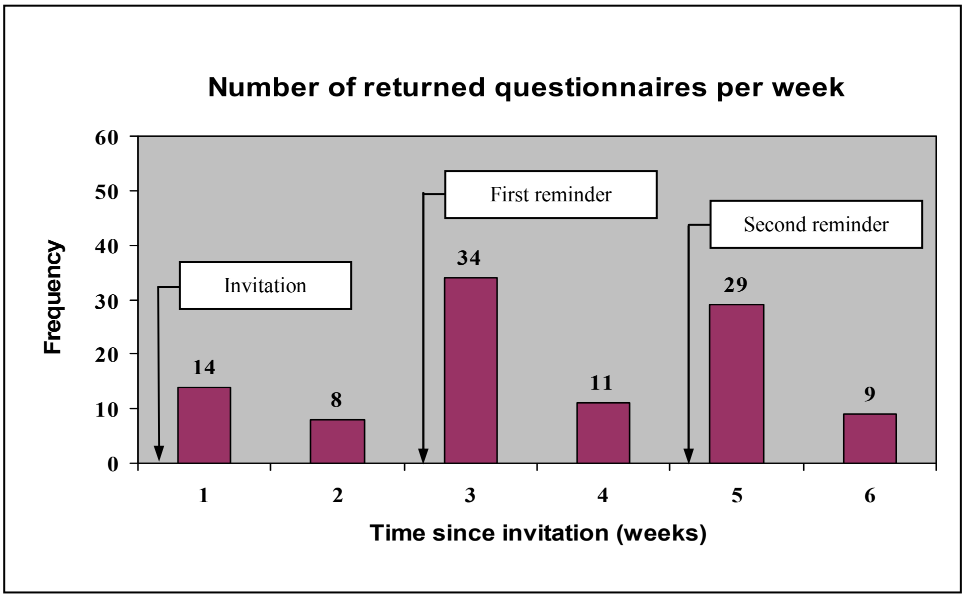


Figure 4.1 Response trend

The active response rate is given by (Saunders *et al.*, 2003: 157):

$$\textit{active response rate} = \frac{\textit{total number of responses}}{\textit{total number in sample} - (\textit{ineligble} + \textit{unreachable})} \qquad (19)$$

Therefore, the active response rate was (no responses were ineligible):

$$\textit{active response rate} = \frac{104}{604-(0+32)} * 100\% = 18.2\%$$

4.1.2 Demographics of respondents

The geographic distribution of respondents is shown in Figure 4.2. Over 86% of the respondents were from the Gauteng, KwaZulu Natal and Western Cape provinces.

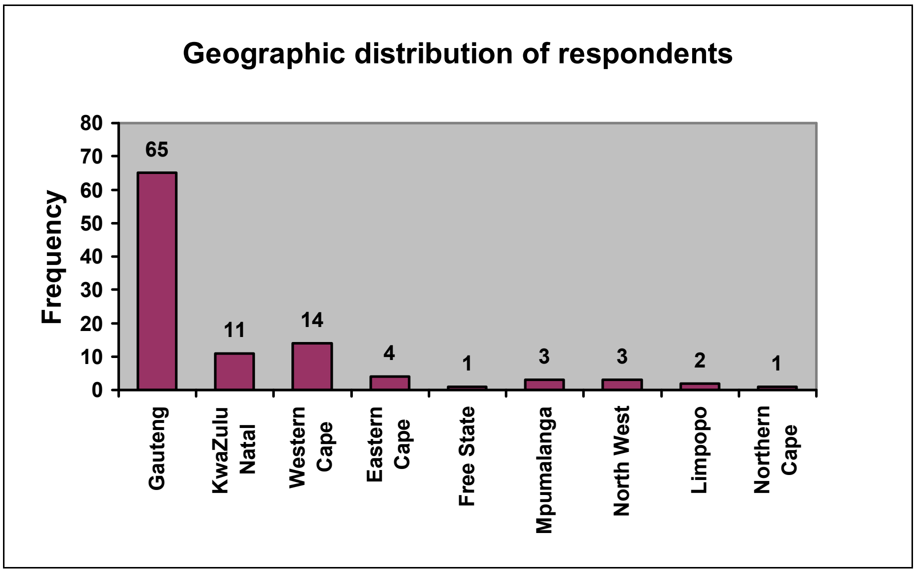


Figure 4.2 Geographic distribution of respondents

Figure 4.3 shows the number of respondents classified by industry sector. More than 80% were from Other, Automotive, Metal Manufacture, Mechanical Engineering, Electrical Engineering, Chemical and Allied, Clothing and Footwear industry sectors.

The classification by type of production system (i.e. manufacturing operating mode) is given in Figure 4.4. Most of the respondents indicated that their production system was Batch, Continuous or Jobbing (93%).

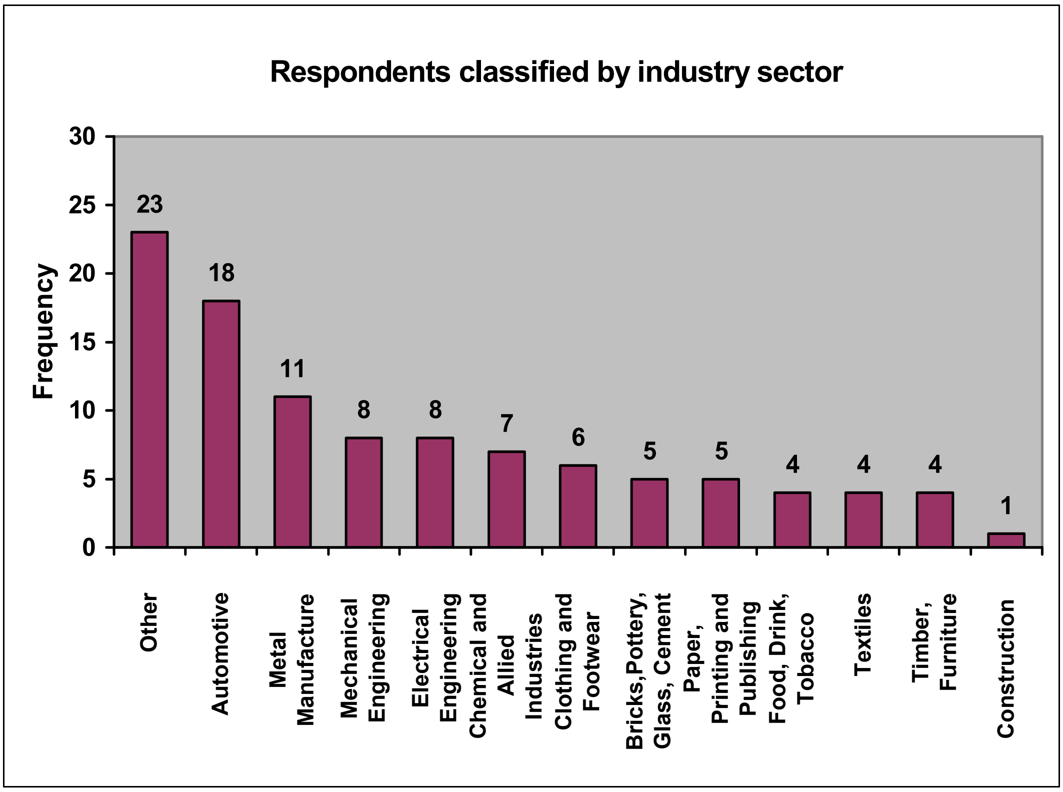


Figure 4.3 Respondents classified by industry sector

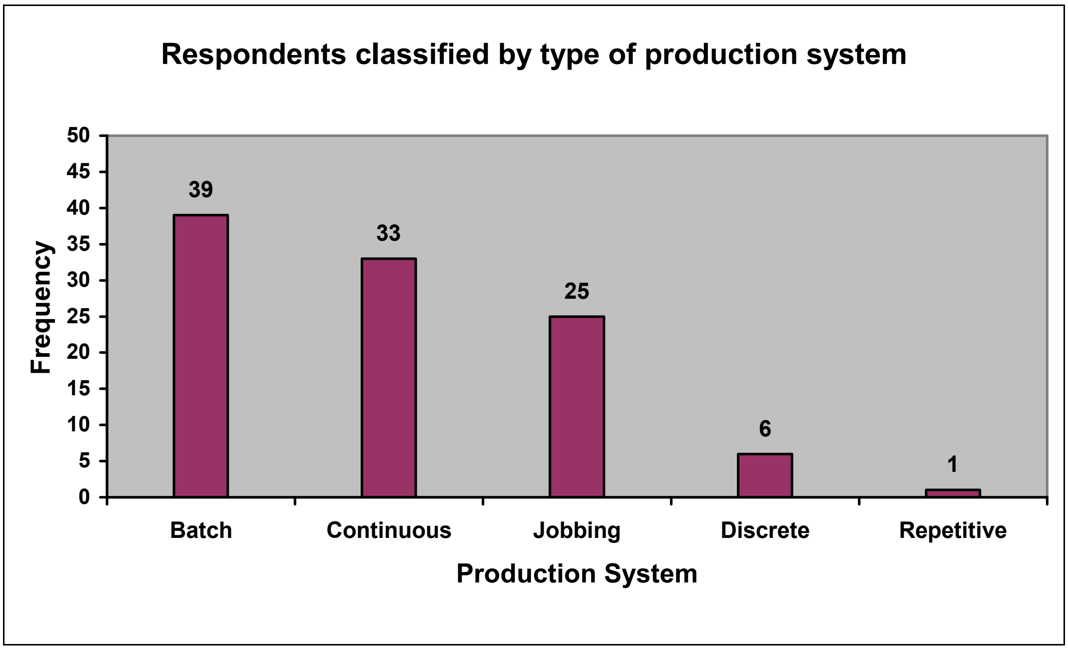


Figure 4.4 Respondents classified by type of production system

Figure 4.5 shows the classification by number of employees. All categories of the number of employees were represented in the sample.

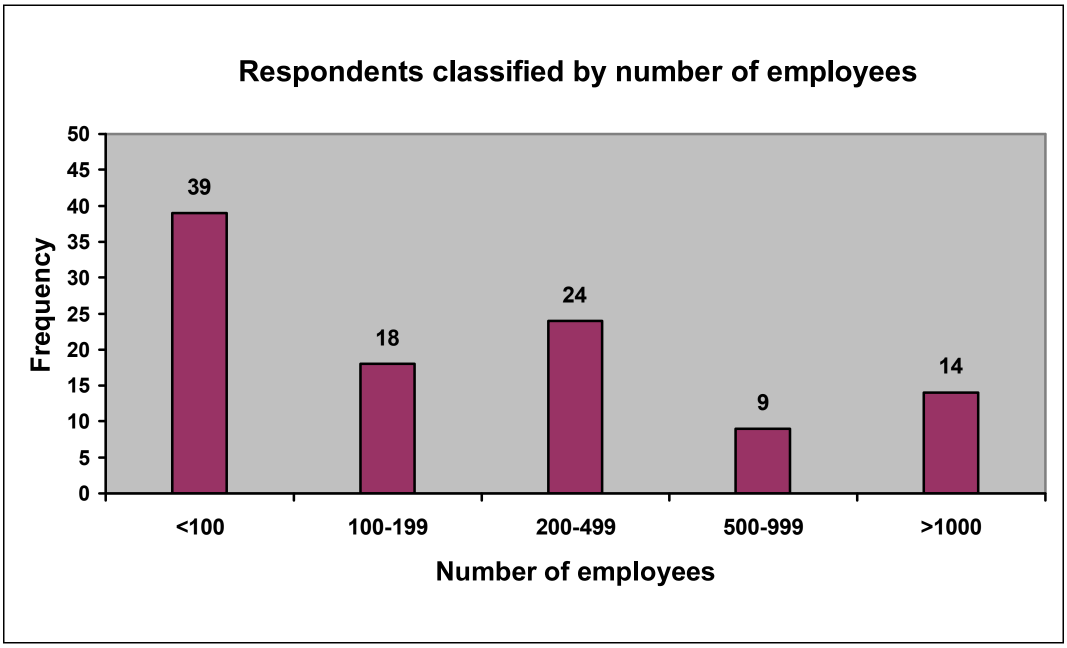


Figure 4.5 Classification by number of employees

Figure 4.6 shows the management level of the respondents. Most of the respondents (73%) were Chief Executive Officers (CEO) or Managing Directors (MD), while a considerable percentage of the respondents (22%) were Executive Manager.

The classification by management area is shown in Figure 4.7. Since most respondents were CEO's or MD's (Figure 4.6), most respondent's management area was company wide, indicated by the CEO/MD category.

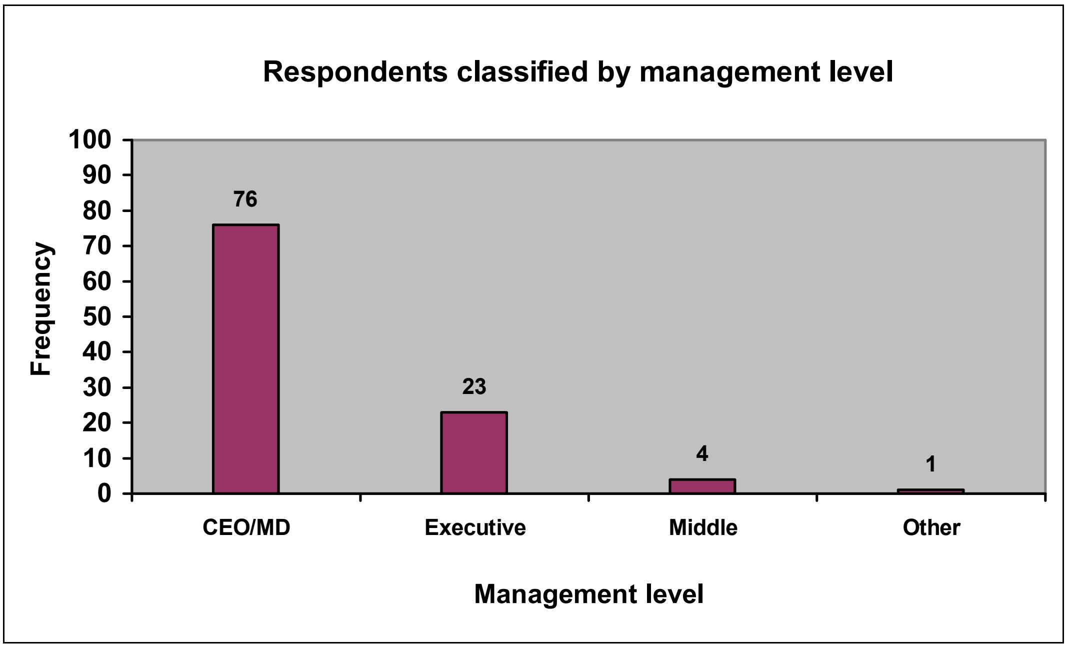


Figure 4.6 Management level of respondents

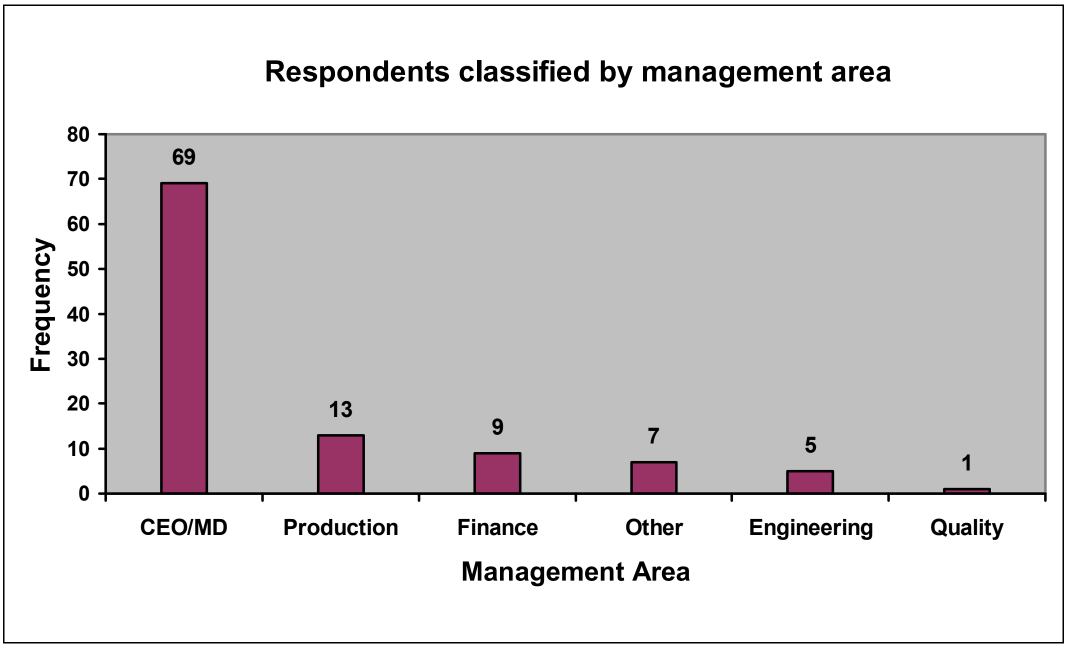


Figure 4.7 Management area of respondents

The classification by annual revenue is given in Figure 4.8. All categories of annual revenue were represented in the sample, but the majority was in the 10-99 and 100-499 million Rand categories. They represented over 65% of the sample.

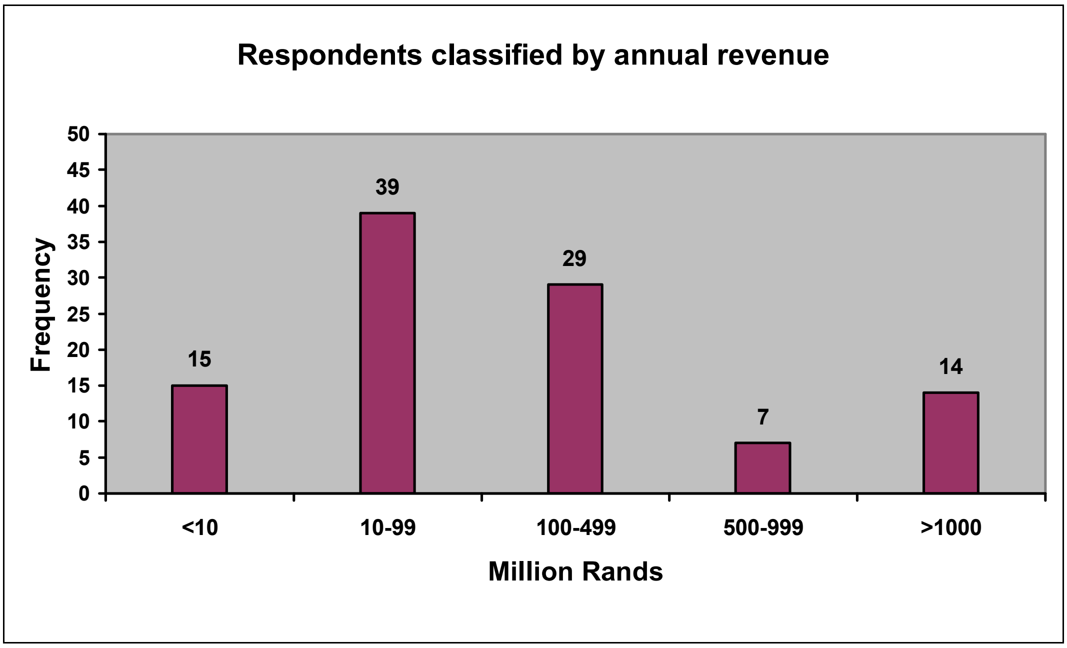


Figure 4.8 Classification by annual revenue

4.1.3 Test for non-response bias

The χ^2 goodness-of-fit test was used to compare the geographical distribution of the actual responses against the target sample distribution. The null and alternative hypotheses are:

H_0: *The actual sample distribution is representative of the target distribution.*
H_a: *The actual sample distribution is not representative of the target distribution.*

Table 4.1 provides the data that have been used for the hypothesis test. The Eastern Cape, Free State, Mpumalanga, North West, Limpopo and Northern Cape provinces have been consolidated to Grouped Provinces to ensure that the expected sample size was at least five. Values less than five may make the χ^2 goodness-of-fit test invalid (Howell, 1995: 368). The expected sample size per province was calculated by multiplying the target sample size with the active response rate of 18.2% (*cf.* Section 4.1.1). The critical χ^2 value was 11.34 (p = 0.01, df = 4 – 1 = 3). From Table 4.1, the χ^2 value was 9.99. Since $\chi^2 < \chi^2_{(p = 0.01,\ df = 3)}$, the null hypothesis could not be rejected, meaning that the actual sample was representative of the target sample. Thus, non-response bias was unlikely to exist.

Table 4.1 χ^2 goodness-of-fit test of the actual against the target sample

Province	Target sample size	Observed sample size (O)	Expected sample size (E)	$\frac{(O - E)^2}{E}$
Gauteng	383	65	69.64	0.31
KwaZulu Natal	45	11	8.18	0.97
Western Cape	106	14	19.27	1.44
Grouped Provinces[1]	38	14	6.91	7.27
Totals	**572**	**104**	**104**	**9.99**

1. Grouped Provinces constitutes the Eastern Cape, Free State, Mpumalanga, North West, Limpopo and Northern Cape provinces to ensure that the expected sample size is greater than five. A lower sample size may make the χ^2 goodness-of-fit test not valid.

4.2 Data preparation and screening

4.2.1 Univariate statistics

The Microsoft Excel 2000 file containing the raw response data was imported into SAS using the PROC IMPORT statement to create a dataset. The value of indicator variables was calculated in SAS as the mean of its five constituent questionnaire items (*cf.* Section 3.6). The relevant univariate statistics are summarised in Table 4.2 from the output of SAS PROC UNIVARIATE given in Appendix E.

Table 4.2 Univariate summary statistics of indicator variables (N = 104)

Indicator variable	Label	Median	Mean	Std. Dev.	Skew-ness	Kurtosis
Quality	v01_qty	4.2000	4.2211	0.5161	-0.5996	0.0221
Speed	v02_spd	3.4000	3.3000	0.6718	-0.5126	0.1041
Dependability	v03_dpn	3.8000	3.6731	0.6207	-0.9651	1.4155
Flexibility	v04_flx	3.7000	3.7000	0.6017	-0.3022	-0.0286
Cost	v05_cst	2.6000	2.6827	0.5723	0.4935	0.1453
Individual skills	v06_skl	3.6000	3.5923	0.6706	-0.7350	1.0638
Team design	v07_tmd	3.6000	3.5442	0.7216	-0.5380	0.0911
Organisation	v08_org	2.6000	2.7115	0.5228	0.2310	-0.4788
Inter-organisational relationships	v09_rel	3.4000	3.2288	0.6461	-0.3173	-0.4000
Corporate culture	v10_cul	4.0000	3.9269	0.6495	-0.9003	1.6393
Design systems	v11_dgn	3.4000	3.2327	1.098	-0.3578	-1.0604
Manufacturing systems	v12_mfg	2.4000	2.4115	0.7921	0.5262	0.8127
Coordination systems	v13_crd	3.6000	3.5712	0.8749	-0.3756	-0.3970
Integration	v14_int	3.0000	3.0481	0.7418	0.0287	-0.0130

The column headed ‘Label’ contains the variable names that have been used in SAS. The last three characters are an abbreviation of the corresponding indicator variable name and were added for ease of reference.

4.2.2 Missing data

The questionnaire was designed to test that all statements and demographic questions were filled in before the data was submitted (*cf.* Section 3.8.1).

Nevertheless, the data were also visually checked for completeness. No questionnaire responses were found with missing data.

4.2.3 Univariate outliers

The composite indicator variables were screened for univariate outliers to filter out cases with extreme values. Table 4.3 shows the lower and upper limits that have been calculated based on the mean and standard deviation from Table 4.2. The limits that have been used were between 1.0 and 5.0 (indicated in bold typeface in Table 4.3). The reason was that the item response codes were limited to a minimum of 1 and a maximum of 5 for five-point Likert scales, thus only limits between 1.0 and 5.0 were relevant. Six cases were removed based on the calculated limits (listwise deletion). This reduced the sample size to 98. Four of the six removed cases were from the Automotive industry sector. The updated relevant univariate statistics after removal of the six cases are summarised in Table 4.4 from the output of SAS PROC UNIVARIATE (Appendix F).

Table 4.3 Lower and upper limits for univariate outlier removal

Indicator variable	**Lower limit (Mean – 3 * Std. Dev.)**	**Upper limit (Mean + 3 * Std. Dev.)**
v01_qty	**2.6728**	5.7694
v02_spd	**1.2846**	5.3154
v03_dpn	**1.8110**	5.5352
v04_flx	**1.8949**	5.5051
v05_cst	0.9658	**4.3996**
v06_skl	**1.5805**	5.6041
v07_tmd	**1.3794**	5.7090
v08_org	**1.1431**	**4.2799**
v09_rel	**1.2905**	5.1671
v10_cul	**1.9784**	5.8754
v11_dgn	-0.0601	6.5255
v12_mfg	0.0352	**4.7878**
v13_crd	0.9465	6.1959
v14_int	0.8227	5.2735

Table 4.4 Updated univariate summary statistics of indicator variables (N = 98)

Indicator variable	Label	Median	Mean	Std. Dev.	Skew-ness	Kurtosis
Quality	v01_qty	4.2000	4.2571	0.4701	-0.4292	-0.3459
Speed	v02_spd	3.4000	3.3653	0.6226	-0.4860	0.3757
Dependability	v03_dpn	3.8000	3.7449	0.5087	-0.3711	0.2527
Flexibility	v04_flx	3.8000	3.7510	0.5472	-0.1845	0.1997
Cost	v05_cst	2.6000	2.6592	0.5481	0.3794	-0.0908
Individual skills	v06_skl	3.6000	3.6347	0.6045	-0.3182	0.1352
Team design	v07_tmd	3.6000	3.5633	0.6954	-0.6372	0.4287
Organisation	v08_org	2.6000	2.7102	0.5320	0.2289	-0.5167
Inter-organisational relationships	v09_rel	3.4000	3.2490	0.6396	-0.3547	-0.2854
Corporate culture	v10_cul	4.0000	3.9857	0.5615	-0.2707	-0.1220
Design systems	v11_dgn	3.2000	3.1959	1.1119	-0.3031	-1.1411
Manufacturing systems	v12_mfg	2.4000	2.3633	0.7233	0.0836	-0.2389
Coordination systems	v13_crd	3.6000	3.5571	0.8932	-0.3397	-0.4894
Integration	v14_int	3.0000	3.0429	0.7396	-0.0147	-0.0349

4.2.4 Univariate and multivariate normality

Table 4.2 shows that variables v03_dpn, v06_skl, v10_cul and v11_dgn had absolute kurtosis values exceeding 1.0, while all absolute skewness values were less than 1.0 before univariate outliers were removed.
Table 4.4 shows univariate skewness and kurtosis values after univariate outliers were removed as discussed in the previous section. The values were reproduced in the table from the SAS output file in Appendix F. Except for v11_dgn, all skewness and kurtosis values were below 1.0 in absolute value. The absolute kurtosis value of v11_dgn was with 1.1411 slightly above the cut-off of 1.0.

Multivariate normality will be discussed in Section 4.3 when the measurement model is evaluated because the KURTOSIS option of PROC CALIS was used to provide multivariate kurtosis statistics.

4.2.5 Multicollinearity

The correlation matrix of the 14 composite indicator variables is shown in Table 4.5 based on the output of the SAS PROC CORR procedure (see Appendix G for the SAS output). Spearman correlation coefficients were used because the data were ordinal measurements. The highest correlation was 0.57 (between v01_qty and v03_dpn) and was well below the recommended maximum value of 0.85 (*cf.* Section 3.8.2). It was therefore accepted that no bivariate multicollinearity existed among the variables.

4.2.6 Internal consistency

The SAS PROC CORR procedure with the ALPHA option calculated raw and standardised values of Cronbach's Alpha, which was used as a measure of internal consistency. The output is shown in Appendix H. The raw and standardised alphas of the 14 indicator variables were 0.71 and 0.72 respectively (N = 98), slightly above the recommended minimum of 0.7 (*cf.* Section 3.8.5).

Table 4.5 Standard Deviations (SD) and intercorrelations of indicators (N = 98)

Indicator Variable	SD	Intercorrelations (Spearman)													
		v01_qty	**v02_spd**	**v03_dpn**	**v04_flx**	**v05_cst**	**v06_skl**	**v07_tmd**	**v08_org**	**v09_rel**	**v10_cul**	**v11_dgn**	**v12_mfg**	**v13_crd**	**v14_int**
v01_qty	0.4701	1.0000													
v02_spd	0.6226	0.3024	1.0000												
v03_dpn	0.5087	0.5692	0.4476	1.0000											
v04_flx	0.5472	0.3403	0.4458	0.3461	1.0000										
v05_cst	0.5481	-0.0773	-0.3622	-0.2727	-0.2688	1.0000									
v06_skl	0.6045	0.2811	0.2798	0.3526	0.3342	-0.2176	1.0000								
v07_tmd	0.6954	0.2628	0.4193	0.2917	0.3220	-0.1186	0.4836	1.0000							
v08_org	0.5320	0.0339	-0.0721	0.0672	0.0077	0.0206	0.1918	0.2025	1.0000						
v09_rel	0.6396	0.2158	-0.0978	0.0547	0.1129	-0.0233	0.1195	0.1866	0.0748	1.0000					
v10_cul	0.5615	0.3189	0.2050	0.3143	0.2414	-0.2749	0.2995	0.3904	0.1275	0.3045	1.0000				
v11_dgn	1.1119	0.0226	0.0081	0.0163	0.1549	-0.1696	0.3454	0.1437	0.0137	0.1881	0.2405	1.0000			
v12_mfg	0.7233	-0.0678	0.0559	-0.0105	0.0782	-0.2541	0.2140	0.2783	0.1813	0.2582	0.3082	0.4174	1.0000		
v13_crd	0.8932	0.0333	0.0069	-0.0099	0.1136	-0.0067	0.1141	0.1399	0.2853	0.2509	0.0981	0.0674	0.1064	1.0000	
v14_int	0.7396	0.0977	0.1217	0.1716	0.2573	-0.1968	0.1968	0.3207	0.1540	0.2532	0.3143	0.3289	0.3923	0.2855	1.0000

4.3 Evaluation of the measurement model

The measurement and structural models have been evaluated with The SAS System's CALIS procedure (release 8.02). The approach was based on a two-step procedure recommended by Anderson and Gerbing (1988) that has been discussed in chapter 3. The first step, presented in this section, was to evaluate a measurement model (*cf.* Figure 3.1) with Confirmatory Factor Analysis (CFA) until an acceptable fit to the data was obtained. The second step of the procedure is discussed in Section 4.4. The standard deviations and intercorrelations for this study's 14 indicator variables are presented in Table 4.5. The SAS dataset was created from raw response data stored in a Microsoft Excel file by using SAS PROC IMPORT.

4.3.1 Separate construct analysis

Before the entire measurement model was evaluated with CFA, each latent construct (Technology, Organisation and Operational Performance) was separately subjected to CFA (Jöreskog, 1993: 294-314). The analysis of the constructs was limited to an assessment of goodness-of-fit measures, significance of factor loadings and the distribution of residuals. The reason for this was that the separate construct analysis was intended as an overall assessment before a more complex full measurement model was assessed in detail. Presented in Section 4.3.2, the evaluation of the full measurement model also included an assessment of composite reliability, variance extracted estimates as well as convergent and discriminant validity.

4.3.1.1 The Technology construct

The SAS output files of PROC CALIS for the Technology construct are presented in Appendix I. Multivariate normality was assessed with the KURTOSIS option of PROC CALIS which provided, among others, Mardia's Multivariate Kurtosis measure. The value for the four indicator variables was -2.04 (N = 98). Because this was only marginally above the absolute cut-off value of 2.0 (*cf*. Section 3.8.4), it was accepted that the data was approximately multivariate normal.

The Levenberg-Marquardt optimisation technique completed successfully indicated by the message 'GCONV convergence criterion satisfied' in the SAS output and log files. The measurement model of the Technology construct was estimated using the maximum likelihood method.

The χ^2 value was 6.26 with a *p*-value of 0.044 (df = 2). The χ^2/df ratio was therefore 3.13, which was above the recommended maximum of 2.0. The CFI and the NNFI was 0.90 and 0.69 respectively. Combined, the goodness-of-fit measures point to a problem with the model's fit as far as the Technology construct is concerned.

All absolute *t*-values representing *t*-tests of the null hypothesis that the factor loadings were equal to zero exceeded 1.96 ($p < 0.05$). The smallest *t*-value was 2.16 (v13_crd) and the highest 5.03 (v12_mfg). Therefore, the factor loadings were significant at a confidence level of at least 95%. The corresponding standard errors were not excessively small (between 0.09 and 0.14), which indicated that no estimation problem existed. The standardised factor loading for v13_crd was small at a value of 0.268, compared to the other variables which had factor loadings ranging from 0.558 to 0.644.

The distribution of normalised residuals was not symmetrical, while two residuals exceeded 2.0. One excessive residual was between v13_crd and v14_int (2.544). The other high residual was between v11_dgn and v12_mfg (2.544).

The Wald test did not provide information about which parameters could be eliminated to improve the model's fit. The Lagrange multiplier test suggested to correlate measurement errors, but this was generally not preferred for reasons that have been discussed in Section 3.9.1.

Because the *t*-value and the standardised factor loading of v13_crd was the smallest compared to the other variables, it seemed reasonable to expect that the elimination of v13_crd may improve the model's fit. However, this would make the number of observations equal to the number of parameters, meaning that the model's goodness-of-fit could not be estimated. This was evidenced by a χ^2 value of 0.00 (df = 0) and CFI and NNFI values of 1.00. Therefore, whether v13_crd should be eliminated or not will be addressed later when the full measurement model is evaluated in Section 4.3.2.

4.3.1.2 The Organisation construct

The SAS output files of PROC CALIS for the Organisation construct are presented in Appendix J. Similarly as with the Technology construct, multivariate normality was checked with Mardia's Multivariate Kurtosis measure. The value for the five indicator variables was 3.46. Because this was above the maximum of 2.0, the case with the highest contribution to multivariate kurtosis was excluded from the dataset. This decreased multivariate kurtosis to an acceptable value of 1.10 (N = 97).

The Levenberg-Marquardt optimisation technique completed successfully indicated by the message 'GCONV convergence criterion satisfied' in the SAS output and log files. The measurement model of the Organisation construct was estimated using the maximum likelihood method.

The χ^2 value was 2.76 with a *p*-value of 0.737 (df = 5). The χ^2 value relative to the degrees of freedom (χ^2/df) was therefore 0.552, well below the recommended maximum value of 2.0. The CFI and the NNFI was 1.00 and 1.10 respectively. This means that all goodness-of-fit measures that have been used indicated an acceptable model fit.

The *t*-values of the *t*-tests were all above the minimum of 1.96 ($p < 0.05$). The lowest *t*-value was 2.20 (v09_rel) and the highest was 6.11 (v07_tmd). Therefore, all factor loadings were significant with a confidence level higher than 95%. No standard errors were excessively small. The distribution of normalised residuals was fairly centred on zero, while the highest residual was at an acceptable value of 1.55.

4.3.1.3 The Operational Performance construct

The SAS output files of PROC CALIS for the Operational Performance construct are presented in Appendix K. Similarly as with the Technology and Organisation constructs, multivariate normality was checked with Mardia's Multivariate Kurtosis measure. The value for the five indicator variables was 2.02 (N = 97). Because this was only marginally above the maximum of 2.0, it was accepted that the data came from an approximate multivariate normal distribution.
The Levenberg-Marquardt optimisation technique completed successfully indicated by the message 'GCONV convergence criterion satisfied' in the SAS output and log files. The measurement model of the Operational Performance construct was estimated using the maximum likelihood method.

The χ^2 value was 18.99 with a *p*-value of 0.002 (df = 5) which resulted in a χ^2/df ratio of 3.80. The CFI and the NNFI was 0.86 and 0.72 respectively. This means that none of the used goodness-of-fit measures indicated an acceptable fit of the Operational Performance construct.

All absolute *t*-values of the *t*-tests for the factor loadings were 3.05 or higher, indicating that all factor loadings were significant at a confidence level higher than 99%. No standard errors were excessively small. Standardised factor loadings were moderate to high (between 0.554 and 0.779), except for v05_cst which was -0.344. So far no indication was found of what caused the lack of model fit. Next, the normalised residuals were analysed. Its distribution was reasonably centred on zero, but all indicator variables contributed to residual covariances above 2.0 in absolute value. The Wald test did not provide any information which parameter could be eliminated, while the Lagrange multiplier test indicated that error terms should be correlated.

The model was then tested without v01_qty since that variable was contributing to the two highest residuals. Mardia's Multivariate Kurtosis measure increased from 2.02 to 2.29. After removal of one outlier, Mardia's Multivariate Kurtosis decreased to an acceptable 0.84 (N = 96). The χ^2 value decreased to 0.10 with a *p*-value of 0.952 (df = 2), resulting in a χ^2/df ratio of 0.05. The CFI and the NNFI increased to 1.00 and 1.10 respectively. Also, the range of residuals decreased to between -0.27 and 0.27, while its distribution was centred on zero. The lowest absolute *t*-value was now 4.65, while the lowest standardised factor loading increased to 0.531. Overall, it appeared that the elimination of v01_qty provided an acceptable model fit. However, this result was used only as an indication for improving the full measurement model in case of lack of fit. The indicator variable v01_qty was therefore not removed yet from the analysis of the full measurement model, which will be presented next.

4.3.2 The full measurement model

Although the separate evaluation of the three latent constructs indicated that v13_crd and v01_qty should be removed from the model, the full measurement model was first evaluated with all 14 indicators. The reason for this was that with the full measurement model, many more parameters needed to be estimated. This may influence the results compared to the analysis of the relatively smaller CFA models of the separate latent constructs.

4.3.2.1 The initial measurement model

Multivariate normality was checked with Mardia's Multivariate Kurtosis measure. The value for the 14 indicator variables was 8.92. Consequently, cases with the highest contribution to multivariate kurtosis were removed one by one until Mardia's Multivariate Kurtosis measure was at an acceptable level of 2.01, which resulted in a sample size of 93.

The Levenberg-Marquardt optimisation technique completed successfully indicated by the message ‘GCONV convergence criterion satisfied’ in the SAS output and log files. The full measurement model was estimated using the maximum likelihood method.

The χ^2 value was 111.47 with a *p*-value of 0.003 (df = 74). The χ^2 value relative to the degrees of freedom (χ^2/df) was therefore 1.51. The CFI and the NNFI was 0.88 and 0.86 respectively. This means that except for the χ^2/df ratio, none of the used goodness-of-fit measures indicated an acceptable model fit.
The lowest absolute *t*-value was 1.79 for v08_org, which was below the minimum required value of 1.96 ($p < 0.05$). This means that the factor loading for v08_org was non-significant. No standard errors were excessively small.
Standardised factor loadings of the indicator variables ranged from 0.202 (v08_org) to 0.798 (v03_dpn). The distribution of normalised residual covariances was centred on zero but eight residuals were above 2.0 in absolute value.
The Wald test suggested that v08_org should be removed from the model, which was also consistent with a low *t*-value of 1.79. No evidence was found that v13_crd and v01_qty should be eliminated from the model as was suggested by the assessment of each construct discussed in the previous sections. As a result, the model was evaluated without v08_org.

4.3.2.2 The revised measurement model 1

The first revision of the initial measurement model was to remove v08_org from the model. Mardia’s Multivariate Kurtosis measure decreased to 1.89 (N = 93). The optimisation algorithm completed successfully as was evidenced by the ‘GCONV convergence criterion satisfied’ message in the log and output files.
The χ^2 value was 97.34 with a *p*-value of 0.003 (df = 62). The χ^2 value relative to the degrees of freedom (χ^2/df) was therefore 1.57. The CFI and the NNFI was 0.89 and 0.86 respectively. This means that the model fit slightly improved compared to the initial measurement model, but that it was still poor.

The Wald test suggested that the covariance between Operational Performance (F_1) and Technology (F_3) should be fixed at 0. However, since this was a CFA measurement model in which all latent constructs were allowed to covary, the covariance between these two constructs were retained.

The pattern of residuals was centred on zero. There were seven residuals above 2.0 with one residual above 3.0 (between v09_rel and v02_spd). The Lagrange multiplier test suggested that v09_rel was multidimensional, and that it contributed to a large χ^2. Combined with the residual pattern, the model was re-estimated without v09_rel.

4.3.2.3 The revised measurement model 2

The second revision of the model was to remove v09_rel. Mardia's Multivariate Kurtosis increased to 1.99 (N = 93). The optimisation algorithm completed successfully, which was evidenced by the 'GCONV convergence criterion satisfied' message in the log and output files.

The χ^2 value reduced to 70.18 with a *p*-value of 0.039 (df = 51). The χ^2 value relative to the degrees of freedom (χ^2/df) was therefore 1.38. The CFI and the NNFI was 0.93 and 0.91 respectively. Although the CFI and NNFI were at acceptable levels, the *p*-value of the χ^2 test was still too low (below the minimum of 0.05). The pattern of residuals showed that one residual was high (3.00) between v03_dpn and v01_qty. The Wald test did not provide suggestions which parameter should be deleted, except for the removal of the covariance between Operational Performance (F_1) and Technology (F_3). Again, this covariance was retained as was mentioned in the previous section

4.3.2.4 The revised measurement model 3

The third revision of the model was to either remove v03_dpn or v01_qty since these variables contributed to the largest residual covariance. Despite that the separate CFA of the Operational Performance latent construct (F_1) suggested that v01_qty (quality) should be removed, it was decided also to test the effect of removing v03_dpn only. These two scenarios are discussed next.

Firstly, v01_qty was removed from the model. Mardia's Multivariate Kurtosis increased to 2.63. It reduced to 1.23 after one outlier was removed (N = 92). The χ^2 value was 60.57 with a p-value of 0.025 (df = 41). The χ^2 value relative to the degrees of freedom (χ^2/df) was therefore 1.53. The CFI and the NNFI was 0.92 and 0.90 respectively. The pattern of standardised residuals was centred on zero, but two residuals exceeded 2.0. The removal of v01_qty did not provide an acceptable model fit due to the low p-value of the χ^2 test.

Next, the model was re-estimated without v03_dpn instead of v01_qty. Mardia's Multivariate Kurtosis was now 1.99 (N = 93) after including the outlier that was removed when the model was estimated without v01_qty. The χ^2 value was 50.18 with a p-value of 0.154 (df = 41). The χ^2 value relative to the degrees of freedom (χ^2/df) was therefore 1.22. The CFI and the NNFI was 0.96 and 0.94 respectively. The pattern of standardised residuals was centred on zero, but with a slight skewness to negative residuals. Only one residual was above 2.0.

Overall, the third revised model showed an acceptable fit without v03_dpn as opposed to the removal of v01_qty. This measurement model was tentatively accepted as the final measurement model. The SAS output files of PROC CALIS for this model are presented in Appendix L. Goodness-of-fit and parsimony indices for the final model are summarised in Table 4.7 under model M_m. A number of tests were conducted to assess its reliability and validity, which are presented with reference to Table 4.6.

The t-values of the t-tests representing the null hypothesis that the standardised factor loadings were equal to zero in the population, ranged from 2.35 ($p < 0.05$) to 7.75 ($p < 0.001$) in absolute value. Convergent validity of the indicator variables measuring latent constructs was therefore supported.

Table 4.6 also shows the reliability of the indicator variables as well as the composite reliability of the latent constructs. The latter is comparable to

Cronbach's coefficient alpha (Fornell and Larcker, 1981). The reliabilities of the indicators were relatively low, but the composite reliabilities demonstrated acceptable values of more than the minimum of 0.60 (*cf.* Section 3.9.1).
The last column of Table 4.6 provides estimates of the variance extracted by a latent construct relative to random measurement error variance. The variance extracted was low for all constructs, but not unusual (Hatcher: 2003: 331).

Because the correlation between Organisation (F_2) and Operational Performance (F_1) was relatively high at 0.75 (see Appendix L), it was important to assess its discriminant validity. The same argument holds for the correlation between Organisation (F_2) and Technology (F_3), which was 0.68. The χ^2 difference test was used to assess discriminant validity.

Table 4.6 Properties of the final measurement model

Constructs and Indicators	**Standardised Loading**	***t*-values[a]**	**Reliability**	**Variance Extracted estimate**
Operational Performance (F_1)			**0.708[b]**	**0.385**
v01_qty	0.543	4.99	0.295	
v02_spd	0.772	7.52	0.596	
v04_flx	0.657	6.24	0.432	
v05_cst	-0.468	-4.21	0.219	
Organisation (F_2)			**0.732[b]**	**0.479**
v06_skl	0.601	5.77	0.361	
v07_tmd	0.763	7.75	0.582	
v10_cul	0.703	7.01	0.495	
Technology (F_3)			**0.625[b]**	**0.310**
v11_dgn	0.571	4.97	0.326	
v12_mfg	0.627	5.49	0.393	
v13_crd	0.284	2.35*	0.080	
v14_int	0.663	5.82	0.440	

a All *t*-tests were significant at $p < 0.001$, except where indicated with a * meaning $p < 0.05$

b Denotes composite reliability

The χ^2 value of the standard measurement model was 50.18 with 41 degrees of freedom. The χ^2 value of the unidimensional measurement model in which the covariance between Organisation (F_2) and Operational Performance (F_1) was fixed to 1, was 60.33 with 42 degrees of freedom. Therefore, the χ^2 difference was 10.15 with 1 degree of freedom. Since this was greater than the critical χ^2 of 6.64 (df = 1, p = 0.01), discriminant validity between F_2 and F_1 was supported.
Similarly, the χ^2 difference between the standard measurement model and the unidimensional model in which the covariance between Organisation (F_2) and Technology (F_3) was fixed at 1, was 12.09 with 1 degree of freedom. Since this was greater than the critical χ^2 of 10.83 (df = 1, p = 0.001), discriminant validity between F_2 and F_3 was also supported. In short, the standard measurement model provided a significantly better fit than any of the unidimensional models, thus discriminant validity was supported.

Combined, these results supported the reliability and validity of the final measurement model, which was therefore retained for this study. The next section presents the results of the evaluation of the structural model.

4.4 Evaluation of the structural model

In the second step of Anderson and Gerbing's (1988) recommended two-step procedure, the final measurement model was modified to represent a theoretical causal model which included measurement and structural components. This model was tested and modified until a statistically acceptable model was found for hypotheses testing.

4.4.1 The initial theoretical model

In the initial theoretical model, Organisation (F_2) and Technology (F_3) were exogenous latent variables causally affecting the endogenous latent variable Operational Performance (F_1). This model is identical to the model presented in

Figure 3.2 of the previous chapter. The measurement of the latent variables by indicator variables was the same as the final measurement model discussed in the previous section for which v03_dpn (dependability), v08_org (organisation design) and v09_rel (organisational relationships) were dropped.

The latent variables were scaled by fixing the indicator variable with the highest standardised loading (in the final measurement model) to 1.0. The model was estimated with the maximum likelihood method. The optimisation algorithm converged successfully indicated by the 'GCONV convergence criterion satisfied' message in the SAS output and log files.

Goodness-of-fit indices for the initial theoretical model (M_t) are shown in Table 4.7. The χ^2 value was 50.18 with a *p*-value of 0.154 (df = 41). The χ^2/df ratio was therefore 1.22, which was below the maximum value of 2.0. The CFI and NNFI was 0.96 and 0.94 respectively. Both goodness-of-fit indices were therefore above the minimum of 0.90.

Absolute *t*-values of the *t*-tests evidenced that standardised factor loadings and standardised path coefficients were significant, except for the path from Technology (F_3) to Operational Performance (F_1). The *t*-value for this path coefficient was –1.71. This means that the null hypothesis of the *t*-test that this path coefficient is non-significant could not be rejected.
The absolute *t*-values for the standardised factor loadings ranged from 2.22 to 6.03. The *t*-value of the standardised path coefficient between Organisation (F_2) and Operational Performance (F_1) was 3.70. The *t*-value for the covariance between Organisation (F_2) and Technology (F_3) was 3.55. None of the standard errors were excessively low in value.
The distribution of normalised residuals was centred on zero and fairly symmetrical with the lowest residual of –2.00 and the highest 2.30. Only one residual exceeded 2.0 in absolute value.

Overall, the assessment of the initial theoretical model pointed to a problem with the path coefficient between Technology (F_3) and Operational Performance (F_1). Additionally, the model was just-identified resulting in a model that was identical in fit and parsimony as the measurement model (M_m). These results combined necessitated to revise the model and will be discussed in the next section.

Table 4.7 Goodness-of-fit and parsimony indices

	Combined model (measurement and structural components)							**Structural model**		
Model	χ^2	**df**	**NFI**	**CFI**	**NNFI**	**PR**	**PNFI**	**RNFI**	**RPR**	**RPFI**
M_0	275.05	55	0.000	-	-	-	-	-	-	-
M_u	108.90	44	0.604	0.705	0.631	0.800	0.483	0.000	1.000	0.000
M_t	50.18	41	0.818	0.958	0.944	0.745	0.610	1.000	0.000	0.000
M_r	54.00	42	0.804	0.946	0.929	0.764	0.614	0.951	0.333	0.317
M_m	50.18	41	0.818	0.958	0.944	0.745	0.610	1.000	0.000	0.000

Note: N = 93. M_0 = null model; M_u = uncorrelated factors; M_t = initial theoretical model; M_r = revised model; M_m = measurement model; df = degrees of freedom; NFI = normed-fit index; NNFI = non-normed-fit index; CFI = comparative fit index; PR = parsimony ratio; PNFI = parsimonious normed-fit index; RNFI = relative normed-fit index; RPR = relative parsimony ratio; RPFI = relative parsimonious-fit index.

4.4.2 The revised theoretical model

The initial theoretical model was revised by fixing the path coefficient between Technology (F_3) and Operational Performance (F_1) at 0, effectively removing the relationship between them. The revised theoretical model is referred to as Model M_r in Table 4.7. The model was re-estimated with the maximum likelihood method. The optimisation algorithm converged successfully indicated by the 'GCONV convergence criterion satisfied' message in the SAS output and log files. Appendix M presents the SAS output of this model's assessment.

The χ^2 value was 54.00 with a p-value of 0.101 (df = 42). The χ^2/df ratio was therefore at an acceptable value of 1.29. As shown in Table 4.7, the CFI and NNFI was 0.95 and 0.93 respectively. Both goodness-of-fit indices were therefore above the minimum of 0.90.

Absolute t-values of the t-tests evidenced that standardised factor loadings and the only remaining standardised path coefficient were significant in the population. The absolute t-values for the standardised factor loadings ranged from 2.33 to 5.85. The t-value of the standardised path coefficient between Organisation (F_2) and Operational Performance (F_1) was 4.77. For the covariance between Organisation (F_2) and Technology (F_3), the t-value was 3.50. None of the standard errors were excessively low in value.
The distribution of normalised residuals was centred on zero and fairly symmetrical with the lowest residual of –2.56 and the highest 2.31. Only four residuals exceeded 2.0 in absolute value.

The standardised path coefficient (pf1f2 in Appendix M) was 0.722 ($p < 0.001$). The correlation between F_2 and F_3 (cf2f3 in Appendix M) was 0.621 ($p < 0.001$). The results showed that Organisation (F_2) accounted for 52.1% (R^2) of the variance in Operational Performance (F_1).

Table 4.7 also presents parsimony indices of the models that were tested. The Parsimony Ratio (PR) indicates the parsimony of the overall model including measurement and structural components. The PR is calculated as the ratio of the degrees of freedom of the model of interest and the null model (M_0). The Parsimonious Normed-Fit Index (PNFI) is calculated by multiplying a model's PR with its Normed-Fit Index (NFI). The PNFI reflects the parsimony and the fit of the overall model. These indices show that the revised model (M_r) displayed a PR of 0.76, while the initial model's PR was 0.75. In other words, the parsimony of the revised model was slightly better then the initial theoretical model. Similarly, the PNFI for the revised model was 0.61, which was marginally better than the PNFI of the initial model.

Table 4.7 also presents parsimony and fit indices in just the structural part of the model. The structural part represents the relationships between the latent variables. The Relative Normed-Fit Index (RNFI) reflects the fit of the structural part independent of the measurement model's fit. Similarly, the Relative Parsimony Ratio (RPR) reflects the parsimony of just the structural part of the model, independent of the measurement model's parsimony. The Relative Parsimonious-Fit Index (RPFI) is calculated by multiplying the RNFI and the RPR. It simultaneously reflects the fit and parsimony of the structural part of the model. The fit of the structural part of the revised theoretical model (M_r) as measured by the RNFI, was at an acceptable level of 0.95. The RPR and RPFI was 0.33 and 0.32 respectively. These two indices may be used to compare different models. Since only two models were compared (M_t and M_r), and M_t was a just identified model for which both RPR and RPFI were 0, the RPR and RPFI in itself were not very useful in this case but were nevertheless reported.

As a final test, a χ^2 difference test was conducted to compare the revised theoretical model (M_r) with the final measurement model (M_m). If there is no significant difference, then the revised theoretical model provides a fit to the data as good as the measurement model. The difference in χ^2 was 54.00 – 50.18 = 3.82. The degrees of freedom for the test were 42 – 41 = 1. The critical χ^2 value was 3.84 (df = 1, p = 0.05). Therefore, the difference between the revised theoretical model and the final measurement model was non-significant. Shown in Figure 4.9, model M_t was retained as this study's final model. The standardised path coefficient appears on the causal path between Organisation (F_2) and Operational Performance (F_1). The correlation between Organisation (F_2) and Technology (F_3) appears on the curved double-headed arrow.

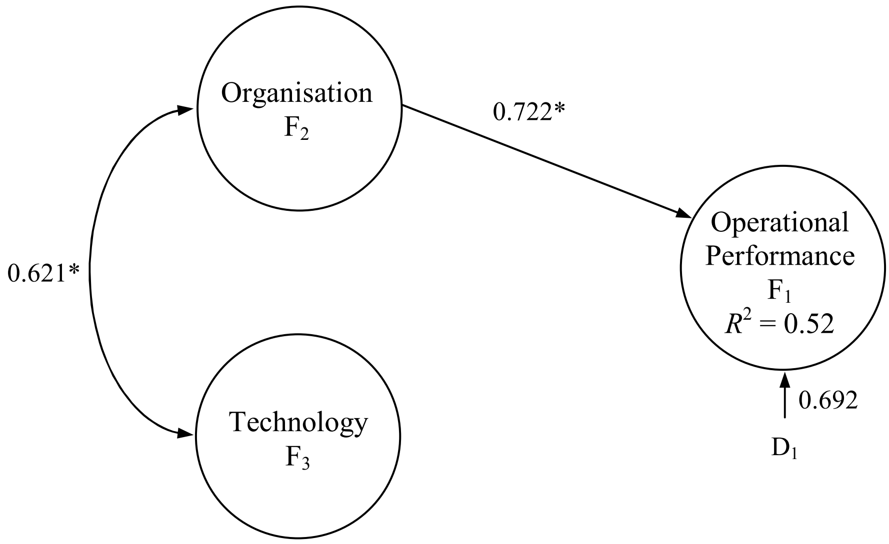


Figure 4.9 The final model (* $p < 0.001$)

4.5 Summary

This chapter presented the results of this study. The questionnaire responses were collected over a period of six weeks in which two reminder letters were sent in addition to the initial cover letter. The target sample size was 604. With an active response rate of 18.2% and 32 unreachable respondents, the actual sample size was 104. The demographics of the respondents were presented including geographic distribution, industry sector, production system, number of employees, management level, management area, and annual revenue. The actual sample was tested for non-response bias with the χ^2 goodness-of-fit test. It was shown that the actual sample was representative of the target sample.

The raw response data was subjected to several data preparation and screening steps. No missing data was found, while six univariate outliers have been listwise removed to ensure that the data conformed to univariate normality. This reduced the sample size from 104 to 98. The correlation matrix of the 14 indicator variables showed that no multicollinearity existed. The internal consistency of the indicator variables was demonstrated with a standardised Cronbach Alpha coefficient of 0.72.

The measurement and structural models have been evaluated with The SAS System's PROC CALIS procedure (release 8.02). This procedure was also used to assess multivariate normality of the data with Mardia's Multivariate Kurtosis measure. The overall approach was based on a two-step procedure in which an acceptable measurement model was obtained before the structural model was assessed.

For the first step of this approach, the latent constructs were separately subjected to CFA before the full measurement model was assessed. The CFA of the full measurement model in which all latent constructs were allowed to covary, showed that three indicator variables had to be removed to obtain an acceptable fit to the data. These were v03_dpn (dependability), v08_org (organisation design), and v09_rel (organisational relationships). Additionally, to ensure multivariate normality of the data, a total of five cases have been removed that were identified as multivariate outliers. This resulted in a sample size of 93. A number of tests demonstrated the reliability and validity of the model.

The second step of the approach was to assess a theoretical causal model in which Technology (F_3) and Organisation (F_2) were latent exogenous variables affecting the endogenous latent variable Operational Performance (F_1). A revision of this initial model was necessary because the standardised path coefficient between Technology (F_3) and Operational Performance (F_1) appeared to be non-significant. The assessment of the revised model showed that the fit to the data and its parsimony was at acceptable levels. The revised theoretical model was therefore retained as this study's final model.

The next chapter provides a discussion and interpretation of the results that were presented in this chapter. Furthermore, the model will be used to test this study's hypotheses.

5 DISCUSSION OF RESULTS

This chapter presents a discussion and interpretation of the results. The hypotheses are assessed in Section 5.1 by using the final theoretical causal model that was presented in the previous chapter. This will be used to answer the primary research question in Section 5.2, while Section 5.3 presents an assessment of the research problem. Additionally, the questionnaire response will be discussed in Section 5.4. This is followed with a discussion of the evaluation of the measurement and structural models in Sections 5.5 and 5.6 respectively.

5.1 Research hypotheses

The research hypotheses are assessed with reference to the final model presented in Figure 4.9 in the previous chapter. Section 5.2 and 5.3 will elaborate further on the results of the hypotheses tests.

5.1.1 Research hypothesis I

The first research hypothesis asserts that (*cf*. Section 1.4.1 and 3.2.1):

$H1_0$:

Development along one dimension (technology or organisation) does not correlate with development along the other dimension.

$H1_a$:

Development along one dimension (technology or organisation) correlates with development along the other dimension.

As can be seen from Figure 4.9, Organisation (F_2) correlates quite strongly (0.62, $p < 0.001$) with Technology (F_3). Therefore, the null hypothesis $H1_0$ which states that they are not correlated is rejected.

5.1.2 Research hypothesis II

The second research hypothesis asserts that (*cf.* Section 1.4.2 and 3.2.2):

$H2_0$:

Development along the organisational dimension alone does not result in marginal operational performance.

$H2_a$:

Development along the organisational dimension alone results in marginal operational performance.

The causal effect of Organisation (F_2) on Operational Performance (F_1) is clearly demonstrated by a strong positive path coefficient of 0.72 ($p < 0.001$). This means that development along the organisational dimension has a considerable effect on the operational performance of a manufacturing firm. Against prior expectation (*cf.* Section 1.4.2), the null hypothesis ($H2_0$) need to be retained.

5.1.3 Research hypothesis III

The third research hypothesis asserts that (*cf.* Section 1.4.3 and 3.2.3):

$H3_0$:

Development along the technological dimension alone does not result in marginal operational performance.

$H3_a$:

Development along the technological dimension alone results in marginal operational performance.

The analysis of the structural model has shown that the causal effect of Technology (F_3) on Operational Performance (F_1) is non-significant ($p > 0.05$).

Strictly, it means that the null and alternative hypotheses ($H3_0$ and $H3_a$) are inappropriate because both assume that there is at least some relationship between development along the technological dimension and operational performance. Stated differently, the null hypothesis reflects the viewpoint that the adoption of technology alone causes high levels of operational performance. This can only hold if the relationship is positive and strong. Conversely, the alternative hypothesis reflects that the adoption of technology alone causes low levels of operational performance, which only seems likely when the relationship is weak or negative. But the prerequisite for both hypotheses is that there is a statistically significant relationship between both latent variables.

However, if it is assumed that no relationship is a special case of a weak relationship, then it seems plausible that the null hypothesis ($H3_0$) should be rejected. That is, the alternative hypothesis should be retained meaning that Technology (F_3) alone has a marginal causal effect on Operational Performance (F_1). In light of this study's final model (*cf.* Figure 4.9), this marginal causal effect appears to be mediated by Organisation (F_2).

5.2 Primary research question

As discussed in Section 1.2 and 3.1, the primary research question captures the hypothesised relationship between Technology, Organisation and Operational Performance:

Does a balanced development of organisational and technological dimensions result in optimum levels of operational performance of manufacturing?

A balanced development of organisational and technological dimensions refers to approximately equal path coefficients. Since this is clearly not the case, the primary research question cannot be supported. The non-significant path between Technology (F_3) and Operational Performance (F_1), and the highly significant path between Organisation (F_2) and Operational Performance (F_1), means that development along the organisational dimension is by far the most important in obtaining optimum levels of operational performance of manufacturing. The meaning and implication of this will be further discussed in the next section.

5.3 Research problem

The central research problem of this study is (*cf.* Section 1.2 and 3.1):

To analyse the effect of development along organisational and technological dimensions on operational performance of manufacturing firms in South Africa.

The finding of this study that Organisation (F_2) has a significant direct causal effect on Operational Performance (F_1) is in line with Tidd *et al.*'s (1999: 261-267) and Sonntag's (2003: 319) view that organisational change management is a critical success factor of manufacturing technology (*cf.* Section 2.4).

This study's finding that Technology (F_3) does not have a direct causal effect on Operational Performance (F_1) appears to be supported by reviewed empirical research that investigated the relationship between all three variables (technology, organisation and performance).

For example, Frick *et al.* (1998: 359) conclude that the lowest performance was seen with technology-oriented firms suggesting a low correlation between technology and business performance (*cf.* Section 2.4.1). But business performance may obscure true operational performance as was discussed in Section 2.3.

Therefore, the strongest support is provided by Challis *et al.*'s (2002: 1956-1958) study. They state specifically that AMT did not correlate directly with operational performance. In fact, there is a striking similarity with their findings (*cf.* Section 2.4.2) and this study's findings in terms of the final model presented in Figure 4.9. This also provides some support for the broader models of technology and organisation that have been employed by this study as opposed to Challis *et al.*'s focus on 'best practice' concepts.

Reviewed empirical research that only investigated Technology-Performance relationships do not support this study's finding that the relationship between Technology (F_3) and Operational Performance (F_1) is non-significant.

How could this be explained? Small's (1999: 266-267) conclusion that technology and operational performance are positively correlated might be based on an undetected intervening or spurious relationship with organisational development. Figure 5.1 highlights this point. Organisation may causally affect both Technology and Operational Performance (spurious relationship), or Organisation may be an intervening variable between Technology and Operational Performance.

A similar argument may hold for Boyer's (1999) study. On the other hand, since he investigated technology's relationship with business performance, other factors may have played a role. For example, a market upswing also may have caused increased business performance.

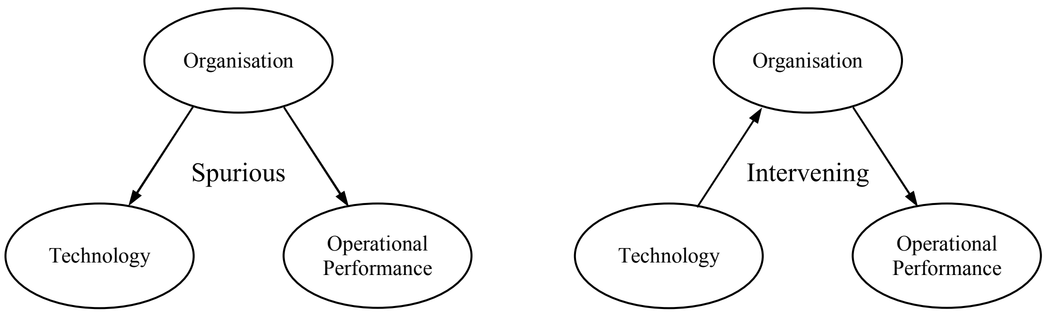


Figure 5.1 Spurious and intervening relationships

Overall, the findings of this study compares favourably with Frick *et al.*'s (1998) and Challis *et al.*'s (2002) research, despite that the former measured business performance (as opposed to operational performance) and the latter focused on 'best practice' concepts such as TQM and JIT.

What, then, is the implication for the manufacturing industry? This question is probably best answered by using Ettlie's (1988: 15-17) and Bessant's (1991: 344-345) argument for simultaneous innovation of technological and organisational dimensions (*cf.* Section 2.4). However, since this study showed that organisational development has a direct causal effect on operational performance, while technological development only has an indirect effect, it seems logical that manufacturing companies should first develop along the organisational dimension before adopting technology. On the other hand, it would be impractical to develop first entirely along the organisational dimension before developing along the technological dimension. A company should rather identify implementation phases or milestones as part of a technology strategy. Before such phase is implemented, or even specified in detail, a company should develop along the organisational dimension until for example skills and team structures are appropriate for the planned technology implementation phase. Once that phase is successfully implemented and measured in terms of operational performance, the next phase could be started in a similar stepwise fashion.

5.4 Questionnaire response

5.4.1 Response statistics

An active response rate of 18.2% (*cf.* Section 4.1.1) was somewhat disappointing. Based on a likely response rate of between 10% and 30% (*cf.* Section 3.5), it was expected that the response rate would at least be above 20% because the online questionnaire used by this study was more convenient and probably less time consuming for respondents than a traditional postal questionnaire. This point is supported by a respondent's comment:

"I get many of these requests per year and I must single your Questionaire (*sic*) out as one of the best received to-date. Clear, concise and user-friendly." – Charles Scheltema, Managing Director, Freudenberg Nonwovens (Pty) Ltd, April 2004.

The likely cause for the relatively low response rate might be related to the proliferation of electronic mass mailing systems for marketing and advertising of products and services. In such environment, this study's e-mailed invitations (or reminder letters) could easily be seen as electronic junk mail and be discarded. Perhaps it would have been better to send a postal invitation that refers to the online questionnaire. It might be that traditional post is not as quickly discarded as an e-mailed letter.

Furthermore, the target respondents were Managing Directors who are likely to receive many requests to fill in research questionnaires (see also the above quote). On the one hand, it seems that this might be the reason that some Managing Directors referred the invitations to participate in this research to other managers. This is evidenced by Figure 4.6 which shows that about 27% (28 cases) of the respondents were not CEO or MD. On the other hand, it may also be the reason for a relatively low response rate because Managing Directors seem to receive so many of them, which raised the danger of sample saturation.

5.4.2 Demographics of respondents

Most of the industry sectors were represented in the actual sample as was shown in Figure 4.3. However, the 'Other' category was disturbingly high at almost 22% of the sample. This could mean that these respondents were not from the manufacturing sector, and only casually participated. It could also mean that the respondents did not know which industry sector to choose or mistakenly selected 'Other', but this is unlikely given the high percentage in this category. Another possibility is that a respondent's industry sector was simply not listed on the questionnaire. This is however also unlikely because the industry sectors were similar to those used by Sohal *et al.* (2001) who investigated the adoption of AMT in the South African manufacturing industry. Whatever the reason, the demographics in terms of industry sector need to be interpreted with some caution.

As was shown in Figure 4.4, most respondents selected ‘Batch’ (38%), ‘Continuous’ (32%) or ‘Jobbing’ (24%) as the type of production system (i.e. manufacturing operating mode). This means that the initial scope of this study – the repetitive manufacturing industry (*cf.* Section 1.8.1) – had to be relaxed to obtain a reasonable sample size for statistical analysis. This was justified on grounds that it is plausible that similar manufacturing technology is utilised in batch, jobbing, discrete and repetitive modes. The only exception is the continuous manufacturing mode (e.g. oil and gas industry) for which it is unlikely that Flexible Manufacturing Systems are utilised for example.

It is therefore a concern that almost one third of the respondents indicated that their production system is continuous. Consequently, 10 cases that responded with such production system have been randomly selected (by using Microsoft Excel’s RAND-function on the raw response data presented in Appendix D) for further investigation. The 10 cases are shown in Table 5.1.
It was found by visiting the case’s website that most of them were probably not using a continuous operating mode. The most likely explanation is that the respondents misunderstood the meaning of the different types of production systems that they could select on the online questionnaire. It would probably have been better if a short explanation of the meaning of the types of production systems was provided on the questionnaire.

Based on Table 5.1, only 20% of the respondents correctly selected ‘Continuous’ as their production system. Therefore, with a total of 33 respondents (*cf.* Figure 4.4), only 7 are likely to have correctly indicated ‘Continuous’. The implication for this study is that the operationalisation of the Technology latent variable for the actual sample was probably valid as only 6.7% (7/104) was likely to use a continuous production system. Nevertheless, the reported respondent’s production system need to be interpreted with some caution.

Table 5.1 Most likely production system of 10 'Continuous' cases

Respondent's e-mail address	Respondent's website	Likely production system
ronald@clickon.co.za	www.clickon.co.za	Batch
wolfgang.stadler@bmw.co.za	www.bmw.co.za	Batch
kockottdb@nampak.co.za	www.nampak.co.za	Repetitive
roberto.nobili@fiat.com	www.fiat.com	Batch
mail@andersoneng.co.za	www.andersoneng.co.za	Jobbing
HFischer@cbi.co.za	www.cbi.co.za	Repetitive
andrew@gmpsa.co.za	www.gmpsa.co.za	Continuous
snymanh@tsb.co.za	www.tsb.co.za	Continuous
carol@mutual.co.za	www.mutual.co.za	Batch
whitehousec@detnet.com	www.detnet.com	Batch

5.5 Evaluation of the measurement model

Jöreskog's (1993: 294-314) recommendation that constructs should be separately subjected to CFA before a full measurement model is assessed did not demonstrate satisfactory results. This was evidenced by the fact that the separate construct CFA suggested that v13_crd (coordination) and v01_qty (quality) should be removed from their respective constructs, while the CFA of the full measurement model suggested that other indicator variables should be removed. One explanation might be that the separate construct CFA models were too small compared to the many more parameters that had to be estimated for the full measurement model.

Another possible reason, which is of more concern for this study, is the relatively small final sample. While data quality in terms of univariate and multivariate normality was demonstrated, the removal of cases resulted in a disturbingly small sample of 93 cases. The final measurement model had 25 parameters, resulting in a minimum sample size requirement of 5 * 25 = 125 (*cf.* Section 3.5). This means

that there was a danger of data-driven modifications to arrive at an acceptable measurement model (MacCallum *et al.*, 1992: 492).
This might also be an explanation for the removal of v03_dpn (dependability), v08_org (organisation) and v09_rel (organisational relationships) in the final measurement model while this could not be underpinned by the reviewed literature for the organisational dimension (*cf.* Section 2.2) and operational performance (*cf.* Section 2.3.2). Although there is a possibility that the measurement of the removed indicator variables by its corresponding questionnaire items was simply incorrect, it seems unlikely given the acceptable internal consistency of 0.72 (Cronbach's Alpha, *cf.* Section 4.2.6) and the results of the pilot study that demonstrated content validity.

Another point that needs some discussion is the widely used Maximum Likelihood estimation method in combination with ordinal data as a result of using Likert-type measurement scales. While some literature suggests using polychoric correlations as input to, for example, the Weighted Least Squares (WLS) or Asymptotically Distribution Free (ADF) estimation methods (for example, Jöreskog, 1993: 305; Hox and Bechger, 1998), it appears that empirical research that used SEM generally ignored the ordinality problem. This might well be attributed to the more stringent requirement of using a very large sample size for ADF estimation even for relatively simple models. Additionally, using ordinal data with the Maximum Likelihood method provides satisfactory results when certain conditions are met (Kline, 1998: 145; Babakus, Ferguson and Jöreskog, 1987). These are, among others, using a minimum of five response options with Likert-type scales, low univariate skewness and multivariate normal distribution of the data. Since this study satisfied these requirements and used a small sample, polychoric correlations and WLS (or ADF) were not feasible.

While the SEM literature generally recommends using at least three indicator variables to measure a latent variable, the experience by this study was that at least five indicators should be used. The reason is that if four indicator variables are used and one needs to be removed, the separate CFA of a latent construct becomes just-identified. This means that the goodness-of-fit cannot be assessed anymore. This was evidenced by the separate analysis of the Technology construct in Section 4.3.1.1.

Despite the concerns mentioned in this section, the final measurement model demonstrated satisfactory fit, reliability and validity.

5.6 Evaluation of the structural model

The final theoretical causal model that is shown in Table 4.7 (model M_r) and Figure 4.9 demonstrated acceptable levels of parsimony. The satisfactory fit to the sample data was evidenced by a non-significant difference with the final measurement model. Consequently, the model was used for hypotheses testing as discussed in Section 5.1. A concern however, is the magnitude of the path coefficient of the disturbance term D_1 (0.69). It may indicate that this study's hypothesised model is oversimplified because there seems to be a considerable effect of omitted unknown latent effects on the endogenous latent variable Operational Performance (F_1).

While the hypothesised causality was drawn from the literature review presented in chapter 2, it cannot be claimed by measurement due to the cross-sectional nature of this study. Kelloway (1995: 216) points out that causality can only be supported when the exogenous latent variable precedes the endogenous latent variable in time, and that all relevant causes of the endogenous variables are included in the model. On the other hand, in the absence of these conditions, the literature review provided at least some support for the suggested causality (Kline, 1998: 96-99).

Furthermore, other models may equally well account for the variances and covariances in the sample data. For example, an organisation can only learn and adapt if feedback loops exist. In terms of this study, if the level of operational performance is low, an investigation might reveal that individual skills are not appropriate. This may motivate a firm to conduct training courses for increasing the skills of their staff. The effect is, hopefully, that operational performance increases. This example shows that it is possible that a reciprocal relationship may exist between Organisation (F_2) and Operational Performance (F_1). This was not investigated as it would make the model non-recursive and more complex, which is beyond the scope of the research problem.

Likewise, the correlation between Organisation (F_2) and Technology (F_3) might be reciprocal. Although the usual assumption with exogenous variables in SEM is that they covary, it might not necessarily be the case. For example, it seems reasonable to assume that the synergy of skills, structure and corporate culture determines what manufacturing technology must be employed (Organisation affects Technology). Similarly, new technology provides opportunities for learning and thus may have a positive effect on skills, structure and corporate culture (Technology affects Organisation).
To support this point, the model was modified so that Technology (F_3) causally affects Organisation (F_2), which in turn causally affects Operational Performance (F_1). This model is presented in Figure 5.2. Without going into the same detail as presented in Section 4.4, it was shown that also this model acceptably accounts for the sample data indicated by significant path coefficients of 0.621 and 0.722 ($p < 0.001$). A negative point however is the relatively low percentage of variance accounted for in the endogenous Organisation (F_2) latent variable of only 39% (R^2), and a high path coefficient of the disturbance term D_2. The results shown in Figure 5.2 are the same when the direction of the path between Technology (F_3) and Organisation (F_2) is reversed. The main point being made here is that alternative models exist for this sample.

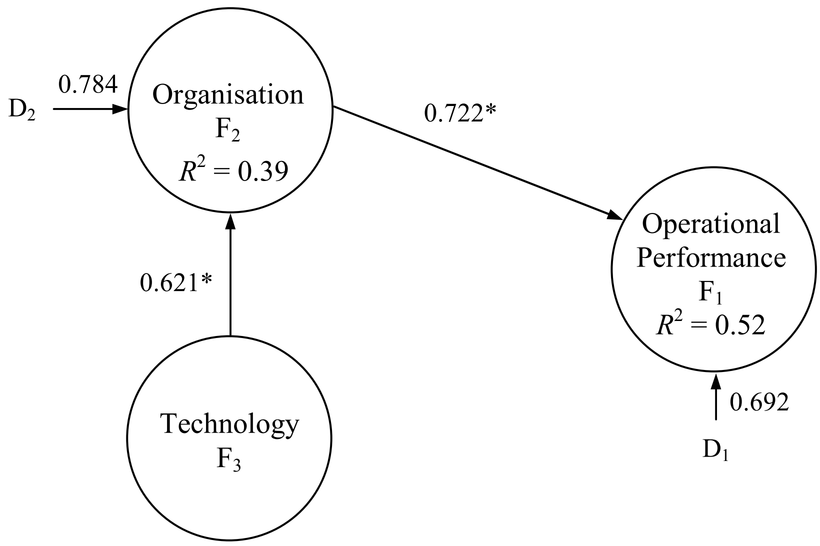


Figure 5.2 An alternative model (* $p < 0.001$)

Nonetheless, the SEM methodology provided an acceptable final theoretical causal model (*cf*. Figure 4.9) – at least for this sample – to assess the hypotheses, primary research question and research problem as discussed in Sections 5.1, 5.2, and 5.3.

The next chapter provides a conclusion, implications, and suggestions for further research based on the discussion that was presented in this chapter.

6 CONCLUSION

This study investigated a hypothesised triangular relationship between the dimensions of technology (AMT), organisation and operational performance on a final sample of 93 manufacturing firms in South Africa. Although it was shown that the actual sample was representative for the target sample of 604 cases, it was not representative for the population of manufacturing firms in South Africa. Furthermore, the initial measurement and structural models had to be modified to fit the sample. Due to the relatively low sample size, it could have been that these modifications were data-driven. Overall, the main implication for this study is that the generalisability of the results – including model modifications – to other samples and the population remains to be determined (MacCallum *et al.*, 1992: 492; Saunders *et al.*, 2003: 102-103). Notwithstanding these limitations, the results demonstrated acceptable validity and reliability (*cf.* Sections 4.2, 4.3.2.4, 4.4.2, 5.4, 5.5, and 5.6).

Referring to the central research problem and the primary research question of this study, it was clearly shown that development along technological and organisational dimensions affects operational performance of a manufacturing firm. However, the statistically non-significant direct impact of the Technology latent variable on Operational Performance was unexpected and shed different light on some of the reviewed empirical research. In fact, this study showed that only investigating the relationship between technological dimensions and operational performance is probably an oversimplification that obscures the effect of important organisational issues (*cf.* Section 5.3). Moreover, a reasonable contribution to the body of empirical knowledge was made by this study's hypothesised model of the triangular relationship which was independent of limited 'best practice' concepts (*cf.* Sections 1.2 and 3.1).

The overall conclusion of this study for the investigated sample is that only the organisation of a firm enabled the promise of manufacturing technology, namely to obtain high levels of operational performance. The implication for the manufacturing industry – at least for this sample – is that firms should strongly emphasise the development of its organisation as part of a technology strategy (*cf.* Section 5.3). The question that inspired this research – 'Why could a modern plant with sophisticated manufacturing technology not compete in world markets?' (*cf.* Section 1.6) – is therefore answered: the firm underestimated the impact of the organisational dimension on operational performance.

In terms of the research objectives of this study (*cf.* Section 1.5), it was somewhat disappointing that the results could not be generalised to the population of manufacturing firms in South Africa. This was probably due to not having detailed information of the population available for this research project (*cf.* Sections 3.4 and 3.5).

Although this study contributed to the body of empirical knowledge of the impact of technological and organisational dimensions on operational performance of manufacturing firms, further research is required. More specifically:

1. The operationalisation of the Technology and Operational Performance constructs was comparable to other studies, but the operationalisation of the Organisation construct was hypothesised as a consolidated framework from four literature sources (*cf.* Section 2.2). The validity of conceptualising and measuring the Organisation construct as it was done by this study requires further research.

2. The exogenous Organisation and Technology latent variables were assumed to covary. Further research should investigate the exact relationship. Do they affect each other reciprocally? Is Organisation a spurious or intervening variable between Technology and Operational Performance (*cf.* Section 5.3)?

3. Future research is also required to investigate the omitted unknown exogenous latent effects on operational performance that were modelled by this study. This may provide a more holistic model with deeper insight of the determinants of operational performance (*cf.* Section 5.6).

4. Most of the respondents (73%, *cf.* Figure 4.6) were Chief Executive Officers (CEO) or Managing Directors (MD) who should be able to provide valid responses to the questionnaire items. However, results might be different when respondents are senior operational managers responsible for Quality, Engineering, Human Resources, and Production for example. They are probably closer than CEO's or MD's to the operational issues that were measured by this study. Future research to investigate relationships among technological, organisational, and operational performance dimensions should take this possibility into account.

5. It was mentioned that continuous manufacturing operating modes are markedly different than repetitive, batch and jobbing modes (*cf.* Sections 1.8.1, 3.5, and 5.4.2). It might be useful to investigate the relationship of technology, organisation and operational performance for each mode.

6. Although SEM was an appropriate method for this study, large sample research is required possibly in conjunction with using polychoric correlations for ordinal data and the Weighted Least Squares method, for generalising results to the population of manufacturing firms in South Africa (*cf.* Section 5.5).

7. Research is required on the viability of Internet-based survey methods as opposed to traditional postal surveys, or a combination of the two (*cf.* Section 5.4.1). Although an Internet-based approach is intuitively more appealing than traditional methods, it seems that respondents have

different views as evidenced by the relatively low response rate. A central question here is: How does the apparent proliferation of unsolicited e-mails used for marketing and advertising purposes influence the response rate of Internet-based surveys?

8. Finally, longitudinal research on the relationship between Technology, Organisation and Operational Performance might reveal important patterns that may be used for integrating technology, manufacturing, and corporate strategies.

Everything considered, this study provided a different perspective relative to extant empirical literature and a reasonable basis upon which further research on the relationship between technological, organisational and operational performance dimensions could build.

APPENDIX A: QUESTIONNAIRE

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

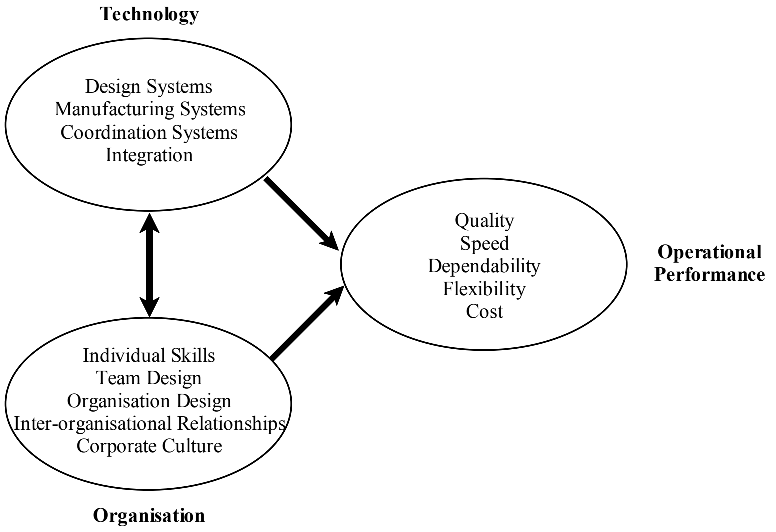
Impact of Technology and Organisation on Performance of Manufacturing Companies

Version: 10 March 2004

An M.Sc Research Project by Peter Jumelet

Thank you for participating in this survey.

This study investigates a possible relationship between adopted manufacturing technology, organisational practices and operational performance of the manufacturing function. The figure below depicts this relationship including its measurement variables.



The questionnaire on the following pages consists of five questions for each measurement variable. Tests have shown that it will take approximately 15 minutes to complete the questionnaire.

All information you provide will be treated as strictly confidential and will not be used for any commercial purposes.

Please select whether you wish to receive a copy of the study results in appreciation of your participation:

- ○ Yes, I wish to receive a copy of the results.
- ○ No, thank you.

How to fill in this web survey

Most of the questions in this survey are statements which require you to click on a response option on a scale from 'Strongly disagree' to 'Strongly agree' presented to the right of the statement. In between these two endpoints of the scale you also have the option of 'Disagree', 'Not Sure' and 'Agree'. The scale allows you to choose the response option which is best applicable to your company. Please note that there are no right or wrong answers.

Example statement:	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
1. We use industrial robots in our plant.	○	○	○	○	○

For this example, the scale could translate to the following options that may be applicable to your company:

Option	Possible situation
Strongly Disagree	We do not use industrial robots at all
Disagree	We do not use industrial robots, but we will use them in the near future
Not Sure	I am not sure whether we use them or not
Agree	A small percentage of our automation consists of industrial robots
Strongly Agree	We use many industrial robots

If you later on wish to change a previously selected response option, simply click on another one. At the end of the questionnaire, please submit your response by clicking on the SUBMIT button. This will send the data that you filled in to my e-mail account. If you have any questions, please do not hesitate to contact me by e-mail (jumelet@absamail.co.za) or by phone (083 653-8110).

The following statements comprise the survey. They relate to the measurement variables for investigating the relationship between:

Technology:
- Design Systems
- Manufacturing Systems
- Coordination Systems
- Integration of Design, Manufacturing and Coordination Systems

Organisation:
- Skills
- Team Design
- Organisation Design
- Inter-organisational Relationships
- Corporate Culture

Operational Performance:
- Quality
- Speed
- Dependability
- Flexibility
- Cost

Technology: Design Systems

	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
1. We use Computer Aided Design (CAD) systems.	○	○	○	○	○
2. We use Computer Aided Engineering (CAE) systems for advanced engineering analysis of our product designs.	○	○	○	○	○
3. Our CAD (or CAE) workstations are linked with each other.	○	○	○	○	○
4. Our products are designed by using traditional design tools such as a drawing board.	○	○	○	○	○
5. We use our design systems for simulation of product dynamics before a physical prototype is built.	○	○	○	○	○

Technology: Manufacturing Systems

	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
6. Our machinery are computer controlled by, for example, industrial computers or Programmable Logic Controllers (PLCs).	○	○	○	○	○
7. Industrial robots handle parts or products in our plant.	○	○	○	○	○
8. We use Automatic Guided Vehicles (AGV) for handling material between machines and stores.	○	○	○	○	○
9. We use automatic storage systems in our plant.	○	○	○	○	○
10. Disparate machinery (e.g. lathes, mills, drills) in our plant are grouped in cells. Raw material that enters the cell, is converted to semi-finished or final products before it leaves the cell.	○	○	○	○	○

Technology: Coordination Systems

	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
11. Our coordination systems are predominantly stand-alone applications of spreadsheet programs such as Microsoft Excel for example.	○	○	○	○	○
12. We use basic Material Requirements Planning (MRP) for production scheduling.	○	○	○	○	○
13. Bills of Material (BOM) information are stored in a central database which is accessible to many relevant departments within our company.	○	○	○	○	○
14. It is common practice in our company that various production information is locally stored and therefore not electronically shared among relevant departments.	○	○	○	○	○
15. Peripheral departments such Human Resources, Finance and Logistics each have their own local computer system to keep track of data.	○	○	○	○	○

Technology: Integration of Design, Manufacturing and Coordination Systems

	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
16. In our company, design and manufacturing systems are technologically integrated as Computer-Aided Design and Computer-Aided Manufacturing (CAD/CAM) systems.	○	○	○	○	○
17. Production data of our factory are **manually** fed back into Master Production Scheduling (MPS) systems.	○	○	○	○	○
18. Departments such as Planning, Manufacturing, Engineering, Marketing and Finance for example, are integrated by computer systems such that relevant information are shared.	○	○	○	○	○
19. Our systems are technically integrated with other elements of the value chain (e.g. suppliers or customers) in order to synchronise the operations of our manufacturing division.	○	○	○	○	○
20. We have an interactive website (e.g. customers can place orders or view online catalogues) of our company.	○	○	○	○	○

Organisation: Individual Skills

	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
21. Operational staff understand the functionality of manufacturing technology as implemented in our plant.	○	○	○	○	○
22. Our operational staff are multi-skilled.	○	○	○	○	○
23. When we need to modify our manufacturing technology, we contract external specialised engineering companies to do the work.	○	○	○	○	○
24. Our engineering staff know the low-level technical details of manufacturing technology as implemented in our plant.	○	○	○	○	○
25. It is difficult for us to find technical contractors to help us with maintaining our systems.	○	○	○	○	○

Organisation: Team Design

	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
26. Work teams in our company are autonomous regarding operational decision-making.	○	○	○	○	○
27. Our work teams respond effectively to operational contingencies.	○	○	○	○	○
28. Work teams in our company take ownership of its purpose within the manufacturing function.	○	○	○	○	○
29. In our company, work teams generally consist of theoretical and practical people.	○	○	○	○	○
30. Our work teams lack adequate resources such as equipment, meeting space and an appropriate budget for example, to do their tasks.	○	○	○	○	○

Organisation: Organisation Design

	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
31. To cope with manufacturing technology in our company, we had to create more specialised jobs.	○	○	○	○	○
32. Due to the manufacturing technology that is implemented in our company, we could reduce the number of managerial levels, that is, changed to a flat organisation structure.	○	○	○	○	○
33. To make optimal use of manufacturing technology, we had to standardise job outputs by creating more documented work procedures.	○	○	○	○	○
34. Top management makes most of the operational decisions.	○	○	○	○	○
35. The flow of information is predominantly downward, that is, from top management to workers.	○	○	○	○	○

Organisation: Inter-organisational Relationships

	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
36. Relationships with other companies enabled us to learn about manufacturing technology implementation.	○	○	○	○	○
37. We acquired knowledge of manufacturing technology from academic institutions.	○	○	○	○	○
38. We are **not** aware of government-supported programs for technological innovation.	○	○	○	○	○
39. We are aware of industry trends regarding the adoption of manufacturing technology.	○	○	○	○	○
40. We attend workshops or seminars related to manufacturing technology that are hosted by professional associations .	○	○	○	○	○

Organisation: Corporate Culture

	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
41. The way we solve technology-related problems rather address the symptoms as opposed to the root-cause.	○	○	○	○	○
42. We systematically experiment with technology in order to continuously improve our company's manufacturing capabilities.	○	○	○	○	○
43. We learn from past experience.	○	○	○	○	○
44. We do **not** benchmark ourselves against customer needs.	○	○	○	○	○
45. Knowledge is shared at all levels of our organisation.	○	○	○	○	○

Operational Performance: Quality

	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
46. Our products are manufactured within customer specifications.	○	○	○	○	○
47. Our reject rate of final or semi-final products fluctuates unacceptably.	○	○	○	○	○
48. The variability of critical product attributes is under our control.	○	○	○	○	○
49. Our final product functions according to the customer's expectation over a reasonable lifetime.	○	○	○	○	○
50. The overall quality of our products is better than our competitor(s).	○	○	○	○	○

Operational Performance: Speed

	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
51. Our product development cycle time (i.e. time from design to start of production) is relatively low.	○	○	○	○	○
52. Total lead time (i.e. time from customer order to physical delivery) of our products can be improved significantly.	○	○	○	○	○
53. Our manufacturing cycle time (i.e. time to manufacture a finished product from raw materials in stock) is competitive.	○	○	○	○	○
54. Total time spent on non-value-added activities (e.g. moving materials, waiting, queuing, machine set-ups) significantly outweigh total time of value-added activities.	○	○	○	○	○
55. Levels of work-in-process (WIP) are relatively high in our plant.	○	○	○	○	○

Operational Performance: Dependability

	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
56. Due to uncertainties in our manufacturing processes, we need to reserve spare manufacturing capacity as a buffer to ensure on-time delivery to our customers.	○	○	○	○	○
57. Our manufacturing work centers generally attain production schedules.	○	○	○	○	○
58. The ratio of breakdown versus preventative maintenance is such that we can rely on our machinery.	○	○	○	○	○
59. Actual dispatch dates of final products to our customers conforms planned dispatch dates.	○	○	○	○	○
60. In our plant, manufacturing work centers deliver semi-finished products to the next work center on time.	○	○	○	○	○

Operational Performance: Flexibility

	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
61. We introduce new products faster than our competitor(s).	○	○	○	○	○
62. Relative to our product range, we efficiently manufacture different products at the same time.	○	○	○	○	○
63. We efficiently modify existing products to meet different customer requirements.	○	○	○	○	○
64. To re-organise manufacturing operations when customers request changes in planned delivery dates, is problematic.	○	○	○	○	○
65. We cannot keep up with changing market conditions because it is difficult for us to modify our manufacturing technology.	○	○	○	○	○

Operational Performance: Cost

	Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
66. The price of our products is competitive.	○	○	○	○	○
67. Our direct material costs could decrease if we upgrade our manufacturing technology.	○	○	○	○	○
68. Our direct labour costs are low relative to our industry.	○	○	○	○	○
69. Our factory overhead costs are high relative to our industry.	○	○	○	○	○
70. Our company's manufacturing technology enabled us to reduce total manufacturing costs.	○	○	○	○	○

General Information

Please select your company's industry sector by clicking on a category from the drop-down menu to the right.	Automotive
Please select the number of employees in your organisation by clicking on a category:	Less than 100 100 - 199 200 - 499 500 - 999 More than 1 000
Please select the annual sales revenue of your organisation by clicking on a category:	Less than R 10 million R 10 million - R 99 million R 100 million - R 499 million R 500 million - R 999 million More than R 1 000 million
Please select the type of your production system by clicking on a category:	Jobbing production Batch production Discrete production Continuous flow production
Please select your management level by clicking on a category:	CEO/MD Executive Management Middle Management Other
Please select your area of management by clicking on a category:	CEO/MD Production Finance Quality Engineering Other
Please select in which province your head office resides:	Eastern Cape
Your e-mail address on the e-mailed invitation: *(required to validate your response against the invitation)*	

Thank you for filling in this on-line web questionnaire. Please click on the SUBMIT button below to transmit the data.

SUBMIT RESET

APPENDIX B: PILOT STUDY EVALUATION FORMS

B.1

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Impact of Technology and Organisation on Performance of Manufacturing Companies

10 February 2004

An M.Sc. Research Project by Peter Jumelet

Please use the following checklist to evaluate the e-mail invitation and the on-line web questionnaire.

Criteria	Comments
Was the e-mail invitation clear?	Yes
How long did it take to complete the questionnaire (in minutes)?	20 min
Were the instructions in the questionnaire clear?	Yes
Were any questions unclear or ambiguous?	Yes, was not sure of the meaning of Q10
Were there any questions you felt uneasy about answering?	Yes Q2 & Q10
Were there, in your opinion, any major topic omissions that should be included?	Not really, the skills and education level of the work teams could be useful info in the survey.
Any other comments you wish to communicate?	Interesting survey, made me realise how technology should be well integrated with people and performance; I realise some gaps in this respect for our organisation.

Your name : Princess Thwala

Your occupation : General Manager

Date : 24 February 2004

Signature :

B.2

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Impact of Technology and Organisation on Performance of Manufacturing Companies

10 February 2004

An M.Sc. Research Project by Peter Jumelet

Please use the following checklist to evaluate the e-mail invitation and the on-line web questionnaire.

Criteria	Comments
Was the e-mail invitation clear?	yes
How long did it take to complete the questionnaire (in minutes)?	15
Were the instructions in the questionnaire clear?	yes
Were any questions unclear or ambiguous?	no
Were there any questions you felt uneasy about answering?	no
Were there, in your opinion, any major topic omissions that should be included?	no
Any other comments you wish to communicate?	no

Your name : _Antonie Naude_

Your occupation : _Quality Manager_

Date : 18/2/2004

Signature :

B.3

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Impact of Technology and Organisation on Performance of Manufacturing Companies

10 February 2004

An M.Sc. Research Project by Peter Jumelet

Please use the following checklist to evaluate the e-mail invitation and the on-line web questionnaire.

Criteria	Comments
Was the e-mail invitation clear?	We could understand the in-structions clearly. All questions were understood.
How long did it take to complete the questionnaire (in minutes)?	17 minutes 05:43 – 06:00.
Were the instructions in the questionnaire clear?	Yes
Were any questions unclear or ambiguous?	Some were ambiguous – Q 10
Were there any questions you felt uneasy about answering?	None
Were there, in your opinion, any major topic omissions that should be included?	Motivational issues caused by Automation
Any other comments you wish to communicate?	

Your name : WHA DU PLESSIS

Your occupation : General Manager.

Date : 15/2/04

Signature :

B.4

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Impact of Technology and Organisation on Performance of Manufacturing Companies

10 February 2004

An M.Sc. Research Project by Peter Jumelet

Please use the following checklist to evaluate the e-mail invitation and the on-line web questionnaire.

Criteria	Comments
Was the e-mail invitation clear?	Yes
How long did it take to complete the questionnaire (in minutes)?	15 minutes
Were the instructions in the questionnaire clear?	Yes
Were any questions unclear or ambiguous?	The technical terms that had been shorten
Were there any questions you felt uneasy about answering?	No
Were there, in your opinion, any major topic omissions that should be included?	No
Any other comments you wish to communicate?	I will highlight when you discuss with me

Your name : __A..R De Nobrega_______________________

Your occupation : _Financial Manager______________________

Date : _2004/02/11_____________________

Signature : ____________________

B.5

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Impact of Technology and Organisation on Performance of Manufacturing Companies

10 February 2004

An M.Sc. Research Project by Peter Jumelet

Please use the following checklist to evaluate the e-mail invitation and the on-line web questionnaire.

Criteria	Comments
Was the e-mail invitation clear?	Yes, it made clear the intension
How long did it take to complete the questionnaire (in minutes)?	10min
Were the instructions in the questionnaire clear?	yes
Were any questions unclear or ambiguous?	no
Were there any questions you felt uneasy about answering?	No, possible on the sensitivity around job cuts could be a point of non disclorues for some firms. However that was addressed in the non disclosure point..
Were there, in your opinion, any major topic omissions that should be included?	No
Any other comments you wish to communicate?	In terms of Design systems, co-ordination, much is said about the tools,etc. but not about what process methodologies that have been used to blue print the process – was a specific model or international standards followed? – (like S95)

Your name : ______Machiel Lucsas______________

Your occupation : _______Engineering Manager_________________

Date : _______17/2/04_________________

Signature : ___________signed_____________

B.6

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Impact of Technology and Organisation on Performance of Manufacturing Companies

10 February 2004

An M.Sc. Research Project by Peter Jumelet

Please use the following checklist to evaluate the e-mail invitation and the on-line web questionnaire.

Criteria	Comments
Was the e-mail invitation clear?	Yes
How long did it take to complete the questionnaire (in minutes)?	15 Min
Were the instructions in the questionnaire clear?	Yes
Were any questions unclear or ambiguous?	No
Were there any questions you felt uneasy about answering?	Yes, no industry standards for measuring cost
Were there, in your opinion, any major topic omissions that should be included?	No
Any other comments you wish to communicate?	

Your name : Gert van der Walt__________

Your occupation : IT Facilities Manager_______

Date : 16/02/04________________

Signature : ____________________

B.7

University of the Witwatersrand, Johannesburg

Impact of Technology and Organisation on Performance of Manufacturing Companies

10 February 2004

An M.Sc. Research Project by Peter Jumelet

Please use the following checklist to evaluate the e-mail invitation and the on-line web questionnaire.

Criteria	Comments
Was the e-mail invitation clear?	Yes
How long did it take to complete the questionnaire (in minutes)?	± 12 min.
Were the instructions in the questionnaire clear?	Yes
Were any questions unclear or ambiguous?	Question 6. Replace "few" with "all" or "none"
Were there any questions you felt uneasy about answering?	No
Were there, in your opinion, any major topic omissions that should be included?	No
Any other comments you wish to communicate?	No

Your name : T Davel.

Your occupation : General Manager.

Date : 20/02/2004

Signature : [signature]

B.8

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Impact of Technology and Organisation on Performance of Manufacturing Companies

10 February 2004

An M.Sc. Research Project by Peter Jumelet

Please use the following checklist to evaluate the e-mail invitation and the on-line web questionnaire.

Criteria	Comments
Was the e-mail invitation clear?	Clear
How long did it take to complete the questionnaire (in minutes)?	15 – 20 minutes
Were the instructions in the questionnaire clear?	Maybe it would be better to give detailed definitions of some of the terms used. eg. cellular manufacturing, manufacturing technology, etc. will ensure common understanding amongst all respondents.
Were any questions unclear or ambiguous?	None
Were there any questions you felt uneasy about answering?	None As long as the questionnaire will be used only/solely for the research and for no other reasons.
Were there, in your opinion, any major topic omissions that should be included?	Depends on the objectives of the research study. As a means of understanding more broadly manufacturing principles used in the country, then this should be sufficient
Any other comments you wish to communicate?	Good luck

Your name : ANDILE MVINJELWA

Your occupation : MD

Date : 26/02/2004

Signature : Am

APPENDIX C: COVER AND REMINDER LETTERS

C.1 Cover letter

Impact of Technology and Organisation on
Performance of Manufacturing Companies

A research project by the
University of the Witwatersrand,
Johannesburg

Dear Mr. Anderson,

Many manufacturing companies use various forms of manufacturing technology for gaining a competitive market position, possibly in conjunction with innovative organisational practices. Some succeed in obtaining outstanding performance; others may experience disappointing performance despite the adoption of such technologies or organisational practices.

You are kindly invited to participate in a study that investigates a possible relationship between adopted manufacturing technology, organisational practices and operational performance of the manufacturing division. The survey is part of a Master's of Science degree research project at the Department of Industrial Engineering at the University of the Witwatersrand in Johannesburg.

You have been selected from a database of over 700 manufacturing companies in South Africa. Your input is important for obtaining a reliable representation of adopted manufacturing technology, organisational practices and operational performance. The results of this study could assist you in improving the performance of your company.

Please click on http://myweb.absa.co.za/jumelet to proceed with the on-line web questionnaire. Tests have shown that it will take approximately 15 minutes to complete it.

If you have any questions related to this study, please do not hesitate to contact me by e-mail (jumelet@absamail.co.za) or by phone (083 653-8110).

Kind regards,
Peter Jumelet

C.2 First reminder letter

Dear Mr. Anderson,

On the 23rd of March 2004 I mailed you an invitation to participate in research. This study investigates a possible relationship between manufacturing technology, organisational practices and operational performance.

The University of the Witwatersrand would appreciate your participation. Without your response, it is not possible to obtain a good representation of the manufacturing industry in South Africa.

For this reason you are kindly reminded to fill in the online web-questionnaire at http://myweb.absa.co.za/jumelet. It will not take more than 15 minutes to complete it.

Kind regards,
Peter Jumelet

C.3 Second reminder letter

Dear Mr. Anderson,

On the 23rd of March 2004 I mailed you an invitation to participate in a study that investigates the impact of technology and organisation on operational performance of manufacturing. A reminder was sent on the 5th of April 2004. To date, I have not received your response.

The University of the Witwatersrand would appreciate your participation. Without your response, it would be difficult to obtain a reliable representation of the manufacturing industry in South Africa.

For this reason you are kindly reminded to fill in the online web-questionnaire at http://myweb.absa.co.za/jumelet. It will not take more than 15 minutes to complete it.
If you are unavailable, you may forward this invitation to other senior managers who are involved in the operational management of your manufacturing division.

I look forward to receiving your questionnaire response.

Kind regards,
Peter Jumelet

APPENDIX D: RAW RESPONSE DATA

SUBJECT	INCLUDE	PROVINCE	EMAIL_ADDRESS	ANNUAL_REVENUE	COPY_OF_RESULTS	INDUSTRY_SECTOR
1	y	Gauteng	tomd@samint.co.za	10m-99m	YES	Metal Manufacture
2	y	Gauteng	logistics@bantex.co.za	100m-499m	YES	Paper, Printing and Publishing
3	y	Gauteng	ernst.schutte@africancables.com	500m-999m	YES	Other
4	y	Eastern Cape	alanclarke@ehwalton.co.za	100m-499m	YES	Paper, Printing and Publishing
5	y	Mpumalanga	march@mcwade.co.za	10m-99m	YES	Metal Manufacture
6	y	Gauteng	GamedeC@ael.co.za	>1000m	YES	Chemical and Allied Industries
7	y	Kwazulu Natal	avermaak@afripack.co.za	100m-499m	YES	Paper, Printing and Publishing
8	y	Gauteng	quintonb@troxsa.co.za	10m-99m	YES	Mechanical Engineering
9	y	Kwazulu Natal	r.turnbull@workmanufacturing.com	10m-99m	YES	Timber, Furniture
10	y	Gauteng	francesco@spazio.co.za	10m-99m	NO	Electrical Engineering
11	y	Gauteng	schleritzkoj@beka.co.za	100m-499m	YES	Electrical Engineering
12	y	Western Cape	david_crow@bat.com	>1000m	YES	Food, Drink, Tobacco
13	y	Kwazulu Natal	jan@allwear.co.za	100m-499m	NO	Clothing and Footwear
14	y	Mpumalanga	snymanh@tsb.co.za	>1000m	YES	Food, Drink, Tobacco
15	y	Gauteng	whitehousec@detnet.com	100m-499m	YES	Other
16	y	Kwazulu Natal	arveen@dickwhittington.co.za	10m-99m	YES	Clothing and Footwear
17	y	Gauteng	jwallace@g5.co.za	100m-499m	YES	Bricks, Pottery, Glass, Cement
18	y	Gauteng	barry.pieters@murrob.com	100m-499m	YES	Metal Manufacture
19	y	Western Cape	joel@hkman.co.za	10m-99m	YES	Textiles
20	y	Gauteng	andrew.carr@sappi.com	>1000m	YES	Paper, Printing and Publishing
21	y	Gauteng	mervynn@bosal.co.za	10m-99m	YES	Automotive
22	y	Gauteng	kobust@consol.co.za	100m-499m	YES	Bricks, Pottery, Glass, Cement
23	y	Kwazulu Natal	rico.taxer@manturbo.co.za	10m-99m	YES	Mechanical Engineering
24	y	Gauteng	andreas.theodorou@fuchs.co.za	100m-499m	YES	Other
25	y	Western Cape	charles.scheltema@freudenberg.co.za	100m-499m	YES	Textiles
26	y	Kwazulu Natal	ann-christin.wagenmann@Beiersdorf.com	100m-499m	YES	Automotive

SUBJECT	INCLUDE	PROVINCE	EMAIL_ADDRESS	ANNUAL_REVENUE	COPY_OF_RESULTS	INDUSTRY_SECTOR
27	y	Gauteng	jsmit@grinaker-lta.com	100m-499m	YES	Metal Manufacture
28	y	Gauteng	greg.anderson@tigerbrands.com	>1000m	YES	Food, Drink, Tobacco
29	y	Gauteng	Willem.VanNiekerk@kumbaresources.com	>1000m	YES	Metal Manufacture
30	y	Gauteng	becker@supremespring.co.za	100m-499m	YES	Automotive
31	y	Kwazulu Natal	Walter.Simeoni@frame.co.za	>1000m	NO	Textiles
32	y	Western Cape	mariusc@iwt.co.za	10m-99m	YES	Chemical and Allied Industries
33	y	Gauteng	paul.wheeler@hp.com	>1000m	YES	Other
34	y	Gauteng	juergen.dresel@poynting.co.za	10m-99m	YES	Electrical Engineering
35	y	Gauteng	HFischer@cbi.co.za	500m-999m	NO	Electrical Engineering
36	y	Gauteng	andilem@samint.co.za	100m-499m	YES	Metal Manufacture
37	y	Gauteng	geraldb@cdt.co.za	10m-99m	YES	Other
38	y	Gauteng	robl@robor.co.za	500m-999m	YES	Other
39	y	Gauteng	m.walker@venture-sa.co.za	500m-999m	YES	Automotive
40	y	Gauteng	jdewitt@g5.co.za	100m-499m	YES	Bricks, Pottery, Glass, Cement
41	y	Gauteng	bfield@stoncor.com	100m-499m	YES	Chemical and Allied Industries
42	y	Gauteng	james@cssi.co.za	10m-99m	YES	Electrical Engineering
43	y	Gauteng	genhinge1@global.co.za	10m-99m	YES	Automotive
44	y	Kwazulu Natal	peter.dutrevou@corobrik.co.za	500m-999m	YES	Bricks, Pottery, Glass, Cement
45	y	Gauteng	egbert.harmse@kumbaresources.com	>1000m	YES	Metal Manufacture
46	y	Gauteng	erich.caro@airliquide.com	100m-499m	YES	Chemical and Allied Industries
47	y	Gauteng	kockottdb@nampak.co.za	>1000m	YES	Other
48	y	Mpumalanga	tdennison@trellidor.co.za	100m-499m	YES	Metal Manufacture
49	y	Limpopo	jim@quickpools.co.za	<10m	YES	Other
50	y	Gauteng	andre.crause@sasco.co.za	<10m	YES	Metal Manufacture
51	y	Gauteng	rhodesn@multotec.co.za	100m-499m	YES	Other
52	y	Western Cape	tryg@tank.co.za	10m-99m	YES	Electrical Engineering

SUBJECT	INCLUDE	PROVINCE	EMAIL_ADDRESS	ANNUAL_REVENUE	COPY_OF_RESULTS	INDUSTRY_SECTOR
53	y	Northern Cape	rory@norths.co.za	10m-99m	YES	Timber, Furniture
54	y	Kwazulu Natal	hardware@iafrica.com	100m-499m	YES	Electrical Engineering
55	y	Gauteng	winston@darbel.co.za	100m-499m	YES	Other
56	y	Gauteng	kparker@global.co.za	<10m	YES	Timber, Furniture
57	y	Gauteng	saws@mweb.co.za	10m-99m	YES	Other
58	y	Western Cape	apanels@netactive.co.za	10m-99m	YES	Other
59	y	Gauteng	eva@vaccent.co.za	10m-99m	YES	Mechanical Engineering
60	y	Eastern Cape	aubrey@donkin.co.za	10m-99m	YES	Metal Manufacture
61	y	Gauteng	boscomd@bosco.co.za	10m-99m	YES	Electrical Engineering
62	y	Gauteng	john@genlux.co.za	10m-99m	YES	Automotive
63	y	Limpopo	rocky@pixie.co.za	<10m	NO	Paper, Printing and Publishing
64	y	Gauteng	keepsakes@mweb.co.za	<10m	YES	Textiles
65	y	Gauteng	rgsheet@netdial.co.za	10m-99m	YES	Metal Manufacture
66	y	Gauteng	ronald@clickon.co.za	<10m	YES	Automotive
67	y	Gauteng	drien@genophc.co.za	500m-999m	YES	Chemical and Allied Industries
68	y	Western Cape	andrew@capestorm.co.za	10m-99m	YES	Clothing and Footwear
69	y	Gauteng	roberto.nobili@fiat.com	>1000m	YES	Automotive
70	y	Kwazulu Natal	mail@andersoneng.co.za	10m-99m	YES	Other
71	y	Gauteng	hifreq@global.co.za	10m-99m	YES	Other
72	y	Gauteng	colin@makro-med.com	10m-99m	YES	Other
73	y	Gauteng	carol@mutual.co.za	10m-99m	NO	Mechanical Engineering
74	y	Western Cape	b-loony@mweb.co.za	<10m	NO	Other
75	y	Western Cape	doradogifts@telkomsa.net	<10m	YES	Chemical and Allied Industries
76	y	Gauteng	allanhardy@amd-rotolok.co.za	10m-99m	YES	Mechanical Engineering
77	y	Gauteng	jph@improvair.co.za	100m-499m	YES	Mechanical Engineering
78	y	Kwazulu Natal	hbeier@beiersa.co.za	100m-499m	YES	Automotive

SUBJECT	INCLUDE	PROVINCE	EMAIL_ADDRESS	ANNUAL_REVENUE	COPY_OF_RESULTS	INDUSTRY_SECTOR
79	y	Free State	manager@fashionation.co.za	>1000m	YES	Clothing and Footwear
80	y	Gauteng	bstclothing@worldonline.co.za	<10m	YES	Clothing and Footwear
81	y	Gauteng	chrisg@apex-leads.co.za	10m-99m	YES	Other
82	y	Gauteng	barry@spirotech.co.za	10m-99m	YES	Mechanical Engineering
83	y	Western Cape	agave@worldonline	<10m	YES	Food, Drink, Tobacco
84	y	Gauteng	kostag@apex-leads.co.za	10m-99m	YES	Other
85	y	Gauteng	johan@afrit.co.za	100m-499m	YES	Other
86	y	Western Cape	andrew@gmpsa.co.za	10m-99m	YES	Automotive
87	y	Western Cape	multicam@mweb.co.za	<10m	YES	Other
88	y	Western Cape	sachal@iafrica.com	<10m	NO	Construction
89	y	Gauteng	louis.dutoit@improchem.co.za	100m-499m	YES	Chemical and Allied Industries
90	y	Gauteng	dean@sportswear.co.za	<10m	YES	Clothing and Footwear
91	y	Western Cape	davel@atlantis-forge.co.za	100m-499m	YES	Automotive
92	y	Gauteng	richard@dixonbatteries.co.za	10m-99m	YES	Automotive
93	y	Gauteng	prima@iafrica.com	10m-99m	NO	Automotive
94	y	Gauteng	penny@progroup.co.za	<10m	YES	Other
95	y	Gauteng	eezee1@icon.co.za	10m-99m	YES	Timber, Furniture
96	y	North West	andre@waw.co.za	10m-99m	YES	Automotive
97	y	Gauteng	wolfgang.stadler@bmw.co.za	>1000m	YES	Automotive
98	y	Gauteng	admin@aluvin.co.za	10m-99m	YES	Other
99	y	North West	afmit@intekom.co.za	10m-99m	YES	Mechanical Engineering
100	y	North West	keithl@jurgens-ci.co.za	100m-499m	YES	Automotive
101	y	Eastern Cape	wernerv@shatterprufe.co.za	500m-999m	YES	Automotive
102	y	Gauteng	jolynp@mweb.co.za	<10m	YES	Other
103	y	Eastern Cape	erasmus@eberspacher.co.za	>1000m	YES	Automotive
104	y	Gauteng	pdeppe@concor.co.za	100m-499m	YES	Bricks, Pottery, Glass, Cement

SUBJECT	MANAGEMENT_AREA	MANAGEMENT_LEVEL	NUMBER_OF_EMPLOYEES	PRODUCTION_SYSTEM
1	Other	Executive	<100	Jobbing
2	Other	Executive	200-499	Batch
3	CEO/MD	CEO/MD	500-999	Continuous
4	CEO/MD	CEO/MD	200-499	Jobbing
5	CEO/MD	CEO/MD	100-199	Jobbing
6	Production	Executive	>1000	Continuous
7	CEO/MD	CEO/MD	200-499	Discrete
8	CEO/MD	CEO/MD	100-199	Batch
9	CEO/MD	CEO/MD	100-199	Jobbing
10	CEO/MD	CEO/MD	<100	Batch
11	Finance	Executive	100-199	Batch
12	Production	Executive	>1000	Discrete
13	CEO/MD	CEO/MD	>1000	Batch
14	Other	Executive	>1000	Continuous
15	CEO/MD	CEO/MD	100-199	Continuous
16	Finance	CEO/MD	200-499	Continuous
17	CEO/MD	CEO/MD	500-999	Continuous
18	CEO/MD	CEO/MD	100-199	Continuous
19	CEO/MD	CEO/MD	200-499	Batch
20	Other	Executive	>1000	Continuous
21	Engineering	Executive	500-999	Batch
22	Production	Executive	200-499	Continuous
23	CEO/MD	CEO/MD	<100	Jobbing
24	CEO/MD	CEO/MD	200-499	Batch
25	CEO/MD	CEO/MD	100-199	Batch
26	CEO/MD	CEO/MD	<100	Batch

SUBJECT	MANAGEMENT_AREA	MANAGEMENT_LEVEL	NUMBER_OF_EMPLOYEES	PRODUCTION_SYSTEM
27	CEO/MD	CEO/MD	500-999	Batch
28	Production	Executive	>1000	Batch
29	CEO/MD	CEO/MD	500-999	Continuous
30	CEO/MD	CEO/MD	500-999	Discrete
31	Finance	Executive	>1000	Batch
32	CEO/MD	CEO/MD	200-499	Continuous
33	Other	Middle	>1000	Continuous
34	CEO/MD	CEO/MD	100-199	Batch
35	CEO/MD	CEO/MD	>1000	Continuous
36	CEO/MD	CEO/MD	200-499	Repetitive
37	CEO/MD	CEO/MD	<100	Batch
38	Finance	Executive	200-499	Batch
39	CEO/MD	CEO/MD	>1000	Continuous
40	CEO/MD	CEO/MD	200-499	Continuous
41	Production	Executive	100-199	Batch
42	CEO/MD	CEO/MD	<100	Continuous
43	Finance	CEO/MD	<100	Continuous
44	CEO/MD	CEO/MD	>1000	Continuous
45	Engineering	Middle	200-499	Continuous
46	CEO/MD	CEO/MD	200-499	Batch
47	CEO/MD	CEO/MD	>1000	Continuous
48	CEO/MD	CEO/MD	200-499	Jobbing
49	CEO/MD	CEO/MD	<100	Jobbing
50	CEO/MD	CEO/MD	<100	Jobbing
51	Other	Other	200-499	Discrete
52	CEO/MD	CEO/MD	<100	Batch

SUBJECT	MANAGEMENT_AREA	MANAGEMENT_LEVEL	NUMBER_OF_EMPLOYEES	PRODUCTION_SYSTEM
53	CEO/MD	CEO/MD	100-199	Jobbing
54	CEO/MD	CEO/MD	200-499	Jobbing
55	Quality	Middle	100-199	Batch
56	CEO/MD	CEO/MD	<100	Continuous
57	CEO/MD	CEO/MD	<100	Jobbing
58	Finance	Executive	<100	Jobbing
59	CEO/MD	CEO/MD	<100	Jobbing
60	CEO/MD	CEO/MD	100-199	Jobbing
61	Finance	CEO/MD	<100	Batch
62	CEO/MD	CEO/MD	100-199	Batch
63	CEO/MD	CEO/MD	<100	Jobbing
64	CEO/MD	CEO/MD	<100	Continuous
65	Production	CEO/MD	<100	Jobbing
66	CEO/MD	CEO/MD	<100	Continuous
67	CEO/MD	CEO/MD	<100	Continuous
68	CEO/MD	CEO/MD	<100	Continuous
69	Production	Executive	100-199	Continuous
70	Engineering	CEO/MD	<100	Continuous
71	CEO/MD	CEO/MD	<100	Discrete
72	Production	Executive	<100	Batch
73	CEO/MD	Executive	100-199	Continuous
74	CEO/MD	CEO/MD	<100	Jobbing
75	Other	Executive	<100	Batch
76	Engineering	CEO/MD	<100	Batch
77	CEO/MD	CEO/MD	100-199	Jobbing
78	CEO/MD	CEO/MD	200-499	Batch

SUBJECT	MANAGEMENT_AREA	MANAGEMENT_LEVEL	NUMBER_OF_EMPLOYEES	PRODUCTION_SYSTEM
79	Production	Middle	<100	Continuous
80	Production	CEO/MD	<100	Jobbing
81	Engineering	Executive	200-499	Batch
82	CEO/MD	CEO/MD	<100	Batch
83	Production	CEO/MD	<100	Batch
84	CEO/MD	CEO/MD	200-499	Batch
85	CEO/MD	CEO/MD	200-499	Batch
86	CEO/MD	CEO/MD	<100	Continuous
87	CEO/MD	CEO/MD	<100	Jobbing
88	CEO/MD	CEO/MD	<100	Jobbing
89	CEO/MD	CEO/MD	200-499	Batch
90	CEO/MD	CEO/MD	<100	Discrete
91	CEO/MD	CEO/MD	200-499	Batch
92	CEO/MD	CEO/MD	200-499	Batch
93	Finance	Executive	200-499	Jobbing
94	CEO/MD	CEO/MD	<100	Jobbing
95	Finance	Executive	<100	Jobbing
96	CEO/MD	CEO/MD	100-199	Batch
97	Production	Executive	>1000	Continuous
98	CEO/MD	CEO/MD	<100	Batch
99	CEO/MD	CEO/MD	100-199	Batch
100	CEO/MD	CEO/MD	500-999	Batch
101	Production	Executive	>1000	Batch
102	CEO/MD	CEO/MD	<100	Jobbing
103	CEO/MD	CEO/MD	500-999	Continuous
104	CEO/MD	CEO/MD	500-999	Continuous

SUBJECT	T_des01	T_des02	T_des03	T_des04	T_des05	T_mfg06	T_mfg07	T_mfg08	T_mfg09	T_mfg10	T_crd11	T_crd12	T_crd13	T_crd14	T_crd15
1	1	1	4	1	1	1	1	1	1	1	5	5	5	5	5
2	1	1	1	2	2	3	1	1	1	1	5	5	5	5	5
3	4	4	1	4	2	5	1	1	1	4	5	5	5	5	5
4	5	1	1	5	5	5	1	1	1	5	5	5	5	5	5
5	5	2	5	5	1	2	1	1	1	5	5	4	5	5	5
6	5	3	5	4	3	5	1	1	1	5	5	5	5	4	5
7	2	2	1	4	2	5	4	1	2	5	4	5	5	4	5
8	5	4	5	5	4	4	1	1	1	4	4	4	5	5	5
9	5	1	4	5	4	5	1	1	1	3	4	5	5	4	5
10	4	2	2	5	2	2	1	4	2	1	5	4	4	5	5
11	5	4	1	5	5	1	1	1	1	4	4	4	5	5	5
12	5	4	5	5	5	5	4	1	4	4	5	5	5	4	4
13	5	2	4	4	1	4	1	1	1	4	5	5	5	4	4
14	4	2	2	4	2	4	2	2	2	2	5	4	4	5	5
15	5	2	5	5	4	4	4	1	1	4	4	4	5	5	5
16	1	1	1	1	5	1	1	1	1	1	4	5	5	5	4
17	4	4	4	4	4	5	4	4	2	4	4	5	5	5	4
18	1	1	1	5	1	5	2	2	2	1	5	4	4	5	5
19	5	4	5	2	4	1	1	1	1	1	4	5	5	4	4
20	5	5	3	4	4	5	1	1	4	4	4	4	5	5	4
21	5	4	2	5	2	5	4	1	1	4	4	4	5	5	4
22	4	4	3	5	5	5	5	1	1	4	5	4	4	4	5
23	5	5	5	5	3	5	1	1	1	5	5	5	5	5	2
24	5	4	5	5	4	5	2	1	1	4	5	5	5	2	5
25	4	2	5	2	2	4	1	1	1	2	2	4	5	5	5
26	5	4	5	5	5	5	5	5	4	5	5	4	5	2	5

SUBJECT	T_des01	T_des02	T_des03	T_des04	T_des05	T_mfg06	T_mfg07	T_mfg08	T_mfg09	T_mfg10	T_crd11	T_crd12	T_crd13	T_crd14	T_crd15
27	5	5	5	5	4	5	2	1	2	4	2	4	5	5	5
28	4	1	1	5	1	5	2	1	4	1	4	5	5	2	5
29	4	2	3	4	4	4	1	1	2	2	4	4	4	4	4
30	4	4	4	4	2	4	4	1	1	4	4	4	4	4	4
31	4	2	4	2	4	4	2	2	4	4	4	4	4	4	4
32	2	2	2	4	4	4	2	1	2	4	5	5	5	5	1
33	5	5	5	3	3	5	5	3	3	3	5	5	5	5	1
34	5	4	5	5	4	4	1	1	1	4	1	5	5	5	5
35	5	5	5	5	2	4	4	1	1	2	5	2	5	4	4
36	5	2	5	5	2	1	5	5	5	5	4	5	5	5	1
37	1	1	1	3	1	5	5	1	4	5	4	4	5	4	2
38	5	4	4	3	4	4	2	2	4	4	4	4	5	4	2
39	4	4	4	5	4	4	4	2	2	3	4	4	4	2	5
40	4	4	3	2	4	4	5	1	2	2	4	4	4	2	5
41	1	1	1	2	4	1	1	1	1	4	2	4	5	3	5
42	1	1	1	2	4	5	4	1	4	1	1	5	4	5	4
43	4	2	1	5	4	1	1	1	1	5	1	4	4	5	5
44	5	4	4	2	4	5	1	4	2	1	2	4	4	4	4
45	4	2	5	4	4	4	1	1	1	2	2	4	4	4	4
46	1	1	1	2	1	5	1	1	1	1	2	4	4	4	4
47	4	4	3	4	4	5	2	4	1	4	4	4	4	4	2
48	4	1	1	5	1	1	1	1	1	4	2	3	4	4	4
49	2	2	2	1	4	1	1	1	1	4	5	1	2	5	5
50	5	4	5	5	4	2	1	1	1	5	2	5	5	5	1
51	5	4	5	5	4	4	1	1	1	4	4	2	5	4	2
52	4	2	1	5	1	5	1	1	1	4	2	4	5	4	2

SUBJECT	T_des01	T_des02	T_des03	T_des04	T_des05	T_mfg06	T_mfg07	T_mfg08	T_mfg09	T_mfg10	T_crd11	T_crd12	T_crd13	T_crd14	T_crd15
53	1	1	1	2	1	1	1	1	1	3	5	4	4	2	2
54	5	5	5	5	5	5	1	1	1	4	2	4	4	2	5
55	4	3	2	4	1	5	2	2	2	2	4	4	5	2	2
56	1	1	1	1	5	1	1	1	1	5	2	4	4	4	2
57	5	4	4	5	3	5	2	1	2	4	4	4	2	4	2
58	2	2	2	4	2	2	2	2	2	2	4	2	2	4	4
59	5	2	2	5	1	1	1	1	1	1	4	4	4	2	2
60	5	4	4	4	4	4	4	2	2	4	2	4	4	4	2
61	1	1	1	5	1	5	4	1	1	4	2	4	4	4	2
62	4	4	1	3	4	1	1	1	1	2	2	4	5	2	3
63	4	1	4	3	4	4	1	1	1	1	5	4	3	2	2
64	1	1	1	1	1	1	1	1	1	5	1	5	5	5	1
65	5	2	5	5	5	5	4	1	1	5	1	5	5	5	1
66	5	5	5	5	4	5	1	1	4	1	5	1	5	5	1
67	5	5	5	1	5	5	5	5	5	5	1	5	1	5	5
68	4	4	4	2	1	2	1	1	1	4	2	2	2	4	5
69	4	1	1	5	4	5	1	1	1	1	4	5	5	1	1
70	4	2	4	4	1	1	1	2	1	1	4	5	5	1	1
71	5	4	1	5	3	5	1	1	1	5	2	4	4	4	1
72	1	1	1	2	4	5	1	1	1	5	2	4	4	1	4
73	5	4	4	2	4	5	2	2	2	4	1	4	4	4	2
74	1	1	1	5	1	5	1	1	1	1	2	5	1	2	5
75	2	2	2	4	2	2	2	2	2	2	4	2	4	2	2
76	5	4	4	5	4	4	2	2	2	4	2	2	4	4	2
77	5	4	4	5	1	5	4	1	1	4	4	4	2	2	2
78	5	4	4	4	4	5	5	2	2	1	2	2	4	4	2

SUBJECT	T_des01	T_des02	T_des03	T_des04	T_des05	T_mfg06	T_mfg07	T_mfg08	T_mfg09	T_mfg10	T_crd11	T_crd12	T_crd13	T_crd14	T_crd15
79	1	1	1	1	4	1	1	1	1	4	1	1	4	4	5
80	1	1	1	1	3	1	1	1	1	1	1	5	1	3	5
81	5	2	5	2	1	4	2	2	2	4	2	2	5	2	2
82	5	3	5	5	3	2	1	1	1	4	1	5	5	1	2
83	1	1	1	1	5	4	1	1	1	4	1	4	4	2	2
84	5	4	5	4	2	5	2	2	2	4	2	2	4	2	2
85	5	5	5	5	4	4	2	1	1	4	2	4	5	1	1
86	3	2	1	4	2	3	2	3	3	3	2	4	3	2	1
87	5	1	5	5	4	5	1	1	1	4	4	2	1	3	2
88	5	4	5	4	5	1	1	1	1	5	1	4	4	2	1
89	1	1	1	5	1	4	1	1	1	5	2	2	4	2	1
90	2	1	2	4	4	2	2	2	2	4	2	2	2	2	2
91	5	2	4	4	1	5	1	1	1	3	2	2	2	2	2
92	2	4	1	2	2	4	2	1	1	4	2	2	2	2	2
93	5	5	1	5	5	5	1	1	1	5	1	3	1	5	1
94	5	2	2	5	4	1	1	1	2	5	1	2	2	2	1
95	5	1	2	2	4	4	1	1	1	4	2	2	1	1	1
96	5	1	5	5	5	5	2	1	1	5	1	2	1	1	1
97	4	4	4	5	4	5	4	1	1	4	4	5	5	4	4
98	2	1	1	2	3	1	1	1	1	1	3	4	1	3	2
99	1	1	1	5	1	1	1	1	1	5	1	4	4	1	4
100	5	4	5	5	4	4	2	1	1	4	1	2	4	2	4
101	4	4	2	4	4	5	5	1	1	4	5	5	5	5	5
102	1	1	1	1	2	2	1	1	1	1	5	4	1	4	5
103	5	2	2	5	2	5	5	2	2	5	5	2	5	5	5
104	1	1	1	2	1	5	1	1	1	1	5	2	5	4	4

SUBJECT	T_int16	T_int17	T_int18	T_int19	T_int20	O_skl21	O_skl22	O_skl23	O_skl24	O_skl25	O_tmd26	O_tmd27	O_tmd28	O_tmd29	O_tmd30
1	2	1	5	5	1	1	4	2	4	2	1	4	4	4	4
2	1	5	5	3	4	3	2	4	3	2	2	3	2	2	4
3	4	1	5	2	4	5	4	2	5	4	4	4	4	4	4
4	5	5	5	5	1	5	2	2	4	5	2	4	4	4	5
5	2	1	5	1	1	5	5	5	5	1	4	4	4	2	2
6	2	5	5	5	2	4	4	2	4	4	4	4	4	4	4
7	1	2	5	4	4	4	4	2	5	4	4	4	4	2	5
8	2	2	5	2	4	4	4	5	4	4	2	4	4	4	4
9	2	2	5	1	1	4	4	2	4	1	1	3	4	4	1
10	4	2	4	4	4	4	4	2	4	4	4	4	4	4	2
11	1	4	5	2	5	4	4	4	4	3	1	4	3	2	4
12	4	5	5	4	2	5	4	4	5	2	4	5	5	5	5
13	2	4	4	4	2	4	4	4	4	3	2	4	3	2	2
14	2	4	5	4	2	4	4	2	4	4	4	4	4	4	4
15	2	3	5	2	2	5	5	1	4	5	4	4	5	5	5
16	1	5	5	1	2	4	3	4	4	3	2	4	4	3	4
17	4	4	5	2	4	4	3	2	5	4	4	4	4	4	4
18	1	5	4	4	4	4	4	2	4	3	4	4	4	4	5
19	2	2	5	4	1	4	4	2	4	4	2	3	3	3	3
20	3	1	5	4	4	4	4	2	4	4	4	4	4	4	4
21	2	2	2	2	2	4	4	4	4	4	2	3	2	1	2
22	5	2	5	2	4	5	4	5	5	2	2	4	4	4	4
23	5	2	5	5	1	4	4	4	4	2	2	4	4	4	5
24	2	2	5	2	1	4	5	4	5	4	4	4	4	4	5
25	2	2	4	4	4	4	4	4	5	4	4	4	4	4	5
26	4	5	5	4	5	4	4	4	4	4	5	5	5	4	5

SUBJECT	T_int16	T_int17	T_int18	T_int19	T_int20	O_skl21	O_skl22	O_skl23	O_skl24	O_skl25	O_tmd26	O_tmd27	O_tmd28	O_tmd29	O_tmd30
27	4	2	4	2	2	4	4	4	4	4	4	4	4	4	5
28	1	1	4	4	3	4	4	3	5	5	4	4	3	2	4
29	2	3	2	2	2	2	3	2	5	3	2	2	4	4	5
30	2	4	4	4	2	3	2	2	3	1	2	2	2	4	4
31	4	2	4	2	2	4	4	2	4	4	4	4	4	4	4
32	2	4	5	4	4	4	5	2	4	4	4	4	4	4	4
33	5	5	5	5	5	3	4	2	3	3	2	4	4	4	3
34	4	2	5	1	2	4	4	4	4	3	4	2	4	4	2
35	4	3	5	2	5	5	5	4	4	1	2	4	4	4	5
36	4	4	5	1	2	4	2	2	4	5	2	4	2	2	4
37	1	4	5	4	2	5	4	2	5	5	4	4	5	4	4
38	4	2	4	4	4	4	4	2	4	4	4	4	4	4	2
39	4	4	4	5	3	4	4	4	4	4	2	4	3	4	5
40	3	2	4	2	2	4	3	3	4	2	3	3	3	3	4
41	1	1	5	1	4	4	3	2	4	2	1	2	2	1	2
42	1	3	5	5	5	5	5	5	4	2	5	5	4	4	4
43	2	2	4	2	4	5	5	5	5	5	2	5	2	2	5
44	4	4	5	4	2	4	4	1	5	2	2	4	4	4	5
45	1	4	5	4	1	1	1	2	4	2	2	1	2	4	5
46	1	2	4	4	2	2	2	3	4	3	2	4	4	2	4
47	4	4	4	2	2	4	4	4	4	4	4	4	4	4	4
48	2	4	4	2	2	4	3	2	5	3	4	4	4	3	3
49	1	5	1	1	4	4	4	4	5	4	4	4	5	4	4
50	5	2	5	5	2	4	4	4	4	5	4	4	4	4	1
51	2	4	3	3	2	3	4	4	4	2	3	4	4	4	4
52	2	2	2	1	4	4	5	4	5	2	4	4	4	4	4

SUBJECT	T_int16	T_int17	T_int18	T_int19	T_int20	O_skl21	O_skl22	O_skl23	O_skl24	O_skl25	O_tmd26	O_tmd27	O_tmd28	O_tmd29	O_tmd30
53	1	2	1	4	4	4	4	3	4	2	4	4	4	3	4
54	5	2	4	2	1	4	4	4	4	4	4	4	4	4	4
55	3	2	4	2	3	4	4	2	4	4	2	4	4	4	2
56	1	2	4	4	2	4	4	2	4	4	4	4	4	4	4
57	2	4	4	4	2	4	4	4	5	4	4	4	4	4	4
58	2	4	2	2	2	2	2	4	2	4	2	2	2	2	2
59	2	3	4	1	4	5	5	4	4	4	4	4	5	5	2
60	4	4	4	2	4	4	5	4	4	4	2	4	4	4	4
61	4	2	4	2	2	4	4	5	4	4	2	4	4	2	4
62	1	5	4	4	5	4	4	2	4	2	2	4	2	4	2
63	4	5	4	1	2	4	4	2	4	2	3	4	4	4	2
64	5	1	5	5	5	5	4	5	5	1	4	4	5	4	5
65	5	1	2	4	4	5	5	1	5	5	5	5	5	5	5
66	5	5	5	5	4	4	4	5	5	5	2	5	5	5	5
67	1	4	3	2	4	1	2	1	1	1	1	4	2	3	3
68	4	2	4	2	5	4	4	4	4	4	4	4	5	3	4
69	1	5	5	1	4	5	5	1	5	4	5	5	5	5	2
70	5	1	5	3	5	5	5	1	4	4	3	4	5	5	1
71	4	2	5	3	5	5	4	4	5	2	1	5	4	4	4
72	1	1	5	1	4	4	4	1	4	5	1	2	4	4	4
73	4	2	4	4	5	4	4	3	4	2	2	4	2	3	5
74	1	1	5	1	5	4	4	2	4	1	5	5	5	5	2
75	2	4	2	2	2	4	4	4	4	4	2	4	2	2	2
76	4	3	4	4	4	4	4	2	4	2	1	2	2	4	4
77	4	3	2	2	2	3	4	4	3	2	2	3	4	4	4
78	4	4	4	4	5	4	4	5	2	3	2	4	4	4	4

SUBJECT	T_int16	T_int17	T_int18	T_int19	T_int20	O_skl21	O_skl22	O_skl23	O_skl24	O_skl25	O_tmd26	O_tmd27	O_tmd28	O_tmd29	O_tmd30
79	1	1	2	2	2	2	5	1	1	1	2	5	4	2	2
80	1	3	1	1	1	4	4	2	1	1	3	3	4	4	4
81	2	2	5	4	4	4	5	4	5	5	4	4	4	4	5
82	2	2	2	1	5	5	5	5	5	5	1	4	5	5	5
83	1	1	2	4	5	4	4	1	5	1	5	4	4	2	3
84	2	2	4	4	4	4	4	2	4	2	2	4	4	4	4
85	4	2	4	2	2	4	4	5	5	5	3	4	2	4	4
86	1	2	2	4	4	2	4	2	2	4	3	4	2	4	2
87	5	4	4	1	5	4	5	3	4	2	4	4	3	4	2
88	5	1	4	4	4	5	5	2	4	4	5	5	4	4	5
89	1	1	5	1	4	5	4	1	5	5	5	5	4	5	5
90	2	2	4	4	5	4	2	2	2	2	4	4	2	4	4
91	3	4	2	2	1	4	3	3	5	2	3	4	3	4	2
92	2	4	2	4	5	4	4	1	4	2	4	4	4	5	4
93	1	1	1	1	1	5	4	1	5	1	2	2	1	1	3
94	2	1	2	1	3	4	5	4	5	4	4	5	5	5	4
95	2	1	2	2	2	2	4	2	3	4	2	2	2	2	2
96	3	4	2	2	1	4	5	5	5	5	2	2	4	4	5
97	4	4	5	5	4	5	5	2	5	3	4	4	4	4	3
98	1	2	4	1	5	3	3	2	4	2	1	2	3	2	3
99	1	1	5	2	1	1	2	1	5	1	1	1	1	1	5
100	2	2	2	2	2	4	2	2	4	1	2	4	4	4	2
101	1	4	4	4	2	4	4	2	5	2	5	5	5	4	4
102	1	5	1	2	1	1	4	5	4	2	1	2	4	4	2
103	2	4	5	4	5	5	4	2	4	4	4	4	4	4	5
104	1	1	4	1	4	4	4	2	5	4	4	4	4	2	4

SUBJECT	O_org31	O_org32	O_org33	O_org34	O_org35	O_rel36	O_rel37	O_rel38	O_rel39	O_rel40	O_cul41	O_cul42	O_cul43	O_cul44	O_cul45
1	4	3	4	2	2	3	3	2	5	3	4	3	4	2	4
2	4	2	4	2	2	4	2	2	4	3	3	2	2	3	2
3	2	4	2	4	4	4	4	2	5	4	4	4	5	1	4
4	2	2	2	2	2	4	4	4	4	4	4	4	4	5	4
5	4	4	2	5	4	4	4	2	4	2	2	4	4	4	5
6	4	4	2	4	4	4	2	3	4	4	5	5	5	4	5
7	4	2	2	5	4	4	2	4	4	4	4	4	4	5	4
8	4	4	2	4	2	1	2	4	4	2	4	4	5	5	4
9	1	3	1	1	5	4	1	3	5	1	5	1	5	5	4
10	2	4	2	2	2	3	4	2	4	4	1	5	4	5	4
11	4	2	2	1	2	4	2	4	4	2	4	2	4	4	3
12	2	4	1	5	4	5	3	2	5	5	5	4	5	5	5
13	4	4	4	2	2	4	2	4	4	4	4	4	4	4	4
14	4	4	2	4	4	4	2	4	4	4	4	4	4	4	4
15	2	4	2	4	4	4	2	5	4	5	5	5	5	4	5
16	4	2	2	2	2	4	2	4	4	4	3	2	4	4	2
17	1	5	1	4	2	4	2	4	4	4	4	5	5	5	4
18	2	4	2	4	4	4	4	4	5	5	5	4	4	5	5
19	4	3	2	4	3	4	2	4	4	4	4	4	4	4	4
20	2	4	2	4	5	4	2	4	4	4	4	4	4	4	4
21	5	4	2	1	1	2	2	5	4	4	1	2	2	1	2
22	2	3	1	2	2	4	2	1	4	4	5	5	5	4	5
23	2	4	2	4	2	4	2	4	3	4	4	4	4	4	4
24	4	2	2	2	2	4	2	4	3	4	4	2	5	2	4
25	4	4	4	4	4	4	4	4	4	4	4	5	5	4	4
26	3	5	2	2	4	3	1	3	4	1	1	5	5	5	5

SUBJECT	O_org31	O_org32	O_org33	O_org34	O_org35	O_rel36	O_rel37	O_rel38	O_rel39	O_rel40	O_cul41	O_cul42	O_cul43	O_cul44	O_cul45
27	4	4	3	4	4	4	1	5	5	2	4	4	5	2	5
28	2	3	2	4	4	4	1	4	4	4	4	4	3	4	4
29	2	2	2	3	3	4	4	3	2	4	2	4	4	4	4
30	2	4	2	2	2	2	2	4	3	2	4	4	3	4	3
31	4	2	2	2	2	4	4	4	4	4	4	4	4	4	4
32	2	4	4	3	4	4	4	4	4	3	4	5	5	5	4
33	2	4	3	2	2	5	3	4	5	5	4	4	5	5	5
34	2	2	2	2	2	4	4	4	3	4	2	4	4	4	4
35	1	2	1	4	4	4	4	4	4	2	5	5	4	5	4
36	2	5	1	4	2	2	3	1	4	4	4	4	4	4	1
37	3	5	1	4	4	4	2	3	4	4	5	4	4	4	1
38	3	2	2	4	4	2	4	2	4	4	2	4	4	4	4
39	2	3	2	2	3	4	1	4	4	3	4	4	4	4	3
40	2	4	3	2	2	4	3	3	4	4	3	4	4	4	4
41	2	2	2	1	2	4	2	1	4	2	2	2	4	2	5
42	1	1	5	1	4	4	1	2	4	1	4	5	5	5	5
43	4	1	5	1	1	1	1	5	4	4	5	5	5	5	1
44	2	1	4	4	4	2	4	1	2	4	4	4	5	5	2
45	4	1	2	2	4	2	4	1	1	2	1	1	1	4	2
46	4	2	3	2	2	4	4	2	4	3	4	2	4	4	4
47	2	3	2	4	4	4	2	2	4	4	4	4	4	4	5
48	4	2	2	2	2	4	2	4	4	5	4	4	4	5	4
49	1	1	5	2	2	5	1	1	4	1	4	2	5	4	5
50	4	2	2	4	4	5	4	5	4	4	4	4	5	4	4
51	4	2	2	2	2	3	1	3	3	3	4	4	4	4	3
52	2	4	2	4	2	4	2	2	2	2	4	4	4	2	4

SUBJECT	O_org31	O_org32	O_org33	O_org34	O_org35	O_rel36	O_rel37	O_rel38	O_rel39	O_rel40	O_cul41	O_cul42	O_cul43	O_cul44	O_cul45
53	5	1	2	2	4	4	3	1	4	4	5	4	4	5	2
54	2	4	2	4	4	4	2	2	2	2	4	4	4	4	4
55	4	2	4	2	2	4	4	2	5	4	2	4	5	5	4
56	4	2	2	2	2	4	2	2	4	2	4	4	4	4	4
57	2	4	4	1	2	5	5	2	5	5	5	4	5	4	5
58	4	2	2	2	2	4	3	3	3	2	4	4	4	4	4
59	4	2	2	2	4	4	3	2	3	2	5	4	4	5	5
60	4	4	2	4	4	4	2	4	4	4	5	4	5	5	5
61	5	4	2	2	2	1	1	4	4	1	5	4	4	2	4
62	2	2	4	2	2	2	1	1	4	4	2	4	5	4	4
63	2	4	2	2	2	4	2	2	4	3	4	4	4	4	4
64	5	1	5	5	2	2	1	5	2	1	1	5	4	1	5
65	1	5	1	5	1	5	2	1	5	1	5	5	5	5	5
66	4	5	1	2	3	4	1	4	4	1	5	5	5	5	5
67	2	3	3	3	5	1	3	5	5	1	1	5	1	3	2
68	3	4	2	4	4	5	2	4	4	4	2	4	5	1	4
69	4	2	4	1	1	5	2	4	5	4	5	2	5	5	4
70	4	1	1	1	1	4	3	4	4	4	5	4	5	4	5
71	4	2	2	1	2	5	4	2	4	4	3	5	4	2	4
72	2	4	2	2	4	4	2	4	4	5	4	5	5	4	5
73	2	2	2	2	2	5	1	2	4	2	5	5	5	5	4
74	2	2	2	2	2	4	2	2	3	2	2	3	4	4	4
75	4	2	2	2	2	2	2	3	2	2	2	4	4	3	4
76	2	4	4	2	2	2	2	1	4	4	2	2	4	4	4
77	4	2	3	2	4	2	3	2	2	4	3	2	4	4	4
78	4	3	2	2	2	4	2	2	4	4	4	4	4	5	4

SUBJECT	O_org31	O_org32	O_org33	O_org34	O_org35	O_rel36	O_rel37	O_rel38	O_rel39	O_rel40	O_cul41	O_cul42	O_cul43	O_cul44	O_cul45
79	2	2	2	4	5	5	2	2	4	2	4	2	5	4	5
80	5	3	2	2	5	1	1	1	5	1	5	5	5	3	5
81	5	4	2	2	2	4	4	5	4	4	5	4	4	5	5
82	5	2	1	1	1	2	3	4	4	4	2	4	5	4	2
83	2	5	2	1	1	5	5	5	2	1	4	5	5	2	3
84	2	4	2	2	2	4	4	5	4	4	4	4	4	4	5
85	5	5	1	1	1	4	4	4	4	2	5	5	5	2	3
86	2	3	2	2	2	4	4	2	4	4	2	4	4	2	4
87	1	5	1	4	4	4	1	2	2	1	3	5	5	5	5
88	2	4	2	1	1	4	4	4	4	2	4	4	4	2	4
89	4	4	1	1	2	4	1	3	5	1	5	4	5	4	4
90	4	2	4	2	2	4	2	2	2	2	4	4	4	4	2
91	4	4	2	2	2	4	3	4	4	4	3	3	4	4	3
92	4	2	2	1	2	4	2	4	5	4	5	4	5	5	5
93	4	1	2	1	1	2	5	5	4	5	5	5	5	5	5
94	4	1	2	2	2	5	1	2	4	2	4	4	5	4	5
95	2	2	4	2	2	4	2	2	4	2	2	2	4	4	4
96	5	1	4	1	4	4	1	5	4	1	2	5	5	2	5
97	2	4	2	3	3	4	4	4	5	4	4	5	5	5	4
98	4	1	2	2	2	5	1	2	4	3	3	2	4	5	3
99	5	1	5	4	4	1	1	3	1	1	2	1	5	1	3
100	2	2	2	2	2	4	2	2	4	2	2	4	4	2	4
101	2	4	2	4	4	5	2	4	5	4	4	4	4	5	4
102	2	2	2	1	1	3	1	4	1	1	3	4	5	5	2
103	2	2	2	3	2	4	1	4	4	4	4	3	4	5	3
104	2	4	2	1	4	4	2	4	4	4	4	4	4	5	5

SUBJECT	P_qty46	P_qty47	P_qty48	P_qty49	P_qty50	P_spd51	P_spd52	P_spd53	P_spd54	P_spd55	P_dpn56	P_dpn57	P_dpn58	P_dpn59	P_dpn60
1	5	4	5	5	5	1	2	4	1	1	2	5	4	5	5
2	4	2	4	4	4	2	2	4	4	3	4	4	4	4	4
3	5	5	5	5	2	2	4	4	2	4	4	4	4	4	4
4	4	5	2	4	4	4	2	5	2	4	4	4	4	4	4
5	5	2	3	5	5	1	2	4	4	4	2	4	5	4	4
6	5	3	2	4	3	1	2	4	4	4	4	4	4	4	4
7	5	4	4	5	5	2	4	5	5	5	5	4	2	4	4
8	5	4	4	5	5	4	2	2	2	2	4	4	4	4	4
9	4	4	4	5	5	2	2	4	3	3	4	2	2	3	3
10	4	4	4	4	5	4	2	4	2	5	2	4	4	4	4
11	5	5	5	5	5	4	5	5	5	5	5	4	5	4	4
12	5	5	5	5	5	4	2	5	5	4	2	5	5	5	5
13	4	4	4	4	4	4	2	2	2	2	2	2	4	4	4
14	4	4	4	4	4	4	4	4	4	4	2	4	4	4	4
15	5	4	5	5	4	5	2	4	4	4	1	5	5	5	5
16	5	5	5	5	5	4	2	4	4	4	4	4	4	5	4
17	4	4	5	4	4	2	4	4	3	5	4	4	5	4	4
18	5	5	4	4	5	4	2	4	5	4	2	4	4	4	4
19	5	4	4	5	4	4	2	4	4	4	4	4	4	4	4
20	4	2	3	4	3	2	3	4	4	4	2	3	3	3	4
21	4	2	4	4	5	3	1	2	1	2	2	2	4	4	4
22	5	4	4	5	5	4	2	4	4	4	4	4	4	4	4
23	4	4	4	5	4	3	2	4	4	4	2	4	4	3	3
24	5	4	4	5	4	4	4	5	5	2	4	4	4	4	4
25	5	4	4	4	5	4	4	4	4	4	4	4	5	5	4
26	5	5	5	5	5	1	2	5	4	4	5	5	5	4	3

SUBJECT	P_qty46	P_qty47	P_qty48	P_qty49	P_qty50	P_spd51	P_spd52	P_spd53	P_spd54	P_spd55	P_dpn56	P_dpn57	P_dpn58	P_dpn59	P_dpn60
27	4	5	4	5	5	2	4	4	4	4	4	4	2	4	4
28	5	4	4	5	4	2	2	4	2	4	3	4	4	4	3
29	5	4	4	5	2	4	4	4	4	2	4	2	1	4	4
30	4	2	4	4	2	2	2	4	2	2	2	2	1	2	2
31	5	4	4	5	5	4	2	4	4	4	4	4	4	4	4
32	5	4	4	4	4	4	3	4	4	4	3	4	2	4	4
33	5	3	4	5	5	4	2	4	2	3	1	4	4	4	3
34	4	3	5	4	3	4	4	4	2	2	1	5	4	2	2
35	4	4	4	4	2	2	2	5	3	5	4	4	2	3	4
36	4	4	4	5	2	5	1	2	1	1	4	2	4	2	4
37	5	2	4	5	4	3	4	5	4	5	4	5	4	5	1
38	4	2	4	4	4	4	2	4	4	2	2	4	4	4	4
39	4	4	4	5	4	3	4	5	2	4	2	4	2	4	4
40	4	3	4	3	4	2	2	3	3	2	2	3	3	3	3
41	4	2	4	5	3	1	1	3	2	1	2	5	4	2	4
42	5	5	4	5	3	5	3	4	4	2	3	4	5	5	4
43	5	5	5	5	5	4	2	5	5	2	5	4	5	5	4
44	5	5	4	5	5	2	4	5	4	4	4	5	4	4	4
45	4	1	4	3	2	1	1	2	2	2	1	2	1	4	2
46	5	4	4	4	4	2	4	4	4	4	2	4	4	4	4
47	4	4	4	4	3	2	3	4	4	2	4	4	4	4	4
48	5	5	4	5	5	2	2	4	3	5	3	3	4	3	4
49	4	5	4	5	4	4	4	4	5	5	4	4	2	5	4
50	5	5	4	4	4	4	2	4	2	2	4	4	4	4	4
51	5	5	5	4	4	3	3	4	5	5	4	3	5	3	3
52	4	4	4	4	4	4	4	4	4	4	2	4	4	4	4

SUBJECT	P_qty46	P_qty47	P_qty48	P_qty49	P_qty50	P_spd51	P_spd52	P_spd53	P_spd54	P_spd55	P_dpn56	P_dpn57	P_dpn58	P_dpn59	P_dpn60
53	4	5	3	4	5	2	5	4	5	2	5	4	4	4	4
54	4	2	4	4	4	4	4	4	2	2	4	4	4	2	2
55	5	5	4	5	5	2	2	4	3	2	2	5	4	4	4
56	4	3	4	4	4	4	3	4	3	2	2	4	4	4	4
57	5	4	4	5	5	4	1	4	4	2	4	4	4	4	4
58	4	3	4	4	3	2	4	4	4	4	4	4	3	4	4
59	5	5	4	5	5	1	3	5	4	4	2	4	4	4	1
60	5	4	4	4	5	2	2	4	4	4	4	4	4	4	4
61	5	4	4	4	4	2	4	5	4	2	4	4	4	4	4
62	4	5	3	5	4	4	4	5	4	2	4	4	4	5	5
63	4	4	4	4	3	2	2	4	4	2	3	4	4	4	4
64	5	5	5	5	5	1	5	5	5	1	5	5	1	5	5
65	5	5	5	5	5	5	4	5	5	1	5	5	5	5	5
66	5	5	5	5	4	5	5	5	5	4	5	3	5	5	5
67	2	1	1	5	5	1	2	5	1	1	5	1	1	1	1
68	5	5	4	5	5	4	1	4	4	2	4	4	4	4	4
69	5	4	5	5	2	2	2	2	4	2	2	2	2	2	1
70	5	4	3	4	5	2	1	4	4	2	2	4	4	4	4
71	4	2	2	5	5	4	2	4	4	4	2	3	4	3	3
72	4	2	4	4	2	2	4	4	4	2	2	4	4	4	4
73	4	4	4	4	5	4	2	4	4	2	2	4	4	4	4
74	4	2	4	4	4	4	4	4	4	4	2	4	4	5	3
75	4	4	4	4	3	4	4	3	4	4	4	3	4	4	4
76	4	4	3	4	4	4	2	4	4	4	4	4	4	2	2
77	4	4	4	4	5	4	2	4	4	4	5	4	4	4	4
78	4	4	4	4	5	4	3	4	4	4	4	4	4	4	4

SUBJECT	P_qty46	P_qty47	P_qty48	P_qty49	P_qty50	P_spd51	P_spd52	P_spd53	P_spd54	P_spd55	P_dpn56	P_dpn57	P_dpn58	P_dpn59	P_dpn60
79	5	4	4	5	5	2	4	5	4	2	4	4	2	5	4
80	4	5	5	4	4	1	2	3	2	3	1	5	4	4	2
81	5	5	5	5	5	5	1	5	2	4	5	4	4	4	5
82	5	5	4	4	5	5	2	4	3	4	4	4	4	4	4
83	5	4	4	5	5	2	4	5	3	2	2	4	5	4	4
84	5	5	5	4	5	5	2	4	4	2	4	4	4	4	4
85	5	4	4	5	5	4	3	5	4	4	5	5	5	4	4
86	4	3	4	4	5	4	2	4	2	2	2	4	4	4	2
87	5	4	4	4	4	5	4	5	2	4	4	4	5	4	3
88	4	4	4	4	4	4	4	4	2	2	4	4	4	4	2
89	2	4	5	5	5	5	4	4	4	5	2	5	5	4	5
90	5	4	4	4	4	4	4	4	4	2	2	4	4	4	4
91	5	4	4	5	3	2	1	2	2	4	2	2	2	4	3
92	5	5	5	5	4	4	4	4	4	4	4	5	5	5	4
93	5	5	5	5	4	2	2	4	5	4	5	5	5	3	4
94	5	4	4	5	5	5	5	5	4	2	4	5	4	5	5
95	4	4	4	4	4	2	3	4	2	2	2	4	4	4	3
96	5	1	5	5	4	4	1	4	2	2	2	4	4	4	4
97	5	5	5	5	4	4	3	4	3	3	3	4	4	4	4
98	4	5	4	5	5	2	5	4	2	3	5	4	3	4	4
99	1	4	2	4	5	3	2	3	1	1	4	4	1	2	2
100	3	2	3	4	3	2	2	3	2	2	3	2	2	2	2
101	4	2	4	5	5	4	2	4	2	2	2	4	2	5	4
102	5	5	1	5	5	5	4	5	5	1	1	5	1	5	5
103	5	4	4	5	4	5	3	4	3	2	2	4	4	4	3
104	5	5	5	5	4	4	3	4	4	5	5	5	4	4	1

SUBJECT	P_flx61	P_flx62	P_flx63	P_flx64	P_flx65	P_cst66	P_cst67	P_cst68	P_cst69	P_cst70
1	3	5	5	4	4	2	1	2	5	4
2	3	4	4	4	4	2	4	3	3	2
3	3	5	2	4	4	2	4	4	2	2
4	4	4	4	4	4	2	2	4	2	2
5	2	5	5	4	5	1	4	4	2	2
6	1	4	4	2	3	2	4	4	3	4
7	3	4	4	4	4	2	2	2	4	1
8	4	4	5	2	4	2	2	4	4	4
9	4	4	5	1	2	2	5	5	5	2
10	4	4	4	2	2	2	4	2	4	2
11	4	4	5	4	4	2	2	4	2	2
12	3	5	5	2	5	1	2	2	2	2
13	2	4	4	4	4	2	2	2	2	4
14	4	4	4	4	4	2	4	2	2	2
15	5	5	2	4	5	1	4	4	4	2
16	3	4	2	2	2	2	4	4	4	3
17	5	4	4	4	4	2	2	2	2	2
18	4	4	4	4	4	2	2	2	2	2
19	3	4	4	4	4	2	2	3	3	3
20	4	3	4	3	4	2	4	2	3	2
21	2	2	4	2	4	3	4	2	4	4
22	4	4	5	2	4	1	2	3	2	2
23	3	4	4	2	4	2	2	4	2	2
24	5	5	5	4	5	2	2	4	2	4
25	5	4	5	2	4	2	3	2	4	2
26	5	5	4	4	5	3	1	4	1	1

SUBJECT	P_flx61	P_flx62	P_flx63	P_flx64	P_flx65	P_cst66	P_cst67	P_cst68	P_cst69	P_cst70
27	3	3	4	4	4	4	1	4	2	2
28	2	4	3	3	4	2	4	3	2	2
29	2	4	5	3	4	1	5	2	4	4
30	1	4	2	2	2	2	2	4	4	2
31	4	4	4	4	4	2	2	4	2	2
32	4	4	4	4	5	2	4	5	2	2
33	4	5	5	4	4	2	2	4	3	2
34	5	5	5	4	4	2	3	2	3	2
35	3	5	5	4	4	1	3	2	2	1
36	3	4	4	4	2	4	4	2	5	4
37	3	5	4	4	4	1	2	4	2	2
38	2	4	4	4	4	2	4	2	2	2
39	3	5	2	2	4	3	3	3	4	4
40	4	3	4	3	4	2	4	4	4	2
41	3	4	4	2	3	2	4	5	4	3
42	5	5	4	4	4	1	1	3	2	2
43	2	4	5	2	5	2	2	4	1	2
44	4	4	2	2	4	1	2	4	2	1
45	1	5	4	1	2	4	5	4	5	4
46	2	4	4	4	4	1	4	2	2	2
47	3	4	4	4	4	2	2	2	2	2
48	2	4	4	2	4	2	4	3	3	3
49	3	4	5	1	4	1	2	2	3	2
50	4	4	4	3	5	3	2	5	2	2
51	3	4	5	3	5	2	2	4	2	2
52	4	4	4	4	4	2	4	4	2	2

SUBJECT	P_flx61	P_flx62	P_flx63	P_flx64	P_flx65	P_cst66	P_cst67	P_cst68	P_cst69	P_cst70
53	2	4	4	4	3	4	4	5	4	3
54	4	4	4	2	4	2	2	4	4	2
55	3	4	5	4	4	2	2	2	4	2
56	2	4	4	2	3	2	4	4	2	2
57	3	4	5	2	4	1	2	4	2	2
58	4	4	4	3	3	2	3	2	3	2
59	5	5	5	4	5	2	3	4	2	3
60	2	4	4	2	4	2	2	4	4	3
61	2	2	2	4	4	1	2	3	4	2
62	5	4	4	4	5	1	3	2	2	2
63	3	4	4	2	4	2	4	3	4	2
64	5	5	5	1	5	1	1	5	5	1
65	5	5	5	5	5	1	5	1	5	1
66	5	5	5	4	5	2	2	3	2	1
67	1	1	1	5	5	5	1	5	1	5
68	3	4	5	4	5	3	1	5	5	3
69	2	2	4	2	2	1	1	4	2	4
70	3	4	4	2	4	2	4	4	3	4
71	4	4	4	2	5	1	3	5	2	2
72	2	4	4	2	4	1	2	1	2	2
73	5	4	4	2	4	2	3	4	2	2
74	3	4	4	4	3	2	3	3	3	3
75	3	4	4	4	3	3	2	3	3	2
76	4	4	4	2	4	2	4	5	4	2
77	4	4	3	2	4	1	2	1	4	2
78	5	4	4	4	4	2	3	3	2	2

SUBJECT	P_flx61	P_flx62	P_flx63	P_flx64	P_flx65	P_cst66	P_cst67	P_cst68	P_cst69	P_cst70
79	4	5	4	1	5	1	1	2	2	3
80	3	4	5	1	2	2	4	4	4	4
81	5	5	4	5	5	2	4	5	2	2
82	4	4	4	4	5	2	5	4	2	2
83	2	4	4	4	5	1	4	2	4	2
84	4	5	4	4	4	2	4	4	2	2
85	4	5	5	2	4	2	2	3	3	2
86	5	5	5	2	1	1	5	4	5	2
87	4	5	5	4	5	1	2	1	2	1
88	4	4	4	2	4	2	2	2	2	2
89	5	5	4	2	5	2	2	2	4	2
90	3	4	4	4	4	2	4	4	2	4
91	2	2	3	4	3	1	4	3	3	3
92	3	4	4	3	1	2	4	4	3	1
93	3	4	5	1	5	1	5	3	1	1
94	5	5	5	4	5	1	2	4	4	3
95	3	4	5	2	4	2	2	4	2	4
96	2	2	1	4	5	2	1	3	3	2
97	4	4	4	4	4	2	2	2	4	2
98	4	5	1	3	4	3	3	5	3	5
99	2	2	3	4	1	1	4	5	5	5
100	2	2	2	2	3	2	2	2	2	3
101	2	5	4	4	2	4	4	4	4	2
102	5	5	5	2	5	1	5	4	2	1
103	3	5	4	4	4	3	3	2	3	2
104	3	5	4	4	5	2	4	4	2	2

APPENDIX E: DESCRIPTIVE STATISTICS I

The UNIVARIATE Procedure

Variable: v01_qty

Moments

N	104	Sum Weights	104
Mean	4.22115385	Sum Observations	439
Std Deviation	0.51608554	Variance	0.26634429
Skewness	-0.5996045	Kurtosis	0.02211945
Uncorrected SS	1880.52	Corrected SS	27.4334615
Coeff Variation	12.2261723	Std Error Mean	0.05060635

Basic Statistical Measures

Location		Variability	
Mean	4.221154	Std Deviation	0.51609
Median	4.200000	Variance	0.26634
Mode	4.200000	Range	2.20000
		Interquartile Range	0.70000

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	83.41154	Pr > |t|	<.0001
Sign	M	52	Pr >= |M|	<.0001
Signed Rank	S	2730	Pr >= |S|	<.0001

Quantiles (Definition 5)

Quantile	Estimate
100% Max	5.0
99%	5.0
95%	5.0
90%	4.8
75% Q3	4.6
50% Median	4.2
25% Q1	3.9
10%	3.6
5%	3.2
1%	2.8
0% Min	2.8

Extreme Observations

----Lowest----		----Highest---	
Value	Obs	Value	Obs
2.8	67	5	26
2.8	45	5	43
3.0	100	5	64
3.2	99	5	65
3.2	72	5	81

```
                    The UNIVARIATE Procedure
                       Variable:  v02_spd

                            Moments

N                          104    Sum Weights                104
Mean                       3.3    Sum Observations         343.2
Std Deviation       0.67176048    Variance            0.45126214
Skewness            -0.5125563    Kurtosis            0.10406871
Uncorrected SS         1179.04    Corrected SS             46.48
Coeff Variation      20.356378    Std Error Mean      0.06587153


                  Basic Statistical Measures

        Location                    Variability

    Mean     3.300000     Std Deviation            0.67176
    Median   3.400000     Variance                 0.45126
    Mode     3.600000     Range                    3.20000
                          Interquartile Range      0.80000


                  Tests for Location: Mu0=0

       Test           -Statistic-    -----p Value------

       Student's t    t  50.09751    Pr > |t|    <.0001
       Sign           M        52    Pr >= |M|   <.0001
       Signed Rank    S      2730    Pr >= |S|   <.0001


                   Quantiles (Definition 5)

                    Quantile      Estimate

                    100% Max           4.8
                    99%                4.8
                    95%                4.2
                    90%                4.0
                    75% Q3             3.8
                    50% Median         3.4
                    25% Q1             3.0
                    10%                2.4
                    5%                 2.0
                    1%                 1.6
                    0% Min             1.6


                     Extreme Observations

              ----Lowest----        ----Highest---

              Value      Obs        Value      Obs

               1.6        45         4.2        94
               1.6        41         4.4        49
               1.8        21         4.4        89
               1.8         1         4.8        11
               2.0        99         4.8        66




                    The UNIVARIATE Procedure
```

Variable: v03_dpn

Moments

N	104	Sum Weights	104
Mean	3.67307692	Sum Observations	382
Std Deviation	0.62071534	Variance	0.38528753
Skewness	-0.9651285	Kurtosis	1.41545885
Uncorrected SS	1442.8	Corrected SS	39.6846154
Coeff Variation	16.8990563	Std Error Mean	0.06086615

Basic Statistical Measures

Location		Variability	
Mean	3.673077	Std Deviation	0.62072
Median	3.800000	Variance	0.38529
Mode	4.000000	Range	3.20000
		Interquartile Range	0.60000

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	60.3468	Pr > |t|	<.0001
Sign	M	52	Pr >= |M|	<.0001
Signed Rank	S	2730	Pr >= |S|	<.0001

Quantiles (Definition 5)

Quantile	Estimate
100% Max	5.0
99%	4.6
95%	4.6
90%	4.4
75% Q3	4.0
50% Median	3.8
25% Q1	3.4
10%	3.0
5%	2.6
1%	1.8
0% Min	1.8

Extreme Observations

----Lowest----		----Highest---	
Value	Obs	Value	Obs
1.8	69	4.6	66
1.8	67	4.6	85
1.8	30	4.6	92
2.0	45	4.6	94
2.2	100	5.0	65

The UNIVARIATE Procedure
Variable: v04_flx

Moments

N	104	Sum Weights	104
Mean	3.7	Sum Observations	384.8
Std Deviation	0.60161595	Variance	0.36194175
Skewness	-0.302224	Kurtosis	-0.0286194
Uncorrected SS	1461.04	Corrected SS	37.28
Coeff Variation	16.2598905	Std Error Mean	0.0589933

Basic Statistical Measures

Location		Variability	
Mean	3.700000	Std Deviation	0.60162
Median	3.700000	Variance	0.36194
Mode	3.600000	Range	2.80000
		Interquartile Range	0.80000

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	62.71899	Pr > |t|	<.0001
Sign	M	52	Pr >= |M|	<.0001
Signed Rank	S	2730	Pr >= |S|	<.0001

Quantiles (Definition 5)

Quantile	Estimate
100% Max	5.0
99%	4.8
95%	4.8
90%	4.4
75% Q3	4.2
50% Median	3.7
25% Q1	3.4
10%	2.8
5%	2.6
1%	2.2
0% Min	2.2

Extreme Observations

----Lowest----		----Highest---	
Value	Obs	Value	Obs
2.2	100	4.8	59
2.2	30	4.8	66
2.4	99	4.8	81
2.4	69	4.8	94
2.6	67	5.0	65

The UNIVARIATE Procedure
Variable: v05_cst

Moments

N	104	Sum Weights	104
Mean	2.68269231	Sum Observations	279
Std Deviation	0.57224516	Variance	0.32746453
Skewness	0.49349436	Kurtosis	0.14529755
Uncorrected SS	782.2	Corrected SS	33.7288462
Coeff Variation	21.3310025	Std Error Mean	0.05611325

Basic Statistical Measures

Location		Variability	
Mean	2.682692	Std Deviation	0.57225
Median	2.600000	Variance	0.32746
Mode	2.800000	Range	3.00000
		Interquartile Range	0.60000

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	47.80853	Pr > |t|	<.0001
Sign	M	52	Pr >= |M|	<.0001
Signed Rank	S	2730	Pr >= |S|	<.0001

Quantiles (Definition 5)

Quantile	Estimate
100% Max	4.4
99%	4.0
95%	3.8
90%	3.4
75% Q3	3.0
50% Median	2.6
25% Q1	2.4
10%	2.0
5%	1.8
1%	1.6
0% Min	1.4

Extreme Observations

----Lowest----		----Highest---	
Value	Obs	Value	Obs
1.4	87	3.8	36
1.6	72	3.8	98
1.8	79	4.0	53
1.8	42	4.0	99
1.8	35	4.4	45

The UNIVARIATE Procedure
Variable: v06_skl

Moments

N	104	Sum Weights	104
Mean	3.59230769	Sum Observations	373.6

Std Deviation	0.67055872	Variance	0.44964899
Skewness	-0.7349956	Kurtosis	1.06380078
Uncorrected SS	1388.4	Corrected SS	46.3138462
Coeff Variation	18.6665167	Std Error Mean	0.06575369

Basic Statistical Measures

Location		Variability	
Mean	3.592308	Std Deviation	0.67056
Median	3.600000	Variance	0.44965
Mode	4.000000	Range	3.80000
		Interquartile Range	0.80000

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	54.63279	Pr > |t|	<.0001
Sign	M	52	Pr >= |M|	<.0001
Signed Rank	S	2730	Pr >= |S|	<.0001

Quantiles (Definition 5)

Quantile	Estimate
100% Max	5.0
99%	5.0
95%	4.6
90%	4.2
75% Q3	4.0
50% Median	3.6
25% Q1	3.2
10%	2.8
5%	2.4
1%	2.0
0% Min	1.2

Extreme Observations

----Lowest----		----Highest---	
Value	Obs	Value	Obs
1.2	67	4.6	81
2.0	99	4.6	85
2.0	79	4.8	96
2.0	45	5.0	43
2.2	30	5.0	82

The UNIVARIATE Procedure
Variable: v07_tmd

Moments

N	104	Sum Weights	104
Mean	3.54423077	Sum Observations	368.6
Std Deviation	0.72162531	Variance	0.52074309
Skewness	-0.5380279	Kurtosis	0.0911016

Uncorrected SS	1360.04	Corrected SS	53.6365385
Coeff Variation	20.3605623	Std Error Mean	0.07076118

Basic Statistical Measures

Location		Variability	
Mean	3.544231	Std Deviation	0.72163
Median	3.600000	Variance	0.52074
Mode	3.600000	Range	3.40000
		Interquartile Range	0.80000

NOTE: The mode displayed is the smallest of 2 modes with a count of 15.

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	50.08722	Pr > |t|	<.0001
Sign	M	52	Pr >= |M|	<.0001
Signed Rank	S	2730	Pr >= |S|	<.0001

Quantiles (Definition 5)

Quantile	Estimate
100% Max	5.0
99%	4.8
95%	4.6
90%	4.4
75% Q3	4.0
50% Median	3.6
25% Q1	3.2
10%	2.6
5%	2.0
1%	1.8
0% Min	1.6

Extreme Observations

----Lowest----		----Highest---	
Value	Obs	Value	Obs
1.6	41	4.6	101
1.8	99	4.8	12
1.8	93	4.8	26
2.0	95	4.8	89
2.0	58	5.0	65

The UNIVARIATE Procedure
Variable: v08_org

Moments

N	104	Sum Weights	104
Mean	2.71153846	Sum Observations	282
Std Deviation	0.52274624	Variance	0.27326363
Skewness	0.23100969	Kurtosis	-0.4787678
Uncorrected SS	792.8	Corrected SS	28.1461538
Coeff Variation	19.2785847	Std Error Mean	0.05125949

```
                    Basic Statistical Measures

          Location                    Variability

      Mean     2.711538     Std Deviation            0.52275
      Median   2.600000     Variance                 0.27326
      Mode     2.400000     Range                    2.40000
                            Interquartile Range      0.70000


                    Tests for Location: Mu0=0

         Test           -Statistic-    -----p Value------

         Student's t    t  52.89828    Pr > |t|    <.0001
         Sign           M        52    Pr >= |M|   <.0001
         Signed Rank    S      2730    Pr >= |S|   <.0001


                     Quantiles (Definition 5)

                      Quantile      Estimate

                      100% Max           4.0
                      99%                3.8
                      95%                3.6
                      90%                3.4
                      75% Q3             3.1
                      50% Median         2.6
                      25% Q1             2.4
                      10%                2.0
                      5%                 2.0
                      1%                 1.6
                      0% Min             1.6


                       Extreme Observations

             ----Lowest----        ----Highest---

             Value      Obs        Value      Obs

               1.6      102          3.6       64
               1.6       70          3.8        5
               1.8       93          3.8       27
               1.8       41          3.8       99
               2.0      100          4.0       25
```

```
                     The UNIVARIATE Procedure
                        Variable:  v09_rel

                             Moments

 N                          104    Sum Weights                104
 Mean                3.22884615    Sum Observations         335.8
 Std Deviation       0.64607449    Variance            0.41741225
 Skewness            -0.3172612    Kurtosis            -0.3999756
 Uncorrected SS         1127.24    Corrected SS        42.9934615
 Coeff Variation     20.0094542    Std Error Mean      0.06335282
```

Basic Statistical Measures

Location		Variability	
Mean	3.228846	Std Deviation	0.64607
Median	3.400000	Variance	0.41741
Mode	3.600000	Range	3.00000
		Interquartile Range	0.90000

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	50.9661	Pr > |t|	<.0001
Sign	M	52	Pr >= |M|	<.0001
Signed Rank	S	2730	Pr >= |S|	<.0001

Quantiles (Definition 5)

Quantile	Estimate
100% Max	4.4
99%	4.4
95%	4.2
90%	4.0
75% Q3	3.7
50% Median	3.4
25% Q1	2.8
10%	2.4
5%	2.2
1%	1.8
0% Min	1.4

Extreme Observations

----Lowest----		----Highest---	
Value	Obs	Value	Obs
1.4	99	4.2	97
1.8	80	4.4	18
2.0	102	4.4	33
2.0	87	4.4	50
2.0	45	4.4	57

The UNIVARIATE Procedure
Variable: v10_cul

Moments

N	104	Sum Weights	104
Mean	3.92692308	Sum Observations	408.4
Std Deviation	0.64945545	Variance	0.42179238
Skewness	-0.9003452	Kurtosis	1.63930511
Uncorrected SS	1647.2	Corrected SS	43.4446154
Coeff Variation	16.5385325	Std Error Mean	0.06368435

Basic Statistical Measures

Location		Variability	
Mean	3.926923	Std Deviation	0.64946
Median	4.000000	Variance	0.42179
Mode	4.000000	Range	3.40000
		Interquartile Range	0.80000

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	61.6623	Pr > |t|	<.0001
Sign	M	52	Pr >= |M|	<.0001
Signed Rank	S	2730	Pr >= |S|	<.0001

Quantiles (Definition 5)

Quantile	Estimate
100% Max	5.0
99%	5.0
95%	4.8
90%	4.8
75% Q3	4.4
50% Median	4.0
25% Q1	3.6
10%	3.2
5%	3.0
1%	1.8
0% Min	1.6

Extreme Observations

----Lowest----		----Highest---	
Value	Obs	Value	Obs
1.6	21	4.8	73
1.8	45	4.8	92
2.4	99	5.0	65
2.4	67	5.0	66
2.4	2	5.0	93

The UNIVARIATE Procedure
Variable: v11_dgn

Moments

N	104	Sum Weights	104
Mean	3.23269231	Sum Observations	336.2
Std Deviation	1.09760926	Variance	1.20474608
Skewness	-0.3578173	Kurtosis	-1.0604453
Uncorrected SS	1210.92	Corrected SS	124.088846
Coeff Variation	33.9534095	Std Error Mean	0.10762944

Basic Statistical Measures

Location Variability

Mean	3.232692	Std Deviation	1.09761
Median	3.400000	Variance	1.20475
Mode	4.200000	Range	4.00000
		Interquartile Range	1.80000

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	30.03539	Pr > |t|	<.0001
Sign	M	52	Pr >= |M|	<.0001
Signed Rank	S	2730	Pr >= |S|	<.0001

Quantiles (Definition 5)

Quantile	Estimate
100% Max	5.0
99%	4.8
95%	4.8
90%	4.6
75% Q3	4.2
50% Median	3.4
25% Q1	2.4
10%	1.8
5%	1.4
1%	1.2
0% Min	1.0

Extreme Observations

----Lowest----		----Highest---	
Value	Obs	Value	Obs
1.0	64	4.8	26
1.2	104	4.8	27
1.2	102	4.8	66
1.2	53	4.8	85
1.2	46	5.0	54

The UNIVARIATE Procedure
Variable: v12_mfg

Moments

N	104	Sum Weights	104
Mean	2.41153846	Sum Observations	250.8
Std Deviation	0.79211009	Variance	0.62743839
Skewness	0.52620151	Kurtosis	0.81265842
Uncorrected SS	669.44	Corrected SS	64.6261538
Coeff Variation	32.8466702	Std Error Mean	0.07767278

Basic Statistical Measures

Location		Variability	
Mean	2.411538	Std Deviation	0.79211
Median	2.400000	Variance	0.62744

```
         Mode     1.800000     Range                     4.00000
                               Interquartile Range       1.10000

NOTE: The mode displayed is the smallest of 2 modes with a count of 13.


                      Tests for Location: Mu0=0

            Test           -Statistic-    -----p Value------

            Student's t    t  31.04741    Pr > |t|    <.0001
            Sign           M        52    Pr >= |M|   <.0001
            Signed Rank    S      2730    Pr >= |S|   <.0001


                      Quantiles (Definition 5)

                       Quantile      Estimate

                       100% Max           5.0
                       99%                4.8
                       95%                3.8
                       90%                3.2
                       75% Q3             2.9
                       50% Median         2.4
                       25% Q1             1.8
                       10%                1.4
                       5%                 1.0
                       1%                 1.0
                       0% Min             1.0


                         Extreme Observations

                  ----Lowest----        ----Highest---

                  Value      Obs        Value      Obs

                    1       98          3.8      103
                    1       80          4.0       37
                    1       59          4.2       36
                    1       19          4.8       26
                    1       16          5.0       67




                      The UNIVARIATE Procedure
                         Variable:  v13_crd

                               Moments

      N                         104    Sum Weights                104
      Mean               3.57115385    Sum Observations         371.4
      Std Deviation      0.87485622    Variance            0.76537341
      Skewness           -0.3756174    Kurtosis            -0.3969831
      Uncorrected SS        1405.16    Corrected SS        78.8334615
      Coeff Variation    24.4978587    Std Error Mean      0.08578671


                     Basic Statistical Measures

            Location                    Variability

         Mean     3.571154     Std Deviation             0.87486
         Median   3.600000     Variance                  0.76537
         Mode     4.600000     Range                     3.80000
                               Interquartile Range       1.40000
```

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	41.62829	Pr > |t|	<.0001
Sign	M	52	Pr >= |M|	<.0001
Signed Rank	S	2730	Pr >= |S|	<.0001

Quantiles (Definition 5)

Quantile	Estimate
100% Max	5.0
99%	5.0
95%	4.8
90%	4.6
75% Q3	4.4
50% Median	3.6
25% Q1	3.0
10%	2.4
5%	2.0
1%	1.4
0% Min	1.2

Extreme Observations

----Lowest----		----Highest---	
Value	Obs	Value	Obs
1.2	96	5	1
1.4	95	5	2
1.6	94	5	3
2.0	92	5	4
2.0	91	5	101

The UNIVARIATE Procedure
Variable: v14_int

Moments

N	104	Sum Weights	104
Mean	3.04807692	Sum Observations	317
Std Deviation	0.74181367	Variance	0.55028753
Skewness	0.02865132	Kurtosis	-0.0129689
Uncorrected SS	1022.92	Corrected SS	56.6796154
Coeff Variation	24.3371048	Std Error Mean	0.07274082

Basic Statistical Measures

Location		Variability	
Mean	3.048077	Std Deviation	0.74181
Median	3.000000	Variance	0.55029
Mode	2.800000	Range	4.00000
		Interquartile Range	1.00000

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	41.90325	Pr > |t|	<.0001
Sign	M	52	Pr >= |M|	<.0001
Signed Rank	S	2730	Pr >= |S|	<.0001

Quantiles (Definition 5)

Quantile	Estimate
100% Max	5.0
99%	4.8
95%	4.2
90%	3.8
75% Q3	3.6
50% Median	3.0
25% Q1	2.6
10%	2.2
5%	2.0
1%	1.4
0% Min	1.0

Extreme Observations

----Lowest----		----Highest---	
Value	Obs	Value	Obs
1.0	93	4.2	78
1.4	80	4.4	97
1.6	79	4.6	26
1.8	95	4.8	66
1.8	94	5.0	33

APPENDIX F: DESCRIPTIVE STATISTICS II

The UNIVARIATE Procedure
Variable: v01_qty

Moments

N	98	Sum Weights	98
Mean	4.25714286	Sum Observations	417.2
Std Deviation	0.47013926	Variance	0.22103093
Skewness	-0.4291758	Kurtosis	-0.3458513
Uncorrected SS	1797.52	Corrected SS	21.44
Coeff Variation	11.0435398	Std Error Mean	0.04749124

Basic Statistical Measures

Location		Variability	
Mean	4.257143	Std Deviation	0.47014
Median	4.200000	Variance	0.22103
Mode	4.200000	Range	2.00000
		Interquartile Range	0.60000

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	89.6406	Pr > |t|	<.0001
Sign	M	49	Pr >= |M|	<.0001
Signed Rank	S	2425.5	Pr >= |S|	<.0001

Quantiles (Definition 5)

Quantile	Estimate
100% Max	5.0
99%	5.0
95%	5.0
90%	4.8
75% Q3	4.6
50% Median	4.2
25% Q1	4.0
10%	3.6
5%	3.4
1%	3.0
0% Min	3.0

Extreme Observations

----Lowest----		----Highest---	
Value	Obs	Value	Obs
3.0	94	5	16
3.2	93	5	40
3.2	66	5	60
3.2	20	5	61
3.4	6	5	75

```
                         The UNIVARIATE Procedure
                            Variable:  v02_spd

                                  Moments

N                              98    Sum Weights                 98
Mean                   3.36530612    Sum Observations         329.8
Std Deviation          0.62261538    Variance            0.38764991
Skewness                -0.486017    Kurtosis            0.37565354
Uncorrected SS            1147.48    Corrected SS        37.6020408
Coeff Variation        18.5010027    Std Error Mean      0.06289365


                        Basic Statistical Measures

            Location                    Variability

        Mean     3.365306     Std Deviation            0.62262
        Median   3.400000     Variance                 0.38765
        Mode     3.600000     Range                    3.20000
                              Interquartile Range      0.80000


                         Tests for Location: Mu0=0

           Test           -Statistic-    -----p Value------

           Student's t    t  53.50788    Pr > |t|    <.0001
           Sign           M        49    Pr >= |M|   <.0001
           Signed Rank    S    2425.5    Pr >= |S|   <.0001


                         Quantiles (Definition 5)

                          Quantile      Estimate

                          100% Max           4.8
                          99%                4.8
                          95%                4.2
                          90%                4.0
                          75% Q3             3.8
                          50% Median         3.4
                          25% Q1             3.0
                          10%                2.4
                          5%                 2.2
                          1%                 1.6
                          0% Min             1.6


                           Extreme Observations

                    ----Lowest----        ----Highest---

                    Value      Obs        Value      Obs

                      1.6       38          4.2       88
                      1.8        1          4.4       45
                      2.0       93          4.4       83
                      2.0       33          4.8       11
                      2.2       94          4.8       62
```

```
                    The UNIVARIATE Procedure
                       Variable:  v03_dpn

                             Moments

N                          98    Sum Weights                 98
Mean               3.74489796    Sum Observations           367
Std Deviation      0.50871223    Variance            0.25878813
Skewness           -0.3710848    Kurtosis            0.25274044
Uncorrected SS        1399.48    Corrected SS         25.102449
Coeff Variation    13.5841413    Std Error Mean       0.0513877


                   Basic Statistical Measures

         Location                    Variability

    Mean     3.744898     Std Deviation            0.50871
    Median   3.800000     Variance                 0.25879
    Mode     4.000000     Range                    2.80000
                          Interquartile Range      0.60000


                  Tests for Location: Mu0=0

       Test           -Statistic-    -----p Value------

       Student's t    t  72.87538    Pr > |t|    <.0001
       Sign           M        49    Pr >= |M|   <.0001
       Signed Rank    S    2425.5    Pr >= |S|   <.0001


                   Quantiles (Definition 5)

                    Quantile      Estimate

                    100% Max           5.0
                    99%                5.0
                    95%                4.6
                    90%                4.4
                    75% Q3             4.0
                    50% Median         3.8
                    25% Q1             3.4
                    10%                3.0
                    5%                 2.8
                    1%                 2.2
                    0% Min             2.2


                     Extreme Observations

             ----Lowest----        ----Highest---

             Value      Obs        Value      Obs

               2.2       94          4.6       62
               2.6       93          4.6       79
               2.6       85          4.6       86
               2.8       37          4.6       88
               2.8       31          5.0       61
```

```
                    The UNIVARIATE Procedure
                       Variable:  v04_flx

                            Moments

N                           98    Sum Weights                 98
Mean                3.75102041    Sum Observations         367.6
Std Deviation       0.54720374    Variance            0.29943194
Skewness            -0.1845103    Kurtosis            0.19967444
Uncorrected SS         1407.92    Corrected SS         29.044898
Coeff Variation     14.5881303    Std Error Mean      0.05527593


                   Basic Statistical Measures

         Location                    Variability

    Mean     3.751020     Std Deviation            0.54720
    Median   3.800000     Variance                 0.29943
    Mode     3.600000     Range                    2.80000
                          Interquartile Range      0.80000


                   Tests for Location: Mu0=0

       Test           -Statistic-    -----p Value------

       Student's t    t  67.85993    Pr > |t|    <.0001
       Sign           M        49    Pr >= |M|   <.0001
       Signed Rank    S    2425.5    Pr >= |S|   <.0001


                    Quantiles (Definition 5)

                     Quantile      Estimate

                     100% Max           5.0
                     99%                5.0
                     95%                4.8
                     90%                4.4
                     75% Q3             4.2
                     50% Median         3.8
                     25% Q1             3.4
                     10%                3.0
                     5%                 2.8
                     1%                 2.2
                     0% Min             2.2


                      Extreme Observations

            ----Lowest----        ----Highest---

            Value      Obs        Value      Obs

              2.2       94          4.8       55
              2.4       93          4.8       62
              2.6       16          4.8       75
              2.8       90          4.8       88
              2.8       85          5.0       61
```

```
                     The UNIVARIATE Procedure
                        Variable:  v05_cst

                              Moments

N                          98    Sum Weights                 98
Mean               2.65918367    Sum Observations         260.6
Std Deviation      0.54806816    Variance            0.30037871
Skewness           0.37936583    Kurtosis            -0.0908299
Uncorrected SS         722.12    Corrected SS        29.1367347
Coeff Variation    20.6103913    Std Error Mean      0.05536324


                    Basic Statistical Measures

          Location                    Variability

    Mean     2.659184     Std Deviation            0.54807
    Median   2.600000     Variance                 0.30038
    Mode     2.800000     Range                    2.60000
                          Interquartile Range      0.60000


                    Tests for Location: Mu0=0

       Test           -Statistic-    -----p Value------

       Student's t    t  48.03157    Pr > |t|    <.0001
       Sign           M        49    Pr >= |M|   <.0001
       Signed Rank    S    2425.5    Pr >= |S|   <.0001


                    Quantiles (Definition 5)

                     Quantile      Estimate

                     100% Max           4.0
                     99%                4.0
                     95%                3.8
                     90%                3.4
                     75% Q3             3.0
                     50% Median         2.6
                     25% Q1             2.4
                     10%                2.0
                     5%                 1.8
                     1%                 1.4
                     0% Min             1.4


                      Extreme Observations

            ----Lowest----        ----Highest---

            Value      Obs        Value      Obs

              1.4       81          3.8        9
              1.6       66          3.8       33
              1.8       73          3.8       92
              1.8       39          4.0       49
              1.8       32          4.0       93
```

```
                    The UNIVARIATE Procedure
                       Variable:  v06_skl

                            Moments

N                          98    Sum Weights                 98
Mean               3.63469388    Sum Observations         356.2
Std Deviation      0.60446825    Variance            0.36538186
Skewness           -0.3181568    Kurtosis            0.13516048
Uncorrected SS        1330.12    Corrected SS        35.4420408
Coeff Variation    16.6305133    Std Error Mean      0.06106051


                   Basic Statistical Measures

         Location                    Variability

    Mean     3.634694     Std Deviation            0.60447
    Median   3.600000     Variance                 0.36538
    Mode     3.600000     Range                    3.00000
                          Interquartile Range      0.80000


                   Tests for Location: Mu0=0

           Test           -Statistic-    -----p Value------

           Student's t    t  59.52609    Pr > |t|    <.0001
           Sign           M        49    Pr >= |M|   <.0001
           Signed Rank    S    2425.5    Pr >= |S|   <.0001


                    Quantiles (Definition 5)

                     Quantile      Estimate

                     100% Max           5.0
                     99%                5.0
                     95%                4.6
                     90%                4.2
                     75% Q3             4.0
                     50% Median         3.6
                     25% Q1             3.2
                     10%                2.8
                     5%                 2.6
                     1%                 2.0
                     0% Min             2.0


                      Extreme Observations

               ----Lowest----        ----Highest---

               Value      Obs        Value      Obs

                 2.0       93          4.6       75
                 2.0       73          4.6       79
                 2.4       84          4.8       90
                 2.4       74          5.0       40
                 2.6       94          5.0       76
```

The UNIVARIATE Procedure
Variable: v07_tmd

Moments

N	98	Sum Weights	98
Mean	3.56326531	Sum Observations	349.2
Std Deviation	0.69540284	Variance	0.4835851
Skewness	-0.6372181	Kurtosis	0.42866036
Uncorrected SS	1291.2	Corrected SS	46.9077551
Coeff Variation	19.5158871	Std Error Mean	0.07024629

Basic Statistical Measures

Location		Variability	
Mean	3.563265	Std Deviation	0.69540
Median	3.600000	Variance	0.48359
Mode	3.600000	Range	3.40000
		Interquartile Range	0.80000

NOTE: The mode displayed is the smallest of 2 modes with a count of 15.

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	50.72531	Pr > |t|	<.0001
Sign	M	49	Pr >= |M|	<.0001
Signed Rank	S	2425.5	Pr >= |S|	<.0001

Quantiles (Definition 5)

Quantile	Estimate
100% Max	5.0
99%	5.0
95%	4.6
90%	4.4
75% Q3	4.0
50% Median	3.6
25% Q1	3.2
10%	2.6
5%	2.0
1%	1.6
0% Min	1.6

Extreme Observations

----Lowest----		----Highest---	
Value	Obs	Value	Obs
1.6	38	4.6	88
1.8	93	4.6	95
1.8	87	4.8	12
2.0	89	4.8	83
2.0	54	5.0	61

The UNIVARIATE Procedure
Variable: v08_org

Moments

N	98	Sum Weights	98
Mean	2.71020408	Sum Observations	265.6
Std Deviation	0.53196578	Variance	0.28298759
Skewness	0.22885326	Kurtosis	-0.516716
Uncorrected SS	747.28	Corrected SS	27.4497959
Coeff Variation	19.6282553	Std Error Mean	0.05373666

Basic Statistical Measures

Location		Variability	
Mean	2.710204	Std Deviation	0.53197
Median	2.600000	Variance	0.28299
Mode	2.400000	Range	2.40000
		Interquartile Range	0.60000

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	50.43492	Pr > |t|	<.0001
Sign	M	49	Pr >= |M|	<.0001
Signed Rank	S	2425.5	Pr >= |S|	<.0001

Quantiles (Definition 5)

Quantile	Estimate
100% Max	4.0
99%	4.0
95%	3.6
90%	3.4
75% Q3	3.0
50% Median	2.6
25% Q1	2.4
10%	2.0
5%	2.0
1%	1.6
0% Min	1.6

Extreme Observations

----Lowest----		----Highest---	
Value	Obs	Value	Obs
1.6	96	3.6	60
1.6	64	3.8	5
1.8	87	3.8	25
1.8	38	3.8	93
2.0	94	4.0	24

The UNIVARIATE Procedure
Variable: v09_rel

Moments

N	98	Sum Weights	98
Mean	3.24897959	Sum Observations	318.4
Std Deviation	0.63962697	Variance	0.40912266
Skewness	-0.3546587	Kurtosis	-0.2854289
Uncorrected SS	1074.16	Corrected SS	39.684898
Coeff Variation	19.687011	Std Error Mean	0.06461208

Basic Statistical Measures

Location		Variability	
Mean	3.248980	Std Deviation	0.63963
Median	3.400000	Variance	0.40912
Mode	3.600000	Range	3.00000
		Interquartile Range	1.00000

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	50.2844	Pr > |t|	<.0001
Sign	M	49	Pr >= |M|	<.0001
Signed Rank	S	2425.5	Pr >= |S|	<.0001

Quantiles (Definition 5)

Quantile	Estimate
100% Max	4.4
99%	4.4
95%	4.2
90%	4.0
75% Q3	3.8
50% Median	3.4
25% Q1	2.8
10%	2.4
5%	2.2
1%	1.4
0% Min	1.4

Extreme Observations

----Lowest----		----Highest---	
Value	Obs	Value	Obs
1.4	93	4.2	91
1.8	74	4.4	18
2.0	96	4.4	30
2.0	81	4.4	46
2.2	69	4.4	53

The UNIVARIATE Procedure
Variable: v10_cul

Moments

N	98	Sum Weights	98
Mean	3.98571429	Sum Observations	390.6
Std Deviation	0.56147817	Variance	0.31525773
Skewness	-0.2707047	Kurtosis	-0.1220376
Uncorrected SS	1587.4	Corrected SS	30.58
Coeff Variation	14.0872658	Std Error Mean	0.05671786

Basic Statistical Measures

Location		Variability	
Mean	3.985714	Std Deviation	0.56148
Median	4.000000	Variance	0.31526
Mode	4.000000	Range	2.60000
		Interquartile Range	0.80000

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	70.27265	Pr > |t|	<.0001
Sign	M	49	Pr >= |M|	<.0001
Signed Rank	S	2425.5	Pr >= |S|	<.0001

Quantiles (Definition 5)

Quantile	Estimate
100% Max	5.0
99%	5.0
95%	4.8
90%	4.8
75% Q3	4.4
50% Median	4.0
25% Q1	3.6
10%	3.2
5%	3.2
1%	2.4
0% Min	2.4

Extreme Observations

----Lowest----		----Highest---	
Value	Obs	Value	Obs
2.4	93	4.8	67
2.4	2	4.8	86
3.0	38	5.0	61
3.0	16	5.0	62
3.2	94	5.0	87

The UNIVARIATE Procedure
Variable: v11_dgn

Moments

N	98	Sum Weights	98
Mean	3.19591837	Sum Observations	313.2
Std Deviation	1.11187761	Variance	1.23627183
Skewness	-0.3030898	Kurtosis	-1.1410765
Uncorrected SS	1120.88	Corrected SS	119.918367
Coeff Variation	34.7905511	Std Error Mean	0.1123166

Basic Statistical Measures

Location		Variability	
Mean	3.195918	Std Deviation	1.11188
Median	3.200000	Variance	1.23627
Mode	1.800000	Range	4.00000
		Interquartile Range	2.00000

NOTE: The mode displayed is the smallest of 2 modes with a count of 12.

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	28.45455	Pr > |t|	<.0001
Sign	M	49	Pr >= |M|	<.0001
Signed Rank	S	2425.5	Pr >= |S|	<.0001

Quantiles (Definition 5)

Quantile	Estimate
100% Max	5.0
99%	5.0
95%	4.8
90%	4.6
75% Q3	4.2
50% Median	3.2
25% Q1	2.2
10%	1.6
5%	1.2
1%	1.0
0% Min	1.0

Extreme Observations

----Lowest----		----Highest---	
Value	Obs	Value	Obs
1.0	60	4.8	12
1.2	98	4.8	25
1.2	96	4.8	62
1.2	49	4.8	79
1.2	42	5.0	50

The UNIVARIATE Procedure
Variable: v12_mfg

Moments

N	98	Sum Weights	98
Mean	2.36326531	Sum Observations	231.6
Std Deviation	0.7233068	Variance	0.52317273
Skewness	0.08358484	Kurtosis	-0.2389035
Uncorrected SS	598.08	Corrected SS	50.7477551
Coeff Variation	30.6062465	Std Error Mean	0.07306502

Basic Statistical Measures

Location		Variability	
Mean	2.363265	Std Deviation	0.72331
Median	2.400000	Variance	0.52317
Mode	2.400000	Range	3.20000
		Interquartile Range	1.00000

Tests for Location: Mu0=0

Test	-Statistic-		-----p Value------	
Student's t	t	32.34469	Pr > |t|	<.0001
Sign	M	49	Pr >= |M|	<.0001
Signed Rank	S	2425.5	Pr >= |S|	<.0001

Quantiles (Definition 5)

Quantile	Estimate
100% Max	4.2
99%	4.2
95%	3.8
90%	3.2
75% Q3	2.8
50% Median	2.4
25% Q1	1.8
10%	1.4
5%	1.0
1%	1.0
0% Min	1.0

Extreme Observations

----Lowest----		----Highest---	
Value	Obs	Value	Obs
1	92	3.8	17
1	74	3.8	30
1	55	3.8	97
1	19	4.0	34
1	16	4.2	33

```
                       The UNIVARIATE Procedure
                         Variable:  v13_crd

                               Moments

N                          98    Sum Weights                 98
Mean               3.55714286    Sum Observations         348.6
Std Deviation      0.89315842    Variance            0.79773196
Skewness           -0.3396559    Kurtosis            -0.4893717
Uncorrected SS         1317.4    Corrected SS             77.38
Coeff Variation    25.1088712    Std Error Mean      0.09022262


                      Basic Statistical Measures

            Location                    Variability

    Mean     3.557143     Std Deviation            0.89316
    Median   3.600000     Variance                 0.79773
    Mode     4.600000     Range                    3.80000
                          Interquartile Range      1.40000


                      Tests for Location: Mu0=0

           Test           -Statistic-    -----p Value------

           Student's t    t  39.42628    Pr > |t|    <.0001
           Sign           M        49    Pr >= |M|   <.0001
           Signed Rank    S    2425.5    Pr >= |S|   <.0001


                       Quantiles (Definition 5)

                        Quantile      Estimate

                        100% Max           5.0
                        99%                5.0
                        95%                5.0
                        90%                4.6
                        75% Q3             4.4
                        50% Median         3.6
                        25% Q1             3.0
                        10%                2.4
                        5%                 2.0
                        1%                 1.2
                        0% Min             1.2


                        Extreme Observations

                  ----Lowest----        ----Highest---

                  Value      Obs        Value      Obs

                    1.2       90            5        1
                    1.4       89            5        2
                    1.6       88            5        3
                    2.0       86            5        4
                    2.0       85            5       95
```

```
                  The UNIVARIATE Procedure
                    Variable:  v14_int

                          Moments

N                          98    Sum Weights                 98
Mean               3.04285714    Sum Observations         298.2
Std Deviation      0.73960145    Variance            0.54701031
Skewness           -0.0147159    Kurtosis            -0.0349075
Uncorrected SS         960.44    Corrected SS             53.06
Coeff Variation     24.306151    Std Error Mean      0.07471103


                 Basic Statistical Measures

         Location                    Variability

     Mean     3.042857     Std Deviation           0.73960
     Median   3.000000     Variance                0.54701
     Mode     2.800000     Range                   4.00000
                           Interquartile Range     1.00000


                 Tests for Location: Mu0=0

         Test           -Statistic-    -----p Value------

         Student's t    t  40.72835    Pr > |t|    <.0001
         Sign           M        49    Pr >= |M|   <.0001
         Signed Rank    S    2425.5    Pr >= |S|   <.0001


                  Quantiles (Definition 5)

                   Quantile      Estimate

                   100% Max           5.0
                   99%                5.0
                   95%                4.2
                   90%                3.8
                   75% Q3             3.6
                   50% Median         3.0
                   25% Q1             2.6
                   10%                2.2
                   5%                 1.8
                   1%                 1.0
                   0% Min             1.0


                   Extreme Observations

              ----Lowest----        ----Highest---

              Value      Obs        Value      Obs

                1.0       87          4.2       60
                1.4       74          4.2       72
                1.8       89          4.8       62
                1.8       88          5.0       30
```

APPENDIX G: CORRELATION MATRIX

The CORR Procedure

Spearman Correlation Coefficients, N = 98
Prob > |r| under H0: Rho=0

	v01_qty	v02_spd	v03_dpn	v04_flx	v05_cst	v06_skl	v07_tmd	v08_org	v09_rel	v10_cul	v11_dgn	v12_mfg	v13_crd	v14_int
v01 qty	1.00000	0.30239	0.56921	0.34031	-0.07731	0.28111	0.26281	0.03391	0.21584	0.31887	0.02264	-0.06775	0.03330	0.09769
		0.0025	<.0001	0.0006	0.4493	0.0050	0.0089	0.7403	0.0328	0.0014	0.8249	0.5074	0.7448	0.3386
v02 spd	0.30239	1.00000	0.44757	0.44583	-0.36223	0.27975	0.41928	-0.07212	-0.09779	0.20503	0.00807	0.05586	0.00687	0.12171
	0.0025		<.0001	<.0001	0.0002	0.0053	<.0001	0.4804	0.3381	0.0428	0.9372	0.5848	0.9464	0.2325
v03 dpn	0.56921	0.44757	1.00000	0.34614	-0.27273	0.35259	0.29168	0.06717	0.05468	0.31432	0.01629	-0.01047	-0.00991	0.17155
	<.0001	<.0001		0.0005	0.0066	0.0004	0.0036	0.5111	0.5928	0.0016	0.8735	0.9185	0.9228	0.0912
v04 flx	0.34031	0.44583	0.34614	1.00000	-0.26883	0.33418	0.32200	0.00768	0.11294	0.24143	0.15490	0.07815	0.11357	0.25733
	0.0006	<.0001	0.0005		0.0074	0.0008	0.0012	0.9402	0.2682	0.0166	0.1278	0.4443	0.2655	0.0105
v05 cst	-0.07731	-0.36223	-0.27273	-0.26883	1.00000	-0.21762	-0.11857	0.02060	-0.02334	-0.27486	-0.16959	-0.25412	-0.00671	-0.19675
	0.4493	0.0002	0.0066	0.0074		0.0314	0.2449	0.8404	0.8195	0.0062	0.0950	0.0116	0.9477	0.0522
v06 skl	0.28111	0.27975	0.35259	0.33418	-0.21762	1.00000	0.48355	0.19180	0.11952	0.29952	0.34540	0.21399	0.11406	0.19684
	0.0050	0.0053	0.0004	0.0008	0.0314		<.0001	0.0585	0.2411	0.0027	0.0005	0.0344	0.2634	0.0521
v07 tmd	0.26281	0.41928	0.29168	0.32200	-0.11857	0.48355	1.00000	0.20246	0.18661	0.39042	0.14367	0.27834	0.13987	0.32069
	0.0089	<.0001	0.0036	0.0012	0.2449	<.0001		0.0456	0.0658	<.0001	0.1581	0.0055	0.1695	0.0013
v08 org	0.03391	-0.07212	0.06717	0.00768	0.02060	0.19180	0.20246	1.00000	0.07475	0.12745	0.01372	0.18131	0.28527	0.15400
	0.7403	0.4804	0.5111	0.9402	0.8404	0.0585	0.0456		0.4645	0.2111	0.8933	0.0740	0.0044	0.1300
v09 rel	0.21584	-0.09779	0.05468	0.11294	-0.02334	0.11952	0.18661	0.07475	1.00000	0.30450	0.18813	0.25820	0.25085	0.25322
	0.0328	0.3381	0.5928	0.2682	0.8195	0.2411	0.0658	0.4645		0.0023	0.0636	0.0103	0.0127	0.0119
v10 cul	0.31887	0.20503	0.31432	0.24143	-0.27486	0.29952	0.39042	0.12745	0.30450	1.00000	0.24049	0.30818	0.09807	0.31432
	0.0014	0.0428	0.0016	0.0166	0.0062	0.0027	<.0001	0.2111	0.0023		0.0171	0.0020	0.3367	0.0016
v11 dgn	0.02264	0.00807	0.01629	0.15490	-0.16959	0.34540	0.14367	0.01372	0.18813	0.24049	1.00000	0.41737	0.06738	0.32890
	0.8249	0.9372	0.8735	0.1278	0.0950	0.0005	0.1581	0.8933	0.0636	0.0171		<.0001	0.5097	0.0009
v12 mfg	-0.06775	0.05586	-0.01047	0.07815	-0.25412	0.21399	0.27834	0.18131	0.25820	0.30818	0.41737	1.00000	0.10640	0.39231
	0.5074	0.5848	0.9185	0.4443	0.0116	0.0344	0.0055	0.0740	0.0103	0.0020	<.0001		0.2971	<.0001
v13 crd	0.03330	0.00687	-0.00991	0.11357	-0.00671	0.11406	0.13987	0.28527	0.25085	0.09807	0.06738	0.10640	1.00000	0.28553
	0.7448	0.9464	0.9228	0.2655	0.9477	0.2634	0.1695	0.0044	0.0127	0.3367	0.5097	0.2971		0.0044
v14 int	0.09769	0.12171	0.17155	0.25733	-0.19675	0.19684	0.32069	0.15400	0.25322	0.31432	0.32890	0.39231	0.28553	1.00000
	0.3386	0.2325	0.0912	0.0105	0.0522	0.0521	0.0013	0.1300	0.0119	0.0016	0.0009	<.0001	0.0044	

APPENDIX H: CRONBACH ALPHA OF INDICATOR VARIABLES

The CORR Procedure

14 Variables: v01_qty v02_spd v03_dpn v04_flx v05_cst v06_skl v07_tmd v08_org v09_rel v10_cul v11_dgn v12_mfg v13_crd v14_int

Simple Statistics

Variable	N	Mean	Std Dev	Median	Minimum	Maximum
v01_qty	98	4.25714	0.47014	4.20000	3.00000	5.00000
v02_spd	98	3.36531	0.62262	3.40000	1.60000	4.80000
v03_dpn	98	3.74490	0.50871	3.80000	2.20000	5.00000
v04_flx	98	3.75102	0.54720	3.80000	2.20000	5.00000
v05_cst	98	2.65918	0.54807	2.60000	1.40000	4.00000
v06_skl	98	3.63469	0.60447	3.60000	2.00000	5.00000
v07_tmd	98	3.56327	0.69540	3.60000	1.60000	5.00000
v08_org	98	2.71020	0.53197	2.60000	1.60000	4.00000
v09_rel	98	3.24898	0.63963	3.40000	1.40000	4.40000
v10_cul	98	3.98571	0.56148	4.00000	2.40000	5.00000
v11_dgn	98	3.19592	1.11188	3.20000	1.00000	5.00000
v12_mfg	98	2.36327	0.72331	2.40000	1.00000	4.20000
v13_crd	98	3.55714	0.89316	3.60000	1.20000	5.00000
v14_int	98	3.04286	0.73960	3.00000	1.00000	5.00000

Cronbach Coefficient Alpha

Variables	Alpha
Raw	0.713088
Standardized	0.722303

Cronbach Coefficient Alpha with Deleted Variable

	Raw Variables		Standardized Variables	
Deleted Variable	Correlation with Total	Alpha	Correlation with Total	Alpha
v01_qty	0.345176	0.697981	0.403373	0.698889
v02_spd	0.329598	0.697251	0.369167	0.702942
v03_dpn	0.360793	0.695743	0.424144	0.696407
v04_flx	0.432887	0.687806	0.454422	0.692762
v05_cst	-.361423	0.759842	-.373092	0.781181
v06_skl	0.540275	0.673987	0.541070	0.682147
v07_tmd	0.568987	0.666083	0.595890	0.675289
v08_org	0.177376	0.712340	0.162663	0.726539
v09_rel	0.380570	0.691285	0.358704	0.704173
v10_cul	0.496787	0.680736	0.503376	0.686798
v11_dgn	0.331393	0.706908	0.312541	0.709560
v12_mfg	0.371528	0.691636	0.318022	0.708924
v13_crd	0.239900	0.713412	0.239600	0.717920
v14_int	0.505510	0.673153	0.470214	0.690848

APPENDIX I: TECHNOLOGY CONSTRUCT ANALYSIS

```
                         The CALIS Procedure
          Covariance Structure Analysis: Pattern and Initial Values

                        LINEQS Model Statement


                     Matrix      Rows    Columns    ------Matrix Type-------

Term 1           1    _SEL_         4          9    SELECTION
                 2    _BETA_        9          9    EQSBETA        IMINUSINV
                 3    _GAMMA_       9          5    EQSGAMMA
                 4    _PHI_         5          5    SYMMETRIC

                      The 4 Endogenous Variables

    Manifest        v11_dgn  v12_mfg  v13_crd  v14_int
    Latent


                      The 5 Exogenous Variables

    Manifest
    Latent          f3
    Error           e11      e12      e13      e14

            Manifest Variable Equations with Initial Estimates


                v11_dgn =        .*f3      +  1.0000 e11
                                  lv11f3
                v12_mfg =        .*f3      +  1.0000 e12
                                  lv12f3
                v13_crd =        .*f3      +  1.0000 e13
                                  lv13f3
                v14_int =        .*f3      +  1.0000 e14
                                  lv14f3


                     Variances of Exogenous Variables

                     Variable Parameter      Estimate

                     f3                       1.00000
                     e11      vare11                .
                     e12      vare12                .
                     e13      vare13                .
                     e14      vare14                .


         Covariance Structure Analysis: Maximum Likelihood Estimation

            Observations          98    Model Terms            1
            Variables              4    Model Matrices         4
            Informations          10    Parameters             8


         Variable          Mean       Std Dev      Skewness      Kurtosis

         v11_dgn        3.19592       1.11188      -0.30309      -1.14108
         v12_mfg        2.36327       0.72331       0.08358      -0.23890
         v13_crd        3.55714       0.89316      -0.33966      -0.48937
         v14_int        3.04286       0.73960      -0.01472      -0.03491


            Mardia's Multivariate Kurtosis                 -2.0392
            Relative Multivariate Kurtosis                  0.9150
            Normalized Multivariate Kurtosis               -1.4569
            Mardia Based Kappa (Browne, 1982)              -0.0850
            Mean Scaled Univariate Kurtosis                -0.1587
```

Adjusted Mean Scaled Univariate Kurtosis -0.1469

Observation Numbers with Largest Contribution to Kurtosis

34	87	60	90	62
104.0709	95.8060	62.1557	37.5806	36.4255

Covariances

	v11_dgn	v12_mfg	v13_crd	v14_int
v11_dgn	1.236271828	0.3276835683	0.0604418262	0.2640942563
v12_mfg	0.327683568	0.5231727330	0.0664506627	0.2053019146
v13_crd	0.060441826	0.0664506627	0.7977319588	0.2068041237
v14_int	0.264094256	0.2053019146	0.2068041237	0.5470103093

Determinant 0.173785 Ln -1.749939

NOTE: Some initial estimates computed by instrumental variable method.

Vector of Initial Estimates

	Parameter	Estimate	Type
1	lv11f3	0.63125	Matrix Entry: _GAMMA_[1:1]
2	lv12f3	0.48553	Matrix Entry: _GAMMA_[2:1]
3	lv13f3	0.24290	Matrix Entry: _GAMMA_[3:1]
4	lv14f3	0.40786	Matrix Entry: _GAMMA_[4:1]
5	vare11	0.83779	Matrix Entry: _PHI_[2:2]
6	vare12	0.28743	Matrix Entry: _PHI_[3:3]
7	vare13	0.73873	Matrix Entry: _PHI_[4:4]
8	vare14	0.38066	Matrix Entry: _PHI_[5:5]

Levenberg-Marquardt Optimization

Scaling Update of More (1978)

Parameter Estimates	8
Functions (Observations)	10

Optimization Start

Active Constraints	0	Objective Function	0.0690122222
Max Abs Gradient Element	0.0962520553	Radius	1

Iter	Restarts	Func Calls	Act Con	Objective Function	Obj Fun Change	Max Abs Gradient Element	Lambda	Actual Over Pred Change
1	0	2	0	0.06502	0.00399	0.0310	0	0.869
2	0	3	0	0.06463	0.000398	0.00865	0	1.034
3	0	4	0	0.06455	0.000074	0.00468	0	1.266
4	0	5	0	0.06453	0.000019	0.00169	0	1.434
5	0	6	0	0.06453	5.191E-6	0.00106	0	1.506
6	0	7	0	0.06453	1.516E-6	0.000460	0	1.534
7	0	8	0	0.06453	4.5E-7	0.000287	0	1.543
8	0	9	0	0.06453	1.346E-7	0.000146	0	1.546
9	0	10	0	0.06453	4.037E-8	0.000083	0	1.548
10	0	11	0	0.06453	1.213E-8	0.000045	0	1.548
11	0	12	0	0.06453	3.646E-9	0.000025	0	1.548
12	0	13	0	0.06453	1.097E-9	0.000014	0	1.548
13	0	14	0	0.06453	3.3E-10	7.45E-6	0	1.549

Optimization Results

Iterations	13	Function Calls	15

```
Jacobian Calls                        14  Active Constraints                0
Objective Function           0.064526266  Max Abs Gradient Element   7.4499272E-6
Lambda                                 0  Actual Over Pred Change    1.5485062484
Radius                      0.0000938927

GCONV convergence criterion satisfied.

                            Predicted Model Matrix

                 v11_dgn          v12_mfg          v13_crd          v14_int

v11_dgn       1.236271828      0.2888033813     0.1485812816     0.2862438567
v12_mfg       0.288803381      0.5231727330     0.1116835329     0.2151598427
v13_crd       0.148581282      0.1116835329     0.7977319588     0.1106937357
v14_int       0.286243857      0.2151598427     0.1106937357     0.5470103093

                Determinant      0.185368    Ln     -1.685413

          Fit Function                                           0.0645
          Goodness of Fit Index (GFI)                            0.9675
          GFI Adjusted for Degrees of Freedom (AGFI)             0.8374
          Root Mean Square Residual (RMR)                        0.0460
          Parsimonious GFI (Mulaik, 1989)                        0.3225
          Chi-Square                                             6.2590
          Chi-Square DF                                               2
          Pr > Chi-Square                                        0.0437
          Independence Model Chi-Square                          47.038
          Independence Model Chi-Square DF                            6
          RMSEA Estimate                                         0.1482
          RMSEA 90% Lower Confidence Limit                       0.0216
          RMSEA 90% Upper Confidence Limit                       0.2862
          ECVI Estimate                                          0.2384
          ECVI 90% Lower Confidence Limit                             .
          ECVI 90% Upper Confidence Limit                        0.3625
          Probability of Close Fit                               0.0790
          Bentler's Comparative Fit Index                        0.8962
          Elliptic Corrected Chi-Square                          6.8403
          Pr > Elliptic Corrected Chi-Square                     0.0327
          Normal Theory Reweighted LS Chi-Square                 6.5189
          Akaike's Information Criterion                         2.2590
          Bozdogan's (1987) CAIC                                -4.9109
          Schwarz's Bayesian Criterion                          -2.9109
          McDonald's (1989) Centrality                           0.9785
          Bentler & Bonett's (1980) Non-normed Index             0.6886
          Bentler & Bonett's (1980) NFI                          0.8669
          James, Mulaik, & Brett (1982) Parsimonious NFI         0.2890
          Z-Test of Wilson & Hilferty (1931)                     1.7215
          Bollen (1986) Normed Index Rho1                        0.6008
          Bollen (1988) Non-normed Index Delta2                  0.9054
          Hoelter's (1983) Critical N                                94

                              Raw Residual Matrix

                     v11_dgn       v12_mfg       v13_crd       v14_int

        v11_dgn  0.0000000000  0.0388801869  -.0881394554  -.0221496005
        v12_mfg  0.0388801869  0.0000000000  -.0452328701  -.0098579281
        v13_crd  -.0881394554  -.0452328701  0.0000000000  0.0961103880
        v14_int  -.0221496005  -.0098579281  0.0961103880  0.0000000000

            Average Absolute Residual                         0.030037
            Average Off-diagonal Absolute Residual            0.050062


                      Rank Order of the 5 Largest Raw Residuals

                         Row         Column        Residual

                         v14_int     v13_crd        0.09611
                         v13_crd     v11_dgn       -0.08814
```

```
                  v13_crd     v12_mfg       -0.04523
                  v12_mfg     v11_dgn        0.03888
                  v14_int     v11_dgn       -0.02215


             Asymptotically Standardized Residual Matrix

                 v11_dgn       v12_mfg       v13_crd       v14_int

   v11_dgn   0.000000000   2.544070881  -1.325131043  -1.297092957
   v12_mfg   2.544070881   0.000000000  -1.297090377  -1.325111469
   v13_crd  -1.325131043  -1.297090377   0.000000000   2.544389925
   v14_int  -1.297092957  -1.325111469   2.544389925   0.000000000

       Average Standardized Residual                    1.033289
       Average Off-diagonal Standardized Residual       1.722148


   Rank Order of the 5 Largest Asymptotically Standardized Residuals

                  Row         Column        Residual

                  v14_int     v13_crd        2.54439
                  v12_mfg     v11_dgn        2.54407
                  v13_crd     v11_dgn       -1.32513
                  v14_int     v12_mfg       -1.32511
                  v14_int     v11_dgn       -1.29709


          Distribution of Asymptotically Standardized Residuals

                     Each * Represents 1 Residuals

 ----------Range---------    Freq    Percent

   -1.50000      -1.25000       4      40.00    ****
   -1.25000      -1.00000       0       0.00
   -1.00000      -0.75000       0       0.00
   -0.75000      -0.50000       0       0.00
   -0.50000      -0.25000       0       0.00
   -0.25000             0       0       0.00
          0       0.25000       4      40.00    ****
    0.25000       0.50000       0       0.00
    0.50000       0.75000       0       0.00
    0.75000       1.00000       0       0.00
    1.00000       1.25000       0       0.00
    1.25000       1.50000       0       0.00
    1.50000       1.75000       0       0.00
    1.75000       2.00000       0       0.00
    2.00000       2.25000       0       0.00
    2.25000       2.50000       0       0.00
    2.50000       2.75000       2      20.00    **


              Manifest Variable Equations with Estimates


            v11_dgn =   0.6199*f3       +  1.0000 e11
            Std Err     0.1370 lv11f3
            t Value     4.5251
            v12_mfg =   0.4659*f3       +  1.0000 e12
            Std Err     0.0926 lv12f3
            t Value     5.0314
            v13_crd =   0.2397*f3       +  1.0000 e13
            Std Err     0.1110 lv13f3
            t Value     2.1602
            v14_int =   0.4618*f3       +  1.0000 e14
            Std Err     0.0938 lv14f3
            t Value     4.9231
```

Variances of Exogenous Variables

Variable	Parameter	Estimate	Standard Error	t Value
f3		1.00000		
e11	vare11	0.85205	0.16512	5.16
e12	vare12	0.30609	0.07527	4.07
e13	vare13	0.74027	0.11094	6.67
e14	vare14	0.33376	0.07700	4.33

Manifest Variable Equations with Standardized Estimates

```
v11_dgn =   0.5575*f3      +  0.8302 e11
                   lv11f3
v12_mfg =   0.6442*f3      +  0.7649 e12
                   lv12f3
v13_crd =   0.2684*f3      +  0.9633 e13
                   lv13f3
v14_int =   0.6244*f3      +  0.7811 e14
                   lv14f3
```

Squared Multiple Correlations

	Variable	Error Variance	Total Variance	R-Square
1	v11_dgn	0.85205	1.23627	0.3108
2	v12_mfg	0.30609	0.52317	0.4149
3	v13_crd	0.74027	0.79773	0.0720
4	v14_int	0.33376	0.54701	0.3899

Lagrange Multiplier and Wald Test Indices _PHI_ [5:5]
Diagonal Matrix
Univariate Tests for Constant Constraints
Lagrange Multiplier or Wald Index / Probability / Approx Change of Value

	f3	e11	e12	e13	e14
f3	.	.	.	.	.
	.	.	.	.	.
	.	.	.	.	.
	Sing	Sing	Sing	Sing	Sing
e11	.	26.6291	6.4726	1.7560	1.6824
	.	.	0.0110	0.1851	0.1946
	.	.	0.4476	-0.1296	-0.2227
	Sing	[vare11]			
e12	.	6.4726	16.5350	1.6825	1.7559
	.	0.0110	.	0.1946	0.1851
	.	0.4476	.	-0.0869	-0.1876
	Sing		[vare12]		
e13	.	1.7560	1.6825	44.5285	6.4737
	.	0.1851	0.1946	.	0.0109
	.	-0.1296	-0.0869	.	0.1716
	Sing			[vare13]	
e14	.	1.6824	1.7559	6.4737	18.7865
	.	0.1946	0.1851	0.0109	.
	.	-0.2227	-0.1876	0.1716	.
	Sing				[vare14]

```
      Rank Order of the 6 Largest Lagrange Multipliers in _PHI_

            Row         Column      Chi-Square    Pr > ChiSq

            e14         e13            6.47373       0.0109
            e12         e11            6.47263       0.0110
            e13         e11            1.75603       0.1851
            e14         e12            1.75594       0.1851
            e13         e12            1.68253       0.1946
            e14         e11            1.68242       0.1946

        Lagrange Multiplier and Wald Test Indices _GAMMA_ [4:1]
                             General Matrix
               Univariate Tests for Constant Constraints
Lagrange Multiplier or Wald Index / Probability / Approx Change of Value

                                              f3

                         v11_dgn        20.4762
                                              .
                                              .
                                        [lv11f3]

                         v12_mfg        25.3153
                                              .
                                              .
                                        [lv12f3]

                         v13_crd         4.6666
                                              .
                                              .
                                        [lv13f3]

                         v14_int        24.2369
                                              .
                                              .
                                        [lv14f3]
                                   ]
```

APPENDIX J: ORGANISATION CONSTRUCT ANALYSIS

```
                          The CALIS Procedure
         Covariance Structure Analysis: Pattern and Initial Values

                          LINEQS Model Statement


                       Matrix      Rows    Columns    ------Matrix Type-------

Term 1            1    _SEL_          5         11    SELECTION
                  2    _BETA_        11         11    EQSBETA        IMINUSINV
                  3    _GAMMA_       11          6    EQSGAMMA
                  4    _PHI_          6          6    SYMMETRIC

                        The 5 Endogenous Variables

    Manifest        v06_skl  v07_tmd  v08_org  v09_rel  v10_cul
    Latent


                        The 6 Exogenous Variables

    Manifest
    Latent          f2
    Error           e06      e07      e08      e09      e10


         Covariance Structure Analysis: Pattern and Initial Values

             Manifest Variable Equations with Initial Estimates


                v06_skl =        .*f2      +  1.0000 e06
                                  lv06f2
                v07_tmd =        .*f2      +  1.0000 e07
                                  lv07f2
                v08_org =        .*f2      +  1.0000 e08
                                  lv08f2
                v09_rel =        .*f2      +  1.0000 e09
                                  lv09f2
                v10_cul =        .*f2      +  1.0000 e10
                                  lv10f2


                      Variances of Exogenous Variables

                      Variable Parameter      Estimate

                      f2                       1.00000
                      e06      vare06                .
                      e07      vare07                .
                      e08      vare08                .
                      e09      vare09                .
                      e10      vare10                .


        Covariance Structure Analysis: Maximum Likelihood Estimation

           Observations          97    Model Terms             1
           Variables              5    Model Matrices          4
           Informations          15    Parameters             10


      Variable          Mean       Std Dev      Skewness      Kurtosis

      v06_skl        3.65155       0.58401      -0.21170      -0.00833
      v07_tmd        3.58144       0.67521      -0.59660       0.45910
      v08_org        2.69897       0.52291       0.21306      -0.49695
      v09_rel        3.26804       0.61433      -0.20965      -0.64672
      v10_cul        4.00206       0.54044      -0.13081      -0.40529
```

```
            Mardia's Multivariate Kurtosis                 1.1043
            Relative Multivariate Kurtosis                 1.0316
            Normalized Multivariate Kurtosis               0.6500
            Mardia Based Kappa (Browne, 1982)              0.0316
            Mean Scaled Univariate Kurtosis               -0.0732
            Adjusted Mean Scaled Univariate Kurtosis      -0.0732

          Observation Numbers with Largest Contribution to Kurtosis

          87            74            76            60            68

     217.0203      167.7041       62.2252       51.8964       44.5097

                                 Covariances

              v06_skl       v07_tmd       v08_org       v09_rel       v10_cul

 v06_skl  0.3410652921  0.1755498282  0.0565120275  0.0477061856  0.0869759450
 v07_tmd  0.1755498282  0.4559020619  0.1006056701  0.0691924399  0.1412886598
 v08_org  0.0565120275  0.1006056701  0.2734364261  0.0323625430  0.0372938144
 v09_rel  0.0477061856  0.0691924399  0.0323625430  0.3774054983  0.0831915808
 v10_cul  0.0869759450  0.1412886598  0.0372938144  0.0831915808  0.2920790378

                Determinant      0.002667    Ln     -5.926850

NOTE: Some initial estimates computed by instrumental variable method.


          Covariance Structure Analysis: Maximum Likelihood Estimation

                          Vector of Initial Estimates

                 Parameter      Estimate    Type

            1    lv06f2          0.32391    Matrix Entry: _GAMMA_[1:1]
            2    lv07f2          0.53549    Matrix Entry: _GAMMA_[2:1]
            3    lv08f2          0.17960    Matrix Entry: _GAMMA_[3:1]
            4    lv09f2          0.15880    Matrix Entry: _GAMMA_[4:1]
            5    lv10f2          0.26942    Matrix Entry: _GAMMA_[5:1]
            6    vare06          0.23614    Matrix Entry: _PHI_[2:2]
            7    vare07          0.16915    Matrix Entry: _PHI_[3:3]
            8    vare08          0.24118    Matrix Entry: _PHI_[4:4]
            9    vare09          0.35219    Matrix Entry: _PHI_[5:5]
           10    vare10          0.21949    Matrix Entry: _PHI_[6:6]

          Covariance Structure Analysis: Maximum Likelihood Estimation

                       Levenberg-Marquardt Optimization

                        Scaling Update of More (1978)

                   Parameter Estimates                  10
                   Functions (Observations)             15

                             Optimization Start

Active Constraints                    0  Objective Function          0.02912184
Max Abs Gradient Element   0.0387540113  Radius                               1


                                                                         Actual
                                                     Max Abs               Over
        Rest    Func      Act    Objective  Obj Fun Gradient               Pred
 Iter   arts   Calls      Con     Function   Change  Element   Lambda    Change

    1      0       2        0      0.02876 0.000360  0.00844        0     0.914
    2      0       3        0      0.02875 0.000015  0.00141        0     0.880
    3      0       4        0      0.02875 7.068E-7 0.000412        0     0.874
    4      0       5        0      0.02875 3.426E-8 0.000068        0     0.872
    5      0       6        0      0.02875 1.657E-9 0.000020        0     0.871
```

```
   6       0       7        0      0.02875 8.02E-11   3.3E-6       0    0.870

                              Optimization Results

Iterations                            6  Function Calls                     8
Jacobian Calls                        7  Active Constraints                 0
Objective Function         0.0287462731  Max Abs Gradient Element   3.2996715E-6
Lambda                                0  Actual Over Pred Change    0.8701567922
Radius                      0.000034177

GCONV convergence criterion satisfied.

                             Predicted Model Matrix

               v06_skl       v07_tmd       v08_org       v09_rel       v10_cul

 v06_skl  0.3410652921  0.1725091879  0.0595196723  0.0532405603  0.0901003922
 v07_tmd  0.1725091879  0.4559020619  0.0943788362  0.0844222074  0.1428699089
 v08_org  0.0595196723  0.0943788362  0.2734364261  0.0291276203  0.0492934334
 v09_rel  0.0532405603  0.0844222074  0.0291276203  0.3774054983  0.0440931529
 v10_cul  0.0901003922  0.1428699089  0.0492934334  0.0440931529  0.2920790378

                 Determinant      0.002745    Ln     -5.898104


          Covariance Structure Analysis: Maximum Likelihood Estimation

          Fit Function                                             0.0287
          Goodness of Fit Index (GFI)                              0.9888
          GFI Adjusted for Degrees of Freedom (AGFI)               0.9663
          Root Mean Square Residual (RMR)                          0.0116
          Parsimonious GFI (Mulaik, 1989)                          0.4944
          Chi-Square                                               2.7596
          Chi-Square DF                                                 5
          Pr > Chi-Square                                          0.7370
          Independence Model Chi-Square                            54.129
          Independence Model Chi-Square DF                             10
          RMSEA Estimate                                           0.0000
          RMSEA 90% Lower Confidence Limit                              .
          RMSEA 90% Upper Confidence Limit                         0.1016
          ECVI Estimate                                            0.2510
          ECVI 90% Lower Confidence Limit                               .
          ECVI 90% Upper Confidence Limit                          0.3282
          Probability of Close Fit                                 0.8220
          Bentler's Comparative Fit Index                          1.0000
          Elliptic Corrected Chi-Square                            2.6752
          Pr > Elliptic Corrected Chi-Square                       0.7499
          Normal Theory Reweighted LS Chi-Square                   2.7259
          Akaike's Information Criterion                          -7.2404
          Bozdogan's (1987) CAIC                                 -25.1139
          Schwarz's Bayesian Criterion                           -20.1139
          McDonald's (1989) Centrality                             1.0116
          Bentler & Bonett's (1980) Non-normed Index               1.1015
          Bentler & Bonett's (1980) NFI                            0.9490
          James, Mulaik, & Brett (1982) Parsimonious NFI           0.4745
          Z-Test of Wilson & Hilferty (1931)                      -0.6417
          Bollen (1986) Normed Index Rho1                          0.8980
          Bollen (1988) Non-normed Index Delta2                    1.0456
          Hoelter's (1983) Critical N                                 387

                              Raw Residual Matrix

               v06_skl       v07_tmd       v08_org       v09_rel       v10_cul

 v06_skl  0.0000000000  0.0030406403  -.0030076448  -.0055343747  -.0031244471
 v07_tmd  0.0030406403  0.0000000000  0.0062268339  -.0152297675  -.0015812491
 v08_org  -.0030076448  0.0062268339  0.0000000000  0.0032349227  -.0119996189
 v09_rel  -.0055343747  -.0152297675  0.0032349227  0.0000000000  0.0390984279
 v10_cul  -.0031244471  -.0015812491  -.0119996189  0.0390984279  0.0000000000
```

```
          Average Absolute Residual                         0.006139
          Average Off-diagonal Absolute Residual            0.009208

                  Rank Order of the 7 Largest Raw Residuals

                     Row         Column        Residual

                     v10_cul     v09_rel        0.03910
                     v09_rel     v07_tmd       -0.01523
                     v10_cul     v08_org       -0.01200
                     v08_org     v07_tmd        0.00623
                     v09_rel     v06_skl       -0.00553
                     v09_rel     v08_org        0.00323
                     v10_cul     v06_skl       -0.00312

        Covariance Structure Analysis: Maximum Likelihood Estimation

                Asymptotically Standardized Residual Matrix

              v06_skl       v07_tmd       v08_org       v09_rel       v10_cul

v06_skl   0.000000000   0.531968425  -0.153415114  -0.222004949  -0.219471853
v07_tmd   0.531968425   0.000000000   0.566479471  -1.035209553  -0.232176253
v08_org  -0.153415114   0.566479471   0.000000000   0.114512272  -0.595305043
v09_rel  -0.222004949  -1.035209553   0.114512272   0.000000000   1.549809765
v10_cul  -0.219471853  -0.232176253  -0.595305043   1.549809765   0.000000000

          Average Standardized Residual                     0.348024
          Average Off-diagonal Standardized Residual        0.522035


      Rank Order of the 7 Largest Asymptotically Standardized Residuals

                     Row         Column        Residual

                     v10_cul     v09_rel        1.54981
                     v09_rel     v07_tmd       -1.03521
                     v10_cul     v08_org       -0.59531
                     v08_org     v07_tmd        0.56648
                     v07_tmd     v06_skl        0.53197
                     v10_cul     v07_tmd       -0.23218
                     v09_rel     v06_skl       -0.22200

        Covariance Structure Analysis: Maximum Likelihood Estimation

            Distribution of Asymptotically Standardized Residuals

                        Each * Represents 1 Residuals

  ----------Range---------    Freq    Percent

    -1.25000      -1.00000       1       6.67    *
    -1.00000      -0.75000       0       0.00
    -0.75000      -0.50000       1       6.67    *
    -0.50000      -0.25000       0       0.00
    -0.25000             0       4      26.67    ****
           0       0.25000       6      40.00    ******
     0.25000       0.50000       0       0.00
     0.50000       0.75000       2      13.33    **
     0.75000       1.00000       0       0.00
     1.00000       1.25000       0       0.00
     1.25000       1.50000       0       0.00
     1.50000       1.75000       1       6.67    *


        Covariance Structure Analysis: Maximum Likelihood Estimation

                 Manifest Variable Equations with Estimates

               v06_skl =   0.3298*f2       +  1.0000 e06
```

```
          Std Err     0.0693 lv06f2
          t Value     4.7590
          v07_tmd =   0.5230*f2      +  1.0000 e07
          Std Err     0.0856 lv07f2
          t Value     6.1075
          v08_org =   0.1805*f2      +  1.0000 e08
          Std Err     0.0619 lv08f2
          t Value     2.9133
          v09_rel =   0.1614*f2      +  1.0000 e09
          Std Err     0.0733 lv09f2
          t Value     2.2029
          v10_cul =   0.2732*f2      +  1.0000 e10
          Std Err     0.0635 lv10f2
          t Value     4.2993
```

Variances of Exogenous Variables

Variable	Parameter	Estimate	Standard Error	t Value
f2		1.00000		
e06	vare06	0.23227	0.04376	5.31
e07	vare07	0.18236	0.07127	2.56
e08	vare08	0.24087	0.03687	6.53
e09	vare09	0.35135	0.05231	6.72
e10	vare10	0.21746	0.03739	5.82

Manifest Variable Equations with Standardized Estimates

```
          v06_skl =   0.5648*f2      +  0.8252 e06
                             lv06f2
          v07_tmd =   0.7746*f2      +  0.6325 e07
                             lv07f2
          v08_org =   0.3451*f2      +  0.9386 e08
                             lv08f2
          v09_rel =   0.2627*f2      +  0.9649 e09
                             lv09f2
          v10_cul =   0.5054*f2      +  0.8629 e10
                             lv10f2
```

Squared Multiple Correlations

	Variable	Error Variance	Total Variance	R-Square
1	v06_skl	0.23227	0.34107	0.3190
2	v07_tmd	0.18236	0.45590	0.6000
3	v08_org	0.24087	0.27344	0.1191
4	v09_rel	0.35135	0.37741	0.0690
5	v10_cul	0.21746	0.29208	0.2555

Lagrange Multiplier and Wald Test Indices _PHI_ [6:6]
Diagonal Matrix
Univariate Tests for Constant Constraints
Lagrange Multiplier or Wald Index / Probability / Approx Change of Value

	f2	e06	e07	e08	e09	e10
f2	.	.	.	.	.	.
	.	.	.	.	.	.
	.	.	.	.	.	.
	Sing	Sing	Sing	Sing	Sing	Sing
e06	.	28.1745	0.2830	0.0235	0.0493	0.0482
	.	.	0.5947	0.8781	0.8243	0.8263
	.	.	0.0411	-0.0046	-0.0076	-0.0081

```
          Sing    [vare06]

e07        .         0.2830      6.5470      0.3209      1.0716      0.0539
           .         0.5947        .         0.5711      0.3006      0.8164
           .         0.0411        .         0.0236     -0.0470     -0.0141
          Sing                 [vare07]

e08        .         0.0235      0.3209     42.6752      0.0131      0.3544
           .         0.8781      0.5711        .         0.9088      0.5516
           .        -0.0046      0.0236        .         0.0036     -0.0161
          Sing                             [vare08]

e09        .         0.0493      1.0716      0.0131     45.1227      2.4019
           .         0.8243      0.3006      0.9088        .         0.1212
           .        -0.0076     -0.0470      0.0036        .         0.0489
          Sing                                         [vare09]

e10        .         0.0482      0.0539      0.3544      2.4019     33.8259
           .         0.8263      0.8164      0.5516      0.1212        .
           .        -0.0081     -0.0141     -0.0161      0.0489        .
          Sing                                                     [vare10]

       Rank Order of the 10 Largest Lagrange Multipliers in _PHI_

             Row         Column      Chi-Square    Pr > ChiSq

             e10         e09            2.40191        0.1212
             e09         e07            1.07164        0.3006
             e10         e08            0.35439        0.5516
             e08         e07            0.32089        0.5711
             e07         e06            0.28299        0.5947
             e10         e07            0.05391        0.8164
             e09         e06            0.04928        0.8243
             e10         e06            0.04817        0.8263
             e08         e06            0.02354        0.8781
             e09         e08            0.01311        0.9088


         Lagrange Multiplier and Wald Test Indices _GAMMA_ [5:1]
                              General Matrix
                  Univariate Tests for Constant Constraints
  Lagrange Multiplier or Wald Index / Probability / Approx Change of Value

                                         f2

                      v06_skl        22.6481
                                        .
                                        .
                                    [lv06f2]

                      v07_tmd        37.3016
                                        .
                                        .
                                    [lv07f2]

                      v08_org         8.4874
                                        .
                                        .
                                    [lv08f2]

                      v09_rel         4.8527
                                        .
                                        .
                                    [lv09f2]

                      v10_cul        18.4844
                                        .
                                        .
                                    [lv10f2]
```

APPENDIX K: OPERATIONAL PERFORMANCE CONSTRUCT ANALYSIS

```
                              The CALIS Procedure
           Covariance Structure Analysis: Pattern and Initial Values

                             LINEQS Model Statement


                      Matrix      Rows    Columns    ------Matrix Type-------

Term 1             1    _SEL_         5         11    SELECTION
                   2    _BETA_       11         11    EQSBETA        IMINUSINV
                   3    _GAMMA_      11          6    EQSGAMMA
                   4    _PHI_         6          6    SYMMETRIC

                          The 5 Endogenous Variables

    Manifest        v01_qty  v02_spd  v03_dpn  v04_flx  v05_cst
    Latent


                          The 6 Exogenous Variables

    Manifest
    Latent          f1
    Error           e01      e02      e03      e04      e05

          Covariance Structure Analysis: Pattern and Initial Values

              Manifest Variable Equations with Initial Estimates


                 v01_qty =        .*f1      +  1.0000 e01
                                   lv01f1
                 v02_spd =        .*f1      +  1.0000 e02
                                   lv02f1
                 v03_dpn =        .*f1      +  1.0000 e03
                                   lv03f1
                 v04_flx =        .*f1      +  1.0000 e04
                                   lv04f1
                 v05_cst =        .*f1      +  1.0000 e05
                                   lv05f1


                       Variances of Exogenous Variables

                       Variable Parameter      Estimate

                       f1                       1.00000
                       e01      vare01                .
                       e02      vare02                .
                       e03      vare03                .
                       e04      vare04                .
                       e05      vare05                .


         Covariance Structure Analysis: Maximum Likelihood Estimation

            Observations          97    Model Terms            1
            Variables              5    Model Matrices         4
            Informations          15    Parameters            10

       Variable          Mean       Std Dev      Skewness      Kurtosis

       v01_qty        4.26804       0.45997      -0.40662      -0.33513
       v02_spd        3.37938       0.60998      -0.47378       0.47695
       v03_dpn        3.75670       0.49768      -0.34369       0.31878
       v04_flx        3.76495       0.53230      -0.10885       0.17156
       v05_cst        2.64536       0.53347       0.32626      -0.12370
```

```
              Mardia's Multivariate Kurtosis                 2.0150
              Relative Multivariate Kurtosis                 1.0576
              Normalized Multivariate Kurtosis               1.1860
              Mardia Based Kappa (Browne, 1982)              0.0576
              Mean Scaled Univariate Kurtosis                0.0339
              Adjusted Mean Scaled Univariate Kurtosis       0.0339

            Observation Numbers with Largest Contribution to Kurtosis

              93             1             16             55             6

        176.0059       137.9801        93.5682        88.6481        74.3541

                                   Covariances

                v01_qty       v02_spd       v03_dpn       v04_flx       v05_cst

 v01_qty  0.2115721649  0.0851675258  0.1300601375  0.0865764605  -.0085352234
 v02_spd  0.0851675258  0.3720704467  0.1440979381  0.1430197595  -.1261383162
 v03_dpn  0.1300601375  0.1440979381  0.2476890034  0.0972164948  -.0642654639
 v04_flx  0.0865764605  0.1430197595  0.0972164948  0.2833419244  -.0729768041
 v05_cst  -.0085352234  -.1261383162  -.0642654639  -.0729768041  0.2845876289

                  Determinant      0.000500    Ln     -7.600251

NOTE: Some initial estimates computed by instrumental variable method.

          Covariance Structure Analysis: Maximum Likelihood Estimation

                            Vector of Initial Estimates

                   Parameter      Estimate    Type

              1    lv01f1          0.34330    Matrix Entry: _GAMMA_[1:1]
              2    lv02f1          0.35140    Matrix Entry: _GAMMA_[2:1]
              3    lv03f1          0.40810    Matrix Entry: _GAMMA_[3:1]
              4    lv04f1          0.24556    Matrix Entry: _GAMMA_[4:1]
              5    lv05f1         -0.18605    Matrix Entry: _GAMMA_[5:1]
              6    vare01          0.09372    Matrix Entry: _PHI_[2:2]
              7    vare02          0.24859    Matrix Entry: _PHI_[3:3]
              8    vare03          0.08114    Matrix Entry: _PHI_[4:4]
              9    vare04          0.22304    Matrix Entry: _PHI_[5:5]
             10    vare05          0.24997    Matrix Entry: _PHI_[6:6]

          Covariance Structure Analysis: Maximum Likelihood Estimation

                          Levenberg-Marquardt Optimization

                           Scaling Update of More (1978)

                     Parameter Estimates                   10
                     Functions (Observations)              15

                                Optimization Start

Active Constraints                    0  Objective Function         0.2441115652
Max Abs Gradient Element   1.7023908976  Radius                      14.24659199


                                                                           Actual
                                                       Max Abs               Over
        Rest     Func       Act     Objective  Obj Fun Gradient              Pred
 Iter   arts    Calls       Con      Function   Change  Element   Lambda   Change

    1      0        2         0       0.20921   0.0349   0.5102        0    0.676
    2      0        3         0       0.20116  0.00804   0.2699        0    0.649
    3      0        4         0       0.19879  0.00237   0.1453        0    0.617
    4      0        5         0       0.19809 0.000709   0.0787        0    0.639
    5      0        6         0       0.19788 0.000205   0.0411        0    0.669
```

```
   6       0       7       0      0.19782 0.000061   0.0224       0    0.718
   7       0       8       0      0.19780 0.000018   0.0117       0    0.779
   8       0       9       0      0.19780 5.603E-6  0.00648       0    0.855
   9       0      10       0      0.19779  1.77E-6  0.00344       0    0.942
  10       0      11       0      0.19779 5.744E-7  0.00193       0    1.037
  11       0      12       0      0.19779 1.907E-7  0.00104       0    1.133
  12       0      13       0      0.19779 6.452E-8 0.000591       0    1.224
  13       0      14       0      0.19779 2.217E-8 0.000323       0    1.306
  14       0      15       0      0.19779 7.706E-9 0.000187       0    1.376
  15       0      16       0      0.19779 2.702E-9 0.000104       0    1.433
  16       0      17       0      0.19779 9.54E-10 0.000061       0    1.477

                          Optimization Results

Iterations                          16  Function Calls                     18
Jacobian Calls                      17  Active Constraints                  0
Objective Function        0.1977927327  Max Abs Gradient Element  0.0000605963
Lambda                               0  Actual Over Pred Change    1.4768207367
Radius                    0.0001628538

GCONV convergence criterion satisfied.


          Covariance Structure Analysis: Maximum Likelihood Estimation

                            Predicted Model Matrix

             v01_qty       v02_spd       v03_dpn       v04_flx       v05_cst

 v01_qty  0.2115721650  0.1112961268  0.1112490727  0.0846132584  -.0525755198
 v02_spd  0.1112961268  0.3720704468  0.1504160078  0.1144026483  -.0710855345
 v03_dpn  0.1112490727  0.1504160078  0.2476890035  0.1143542808  -.0710554807
 v04_flx  0.0846132584  0.1144026483  0.1143542808  0.2833419244  -.0540430191
 v05_cst  -.0525755198  -.0710855345  -.0710554807  -.0540430191  0.2845876289

                Determinant      0.000610    Ln     -7.402458

          Covariance Structure Analysis: Maximum Likelihood Estimation

          Fit Function                                              0.1978
          Goodness of Fit Index (GFI)                               0.9220
          GFI Adjusted for Degrees of Freedom (AGFI)                0.7659
          Root Mean Square Residual (RMR)                           0.0225
          Parsimonious GFI (Mulaik, 1989)                           0.4610
          Chi-Square                                               18.9881
          Chi-Square DF                                                  5
          Pr > Chi-Square                                           0.0019
          Independence Model Chi-Square                             109.92
          Independence Model Chi-Square DF                              10
          RMSEA Estimate                                            0.1707
          RMSEA 90% Lower Confidence Limit                          0.0937
          RMSEA 90% Upper Confidence Limit                          0.2554
          ECVI Estimate                                             0.4200
          ECVI 90% Lower Confidence Limit                           0.3169
          ECVI 90% Upper Confidence Limit                           0.6071
          Probability of Close Fit                                  0.0079
          Bentler's Comparative Fit Index                           0.8600
          Elliptic Corrected Chi-Square                            17.9544
          Pr > Elliptic Corrected Chi-Square                        0.0030
          Normal Theory Reweighted LS Chi-Square                   20.3118
          Akaike's Information Criterion                            8.9881
          Bozdogan's (1987) CAIC                                   -8.8855
          Schwarz's Bayesian Criterion                             -3.8855
          McDonald's (1989) Centrality                              0.9304
          Bentler & Bonett's (1980) Non-normed Index                0.7200
          Bentler & Bonett's (1980) NFI                             0.8273
          James, Mulaik, & Brett (1982) Parsimonious NFI            0.4136
          Z-Test of Wilson & Hilferty (1931)                        2.8679
          Bollen (1986) Normed Index Rho1                           0.6545
          Bollen (1988) Non-normed Index Delta2                     0.8667
```

Hoelter's (1983) Critical N 57

Covariance Structure Analysis: Maximum Likelihood Estimation

Raw Residual Matrix

	v01_qty	v02_spd	v03_dpn	v04_flx	v05_cst
v01_qty	0.0000000000	-.0261286010	0.0188110648	0.0019632021	0.0440402964
v02_spd	-.0261286010	0.0000000000	-.0063180696	0.0286171111	-.0550527816
v03_dpn	0.0188110648	-.0063180696	0.0000000000	-.0171377859	0.0067900168
v04_flx	0.0019632021	0.0286171111	-.0171377859	0.0000000000	-.0189337851
v05_cst	0.0440402964	-.0550527816	0.0067900168	-.0189337851	0.0000000000

Average Absolute Residual 0.014920
Average Off-diagonal Absolute Residual 0.022379

Rank Order of the 7 Largest Raw Residuals

Row	Column	Residual
v05_cst	v02_spd	-0.05505
v05_cst	v01_qty	0.04404
v04_flx	v02_spd	0.02862
v02_spd	v01_qty	-0.02613
v05_cst	v04_flx	-0.01893
v03_dpn	v01_qty	0.01881
v04_flx	v03_dpn	-0.01714

Covariance Structure Analysis: Maximum Likelihood Estimation

Asymptotically Standardized Residual Matrix

	v01_qty	v02_spd	v03_dpn	v04_flx	v05_cst
v01_qty	0.000000000	-2.277543403	3.671419899	0.158744011	2.774616218
v02_spd	-2.277543403	0.000000000	-0.975746307	1.800511219	-2.675822301
v03_dpn	3.671419899	-0.975746307	0.000000000	-2.277540262	0.625412977
v04_flx	0.158744011	1.800511219	-2.277540262	0.000000000	-0.926976785
v05_cst	2.774616218	-2.675822301	0.625412977	-0.926976785	0.000000000

Average Standardized Residual 1.210956
Average Off-diagonal Standardized Residual 1.816433

Rank Order of the 7 Largest Asymptotically Standardized Residuals

Row	Column	Residual
v03_dpn	v01_qty	3.67142
v05_cst	v01_qty	2.77462
v05_cst	v02_spd	-2.67582
v02_spd	v01_qty	-2.27754
v04_flx	v03_dpn	-2.27754
v04_flx	v02_spd	1.80051
v03_dpn	v02_spd	-0.97575

Covariance Structure Analysis: Maximum Likelihood Estimation

Distribution of Asymptotically Standardized Residuals

Each * Represents 1 Residuals

----------Range---------		Freq	Percent	
-2.75000	-2.50000	1	6.67	*
-2.50000	-2.25000	2	13.33	**
-2.25000	-2.00000	0	0.00	
-2.00000	-1.75000	0	0.00	
-1.75000	-1.50000	0	0.00	
-1.50000	-1.25000	0	0.00	
-1.25000	-1.00000	0	0.00	
-1.00000	-0.75000	2	13.33	**
-0.75000	-0.50000	0	0.00	
-0.50000	-0.25000	0	0.00	
-0.25000	0	0	0.00	
0	0.25000	6	40.00	******
0.25000	0.50000	0	0.00	
0.50000	0.75000	1	6.67	*
0.75000	1.00000	0	0.00	
1.00000	1.25000	0	0.00	
1.25000	1.50000	0	0.00	
1.50000	1.75000	0	0.00	
1.75000	2.00000	1	6.67	*
2.00000	2.25000	0	0.00	
2.25000	2.50000	0	0.00	
2.50000	2.75000	0	0.00	
2.75000	3.00000	1	6.67	*
3.00000	3.25000	0	0.00	
3.25000	3.50000	0	0.00	
3.50000	3.75000	1	6.67	*

Covariance Structure Analysis: Maximum Likelihood Estimation

Manifest Variable Equations with Estimates

```
v01_qty =   0.2869*f1      +  1.0000 e01
Std Err     0.0487 lv01f1
t Value     5.8956
v02_spd =   0.3879*f1      +  1.0000 e02
Std Err     0.0644 lv02f1
t Value     6.0257
v03_dpn =   0.3878*f1      +  1.0000 e03
Std Err     0.0515 lv03f1
t Value     7.5327
v04_flx =   0.2949*f1      +  1.0000 e04
Std Err     0.0573 lv04f1
t Value     5.1510
v05_cst =  -0.1832*f1      +  1.0000 e05
Std Err     0.0601 lv05f1
t Value    -3.0504
```

Variances of Exogenous Variables

Variable	Parameter	Estimate	Standard Error	t Value
f1		1.00000		
e01	vare01	0.12926	0.02331	5.55
e02	vare02	0.22159	0.04070	5.44
e03	vare03	0.09734	0.02665	3.65
e04	vare04	0.19637	0.03278	5.99
e05	vare05	0.25101	0.03772	6.65

```
        Covariance Structure Analysis: Maximum Likelihood Estimation

          Manifest Variable Equations with Standardized Estimates


                v01_qty =   0.6238*f1      +  0.7816 e01
                                   lv01f1
                v02_spd =   0.6360*f1      +  0.7717 e02
                                   lv02f1
                v03_dpn =   0.7791*f1      +  0.6269 e03
                                   lv03f1
                v04_flx =   0.5540*f1      +  0.8325 e04
                                   lv04f1
                v05_cst =  -0.3435*f1      +  0.9392 e05
                                   lv05f1


                       Squared Multiple Correlations

                                   Error         Total
                  Variable      Variance      Variance    R-Square

             1    v01_qty        0.12926       0.21157      0.3891
             2    v02_spd        0.22159       0.37207      0.4044
             3    v03_dpn        0.09734       0.24769      0.6070
             4    v04_flx        0.19637       0.28334      0.3070
             5    v05_cst        0.25101       0.28459      0.1180


        Covariance Structure Analysis: Maximum Likelihood Estimation

          Lagrange Multiplier and Wald Test Indices _PHI_   [6:6]
                              Diagonal Matrix
                   Univariate Tests for Constant Constraints
 Lagrange Multiplier or Wald Index / Probability / Approx Change of Value

             f1         e01         e02         e03         e04         e05

f1          .           .           .           .           .           .
            .           .           .           .           .           .
            .           .           .           .           .           .
          Sing        Sing        Sing        Sing        Sing        Sing

e01         .         30.7481      5.1871     13.4805      0.0252      7.6985
            .           .          0.0228      0.0002      0.8739      0.0055
            .           .         -0.0592      0.0939      0.0034      0.0591
          Sing     [vare01]

e02         .          5.1871     29.6434      0.9522      3.2416      7.1598
            .          0.0228       .          0.3292      0.0718      0.0075
            .         -0.0592       .         -0.0339      0.0513     -0.0754
          Sing                 [vare02]

e03         .         13.4805      0.9522     13.3393      5.1875      0.3912
            .          0.0002      0.3292       .          0.0228      0.5317
            .          0.0939     -0.0339       .         -0.0603      0.0147
          Sing                             [vare03]

e04         .          0.0252      3.2416      5.1875     35.8855      0.8592
            .          0.8739      0.0718      0.0228       .          0.3540
            .          0.0034      0.0513     -0.0603       .         -0.0233
          Sing                                         [vare04]

e05         .          7.6985      7.1598      0.3912      0.8592     44.2868
            .          0.0055      0.0075      0.5317      0.3540       .
            .          0.0591     -0.0754      0.0147     -0.0233       .
          Sing                                                     [vare05]
```

```
             Rank Order of the 10 Largest Lagrange Multipliers in _PHI_

                   Row         Column      Chi-Square    Pr > ChiSq

                   e03         e01           13.48046        0.0002
                   e05         e01            7.69855        0.0055
                   e05         e02            7.15981        0.0075
                   e04         e03            5.18749        0.0228
                   e02         e01            5.18705        0.0228
                   e04         e02            3.24163        0.0718
                   e03         e02            0.95216        0.3292
                   e05         e04            0.85922        0.3540
                   e05         e03            0.39121        0.5317
                   e04         e01            0.02520        0.8739

             Covariance Structure Analysis: Maximum Likelihood Estimation

               Lagrange Multiplier and Wald Test Indices _GAMMA_ [5:1]
                                    General Matrix
                      Univariate Tests for Constant Constraints
       Lagrange Multiplier or Wald Index / Probability / Approx Change of Value

                                              f1

                          v01_qty        34.7578
                                               .
                                               .
                                        [lv01f1]

                          v02_spd        36.3091
                                               .
                                               .
                                        [lv02f1]

                          v03_dpn        56.7409
                                               .
                                               .
                                        [lv03f1]

                          v04_flx        26.5329
                                               .
                                               .
                                        [lv04f1]

                          v05_cst         9.3049
                                               .
                                               .
                                        [lv05f1]
```

APPENDIX L: THE MEASUREMENT MODEL’S ANALYSIS

```
                              The CALIS Procedure
           Covariance Structure Analysis: Pattern and Initial Values

                  Automatic Variable Selection, the Following
                  Manifest Variables are not Used in the Model

                           v03_dpn  v08_org  v09_rel

Using the VAR statement for variable selection could save memory and computing
time.



                             LINEQS Model Statement


                        Matrix      Rows    Columns    ------Matrix Type-------

 Term 1            1    _SEL_         11         25    SELECTION
                   2    _BETA_        25         25    EQSBETA        IMINUSINV
                   3    _GAMMA_       25         14    EQSGAMMA
                   4    _PHI_         14         14    SYMMETRIC

                         The 11 Endogenous Variables

     Manifest        v01_qty  v02_spd  v04_flx  v05_cst  v06_skl  v07_tmd
                     v10_cul  v11_dgn  v12_mfg  v13_crd  v14_int
     Latent


                          The 14 Exogenous Variables

     Manifest
     Latent          f1       f2       f3
     Error           e01      e02      e04      e05      e06      e07
                     e10      e11      e12      e13      e14

           Covariance Structure Analysis: Pattern and Initial Values

               Manifest Variable Equations with Initial Estimates


                  v01_qty =       .*f1      +  1.0000 e01
                                   lv01f1
                  v02_spd =       .*f1      +  1.0000 e02
                                   lv02f1
                  v04_flx =       .*f1      +  1.0000 e04
                                   lv04f1
                  v05_cst =       .*f1      +  1.0000 e05
                                   lv05f1
                  v06_skl =       .*f2      +  1.0000 e06
                                   lv06f2
                  v07_tmd =       .*f2      +  1.0000 e07
                                   lv07f2
                  v10_cul =       .*f2      +  1.0000 e10
                                   lv10f2
                  v11_dgn =       .*f3      +  1.0000 e11
                                   lv11f3
                  v12_mfg =       .*f3      +  1.0000 e12
                                   lv12f3
                  v13_crd =       .*f3      +  1.0000 e13
                                   lv13f3
                  v14_int =       .*f3      +  1.0000 e14
                                   lv14f3


                        Variances of Exogenous Variables

                        Variable Parameter      Estimate
```

f1		1.00000
f2		1.00000
f3		1.00000
e01	vare01	.
e02	vare02	.
e04	vare04	.
e05	vare05	.
e06	vare06	.
e07	vare07	.
e10	vare10	.
e11	vare11	.
e12	vare12	.
e13	vare13	.
e14	vare14	.

Covariances Among Exogenous Variables

Var1	Var2	Parameter	Estimate
f1	f2	cf1f2	.
f1	f3	cf1f3	.
f2	f3	cf2f3	.

Covariance Structure Analysis: Maximum Likelihood Estimation

Observations	93	Model Terms	1
Variables	11	Model Matrices	4
Informations	66	Parameters	25

Variable	Mean	Std Dev	Skewness	Kurtosis
v01_qty	4.23011	0.46527	-0.38750	-0.32397
v02_spd	3.39355	0.60538	-0.42997	0.39972
v04_flx	3.73978	0.54116	-0.20135	0.30529
v05_cst	2.65161	0.55160	0.38580	-0.08577
v06_skl	3.65161	0.58896	-0.31114	0.35051
v07_tmd	3.56989	0.68267	-0.57250	0.39142
v10_cul	3.97634	0.54998	-0.30662	0.05892
v11_dgn	3.24731	1.08363	-0.32139	-1.10620
v12_mfg	2.41075	0.69618	0.14517	-0.16775
v13_crd	3.56774	0.89067	-0.40245	-0.43832
v14_int	3.07527	0.69652	0.21466	-0.34663

Mardia's Multivariate Kurtosis	1.9860
Relative Multivariate Kurtosis	1.0139
Normalized Multivariate Kurtosis	0.5663
Mardia Based Kappa (Browne, 1982)	0.0139
Mean Scaled Univariate Kurtosis	-0.0292
Adjusted Mean Scaled Univariate Kurtosis	-0.0096

Observation Numbers with Largest Contribution to Kurtosis

89	70	1	15	85
128.7812	116.3394	102.6785	86.6176	85.5957

Covariances

	v01_qty	v02_spd	v04_flx	v05_cst
v01_qty	0.2164749883	0.1158485273	0.0953108929	-.0246143058
v02_spd	0.1158485273	0.3664796634	0.1674333801	-.1370546985
v04_flx	0.0953108929	0.1674333801	0.2928564750	-.0912061711
v05_cst	-.0246143058	-.1370546985	-.0912061711	0.3042636746
v06_skl	0.0940813464	0.1051192146	0.1092286115	-.0787798036
v07_tmd	0.1017858813	0.1954558205	0.1286021505	-.0945161290

v10_cul	0.0915895278	0.1041935484	0.1072557270	-.1092005610
v11_dgn	0.0289948574	-.0166479663	0.1167928939	-.0824684432
v12_mfg	-.0068489949	-.0038429173	0.0523936419	-.0801262272
v13_crd	0.0183730715	0.0276157083	0.0480364656	0.0042917251
v14_int	0.0446657317	0.0704908836	0.0963207106	-.0774053296

Covariance Structure Analysis: Maximum Likelihood Estimation

Covariances

	v06_skl	v07_tmd	v10_cul	v11_dgn
v01_qty	0.0940813464	0.1017858813	0.0915895278	0.028994857
v02_spd	0.1051192146	0.1954558205	0.1041935484	-0.016647966
v04_flx	0.1092286115	0.1286021505	0.1072557270	0.116792894
v05_cst	-.0787798036	-.0945161290	-.1092005610	-0.082468443
v06_skl	0.3468723703	0.1980925666	0.1238429173	0.235357644
v07_tmd	0.1980925666	0.4660402057	0.2005843852	0.179700795
v10_cul	0.1238429173	0.2005843852	0.3024777934	0.153740065
v11_dgn	0.2353576438	0.1797007948	0.1537400655	1.174259000
v12_mfg	0.0807433380	0.1677185601	0.1254745208	0.273833567
v13_crd	0.0608134642	0.0768443198	0.0648807854	0.087629734
v14_int	0.0765077139	0.1453342683	0.1609303413	0.289878448

Covariances

	v12_mfg	v13_crd	v14_int
v01_qty	-.0068489949	0.0183730715	0.0446657317
v02_spd	-.0038429173	0.0276157083	0.0704908836
v04_flx	0.0523936419	0.0480364656	0.0963207106
v05_cst	-.0801262272	0.0042917251	-.0774053296
v06_skl	0.0807433380	0.0608134642	0.0765077139
v07_tmd	0.1677185601	0.0768443198	0.1453342683
v10_cul	0.1254745208	0.0648807854	0.1609303413
v11_dgn	0.2738335671	0.0876297335	0.2898784479
v12_mfg	0.4846657317	0.0799158485	0.1957035998
v13_crd	0.0799158485	0.7932959327	0.1824544180
v14_int	0.1957035998	0.1824544180	0.4851425900

Determinant 0.000003809 Ln -12.478249

NOTE: Some initial estimates computed by instrumental variable method.

Covariance Structure Analysis: Maximum Likelihood Estimation

Vector of Initial Estimates

	Parameter	Estimate	Type
1	lv01f1	0.26479	Matrix Entry: _GAMMA_[1:1]
2	lv02f1	0.43916	Matrix Entry: _GAMMA_[2:1]
3	lv04f1	0.34562	Matrix Entry: _GAMMA_[3:1]
4	lv05f1	-0.28167	Matrix Entry: _GAMMA_[4:1]
5	lv06f2	0.33420	Matrix Entry: _GAMMA_[5:2]
6	lv07f2	0.51881	Matrix Entry: _GAMMA_[6:2]
7	lv10f2	0.40940	Matrix Entry: _GAMMA_[7:2]
8	lv11f3	0.61945	Matrix Entry: _GAMMA_[8:3]
9	lv12f3	0.44203	Matrix Entry: _GAMMA_[9:3]
10	lv13f3	0.24883	Matrix Entry: _GAMMA_[10:3]
11	lv14f3	0.43757	Matrix Entry: _GAMMA_[11:3]
12	cf1f2	0.77235	Matrix Entry: _PHI_[2:1]
13	cf1f3	0.27819	Matrix Entry: _PHI_[3:1]
14	cf2f3	0.68587	Matrix Entry: _PHI_[3:2]
15	vare01	0.14636	Matrix Entry: _PHI_[4:4]
16	vare02	0.17362	Matrix Entry: _PHI_[5:5]
17	vare04	0.17341	Matrix Entry: _PHI_[6:6]
18	vare05	0.22493	Matrix Entry: _PHI_[7:7]
19	vare06	0.23519	Matrix Entry: _PHI_[8:8]

```
          20    vare07          0.19688    Matrix Entry: _PHI_[9:9]
          21    vare10          0.13487    Matrix Entry: _PHI_[10:10]
          22    vare11          0.79054    Matrix Entry: _PHI_[11:11]
          23    vare12          0.28927    Matrix Entry: _PHI_[12:12]
          24    vare13          0.73138    Matrix Entry: _PHI_[13:13]
          25    vare14          0.29368    Matrix Entry: _PHI_[14:14]

          Covariance Structure Analysis: Maximum Likelihood Estimation

                       Levenberg-Marquardt Optimization

                        Scaling Update of More (1978)

                   Parameter Estimates                   25
                   Functions (Observations)              66

                             Optimization Start

Active Constraints                     0  Objective Function         0.5638817241
Max Abs Gradient Element    0.4018687767  Radius                     3.1060053344


                                                                         Actual
                                                       Max Abs             Over
        Rest     Func       Act     Objective  Obj Fun Gradient            Pred
 Iter   arts    Calls       Con      Function   Change  Element  Lambda  Change

    1      0        2         0       0.54631   0.0176   0.0459       0   0.951
    2      0        3         0       0.54550 0.000813   0.0211       0   0.934
    3      0        4         0       0.54544 0.000056  0.00428       0   0.940
    4      0        5         0       0.54544 4.789E-6  0.00239       0   0.932
    5      0        6         0       0.54544 4.941E-7 0.000545       0   0.890
    6      0        7         0       0.54544 6.638E-8 0.000363       0   0.817
    7      0        8         0       0.54544 1.141E-8 0.000099       0   0.747
    8      0        9         0       0.54544 2.286E-9 0.000069       0   0.697
    9      0       10         0       0.54544 4.94E-10 0.000021       0   0.662

                            Optimization Results

Iterations                             9  Function Calls                       11
Jacobian Calls                        10  Active Constraints                    0
Objective Function          0.5454365145  Max Abs Gradient Element   0.0000207475
Lambda                                 0  Actual Over Pred Change    0.6623720851
Radius                      0.0001045443

GCONV convergence criterion satisfied.

                           Predicted Model Matrix

                  v01_qty            v02_spd            v04_flx            v05_cst

v01_qty      0.2164749883       0.1179774274       0.0897719371       -.0651185771
v02_spd      0.1179774274       0.3664796634       0.1661379154       -.1205127682
v04_flx      0.0897719371       0.1661379154       0.2928564750       -.0917011405
v05_cst      -.0651185771       -.1205127682       -.0917011405       0.3042636746
v06_skl      0.0673591990       0.1246594122       0.0948564243       -.0688067516
v07_tmd      0.0991643530       0.1835201448       0.1396450088       -.1012953999
v10_cul      0.0736213376       0.1362485423       0.1036748795       -.0752034639
v11_dgn      0.0423788014       0.0784290276       0.0596785833       -.0432895240
v12_mfg      0.0298687619       0.0552771167       0.0420617228       -.0305106431
v13_crd      0.0172867640       0.0319920347       0.0243435290       -.0176582574
v14_int      0.0316229999       0.0585236261       0.0445320719       -.0323025797


          Covariance Structure Analysis: Maximum Likelihood Estimation

                           Predicted Model Matrix

                  v06_skl            v07_tmd            v10_cul            v11_dgn
```

v01_qty	0.0673591990	0.0991643530	0.0736213376	0.042378801
v02_spd	0.1246594122	0.1835201448	0.1362485423	0.078429028
v04_flx	0.0948564243	0.1396450088	0.1036748795	0.059678583
v05_cst	-.0688067516	-.1012953999	-.0752034639	-0.043289524
v06_skl	0.3468723703	0.1843507855	0.1368652244	0.149757668
v07_tmd	0.1843507855	0.4660402057	0.2014892045	0.220469105
v10_cul	0.1368652244	0.2014892045	0.3024777934	0.163680092
v11_dgn	0.1497576685	0.2204691048	0.1636800918	1.174259000
v12_mfg	0.1055498503	0.1553875754	0.1153624343	0.269980429
v13_crd	0.0610877462	0.0899316934	0.0667668508	0.156253144
v14_int	0.1117489540	0.1645137248	0.1221378460	0.285836792

Predicted Model Matrix

	v12_mfg	v13_crd	v14_int
v01_qty	0.0298687619	0.0172867640	0.0316229999
v02_spd	0.0552771167	0.0319920347	0.0585236261
v04_flx	0.0420617228	0.0243435290	0.0445320719
v05_cst	-.0305106431	-.0176582574	-.0323025797
v06_skl	0.1055498503	0.0610877462	0.1117489540
v07_tmd	0.1553875754	0.0899316934	0.1645137248
v10_cul	0.1153624343	0.0667668508	0.1221378460
v11_dgn	0.2699804293	0.1562531440	0.2858367918
v12_mfg	0.4846657317	0.1101278894	0.2014590030
v13_crd	0.1101278894	0.7932959327	0.1165958684
v14_int	0.2014590030	0.1165958684	0.4851425900

Determinant 0.000006571 Ln -11.932812

Covariance Structure Analysis: Maximum Likelihood Estimation

Fit Function	0.5454
Goodness of Fit Index (GFI)	0.9165
GFI Adjusted for Degrees of Freedom (AGFI)	0.8656
Root Mean Square Residual (RMR)	0.0295
Parsimonious GFI (Mulaik, 1989)	0.6832
Chi-Square	50.1802
Chi-Square DF	41
Pr > Chi-Square	0.1541
Independence Model Chi-Square	275.05
Independence Model Chi-Square DF	55
RMSEA Estimate	0.0493
RMSEA 90% Lower Confidence Limit	.
RMSEA 90% Upper Confidence Limit	0.0911
ECVI Estimate	1.1704
ECVI 90% Lower Confidence Limit	.
ECVI 90% Upper Confidence Limit	1.4217
Probability of Close Fit	0.4809
Bentler's Comparative Fit Index	0.9583
Elliptic Corrected Chi-Square	49.4928
Pr > Elliptic Corrected Chi-Square	0.1704
Normal Theory Reweighted LS Chi-Square	46.0852
Akaike's Information Criterion	-31.8198
Bozdogan's (1987) CAIC	-176.6564
Schwarz's Bayesian Criterion	-135.6564
McDonald's (1989) Centrality	0.9518
Bentler & Bonett's (1980) Non-normed Index	0.9440
Bentler & Bonett's (1980) NFI	0.8176
James, Mulaik, & Brett (1982) Parsimonious NFI	0.6095
Z-Test of Wilson & Hilferty (1931)	1.0199
Bollen (1986) Normed Index Rho1	0.7553
Bollen (1988) Non-normed Index Delta2	0.9608
Hoelter's (1983) Critical N	106

Covariance Structure Analysis: Maximum Likelihood Estimation

Raw Residual Matrix

v01_qty	v02_spd	v04_flx	v05_cst

```
v01_qty  0.0000000000  -.0021289001  0.0055389558  0.0405042713
v02_spd  -.0021289001  0.0000000000  0.0012954646  -.0165419302
v04_flx  0.0055389558  0.0012954646  0.0000000000  0.0004949694
v05_cst  0.0405042713  -.0165419302  0.0004949694  0.0000000000
v06_skl  0.0267221474  -.0195401976  0.0143721872  -.0099730521
v07_tmd  0.0026215282  0.0119356757  -.0110428583  0.0067792709
v10_cul  0.0179681902  -.0320549939  0.0035808475  -.0339970971
v11_dgn  -.0133839440  -.0950769939  0.0571143106  -.0391789192
v12_mfg  -.0367177568  -.0591200340  0.0103319191  -.0496155841
v13_crd  0.0010863076  -.0043763265  0.0236929366  0.0219499825
v14_int  0.0130427318  0.0119672575  0.0517886387  -.0451027499

                         Raw Residual Matrix

              v06_skl       v07_tmd       v10_cul       v11_dgn

v01_qty  0.0267221474  0.0026215282  0.0179681902  -.0133839440
v02_spd  -.0195401976  0.0119356757  -.0320549939  -.0950769939
v04_flx  0.0143721872  -.0110428583  0.0035808475  0.0571143106
v05_cst  -.0099730521  0.0067792709  -.0339970971  -.0391789192
v06_skl  0.0000000000  0.0137417811  -.0130223071  0.0855999753
v07_tmd  0.0137417811  0.0000000000  -.0009048193  -.0407683100
v10_cul  -.0130223071  -.0009048193  0.0000000000  -.0099400263
v11_dgn  0.0855999753  -.0407683100  -.0099400263  0.0000000000
v12_mfg  -.0248065123  0.0123309847  0.0101120866  0.0038531378
v13_crd  -.0002742820  -.0130873736  -.0018860654  -.0686234105
v14_int  -.0352412402  -.0191794564  0.0387924953  0.0040416560

                         Raw Residual Matrix

                     v12_mfg       v13_crd       v14_int

       v01_qty  -.0367177568  0.0010863076  0.0130427318
       v02_spd  -.0591200340  -.0043763265  0.0119672575
       v04_flx  0.0103319191  0.0236929366  0.0517886387
       v05_cst  -.0496155841  0.0219499825  -.0451027499
       v06_skl  -.0248065123  -.0002742820  -.0352412402
       v07_tmd  0.0123309847  -.0130873736  -.0191794564
       v10_cul  0.0101120866  -.0018860654  0.0387924953
       v11_dgn  0.0038531378  -.0686234105  0.0040416560
       v12_mfg  0.0000000000  -.0302120409  -.0057554032
       v13_crd  -.0302120409  0.0000000000  0.0658585495
       v14_int  -.0057554032  0.0658585495  0.0000000000

    Average Absolute Residual                       0.019525
    Average Off-diagonal Absolute Residual          0.023430

  Covariance Structure Analysis: Maximum Likelihood Estimation

           Rank Order of the 10 Largest Raw Residuals

               Row         Column        Residual

               v11_dgn     v02_spd       -0.09508
               v11_dgn     v06_skl        0.08560
               v13_crd     v11_dgn       -0.06862
               v14_int     v13_crd        0.06586
               v12_mfg     v02_spd       -0.05912
               v11_dgn     v04_flx        0.05711
               v14_int     v04_flx        0.05179
               v12_mfg     v05_cst       -0.04962
               v14_int     v05_cst       -0.04510
               v11_dgn     v07_tmd       -0.04077

  Covariance Structure Analysis: Maximum Likelihood Estimation

          Asymptotically Standardized Residual Matrix

              v01_qty       v02_spd       v04_flx       v05_cst
```

v01_qty	0.000000000	-0.221547449	0.431365320	2.304288651
v02_spd	-0.221547449	0.000000000	0.164079498	-1.265736873
v04_flx	0.431365320	0.164079498	0.000000000	0.029313279
v05_cst	2.304288651	-1.265736873	0.029313279	0.000000000
v06_skl	1.296474243	-0.941338951	0.669290102	-0.387612491
v07_tmd	0.132363420	0.702882388	-0.570163779	0.267999214
v10_cul	1.039274405	-2.002051672	0.205664663	-1.555238016
v11_dgn	-0.290558125	-1.851969795	1.137974303	-0.694326385
v12_mfg	-1.275188895	-1.927276784	0.334932162	-1.396130545
v13_crd	0.026211611	-0.084610353	0.500777018	0.442281720
v14_int	0.461903253	0.413034347	1.734942845	-1.286878192

Asymptotically Standardized Residual Matrix

	v06_skl	v07_tmd	v10_cul	v11_dgn
v01_qty	1.296474243	0.132363420	1.039274405	-0.290558125
v02_spd	-0.941338951	0.702882388	-2.002051672	-1.851969795
v04_flx	0.669290102	-0.570163779	0.205664663	1.137974303
v05_cst	-0.387612491	0.267999214	-1.555238016	-0.694326385
v06_skl	0.000000000	0.959883854	-0.899538511	1.793462759
v07_tmd	0.959883854	0.000000000	-0.099218732	-0.911321600
v10_cul	-0.899538511	-0.099218732	0.000000000	-0.251380450
v11_dgn	1.793462759	-0.911321600	-0.251380450	0.000000000
v12_mfg	-0.850995082	0.469586144	0.427344643	0.117763396
v13_crd	-0.005978655	-0.278016395	-0.047234206	-0.994614035
v14_int	-1.251727420	-0.778413150	1.722152681	0.139704650

Asymptotically Standardized Residual Matrix

	v12_mfg	v13_crd	v14_int
v01_qty	-1.275188895	0.026211611	0.461903253
v02_spd	-1.927276784	-0.084610353	0.413034347
v04_flx	0.334932162	0.500777018	1.734942845
v05_cst	-1.396130545	0.442281720	-1.286878192
v06_skl	-0.850995082	-0.005978655	-1.251727420
v07_tmd	0.469586144	-0.278016395	-0.778413150
v10_cul	0.427344643	-0.047234206	1.722152681
v11_dgn	0.117763396	-0.994614035	0.139704650
v12_mfg	0.000000000	-0.753368311	-0.373549279
v13_crd	-0.753368311	0.000000000	1.785735770
v14_int	-0.373549279	1.785735770	0.000000000

Average Standardized Residual	0.650859
Average Off-diagonal Standardized Residual	0.781030

Covariance Structure Analysis: Maximum Likelihood Estimation

Rank Order of the 10 Largest Asymptotically Standardized Residuals

Row	Column	Residual
v05_cst	v01_qty	2.30429
v10_cul	v02_spd	-2.00205
v12_mfg	v02_spd	-1.92728
v11_dgn	v02_spd	-1.85197
v11_dgn	v06_skl	1.79346
v14_int	v13_crd	1.78574
v14_int	v04_flx	1.73494
v14_int	v10_cul	1.72215
v10_cul	v05_cst	-1.55524
v12_mfg	v05_cst	-1.39613

Covariance Structure Analysis: Maximum Likelihood Estimation

Distribution of Asymptotically Standardized Residuals

Each * Represents 1 Residuals

```
----------Range---------    Freq    Percent

  -2.25000      -2.00000       1       1.52    *
  -2.00000      -1.75000       2       3.03    **
  -1.75000      -1.50000       1       1.52    *
  -1.50000      -1.25000       5       7.58    *****
  -1.25000      -1.00000       0       0.00
  -1.00000      -0.75000       7      10.61    *******
  -0.75000      -0.50000       2       3.03    **
  -0.50000      -0.25000       5       7.58    *****
  -0.25000             0       5       7.58    *****
         0       0.25000      18      27.27    ******************
   0.25000       0.50000       8      12.12    ********
   0.50000       0.75000       3       4.55    ***
   0.75000       1.00000       1       1.52    *
   1.00000       1.25000       2       3.03    **
   1.25000       1.50000       1       1.52    *
   1.50000       1.75000       2       3.03    **
   1.75000       2.00000       2       3.03    **
   2.00000       2.25000       0       0.00
   2.25000       2.50000       1       1.52    *

       Covariance Structure Analysis: Maximum Likelihood Estimation

                Manifest Variable Equations with Estimates


              v01_qty =   0.2525*f1       +  1.0000 e01
              Std Err     0.0506 lv01f1
              t Value     4.9862
              v02_spd =   0.4673*f1       +  1.0000 e02
              Std Err     0.0621 lv02f1
              t Value     7.5201
              v04_flx =   0.3556*f1       +  1.0000 e04
              Std Err     0.0570 lv04f1
              t Value     6.2357
              v05_cst =  -0.2579*f1       +  1.0000 e05
              Std Err     0.0612 lv05f1
              t Value    -4.2120
              v06_skl =   0.3539*f2       +  1.0000 e06
              Std Err     0.0613 lv06f2
              t Value     5.7717
              v07_tmd =   0.5210*f2       +  1.0000 e07
              Std Err     0.0672 lv07f2
              t Value     7.7488
              v10_cul =   0.3868*f2       +  1.0000 e10
              Std Err     0.0552 lv10f2
              t Value     7.0088
              v11_dgn =   0.6189*f3       +  1.0000 e11
              Std Err     0.1245 lv11f3
              t Value     4.9698
              v12_mfg =   0.4362*f3       +  1.0000 e12
              Std Err     0.0795 lv12f3
              t Value     5.4882
              v13_crd =   0.2525*f3       +  1.0000 e13
              Std Err     0.1074 lv13f3
              t Value     2.3497
              v14_int =   0.4618*f3       +  1.0000 e14
              Std Err     0.0794 lv14f3
              t Value     5.8193


                    Variances of Exogenous Variables

                                               Standard
        Variable Parameter      Estimate          Error    t Value

        f1                       1.00000
        f2                       1.00000
```

f3		1.00000		
e01	vare01	0.15273	0.02548	5.99
e02	vare02	0.14814	0.03750	3.95
e04	vare04	0.16644	0.03137	5.31
e05	vare05	0.23775	0.03798	6.26
e06	vare06	0.22165	0.03746	5.92
e07	vare07	0.19464	0.04281	4.55
e10	vare10	0.15289	0.02914	5.25
e11	vare11	0.79120	0.14493	5.46

Covariance Structure Analysis: Maximum Likelihood Estimation

Variances of Exogenous Variables

Variable	Parameter	Estimate	Standard Error	t Value
e12	vare12	0.29438	0.05890	5.00
e13	vare13	0.72956	0.11137	6.55
e14	vare14	0.27185	0.05891	4.61

Covariances Among Exogenous Variables

Var1	Var2	Parameter	Estimate	Standard Error	t Value
f1	f2	cf1f2	0.75391	0.08785	8.58
f1	f3	cf1f3	0.27119	0.14099	1.92
f2	f3	cf2f3	0.68378	0.10598	6.45

Covariance Structure Analysis: Maximum Likelihood Estimation

Manifest Variable Equations with Standardized Estimates

```
v01_qty =   0.5427*f1      +  0.8399 e01
                   lv01f1
v02_spd =   0.7719*f1      +  0.6358 e02
                   lv02f1
v04_flx =   0.6570*f1      +  0.7539 e04
                   lv04f1
v05_cst =  -0.4676*f1      +  0.8840 e05
                   lv05f1
v06_skl =   0.6008*f2      +  0.7994 e06
                   lv06f2
v07_tmd =   0.7631*f2      +  0.6463 e07
                   lv07f2
v10_cul =   0.7032*f2      +  0.7110 e10
                   lv10f2
v11_dgn =   0.5711*f3      +  0.8208 e11
                   lv11f3
v12_mfg =   0.6266*f3      +  0.7794 e12
                   lv12f3
v13_crd =   0.2835*f3      +  0.9590 e13
                   lv13f3
v14_int =   0.6631*f3      +  0.7486 e14
                   lv14f3
```

Squared Multiple Correlations

	Variable	Error Variance	Total Variance	R-Square
1	v01_qty	0.15273	0.21647	0.2945
2	v02_spd	0.14814	0.36648	0.5958
3	v04_flx	0.16644	0.29286	0.4317
4	v05_cst	0.23775	0.30426	0.2186
5	v06_skl	0.22165	0.34687	0.3610

```
                   6    v07_tmd        0.19464       0.46604      0.5823
                   7    v10_cul        0.15289       0.30248      0.4945
                   8    v11_dgn        0.79120       1.17426      0.3262
                   9    v12_mfg        0.29438       0.48467      0.3926
                  10    v13_crd        0.72956       0.79330      0.0803
                  11    v14_int        0.27185       0.48514      0.4396


                        Correlations Among Exogenous Variables

                        Var1    Var2    Parameter      Estimate

                        f1      f2      cf1f2           0.75391
                        f1      f3      cf1f3           0.27119
                        f2      f3      cf2f3           0.68378

              Covariance Structure Analysis: Maximum Likelihood Estimation

               Lagrange Multiplier and Wald Test Indices _PHI_   [14:14]
                                    Symmetric Matrix
                          Univariate Tests for Constant Constraints
       Lagrange Multiplier or Wald Index / Probability / Approx Change of Value

                f1          f2          f3         e01         e02         e04         e05

f1               .     73.6472      3.6997      1.9891      1.0393      0.2739      0.1913
                 .           .           .      0.1584      0.3080      0.6007      0.6618
                 .           .           .     -0.0851      0.0973      0.0390      0.0312
              Sing     [cf1f2]     [cf1f3]

f2         73.6472           .     41.6254      2.5208      0.0452      1.3130      0.0003
                 .           .           .      0.1124      0.8316      0.2518      0.9864
                 .           .           .      0.0647     -0.0134     -0.0572      0.0008
           [cf1f2]        Sing     [cf2f3]

f3          3.6997     41.6254           .      1.0742      3.3712      4.0467      1.8161
                 .           .           .      0.3000      0.0663      0.0443      0.1778
                 .           .           .     -0.0488     -0.1124      0.1066     -0.0770
           [cf1f3]     [cf2f3]        Sing

e01         1.9891      2.5208      1.0742     35.9274      0.0491      0.1861      5.3098
            0.1584      0.1124      0.3000           .      0.8247      0.6662      0.0212
           -0.0851      0.0647     -0.0488           .     -0.0057      0.0093      0.0517
                                               [vare01]

e02         1.0393      0.0452      3.3712      0.0491     15.6052      0.0269      1.6020
            0.3080      0.8316      0.0663      0.8247           .      0.8697      0.2056
            0.0973     -0.0134     -0.1124     -0.0057           .      0.0056     -0.0371
                                                           [vare02]

e04         0.2739      1.3130      4.0467      0.1861      0.0269     28.1522      0.0009
            0.6007      0.2518      0.0443      0.6662      0.8697           .      0.9766
            0.0390     -0.0572      0.1066      0.0093      0.0056           .      0.0007
                                                                       [vare04]

e05         0.1913      0.0003      1.8161      5.3098      1.6020      0.0009     39.1807
            0.6618      0.9864      0.1778      0.0212      0.2056      0.9766           .
            0.0312      0.0008     -0.0770      0.0517     -0.0371      0.0007           .
                                                                                   [vare05]

e06         0.0256      0.0098      0.1139      1.5923      0.9052      0.1701      0.0066
            0.8730      0.9210      0.7358      0.2070      0.3414      0.6800      0.9352
            0.0094      0.0062     -0.0214      0.0272     -0.0243      0.0098      0.0021


e07         0.0134      0.8089      0.9204      0.0790      4.3621      2.2358      1.5875
            0.9080      0.3684      0.3374      0.7787      0.0367      0.1348      0.2077
           -0.0091      0.0871     -0.0770     -0.0064      0.0595     -0.0383      0.0347
```

```
          Covariance Structure Analysis: Maximum Likelihood Estimation

           Lagrange Multiplier and Wald Test Indices _PHI_   [14:14]
                               Symmetric Matrix
                       Univariate Tests for Constant Constraints
    Lagrange Multiplier or Wald Index / Probability / Approx Change of Value

              e06         e07         e10         e11         e12         e13         e14

f1         0.0256      0.0134      0.0009      0.5151      2.0741      0.0291      3.7655
           0.8730      0.9080      0.9762      0.4729      0.1498      0.8646      0.0523
           0.0094     -0.0091     -0.0018     -0.0732     -0.0951      0.0148      0.1300


f2         0.0098      0.8089      0.9213      0.2355      1.3442      0.0697      2.1733
           0.9210      0.3684      0.3371      0.6275      0.2463      0.7918      0.1404
           0.0062      0.0871     -0.0660      0.0502      0.0814     -0.0214     -0.1081


f3         0.1139      0.9204      1.6624      0.0547      0.4394      0.0554      0.5834
           0.7358      0.3374      0.1973      0.8152      0.5074      0.8139      0.4450
          -0.0214     -0.0770      0.0792     -0.0421     -0.0817      0.0327      0.0990


e01        1.5923      0.0790      1.4591      0.0102      1.9811      0.0033      0.0264
           0.2070      0.7787      0.2271      0.9194      0.1593      0.9542      0.8709
           0.0272     -0.0064      0.0229     -0.0041     -0.0362      0.0021      0.0041


e02        0.9052      4.3621      2.8776      3.4802      1.9688      0.0760      0.7245
           0.3414      0.0367      0.0898      0.0621      0.1606      0.7828      0.3947
          -0.0243      0.0595     -0.0393     -0.0882     -0.0419      0.0116      0.0252


e04        0.1701      2.2358      0.0052      1.7165      0.0359      0.1511      0.7629
           0.6800      0.1348      0.9424      0.1901      0.8497      0.6974      0.3824
           0.0098     -0.0383      0.0015      0.0587      0.0053      0.0156      0.0243


e05        0.0066      1.5875      2.1491      0.1027      2.0000      0.7513      0.1098
           0.9352      0.2077      0.1427      0.7486      0.1573      0.3861      0.7404
           0.0021      0.0347     -0.0338     -0.0161     -0.0446      0.0393     -0.0103


e06       35.0112      0.9214      0.8091      6.4723      0.5964      0.0085      3.3039
            .          0.3371      0.3684      0.0110      0.4400      0.9266      0.0691
            .          0.0314     -0.0229      0.1293     -0.0248      0.0042     -0.0579
         [vare06]

e07        0.9214     20.6760      0.0098      0.7213      1.7826      0.0493      1.8083
           0.3371       .          0.9210      0.3957      0.1818      0.8242      0.1787
           0.0314       .         -0.0035     -0.0461      0.0465     -0.0104     -0.0469
                     [vare07]

          Covariance Structure Analysis: Maximum Likelihood Estimation

           Lagrange Multiplier and Wald Test Indices _PHI_   [14:14]
                               Symmetric Matrix
                       Univariate Tests for Constant Constraints
    Lagrange Multiplier or Wald Index / Probability / Approx Change of Value

               f1          f2          f3         e01         e02         e04         e05

e10        0.0009      0.9213      1.6624      1.4591      2.8776      0.0052      2.1491
           0.9762      0.3371      0.1973      0.2271      0.0898      0.9424      0.1427
          -0.0018     -0.0660      0.0792      0.0229     -0.0393      0.0015     -0.0338


e11        0.5151      0.2355      0.0547      0.0102      3.4802      1.7165      0.1027
```

```
         0.4729     0.6275     0.8152     0.9194     0.0621     0.1901     0.7486
        -0.0732     0.0502    -0.0421    -0.0041    -0.0882     0.0587    -0.0161


e12      2.0741     1.3442     0.4394     1.9811     1.9688     0.0359     2.0000
         0.1498     0.2463     0.5074     0.1593     0.1606     0.8497     0.1573
        -0.0951     0.0814    -0.0817    -0.0362    -0.0419     0.0053    -0.0446


e13      0.0291     0.0697     0.0554     0.0033     0.0760     0.1511     0.7513
         0.8646     0.7918     0.8139     0.9542     0.7828     0.6974     0.3861
         0.0148    -0.0214     0.0327     0.0021     0.0116     0.0156     0.0393


e14      3.7655     2.1733     0.5834     0.0264     0.7245     0.7629     0.1098
         0.0523     0.1404     0.4450     0.8709     0.3947     0.3824     0.7404
         0.1300    -0.1081     0.0990     0.0041     0.0252     0.0243    -0.0103


           Lagrange Multiplier and Wald Test Indices _PHI_   [14:14]
                                Symmetric Matrix
                       Univariate Tests for Constant Constraints
    Lagrange Multiplier or Wald Index / Probability / Approx Change of Value

            e06        e07        e10        e11        e12        e13        e14

e10      0.8091     0.0098    27.5187     0.3212     0.1398     0.0235     2.2151
         0.3684     0.9210       .        0.5709     0.7085     0.8781     0.1367
        -0.0229    -0.0035       .       -0.0255     0.0107    -0.0060     0.0425
                              [vare10]

e11      6.4723     0.7213     0.3212    29.8020     0.0139     0.9892     0.0195
         0.0110     0.3957     0.5709       .        0.9063     0.3199     0.8889
         0.1293    -0.0461    -0.0255       .        0.0091    -0.0904     0.0113
                                         [vare11]

e12      0.5964     1.7826     0.1398     0.0139    24.9766     0.5675     0.1395
         0.4400     0.1818     0.7085     0.9063       .        0.4512     0.7087
        -0.0248     0.0465     0.0107     0.0091       .       -0.0439    -0.0211
                                                    [vare12]

          Covariance Structure Analysis: Maximum Likelihood Estimation

           Lagrange Multiplier and Wald Test Indices _PHI_   [14:14]
                                Symmetric Matrix
                       Univariate Tests for Constant Constraints
    Lagrange Multiplier or Wald Index / Probability / Approx Change of Value

            e06        e07        e10        e11        e12        e13        e14

e13      0.0085     0.0493     0.0235     0.9892     0.5675    42.9100     3.1889
         0.9266     0.8242     0.8781     0.3199     0.4512       .        0.0741
         0.0042    -0.0104    -0.0060    -0.0904    -0.0439       .        0.1044
                                                               [vare13]

e14      3.3039     1.8083     2.2151     0.0195     0.1395     3.1889    21.2973
         0.0691     0.1787     0.1367     0.8889     0.7087     0.0741       .
        -0.0579    -0.0469     0.0425     0.0113    -0.0211     0.1044       .
                                                                          [vare14]


          Rank Order of the 10 Largest Lagrange Multipliers in _PHI_

                Row         Column      Chi-Square    Pr > ChiSq

                e11         e06            6.47235        0.0110
                e05         e01            5.30982        0.0212
                e07         e02            4.36206        0.0367
                e04         f3             4.04668        0.0443
                e14         f1             3.76554        0.0523
```

```
            e11         e02             3.48018         0.0621
            e02         f3              3.37124         0.0663
            e14         e06             3.30392         0.0691
            e14         e13             3.18891         0.0741
            e10         e02             2.87762         0.0898

      Covariance Structure Analysis: Maximum Likelihood Estimation

        Lagrange Multiplier and Wald Test Indices _GAMMA_ [11:3]
                             General Matrix
                 Univariate Tests for Constant Constraints
Lagrange Multiplier or Wald Index / Probability / Approx Change of Value

                             f1             f2             f3

          v01_qty       24.8626         0.3415         0.0098
                         .              0.5589         0.9211
                         .              0.0546        -0.0056
                       [lv01f1]

          v02_spd       56.5512         4.5780         5.0195
                         .              0.0324         0.0251
                         .             -0.2891        -0.1706
                       [lv02f1]

          v04_flx       38.8840         0.8434         2.4713
                         .              0.3584         0.1159
                         .              0.1019         0.1023
                       [lv04f1]

          v05_cst       17.7406         1.5542         2.2291
                         .              0.2125         0.1354
                         .             -0.1393        -0.1028
                       [lv05f1]

          v06_skl        0.0831        33.3129         0.1304
                         0.7732          .             0.7181
                         0.0335          .            -0.0372
                                      [lv06f2]

          v07_tmd        0.1011        60.0445         0.5261
                         0.7505          .             0.4683
                         0.0443          .            -0.0876
                                      [lv07f2]

          v10_cul        0.3365        49.1235         1.1458
                         0.5619          .             0.2844
                        -0.0630          .             0.1014
                                      [lv10f2]

          v11_dgn        0.2634         0.0897        24.6987
                         0.6078         0.7646          .
                        -0.0684        -0.0597          .
                                                     [lv11f3]

          v12_mfg        0.8860         0.2290        30.1207
                         0.3466         0.6323          .
                        -0.0819        -0.0635          .
                                                     [lv12f3]
```

```
      Covariance Structure Analysis: Maximum Likelihood Estimation

        Lagrange Multiplier and Wald Test Indices _GAMMA_ [11:3]
                             General Matrix
                 Univariate Tests for Constant Constraints
Lagrange Multiplier or Wald Index / Probability / Approx Change of Value

                             f1             f2             f3

          v13_crd        0.0000         0.0099         5.5210
```

```
                  0.9971        0.9206          .
                 -0.0004       -0.0161          .
                                              [lv13f3]

      v14_int     1.8674        0.6217       33.8648
                  0.1718        0.4304          .
                  0.1213        0.1080          .
                                              [lv14f3]
```

Rank Order of the 10 Largest Lagrange Multipliers in _GAMMA_

Row	Column	Chi-Square	Pr > ChiSq
v02_spd	f3	5.01945	0.0251
v02_spd	f2	4.57801	0.0324
v04_flx	f3	2.47128	0.1159
v05_cst	f3	2.22906	0.1354
v14_int	f1	1.86736	0.1718
v05_cst	f2	1.55423	0.2125
v10_cul	f3	1.14584	0.2844
v12_mfg	f1	0.88597	0.3466
v04_flx	f2	0.84344	0.3584
v14_int	f2	0.62175	0.4304

Stepwise Multivariate Wald Test

	------Cumulative Statistics-----			--Univariate Increment--	
Parameter	Chi-Square	DF	Pr > ChiSq	Chi-Square	Pr > ChiSq
cf1f3	3.69972	1	0.0544	3.69972	0.0544

APPENDIX M: THE FINAL MODEL'S ANALYSIS

```
                                  The CALIS Procedure
                  Covariance Structure Analysis: Pattern and Initial Values

    Automatic Variable Selection, the Following Manifest Variables are not Used in
the Model

                                v03_dpn  v08_org  v09_rel

Using the VAR statement for variable selection could save memory and computing
time.


                                 LINEQS Model Statement


                          Matrix      Rows    Columns    ------Matrix Type--
-----

         Term 1         1    _SEL_         11         26    SELECTION
                        2      _BETA_          26             26      EQSBETA
IMINUSINV
                        3    _GAMMA_       26         14    EQSGAMMA
                        4    _PHI_         14         14    SYMMETRIC

                             The 12 Endogenous Variables

             Manifest       v01_qty  v02_spd  v04_flx  v05_cst  v06_skl  v07_tmd
                            v10_cul  v11_dgn  v12_mfg  v13_crd  v14_int
             Latent         f1


                              The 14 Exogenous Variables

             Manifest
             Latent         f2       f3
             Error          e01      e02      e04      e05      e06      e07
                            e10      e11      e12      e13      e14      d1

                  Covariance Structure Analysis: Pattern and Initial Values

                      Manifest Variable Equations with Initial Estimates


                         v01_qty =        .*f1      +  1.0000 e01
                                            lv01f1
                         v02_spd =   1.0000 f1      +  1.0000 e02
                         v04_flx =        .*f1      +  1.0000 e04
                                            lv04f1
                         v05_cst =        .*f1      +  1.0000 e05
                                            lv05f1
                         v06_skl =        .*f2      +  1.0000 e06
                                            lv06f2
                         v07_tmd =   1.0000 f2      +  1.0000 e07
                         v10_cul =        .*f2      +  1.0000 e10
                                            lv10f2
                         v11_dgn =        .*f3      +  1.0000 e11
                                            lv11f3
                         v12_mfg =        .*f3      +  1.0000 e12
                                            lv12f3
                         v13_crd =        .*f3      +  1.0000 e13
                                            lv13f3
                         v14_int =   1.0000 f3      +  1.0000 e14
```

```
       Covariance Structure Analysis: Pattern and Initial Values

            Latent Variable Equations with Initial Estimates


              f1      =        .*f2      +  1.0000 d1
                                pf1f2


                      Variances of Exogenous Variables

                      Variable Parameter      Estimate

                      f2       varf2                 .
                      f3       varf3                 .
                      e01      vare01                .
                      e02      vare02                .
                      e04      vare04                .
                      e05      vare05                .
                      e06      vare06                .
                      e07      vare07                .
                      e10      vare10                .
                      e11      vare11                .
                      e12      vare12                .
                      e13      vare13                .
                      e14      vare14                .
                      d1       vard1                 .


                   Covariances Among Exogenous Variables

                  Var1    Var2    Parameter      Estimate

                  f2      f3      cf2f3                 .

     Covariance Structure Analysis: Maximum Likelihood Estimation

        Observations          93    Model Terms             1
        Variables             11    Model Matrices          4
        Informations          66    Parameters             24


   Variable           Mean       Std Dev      Skewness      Kurtosis

   v01_qty         4.23011       0.46527      -0.38750      -0.32397
   v02_spd         3.39355       0.60538      -0.42997       0.39972
   v04_flx         3.73978       0.54116      -0.20135       0.30529
   v05_cst         2.65161       0.55160       0.38580      -0.08577
   v06_skl         3.65161       0.58896      -0.31114       0.35051
   v07_tmd         3.56989       0.68267      -0.57250       0.39142
   v10_cul         3.97634       0.54998      -0.30662       0.05892
   v11_dgn         3.24731       1.08363      -0.32139      -1.10620
   v12_mfg         2.41075       0.69618       0.14517      -0.16775
   v13_crd         3.56774       0.89067      -0.40245      -0.43832
   v14_int         3.07527       0.69652       0.21466      -0.34663


        Mardia's Multivariate Kurtosis                      1.9860
        Relative Multivariate Kurtosis                      1.0139
        Normalized Multivariate Kurtosis                    0.5663
        Mardia Based Kappa (Browne, 1982)                   0.0139
        Mean Scaled Univariate Kurtosis                    -0.0292
        Adjusted Mean Scaled Univariate Kurtosis           -0.0096

      Observation Numbers with Largest Contribution to Kurtosis

        89            70             1            15            85

 128.7812      116.3394      102.6785       86.6176       85.5957
```

Covariances

	v01_qty	v02_spd	v04_flx	v05_cst	v06_skl	v07_tmd
v01_qty	0.2164749883	0.1158485273	0.0953108929	-.0246143058	0.0940813464	0.1017858813
v02_spd	0.1158485273	0.3664796634	0.1674333801	-.1370546985	0.1051192146	0.1954558205
v04_flx	0.0953108929	0.1674333801	0.2928564750	-.0912061711	0.1092286115	0.1286021505
v05_cst	-.0246143058	-.1370546985	-.0912061711	0.3042636746	-.0787798036	-.0945161290
v06_skl	0.0940813464	0.1051192146	0.1092286115	-.0787798036	0.3468723703	0.1980925666
v07_tmd	0.1017858813	0.1954558205	0.1286021505	-.0945161290	0.1980925666	0.4660402057
v10_cul	0.0915895278	0.1041935484	0.1072557270	-.1092005610	0.1238429173	0.2005843852
v11_dgn	0.0289948574	-.0166479663	0.1167928939	-.0824684432	0.2353576438	0.1797007948
v12_mfg	-.0068489949	-.0038429173	0.0523936419	-.0801262272	0.0807433380	0.1677185601
v13_crd	0.0183730715	0.0276157083	0.0480364656	0.0042917251	0.0608134642	0.0768443198
v14_int	0.0446657317	0.0704908836	0.0963207106	-.0774053296	0.0765077139	0.1453342683

Covariance Structure Analysis: Maximum Likelihood Estimation

Covariances

	v10_cul	v11_dgn	v12_mfg	v13_crd	v14_int
v01_qty	0.0915895278	0.028994857	-.0068489949	0.0183730715	0.0446657317
v02_spd	0.1041935484	-0.016647966	-.0038429173	0.0276157083	0.0704908836
v04_flx	0.1072557270	0.116792894	0.0523936419	0.0480364656	0.0963207106
v05_cst	-.1092005610	-0.082468443	-.0801262272	0.0042917251	-.0774053296
v06_skl	0.1238429173	0.235357644	0.0807433380	0.0608134642	0.0765077139
v07_tmd	0.2005843852	0.179700795	0.1677185601	0.0768443198	0.1453342683
v10_cul	0.3024777934	0.153740065	0.1254745208	0.0648807854	0.1609303413
v11_dgn	0.1537400655	1.174259000	0.2738335671	0.0876297335	0.2898784479
v12_mfg	0.1254745208	0.273833567	0.4846657317	0.0799158485	0.1957035998
v13_crd	0.0648807854	0.087629734	0.0799158485	0.7932959327	0.1824544180
v14_int	0.1609303413	0.289878448	0.1957035998	0.1824544180	0.4851425900

Determinant 0.000003809 Ln -12.478249

NOTE: Some initial estimates computed by instrumental variable method.

NOTE: Some initial estimates computed by two-stage LS method.

```
                    Covariance Structure Analysis: Maximum Likelihood Estimation

                                Vector of Initial Estimates

                         Parameter      Estimate    Type

                     1    lv01f1          0.61191    Matrix Entry: _BETA_[1:12]
                     2    lv04f1          0.89455    Matrix Entry: _BETA_[3:12]
                     3    lv05f1         -0.67736    Matrix Entry: _BETA_[4:12]
                     4    lv06f2          0.72602    Matrix Entry: _GAMMA_[5:1]
                     5    lv10f2          0.81139    Matrix Entry: _GAMMA_[7:1]
                     6    lv11f3          1.18170    Matrix Entry: _GAMMA_[8:2]
                     7    lv12f3          0.73513    Matrix Entry: _GAMMA_[9:2]
                     8    lv13f3          0.41255    Matrix Entry: _GAMMA_[10:2]
                     9    pf1f2           0.65422    Matrix Entry: _GAMMA_[12:1]
                    10    varf2           0.24765    Matrix Entry: _PHI_[1:1]
                    11    cf2f3           0.17761    Matrix Entry: _PHI_[2:1]
                    12    varf3           0.27153    Matrix Entry: _PHI_[2:2]
                    13    vare01          0.15117    Matrix Entry: _PHI_[3:3]
                    14    vare02          0.19207    Matrix Entry: _PHI_[4:4]
                    15    vare04          0.15329    Matrix Entry: _PHI_[5:5]
                    16    vare05          0.22424    Matrix Entry: _PHI_[6:6]
                    17    vare06          0.21633    Matrix Entry: _PHI_[7:7]
                    18    vare07          0.21839    Matrix Entry: _PHI_[8:8]
                    19    vare10          0.13943    Matrix Entry: _PHI_[9:9]
                    20    vare11          0.79510    Matrix Entry: _PHI_[10:10]
                    21    vare12          0.33793    Matrix Entry: _PHI_[11:11]
                    22    vare13          0.74708    Matrix Entry: _PHI_[12:12]
                    23    vare14          0.21362    Matrix Entry: _PHI_[13:13]
                    24    vard1           0.06841    Matrix Entry: _PHI_[14:14]

                    Covariance Structure Analysis: Maximum Likelihood Estimation

                               Levenberg-Marquardt Optimization

                                 Scaling Update of More (1978)

                              Parameter Estimates                  24
                              Functions (Observations)             66

                                      Optimization Start

Active  Constraints                                        0   Objective  Function
0.6165614723
Max   Abs   Gradient   Element                            0.6082027843     Radius
4.8001003824



Ratio

Between

Actual
                                                        Objective        Max   Abs
and
                  Function          Active        Objective     Function   Gradient
Predicted
 Iter    Restarts       Calls   Constraints         Function       Change    Element
Lambda      Change

    1           0          2             0          0.58919       0.0274     0.1282
0      1.088
    2           0          3             0          0.58716      0.00203     0.0314
0      1.201
    3           0          4             0          0.58700     0.000162    0.00829
0      1.232
    4           0          5             0          0.58699     0.000015    0.00284
0      1.226
```

```
    5           0          6             0          0.58698   1.443E-6  0.000719
0      1.213
    6           0          7             0          0.58698   1.443E-7  0.000286
0      1.194
    7           0          8             0          0.58698   1.477E-8  0.000082
0      1.172
    8           0          9             0          0.58698   1.539E-9  0.000030
0      1.147

                                      Optimization Results

Iterations                                                         8   Function Calls
10
Jacobian Calls                                                 9   Active Constraints
0
Objective Function                     0.5869837491   Max Abs Gradient Element
0.0000303051
Lambda                                                    0   Actual Over Pred Change
1.1471546636
Radius                             0.0001867451

GCONV convergence criterion satisfied.


                  Covariance Structure Analysis: Maximum Likelihood Estimation

                                    Predicted Model Matrix

                v01_qty        v02_spd        v04_flx        v05_cst        v06_skl
v07_tmd

  v01_qty   0.2164749883   0.1121486218   0.0911255226   -.0650958426   0.0637877082
0.0952936236
  v02_spd   0.1121486218   0.3664796633   0.1674036042   -.1195853627   0.1171822334
0.1750606812
  v04_flx   0.0911255226   0.1674036042   0.2928564749   -.0971681908   0.0952155460
0.1422442452
  v05_cst  -.0650958426  -.1195853627  -.0971681908  0.3042636746  -.0680175655  -
.1016126847
  v06_skl   0.0637877082   0.1171822334   0.0952155460   -.0680175655   0.3468723702
0.1910998142
  v07_tmd   0.0952936236   0.1750606812   0.1422442452   -.1016126847   0.1910998142
0.4660402057
  v10_cul   0.0689927821   0.1267442980   0.1029851300   -.0735677955   0.1383566637
0.2066935498
  v11_dgn   0.0662523335   0.1217099129   0.0988944781   -.0706456237   0.1328610262
0.1984835164
  v12_mfg   0.0456107415   0.0837899449   0.0680828921   -.0486352572   0.0914668148
0.1366439471
  v13_crd   0.0295309394   0.0542502864   0.0440806638   -.0314891797   0.0592207204
0.0884709170
  v14_int   0.0548491999   0.1007616031   0.0818730859   -.0584863314   0.1099934235
0.1643211866

                                    Predicted Model Matrix

                 v10_cul             v11_dgn             v12_mfg             v13_crd
v14_int

   v01_qty   0.0689927821        0.066252334       0.0456107415       0.0295309394
0.0548491999
   v02_spd   0.1267442980        0.121709913       0.0837899449       0.0542502864
0.1007616031
   v04_flx   0.1029851300        0.098894478       0.0680828921       0.0440806638
0.0818730859
   v05_cst  -.0735677955      -0.070645624      -.0486352572      -.0314891797      -
.0584863314
   v06_skl   0.1383566637        0.132861026       0.0914668148       0.0592207204
0.1099934235
```

v07_tmd	0.2066935498	0.198483516	0.1366439471	0.0884709170	0.1643211866
v10_cul	0.3024777932	0.143702479	0.0989305024	0.0640531283	0.1189688815
v11_dgn	0.1437024795	1.174258999	0.2461759503	0.1593880485	0.2960389036
v12_mfg	0.0989305024	0.246175950	0.4846657316	0.1097290720	0.2038049557
v13_crd	0.0640531283	0.159388049	0.1097290720	0.7932959328	0.1319547020
v14_int	0.1189688815	0.296038904	0.2038049557	0.1319547020	0.4851425900

Determinant 0.000006850 Ln -11.891265

Covariance Structure Analysis: Maximum Likelihood Estimation

Fit Function	0.5870
Goodness of Fit Index (GFI)	0.9109
GFI Adjusted for Degrees of Freedom (AGFI)	0.8600
Root Mean Square Residual (RMR)	0.0322
Parsimonious GFI (Mulaik, 1989)	0.6956
Chi-Square	54.0025
Chi-Square DF	42
Pr > Chi-Square	0.1014
Independence Model Chi-Square	275.05
Independence Model Chi-Square DF	55
RMSEA Estimate	0.0557
RMSEA 90% Lower Confidence Limit	.
RMSEA 90% Upper Confidence Limit	0.0952
ECVI Estimate	1.1870
ECVI 90% Lower Confidence Limit	.
ECVI 90% Upper Confidence Limit	1.4495
Probability of Close Fit	0.3905
Bentler's Comparative Fit Index	0.9455
Elliptic Corrected Chi-Square	53.2628
Pr > Elliptic Corrected Chi-Square	0.1141
Normal Theory Reweighted LS Chi-Square	49.4789
Akaike's Information Criterion	-29.9975
Bozdogan's (1987) CAIC	-178.3667
Schwarz's Bayesian Criterion	-136.3667
McDonald's (1989) Centrality	0.9375
Bentler & Bonett's (1980) Non-normed Index	0.9286
Bentler & Bonett's (1980) NFI	0.8037
James, Mulaik, & Brett (1982) Parsimonious NFI	0.6137
Z-Test of Wilson & Hilferty (1931)	1.2743
Bollen (1986) Normed Index Rho1	0.7429
Bollen (1988) Non-normed Index Delta2	0.9485
Hoelter's (1983) Critical N	101

Covariance Structure Analysis: Maximum Likelihood Estimation

Raw Residual Matrix

	v01_qty	v02_spd	v04_flx	v05_cst	v06_skl	v07_tmd
v01_qty	0.0000000000	0.0036999056	0.0041853703	0.0404815369	0.0302936382	0.0064922576
v02_spd	0.0036999056	0.0000000000	0.0000297759	-.0174693357	-.0120630188	0.0203951393
v04_flx	0.0041853703	0.0000297759	0.0000000000	0.0059620197	0.0140130655	-.0136420947
v05_cst	0.0404815369	-.0174693357	0.0059620197	0.0000000000	-.0107622382	0.0070965557
v06_skl	0.0302936382	-.0120630188	0.0140130655	-.0107622382	0.0000000000	0.0069927524
v07_tmd	0.0064922576	0.0203951393	-.0136420947	0.0070965557	0.0069927524	0.0000000000

v10_cul	0.0225967457	-.0225507496	0.0042705970	-.0356327655	-.0145137465	-.0061091646
v11_dgn	-.0372574761	-.1383578792	0.0178984158	-.0118228195	0.1024966176	-.0187827216
v12_mfg	-.0524597363	-.0876328621	-.0156892502	-.0314909700	-.0107234768	0.0310746130
v13_crd	-.0111578679	-.0266345781	0.0039558018	0.0357809048	0.0015927439	-.0116265972
v14_int	-.0101834682	-.0302707196	0.0144476247	-.0189189982	-.0334857096	-.0189869183

Raw Residual Matrix

	v10_cul	v11_dgn	v12_mfg	v13_crd	v14_int
v01_qty	0.0225967457	-.0372574761	-.0524597363	-.0111578679	-.0101834682
v02_spd	-.0225507496	-.1383578792	-.0876328621	-.0266345781	-.0302707196
v04_flx	0.0042705970	0.0178984158	-.0156892502	0.0039558018	0.0144476247
v05_cst	-.0356327655	-.0118228195	-.0314909700	0.0357809048	-.0189189982
v06_skl	-.0145137465	0.1024966176	-.0107234768	0.0015927439	-.0334857096
v07_tmd	-.0061091646	-.0187827216	0.0310746130	-.0116265972	-.0189869183
v10_cul	0.0000000000	0.0100375860	0.0265440184	0.0008276571	0.0419614597
v11_dgn	0.0100375860	0.0000000000	0.0276576167	-.0717583150	-.0061604557
v12_mfg	0.0265440184	0.0276576167	0.0000000000	-.0298132235	-.0081013559
v13_crd	0.0008276571	-.0717583150	-.0298132235	0.0000000000	0.0504997159
v14_int	0.0419614597	-.0061604557	-.0081013559	0.0504997159	0.0000000000

Average Absolute Residual	0.020384
Average Off-diagonal Absolute Residual	0.024461

Rank Order of the 10 Largest Raw Residuals

Row	Column	Residual
v11_dgn	v02_spd	-0.13836
v11_dgn	v06_skl	0.10250
v12_mfg	v02_spd	-0.08763
v13_crd	v11_dgn	-0.07176
v12_mfg	v01_qty	-0.05246
v14_int	v13_crd	0.05050
v14_int	v10_cul	0.04196
v05_cst	v01_qty	0.04048
v11_dgn	v01_qty	-0.03726

Covariance Structure Analysis: Maximum Likelihood Estimation

Rank Order of the 10 Largest Raw Residuals

Row	Column	Residual
v13_crd	v05_cst	0.03578

Covariance Structure Analysis: Maximum Likelihood Estimation

Asymptotically Standardized Residual Matrix

	v01_qty	v02_spd	v04_flx	v05_cst	v06_skl	v07_tmd
v01_qty	0.000000000	0.348415695	0.347016299	2.308580480	1.436294437	0.322068005
v02_spd	0.348415695	0.000000000	0.003830138	-1.261888165	-0.550763698	1.157068051
v04_flx	0.347016299	0.003830138	0.000000000	0.384721907	0.658666562	-0.742052305
v05_cst	2.308580480	-1.261888165	0.384721907	0.000000000	-0.415471447	0.281388765
v06_skl	1.436294437	-0.550763698	0.658666562	-0.415471447	0.000000000	0.575975222
v07_tmd	0.322068005	1.157068051	-0.742052305	0.281388765	0.575975222	0.000000000
v10_cul	1.260744761	-1.306557854	0.247178019	-1.604426166	-1.075763601	-0.756450789
v11_dgn	-0.803861099	-2.533938770	0.353914233	-0.211452686	2.042146207	-0.393262627
v12_mfg	-1.786724985	-2.561104836	-0.493068634	-0.887577951	-0.343344359	1.075840599
v13_crd	-0.275470580	-0.535625365	0.087169297	0.737306081	0.034001074	-0.239423886
v14_int	-0.362897689	-0.958583542	0.485548942	-0.555010495	-1.189820976	-0.810747268

Asymptotically Standardized Residual Matrix

	v10_cul	v11_dgn	v12_mfg	v13_crd	v14_int
v01_qty	1.260744761	-0.803861099	-1.786724985	-0.275470580	-0.362897689
v02_spd	-1.306557854	-2.533938770	-2.561104836	-0.535625365	-0.958583542
v04_flx	0.247178019	0.353914233	-0.493068634	0.087169297	0.485548942
v05_cst	-1.604426166	-0.211452686	-0.887577951	0.737306081	-0.555010495
v06_skl	-1.075763601	2.042146207	-0.343344359	0.034001074	-1.189820976
v07_tmd	-0.756450789	-0.393262627	1.075840599	-0.239423886	-0.810747268
v10_cul	0.000000000	0.235411129	1.012861652	0.019991927	1.854775736
v11_dgn	0.235411129	0.000000000	0.760384450	-1.024816314	-0.257927239
v12_mfg	1.012861652	0.760384450	0.000000000	-0.706914891	-0.606050188
v13_crd	0.019991927	-1.024816314	-0.706914891	0.000000000	1.621568573
v14_int	1.854775736	-0.257927239	-0.606050188	1.621568573	0.000000000

Average Standardized Residual	0.680362
Average Off-diagonal Standardized Residual	0.816434

Rank Order of the 10 Largest Asymptotically Standardized Residuals

Row	Column	Residual
v12_mfg	v02_spd	-2.56110
v11_dgn	v02_spd	-2.53394
v05_cst	v01_qty	2.30858
v11_dgn	v06_skl	2.04215

```
v14_int     v10_cul        1.85478
v12_mfg     v01_qty       -1.78672
v14_int     v13_crd        1.62157
v10_cul     v05_cst       -1.60443
v06_skl     v01_qty        1.43629
v10_cul     v02_spd       -1.30656
```

Covariance Structure Analysis: Maximum Likelihood Estimation

Distribution of Asymptotically Standardized Residuals

Each * Represents 1 Residuals

----------Range---------		Freq	Percent	
-2.75000	-2.50000	2	3.03	**
-2.50000	-2.25000	0	0.00	
-2.25000	-2.00000	0	0.00	
-2.00000	-1.75000	1	1.52	*
-1.75000	-1.50000	1	1.52	*
-1.50000	-1.25000	2	3.03	**
-1.25000	-1.00000	3	4.55	***
-1.00000	-0.75000	5	7.58	*****
-0.75000	-0.50000	6	9.09	******
-0.50000	-0.25000	7	10.61	*******
-0.25000	0	2	3.03	**
0	0.25000	17	25.76	*****************
0.25000	0.50000	7	10.61	*******
0.50000	0.75000	3	4.55	***
0.75000	1.00000	1	1.52	*
1.00000	1.25000	3	4.55	***
1.25000	1.50000	2	3.03	**
1.50000	1.75000	1	1.52	*
1.75000	2.00000	1	1.52	*
2.00000	2.25000	1	1.52	*
2.25000	2.50000	1	1.52	*

Covariance Structure Analysis: Maximum Likelihood Estimation

Manifest Variable Equations with Estimates

```
v01_qty =   0.5443*f1       +  1.0000 e01
Std Err     0.1261 lv01f1
t Value     4.3176
v02_spd =   1.0000 f1       +  1.0000 e02
v04_flx =   0.8125*f1       +  1.0000 e04
Std Err     0.1544 lv04f1
t Value     5.2610
v05_cst =  -0.5804*f1       +  1.0000 e05
Std Err     0.1481 lv05f1
t Value    -3.9202
v06_skl =   0.6694*f2       +  1.0000 e06
Std Err     0.1295 lv06f2
t Value     5.1683
v07_tmd =   1.0000 f2       +  1.0000 e07
v10_cul =   0.7240*f2       +  1.0000 e10
Std Err     0.1238 lv10f2
t Value     5.8483
v11_dgn =   1.2079*f3       +  1.0000 e11
Std Err     0.3116 lv11f3
t Value     3.8763
v12_mfg =   0.8316*f3       +  1.0000 e12
Std Err     0.2061 lv12f3
t Value     4.0339
v13_crd =   0.5384*f3       +  1.0000 e13
Std Err     0.2304 lv13f3
t Value     2.3370
v14_int =   1.0000 f3       +  1.0000 e14
```

```
          Covariance Structure Analysis: Maximum Likelihood Estimation

                    Latent Variable Equations with Estimates


              f1      =   0.6132*f2       +  1.0000 d1
              Std Err     0.1285 pf1f2
              t Value     4.7715

                          Variances of Exogenous Variables

                                                    Standard
    Variable Parameter      Estimate         Error    t Value

    f2       varf2           0.28549       0.07268       3.93
    f3       varf3           0.24509       0.07985       3.07
    e01      vare01          0.15543       0.02588       6.01
    e02      vare02          0.16046       0.03833       4.19
    e04      vare04          0.15683       0.03130       5.01
    e05      vare05          0.23485       0.03786       6.20
    e06      vare06          0.21895       0.03784       5.79
    e07      vare07          0.18055       0.04448       4.06
    e10      vare10          0.15283       0.03015       5.07
    e11      vare11          0.81667       0.14715       5.55
    e12      vare12          0.31519       0.06005       5.25
    e13      vare13          0.72225       0.11084       6.52
    e14      vare14          0.24006       0.06136       3.91
    d1       vard1           0.09868       0.03682       2.68


                    Covariances Among Exogenous Variables

                                                        Standard
 Var1    Var2    Parameter      Estimate         Error    t Value

 f2      f3      cf2f3           0.16432       0.04693       3.50

          Covariance Structure Analysis: Maximum Likelihood Estimation

            Manifest Variable Equations with Standardized Estimates


               v01_qty =   0.5310*f1      +  0.8473 e01
                                  lv01f1
               v02_spd =   0.7498 f1      +  0.6617 e02
               v04_flx =   0.6815*f1      +  0.7318 e04
                                  lv04f1
               v05_cst =  -0.4776*f1      +  0.8786 e05
                                  lv05f1
               v06_skl =   0.6073*f2      +  0.7945 e06
                                  lv06f2
               v07_tmd =   0.7827 f2      +  0.6224 e07
               v10_cul =   0.7034*f2      +  0.7108 e10
                                  lv10f2
               v11_dgn =   0.5518*f3      +  0.8340 e11
                                  lv11f3
               v12_mfg =   0.5913*f3      +  0.8064 e12
                                  lv12f3
               v13_crd =   0.2993*f3      +  0.9542 e13
                                  lv13f3
               v14_int =   0.7108 f3      +  0.7034 e14

          Covariance Structure Analysis: Maximum Likelihood Estimation

             Latent Variable Equations with Standardized Estimates


               f1      =   0.7218*f2      +  0.6921 d1
                                  pf1f2
```

Squared Multiple Correlations

	Variable	Error Variance	Total Variance	R-Square
1	v01_qty	0.15543	0.21647	0.2820
2	v02_spd	0.16046	0.36648	0.5622
3	v04_flx	0.15683	0.29286	0.4645
4	v05_cst	0.23485	0.30426	0.2281
5	v06_skl	0.21895	0.34687	0.3688
6	v07_tmd	0.18055	0.46604	0.6126
7	v10_cul	0.15283	0.30248	0.4947
8	v11_dgn	0.81667	1.17426	0.3045
9	v12_mfg	0.31519	0.48467	0.3497
10	v13_crd	0.72225	0.79330	0.0896
11	v14_int	0.24006	0.48514	0.5052
12	f1	0.09868	0.20602	0.5210

Correlations Among Exogenous Variables

Var1	Var2	Parameter	Estimate
f2	f3	cf2f3	0.62121

Covariance Structure Analysis: Maximum Likelihood Estimation

Lagrange Multiplier and Wald Test Indices _PHI_ [14:14]
Symmetric Matrix
Univariate Tests for Constant Constraints
Lagrange Multiplier or Wald Index / Probability / Approx Change of Value

	f2	f3	e01	e02	e04	e05	e06
f2	15.4280	12.2589	2.7774	2.3581	1.0419	0.0472	0.0066
	.	.	0.0956	0.1246	0.3074	0.8281	0.9352
	.	.	0.0575	0.0653	-0.0393	0.0090	0.0042
	[varf2]	[cf2f3]					
f3	12.2589	9.4205	1.4463	6.4767	1.3165	0.8906	0.0066
	.	.	0.2291	0.0109	0.2512	0.3453	0.9352
	.	.	-0.0279	-0.0687	0.0286	-0.0266	-0.0024
	[cf2f3]	[varf3]					
e01	2.7774	1.4463	36.0776	0.1214	0.1204	5.3295	1.5562
	0.0956	0.2291	.	0.7275	0.7286	0.0210	0.2122
	0.0575	-0.0279	.	0.0089	0.0076	0.0522	0.0269
			[vare01]				
e02	2.3581	6.4767	0.1214	17.5256	0.0000	1.5924	0.5761
	0.1246	0.0109	0.7275	.	0.9970	0.2070	0.4478
	0.0653	-0.0687	0.0089	.	0.0001	-0.0373	-0.0192
				[vare02]			

```
 e04        1.0419        1.3165        0.1204        0.0000       25.1076        0.1480
0.3606
            0.3074        0.2512        0.7286        0.9970          .           0.7005
0.5482
           -0.0393        0.0286        0.0076        0.0001          .           0.0099
0.0140
                                                                 [vare04]

 e05        0.0472        0.8906        5.3295        1.5924        0.1480       38.4691
0.0012
            0.8281         0.3453        0.0210        0.2070        0.7005           .
0.9726
            0.0090        -0.0266        0.0522       -0.0373        0.0099           .
-0.0009
                                                                                [vare05]

 e06        0.0066        0.0066        1.5562        0.5761        0.3606        0.0012
33.4889
            0.9352        0.9352        0.2122        0.4478        0.5482        0.9726
.
            0.0042       -0.0024        0.0269       -0.0192        0.0140       -0.0009
.
[vare06]

 e07        0.0661        0.0661        0.0798        5.5949        1.6374        1.2476
0.3317
            0.7971        0.7971        0.7776        0.0180        0.2007        0.2640
0.5647
            0.0154       -0.0088       -0.0064        0.0656       -0.0321        0.0305
0.0204

                Covariance Structure Analysis: Maximum Likelihood Estimation

                 Lagrange Multiplier and Wald Test Indices _PHI_   [14:14]
                                    Symmetric Matrix
                             Univariate Tests for Constant Constraints
            Lagrange  Multiplier  or  Wald  Index  /  Probability  /  Approx  Change  of
Value

                   e07           e10           e11           e12           e13           e14
d1

 f2         0.0661        3.4506        0.0045        0.0784        0.0609        0.0411
2.9914
            0.7971        0.0632        0.9468        0.7795        0.8051        0.8393
0.0837
            0.0154       -0.0875        0.0043        0.0119       -0.0125       -0.0100
0.0791


 f3         0.0661        3.4505        0.0045        0.0784        0.0609        0.0411
2.9913
            0.7971        0.0632        0.9468        0.7795        0.8051        0.8393
0.0837
           -0.0088        0.0504       -0.0064       -0.0178        0.0187        0.0150
-0.0455


 e01        0.0798        1.2277        0.0570        2.1329        0.0001        0.0009
0.8786
            0.7776        0.2678        0.8113        0.1442        0.9917        0.9762
0.3486
           -0.0064        0.0211       -0.0099       -0.0383        0.0004        0.0007
-0.0268


 e02        5.5949        2.3647        4.9305        3.3032        0.0080        0.0955
1.9609
```

```
              0.0180        0.1241        0.0264        0.0691        0.9285        0.7573
0.1614
              0.0656       -0.0350       -0.1061       -0.0549        0.0038        0.0089
0.0608


 e04          1.6374        0.0438        1.1027        0.0054        0.0712        0.1839
0.0000
              0.2007        0.8342        0.2937        0.9413        0.7895        0.6681
0.9981
             -0.0321        0.0043        0.0467       -0.0021        0.0106        0.0115
0.0001


 e05          1.2476        2.5409        0.0588        1.7177        0.8743        0.0207
0.7206
              0.2640        0.1109        0.8084        0.1900        0.3498        0.8855
0.3960
              0.0305       -0.0367       -0.0122       -0.0418        0.0421       -0.0044
0.0288


 e06          0.3317        1.1573        7.1211        0.2862        0.0296        2.8394
0.3459
              0.5647        0.2820        0.0076        0.5926        0.8634        0.0920
0.5565
              0.0204       -0.0290        0.1349       -0.0171        0.0077       -0.0519
0.0149


 e07         16.4761        0.5722        0.3452        2.5069        0.0150        1.1064
0.1826
               .            0.4494        0.5568        0.1134        0.9024        0.2929
0.6692
               .           -0.0281       -0.0312        0.0535       -0.0057       -0.0350
0.0137
          [vare07]

                  Covariance Structure Analysis: Maximum Likelihood Estimation

                   Lagrange Multiplier and Wald Test Indices _PHI_   [14:14]
                                     Symmetric Matrix
                              Univariate Tests for Constant Constraints
           Lagrange  Multiplier  or  Wald  Index  /  Probability  /  Approx  Change  of
Value

                  f2            f3           e01           e02           e04           e05
e06

 e10          3.4506        3.4505        1.2277        2.3647        0.0438        2.5409
1.1573
              0.0632        0.0632        0.2678        0.1241        0.8342        0.1109
0.2820
             -0.0875        0.0504        0.0211       -0.0350        0.0043       -0.0367
-0.0290


 e11          0.0045        0.0045        0.0570        4.9305        1.1027        0.0588
7.1211
              0.9468        0.9468        0.8113        0.0264        0.2937        0.8084
0.0076
              0.0043       -0.0064       -0.0099       -0.1061        0.0467       -0.0122
0.1349


 e12          0.0784        0.0784        2.1329        3.3032        0.0054        1.7177
0.2862
              0.7795        0.7795        0.1442        0.0691        0.9413        0.1900
0.5926
```

```
              0.0119       -0.0178      -0.0383      -0.0549      -0.0021      -0.0418
-0.0171


 e13          0.0609        0.0609       0.0001       0.0080       0.0712       0.8743
0.0296
              0.8051        0.8051       0.9917       0.9285       0.7895       0.3498
0.8634
             -0.0125        0.0187       0.0004       0.0038       0.0106       0.0421
0.0077


 e14          0.0411        0.0411       0.0009       0.0955       0.1839       0.0207
2.8394
              0.8393        0.8393       0.9762       0.7573       0.6681       0.8855
0.0920
             -0.0100        0.0150       0.0007       0.0089       0.0115      -0.0044
-0.0519


 d1           2.9914        2.9913       0.8786       1.9609       0.0000       0.7206
0.3459
              0.0837        0.0837       0.3486       0.1614       0.9981       0.3960
0.5565
              0.0791       -0.0455      -0.0268       0.0608       0.0001       0.0288
0.0149

                  Covariance Structure Analysis: Maximum Likelihood Estimation

                   Lagrange Multiplier and Wald Test Indices _PHI_   [14:14]
                                     Symmetric Matrix
                           Univariate Tests for Constant Constraints
            Lagrange  Multiplier  or  Wald  Index  /  Probability  /  Approx  Change  of
Value

                 e07           e10          e11          e12          e13          e14
d1

 e10          0.5722       25.6870       0.1510       0.2599       0.0135       3.2477
0.0916
              0.4494          .          0.6976       0.6102       0.9074       0.0715
0.7622
             -0.0281          .         -0.0173       0.0144      -0.0046       0.0495
0.0074
                          [vare10]

 e11          0.3452        0.1510      30.8018       0.5782       1.0502       0.0665
1.5382
              0.5568        0.6976         .          0.4470       0.3055       0.7965
0.2149
             -0.0312       -0.0173         .          0.0585      -0.0938      -0.0230
-0.0557
                                       [vare11]

 e12          2.5069        0.2599       0.5782      27.5500       0.4997       0.3673
3.8264
              0.1134        0.6102       0.4470         .          0.4796       0.5445
0.0505
              0.0535        0.0144       0.0585         .         -0.0415      -0.0373
-0.0557
                                                    [vare12]

 e13          0.0150        0.0135       1.0502       0.4997      42.4630       2.6296
0.0295
              0.9024        0.9074       0.3055       0.4796          .         0.1049
0.8637
             -0.0057       -0.0046      -0.0938      -0.0415          .         0.0981
-0.0068
                                                                 [vare13]
```

```
 e14      1.1064      3.2477      0.0665      0.3673      2.6296     15.3055
0.5520
          0.2929      0.0715      0.7965      0.5445      0.1049           .
0.4575
         -0.0350      0.0495     -0.0230     -0.0373      0.0981           .
0.0204
                                                                    [vare14]

 d1       0.1826      0.0916      1.5382      3.8264      0.0295      0.5520
7.1822
          0.6692      0.7622      0.2149      0.0505      0.8637      0.4575
.
          0.0137      0.0074     -0.0557     -0.0557     -0.0068      0.0204
.
[vard1]

                  Rank Order of the 10 Largest Lagrange Multipliers in _PHI_

                        Row         Column      Chi-Square    Pr > ChiSq

                        e11         e06            7.12106        0.0076
                        e02         f3             6.47666        0.0109
                        e07         e02            5.59486        0.0180
                        e05         e01            5.32946        0.0210
                        e11         e02            4.93054        0.0264
                        d1          e12            3.82636        0.0505
                        e10         f2             3.45060        0.0632

                  Covariance Structure Analysis: Maximum Likelihood Estimation

                  Rank Order of the 10 Largest Lagrange Multipliers in _PHI_

                        Row         Column      Chi-Square    Pr > ChiSq

                        e10         f3             3.45049        0.0632
                        e12         e02            3.30322        0.0691
                        e14         e10            3.24767        0.0715

                  Covariance Structure Analysis: Maximum Likelihood Estimation

                    Lagrange Multiplier and Wald Test Indices _GAMMA_ [12:2]
                                         General Matrix
                                Univariate Tests for Constant Constraints
            Lagrange  Multiplier  or  Wald  Index  /  Probability  /  Approx  Change  of
Value

                                                 f2            f3

                             v01_qty         0.8785        0.3822
                                             0.3486        0.5364
                                             0.1668       -0.0801


                             v02_spd         1.9606        7.6246
                                             0.1614        0.0058
                                            -0.3776       -0.4437


                             v04_flx         0.0000        1.0070
                                             0.9981        0.3156
                                            -0.0005        0.1456


                             v05_cst         0.7205        1.3208
                                             0.3960        0.2504
                                            -0.1792       -0.1794
```

```
                 v06_skl        26.7117         0.0066
                                    .           0.9352
                                    .          -0.0159
                               [lv06f2]

                 v07_tmd            .           0.0661
                                    .           0.7971
                                    .          -0.0587
                                     Sing

                 v10_cul        34.2032         3.4504
                                    .           0.0632
                                    .           0.3345
                               [lv10f2]

                 v11_dgn         0.0045        15.0256
                                 0.9468            .
                                 0.0244            .
                                              [lv11f3]

        Covariance Structure Analysis: Maximum Likelihood Estimation

          Lagrange Multiplier and Wald Test Indices _GAMMA_ [12:2]
                              General Matrix
                    Univariate Tests for Constant Constraints
  Lagrange Multiplier or Wald Index / Probability / Approx Change of
Value

                                     f2             f3

                 v12_mfg         0.0784        16.2725
                                 0.7795            .
                                 0.0682            .
                                              [lv12f3]

                 v13_crd         0.0609         5.4615
                                 0.8050            .
                                -0.0715            .
                                              [lv13f3]

                 v14_int         0.0411            .
                                 0.8393            .
                                -0.0573            .
                                                 Sing

                 f1             22.7676         2.9913
                                    .           0.0837
                                    .          -0.3025
                                 [pf1f2]


        Rank Order of the 9 Largest Lagrange Multipliers in _GAMMA_

              Row         Column      Chi-Square    Pr > ChiSq

              v02_spd     f3             7.62462        0.0058
              v10_cul     f3             3.45042        0.0632
              f1          f3             2.99131        0.0837
              v02_spd     f2             1.96064        0.1614
              v05_cst     f3             1.32083        0.2504
              v04_flx     f3             1.00699        0.3156
              v01_qty     f2             0.87853        0.3486
              v05_cst     f2             0.72051        0.3960
              v01_qty     f3             0.38217        0.5364

        Covariance Structure Analysis: Maximum Likelihood Estimation

         Lagrange Multiplier and Wald Test Indices _BETA_  [12:12]
                              General Matrix
```

Identity-Minus-Inverse Model Matrix
Univariate Tests for Constant Constraints
Lagrange Multiplier or Wald Index / Probability / Approx Change of Value

	v01_qty	v02_spd	v04_flx	v05_cst	v06_skl	v07_tmd
v01_qty	.	0.1214	0.1204	5.3295	1.9545	0.0682
	.	0.7275	0.7286	0.0210	0.1621	0.7939
	.	0.0554	0.0486	0.2224	0.1208	0.0226
	Sing					
v02_spd	0.1214	.	0.0000	1.5924	1.1418	1.4375
	0.7275	.	0.9969	0.2070	0.2853	0.2305
	0.0572	.	0.0008	-0.1590	-0.1138	0.1407
		Sing				
v04_flx	0.1204	0.0000	.	0.1480	0.2939	0.8886
	0.7286	0.9970	.	0.7005	0.5877	0.3459
	0.0491	0.0008	.	0.0423	0.0522	-0.0963
			Sing			
v05_cst	5.3295	1.5923	0.1480	.	0.0964	0.1219
	0.0210	0.2070	0.7004	.	0.7562	0.7270
	0.3361	-0.2327	0.0634	.	-0.0324	0.0362
				Sing		
v06_skl	1.6625	0.0821	0.4975	0.0287	.	0.3317
	0.1973	0.7745	0.4806	0.8654	.	0.5646
	0.1626	-0.0326	0.0844	-0.0176	.	0.1129
					Sing	
v07_tmd	0.0278	3.9621	0.8831	0.9560	0.3317	.
	0.8676	0.0465	0.3474	0.3282	0.5646	.
	-0.0226	0.2640	-0.1272	0.1081	0.0931	.
						Sing
v10_cul	1.1992	1.0241	0.0793	2.4464	1.1573	0.5722
	0.2735	0.3116	0.7783	0.1178	0.2820	0.4494
	0.1233	-0.1064	0.0307	-0.1441	-0.1325	-0.1556
v11_dgn	0.2810	3.5670	0.1057	0.0055	5.4602	0.1295
	0.5960	0.0589	0.7451	0.9410	0.0195	0.7190

```
                 -0.1214        -0.3544         0.0667         0.0141         0.4674
-0.0713

                  Covariance Structure Analysis: Maximum Likelihood Estimation

                   Lagrange Multiplier and Wald Test Indices _BETA_  [12:12]
                                       General Matrix
                             Identity-Minus-Inverse Model Matrix
                          Univariate Tests for Constant Constraints
           Lagrange  Multiplier  or  Wald  Index  /  Probability  /  Approx  Change  of
Value

                 v10_cul        v11_dgn        v12_mfg        v13_crd        v14_int
f1

  v01_qty         1.6031         0.1897         1.9724         0.0134         0.0905
18.6420
                  0.2055         0.6632         0.1602         0.9078         0.7635
.
                  0.1261        -0.0181        -0.0917        -0.0057        -0.0202
.

[lv01f1]

  v02_spd         3.2575         8.1547         6.4763         0.1905         1.3472
.
                  0.0711         0.0043         0.0109         0.6625         0.2458
.
                 -0.2310        -0.1389        -0.1948        -0.0246        -0.0922
.

Sing

  v04_flx         0.0304         1.5458         0.1209         0.2029         0.6162
27.6778
                  0.8615         0.2138         0.7280         0.6524         0.4325
.
                  0.0199         0.0559         0.0246         0.0236         0.0573
.

[lv04f1]

  v05_cst         2.6058         0.4189         2.2814         0.4297         0.4761
15.3676
                  0.1065         0.5175         0.1309         0.5121         0.4902
.
                 -0.1931        -0.0327        -0.1196         0.0390        -0.0560
.

[lv05f1]

  v06_skl         1.1572         5.0702         0.2204         0.0233         1.4413
0.3459
                  0.2820         0.0243         0.6388         0.8786         0.2299
0.5564
                 -0.1898         0.1190        -0.0393         0.0091        -0.1064
0.1513


  v07_tmd         0.5722         0.3509         1.5825         0.0246         0.7521
0.1826
                  0.4494         0.5536         0.2084         0.8753         0.3858
0.6692
                 -0.1838        -0.0338         0.1145        -0.0098        -0.0862
0.1391


  v10_cul          .             0.0632         1.1376         0.0323         4.3795
0.0916
```

```
                  .            0.8015         0.2862         0.8574         0.0364
0.7622
                  .            0.0118         0.0798         0.0095         0.1680

0.0746
                 Sing

  v11_dgn        0.0757          .            0.5782         1.0502         0.0665
0.7559
                 0.7832          .            0.4470         0.3055         0.7965

0.3846
                -0.0630          .            0.1856        -0.1299        -0.0958

-0.2895
                                Sing

                 Covariance Structure Analysis: Maximum Likelihood Estimation

                  Lagrange Multiplier and Wald Test Indices _BETA_  [12:12]
                                      General Matrix
                           Identity-Minus-Inverse Model Matrix
                        Univariate Tests for Constant Constraints
          Lagrange  Multiplier  or  Wald  Index  /  Probability  /  Approx  Change  of
Value

                v01_qty        v02_spd        v04_flx        v05_cst        v06_skl
v07_tmd

  v12_mfg        3.0178         3.5485         0.4880         0.5499         0.1372
1.5389
                 0.0824         0.0596         0.4848         0.4584         0.7111

0.2148
                -0.2525        -0.2256        -0.0912        -0.0898        -0.0475

0.1602


  v13_crd        0.0091         0.0099         0.0026         0.8384         0.0022
0.0473
                 0.9240         0.9209         0.9591         0.3599         0.9629

0.8278
                -0.0192        -0.0162         0.0092         0.1546         0.0080

-0.0356


  v14_int        0.0388         0.2178         0.3056         0.0790         2.5445
0.7824
                 0.8439         0.6407         0.5804         0.7786         0.1107

0.3764
                 0.0277         0.0551         0.0707        -0.0328        -0.2043

-0.1217


  f1             0.8786         1.9609         0.0000         0.7206         0.3459
0.1826
                 0.3486         0.1614         0.9981         0.3960         0.5565

0.6692
                -0.1727         0.3787         0.0005         0.1228         0.0682

0.0760


                  Lagrange Multiplier and Wald Test Indices _BETA_  [12:12]
                                      General Matrix
                           Identity-Minus-Inverse Model Matrix
                        Univariate Tests for Constant Constraints
          Lagrange  Multiplier  or  Wald  Index  /  Probability  /  Approx  Change  of
Value

                v10_cul        v11_dgn        v12_mfg        v13_crd        v14_int
f1

  v12_mfg        0.2818         0.5782           .            0.4997         0.3673
1.7156
```

```
                 0.5955        0.4470         .          0.4796        0.5445
0.1903
                 0.0785        0.0716         .         -0.0574       -0.1553
-0.2824
                                            Sing

  v13_crd         0.0427        1.0503       0.4997         .           2.6295
0.0699
                 0.8363        0.3054       0.4796         .           0.1049
0.7915
                -0.0399       -0.1149      -0.1316         .           0.4088
-0.0738
                                                          Sing

                  Covariance Structure Analysis: Maximum Likelihood Estimation

                   Lagrange Multiplier and Wald Test Indices _BETA_  [12:12]
                                      General Matrix
                             Identity-Minus-Inverse Model Matrix
                          Univariate Tests for Constant Constraints
           Lagrange  Multiplier  or  Wald  Index  /  Probability  /  Approx  Change  of
Value

                v10_cul       v11_dgn       v12_mfg       v13_crd       v14_int
f1

  v14_int         2.0933        0.0665        0.3673        2.6296          .
0.2492
                 0.1479        0.7965        0.5445        0.1049          .
0.6176
                 0.2200       -0.0282       -0.1183        0.1359          .
0.1116
                                                                        Sing

  f1              0.0916        2.6303        4.9512        0.2016        0.0716
.
                 0.7622        0.1048        0.0261        0.6534        0.7890
.
                 0.0482       -0.0763       -0.1657       -0.0239       -0.0211
.

Sing


                  Rank Order of the 10 Largest Lagrange Multipliers in _BETA_

                        Row         Column      Chi-Square    Pr > ChiSq

                        v02_spd     v11_dgn        8.15468        0.0043
                        v02_spd     v12_mfg        6.47629        0.0109
                        v11_dgn     v06_skl        5.46016        0.0195
                        v01_qty     v05_cst        5.32950        0.0210
                        v05_cst     v01_qty        5.32950        0.0210
                        v06_skl     v11_dgn        5.07019        0.0243
                        f1          v12_mfg        4.95118        0.0261
                        v10_cul     v14_int        4.37948        0.0364
                        v07_tmd     v02_spd        3.96207        0.0465
                        v11_dgn     v02_spd        3.56697        0.0589
```

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