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Assessing the business value of software process improvement using CMMI® in South Africa

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ABSTRACT

The focus of software process improvement is on enhancing product quality and productivity to increase business competitiveness and profitability. The Capability Maturity Model Integration or CMMI® remains the dominant standard for software process improvement globally. The lack of software quality standards such as CMMI® is seen as one of the causes of the current uncompetitive state of the South African software industry and so in 2007, a pilot programme called "Bringing CMMI® to South Africa" was launched.

This research focused on the experiences of the South African organisations participating in the South African CMMI® pilot study through a combination of semi-structured interviews and questionnaires. The aim was to assist future managerial decision making to assess the business value CMMI® can bring to South African software organisations.

The research found that the adoption of CMMI® improved both the internal quality and efficiencies as well as opportunities for growth. The research also established that CMMI® cannot be regarded as a silver bullet solution and that while process improvements can cause short-term upheaval, there are longer-term tangible and intangible benefits. It is, however, key that the organisational aspects of the change be properly managed. A lack of awareness of quality standards or actual demand for CMMI® along with the relatively high implementation and support costs are further preventing its adoption in South Africa. The recommendations resulting from the research, including a model, are discussed and suggestions for future research are provided.

DECLARATION

I declare that this research project is my own, unaided work. It is submitted in partial fulfilment of the requirements of the degree of Master of Business Administration for the Gordon Institute of Business Science, University of Pretoria. It has not been submitted before for any degree or examination in any other university.

……. ……

Douglas James Cohen Date

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Glossary

AD	Application development
Agile	A group of software development methodologies
BPR	Business process re-engineering
CAGR	Compound annual growth rate
CI	Continuous improvement
CMM	Capability Maturity Model
CMMI®	Capability Maturity Model Integration
COBIT	Control objectives for information and related technology
CoQ	Cost of quality
DTI	Department of Trade and Industry
EFQM	European Foundation for Quality Management
IEEE	Institute of Electrical and Electronics Engineers
ICTE	Information, communication technology and electrotechical
IBM	International Business Machines Corporation, abbreviated IBM
IDEAL model	Initiating, diagnosing, establishing, acting and learning
IRR	Internal rate of return
ISO	International Organisation for Standardisation
ITIL	Information Technology Infrastructure Library
JCSE	Joburg Centre for Software Engineering
KPA	Key performance area
NGO	Non-governmental organisation
NPV	Net present value
PDSA	Plan-do-see-act
PMBOK	Project management body of knowledge
QIP	Quality improvement process
RAD	Rapid application development
RUP	Rational unified process
ROI	Return on investment
SCAMPI	Standard CMMI® Appraisal Method for Process Improvement
SDLC	Software development life cycle
Six Sigma	A business management strategy that seeks to identify and remove the causes of defects and errors in manufacturing and business processes

SPI	Software process improvement
SPICE	ISO/IEC 15504 also known as SPICE (Software Process Improvement and Capability dEtermination)
SQA	Software quality assurance
SW-CMM	Software Capability Maturity Model
TCS	Tata Consulting Services
TickIT	A quality management certification programme for software, supported primarily by the United Kingdom and Swedish software industries
TQM	Total quality management

1 PROBLEM DEFINITION

1.1 Research title

Assessing the business value of software process improvement using CMMI® in South Africa

1.2 Problem background

As early as 1993, a World Bank report saw computer software as becoming the "lifeblood" of business, industry and government (World Bank, 1993). Today, technology, and in particular software, plays an ever-increasing and critical role in day-to-day business operations and has become a direct lever of competitive advantage. Not only have organisations become more dependent on software than ever before, but the impact of software failures can be far-reaching as seen recently when "Software failure, not volumes, shut both the LSE and JSE" (Hazelhurst, 2008), which resulted in the loss of millions of rands worth of trading volumes.

This expanded role of software has led to greater complexity not only in the software itself, but also in managing its development and delivery (Ahmad, 2007). The 2006 Chaos Report from The Standish Group reveals that only 35% of software projects started in 2006 could be categorised as being successful, meaning that they were completed on time, on budget and met user requirements (Rubinstein, 2007). This is however, a marked improvement from the first Chaos Report in 1994, which labelled only 16.2% of projects as successful (Standish Group, 1994). The 2006 Chaos Report also indicates that 46% of software projects continue to be described as challenged, meaning that they have cost or time overruns and do not fully meet the user requirements (Rubinstein, 2007).

Organisations engaged in software development have been forced to adopt new managerial philosophies and techniques that seek to address the technical and human challenges for effective software management (Issac, Rajendran and Anantharaman, 2004). The role of software management as part of a firm's competitiveness has evolved into a strategic one (Ismail and Hashmi, 1999 as cited in Huang, Lo, Shih and Kuo, 2006). Each organisation is faced with the challenge of developing their strategy to improve the quality and delivery of their software.

Although formally identified in the 1980s, the focus on the software development process itself has now reached a stage where it is regarded as an essential part of the strategy in managing software development as software organisations are now realising that "one of the fundamental problems is the inability to effectively manage the software process" (Niazi, Wilson and Zowghi, 2003, p. 1).

According to Rico (2000), software process improvement (SPI) is the discipline of characterising, defining, measuring and improving software management and development processes, leading to software business success and successful software development management. Success is defined in terms of greater design innovation, faster cycle times, lower development costs and higher product quality.

The Capability Maturity Model Integration or CMMI® is a software process improvement model (SPI) that provides a rating of an organisation's processes against a maturity level (level 1 being ad hoc and level 5 being optimised). Developed by the Software Engineering Institute (SEI) at Carnegie Mellon University (CMU) in Pittsburgh in the USA, it is used by companies across many sectors to improve their ability to develop high-quality software and systems.

According to Hotle and Iyengar (2006), it continues to be the most successful model for accessing software development capability.

CMMI® is being adopted worldwide, including in North America, Europe, Asia, Australia, South America and Africa (What is CMMI, 2008), in particular, by organisations in developing countries such as India, China and Russia. According to the SEI, organisations are beginning to see the benefits of adopting various aspects of the CMMI® Product Suite. In fact, two-thirds of the Software Engineering Institute CMMI® level five certified software companies in the world are Indian (Australian Government: Austrade, 2007). CMMI® adoption and certification has, for example, assisted Indian companies such as Tata Consulting Services (TCS), Wipro, Satyam and InfoSys to benefit from the rapid growth in the outsourcing of software services and to develop them into global software services organisations (Heeks and Nicholson, 2004).

The question facing organisations today with regards to quality standards such as CMMI® is whether they regard them as order winners or order qualifiers, terms coined by Terry Hill, professor at the London Business School (Hill, 2000). An order winner serves as a criterion that customers use to differentiate the services or products of one firm from those of another and therefore increases a firm's ability to compete for new business. An order qualifier defines performance dimensions according to which customers expect a minimum level of performance and will not, by itself, give a company a competitive advantage.

1.2.1 The South African software sector

The South African software sector, valued at R13.3 billion in 2007 (Mpahlwa, 2007), is expected to grow at a compound annual growth rate (CAGR) of 11% over the next three years (Mpahlwa, 2007) and is a valuable contributor to the South African

economy. SAVANT, a public/private partnership between the South African government and the local information, communications, telecommunications and electronics (ICTE) industry, was established in the South African software market in 2005. A report commissioned by SAVANT (Wills, Pater, King, Booi and Netshisaulu, 2005) identifies some of the key strengths that South Africa could exploit including:

- specialist skills and products in certain vertical industries such as mining
- specialist expertise and products in certain technologies such as mobile.

South Africa is, however, at a disadvantage to other countries such as India, Ireland and Israel, who have prioritised their software sector, addressed the issue of fragmentation within their industries and developed more coherent strategies. The outcomes of the uncompetitive state of the South African industry include:

- the lack of software quality standards
- the lack of experience and processes required for outsourcing
- not being perceived as a credible supplier.

See also Table 1:1.

Table 1:1 SWOT analysis of different software segments in SA

(Source: Wills *et al*., 2005)

	Packaged software	**Destination for outsourced development**	**Destination for outsourced systems integration**
Strengths	Innovation Can-do attitude	Innovation Can-do attitude Language, culture (Europe, USA) Time zone to Europe Lower total cost of development	Innovation Can-do attitude Language, culture (Europe, USA) Time zone to Europe Lower total cost of development
Weaknesses	Small user base to pilot/build viable business Lack of software quality standard	Salaries high compared to competition Telecoms: bandwidth and price Lack of experience	Telecoms: bandwidth and price Lack of experience and processes for outsourcing

	Packaged software	Destination for outsourced development	Destination for outsourced systems integration
		and processes Lack of software quality standard	High-level skills shortage
Opportunities	Niche applications (mining, distribution, mobile) Mobile technology	Ties with the UK and other countries (through diasporas)	
Threats	Not perceived as a credible supplier Global vendors – upgrades, buy, copy	(Much) cheaper destinations	Countries doing outsourced development can grow to SI Price – exchange rate

These challenges are even forcing larger South African organisations to investigate outsourcing destinations to service their own software needs (Jones, 2008), thereby increasing the possibility of domestic software development contracts being awarded to foreign companies. Without urgently addressing the need for quality and process improvement, it will be more difficult for South African software companies to stay competitive.

1.2.2 CMMI® pilot programme in South Africa

According to Professor Barry Dwolatzky, Director of the Joburg Centre for Software Engineering (JCSE) at the University of the Witwatersrand (Wits), there are several reasons that may explain the lack of SPI and particularly CMMI® adoption in South Africa (Dwolatzky, 2006):

- The years of isolation and sanctions during the apartheid era encouraged software developers to serve only the needs of the domestic market and they did not feel the need to compete in the global market. At the same time, companies in India and elsewhere came to understand that working for the huge and lucrative US market required software quality certification.
- Other quality standards received more attention in South Africa such as ISO 9001.

- CMMI® is perceived in South Africa to be hugely expensive and only suited to the requirements of large organisations.
- Many software developers are simply unaware of CMMI® and the benefits its adoption can offer.

To redress some these challenges the South African government through the Department of Trade and Industry (DTI), together with the City of Johannesburg and the JCSE launched a CMMI® pilot programme for South African based software companies in 2007.

1.3 Research problem

Globally, a wide range of organisations have found that implementing CMMI®-based software process improvement has delivered results in tangible improvements in schedule and cost performance, productivity, product quality, customer satisfaction and return on investment (Gibson, Goldenson and Kost, 2006). Although most of these results come from large organisations with higher levels of maturity such as Ericsson, IBM and Motorola (Mehner *et al.*, 1998 as cited in Ahmad, 2007), there have also been notable improvements achieved by smaller, lower maturity organisations.

Software process improvement (SPI) initiatives are being undertaken not only to cope with the quality problems, poorly managed processes at low levels of maturity, late projects and high costs, but also to improve organisational business performance (Abrahamsson, 2001). Without the widespread acceptance of software quality standards in South Africa, the software development sector will continue to lag behind international trends. The recent CMMI® pilot has provided an opportunity for South African organisations to gain exposure to CMMI® and to explore whether implementing a software process improvement initiative can be

supported by an assessment of the business value. The business case framework provides a mechanism to:

- Convince management to invest money and effort into process and quality improvement initiatives.
- Estimate whether a certain intended benefit is worth it cost.
- Demonstrate how an investment into SPI should be valued against its return, deliver on business value, advance a competitive position and/or improve organisational performance.

1.4 Research objective

The aim of this study is to gain an understanding of how to assess the business value of software process improvement using CMMI® in South Africa. It is intended that this research provides a rational evaluation of the business objectives driving the adoption and measures the tangible benefits and costs to provide a more holistic evaluation including factors apart from those of a financial nature and to identify risks and other factors that would prevent South African organisations gaining advantages from the business value CMMI® can bring. Supported by findings in the literature with regard to quality and process management, the use of a maturity model and organisational performance, the research will be used to assist in future managerial decision making to assess what value CMMI® can bring to South African software organisations. An exploratory approach has been chosen which focuses on the South African organisations currently participating in the CMMI® pilot study. This research attempts to answer the following questions:

1.4.1 Research question one

What are the key business drivers for the adoption of CMMI® in South Africa and how is the impact on business performance measured?

1.4.2 Research question two

How does process improvement, using CMMI®, affect South African software organisations?

1.4.3 Research question three

Where, and to what extent, have the benefits and costs of the adoption of CMMI® determined its business value?

1.4.4 Research question four

What are the internal (organisational) and external (environmental) factors which would influence (support or hinder) the adoption of SPI using CMMI® in South African software organisations?

1.5 Outline of the report

- Chapter 2 introduces the literature review used to describe the drivers of organisational performance and the role quality, process and maturity models play in supporting organisational performance. A framework for assessing the value of adopting CMMI® is introduced.
- Chapter 3 presents the research questions.
- Chapter 4 sets out the research methodology used to assess the value of adopting CMMI® in relation to the framework introduced in Chapter 2.
- Chapter 5 presents and interprets the results of the research.
- Chapter 6 discusses the results of the research in the context of the literature and considers the implications for South African software organisations.
- Chapter 7 concludes the report based on the discussion of the research results and proposes recommendations as well as possible future directions for research.

2 LITERATURE REVIEW

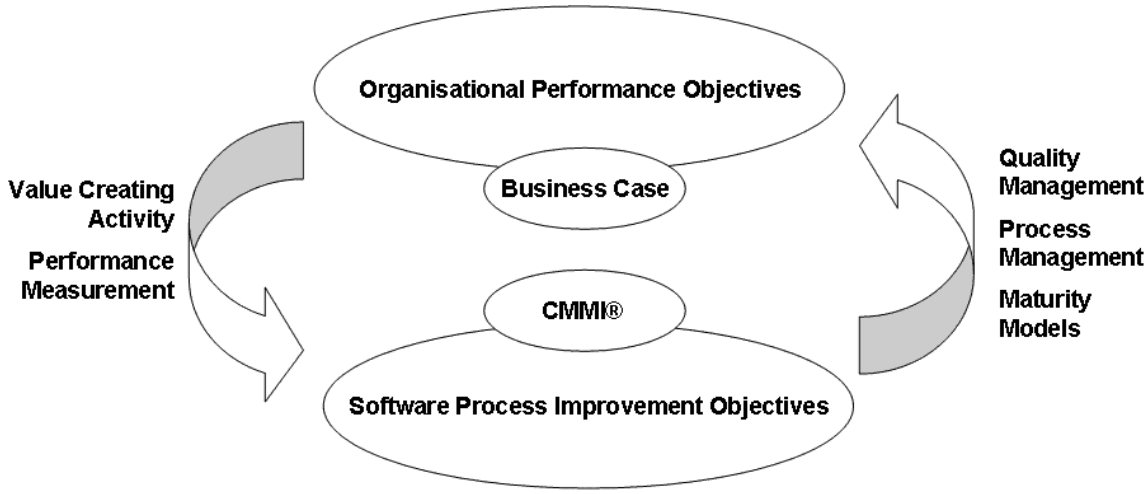
2.1 Introduction

There are six main sections to this chapter:

- The first section focuses on organisational performance including value creation and performance measurement.
- The second section provides an outline of software process improvement.
- The third section explores elements of quality management.
- The fourth section explores elements of process management.
- The fifth section explores maturity models, particularly CMMI®.
- The sixth section focuses on the business case framework.

The relationship between these topics is represented in Figure 2:1.

Figure 2:1 Literature overview
(Adapted from: Grunberg, 2004)



2.2 Organisational performance

2.2.1 Introduction to organisational performance

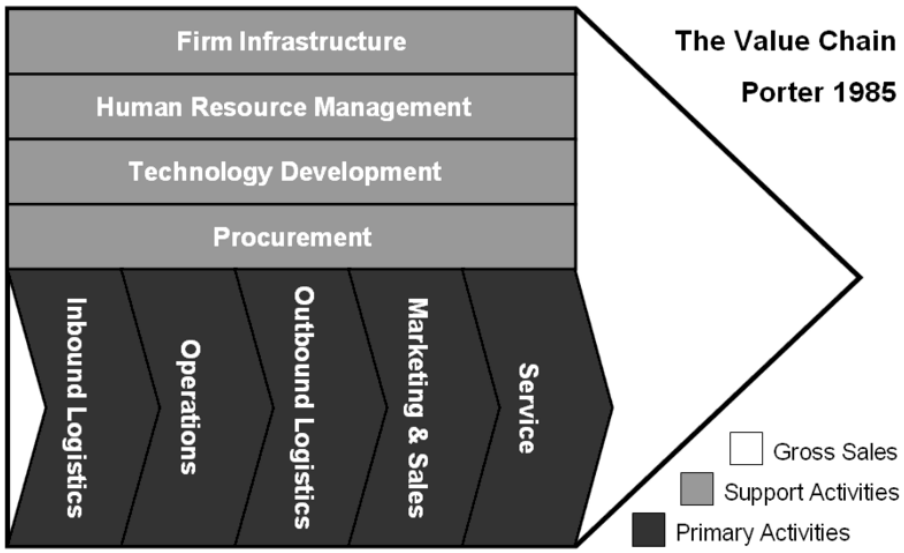
Businesses are established to serve the interests of their shareholders and hence the production of goods and services are undertaken in the pursuit of profit (Barney, 1986 and Makadok, 2001 as cited in Bowman and Ambrosini, 2007). While Bowman and Ambrosini (2007) refer to the pursuit of profit rather as the desire to optimise profits, the long-term survival of a business depends on meeting market needs through a long-term value creation process (Ling Sim and Chye Koh, 2001). Monitoring business performance is, however, a more dynamic quantity as performance is ever-changing by nature (Najmi, Rigas and Fan, 2005) and businesses therefore need to focus constantly on value-creating activities not only to optimise profits, but also to ensure their long-term survival.

2.2.2 Organisational value creation

Porter (1985) suggests that for a business to establish and defend its competitive advantage, the individual activities of the business (the value chain) need to contribute to its overall competitive strategy. Activities that do not support or advance this competitive position must be revised or eliminated. Porter provides a generic model of activities that he identifies as common (in varying degrees of importance) to every business. His value chain model consists of primary and support activities. See Figure 2:2.

Figure 2:2 Porter's value chain

(Source: Porter, 1985)



Bowman and Ambrosini (2007) have expanded on Porter's value chain and isolated only five value-creating activities. See Table 2:1.

Table 2:1: Five types of value-creating activities

(Source: Bowman and Ambrosini, 2007)

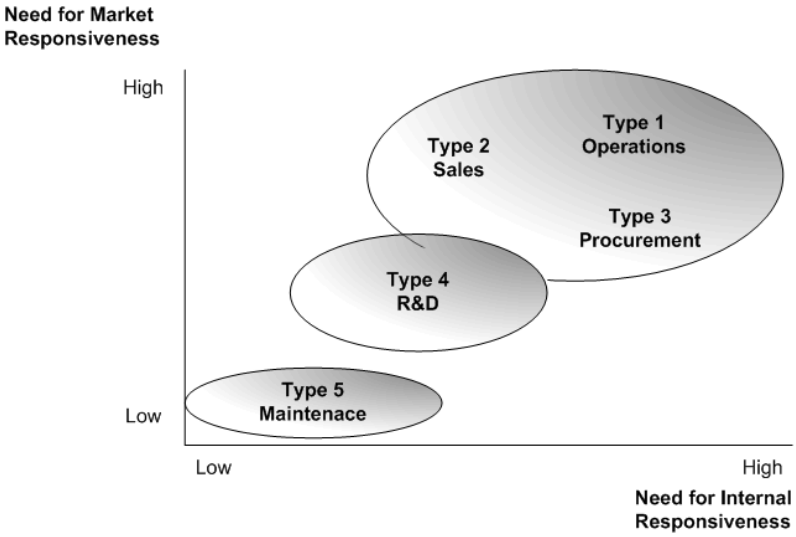
Type	Description
1	Activities involved in the production of products and services
2	Activities directed at realising revenues from the marketing and selling of outputs from Type 1
3	Activities directed at reducing the amount paid to the input suppliers with the aim of obtaining value for money for the firm
4	Activities such as market research, R&D and training that are directed at the creation of future value
5	Activities that are necessary for the maintenance of the firm and include the legal, tax and other activities required for the firm to continue to operate

To identify which of these activities to translate into business value, it is useful to recognise to what extent the activity needs to respond to the external markets and/or to internal activities within the organisation. Types 1, 2 and 3 are regarded as the primary value-creating activities as indicated by the oval in Figure 2:3 and

they must be closely coordinated to become responsive to the external environment as well as internally to ensure internal efficiencies.

Figure 2:3 Value activities and responsiveness

(Source: Bowman and Ambrosini, 2007)



According to Garrison and Noreen (1997), there are two approaches to improving profitability:

- Increasing volume and total revenue while maintaining relative variable and fixed costs
- Reducing variable and fixed costs while maintaining current volume.

Each organisation must establish its own specific priorities and measures of business value and then find means to leverage or balance these value-adding activities, given their competencies and resources at specific points in time (and through time) to create organisational value (Simons, 1995 as cited in Skoog, 2003). Process management, for example SPI, is an integrative means of fostering such a match between the internal and external environments (Christopher, Payne and Ballantyne, 1993).

2.2.3 Organisational performance measurement

Performance measurement systems provide the data necessary for managers to monitor and control business activity. Berliner and Brimson as cited in O'Mara, Hyland and Chapman (1998, p. 2) state, "Performance measurement is a key factor in ensuring the successful implementation of a company's strategy." When organisations are implementing new value-creating activities, they need to ensure that there is an appropriate set of performance measures in place.

Traditional performance measurement systems summarise the performance of the organisation for the benefit of shareholders, lenders, creditors and statutory authorities (O'Mara *et al.*, 1998). These systems have been criticised as being too narrowly focused on financial figures and functional level performance. They often initiate short-term strategies aimed at improving bottom line results and therefore fail to capture organisational long-term business success (Najmi *et al.*, 2005).

This has resulted in the development of more broad-based performance management systems designed to generate sustainable long-term improvements, the strategic alignment of the organisation and the communication of the strategy throughout the business (Najmi *et al.*, 2005). Examples of such innovative performance measurement frameworks include the balanced scorecard (Kaplan and Norton, 1996) and the EFQM excellence model (EFQM, 2008) which both view business performance through more than one perspective (Najmi *et al.*, 2005). These are briefly described below.

2.2.3.1 The balanced scorecard

A balanced scorecard is both a performance measurement and a management system. It is a "strategic management system" rather than a "tactical or

operational measurement system" (Kaplan and Norton, 1996, p. 10). It was designed to help organisations deal effectively with two key issues:

- Implementing strategy
- Measuring the performance of the organisation.

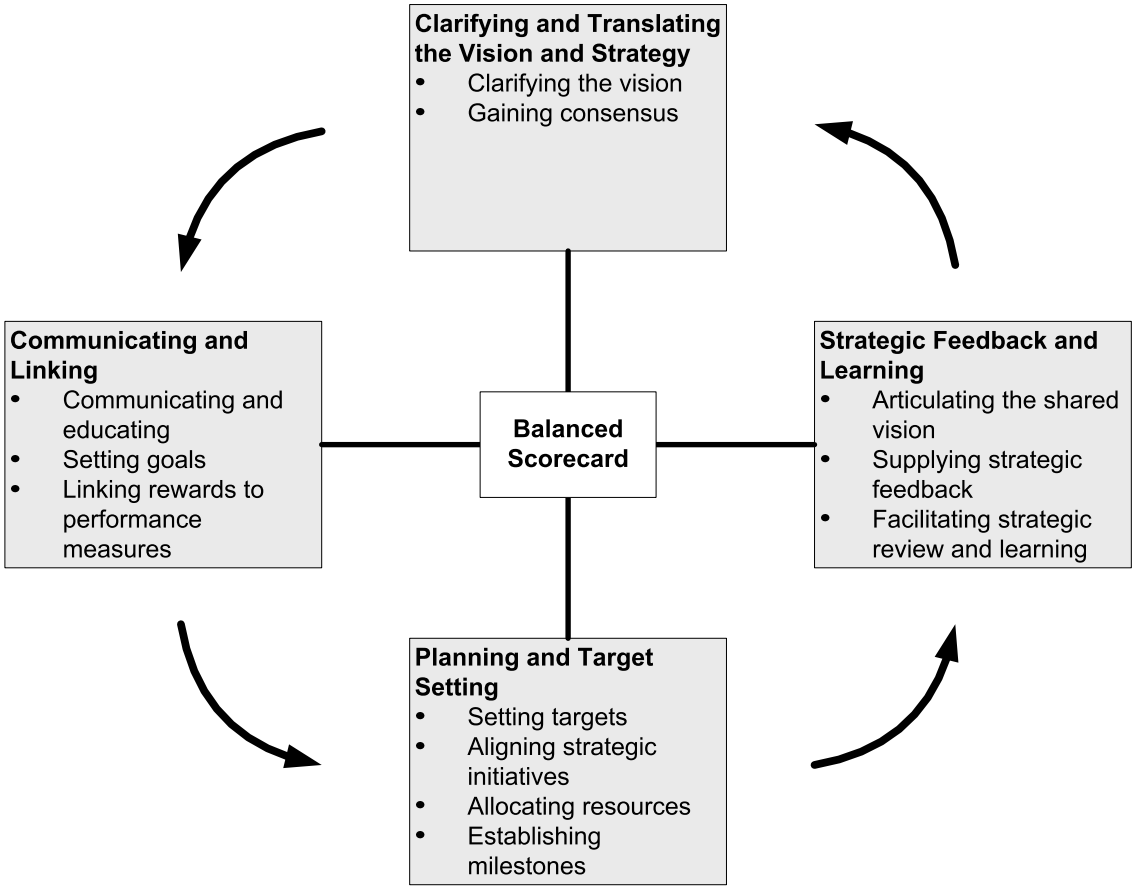
In terms of managing strategy, Kaplan and Norton (1996) propose using the balanced scorecard as a strategy framework for action. See Figure 2:4.

In terms of measuring performance, the balanced scorecard provides a well-established and proven framework and thinking tool for establishing four specific and useful measures of business value:

- *Financial*: business revenue, operational costs and market share
- *Customer satisfaction*: level of satisfaction, number of customers and depth of involvement with the customers
- *Internal business processes*: practices and methods to develop, maintain and deliver products and services as well as manage people in the organisation
- *Learning and growth*: people-related capabilities of the organisation such as technical skills of the staff, number of staff, level of domain knowledge, personnel retention and morale.

These measures provide a simple and clear way of categorising and understanding business goals, the factors which affect achievement and simultaneously monitor the progress in building the capabilities that are necessary for acquiring the intellectual capital or intangible assets needed for future business growth (Kaplan and Norton, 1996).

Figure 2:4 The balanced scorecard as a strategic framework for action
(Source: Kaplan and Norton, 1996)



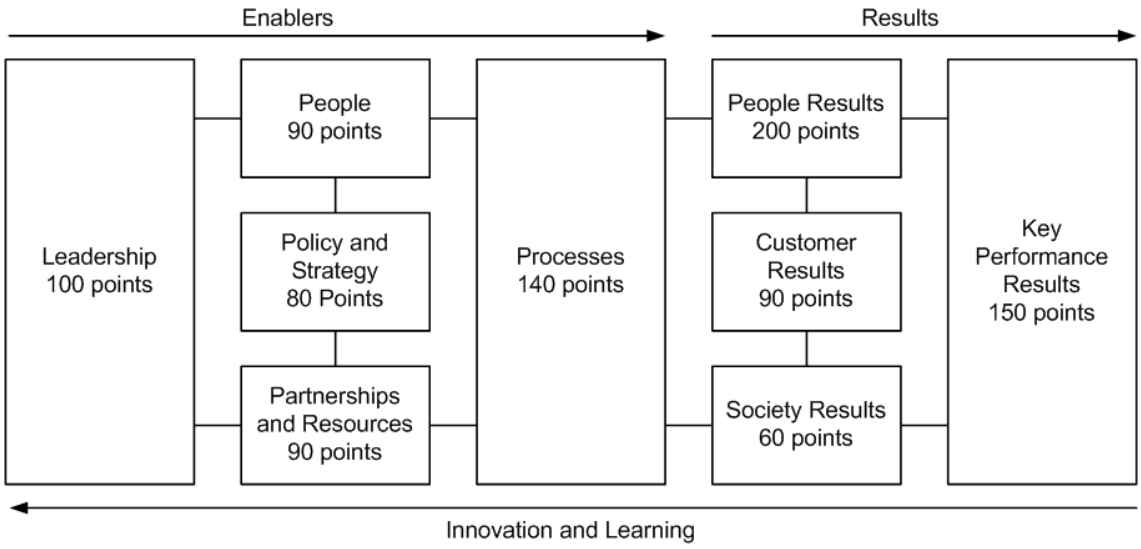
2.2.3.2 EFQM

The European Foundation for Quality Management (EFQM) was founded in 1988 by 14 major European companies. The purpose of the EFQM is to provide a non-prescriptive framework from a systems perspective for understanding performance management. The EFQM Excellence Model was introduced at the beginning of 1992 as the framework for assessing organisations for the European Quality Award. It is now the most widely used organisational framework in Europe and has become the basis for the majority of national and regional Quality Awards (EFQM, 2008). By

2003 the EFQM had grown to over 800 member organisations in 38 countries worldwide, from large corporations to small enterprises (Tobin, 2006).

The EFQM is based on nine criteria used to communicate and share best practice among organisations. Five of the criteria cover enablers which are those things an organisation can manipulate. The other four represent results or what an organisation will achieve (Wongrassamee, Gardiner and Simmons, 2003). See Figure 2:5.

Figure 2:5 EFQM model
(Source: EFQM, 2008)



2.2.4 Conclusion to organisational performance

As business value is always measured in improved business performance as perceived by the business stakeholder, Hunter, Apfel, McGee, Handler, Dreyfuss, Smith, *et al.* (2008) propose a framework of metrics designed around three investment categories – running the business, growing the business or transforming the business. Each should be used to ensure that the metrics chosen are relevant to how the organisation will exploit the new capabilities.

- Run-the-business metrics are not about direct revenue. They are about reducing costs, cutting price-to-performance ratios and lessening risk.
- Grow-the-business metrics are about improvements in operations and performance that are visible to shareholders and customers.
- Transform-the-business metrics are about quantifiable precision in demonstrating business value that is secondary to well-reasoned business logic.

Businesses need to focus constantly on value-creating activities not only to optimise profits but also to ensure their long-term survival. The challenge for organisations is firstly to identify which activities to focus on. Performance measurement systems that focus beyond just financial metrics need to be in place to monitor and control the business activity through balanced external and internal metrics.

When it comes to software, the primary decision drivers include improved quality, more timely delivery and reduced effort. The challenge for software development organisations is extracting business value while attempting to deliver on these drivers. Frameworks such as the balanced scorecard (Kaplan and Norton, 1996) and the EFQM Excellence Model (EFQM, 2008) provide useful tools in turning strategy into activity. The question is whether or not they can be used successfully to translate the benefits from software process improvement initiatives.

2.3 Software process improvement (SPI)

This section provides an overview, background, challenges and factors affecting the adoption of software process improvement.

2.3.1 Introduction to SPI

Organisations involved in the development and implementation of software have continuously to improve and optimise the software processes to make them more effective and efficient (Umarji and Seaman, 2005). The aim of software process improvement (SPI) is to improve the success rates in terms of quality, productivity and scheduling commitments. SPI gained considerable support in management circles during the 1990s (Buglione and Abran, 2000). Little attention has been paid to SPI as an extensive research area in academia (Card, 2004 as cited in Ahmad, 2007) and most of the research efforts have been made by the industry (Serrano, 2004).

Software process improvement has been defined as:

> The integrated procedures, tools, and training in order to increase product quality, increase development team productivity, reduce development time, and increase business competitiveness and profitability (Austin and Paulish, 1993, online).

> The continual and iterative improvement of both the software process and products through the use of project experiences (Bassman, McGarry and Pajerski, 1995, online).

> A deliberate, planned methodology following standardized documentation practices to capture on paper (and in practice) the activities, methods, practices, and transformations that people use to develop and maintain software and the associated products. As each activity, method, practice and

transformation is documented, each is analyzed against the standard of value added to the organisation (Szymanski and Neff, 1998, online).

The above definitions of SPI vary widely and demonstrate that there is neither a standard definition of software process improvement (SPI) nor can there be a standard set of SPI metrics to measure the costs and benefits of SPI for the various SPI strategies (Rico, 2000). The result is that currently many companies have either a formal or informal SPI programme based on one of the popular SPI models (Baddoo and Hall, 2001).

2.3.2 Background to SPI

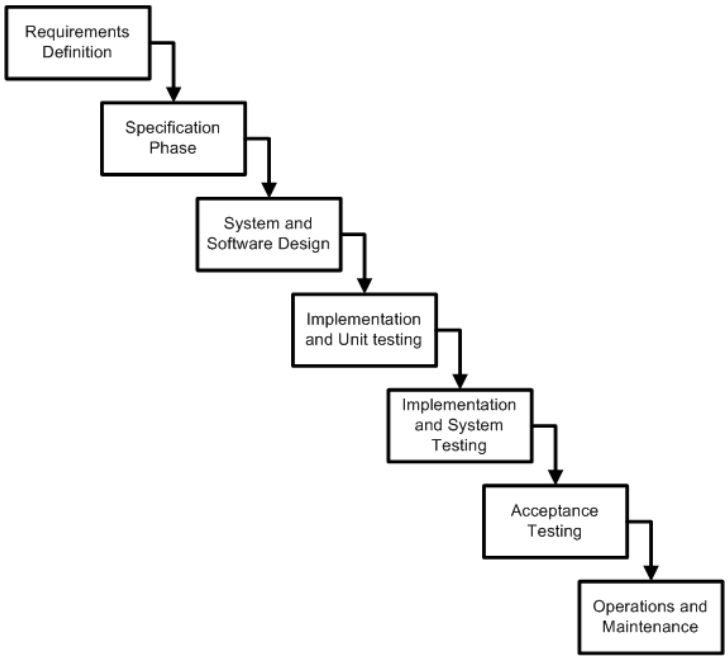
The development of software has a long evolving history and was conventionally divided into two steps, analysis and coding. The different phases of the software development life cycle (SDLC) methodology, initially presented by Royce (1970), are generally outlined as:

- requirements analysis and definition
- system and software design
- implementation
- integration and testing
- operation and maintenance.

See Figure 2:6 for an expanded view of the SDLC. This framework is called the waterfall model because each phase runs naturally into the next one like water over a series of falls.

Figure 2:6 The SDLC waterfall model

(Source: Royce, 1970)

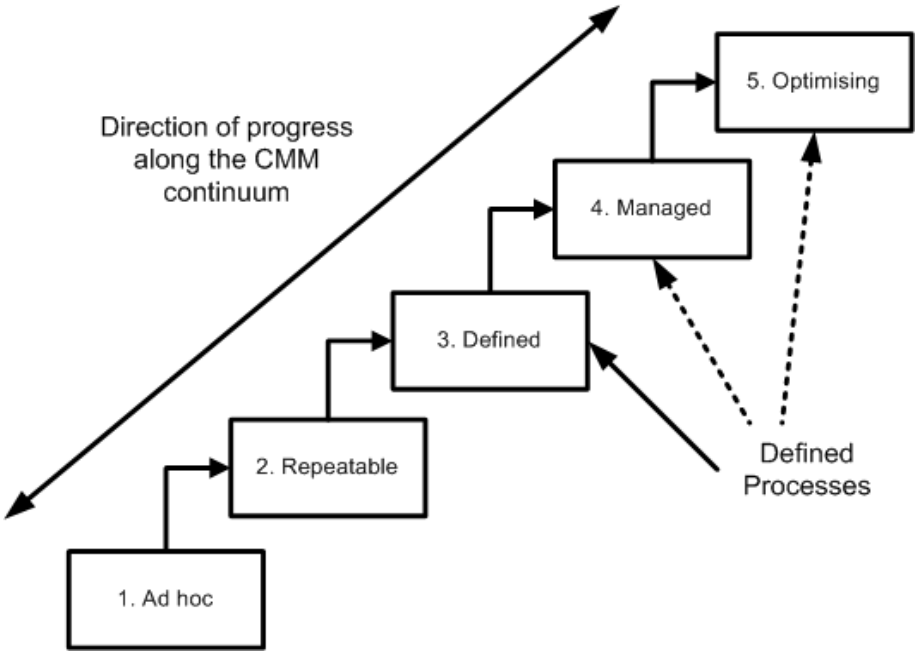


Although the SDLC model has since been followed by many software development models such as the spiral model, evolutionary models, rapid application development (RAD) and rational unified process (RUP), it is accredited with beginning the evolution of software development as a process (Fuggetta, 2000 as cited in Ahmad, 2007).

Humphrey (1989) created a five-stage SPI method known as the Software Engineering Institute's (SEI's) Capability Maturity Model for Software (CMM) beginning in 1987. The origin of the CMM can probably be traced to an early 1960s era IBM manufacturing process improvement concept and technical report entitled, "Process Qualification – Manufacturing's Insurance Policy", which discussed how to evaluate and control manufacturing processes according to Harrington (1991) and to Crosby's (1979) Maturity Grid, in which he built his five-step quality management model (Tobin, 2006). According to Rico (2000), the process maturity

frameworks then evolved into IBM's Process Grid, Humphrey's Process Maturity Grid and then ultimately into the Capability Maturity Model for Software (CMM) illustrated in Figure 2:7.

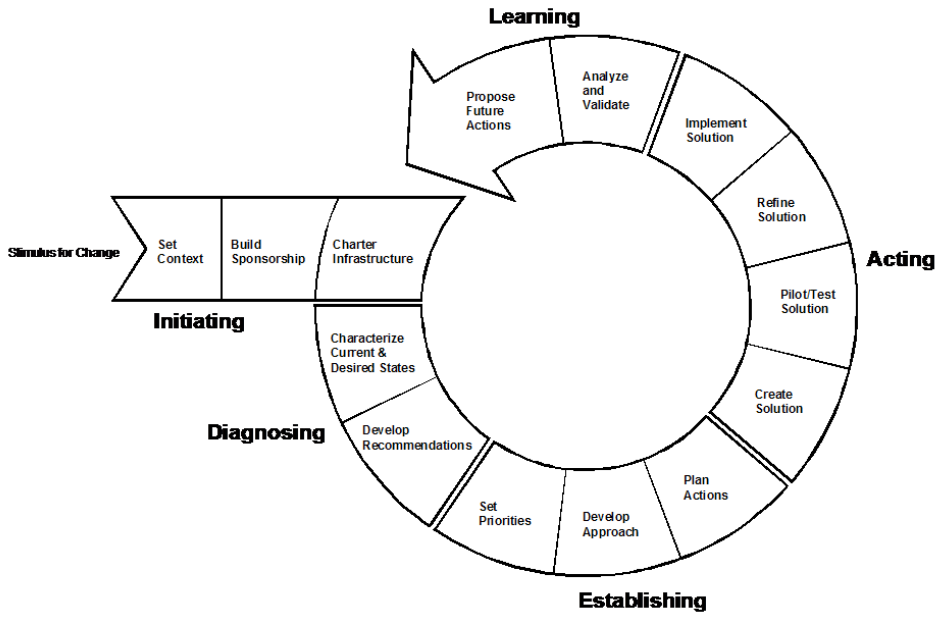
Figure 2:7 Diagram of the CMM
(Adapted from: Humphrey, 1989)



A lack of implementation guidance for these models and methodologies was later identified and the IDEAL model (McFeeley, 1996 as cited by Ahmad, 2007) was introduced by the Software Engineering Institute to provide guidance for the implementation of SPI. It provides a five-phase approach for SPI implementation and is named for the five phases it describes: initiating, diagnosing, establishing, acting and learning (The IDEAL Model, 2008). See Figure 2:8.

Figure 2:8 The IDEAL model

(Source: The IDEAL Model, 2008)



The last twenty years have seen a revolution in the form of methodologies and models in SPI, for example CMM, CMMI®, SPICE, TickIT, QIP, Agile methodologies and Six Sigma etc. (Serrano, 2004). The introduction of the ISO 9000 family of standards and later the Six Sigma methodologies was aimed at improving the capability and reducing the defects in any process.

In the 2000s CMMI® (CMMI Product Team, 2002) was released by SEI, which extended the CMM's practices. CMM mainly focused on software engineering whereas CMMI® integrates system engineering with software engineering. CMMI® remains the dominant standard for software process improvement and assessing software development competency (Hotle and Kopcho, 2008).

More recently, Agile methodologies have been introduced in software process improvement (Börjesson *et al.*, 2006 as cited in Ahmad, 2007), which promote a less structured approach using development iterations, open collaboration and process adaptability throughout the development life cycle.

2.3.3 Reasons for adopting SPI

SPI is regarded as a highly controversial field because the ability to manage the technology called software and its successfully delivery often results in exactly the opposite business, organisational and technical outcomes that are desired (Rico, 2000). These include:

- frequent software project failures
- high software development costs
- unpredictable and uncontrollable software management and development
- poor software quality
- lack of design innovation.

While the aim of SPI is initially to address what Kan (1995) identified as the five major metrics classes for software including software quality, reliability, quality management, structural design and customer satisfaction, more recent literature has set out to address the connection between SPI models or standards and the business goals of an organisation. The research of Liu, Sun, Kane, Kyoya and Noguchi (2006) highlights the three perspectives of business, management and quality requirements and why organisations would adopt SPI using CMM. See Table 2:2 and note that the reasons are listed in descending order of importance per perspective.

Table 2:2 Priorities for seeking SPI

(Adapted from: Liu *et al*., 2006)

Perspectives	Requirements
Business	Increase profit
	Lead in competition
	Reduce cost of development
	Reduce time to develop
	Reduce marketing time
	Improve quality
Management (organisational)	Within budget
	On schedule
	High customer satisfaction
	Increase productivity
	Manage project aggressively
	High conformance to software engineering standard
Quality (technical)	Low failure rate
	Low defect rate
	High reliability
	High requirement satisfaction
	High maintainability
	High usability

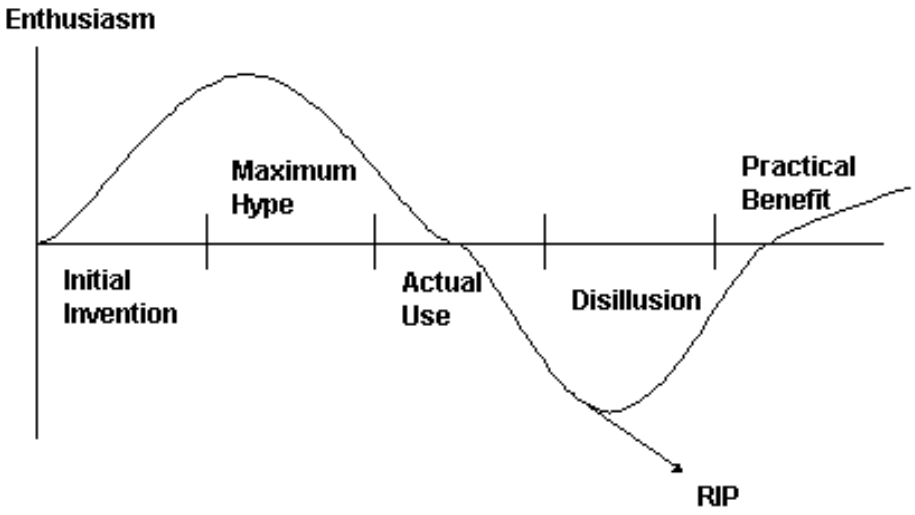
Research by Withers and Ebrahimpour (2000), which identifies reasons why organisations seek ISO 9000 certification, supports the view of Liu *et al.* (2006). They also identify additional factors such as improved employee relations, improved communications and satisfying customer requirements.

2.3.4 Challenges of adopting SPI

When organisations seek silver bullet solutions to solve their problems, unrealistic expectations are often the outcome. The adoption of SPI has been no different and, for many organisations, the adoption of these standards and models has resulted in limited success (Niazi, Wilson and Zowghi, 2004). This is the danger when trying to measure the success of a new technology, skill, initiative or change that an organisation is going through, as it often takes time to measure the real benefits successfully. See Figure 2:9.

Figure 2:9 The silver bullet life cycle

(Source: Mansson, 2002)



According to McConnell (2004), a special kind of silver bullet is created from attempts to implement organisational process improvement half-heartedly, with many of the practices becoming virtually worthless when just applied as buzzwords. With regards to SPI adoption, most of the problems relate to people, and team and community culture and behaviour rather than being of a technical nature (Dorenbos and Combelles, 2004). This supports the notion that the current problem with SPI is not a lack of a specific standard and/or model, but rather a lack of an effective strategy to implement these standards or models: "Too much attention has been paid to "what activities to implement" instead of "how to implement" the activities" (Niazi *et al.*, 2003, p. 1).

Part of the hard work in getting SPI working in practice is never to underestimate the impact of organisational change and to place greater emphasis on how the SPI model is implemented according to Umarji and Seaman (2005). Two areas affecting the adoption of SPI include implementation and motivation factors. These are outlined below.

2.3.4.1 Implementation factors of SPI

There is a significant amount of research in the literature that highlights a number of factors that positively or negatively affect the impact of SPI. Awareness of these factors becomes essential for the successful implementation of SPI programmes (Dorenbos and Combelles, 2004). Many of the factors have been assigned to various categories. Some of the key factors identified in the literature (Guerrero and Eterovic, 2004; Niazi *et al*., 2004; Umarji and Seaman, 2005) are provided in Table 2.3.

Table 2:3 Implementation factors of SPI

Research	Category	Factors
Guerrero and Eterovic (2004)	Environmental dependent	• Process-related training • Developer's involvement • Maintaining momentum • Group focus of SPI • Champions • Frequency of process assessment • Visibility into the SPI process
	Environmental independent	• Management commitment • Cultural awareness • Separation of process and product concerns
Niazi *et al*. (2004)	Awareness	• Senior management commitment • Training and mentoring • Staff involvement • Awareness of SPI
	Organisational	• Creating process action teams • Experienced staff • Staff time and resources • Formal methodology
	Support	• Reviews
Umarji and Seaman (2005)	Organisational	• Visibility • Transparency of process • Reward structures / incentives • Fear of adverse consequences
	Personal	• Communication • Self-efficacy • Degree of control
	SPI specific	• Amount of learning required • Compatibility of work practices • Champions / advocates

Research	Category	Factors
	Social psychology	• Perceived usefulness • Attitude • Perceived behavioural control • Subjective norm • Ease of use

2.3.4.2 Motivational factors of SPI

The research by Baddoo and Hall (2001) states that SPI has a greater chance of success in companies where practitioners experience high motivation for it. A second factor worth noting is that the motivation for the adoption of SPI initiatives varies across practitioner groups and this variation dilutes the effectiveness of the SPI implementation. Baddoo and Hall (2001) further suggest that the identification of both similarities and differences across the hierarchical levels can assist in the implementation of SPI. Other common motivators from the literature (Baddoo and Hall, 2001; Hardgrave, Davis and Riemenschneider, 2003; Dorenbos and Combelles, 2004) are shown in Table 2.4.

Table 2:4 Motivational factors of SPI

Research	Factors
Baddoo and Hall (2001)	• Process ownership whereby practitioners want responsibility for the processes that they work with • Evidence of visible success • Resources to motivate and support the SPI
Hardgrave *et al*., (2003)	• Perceived usefulness • Perceived social pressure • Perceived compatibility • Perceived organisational mandate
Dorenbos and Combelles (2004)	• Company leadership must have a vision of the benefit • Development teams must see the value • Process engineers must recognise that the change will be both interactive and iterative

2.3.5 Conclusion to SPI

While the aim of software process improvement (SPI) is to improve the success rates in terms of quality, productivity and scheduling commitments, no one-size-fits-all approach has yet been defined. This is possibly due to the fact that the SPI outlines the "what" in terms of standards but remains elusive in terms of the "how"

to achieve or implement it. Various standards and models have been developed since the 1960s, starting with IBM's process improvement concept and Crosby's (1979) Maturity Grid which evolved into the Capacity Maturity Models from the SEI that we see today.

To achieve the best possible results, the SPI framework needs to be interpreted and tailored to the individual needs of organisations. Although the less tangible implementation and motivational factors play a part, it is only if the business goals are tied together with quality, process and maturity improvement goals that the adoption of SPI improvement activities will ultimately succeed.

2.4 Quality management

This section provides more specific details on quality management and its relationship with SPI.

2.4.1 Introduction to quality management

According to Withers and Ebrahimpour (2000), perceptions of quality and its role in firms' competitiveness have changed dramatically over the past 30 years. Factors such as consumerism and the global marketplace have played a significant role in these shifts. Consumers and businesses are now demanding even higher quality products. Firms are therefore forced to compete on a basis of quality to gain a strategic competitive advantage (Garvin, 1987 as cited in Withers and Ebrahimpour, 2000).

The effect of quality management on business performance is a relevant topic in both academia and in practice. The early development of quality management systems ultimately led to what is referred to as total quality management (TQM) as a broadly used term (Cameron, 2005). The emergence of TQM was influenced by a

few American and Japanese quality experts, the so-called quality "gurus" including Shewhart, Deming, Juran, Feigenbaum and Crosby (Krüger, 2001).

2.4.2 Background to quality management

In 1930s, Shewhart introduced the control chart and principles of statistical quality control. The control chart provided a means to control the quality of a manufacturing process. Shewhart (1931) also proposed a cycle of quality improvement called PDS (Plan, Do, See), which is considered the basis for all existing principles of quality control.

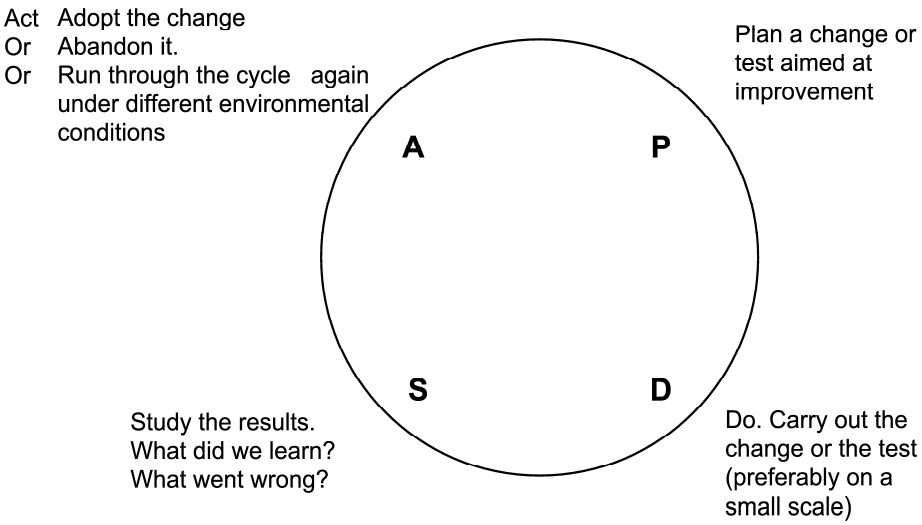
In the late 1940s and 1950s, Deming and Juran began to address issues relating to quality control in more depth and further developed the ideas of Shewhart, in particular extending what Deming referred to as the Shewhart cycle (Deming, 1993) into the plan-do-check-act (PDCA) cycle for purposes of improvement. Later in Deming's career, he modified the PDCA to "Plan, Do, Study, Act" (PDSA) so as to better describe his recommendations of "Study" to better imply an understanding the sources of variation in the process. Deming proposed that business processes should be analysed and measured to identify sources of variations that cause products to deviate from customer requirements. Deming recommended that business processes be placed in a continuous feedback loop so that managers can identify and change the parts of the process that need improvement. The steps in the PDSA can be described as follows and are illustrated in Figure 2:10:

- *Plan*: Using the results of past experimental experience, plan a study that may be expected to lead to process improvement.
- *Do*: Perform the experiment or study designed in the Plan phase.
- *Study*: Evaluate carefully the result obtained.
- *Act*: If positive results are obtained, implement and use as the basis for continuing study and development using the PDSA cycle. If negative results

are obtained, re-enter the planning phase of the cycle and develop a new approach to the problem identified.

Figure 2:10 Deming's PDSA cycle

(Source: Deming, 1988)



Deming's (1982) contribution to quality management is summarised in his 14-point programme that highlights that by improving quality it is possible to increase productivity and therefore the competitiveness of a business enterprise (Krüger, 2001). These ideas affected the Japanese manufacturing and business industry enormously and were the start of a golden period of total quality management (Powell, 1995).

Juran broadened the common understanding of quality control, emphasising the importance of the managerial aspect. He highlighted the responsibility of management to develop measures such as a quality council, a quality policy and quality goals, and for assigning resources such as training to achieve the quality goals (Krüger, 2001). According to Petersen (1999), Juran's notable contributions to the quality management field include the Juran trilogy, the triprol concept and company-wide quality management.

The Juran trilogy is used to explain the interrelationship of three processes used to manage quality:

- Quality planning
- Quality control
- Quality improvement.

While the first two processes are important, the third process is most significant because improvements in the system substantially reduce chronic waste.

Feigenbaum is designated as the originator of the concept of total quality control (Krüger, 2001). He contributed two new aspects to the discussion about quality – firstly, that quality is the responsibility of everybody in the company ranging from top management to the unskilled worker and secondly, that costs of non-quality have to be categorised in order to be managed.

In the 1970s, Crosby proposed a maturity grid (Crosby, 1979). This was actually an early version of an organisational maturity matrix. The maturity grid consisted of five stages: uncertainty, awakening, enlightenment, wisdom and certainty. It provides a tool to help organisations understand their strengths and weaknesses and where attention should be given in an effort to enhance organisational performance (Tobin, 2006). Crosby's new perspective of quality suggested that quality is conformance to requirements and that the intent of quality should be prevention, as per his statement that:

> Quality is free. It's not a gift, but it is free (Crosby, 1979, p. 1).

Since the 1990s, firms have implemented quality improvement through standards such as ISO 9000 and Six Sigma.

2.4.2.1 ISO 9000

ISO 9000 is a family of standards concerned primarily with quality management. It provides the basis for an organisation to fulfil:

- the customer's quality requirements
- applicable regulatory requirements
- enhancement of customer satisfaction
- continual improvement of its performance in pursuit of these objectives (Cameron, 2005).

2.4.2.2 Six Sigma

Six Sigma is a disciplined, data-driven approach and methodology for eliminating defects (driving toward six standard deviations between the mean and the nearest specification limit) in any process and is broadly applied from manufacturing to transactional processes in product to service sectors (Cameron, 2005). Companies such as Motorola and General Electric have used this methodology to ensure a disciplined approach in delivering significant processes results.

2.4.3 Software quality

The increasing demand for quality also forced the software industry worldwide to find solutions for software quality problems (Huang *et al.*, 2006). Based on IBM research, projects that focused on attaining the shortest schedules had high frequencies of cost and schedule overruns, whereas projects that focused on achieving a low defects count had the best schedules and highest productivities (McConnell, 2004).

With regards to the characteristics of quality and software process there is no definitive approach, although one area worth noting is a *Handbook of Software Quality Assurance* (SQA) which identifies 14 quality factors in three stages of the development life cycle according to Ashrafi (2002). See Table 2.5.

Table 2:5 Software quality factors (SQA)

(Source: Ashrafi, 2002)

Factor	Description
Quality of design	
Correctness	Extent to which the software conforms to its specifications and conforms to its declared objectives
Maintainability	Ease of effort for locating and fixing a software failure within a specified time period
Verifiability	Ease of effort to verify software features and performances based on its stated objective
Quality of performance	
Efficiency	Extent to which the software can do more with less system resources (hardware, operating system, communications, etc.)
Integrity	Extent to which the software can withstand intrusion by unauthorised users or software within a specified time period
Reliability	Extent to which the software will perform (according to its stated objectives) within a specified time period
Usability	Relative ease of learning and the operation of the software
Testability	Ease of testing the program to verify that it performs a specified function
Quality of adaptation	
Expandability	Relative effort required to expand software capabilities and/or performance by enhancing current functions or by adding new functionality
Flexibility	Ease of effort for changing the software's mission, functions or data to meet changing needs and requirements
Portability	Ease of effort to transport software to another environment and/or platform
Reusability	Ease of effort to use the software (or its components) in another software system and applications
Operability	Interrelative effort needed to couple the software on one platform to another software and/or another platform
Intra-operability	Effort required for communications between components in the same software system

2.4.4 Quality management and software process improvement

With the generic push towards quality management, Crosby's cost of quality (CoQ) model can be effectively applied to software development. In Crosby's model (Crosby, 1979), CoQ is expressed as the sum of the cost of conformance, the prevention and appraisal costs and the cost of non-conformance or the failure costs. The CoQ is thus the sum of the costs of presenting poor quality, the costs incurred to ensure quality requirements are being met and any other costs incurred due to poor quality being produced. Poor quality is defined as non-value added activities, waste or failure to meet customer needs (Beecroft, 2001).

Adapting the work of Garrison and Noreen (1997), Crosby's CoQ model can be effectively used to explore quality management and software development. To understand fully the nature of the improvement that is possible, organisations must gather data (metrics) about the cost (effort) for each of the model's four categories of cost (Borland, 2006). See Table 2:6.

Table 2:6 Costs for measuring quality of conformance
(Adapted from: Garrison and Noreen, 1997; Crosby, 1979)

Cost/Class	Description	Metrics
Cost of performance	The time required to perform a specific task	Costs to develop and deploy a product or service Resources required to plan and perform a project or ongoing work
Cost of prevention	Costs to establish and maintain processes for enabling a project or ongoing work to be done, e.g. training for those who perform the work	Quality training Quality circles Statistical process control activities Supervision of prevention activities Quality data gathering, analysis and reporting Quality improvement projects Technical support provided to suppliers Audits of the effectiveness of the quality system

Cost/Class	Description	Metrics
Cost of appraisal (cost of review)	Costs to review processes, products and services that are under development or being changed	Final product testing and inspection Supplies used in testing and inspection Supervision of testing and inspection activities Compliance with requirements and organisation processes
Cost of non-conformance (or cost of rework)	Costs incurred to address defects in a product or service, including the number of defects, the type of defects and the time to eliminate defects.	**Internal failure costs** Retesting of reworked products Disposal of defective products Analysis of the cause of defects in production Re-entering data because of keying errors Debugging of software errors **External failure costs** Product recalls Liability arising from defective products Lost sales arising from a reputation for poor quality

2.4.5 Conclusion to quality management

The early development of quality management systems by individuals such as Crosby led to what is referred to today as total quality management (TQM). Quality improvement projects need to be selected on the basis that they link to the strategic objectives of the business. In a case where the strategy is to increase profits, the quality projects should focus on reducing quality costs by reducing errors and removing non-value adding activities and waste. Another dimension of quality is that of ensuring that the product meets customer requirements by being error free and at the lowest possible cost. A by-product of quality improvement is the improvement in productivity.

Due to the intangible nature of software development, there is no reduction in asset investment, but rather an opportunity to increase sales through higher conformance to quality, fewer defects and better on-time delivery. Implementing

quality improvement projects such as CMMI® involves both tangible and intangible costs, or what Crosby (1979) refers to as the cost of quality.

Investing in quality management cannot occur without a process. Concepts such as total quality management also feature process improvements (Davenport, 1996). The relationship between quality and process is highlighted by the process management principle, which states:

> The quality of a product is largely governed by the quality of the process used to build it. The quality of a software product is largely governed by the quality of the software process used to develop and maintain it (Paulk, 1997).

2.5 Process management

This section provides more specific details on process management and its relationship to SPI.

2.5.1 Introduction to process management

What value do processes play in an organisation?

> Processes help to create and deliver the value proposition for customers through the use of employees and other strategies. Therefore, it becomes mandatory to think of an organisation as an interrelated set of processes (Sureshchandar and Leisten, 2005, p. 18).

According to Davenport (2005), a business process describes how a business does its work through the set of activities it pursues to fulfil a particular objective for a particular customer, either internal or external.

Process methodologies have gained acceptance in many areas of business as firms aim to define, measure and improve the flow of business activities to create consistent, reproducible and auditable activities and make possible comparative measures of performance and to provide the ability to benchmark performance.

Harrington (1991) defines process improvement as a systematic methodology that significantly helps businesses simplify and streamline operational processes. The objective of process improvement is to ensure that business processes eliminate errors, minimise delays, promote understanding, are easy to use, are customer friendly, are adaptable, enhance competitiveness and reduce excess capacity.

2.5.2 Background to process management

The development of process standards, as stated by Davenport (2005), began in the 1970s and 1980s when companies improved their processes with total quality management (TQM). In the 1990s they attempted to advance their processes radically through both process improvement and business process re-engineering (BPR) (Davenport and Short, 1990). BPR involves a revolutionary change to an organisation and results in the adoption of radically improved business processes aimed at better satisfying customer requirements. BPR is intended to achieve drastic improvements to the operational results of a company.

Despite the significant growth of the BPR concept, not all organisations that embarked on BPR projects achieved their intended result. Davenport (1996) highlights people's resistance as a major obstacle to BPR's successful implementation. A further area of debate was whether the performance of business processes should be increased by a fundamentally different business process re-engineering (BPR) approach or a more incremental continuous improvement (CI) approach (Sureshchandar and Leisten, 2005). Davenport (1996) proposed that BPR

should better integrate with the other non-revolutionary (incremental) process approaches such as total quality management. Today, it is recognised that both BPR and CI have their own benefits and some companies do integrate these two approaches to a successful degree (Kueng, 2000 as cited in Sureshchandar and Leisten, 2005).

Using either approach, standardising processes internally facilitates business operations, enables smoother handoffs between process boundaries and allows for comparative measures of performance. Standardising processes externally, across companies, makes transactional commerce easier, ensures better communications and more efficient handoffs, and provides an ability to benchmark performance (Davenport, 2005). Davenport (2005) identifies three types of process standards as illustrated in Table 2:7.

Table 2:7 Types of process standards

(Adapted from: Davenport, 2005)

Process Type	Description
Process activity and flow standards	These define a set of process activities and flow standards that represent consensus for specific processes in a particular industry
Process performance standards	With a defined set of activities and process flows in place, companies can begin to measure their own processes and compare their results with those of external providers. This performance benchmarking can be used to help organisations worldwide assess and improve their performance
Process management standards	These indicate how well processes are managed and measured and whether they are on course for continuous improvement. Process management standards are based on the assumption that good process management will eventually result in good process flows and performance. Examples of process management standards include Six Sigma and CMMI®

2.5.3 Software process

Software process is regarded as fundamentally different from other businesses processes, particularly manufacturing (Gillies, 1997 as cited in Antony and Fergusson, 2004). The differences between software processes and other business processes stem from the following:

- Software has no physical existence.
- There is a lack of knowledge about clients' needs at the beginning.
- Clients' needs change over time.
- There is a growth in the expectations of customers, particularly with respect to adaptability.
- The software process uses fault tolerance as opposed to design tolerance used in manufacturing.

While the Institute of Electrical and Electronics Engineers (IEEE) has defined a generic process as a course of action to be taken to perform a given task, (IEEE, 1990), the SEI has expanded on this definition of process to define software process as:

> a set of activities, methods, practices, and transformations that people use to develop and maintain software and the associated products, e.g., project plans, design documents, code, test cases, and user manuals (Paulk, Curtis, Chrissis and Weber, 1993, p. 3).

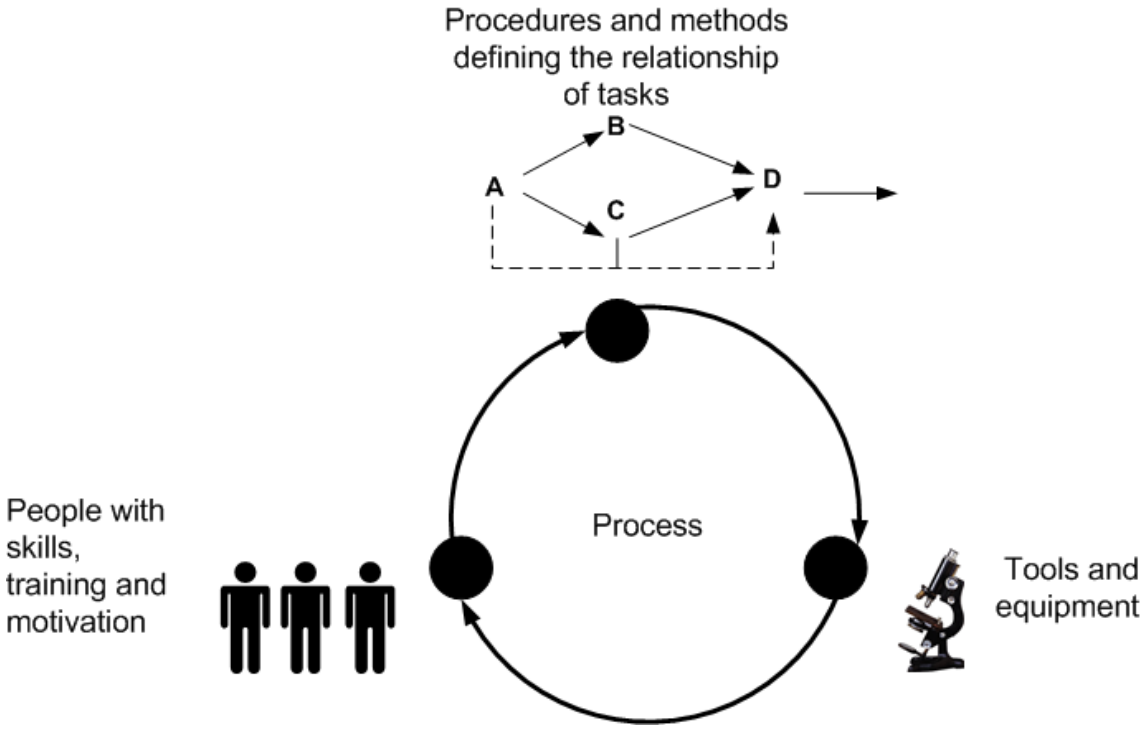
The work of the SEI illustrates the three critical dimensions that organisations typically focus on: people, procedures and methods, and tools and equipment. But, most importantly, it is the processes that hold these three together in an organisation. See Figure 2.11.

According to Chrissis *et al.* (2003), processes allow organisations to:

- align the way the organisation does business
- address scalability
- provide a way to incorporate knowledge of how to do things better
- leverage the resources
- examine business trends.

Figure 2:11 The three critical dimensions

(Source: Chrissis, Konrad and Shrum, 2003)



2.5.4 Process management and SPI

According to Coulson-Thomas (1995), process management can be assessed in two ways depending on the degree of change required:

- *Process simplification*: Simplification usually results in an incremental rather than a major step change. Simplification exercises tend to take for granted an existing framework, the limits of installed information technology, as well as current attitudes and behaviours.

- *Process re-engineering*: Business re-engineering aims at fundamental or frame-breaking change. A re-engineering exercise challenges the existing framework, questions attitudes and behaviours, and may suggest the introduction of new information technology.

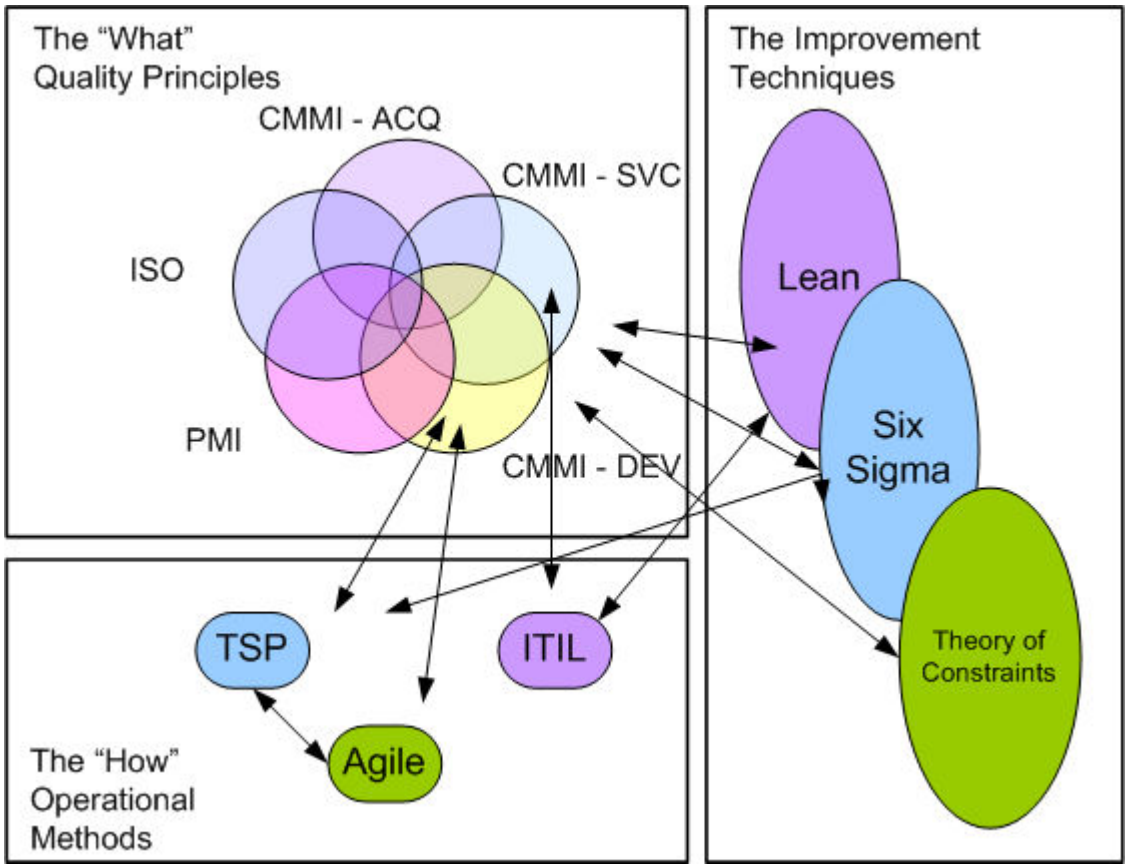
While Davidson (1993) defines re-engineering as a method for identifying and achieving radical business performance improvements in productivity, velocity, quality, business precision and customer service and as being comparable with SPI, in practice Coulson-Thomas (1995) suggests that simplification and re-engineering can overlap and together form the process orientation of an organisation.

Whether through simplification or re-engineering, software organisations need to apply efficient methods and techniques to their development processes to remain competitive. Faced with the constant demand of advancing technology, ensuring the consistency of results in the software development process can only be achieved through standardised and structured processes, right from the requirements gathering phase to the final testing phase (Sureshchandar and Leisten, 2005).

Based on research by Forrester (Cameron, 2005), CIOs traditionally used to deploy mostly home-grown process methodologies to help them run IT. There is now a growing demand to stabilise IT operations that will drive the disciplined adoption of industry-wide standard methodologies. According to Phillips (2008), there is a wide range of improvement approaches that offer a solution to problems confronting organisations that recognise a need to improve. For years, various standards and models captured principles for process improvement, often called best practices, such as ISO, CMM and CMMI® models, collections of other models such as the Project Management Institute's Organisational Project Management Maturity Model

(OPM3) and Control Objectives for Information and related Technology (CoBIT). Examples of current software development methods include Agile methods, Scrum and the SEI's Team Software Process (TSP) methodology. Methods for service related activities include the Information Technology Infrastructure Library (ITIL). There are also improvement techniques that apply in various domains and disciplines. Three current representative techniques are Lean, Six Sigma and the Theory of Constraints. See Figure 2:12. for an overview of how they relate to each other.

Figure 2:12 Drivers for the adoption of standard methodologies
(Source: Phillips, 2008)



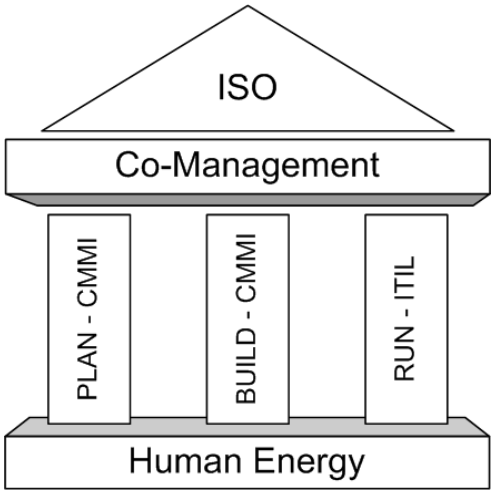
When organisations are faced with a challenge to deliver repeatable, globally competitive products and services, this highlights firstly, that quality cannot be

isolated in one area or function of the organisation and secondly, that each of the above standard methodologies needs to be implemented in a complementary fashion to respond effectively to the organisational challenge. One approach, reflecting in practice the adoption of standard methodologies, is highlighted in Figure 2:13, where the standards according to Banerjee (2008) can defined as follows:

- ISO is used to provide the basic foundations of documented systems.
- Co-Management/COBIT focuses on governance and process structure to ensure all sources of supply operate in similar ways in a multi-sourcing or a multi-supplier environment.
- CMMI® focuses on software engineering practices, particularly the development, integration, deployment and maintenance phases. It is geared specifically for software development organisations and focuses on continuous improvement.
- ITIL focuses specifically on service management, i.e. the operations and infrastructure side of IT. It addresses IT operations issues such as security, change and configuration management and service desk functions.
- Human energy specifically focuses on people and individual capabilities.

Figure 2:13 Use of standard methodologies

(Adopted from: Bogoshi, 2008)



2.5.5 Conclusion to process management

Process improvement is the act of eliminating defects, speeding productivity and delivery, enhancing product desirability, satisfying customers and minimising the use of organisational resources. Internal process improvements therefore become a leading indicator of subsequent improvements in customer and financial outcomes, and tie in closely with the balanced scorecard (Kaplan and Norton, 1996). If business processes are a mechanism through which the above performance expectations are achieved, then software process is the mechanism through which software quality expectations are achieved. With the evolution of mature software process, the probability of the development of good quality software can be further increased.

2.6 Maturity models

This section provides more specific details on maturity models and their relationship to SPI.

2.6.1 Introduction to maturity models

The maturity level of an organisation provides a way to predict its future performance within a given discipline or set of disciplines. A maturity level is a defined evolutionary plateau of process improvement. Each maturity level stabilises an important part of the organisation's processes (IT Governance Network, 2004).

The SEI's Capability Maturity Model consists of five groups or levels of purportedly important software management processes called key process areas (KPAs). The five CMM levels are initial, repeatable, defined, managed and optimising (Humphrey, 1989). As further defined by the SEI:

> Capability [Maturity] Models describe both unique product development practices and the common management practices that any organisation must perform. These practices are organised into five levels, each level describing increasing control and management of the production environment, starting with ad-hoc performance and culminating in controlled, structured, continuous improvement (SECAT, 1998 as cited in Tobin, 2006).

Essentially, the use of maturity models enables an organisation to focus on improving processes. Each level contains the essential elements of effective processes for one or more disciplines and describes an evolutionary improvement path from lower, ad hoc, immature process levels to higher maturity levels with disciplined, mature processes with improved quality and effectiveness. As stated in *Software Process Improvement SPI* (2008), there are four basic pillars of maturity:

1. Evolution is possible, and requires time and resources.
2. Greater process maturity reduces risks and increases performance.

3. Evolution implies there is a pre-established sequence in order to take control of a process with reference to external factors.
4. Maturity will decrease if not constantly maintained.

2.6.2 Background to maturity models

The origins of the CMM can be traced to the approach taken by a number of the so-called quality gurus such as Shewhart, Deming and, in particular, Crosby's (1979) five-step quality management model as described in Section 2.4.2. However, the concept for a process maturity framework, which eventually evolved into the CMM as it is now known, was developed at International Business Machines (IBM) in the early 1980s (Software Engineering Institute, 2008). Later, Humphrey's book *Managing the software process* (Humphrey, 1989) provided a description of the basic principles and concepts on which many of the capability maturity models are based.

The motivation which really drove the uptake of capability maturity models was the aim of improving development project success in the USA Department of Defence (Software Engineering Institute, 2008). To support, manage and drive the process, the Software Engineering Institute (SEI) at Carnegie Mellon University in the USA was established. The Software Capability Maturity Model (SW-CMM) was first released in August 1991 and soon became the de facto framework for evaluating the state of application development (AD) organisations (Hotle and Kopcho, 2008), particularly for Department of Defence projects. The SW-CMM was a five-stage process of defining software project management processes, defining organisational wide software management processes, defining organisational wide measurement and statistical analysis processes and then defining organisational wide software process improvement processes.

CMMI® is the successor to CMM with a model architecture consisting of three areas of interest: development, acquisition and services. It is regarded as consistent with the international standard ISO/IEC 15504 according to Staples, Niazi, Jeffery, Abrahams, Byatt and Murphy (2006). During the past five years in particular, an increasing number of organisations have been using the SW-CMM and the CMMI® to assess their current status and improve it, or to demonstrate their capability for software development externally (Hotle and Iyengar, 2006). According to the SEI's data, between 2002 and 2008 more than 3 000 formal assessments were conducted using CMMI® (Hotle and Kopcho, 2008). Research by the SEI has demonstrated improved performance results, categorised by cost, schedule, productivity, quality, customer satisfaction and return on investment (ROI) (Gibson *et al.*, 2006) from the adoption of CMMI®.

Since the release of SPI there has been a proliferation of maturity models with the current list standing at 34 such models (Software Process Improvement SPI, 2008). Other examples of maturity-based measures according to Saleh and Alshawi (2005) include the following:

- *People CMM*: developing and managing the knowledge, experience and motivation of employees
- *Personal Software Process (PSP)*: supporting individual developers to become more productive and disciplined using a process framework and set of software development methods (Green, Hevner and Collins, 2004)
- *Bootstrap*: assessing and examining process implementation
- *Trillium model*: assessing an organisation’s processes capability by comparison with best practice.

2.6.3 Overview of CMMI® for software development

CMMI® is a framework that describes what a software development organisation should do. It is descriptive, not prescriptive, and therefore does not tell an organisation how to do what it should do. This process improvement framework can be approached through a staged or continuous representation. The essential difference between the two representations is the following (Software Engineering Institute, 2008; Tobin, 2006):

- The staged representation prescribes the order of implementation for each process area according to maturity levels.
- The continuous representation offers a more flexible approach. A particular process area or set of process areas can be implemented in any sequence, with capability levels being defined by each process area or set of process areas.

2.6.3.1 Staged representation

The staged representation is shaped in the classic five-level staircase of maturity levels (Hotle and Kopcho, 2008). As outlined in Figure 2.14, the most well-known representation of CMMI® is the staged representation, which classifies the software capability of organisations into five levels, with level 1 being the lowest (software processes are ad hoc and chaotic) and level 5 the highest (software processes are capable of self-improvement and incorporate the highest levels of quality).

Figure 2:14 Staged representation

(Source: Hotle and Kopcho, 2008)

Level	Focus	Process Areas
5. Optimizing	*Continuous Process Improvement*	Organizational Innovation and Deployment Causal Analysis and Resolution
4. Quantitatively Managed	*Quantitative Management*	Organizational Process Performance Quantitative Project Management
3. Defined	*Process Standardization*	Requirements Development Technical Solution Product Integration Verification Validation Organizational Process Focus Organizational Process Definition +IPPD Organizational Training Integrated Project Management +IPPD Risk Management Decision Analysis and Resolution
2. Managed	*Basic Project Management*	Requirements Management Project Planning Project Monitoring and Control Supplier Agreement Management Measurement and Analysis Process and Product Quality Assurance Configuration Management
1. Initial		

IPPD = integrated product and process development

2.6.3.2 Continuous representation

Continuous representation enables more flexibility when determining what areas to focus on when improving processes. Organisations may choose to focus on improving the capability of one or several process areas that align and support the goals and objectives of the business. The process areas are grouped into categories to support process improvement efforts (Hotle and Kopcho, 2008). See Figure 2:15.

Figure 2:15 Continuous representation

(Source: Hotle and Kopcho, 2008)

Category	Process Areas
Process Management	Organizational Process Focus Organizational Process Definition +IPPD Organizational Training Organizational Process Performance Organizational Innovation and Deployment
Project Management	Project Planning Project Monitoring and Control Supplier Agreement Management Integrated Project Management +IPPD Risk Management Quantitative Project Management
Engineering	Requirements Management Requirements Development Technical Solution Product Integration Verification Validation
Support	Configuration Management Process and Product Quality Assurance Measurement and Analysis Causal Analysis and Resolution Decision Analysis and Resolution

Process areas selected in these categories are measured by the capability levels shown in Table 2:8.

Table 2:8 Capability levels

(Source: Hotle and Kopcho, 2008)

Level	Description
0	Incomplete
1	Performed
2	Managed
3	Defined
4	Quantitatively managed
5	Optimising

Organisations can assess their capability of operating at a specific CMMI® process maturity level by undergoing an appraisal. There are three classes of CMMI® appraisal (CMMI, 2001 as cited by Staples *et al.*, 2006):

- Class A appraisals are costly, time-consuming and resource-intensive, but provide the highest levels of assurance about their findings.
- Class B appraisals are less costly, time-consuming and resource-intensive as they use fewer appraisers, appraise fewer projects and rely on fewer forms of evidence.
- Class C appraisals are the cheapest and easiest to perform, and can approach the simplicity of a structured questionnaire.

All appraisals result in a report of findings about an organisation's capability, but only Class A appraisals can result in a publicly-reportable rating of the organisation's CMMI® level.

2.6.4 Worldwide adoption of CMMI®

Since the release of the CMMI® Product Suite in January 2002, organisations in the systems and software communities have continued to demand credible evidence about the adoption, impact and benefits of CMMI®-based process improvement. In response, the SEI have published a CMMI® Maturity Profile annually, which shows the latest CMMI® adoption trends, as well as various special reports describing how a variety of organisations from different industries and environments are using the CMMI® models. The results show that organisations around the world are enjoying high levels of process maturity through use of the CMMI® models and that several organisations are implementing CMMI® models with significant positive results (Heinz, 2003).

According to the SEI, organisations are beginning to see the benefits of adopting various aspects of the CMMI® Product Suite. CMMI® is being adopted worldwide, including North America, Europe, Asia, Australia, South America and Africa (What is CMMI, 2008). To give an indication of the uptake of CMMI®, the number of SCAMPI

v1.1/v1.2 Class A appraisals conducted from the SCAMPI V1.1 April 2002 release through to June 2007 and reported to the SEI by July 2008, highlights the following (Carnegie Mellon: Software Engineering Institute, 2008):

- 3 553 appraisals
- 3 009 organisations
- 2 168 participating companies
- 451 reappraised organisations
- 17 398 projects
- 69,9% non-USA organisations.

A review of the adoption as highlighted in Figures 2:16 to 2:19 can be further broken down into:

- organisational type
- organisational size
- USA or non-USA based
- geographic distribution
- growth in number of SCAMPI A assessments.

Figure 2:16 Reporting USA and non-USA organisation categories

(Source: Carnegie Mellon: Software Engineering Institute, 2008)

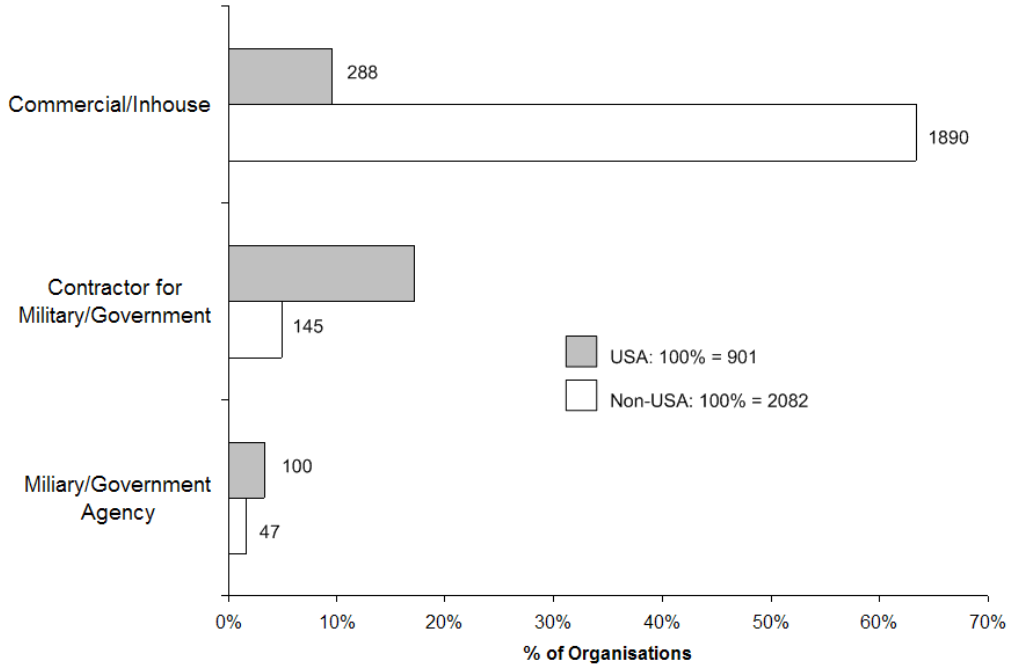


Figure 2:17 Organisation size

(Source: Carnegie Mellon: Software Engineering Institute, 2008)

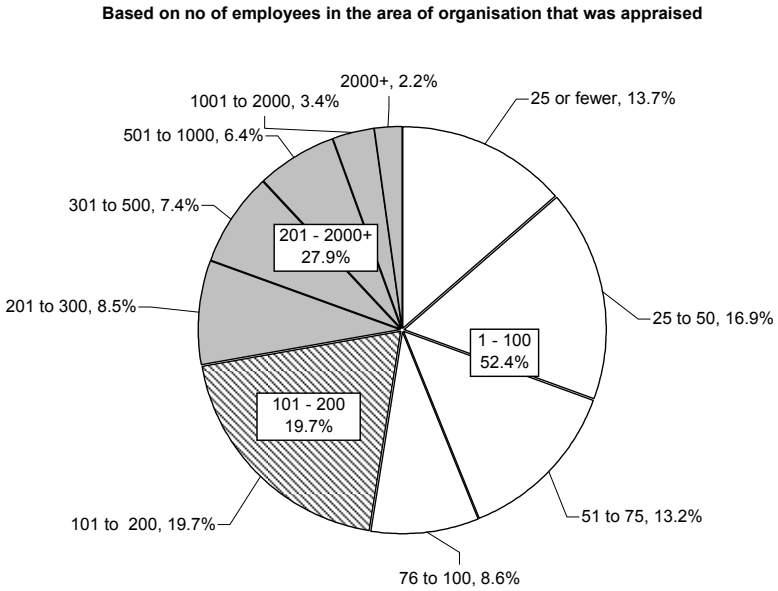
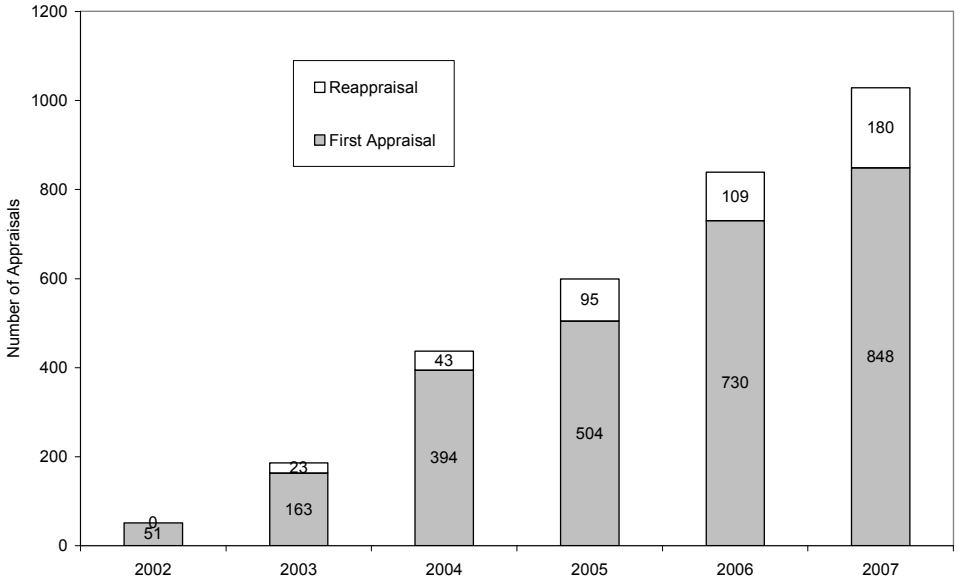


Figure 2:18 Countries where appraisals have been performed

(Source: Carnegie Mellon: Software Engineering Institute, 2008)

Figure 2:19 Number of SCAMPI A appraisals reported to the SEI by year

(Source: Carnegie Mellon: Software Engineering Institute, 2008)



These figures show that:

- although the majority of organisations adopting CMMI® are commercial or in-house, a significant portion are directly related to military and/or government
- the highest percentage of commercial or in-house reporting appraisals is from outside the USA
- the highest percentage of military or government agency reporting appraisals is from the USA
- outside the USA, China, India, Spain, Argentina, Brazil and Malaysia reported appraisals are increasing at a rapid rate
- organisations with 1 to 100 employees make up more than 50% of those adopting CMMI®
- CMMI® has spread globally
- there is both an increasing trend in SCAMPI A first and reappraisals.

The SEI research (Carnegie Mellon: Software Engineering Institute, 2008) also highlights that for organisations that began their CMMI®-based SCAMPI effort in 2002 or later, the median time to move from:

- maturity level 1 to 2 is 4 months
- maturity level 2 to 3 is 17 months
- maturity level 3 to 4 is 15.5 months
- maturity level 4 to 5 is 12.5 months.

2.6.5 Performance measures of CMMI®

Based on previous literature, Huang *et al*. (2006) identify that the performance categories of a CMMI® adoption should include not only customer, finance, process and quality but also organisational and employee. Hyde and Wilson (2004) further suggest that CMM-based SPI initiatives may deliver both tangible and intangible benefits to organisations. The tangible benefits would include increased productivity

and quality and can be easily quantified by software metrics. The intangible benefits would include better quality of work life, better organisational learning and communications. These are difficult to quantify and are thus often expressed in a qualitative manner.

2.6.5.1 Benefits case studies

To demonstrate the impact and benefits of CMMI®, the SEI published a report describing the experiences of organisations that had decided to implement CMMI®. Based on 35 CMMI®-based process improvement implementations globally, covering organisations such as Accenture, the Boeing Company, General Motors and Bosch, the report aims to demonstrate the impact that CMMI®-based process improvement has on each organisation's performance (Heinz, 2003). The SEI report by Gibson *et al*. (2006) uses specific categories such as cost, schedule, productivity, quality, customer satisfaction and return on investment (ROI).

The report provides evidence that the adoption of CMMI® can result in decreased project costs, increased schedule predictability, improved product quality, increased customer satisfaction and a positive return on investment. See Table 2:9 indicating the median percent improvements over time in the first five categories and the median improvement in ROI (Gibson *et al*., 2006).

Table 2:9 Performance of CMM

(Source: Gibson *et al*., 2006)

Performance category	Median improvement
Cost	34%
Schedule	50%
Productivity	61%
Quality	48%
Customer satisfaction	14%
Return on investment	4.0:1

In relation to the adoption of CMMI®, the study goes on to say:

> Many organizations have achieved improvements in product quality and customer satisfaction at the same time that they have achieved higher productivity, cost performance, and schedule performance. Better quality may not always be free, but it can occur with better project performance as a result of disciplined process improvement (Gibson *et al.*, 2006, p. xii).

2.6.6 Conclusion to maturity models

Organisations are being forced to manage and control more and more complex software and systems engineering projects and therefore need a way to manage an integrated approach to their software and systems engineering as part of attaining their business objectives. Experience has shown that organisations do best when they focus their process-improvement efforts on a manageable number of process areas that require increasingly sophisticated effort as the organisations improve.
Maturity models such as CMMI® consist of best practices that address product development and maintenance. They address practices that cover the product's life cycle from conception through to delivery and maintenance. There is an emphasis on both systems engineering and software engineering and the integration necessary to build and maintain the total product.

While the Capability Maturity Model® Integration (CMMI®) provides an opportunity to avoid or eliminate barriers through integrated models that transcend disciplines, there is still a debate on applicability, appropriateness and a true definition of what business value CMMI® can bring.

2.7 Determining the business value of CMMI®

This section provides more specific details in understanding the business case used to translate what business value CMMI® as a software quality and process improvement standard can bring to the South African environment.

2.7.1 Purpose of the business case

There are two perspectives on the purpose of the business case. In the first, the business case is defined as simply a justification for a particular proposal (Shelly *et al.*, 2008 as cited in Cervone, 2008). Whether that proposal is a particular project, strategy or investment decision, the role of the business case is to convince senior management and other stakeholders about the business benefits in justifying resources to support its implementation (Robinson, Carrillo, Anumba and Al-Ghassani, 2004). In most organisations, the process of defining the business case benefits is there to ensure that any spend on the proposal is justified and the payback assured (Acharya and Olive, 2002).

According to the second perspective, the purpose of the business case is more strategic and focuses on an organisation's specific business objectives, mission and needs (Robinson and Dechant, 1997). It is therefore important that the business case justification should be able to present value as wider, deeper and longer (Band, 2003):

- Wider to encompass all enterprise-wide benefits including risks
- Deeper to catch all items of expenditure and possible failure costs
- Longer to incorporate benefits accrued well beyond the project completion date.

Ultimately, whether the business case is used to bring focus on an organisation's objectives or to justify spending resources, the business case must be used to demonstrate how value is being created for the organisation.

2.7.2 Business case framework

According to Band (2003), what is ultimately required from a business case is a business-centric approach that helps the organisation to identify the key pressures on its business and the potential and actual value of the investment. A solid business case should however, never simply be decided only on ROI-style calculations. Other factors have to be considered such as the competitive environment and intangible benefits (Band, 2003).

Based on examples identified in the literature (adapted from: Robinson and Dechant, 1997; Acharya and Olive, 2002; Band, 2003; Cervone, 2008), the business case framework with five keys steps is proposed as illustrated in Table 2:10. Each step is outlined and aims at answering key questions in determining the potential value of allocating resources to a particular goal or project.

Table 2:10 Business case framework

(Adapted from: Robinson and Dechant, 1997; Band, 2003; Acharya and Olive, 2002; Cervone, 2008)

	Step	Key questions
1	Determining the business objectives, market opportunities or needs	What is the nature and purpose of this investment? How does this investment further our business mission and goals? What are the alternatives to this investment?
2	Conducting a cost/benefit analysis	What are the actual and perceived strategic, financial and operational costs and benefits? What are tangible and intangible costs and benefits? Are the costs and benefits measurable? If so, how?
3	Assessing the financial metrics	What is the most appropriate measure to assess the benefits against the cost? When will we realise the benefits? When will we incur the costs? Will this project pay for itself? How quickly?
4	Identifying the risks	What are the assumptions behind the strategic financial and operational costs and benefits? What is the impact on the business if the assumptions are wrong?
5	Developing mechanisms to assess progress and business and operational impact	What indicators, measures and monitoring processes have been identified to track the outcomes in achieving the business objectives? Who is accountable for monitoring these indicators and managing the outcomes?

2.7.2.1 Business objectives and drivers

To develop a business case successfully, there needs to be an understanding of the strategic context of business problems and their implications for the performance of the business. Each organisation has a unique set of circumstances driving the decision-making process when considering an investment (Acharya and Olive, 2002). The eventual goal of process improvement is to gain a competitive edge and business supremacy (Weigers, 1998 as cited in Ahmad, 2007). Stelzer and Mellis

(1999) argue that introducing process change as business practice will increase the probability of success. Thus, the need is to design SPI initiatives that address business goals rather than pursuing compliance with any process improvement model (Hara, 2000 as cited in Ahmad, 2007).

The launch pad for any business case is an understanding of the drivers for adoption (Band, 2003). The key pressures faced by software development organisations and that result in their investing in process improvements, point to three primary decision drivers that they must achieve (Harrison, Raffo, Settle and Eickelmann, 1999; Borland, 2006):

- Better quality than the competition in all phases of the product life cycle, from product conception to deployment
- Greater speed, agility and increased productivity to beat the competition in introducing new and enhanced features and technology
- Cost reductions so that products can be offered at lower price points than the competition.

2.7.2.2 Cost and benefit analysis

There are two sides to the cost versus benefit analysis. The first is the identification and interpretation of what the costs and the benefits are and secondly, how they are quantified (Acharya and Olive, 2002). In the business case, the business benefits from the adoption of CMMI® need to be weighed up against each other to decide whether the investment should be sanctioned or rejected (Band, 2003). Calculating total costs and benefits also needs to take into account the timing, how long it will take to start seeing the benefits or incur costs and therefore a time/cost analysis needs to be considered and the risk factor, how likely is it that the actual future benefits may vary from what they are projected to be (Harrison *et al.* 1999).

Research by Rico (2000) identifies eight criteria (three cost criteria and five benefit criteria) believed to be the most meaningful indicators to evaluate, assess and analyse software process and software process improvement (SPI) performance. See Table 2:11.

Table 2:11 Criteria for evaluating SPI alternatives

(Source: Rico, 2000)

Criterion	Definition
Training hours	The number of person-hours of formal classroom instruction applied for the teaching of a software process
Training cost	The number of training hours plus training fees and travel expenses such as air fare, meals, hotels, car rental and other applicable training costs
Effort	Development effort – the effort required to design, code, unit test and system test, measured in person-months (Come, Dunsmore and Shen, 1986)
Cycle time or duration	The elapsed time in hours or months during which development effort proceeds without interruption (Come *et al*., 1986)
Productivity	The number of lines of source code produced per programmer-month (person-month) of effort (Come *et al*., 1986)
Quality or defect density	The number of software defects committed per thousand lines of software source code (Come *et al*., 1986)
Return on investment	Return on investment metrics are collected for the purpose of measuring the magnitude of the benefits relative to the costs (Lim, 1998)
Break-even hours	The level of activity at which an organisation neither earns a profit nor incurs a loss (Garrison and Noreen, 1997)

Investment costs and benefits fall into two categories – tangible and intangible.

2.7.2.2.1 Tangible costs

The definition of a tangible cost is that it will directly affect the profit in an adverse way while an intangible cost, which maybe also be referred to as a dis-benefit (Remenyi, Sherwood-Smith and White (1997), may be defined as one which will cause problems which will indirectly lead to an increased cost profile. Predicting the costs of a process improvement can be challenging as it is easy to miss certain costs, for example, operating costs that include internal staff time.

Raffo (1996) as cited in Harrison *et al.* (1999) provides a list of general cost categories encountered when implementing process changes. These cost categories include:

- causal analysis
- meetings
- process definition activities
- dissemination and training costs
- tool costs
- communication and motivation costs
- coaching costs
- verification and enforcement costs.

Garrison and Noreen (1997) report that cost-reducing approaches such as process value analysis (PVA), activity-based costing (ABC) and quality management, lead to increased cost control and management, are directly controllable although cumbersome, and have break-even points of their own that need to be monitored carefully.

2.7.2.2.2 Intangible costs

Often, costs and benefits that cannot be quantified are ignored by the financial analysis, but it is essential that both the tangible and intangible factors be considered. In assessing the impact of implementing the process changes, there must be significant strategic value that it is worthwhile even if the financial analysis is not persuasive. The justification for technology-type investments often focuses on investigating the economic tangible benefits. However, according to Shin (1999), it is both intangible and intermediate benefits such as better coordination, quality improvement, increased variety and innovation that complicate the

justification process for IT investments. Shin (1999) goes on to suggest that enhancing coordination of economic activities (intangible benefits) and reducing coordination costs can improve firm performance and productivity (tangible benefits).

For process changes, Raffo, Settle and Harrison (1999) suggest two categories of intangible cost areas:

- *Implementation costs*: Every process change incurs costs during the implementation. These costs may include hours of staff effort dedicated to developing and documenting new processes and checklists, effort and/or fees for developer training, and effort to prepare and conduct kick-off meetings to announce the changes and answer questions.
- *Support costs*: When a process change is introduced, it takes time for staff to make the required changes. Often, additional assistance in terms of on-going consulting and support is required. This cost is also incurred in terms of hours of effort and/or external consulting fees.

2.7.2.2.3 Tangible benefits

A tangible benefit is one which directly affects the firm's profitability, whereas an intangible benefit can be seen to have a positive effect on the firm's business, but does not necessarily directly influence the firm's profitability (Remenyi *et al.*, 1997). There are several financial metrics which could be used to measure profitability. These include the payback period, net present value (NPV) and return on investment (ROI) (Raffo *et al.*, 1999). A typical method for assessing the monetary value of any investment is to calculate the ROI.

2.7.2.2.4 Intangible benefits

According to Sullivan (2000), the value of intangible benefits depends on the firm's view of itself and on the realities of the marketplace. This implies that value

depends on what the organisation or the individuals employed by the organisation define as valuable. Thus the cause and effect relationship of an intangible benefit may not be clearly visible and fully understood.

A further classification of benefits is required as different types of benefits may be quantifiable or unquantifiable, or easily measurable or difficult to measure (Remenyi *et al.*, 1997). As an example, the utility received from software process improvements may not in terms of cash generated, but rather in cost savings and therefore the tangible (financial) and the intangible benefits can be associated with future revenue or cost savings. For example:

- revenue benefits from CMMI® adoption may arise from a growth in demand through marketing and sales opportunities
- avoided costs may include savings from rework avoidance, but may also stem from reduced support costs and less maintenance effort
- improved organisational communications, learning and efficiencies (Hyde and Wilson, 2004)
- improved ability to attract, retain and develop software professionals (Hyde and Wilson, 2004).

It is often the indirect benefits of improved software practices that assist in creating additional revenue opportunities, thereby making the indirect benefits more compelling (McConnell, 2004).

2.7.2.3 Risk management

Elkington and Smallman (2002) categorise risk into two types. Project risk is defined as threats directly to the project and business risk as threats that may affect the delivery of the benefits to be gained from the project. The objective of

risk management in the business case is to describe clearly the impact of risks identified in the risk analysis stage.

Risk management consists of thee closely related actions:

- Risk identification of both project and business risks
- Risk analysis, including the impact and probability of occurrence
- Risk evaluation and control to decide whether the level of risk is acceptable and if not, what actions can be taken.

2.7.2.4 Financial metrics

Any business case has financial performance of the proposed investment at the heart of the analysis (Acharya and Olive, 2002). There are various methods of assessing returns and subsequent returns such as net present value (NPV), internal rate of return (IRR), payback period, a simple definition of ROI or straight cash flow (Band, 2003). Each method can be used to judge the relative merits of various process improvement activities on a financial basis.

2.7.2.4.1 Return on investment (ROI)

ROI is a performance measure used to evaluate the efficiency of an investment or to compare the efficiency of a number of different investments. To calculate ROI, the benefit (return) of an investment is divided by the cost of the investment and the result is expressed as a percentage or a ratio (Burke, 2003). A positive ROI indicates that a project is financially viable. The main criticism of the ROI is that it averages out the profit over successive years, when projects with higher initial profits should actually take preference (Burke, 2003). The ROI for improved software process could be as high as 500% based on an analysis by Watts Humphrey, as cited by McConnell (2004).

2.7.2.4.2 Net present value (NPV)

According to Burke (2003), NPV is a discounting technique that enables the business to compare projects with different investment and cash-flow profiles. It represents a measure of the value or worth added to the company by carrying out a project (Burke, 2003). NPV is calculated using the sum of the present values of all cash flows, i.e. benefits less costs. A positive NPV indicates that a project is financially viable. When deciding between mutually exclusive projects or rationing project funding, NPV indicates which project has the greatest financial value. According to Harrison *et al.* (1999), using net present value is an ideal method for valuing a particular software process improvement effort because most such efforts involve performing work upfront, i.e. investing now for a future payback.

2.7.2.4.3 Internal rate of return (IRR)

According to Burke (2003), the internal rate of return (IRR) is the discount rate that would produce an NPV of zero, i.e. the discount rate at which the cumulative present value of benefits equals the cumulative present value of costs. IRR analysis is a measure of the return on investment. Therefore, if the IRR exceeds the minimum rate of return that an organisation requires for a project, it can be deemed a good investment.

2.7.2.4.4 Payback period

The payback period for a project is defined as the initial fixed investment in the project divided by the estimated annual net cash inflows from the project (Meredith and Mantel, 2006). It is a measure of how much time it will take for an investment to break even. It is calculated by dividing the initial cost of the investment by the net annual cash flow it will generate in the business giving a result in *x* number of years (Band, 2003). The ratio of these numbers is the length of time between the

initial investment (project start) and the break-even point, typically expressed in months or years (Burke, 2003). Like the break-even point, which indicates when in the future projects will break even, the payment period it is not a meaningful financial differentiator and should only serve as an initial filter (Burke, 2003).

2.7.2.5 Measurement

There is a cliché in the supply chain management industry which states, "If you can't measure it, you can't improve it." It suggests that implementation alone is not enough and that measurements are needed to control any improvement initiative. This is further supported by Gartner in May 2001 as cited in Band (2003), who states that up to 70% of enterprises underachieved stated goals due to lack of measurement, while 55% failed to meet benefit objectives due to lack of ongoing measurements.

The purpose of measurements in building a business case for any project or investment should be more than simply to justify the investment. They should also ensure that there is an awareness of what the real benefits are and provide a tool for ongoing measurement of the project (Band, 2003).

Abrahamsson (2001) presents five dimensions to measure SPI success:

- Project efficiency
- Impact on the process user
- Business success
- Direct operational success
- Process improvement fit.

Börjesson *et al.* (2006) as cited by Ahmad, 2007, list the following four practical indicators for tracking and following up SPI:

- Training participation
- Perceived acquired know-how
- The tool use indicator
- The steering group participation indicator.

These indicators focus on competence build-up, employee capabilities, process adoption and management commitment.

2.7.3 Conclusion to determining the business value of SPI

The business case may be more than simply a justification for a particular proposal as it can also be used to drive the specific business objectives, mission and needs of an organisation. In either instance, the business case usually involves a comparison of the costs with benefits and is used to justify the resources required to support the implementation. While there are various methods of calculating the financial return, factors such as risk and timing also play a role. Finally, as the research suggests, implementation on its own is not enough and measurements are required to track any business case initiative.

2.8 Summary of literature review

As illustrated in the map of the literature review in Figure 2:20, software organisations are increasingly looking towards quality, process and maturity initiatives to address key business challenges. As the literature review has highlighted, there is no consensus on a single definition of SPI. In the marketplace, there are maturity models, standards, methodologies and quality guidelines that all aim at helping an organisation improve the way it does business. Most available improvement approaches have been criticised firstly, for focusing only on a specific part of the business and not taking a systemic approach to the problems that the organisation is facing and secondly, for only providing guidance on what activities

to implement instead of providing an effective strategy to implement them successfully.

From the experiences highlighted in the literature, the adoption and implementation of CMMI® (the successor to CMM), a process improvement model, has been no different. The CMMI® remains the standard for software process frameworks and is based on a collection of software engineering best practices. While it outlines the essential elements of effective processes for one or more disciplines and describes an evolutionary improvement path from ad hoc, immature processes to disciplined, mature processes with improved quality and effectiveness, it still needs to be interpreted and tailored to the individual needs of organisations.

According to the literature, organisations who have adopted CMMI® have experienced benefits such as increased productivity and quality, improved cycle time, and more accurate and predictable schedules and budgets. Research has also shown that embracing CMMI® was one of the factors that contributed to the exponential growth of the Indian and other emerging software export markets. Although it is a valuable contributor to the South African economy, the South African software sector has been slow on the uptake of SPI and CMMI® in particular, potentially hampering growth opportunities.

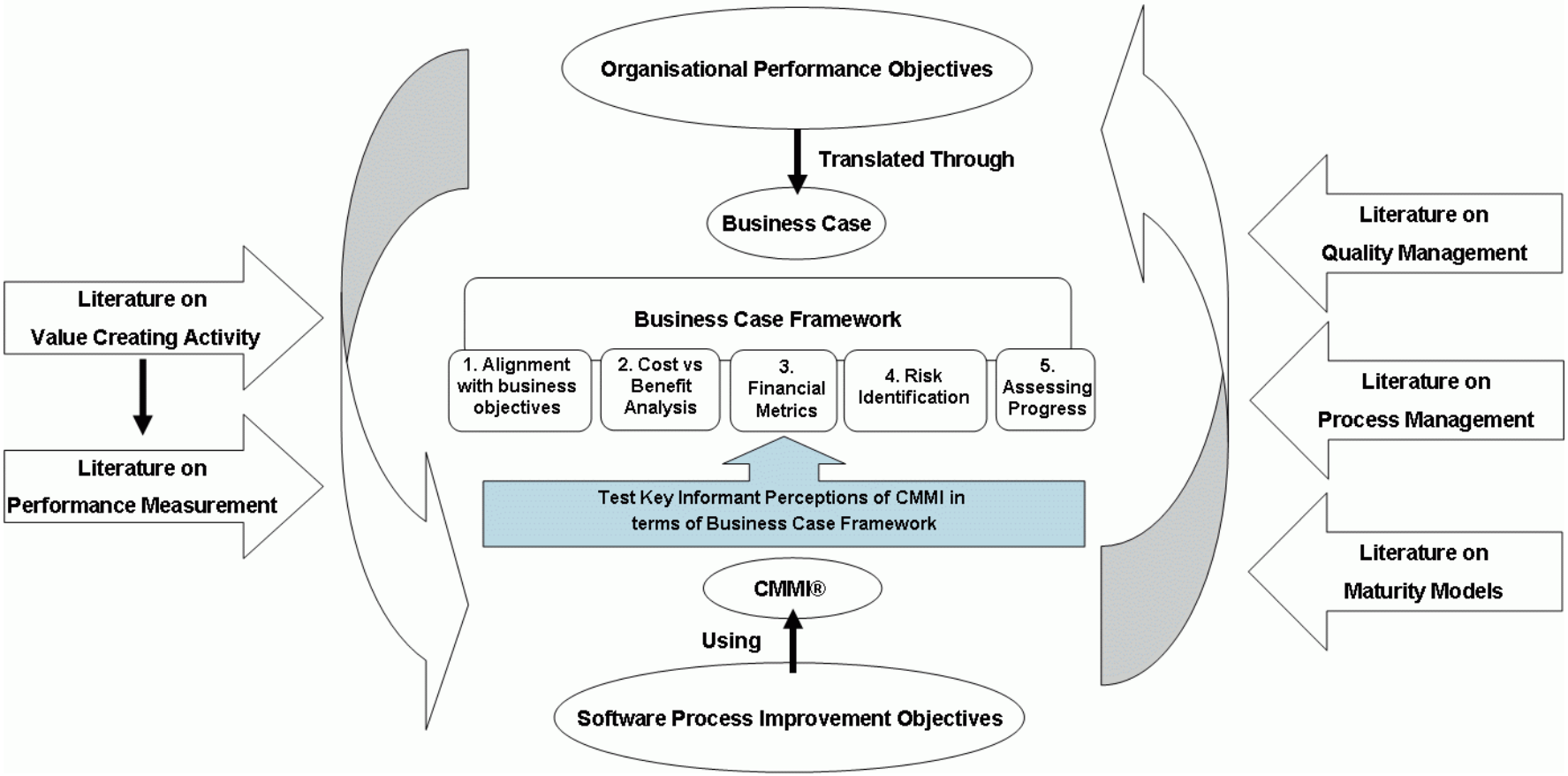
An investment such as the adoption of CMMI® needs to be aligned with the business strategy as it must demonstrate that it will add real business value. The literature provides insights on using the business case as the tool or mechanism that can be used to assess the costs versus the benefits.

The adoption of SPI and specifically CMMI® is relatively new in the South Africa context, and as yet, no research has been directed at the use of CMMI® by South

African software organisations. The next chapter outlines the aim of the study and also restates the various questions which this research intends to answer.

2.9 Map of literature review

Figure 2:20 Map of literature review



3 RESEARCH QUESTIONS

Given the importance of demonstrating value from an investment in SPI, the objectives of the research include finding out the extent to which the various organisations and stakeholders of the South African CMMI® pilot study perceive there to be a business case for the adoption of SPI using CMMI® in South Africa.

3.1 Research question one

What are the key business drivers for the adoption of CMMI® in South Africa and how is the impact on business performance measured?

3.2 Research question two

How does process improvement, using CMMI®, affect South African software organisations?

3.3 Research question three

Where, and to what extent, have the benefits and costs of the adoption of CMMI® determined its business value?

3.4 Research question four

What are the internal (organisational) and external (environmental) factors that would influence (support or hinder) the adoption of SPI using CMMI® in South African software organisations?

4 RESEARCH METHOD

4.1 Introduction

This section describes the methodology used during the research to assess the nature of the adoption of CMMI® in South Africa. The research set out to explore the experiences of the South African organisations currently in the South African CMMI® pilot study and included interviews with key informants associated with the CMMI® study. Key informants were people who, along with having firsthand knowledge about the issue at hand, are described as ”people that you can talk to easily, who understand the information you need, and who are glad to give it to you or get it for you” (Bernard, 2000, p. 346).

Due to the current lack of formal software process improvement and particularly CMMI® adoption in South Africa, the view was taken that the impact in the South African context needed to be investigated through exploratory research. Exploratory research serves to capture patterns, ideas or potential hypotheses to test. It is not used to confirm or test a hypothesis (Hussey and Hussey, 1997). The primary research will be used to create an understanding of the research problem at hand.

Findings of the research can be used to assist future managerial decision making in assessing the value CMMI® can bring to the South African environment.

4.2 Research approach

The research consisted of semi-structured personal interviews with pilot organisations and key informants. The nature of the design revolved around a relatively small sample size (18 people) resulting from a limitation on the number

of current CMMI® pilot companies. Personal interviews are a common technique used to conduct key informant interviews (Bernard, 2000).

The research approach comprised the following stages:

- Performing a literature review
- Drafting a list of open-ended questions for the semi-structured interview
- Drafting a questionnaire using information gleaned from the literature review
- Pre-testing the questionnaire with a sample audience
- Identifying a list of potential interviewees and key informants, namely individuals who would be able to assist in gathering information about the target population
- Administering the semi-structured interview and questionnaire through personal interviews
- Identifying further potential interviewees and key informants through a snowballing approach as part of the personal interview process
- Analysing the feedback of the interviews and questionnaire responses.

4.3 Methodology

Methodology refers to the various means by which data can be collected and/or analysed (Collis and Hussey, 2003). The research was exploratory in nature. Zikmund (2003) describes exploratory research as initial research conducted to clarify and define the nature of a problem. It does not provide conclusive evidence and subsequent research is expected. The research was primarily qualitative as the topic dealt with each individual's perceptions, attitudes and feelings. The underlying belief of qualitative research according to Gay and Airasian (2003) is that meaning is situated in a context, and because different groups have different perspectives, there are many different meanings in the world, none of which is necessarily more valid or true than another.

The study comprised personal interviews using a semi-structured method of data collection (Wisker, 2001) including a combination of open questions and a questionnaire, which included Likert-type questions.

4.3.1 Semi-structured personal interview

To probe more deeply into the findings arising from the survey, personal interviews were conducted. The personal interviews involved qualitative research as it was a type of research involving the interpretation of non-numerical data. Responses obtained from personal interviews are of a high quality (Welman and Kruger, 2001). Using a semi-structured approach allows the interviewer to develop a conversation with the respondent, which can often be rich and rewarding, while allowing the interviewer to return to the structured interview questions when required (Merriam, 2001). The design of the open-ended questions 1-10 was generated from the research questions.

The objectives of the open-ended questions were to:

- establish the motivations for the adoption and implementation of CMMI® and how it was intended to meet business objectives and create business value
- determine the perceptions surrounding the impact in terms of benefits and costs of the adoption and implementation of CMMI®
- identify the internal and external factors that pose a risk to the adoption and implementation of CMMI® in the South African software services sector.

(See Annexure D for an example of the interview guide.)

4.3.2 Questionnaire

According to Zikmund (2003), a questionnaire is relevant if no unnecessary information is collected and if the information that is needed to solve the business

problem is obtained. The design of the questionnaire is an important influencer of the quality of the data generated by it (Sanchez, 1992).

The main purpose of this questionnaire was to obtain relevant information about the perceptions of the adoption and implementation of CMMI® in South Africa. Guidelines from Leedy and Ormrod (2001) are to keep the questionnaire concise and simple to use, to use unambiguous language, to apply consistency in the questions and to make the respondent's task as simple as possible. The design of the questionnaire was generated from the literature review:

- Question 11: The main reasons or motivations for adopting CMMI®, adapted from Wither and Ebrahimpour (2000)
- Question 12: The goals and measures tracked when adopting CMMI®, adapted from Kaplan and Norton (1996) and Borland (2006)
- Question 13: The impact the adoption of CMMI® had on the tangible benefits, adapted from Huang *et al*. (2006)
- Question 14: The impact the adoption of CMMI® had on the tangible costs, adapted from Crosby (1979) and Borland (2006)
- Question 15: The impact the adoption of CMMI® had on the intangible benefits, adapted from Hyde and Wilson (2004)
- Question 16: The impact the adoption of CMMI® had on the intangible costs, adapted from Raffo *et al*. (1999)
- Question 18: Financial techniques most appropriate for evaluating the business value of adopting CMMI®, adapted from Harrison *et al*. (1999)
- Question 19: The key risks faced by organisations in adopting CMMI®, adapted from Niazi *et al*. (2003)
- Question 20: Factors preventing the widespread adoption of CMMI® in South Africa, adapted from Staples *et al.* (2006).

The questionnaire comprised a set of rating scales, a tick box and Likert-type scale statements designed to test the perceptions of the respondents. Pre-testing of the interview instrument or questionnaire was done to test the clarity and objectivity of the questionnaire. Individuals from the South African software development industry matching the sample profile were used to ensure the validity and usability of questions and responses received. (See Annexure E for an example of the questionnaire.)

4.4 Population of relevance

According to Zikmund (2003), the population represents a complete group of entities sharing some common set of characteristics that can be used to generalise the findings of the study (Wellman and Kruger, 2001).

The population of relevance for this research was defined as:

- governmental and educational institutions and NGOs who both participate in and influence the direction of growth and development in the South African software industry
- all types and sizes of companies which perform a software development function or have a software development division
- companies with offices based in South Africa
- companies whose activities include research, design, development, implementation and management of software products and services
- companies who have adopted a CMMI®-based software process initiative within the last 12 to 18 months.

4.5 Size and nature of sample

There are a number of sampling procedures that can be used. Non-probability sampling is defined as a sampling technique in which units of the sample are

selected on the basis of personal judgment or convenience (Zikmund, 2003). Wellman and Kruger (2001) state that non-probability sampling is used when there is a probability of certain members of the population having no chance of being included in the sample.

Judgment sampling was the non-probability sampling technique used in this research. Judgment sampling allows the researcher to select the sample based on some appropriate characteristic of the sample members (Zikmund, 2003).

The sampling frame for this research included representatives of organisations who are currently participating in the JCSE CMMI® pilot study in South Africa (see Annexure A), which were classed in terms of the following three categories:

- Appraisers are described by the Software Engineering Institute (SEI) (2008) as individuals who are trained and registered to head an appraisal of the Standard CMMI® Appraisal Method for Process Improvement (SCAMPI) to provide benchmark quality ratings relative to CMMI® models.
- Practitioners who are also regarded as CMMI® subject matter experts (SMEs) and/or project managers of the implementation process. They are responsible for generating a sense of participation and ownership of the CMMI® adoption in the organisation.
- Sponsors are usually individuals in senior management and sometimes board level. They have the authority or influence to undertake the work and bring about the proposed change in affected parts of the organisation and can also ensure that there is consistent communication from the top to help establish and retain organisational focus.

Other respondents included selected key informants such as senior representatives from governmental and educational institutions that are currently stakeholders in

the CMMI® pilot study in South Africa and have a vested interested in supporting the growth and development of the South African software industry.

The above interview subjects were only those that the researcher had access to and handpicked as key informants in relation to the adoption of CMMI® in South Africa. During the interviews, each of the respondents was asked to identify suitable individuals from the relevant population that could be interviewed, based on their knowledge and expertise on the topic of the CMMI® adoption. As a result, this snowballing effect, as outlined by Wellman and Kruger (2001), was used to increase the size of the sample and to obtain as many contacts for interviews as possible.

4.6 Unit of analysis

The unit of analysis was the software development companies or software development divisions who would invest in software process improvement initiatives using CMMI®.

4.7 Data collection instrument

Data collection for each case study was through semi-structured personal interviews using both open-ended questions and a questionnaire. The questionnaire used for this study was based on the findings the literature review. See Section 4.3.2.

(See Annexure D for an example of the interview guide. See Annexure E for an example of the questionnaire.)

4.8 Data collection

Pre-testing of the interview instrument or questionnaire was done on a pilot group made up of individuals in the South African software development industry who are aware of CMMI®. The questionnaire was administered through a personal interview with the key respondents such as senior managers responsible for the CMMI® pilot process in each of the pilot organisations. Potential participants were contacted via email prior to the interview and briefed with regards to the study and its purpose. Sixteen of the interviews took place at the participant's place of work and the open-ended question responses were recorded and later transcribed. Two of the interviews took place over the telephone as the respondents were based in Pretoria and Cape Town respectively. The questionnaires were also completed at the participant's place of work, except for the two which were emailed to the respondents and returned when completed via fax.

(See Annexure B for a copy of the email requesting an interview. See Annexure C for a copy of the consent letter.)

4.9 Data analysis

4.9.1 Content analysis

Content analysis was used to analyse the data from the open-ended questions in the questionnaire. According to Patton (2002, p. 453), "Content analysis is used to refer to any qualitative data reduction and sense-making effort that takes a volume of qualitative material and attempts to identify core consistencies and meanings." The qualitative data from the interviews was analysed by capturing the common themes for each of the open-ended questions asked. These themes were then grouped into high-level issues using content analysis, ranked in terms of frequency of responses and then used to explain some of the observations made.

4.9.2 Descriptive statistics

Descriptive statistics including quantitative methods were used to present an analysis of the questions in the questionnaire. Zikmund (2003) regards descriptive statistics as the transformation of raw data into a form that will make it easy to understand and interpret, and rearranging, ordering and manipulating data to generate descriptive information. The data collected from questionnaires was captured and analysed using descriptive statistical methods such as frequency analysis, which was appropriate for this type of study. Descriptive statistics were used to describe the basic features of the data in the study to provide simple summaries of the results and simply to describe what was going on in the data.

4.10 Research limitations

The following were limitations of the research study:

- This research was only applicable to organisations participating in the CMMI® pilot study to whom the researcher had access, making the research specific only to a handful of organisations and therefore not the industry as a whole.
- The adoption of CMMI® was relatively recent and responses from the research indicated that it was too soon to access the benefits and costs and secondly, that the returns were only expected to materialise much later when the processes matured in the organisation.
- A relatively small sample size was used, however interviews with over 70% or the pilot organisations were conducted and 18 interviews allowed for sufficient conclusions to be made from the sample population;
- It is worth nothing that the research relies heavily on the perceptions of individuals who are directly involved in the adoption of CMMI® process. However, every individual has the own personal reflections of the experience

but view are treated with equal importance, and this the outcome of the study only represents a generalized view of the adoption process;

- Non-probability sampling was used which means that the sample is not representative of the population and therefore statistical inferences cannot be drawn;
- Organisations from the research are all participating on the JCSE pilot study and their costs and involvement have in some way been subsidised by Government. In this way the responses from these organisations not only reflect a small sample of the population, but also a sample is would not reflect the true costs of adoption CMMI® in South Africa;
- A comment was made by one of the respondents regarding the definition of "somewhat positive" as an option in the Likert-type questions. It was felt that it was unclear and as there was no option between "very positive" and "somewhat positive" it was felt that this option did not satisfy their true opinion.
- The interpretations of the findings were judgmental and potentially subjective and the exploratory data cannot take the place of quantitative research (Zikmund, 2003).
- The population of relevance only consisted of managerial and professional staff and was therefore limited to their perceptions and perspectives.

4.11 Conclusion

This chapter has explained why a semi-structured personal research methodology was used to collect, analyse and interpret the data. To meet the objectives of this research project, an exploratory research method was selected. Once the population of relevance was determined, personal interviews with open-ended questions and questionnaires were used to collect data. Details of the process of data analysis were also provided. The research limitations of the study were then

specified. The results of responses to the open-ended questions and research questionnaire are discussed in the next chapter.

5 RESULTS

The results obtained from the research are presented in this chapter. A total of 18 interviews were achieved. The objective of the research process was to assess the business value of adopting and implementing a software process improvement initiative using CMMI® by organisations in South Africa. The research data and interviews will be presented in the following sequence:

- Profile of the respondents
- Insights from semi-structured interviews
- Data analysis of the close-ended questions.

This chapter concludes with a summary of the most relevant results which leads to the discussion of the findings and answers to the research questions in Chapter 6. All research data has been summarised and provided in the body of the report. However, for purposes of completeness, key graphs and information have been provided in Annexure F.

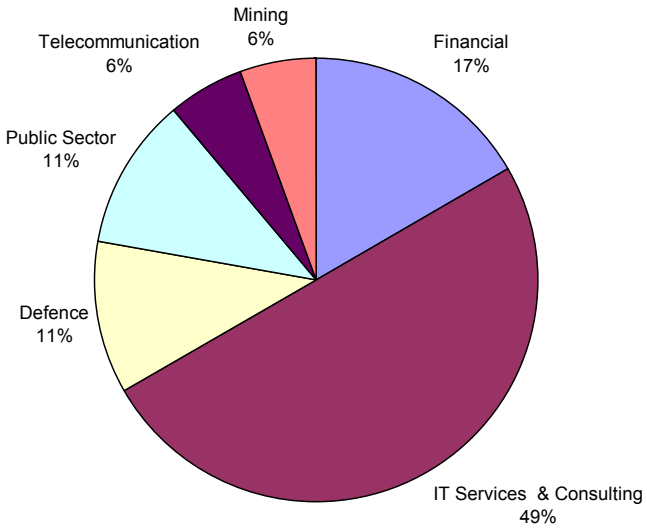
5.1 Profile of respondents

This section of the semi-structured interview consisted of questions preceded by a brief introduction. Respondents were asked to describe their organisation, including the nature of work the organisation does, the types of clients or customers they service and the size (people) and structure of the organisation. Secondly, respondents were asked to describe their organisations' software development capabilities. Finally, respondents were asked about their position and role in the organisation in relation to the CMMI® rollout, and to describe the nature of the CMMI® adoption in their organisation.

5.1.1 Organisation by industry type

The respondents represented various industries as illustrated in Figure 5:1. Organisations in all the South African niche software development industries were represented, with the majority offering direct IT services or IT consulting.

Figure 5:1 Organisations by industry type



5.1.2 Organisation size

In terms of size, the respondent organisations all differed, with small, medium and large-scale organisations participating. The organisations also differed in terms of their software development capabilities and functions. For example, in some organisations, software development is their core business while in others software development (also referred to as application development) is purely a support or secondary function that supports the primary business. Based on the number of employees, the organisations can be categorised into very small, small, medium and large enterprises as used by the South African Department of Trade and Industry (Ntsika, 1997).

Table 5:1 Organisations by size

(Categories source: Ntsika, 1997)

Category	Description	Percentage
Very small enterprises	Less than 10 employees	9%
Small enterprises	Greater than 10 but less than 50	9%
Medium enterprises	Greater than 51 but less than 500	36%
Large	Greater than 100 employees	46%

In terms of function, for 75% of the respondents, software development and other IT services is their primary function. For the remaining 25%, IT and software development is just a support function.

5.1.3 Respondent type

The research focused on organisations that form part of the "Bringing CMMI® to South Africa" (Dwolatzky, 2006) pilot programme as well as other key informants. In term of the research, participants in the pilot programme were classed in the following categories:

- Appraisers as described by the Software Engineering Institute (SEI) (2008) are individuals who are trained and registered to head an appraisal of the Standard CMMI® Appraisal Method for Process Improvement (SCAMPI) to provide benchmark quality ratings relative to CMMI® models. As outlined in the literature review above, there are different types of SCAMPI assessments (A, B and C), and the most formal method (type A) requires a senior SEI-trained lead appraiser to head an appraisal team. In many of the organisations interviewed, B and C appraisers were also practitioners.
- Practitioners are also regarded as the CMMI® subject matter experts (SMEs) and/or project managers of the implementation process. They are responsible for generating a sense of participation and ownership of CMMI® adoption in the organisation.

- Sponsors are usually individuals in senior management and sometimes at board level. They have the authority or influence to undertake the work and bring about the proposed change in affected parts of the organisation and also ensure that there is consistent communication from the top to help establish and retain organisational focus.

Table 5:2 Categories of respondents

Category	Percentage	Frequency
Appraisers	28%	5
Practitioners	56%	10
Sponsors	11%	2
Key informants/stakeholders	6%	1

5.1.4 Nature of CMMI® adoption

In terms of the nature of CMMI® adoption, there were two aspects – firstly, the scope of its current adoption in the organisation and secondly, the nature of exposure of the employees to CMMI®.

5.1.4.1 Scope of CMMI® adoption

That fact that the "Bringing CMMI® to South Africa" is a pilot programme indicated that the actual adoption of CMMI® is relatively new in the South African market. Therefore much of the experience with regards to the scope of the adoption was limited as the organisations involved assessed their current and future rollout approaches. As part of the CMMI® framework, assessments called SCAMPIs were performed in specific areas of the business, which benchmarked current processes against the model and identified where there were significant gaps. The SCAMPIs resulted in different approaches with regards to the scope of the CMMI® adoption as illustrated in Table 5.3.

Table 5:3 Scope of CMMI® adoption

Construct	Frequency
Only in the software, application or solutions development environment	7
Across the entire organisation or all projects	5
Run as a pilot project in the organisation	2
Only in projects that match specific criteria in terms of size, budget and resources	1
Only in projects where the client requires it	1
In specific functional areas, i.e. quality management office, project management	1

5.1.4.2 Exposure of the employees to CMMI®

Similar to the scope of CMMI® adoption, organisations had different approaches with regards to exposing employees to CMMI®. All the participants interviewed had attended the Introduction to CMMI® course, while others had extended that training through People CMM, Intermediate Concepts of CMMI® and through individual SCAMPI B and C appraisal training. Overall, organisations had exposed their employees through external formal and internal informal means.

5.2 Insights from semi-structured interviews

This section discusses the results of the semi-structured interviews and observations made during the research process. The qualitative data was analysed by tabulating the common themes for each set of questions and then grouping them into high-level issues.

Questions were designed to understand respondents' experience better with regards to the adoption of CMMI® and to define the impact it has had on processes in improving their project delivery and, in turn business value.

(See Annexure D for the interview guide.)

5.2.1 The relationship between CMMI® and other SPI methodologies

All the participants interviewed acknowledged that the use of CMMI® did not replace other best practice SPI methodologies but that the methodologies were rather complementary and each methodology should not be used in isolation but should rather serve as best practice in a specific role for each IT category. CMMI® was perceived to provide the most appropriate framework of what to do while other methodologies assist with how to do it. The use and the frequency of the identified SPI methodologies are highlighted in Table 5.4.

Table 5:4 Use of methodologies

Role	Description	Methodology used	Frequency
The "what" quality principles	Quality certification standards	ISO 9001	9
		ISO 20 000	2
		ISO 27 000	2
	Project management	PMBOK	7
		PRINCE 2	2
		Rational SUMMIT Ascendant	1
	Software development standards	MIL-STD	3
		ECOM	1
		IEEE 829-1998	1
The "how" operational methods	Service management	ITIL	6
	Co-management	COBIT,	3
	Human management / development	People CMM	1
		TSP / PSP	2
	Effective software development methods	Agile	1
Improvement techniques	Continuous (process) improvement	Six Sigma	1

5.2.2 The impact of the adoption of CMMI® on project delivery

While both positive and negative aspects were mentioned, overall all the respondents felt that the adoption of CMMI® had had a positive impact on project delivery. There was also the option that it was too soon to assess the benefits. The

most frequently raised issues around the positive and negative aspects are clustered thematically in the tables below.

5.2.2.1 Positive impact factors

Table 5:5 Positive impact factors

Construct	Frequency
The CMMI® model or approach assisted in identifying key areas missing and gaps in existing processes	11
Having quantitative data resulted in better developed plans and estimates	10
Better set of measures to track all projects and make improvements against targets	9
Improved quality delivered by identifying quality issues and defects earlier as part the process	9
Provided a more structured and reusable end-to-end process	7
Ensured best practice in the solutions delivery environment	5
Increased efficiencies and more streamlined projects	4
Improved ability to manage and mitigate risk	4
Elimination of hero culture within project environment	3
Triggered a change of thinking resulting in improvement in individual productivity	2
Easier working off set templates for every phase	2
Increased job satisfaction and retention through a structured work environment	2
Prevented business factors interfering with the software process activities	1
Internal silos disappearing	1

5.2.2.2 Negative impact factors

Respondents perceived resistance from project managers and software/application development teams to the adoption of CMMI® as it was seen not to add value. Further negative impact factors are outlined in Table 5:6.

Table 5:6 Negative impact factors

Category	Frequency
Resistance as it is not seen as adding value to project / organisation	5
The benefits do not justify the effort in terms of budget, training and need to dedicated skilled resources	4
Negative impact on staff morale	3
Impact on change management underestimated	2
Too focused on implementing CMMI® instead of focusing on key	2

Category	Frequency
areas and benefits	
Results in organisational politics	2
It takes too long for processes to be institutionalised	2
Limitations in CMMI® model result in a mismatch to our requirements	2
Perceived to be more costly	2
Had a negative impact on staff retention	1

5.2.3 What value the adoption of CMMI® adds to the organisation

The respondents were asked to describe how the adoption of CMMI® added value to their organisation. Two clear areas were identified – firstly, the ability to increase business and secondly, the creation of internal efficiencies. The complete list of responses categorised into common themes is presented in Table 5:7.

Table 5:7 Value of the adoption of CMMI®

Construct	Frequency
Increased ability to win new business (either through expansion into international markets or through securing outsourced work)	13
Helps to run the business more efficiently	11
Supports the industrialisation of process which is essential in creating a sustainable business	5
Increased staff satisfaction and empowerment	5
Breeding a culture of process and quality improvement initiatives	5
Demonstrates thought leadership / best practice in the industry through maturity rating certification	5
Improved client satisfaction	4
Creating organisational stability as a platform for growth	3
Framework that assists in building processes, learning and continuous improvement	3
Improved communication / standardisation across organisation	3
Ability to become more transparent to clients	3
Increased competitiveness	2

The above themes can further be grouped in terms of frequency into categories as identified in the literature (Hunter *et al.*, 2008):

- Fifty eight per cent of the responses based on the above themes could be categorised as run-the-business initiatives.
- Forty per cent of the responses related to grow-the-business initiatives.

- Eight per cent of the responses related to transform-the-business initiatives which are about new horizons — new markets, new products and new business models.

Besides the risks faced by organisations when adopting CMMI®, there are also reasons which would support or hinder the adoption of CMMI® in South Africa. These are explored in Section 5.2.4.

5.2.4 Factors affecting the uptake of CMMI® in South Africa

The respondents were divided on the extent of an uptake of CMMI® in South Africa. Many felt that the outcome of the CMMI® pilot programme would determine its success as the majority of interested organisations would see evidence of success from the CMMI® pilot programme. Most, however, felt that it was too costly. The positive and negative aspects were categorised based on themes from the responses and are presented in descending order in the tables below.

5.2.4.1 Supporting factors

As shown in Table 5:8, in terms of the supporting factors, the two factors that stood out from the responses include it being an opportunity to use the international certification to improve the profile of organisations wanting to export their software globally. Secondly, organisations in niche industries such as defence and mining, require quality and process standards to compete and therefore CMMI® becomes an order qualifier and not an order winner. Interestingly, some organisations felt that although domestic support through the DTI and the JCSE was a positive factor, many felt that the support was not sufficient and not sustainable in the long term as the JCSE does not have the capacity to drive CMMI® in South Africa. See hindering factors in Table 5:9.

Table 5:8 Supporting factors for CMMI® adoption in South Africa

Construct	Frequency
An opportunity to raise South Africa's profile to compete or export internationally	9
Most applicable in niche industries (defence, aerospace and mining) where there is no tolerance for defects	7
It is an internationally proven methodology	5
Support through domestic institutions such as the DTI and JCSE	3
Demanded by our parent company globally (organisational policy)	3
South Africa late on the SPI trend and therefore needs to catch up	2
Increased demand from customers	2
Increased awareness of quality in the market	2
Works well in conjunction with other SPI methodologies, i.e. ISO 9001	1

5.2.4.2 Hindering factors

As Table 5:9 shows, in terms of hindering factors, the majority of respondents felt that the process of adopting CMMI® was too costly, particularly for South African organisations. For many organisations the significant costs were difficult to justify despite the efficiency returns. In some cases, particularly with smaller organisations, it was felt that it would be difficult to provide the necessary resources. Some felt that it was not appropriate to the South African way or culture as it was in India.

Table 5:9 Hindering factors for CMMI® adoption in South Africa

Construct	Frequency
Too costly	11
Unable to provide necessary time and resources	8
Limited capacity in South Africa to support and sustain CMMI®	8
Not suited to SA culture	7
Lack of demand	7
Clients only want core skills and are not prepared to pay for quality compliance	6
Not applicable to certain industries or projects	5
Acknowledge that it will take a number of years to see the benefit	3
Not accessible for small businesses	3
CMMI® is not a real differentiator	3
Lack of awareness regarding CMMI®	3
Processes cannot replace people	2

5.3 Data analysis of the questionnaire

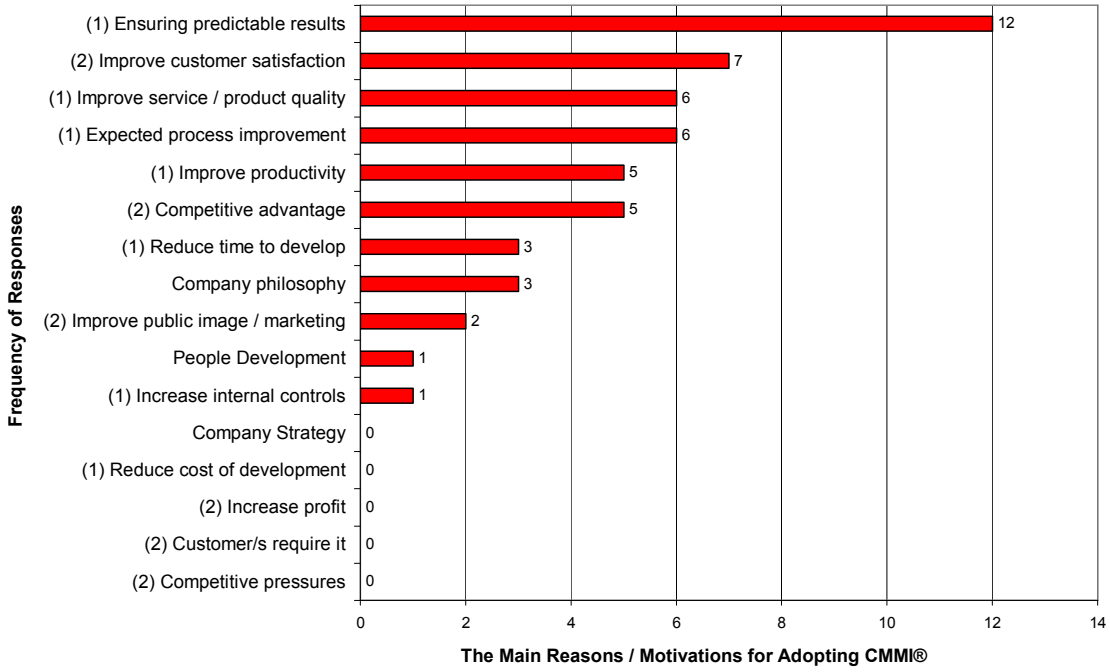
This section presents the data collated from the questionnaires and provides some findings of the results. The data is presented in a graphical format to facilitate greater understanding of the responses. Data was analysed using descriptive statistics, in particular, frequency and percentage of respondents. Column graphs and tables were chosen to present the data in the main body of the report. Data from the eighteen questionnaires was entered into a spreadsheet and analysed to create the graphical representations found in this chapter. The analysis was categorised in accordance with sections of the questionnaire. Each section will be discussed in more detail below. (See Annexure E for a copy of the questionnaire.)

5.3.1 The main reasons for the adoption of CMMI®

Respondents were asked to select all applicable reasons from a list and were then asked to narrow their selection down to their top three reasons. The results are presented in Figure 5:2 which ranks the frequency of responses.

Results show that respondents selected multiple reasons from the options contained in the questionnaire. Two distinct respondent type clusters were found in the analysis. The first cluster of respondents, 65%, were internally focused and adopted CMMI® for the expected increase in process efficiencies that would also ensure more predictable results and improvements in productivity and quality. The second cluster of respondents, 27%, were more externally focused and were motivated to improve customer satisfaction, increase competitive advantage and their public image.

Figure 5:2 Main reasons for the adoption of CMMI®

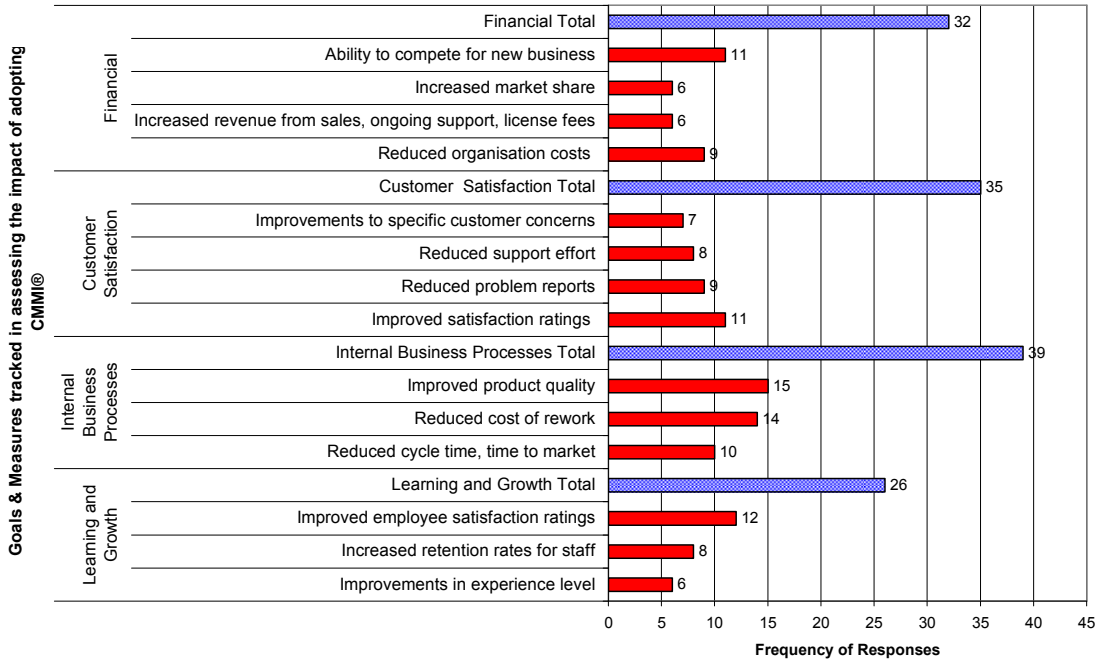


5.3.2 The goals and measures tracking the impact of CMMI®

Using the balanced scorecard (Kaplan and Norton, 1986) as a framework, respondents were asked to select all applicable goals and measures used to track the impact of the adoption of CMMI®. The results are presented in Figure 5:3 which ranks the frequency of responses.

Results showed that respondents selected multiple goals and measures from the four categories contained in the questionnaire. Tracking changes in the internal business processes dominated with 30% of the responses. The impact on customer satisfaction followed with 27% and then financial impact with 24%. The least important area of impact, based on the responses, was learning and growth with 20%.

Figure 5:3 Goals and measures in tracking CMMI® adoption

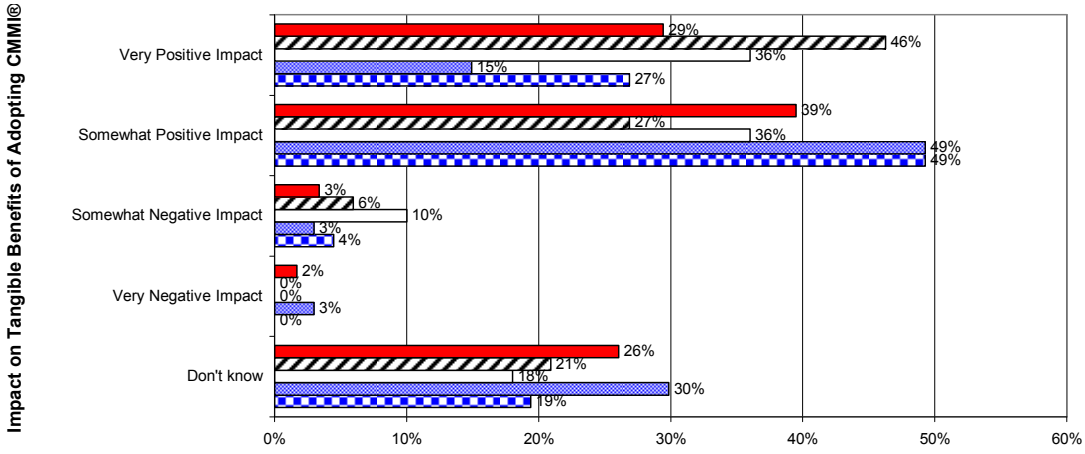


5.3.3 The impact on tangible benefits of adopting CMMI®

A Likert-type scale tested respondents' perceptions regarding the extent to which the adoption of CMMI® had an impact on tangible benefits. Respondents were asked to select benefits across five categories (customer, financial, organisational improvement, process improvement and quality). The results are presented in Figure 5.4.

Results showed that in total 31% perceived there to be a very positive impact and 40% a somewhat positive impact. Only 6% perceived a negative impact in some way and 23% did not know what the impact was. In terms of categories, the most perceived benefit was in process improvements and customer service. A 10% somewhat negative impact in terms of organisational improvement and 6% for process improvements possibly highlights the negative impact change can have on employees when challenging the status quo.

Figure 5:4 Impact on tangible benefits of adopting CMMI®



	Don't know	Very Negative Impact	Somewhat Negative Impact	Somewhat Positive Impact	Very Positive Impact
Quality	26%	2%	3%	39%	29%
Process Improvements	21%	0%	6%	27%	46%
Organisational Improvement	18%	0%	10%	36%	36%
Financial	30%	3%	3%	49%	15%
Customer	19%	0%	4%	49%	27%

Percentage of Responses

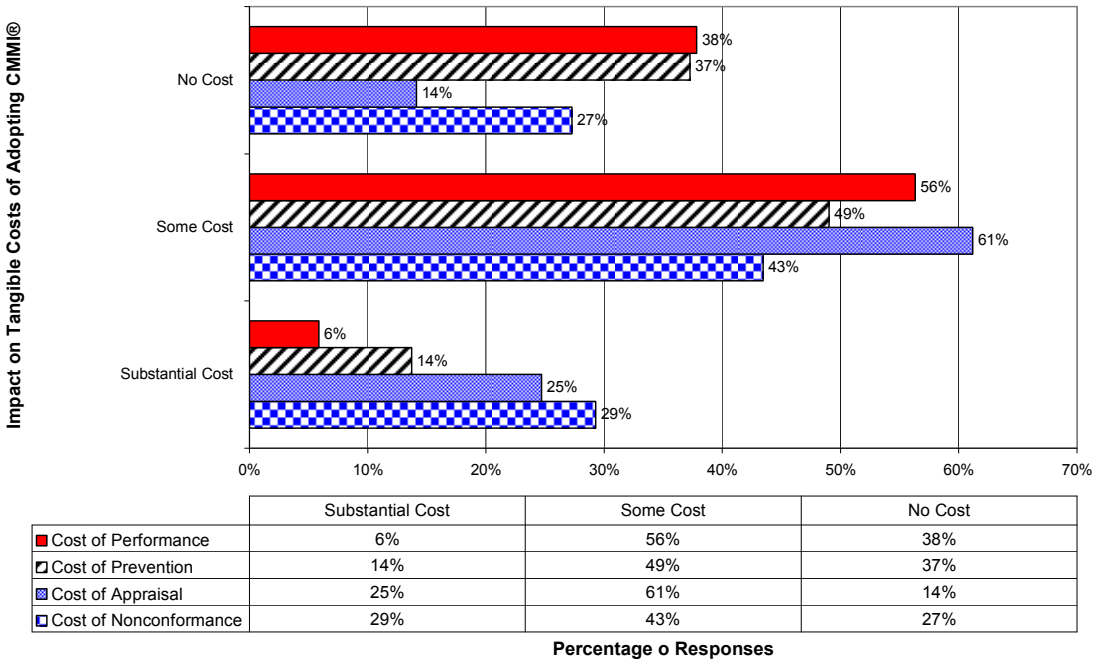
5.3.4 The impact on tangible costs of adopting CMMI®

A Likert-type scale tested respondents' perceptions regarding the extent to which the adoption of CMMI® had an impact on tangible costs. Respondents were asked to select benefits across four categories (cost of performance, cost of prevention, cost of appraisal and cost of non-conformance), based on Crosby's cost of quality model (Crosby, 1979). The results are presented in Figure 5:5.

The results showed that in total 29% of respondents perceived there to be a no-cost impact, 52% perceived there to be some cost and 18% substantial cost. In terms of categories, there was the least impact in the cost of performance as many of the practices such as designing, developing and testing software, are currently performed in the organisations and therefore there would be no change. The respondents felt that there were significant costs regarding appraisal, including training, gathering data, analysing data and installing and maintaining tools. The

most substantial costs were perceived to be non-conformance or failure of a product or service to conform to specified minimum quality levels.

Figure 5:5 Impact of tangible costs of adopting CMMI®



	Substantial Cost	Some Cost	No Cost
Cost of Performance	6%	56%	38%
Cost of Prevention	14%	49%	37%
Cost of Appraisal	25%	61%	14%
Cost of Nonconformance	29%	43%	27%

In terms of the perceived value of the tangible costs, on average 88% of respondents believed that the costs were worthwhile. See Table 5:10. As outlined above, the non-conformance (failure) of a product or service to conform to specified minimum quality levels was not worth the cost involved.

Table 5:10 Assessing the value of the tangible costs

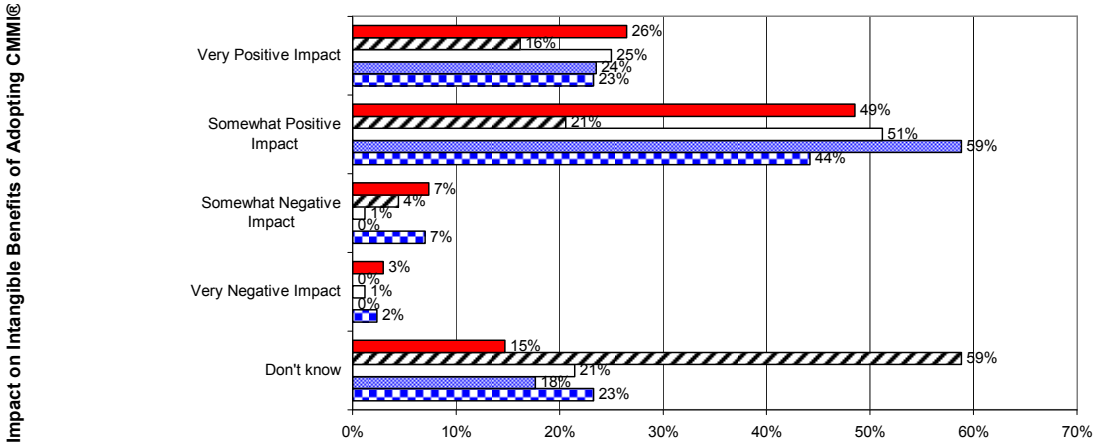
Cost category	Worth the cost	Not worth the cost
Cost of performance	99%	1%
Cost of prevention	94%	6%
Cost of appraisal	93%	7%
Cost of non-conformance	68%	32%
Average	88%	12%

5.3.5 The impact on intangible benefits of adopting CMMI®

A Likert-type scale tested respondents' perceptions regarding the extent to which the adoption of CMMI® had an impact on intangible benefits. Respondents were asked to select benefits across five categories (quality of life/working conditions, organisational communications, organisational learning and efficiencies, ability to attract and retain software professionals and organisational culture). The results are presented in Figure 5:6.

Results showed that across the categories a total of 23% perceived there to be a very positive impact, 45% a somewhat positive impact and only 5% perceived a negative impact in some way. In terms of categories, the most perceived benefits were in organisational communication, learning, efficiencies and culture. There was perceived to be less of a benefit in terms of improved working conditions or the ability to attract/retain professionals, which in turn was influenced by general market forces.

Figure 5:6 Impact on intangible costs of adopting CMMI®



	Don't know	Very Negative Impact	Somewhat Negative Impact	Somewhat Positive Impact	Very Positive Impact
Coherent Organisational culture	15%	3%	7%	49%	26%
Ability to attract software professionals	59%	0%	4%	21%	16%
Organisational learning & efficiencies	21%	1%	1%	51%	25%
Organisational communications	18%	0%	0%	59%	24%
Quality of working conditions	23%	2%	7%	44%	23%

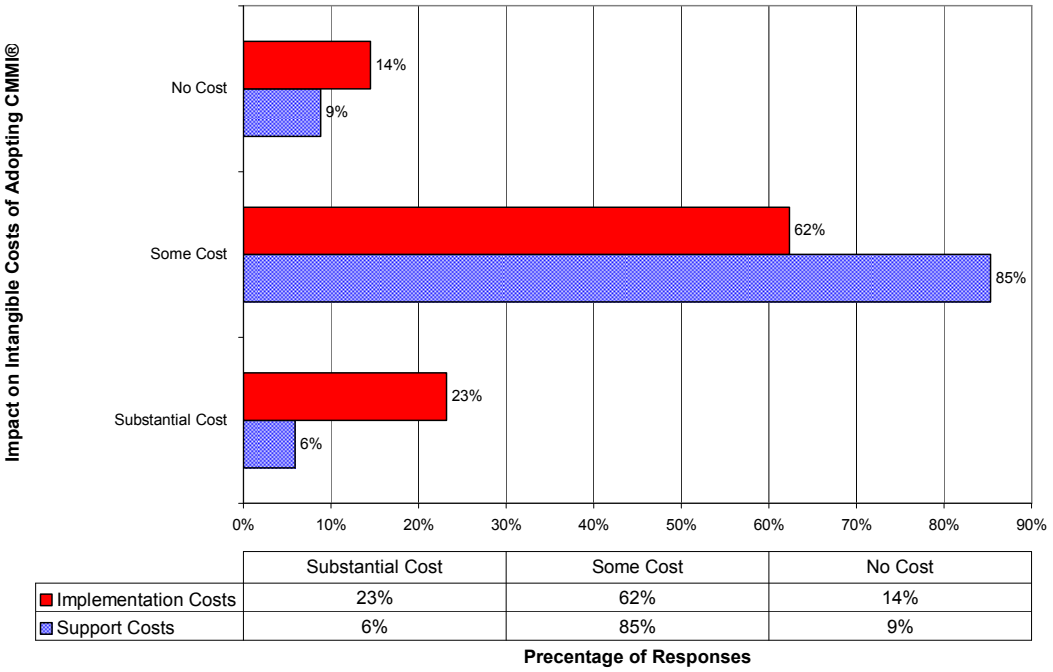
Percentage of Responses

5.3.6 The impact on intangible costs of adopting CMMI®

A Likert-type scale tested respondents' perceptions regarding the extent to which the adoption of CMMI® had an impact on intangible costs. Respondents were asked to select benefits across two categories (implementation costs and support costs). The results are presented in Figure 5:7.

The results showed that 12% of respondents perceived there to be a no-cost impact, 74% perceived there to be some cost and 15% perceived a substantial cost. In terms of categories, the respondents felt that with regards to implementation that the majority of intangible costs revolved around dissemination, communication and motivation. With regards to support, costs verification and enforcement costs were most significant.

Figure 5:7 Impact of intangible costs of adopting CMMI®



In terms of the perceived value of the intangible costs, on average 98% of respondents believed that the costs were worthwhile. See Table 5:11.

Table 5:11 Assessing the value of the intangible costs

Cost category	Worth the cost	Not worth the cost
Implementation costs	98%	2%
Support costs	97%	3%
Average	98%	2%

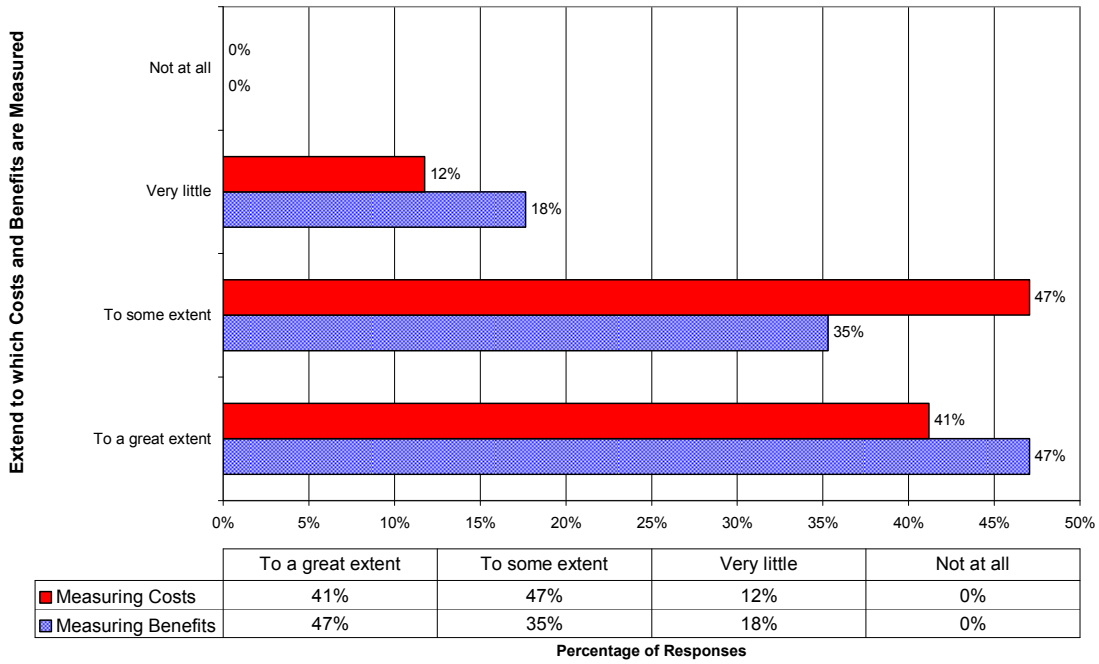
5.3.7 Extent to which costs and benefits were measured

A Likert-type scale tested respondents' perceptions regarding the extent to which the costs and benefits of adopting CMMI® were measured. The results are presented in Figure 5:8.

The results showed that 44% are measuring the costs and benefits to a great extent, 41% to some extent and 15% to a small extent. These results were expected as this is a pilot study and both carry significant costs as well as impact in

terms of organisational change. Respondents were then asked to choose, from a list of detailed financial metrics, which metric they use to measure the benefits. These results are shown in Figure 5:8.

Figure 5:8 Extent to which costs/benefits are measured

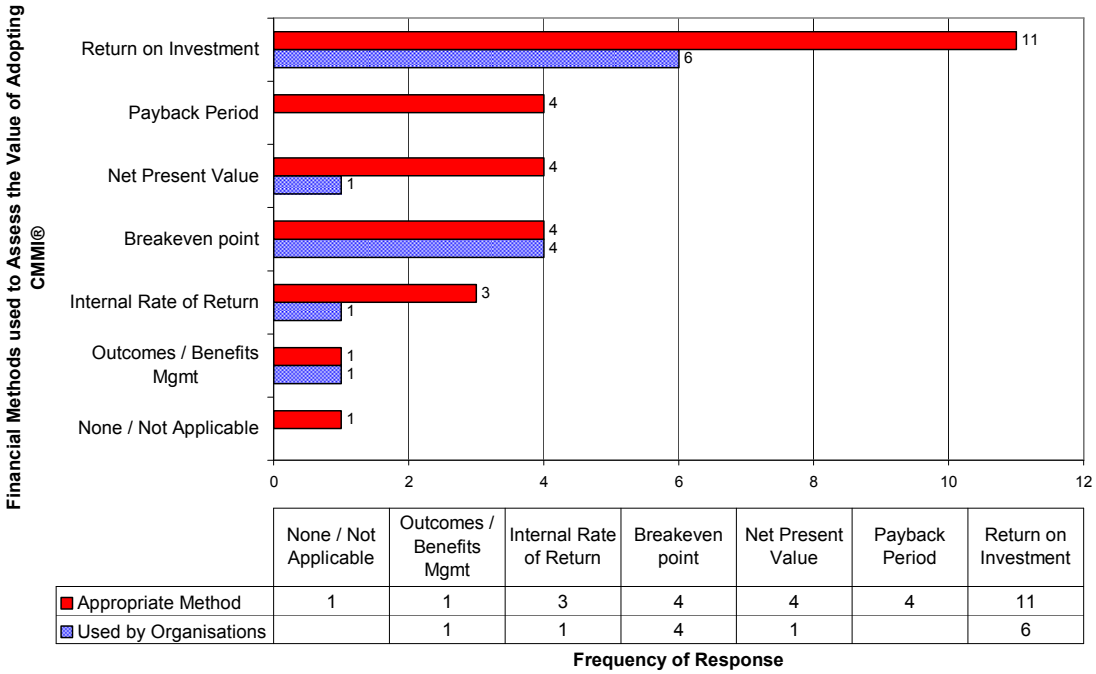


5.3.8 Method for evaluating the business value of CMMI®

Respondents selected a combination of the financial metrics presented. The results are presented in Figure 5:9.

The results showed that 39% of respondents indicated that return on investment (ROI) would be an appropriate financial metric in their calculations. Break-even point, net present value and payback period each represented 14% of responses. Of the respondents who selected ROI, just over half are actually using it in assessing the business value of CMMI® whereas all the organisations who selected break-even point are using it.

Figure 5:9 Methods to assess the value of CMMI® adoption

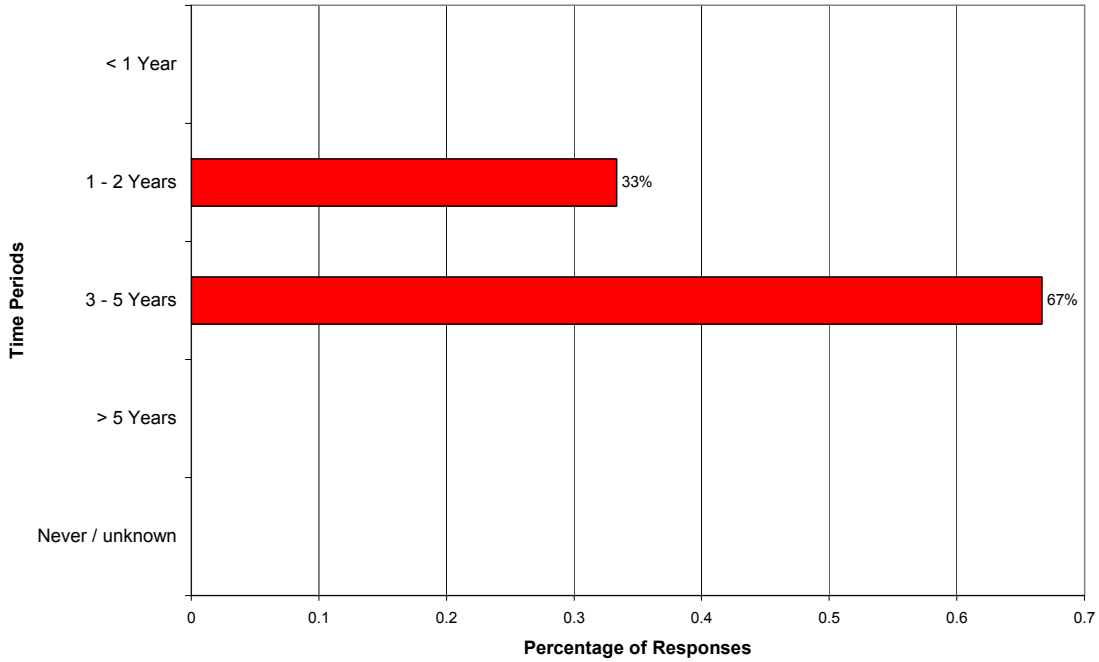


	None / Not Applicable	Outcomes / Benefits Mgmt	Internal Rate of Return	Breakeven point	Net Present Value	Payback Period	Return on Investment
Appropriate Method	1	1	3	4	4	4	11
Used by Organisations		1	1	4	1		6

The respondents were then asked when they would expect to achieve the business goals from adopting CMMI®. The results are presented in Figure 5:10.

The results showed that 66% are expecting returns in three to five years, while the remaining 33% are expecting returns in one to two years. It appears that adopting CMMI® is expected to be a medium to long term exercise for organisations. There are, however, risks faced by organisations which would hamper its success. This is explored in Section 5.3.9.

Figure 5:10 Time to achieve the business goals from adopting CMMI®



5.3.9 The key risks faced by organisations in adopting CMMI®

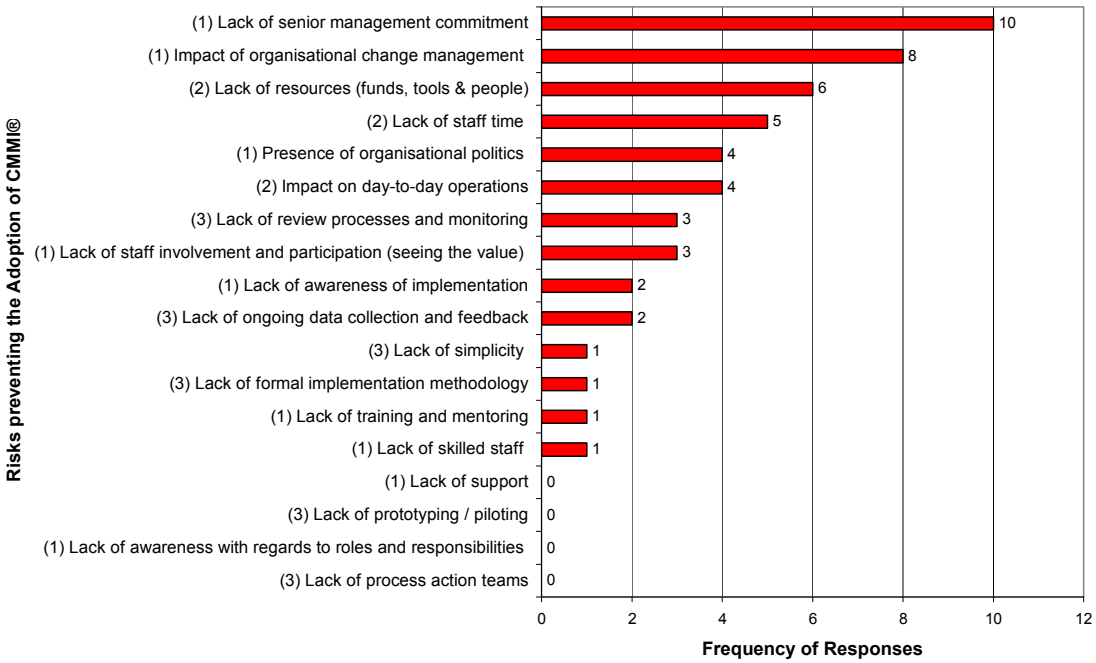
Respondents were asked to select all applicable risks from a list and were then asked to narrow their selection down to their top three reasons. The results are presented in Figure 5:11 which rank the frequency of responses.

Results showed that respondents selected multiple reasons from the options contained in the questionnaire. While the primary risk areas appeared to include a lack of senior management commitment and the impact of organisational change, three distinct respondent type clusters were found in the analysis:

- Fifty seven per cent of the responses related to issues around people such as participation, leadership and communication.
- Twenty nine per cent of the responses related to issues around resources such as time, funds and skilled people.

- Fourteen per cent of the responses related to implementation or adoption factors such as methodology.

Figure 5:11 Risks faced with the adoption of CMMI®

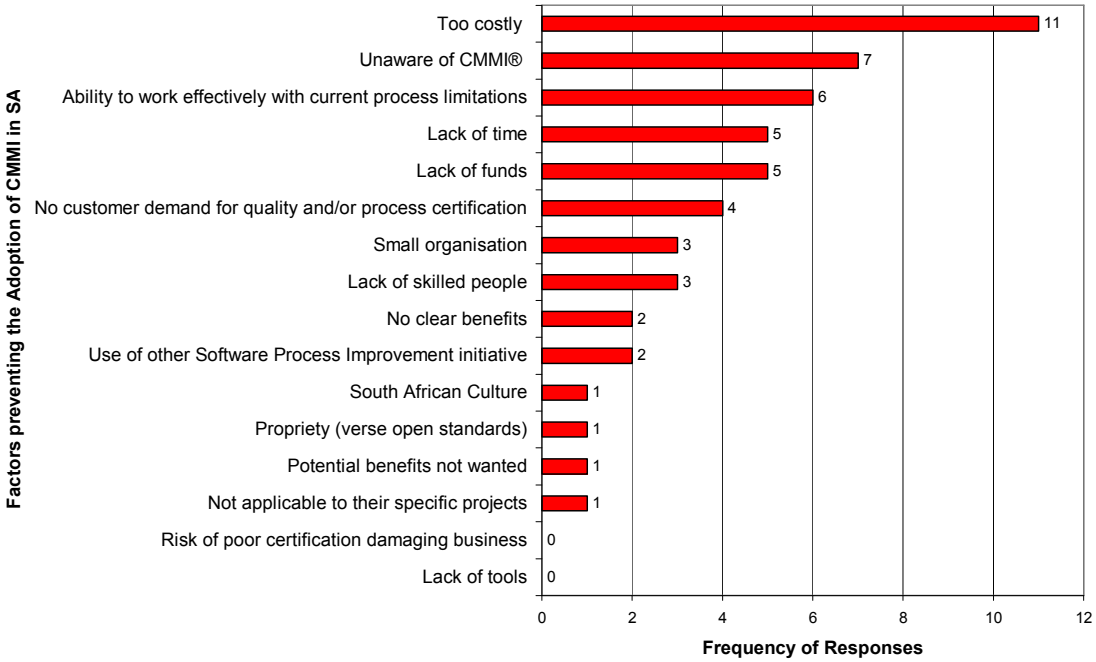


5.3.10 Factors preventing the adoption of CMMI® in SA

Respondents were asked to select all applicable factors from a list and were then asked to narrow their selection down to their top three reasons. The results are presented in Figure 5:12 which ranks the frequency of responses.

Results showed that respondents selected multiple reasons from the options contained in the questionnaire. While the primary risk areas appeared to be cost and a lack of awareness of CMMI® in South Africa, other key factors appeared to be the lack of demand for quality standards or process methodologies, both internally with an emphasis on quality and externally from potential customers.

Figure 5:12 Factors preventing the adoption of CMMI®



5.4 Conclusion

The objective of the research was to assess the business value of adopting and implementing a software process improvement initiative using CMMI® by organisations in South Africa. The research results from both the semi-structured interviews and questionnaires have been stated in this section. Results showed that most respondents perceived there to be significant tangible and intangible benefits in adopting CMMI® and where there were costs, they were worthwhile. There were, however, key risks such as the lack of managerial support, that the respondents felt would hamper the successful adoption of CMMI®. Regarding the widespread adoption of CMMI® in South Africa, the respondents had reservations regarding the cost, the impact on organisational change especially on the type of culture found in South African organisations and, ultimately, the lack of demand for such standards from customers.

The results revealed that while there is a role for CMMI® in the South African software sector, is appears to tie in most with organisations whose strategy involves serving, or planning to serve, the international market and organisations in niche industries where quality is a key criterion even before price.

The following chapter discusses the research questions posed by the study using an analysis of the research results in the context of the literature review.

6 DISCUSSION OF RESULTS

6.1 Results in terms of research questions

This chapter synthesises the key observations identified in the literature in Chapter 2 and the research results, both semi-structured interviews and questionnaire, from Chapter 5 to the research questions as set out in Chapter 3. This discussion is structured in the following sequence:

- Findings on the research questions (Subsections 6.2.1 to 6.2.6)
- Conclusion

6.2 Findings on the research questions

This section serves two purposes. Firstly, the discussion of the results will establish whether this research project has answered the research questions posted in Chapter 3. Secondly, the discussion of the results will establish whether they support or challenge the information stated in the literature review.

6.2.1 Discussion of research question one

What are the key business drivers for the adoption of CMMI® in South Africa and how is the impact on business performance measured?

The respondents were asked to describe how adopting CMMI® is expected to add value to their organisations. From the semi-structured interviews, as illustrated in Table 5:7, two clear areas were identified. Firstly, the respondents hoped to increase their ability to win new business either locally or internationally by being more marketable using the maturity rating certification and secondly, to increase their ability to create internal efficiencies through process standardisation and

developing a culture of quality improvement. To give an indication of how adopting CMMI® would position them to win new business one respondent stated:

> The immediate benefits are in marketing to get more customers. We will now be able to give international clients the confidence that we have CMMI, we use best practice and show thought leadership to our customers. First preach, and then practise what we preach.

Another respondent had a different perspective on how the adoption of CMMI® would position them to win new business:

> The market is getting more and more competitive, and we need to find a niche through quality and using good software architectures.

Regarding the creation of internal efficiencies one respondent stated:

> The focus of adopting CMMI is on running the business better. By addressing inefficiencies in our organisation, it has provided the opportunity to do things better.

The results of the semi-structured interviews were supported by the results from the questionnaire, which also fell into two distinct response categories. See Figure 5:2. Those respondents who were internally focused, up to 65% of the responses, adopted CMMI® for the expected increases in process efficiencies, more predictable development results and improvements in productivity and quality. The second cluster of responses, 27%, were more externally focused and appeared to be motivated to improve customer satisfaction, increase competitive advantage and improve their public image.

While the two reasons why organisations are adopting CMMI® seemed clear, debate arose around the actual motivations and approach. Some of the organisations, although a minority, appeared motivated simply to secure the maturity rating certification, particularly as a marketing tool, while other organisations regarded the benefits of CMMI® as part of a more long-term and sustainable strategic programme. Finally, the majority of organisations saw CMMI® as just another framework that can be used to assist them improve quality and process. With regards to this debate some of the comments made by the respondents included the following:

> It's being adopted for all the wrong reasons. If you are chasing the level, you are going to fail.

> The focus is not getting the rating but rather how it can assist in furthering the achieving strategy. As ensuring growth is one of the ultimate reasons we need to be stable before we can grow.

> CMMI is not the alpha omega (silver bullet); it's just a tool to help you.

While it may be possible to achieve both objectives through the adoption of CMMI®, it appeared that only if there is first an increase in process efficiencies, more predictable results and improvements in productivity and quality, can there be an increased ability to win new business, either locally or internationally, by being more marketable using the maturity rating. In support of Ling Sim and Chye Koh (2001), the long-term survival of a business depends on meeting market needs through a long-term value creation process, so only if the short-to-medium term

objective of CMMI® adoption is ongoing improvements in productivity and quality, can the long-term objective of survival be achieved.

As outlined by the Porter's value chain (1985), for a business to establish and defend its competitive advantage, the individual activities of the business (the value chain) need to contribute to its overall competitive strategy. In terms of Porter's value chain, organisations appeared to regard CMMI® adoption as an opportunity to address the primary activities of service, marketing and sales as well as operations, all key in driving sales. Bowman and Ambrosini (2007) describe these as Type 1 (activities involved in the production of goods and services) and Type 2 (activities related to the marketing and selling of Type 1 activities). Both Type 1 and Type 2 activities are primary activities and must be closely coordinated to become responsive to the external environment as well as internally to ensure internal efficiencies. This is particularly true for some of the respondent organisations that plan to export their products and services or for local organisations that are part of a multinational where CMMI® has become a global standard and therefore process management (such as CMMI®) is an integrative means of fostering a match between internal and external environments as outlined by Christopher *et al*. (1993).

Regarding the measurement of performance against these objectives, respondents were asked to select all applicable goals and measures on a balanced scorecard (Kaplan and Norton, 1986) used to track the impact of adopting CMMI®. Results showed that the measurement of the impact on internal business processes dominated followed by the impact on customer satisfaction and the financial impact. Based on the responses, the least important area of impact was learning and growth. Based on the nine criteria in the EFQM Excellence Model (EFQM, 2008),

the process criterion becomes the key enabler that organisations can manipulate through the adoption of CMMI®.

In summary, CMMI® adoption, based on the responses, is therefore expected to satisfy Garrison and Noreen's (1997) two approaches to improving profitability, firstly by increasing volume and total revenue by increasing the ability to compete for new business while maintaining relative variable and fixed costs, and secondly through efficiencies. Based on the research findings and relevant literature, these two key drivers each with their accompanying goals and metrics are outlined in Table 6.1.

Table 6:1 Key business drivers and metrics for CMMI® adoption

(Adapted from: Liu *et al.*, 2006, Hunter *et al.*, 2008)

Key driver	Description of driver	Key performance metric
Improvements in running the business	The focus is on supporting or improving essential, non-differentiated business functions that do not directly produce revenue	Improving price-to-performance ratios and lessening risk: • Improved product quality • Reduced cost of development • Increased productivity • Reduced cost of rework • Reduced organisational costs
Improvements in growing the business	The focus is on enhancing, extending or differentiating existing business capabilities related to products, services or markets	Improvements in operations and performance that are visible to shareholders and customers: • Reduced time to market • Increased ability to compete for new business • Increased revenue from sales • Improved customer satisfaction ratings

6.2.2 Discussion on research question two

How does process improvement, using CMMI®, affect South African software organisations?

According to Davenport (2005), standardising processes internally facilitates how the business operates, enables smoother handoffs between process boundaries and allows for comparative measures of performance. Davenport (2005) further defines process management standards as a process type which is based on the assumption that good process management will result in good process flows and performance.

Based on the results of the research, the adoption of CMMI® supports such positive process outcomes. According to the results, the use of the CMMI® framework assisted organisations to identify gaps in their existing processes, improve the quality of plans and estimates, improve quality through less defects and define more streamlined, end-to-end processes with improved productivity. See Table 5:5. As part of the CMMI® framework, assessments called SCAMPIs (CMMI®, 2001 as cited by Staples *et al.*, 2006), are performed in specific areas of the business. These assessments benchmarked current processes against the model and identified where there were significant gaps. The SCAMPIs assisted the organisations to identify if and where there were significant gaps in their existing approaches, where the key risk areas were in their processes against a best practice model and where they should therefore focus their attention. Some of the respondents described the outcomes of the adoption process as follows:

> The use of CMMI prevents anything going wrong on projects. You are able to see where you slipped up on the methodology. It is not that the methodology is at fault, rather that it wasn't adopted correctly.

> The use of processes influences better quality to the client. Managed against the methodology, our delivery is on time.

> In order to create stability for software I need to create stability for department, primarily through process and project management, managing people time, schedules, resource planning etc.
>
> We got to see the warts and see where we were.

Adopting the CMMI® model also assisted the organisations to address other challenges they faced when using process management. These challenges included the prevalence of a hero culture, especially in the software development environment, where individuals with expert knowledge and skills were often called on to ensure delivery, which in turn made the organisation dependent on them instead of having a process to ensure delivery. The structure provided by the adoption of CMMI® also provided for a defined process which offered benefits such as the elimination of hero culture in a project environment, counteracting any business interference with the software process activities and in some cases resulted in increased job satisfaction and retention through a structured work environment. One of the outcomes of implementing a process-led methodology was to eliminate heroism in the project environment. As stated by one of the respondents:

> Every project / company has heroes, and although it can succeed for some time, it does lead to failure when they leave.

Another organisation facing a similar hero culture issue was also faced by a lack of skilled resources, which made them even more dependent on their skilled resources. As was stated by one of the respondents:

> The problem with killing hero culture (through process) for us is that the average age of our senior developers is 48. There is no young blood. So if we put process in front of people, we could end up pissing off heroes and we cannot afford to lose them.

The adoption of a process addressed another challenge, that of preventing interference from another part of the business, as noted by a respondent:

> One of the primary motivations for CMMI is to stop the business factors from interfering with the software development practices. It doesn't matter how clever your software is or how well you are maintaining it, if your PM cannot manage a schedule and he over promises, it results in loss of quality and a great deal more overtime to deliver on schedule.

Related to the Shewhart cycle (Deming, 1993, p. 135) in the plan-do-study-act (PDSA) cycle for purposes of improvement, whereby Deming proposed that processes should be analysed and measured, the gathering of quantitative data as part of the process improvements in the CMMI® framework resulted in better developed plans and estimates. This links back to the adage, "If you cannot measure it, you cannot manage it." The collection of quantitative data such as development times and resource requirements provided a tangible input into understanding the complexity of projects. This resulted in better developed plans and estimates, as well as in tracking requirements, managing projects and building quality processes into project schedules. An outcome of the adoption of CMMI® was that it ensured a more structured and reusable end-to-end process including increased efficiencies, more streamlined projects, an improved ability to manage and mitigate risk and, importantly, an improvement in quality as quality issues and

defects were identified earlier as part the process. As an illustration of the practical effects on quality by the process, one of the respondents described it as follows:

> It was amazing. Our estimating on delivery dates had a variance of 4% (even though the allowance was 15%). In the beginning it was difficult but as soon as we started to use the data, our quality and estimation improved. We also had a way of estimating the number of defects based on statistics, the quality defect leakage.

However, not all the process outcomes were positive. Based on the results from the semi-structured interviews, there was resistance from project managers and software or application development teams to the adoption of CMMI® as it was not seen to add value. This is a key factor as highlighted by Dorenbos and Combelles (2004) but in some way contradicts Harrington (1991) who defines the objective of process improvement as simplifying and streamlining operational processes. See Table 5:6. Secondly, from a business perspective, the effort in terms of training time of skilled resources had yet to deliver a return and thirdly, there was the impact of the process changes on the organisation in terms of people, morale and even staff retention. One respondent stated:

> If the methodology is used as intended, then the project managers will see the benefits, but because of tight deadlines, budget and lack of skilled resources, they skip stages and milestones, and run risks instead of minimising risk. The project managers don't always see it as value adding.

The reasons for this were fourfold. Firstly, it appears that the impact on change management was underestimated, supporting the notion that "Too much attention has been paid to "what activities to implement" instead of "how to implement"

(Niazi *et al*., 2003, p. 1) the activities." Secondly, linked to this is the way the changes were implemented. Often, when CMMI® was imposed on the project team, it lacked buy-in. Thirdly, the new processes increased the workload of the project team without additional time set aside to do so. Finally, based on the responses, CMMI® was regarded very much as an internal organisational process improvement activity which the client was neither interested in nor was prepared to pay for. Another criticism of the process changes was the time taken to implement them and to see the benefits and that it took too long for the processes to be institutionalised.

In summary, while the respondents also identified negative aspects of the adoption of process changes, all the respondents felt that adopting the CMMI® process approach would have a positive impact on project delivery and on quality, truly demonstrating the process management principle as highlighted by Paulk (1997), which states that the quality of a product is governed by the process used to develop it. However, in one of the organisations the focus was on adopting CMMI® instead of focusing on the process benefits. Because of this dogmatic approach, a comment was made that CMMI® is a swear word in the organisation and that the recommendation from one respondent was to:

> Call it a process improvement initiative rather than CMMI. Our approach was not to use CMMI terminology, but rather to only refer back to see if everything is covered.

A second key impact from the process was how the effort to make the organisational change was generally underestimated. This resulted in the process never truly becoming entrenched in the organisation, particularly when projects abandoned the process during a crisis. As highlighted by Umarji and Seaman

(2005), part of the hard work in getting SPI working in practice is never to underestimate the impact of organisational change and to place greater emphasis on how the SPI model is implemented. Finally, process changes take time and it is only when process is made part of the day-to-day operations that the benefits will materialise. It is important to provide some evidence of visible success (Baddoo and Hall, 2001) to sustain momentum.

6.2.3 Discussion on research question three

Where, and to what extent, have the benefits and costs from the adoption of CMMI® determined its business value?

The results of the research into the benefits and costs of adopting CMMI® are explained according to their tangible and intangible impacts. Research data and insights gained from key informants confirmed that the organisations were gaining tangible benefits across all five categories (customer, financial, organisational improvement, process improvement and quality) from adopting CMMI®. See Figure 5.4. In terms of categories, the most perceived benefit was in process improvements, with 46% of the respondents indicating a very positive impact in this area, particularly in increasing the efficiency of the software development process, improving the capacity of project monitoring and ensuring an increase in quality for the end customers. This supports to some extent what Kan (1995) identified as the five major metrics classes for software, including software quality, reliability, quality management, structural design and customer satisfaction. The research data and insights gained from the research indicated that the organisations found the following effects on tangible benefits from adopting CMMI® as illustrated in Table 6:2.

Table 6:2 Nature of tangible benefits

Type of benefits	Examples of benefits	Highlighted in literature review
Quality	Early detection of defects Improved requirement satisfaction Lower failure rates	Liu *et al.* (2006) Crosby (1979)
Process	Improved capacity of project monitoring Reduced redundant work Improved efficiency of development process	Ashrafi (2002) Davenport (2005) Gibson *et al.* (2006)
Organisational	Improved organisational reputation Improved organisational productivity	Withers and Ebrahimpour (2000)
Financial	Reduced project costs Increased opportunity of winning contracts	Liu *et al.* (2006) Hotle and Iyengar (2006)
Customer	Increased on-time delivery Improved customer satisfaction	Withers and Ebrahimpour (2000)

The results also showed a somewhat negative impact in terms of organisational improvement in 10% of the responses. This could possibly be explained by the negative impact change has on employees when challenging the status quo, especially if the organisational change is not managed. One respondent described the manner in which they successfully addressed the impact of change as follows:

> Instead of implementing CMMI centrally, we identified a representative from each of our project teams as the thought and change leaders. They defined the process and the process was not imposed on them. Using this approach we noticed the internal silos disappearing as the different team areas are talking to each other. Clients are impressed with the change.

Similarly, across the four categories of intangible benefits (quality of life/working conditions, organisational communications, organisational learning and efficiencies, and organisational culture) the results shown in Figure 5:6 revealed an overall positive impact. In terms of categories, the most perceived benefits were in

organisational communication, learning and efficiencies, with 24% of the respondents indicating a very positive impact and 59% a somewhat positive impact. Other areas where there was an impact on intangible benefits included an improvement in a more coherent organisational culture and improved organisational communications. This not only brought about an awareness of quality but also encouraged participation throughout the organisations. In term of the stimulating change, one respondent described the impact as follows:

> Even before a full process implementation is done it triggers a thinking process within the organisation.

In terms of the impact on an organisation's ability to attract and retain software professionals, a factor identified by Hyde and Wilson (2004), many of the respondents felt that they were not in a position to comment, although based on a more negative experience, one respondent commented:

> We did have some people leave. There is always about 10% of people who don't want to implement the process as they are not suited to working in a process-led environment. We usually move them to a more operational environment.

Results from the questionnaire revealed the following key intangible benefits resulting from the adoption of CMMI® and supported by the literature as shown in Table 6:3.

Table 6:3 Nature of intangible benefits

Type of benefits	Examples of benefits	Highlighted in literature review
Quality of	More stable work environment	Hyde and Wilson (2004)

Type of benefits	Examples of benefits	Highlighted in literature review
life/working conditions		
Organisational communications	Improved communication downward from management	Shin (1999) Hyde and Wilson (2004)
Organisational learning and efficiencies	Enhanced awareness of quality in the organisation Improved understanding of how the organisation develops software	Chrissis *et al.* (2003)
Organisational culture	Participation in process improvement activities	Umarj and Seaman (2005)

As reflected in both Table 5:4 and Table 5:5, a significant number of respondents stated that they were not yet aware of the tangible or intangible benefits. The reason for this could be twofold. Firstly, the South African CMMI® pilot programme has only being running for a year. Secondly, as highlighted in the literature (Carnegie Mellon: Software Engineering Institute, 2008) where a change from level 2 to level 3 maturity takes 17 months, given that many of the pilot organisation are only 6 to 10 months into the pilot programme, this supports the notion that the benefits will only materialise later when the processes are matured in the organisation. As one respondent stated:

> CMMI will make an improvement, but it costs a lot of money and time from the level 2 to the level 3 maturity cycle.

In terms of cost, respondents were asked to select benefits across four categories (cost of performance, cost of prevention, cost of appraisal and cost of non-conformance), based on Crosby's cost of quality model (Crosby, 1979). The results shown in Figure 5:5 highlighted that at least half the respondents perceived there to be some cost and 18% substantial cost, with the most cost in terms of the cost of appraisals, which is related to the SCAMPI process. In terms of categories, there was the least impact in the cost of performance as many of the practices, such as

designing, developing and testing software, are currently performed in the organisations and therefore there would no change. The respondents felt that there were significant costs regarding appraisal, including training, gathering data, analysing data and installing and maintaining tools. In support of CMMI® adoption, the most substantial costs were perceived to result from non-conformance (failure) with quality or process standards. Not adhering to the CMMI® framework resulted not only in lower quality or performance standards but also in higher costs.

In terms of the intangible costs, Shin (1999) highlights costs in terms of the intangible and intermediate benefits as the justification process for IT investments. The respondents were asked to select costs across two categories (implementation costs and support costs) in terms of the benefits they bring. As outlined in Figure 5:7 over 60% perceived there to be some implementation costs and 85% some support costs, including costs for verification, enforcement and external support services. Twenty three per cent of the respondents felt that there were substantial implementation costs, particularly in training and dissemination and the opportunity cost of having staff dedicated to the CMMI® process. But was it worth it? The results indicated that on average 98% of the respondents felt that it was worth both the tangible and intangible costs, based on the benefits they received in return.

The results showed that the majority of the respondents were actively measuring both the costs (41% to a great extent) and the benefits (47% to a great extent) of the adoption process as shown in Figure 5:8. The results also showed that the respondents suggested several different financial metrics to measure the value of the adoption as shown in Figure 5:9, with return on investment (ROI) appearing to be the most popular method. However, only half were actually using ROI to assess the business value of CMMI® whereas all the organisations who selected break-

even point were using it. One of the factors explaining this could be that research conducted by the SEI on organisations that adopted CMMI® had already demonstrated a positive ROI (Gibson *et al*., 2006), together with the fact that it is difficult to use the ROI for a long-term CMMI® benefit case as it averages out the profit over successive years when projects with higher initial profits should actually take preference (Burke, 2003).

As this is a pilot study there needs to be a clear business case built to support the further roll-out or support of CMMI® going forward. What did appear from the research was that very few of the organisations are actually using a specific financial measurement. These results suggested that although the respondents were carefully measuring the extent of costs and benefits of CMMI®, there was no clear use of a financial metric being used to translate that measurement. Although the reasons for the adoption of CMMI® addressed primary value-adding activities and the expectations were high, the organisations have not as yet built their own robust business case to measure the success of the adoption. Without clearly defined numbers, it results in perceptions regarding the value of adopting CMMI® or as one respondent phrased it:

> We have a better quality of delivery in software solutions primarily through an improved quality of service and some efficiency benefits but this doesn't justify the effort and therefore makes the business case more difficult.

The respondents were then asked when they would expect to achieve the business goals from adopting CMMI®. The results presented in Figure 5:10 showed that 66% were expecting returns in three to five years, while the remaining 33% were expecting returns in one to two years. It appeared that adopting CMMI® was expected to be a medium to long term exercise for organisations. This has various

implications for the expectations of respondents. For example, one respondent stated:

> We underestimated the journey and one year down the line, we are no where closer to where we want to be.

Other respondents were more aware that benefits can only be expected in the longer term:

> It's difficult to assess to granular level without having the actual long-term benefit.

In summary, the adoption of CMMI® appears to have positively and tangibly affected the organisations in terms of customer, financial and organisational improvement, process improvement and quality benefits. Similarly, there were improvements in the organisations' intangible benefits such as the improved quality of life/working conditions, organisational communications, organisational learning and efficiencies, and organisational culture. In some cases the impact of change was negatively received, while in other cases the organisational change was not effectively managed.

In terms of cost, although there was some cost incurred, over 80% of the respondents felt that it was worth the cost in both the tangible and intangible cost areas. While many of the respondents appeared to be tracking both the costs and the benefits of the adoption, the financial returns were being less carefully tracked. The reason for this could be twofold. Firstly, this is a pilot study and is therefore a more artificial process than if the adoption had taken place under normal market conditions. Secondly, the actual benefits and costs are unknown as it is still too

early in the pilot study. This leaves the question on the value of adopting CMMI® open. On the one hand, there are organisations who regard CMMI® as a order winner and therefore have high expectations of what CMMI® will deliver as well as having a high concern about the costs. On the other hand, organisations who regard CMMI® as an order qualifier are more determined to achieve the benefits from CMMI® rather than be concerned about the costs. It appeared that the second group extracted more value from the CMMI® adoption process.

6.2.4 Discussion on research question four

What are the internal (organisational) and external (environmental) factors which would influence (support or hinder) the adoption of SPI using CMMI in South African software organisations?

South African organisations appear to face many similar issues of CMMI® adoption as has been highlighted in the research. In term of the supporting factors from the semi-structured interview, as highlighted in Table 5:8, two factors stood out from the responses. Firstly, respondents saw the adoption as an opportunity to use the international certification to improve the profile of organisations wanting to export their software globally as has been successfully illustrated by the Indian examples (Australian Government: Austrade, 2007). As one respondent said:

> We are expanding the business and the next market will be international, and so it will be in the future.

> We are already seeing the barriers by not being able to receive outsourced work or compete internationally. This limits our global expansion. There is therefore pressure to accept global best practices.

Secondly, organisations in niche industries such as defence and mining require quality and process standards to compete and therefore CMMI® becomes an order qualifier and not an order winner. As the respondents described it:

> You have to ask yourself, which industries have no tolerance for defects? Zero-defect type organisations. NASA and defence for example, the fact that CMMI is used in these industries is proof itself. It cannot be used in organisations that follow the Bill Gates syndrome, where software is released with 100s of millions of defects and the world is used as his testing team, for them quality is not critical.

> In defence it is essential; you need to be open about processes.

> Clients will start shopping, CMMI could be a connection.

Interestingly, some organisations felt that although domestic support through the DTI and the JCSE was a positive factor, many felt that the support was neither sufficient nor sustainable in the long term as the JCSE does not have the capacity to drive CMMI® in South Africa.

In terms of hindering factors as shown in Table 5:9, the majority of respondents felt that the process of adopting CMMI® was too costly, particularly for South Africa organisations. For many organisations the significant costs were difficult to justify despite the efficiency returns. In some cases, particularly with smaller organisations, it was felt that it would difficult to provide the necessary resources.

Key factors identified in the literature but not highlighted as hindering factors in the research included the lack of:

- reward structures or incentives (Umarji and Seaman, 2005)
- champions or advocates (Umarji and Seaman, 2005)
- creating process action teams (Niazi *et al*., 2004).

An interesting factor was that CMMI® was seen as not being appropriate to the South African way or culture as it was in India. While the aspect of cultural awareness was raised in the literature by Guerrero and Eterovic (2004), this illustrated not only the huge effort required to create an organisational change towards the new process driven format but also a breakdown of the hero-type culture, which was prevalent in many of the organisations researched. The issue of culture was raised numerous times as described by one respondent:

> It works in India because it is a different culture – to drive it is a culture thing. Africa is different.

The findings of the questionnaire regarding the risks associated with the adoption of CMMI® are presented in Figure 5:11. The primary risk areas appeared to be a lack of commitment on the part of senior management, as highlighted by Niazi *et al*. (2004) and the impact of organisational change. This supports the notion by Dorenbos and Combelles (2004) that problems facing the adoption are not technical, but rather relate to people, and team and community culture and behaviour. It appeared that often the drive for CMMI® adoption did not come from senior management, but as in the case of some of the respondents, it either come from the software development team or from an internal quality department or unit. Organisations that formed part of an international company often had policy standards for quality in place. These often stipulated the use of frameworks such as CMMI®. However, despite the policy, enforcement was often an issue.

Factors relating to the management of organisational change, including the issues concerning people such as participation, leadership and communication, appeared as distinct factors affecting the successful adoption of CMMI®. The respondents often stated that they underestimated the impact of the organisational change of the adoption to the point in some cases where people actually left the organisation. This is similar to what Davenport (1996) states when he highlights people's resistance as a major obstacle to BPR's successful implementation. A failure to ensure that staff are involved and participate in the process makes it more difficult for them to see the value of the CMMI® adoption process. Change cannot be imposed and therefore, just like any other change implementation, it should be carefully planned, possibly piloted first and allowed to have a medium to long term period to mature. As some of the respondents put it:

> Organisations can only take a certain amount of change in one shot. Need to do constant sanity checks. Too much change can be disastrous.

> Need to focus on the people side. You can have the best process framework, but if you don't have the support of the people and don't do the training and development part it will not work, guaranteed. You can be successful without proper processes in place but it's not sustainable.

Other key risk factors facing the adoption of CMMI® related to having the resources available and/or committed to the adoption process. This included a lack of funds, people and tools and the potential impact on the day-to-day operations of the business. Almost a third of responses related to issues of resources such as time, funds and skilled people, which not only reinforced the importance of having senior management commitment, but also created a potential limitation based on the size of the organisation. Larger organisations have a deeper specialisation of resources

as well as a greater amount of funding, while smaller organisations face the challenge of having individuals performing multiple tasks. In this scenario, the role of quality or process leader cannot be played by a single person.

A third key area of risk as highlighted by (Niazi *et al*., 2003) related to how much attention was paid to ''what activities to implement'' instead of ''how to implement'' the activities. Part of the hard work in getting SPI working in practice is related to how CMMI® is adopted, i.e. the methodology and approach.

In terms of factors preventing the adoption of CMMI® as highlighted in Figure 5:12, the primary risk area appeared to be its cost. As some of the respondents highlighted:

> It's still too costly and it is expensive for Africa.

> CMMI is a ticket to play the game, but it's an expensive ticket.

> Small businesses cannot spend this kind of money.

Cost, along with the proprietary nature of CMMI®, were not identified as hindering factors in the research. This was interesting from two perspectives - firstly, the fact that this internationally based certification which also requires training is costly, and secondly, that cost should be related to value. It appeared that for the costs involved not enough value was being delivered. Other key reasons from the research included a lack of awareness of CMMI® in South Africa, a lack of demand for quality standards or process methodologies from clients, essentially no customer demand, and finally issues relating to its not being relevant to smaller companies or to the South African, as opposed to the Indian, culture for example.

In summary the key factors affecting CMMI® adoption in South Africa based on the research findings and relevant literature, are outlined in Table 6.4.

Table 6:4 Factors affecting the adoption of CMMI®

Factors	Internal (Organisational)	External (Environmental)
Supporting factors	• Increasing demand for quality/maturity certifications • Complementary with other standards such as ISO, COBIT etc • Need to catch up with competitors in terms of international quality standards • Ability to learn from other experience globally • Ability to address hero culture through process	• Opportunity to raise South Africa's software development profile in niche industries (defence, aerospace and mining) • Internationally proven/accepted framework • Supported by government through DTI and JCSE • Presence of global organisations using CMMI® in South Africa • Opportunity to address threat of outsourcing/increased global competition
Hindering factors	• Ability to work with current processes • Lack of resources/inability to commit resources • Impact of change management • Not applicable to South African organisational culture • Lack of senior management commitment • Lack of formal implementation methodology • Not applicable to all industries or projects • CMMI® is perceived as not a real differentiator	• Lack of awareness of CMMI® locally • Lack of customer demand for quality / maturity certifications • Too costly • Propriety (US based) • Relevance to smaller organisations • Limited capacity in South Africa to support and sustain CMMI®

6.3 Conclusion

This chapter discussed the results and findings of the study in detail. Results showed that the reasons why organisations are adopting CMMI® included firstly, a focus on improving business operations through productivity, process and quality improvements and secondly, a focus on growing the business by differentiating

their offering, both through the marketing value of maturity rating certification as well enhanced customer delivery.

In terms of expectations, while some organisations regarded the adoption of CMMI® as a marketing tool, other organisations regarded the benefits of CMMI® as part of a long-term and sustainable strategic programme. However, the majority of organisations perceived CMMI® as just another process or quality framework together with other measures such as ISO that would assist them to deliver best practice.

The impact of adopting such a process-led initiative had both positive and negative implications for organisations, but overall it provided a useful framework with which they could understand where they currently stand in terms of best practice while also providing direction for further improvement.

Managing the organisational change involved in the process was generally underestimated and poorly managed. Shortcomings of the existing adoption approaches not identified by this research were highlighted and suggestions were made to improve the management of the organisational change aspects.

This research identified various tangible and intangible benefits and costs relating to the adoption of CMMI®. Both the tangible and intangible benefits were regarded as positive while the costs appeared to have been identified and budgeted for. The research highlighted that the benefits of adopting CMMI® were expected in the medium term of two to three years. The research identified that although there were numerous approaches used to calculate the benefits of its BI implementation, it appeared that ROI was being used as the most popular financial tool to measure the value or return of the adoption. Finally, although there were many factors

supporting the adoption of CMMI® in South Africa, cost, lack of awareness, lack of demand and limited cultural fit could potentially hinder the uptake of CMMI® in South Africa.

The concluding chapter provides a summary of the research study and includes recommendations based on the findings. Suggestions for future studies in the field of software process improvement are also presented.

7 CONCLUSION AND RECOMMENDATIONS

7.1 Introduction

This chapter highlights the conclusions drawn from the research findings and is presented in four sections. The first section summarises the entire study and highlights the main findings of the research report. The second section provides recommendations based on the results obtained. Section three focuses on suggestions for future research in the field of SPI. The chapter ends with a conclusion.

7.2 Overall conclusion

In assessing the business value of software process improvement using CMMI® in South Africa, the business case framework, as developed from the literature and illustrated in Table 2:10, has five key steps which serve as a useful means of framing a conclusion. Each step is outlined below and is aimed at answering key questions in determining the potential value of allocating resources towards a particular goal or project, in this case the value of software process improvement using CMMI® in South Africa.

7.2.1 The business objectives and market need for adopting CMMI® in South Africa

As stated in the introduction to this research, technology today, particularly software, plays an ever-increasing and critical role in both the day-to-day business operations as well as becoming a lever of competitive advantage. This has led to an increase in the complexity of software development and the task of managing software delivery that has transformed the nature of software development and the

related IT services industry. Firstly, with the rise of global business consulting and IT services providers, IT services, including software development, can effectively be sourced, outsourced or off-shored to wherever it makes best business sense. In turn, factors delivered by the adoption of software process improvement such as quality, productivity and on-time delivery, not only improve the management of software development, but also reduce risk and translate into business success.

The business objectives driving CMMI® adoption in South Africa fall into two categories, namely improvements in running the business and improvements in growing the business. One respondent described it as compete versus survive. While there is an overlap between the two areas, each can be discussed separately.

Regarding improvements in running the business, the objective is to increase the firm's ability to create internal efficiencies through process standardisation and developing a culture of quality improvement. While this does not directly produce revenue, the adoption of CMMI® aims at improving essential business functions that in turn improve performance and lessen risk. Using Crosby's Cost of Quality philosophy, such improvements result in improved product quality and productivity and reduced costs in development and rework. Improvements are also made by removing organisational inefficiencies. The impacts of CMMI® on improvements in running the business are twofold. In the first instance, like implementing ISO, it becomes a best practice tool or methodology that is used by organisations to improve their operations and delivery. In the second instance, it is used more strategically to bring about organisational stability through process standardisation, which in turn allows for further growth and/or international expansion and leads to the second objective category.

With regard to improvements in growing the business, the objective of adopting CMMI® revolves around enhancing or differentiating existing business capabilities related to products, services or markets. The impacts of CMMI® on improvements in growth are twofold and relate to the positioning of quality or maturity ratings such as CMMI® as either being order winners or order qualifiers, terms coined by Terry Hill, professor at the London Business School (Hill, 2000). For South African companies hoping to increase their ability to win new business either locally or internationally by being more marketable using the maturity rating certification, it may be an order winner as it serves as a criterion that customers use to differentiate the services or products of one firm from those of another and it therefore increases their ability to compete for new business. This approach would be most applicable for South African organisations planning to export their products or services. However, with increasing numbers of existing global service providers already at CMMI® level 4 and 5, the benchmark has already been set. The impact of this is that a CMMI® rating just becomes an order qualifier as it defines performance dimensions according to which customers expect a minimum level of performance and will not, by itself, give a company a competitive advantage. This is most applicable for South African organisations in niche industries (defence, aerospace and mining) where there is zero tolerance for defects. That said, if improvements in operations and performance, such as reduced time to market, become more visible to shareholders and customers, it would translate into improved financial performance through an increased ability to win business as well as improved customer satisfaction ratings.

Therefore, while it is possible to achieve both objectives through the adoption of CMMI®, it appears that only if there is first an increase in processes efficiencies, more predictable results, improvements in productivity, lower development costs and higher product quality, can there be an improved ability to win new business

either locally or internationally by being more marketable using the maturity rating. However, certification ratings such as CMMI® are increasingly becoming an order qualifier.

7.2.2 Assessing the benefits and costs of adopting CMMI®

The adoption of CMMI® as a process-led improvement initiative can have both positive and tangible impacts, not only in the areas of process and quality improvement, but also with regards to financial and organisational issues such as improved productivity. Ultimately, by addressing the software development process using the CMMI® framework, there are improved results in project monitoring and control which result in an increase in quality of the product and a more satisfied end customer.

However, the change in the organisational environment can potentially have a negative impact, especially if the organisational change is not correctly managed. This supports the notion that it is the "how" and not the "what" that poses a challenge in the adoption of CMMI®. To address successfully the "how" requires both tangible costs in developing a change management plan with the use of external consultants for example as well as intangible costs such as facilitating meetings and internal communications.

Adopting CMMI® also affects the intangible benefits such as the improved quality of life or working conditions, organisational communications, organisational learning and efficiencies, and organisational culture. The process-led change creates a catalyst that encourages organisational communication to and from senior management, empowers employees to think about what they do and how it can be improved and assists in developing a more coherent organisational culture and stable work environment by encouraging participation throughout the organisation.

By bringing about an awareness of quality, it has highlighted the cost of non-conformance such as rework, client penalties and excessive post-implementation support and maintenance.

The adoption process does, however, carry some significant costs in both the tangible and intangible cost areas. Because many of the practices such as designing, developing and testing software are currently performed in the organisations and there would therefore be no change, the significant costs are to be found in the required investment in the SEI's / JCSE's appraisal and training for CMMI®, in developing, installing and maintaining gathering tools and managing and analysing data. Similarly, adopting CMMI® carries some intangible costs including implementation costs such as enforcement and external support services and support costs particularly in training and dissemination. The significant cost for organisations is in the resource, by possibly having someone dedicated to driving, managing and enforcing the CMMI® process in the organisation. Smaller organisations struggle with the opportunity cost of "losing" staff to the CMMI® process where they could be bringing in revenue for the organisation.

In assessing the true value of the benefits and costs, a period of at least eighteen months is required for a better evaluation. However, based on the experience thus far, it appears that there are real benefits and while there are costs, they are worthwhile.

7.2.3 Measuring the financial return of CMMI®

While there is no one single financial metric that can be used to measure the value of the adoption, using the return on investment (ROI) method appears to be the most accepted. One of the factors explaining this could be that research by the SEI on organisations adopting CMMI® has already demonstrated a positive ROI when

adopting CMMI®. A second factor is that having a CMMI® rating is becoming more and more an order qualifier and therefore a "ticket to play the game" as described by one of the respondents. A third factor worth noting is that the success of the adoption will be affected by factors such as the work environment, the economy, company culture, one-time events (such as downsizing) and a host of other variables. Returns in terms of the real benefits are expected in three to five years and it appears that adopting CMMI® is expected to be a medium to long-term exercise for organisations.

For example, when calculating the ROI for the adoption of CMMI®, organisations need to be aware that ROI studies are rarely calculated in a vacuum as outlined in the range of benefits and costs above. A broad range of measures to create an overall body of evidence in support of the calculation is required, based on the equation for calculating the ROI:

ROI = [(total gains – financial outlay)/(financial outlay)] × 100

By accepting that the estimation of the costs and benefits might not be perfectly accurate an approach that is simple, fast and involves all the various stakeholders. Such an approach would involve the following:

- Determining the specific role CMMI® plays in a specific environment, for example, an organisation with severe quality problems will have different goals and benchmarks to an organisation wanting to increase productivity.
- Recognising that while there are some significant tangible costs in terms of appraisal and training the benefits may remain less visible.
- Multiple stakeholders, including marketers and testers for example, need to be involved to identify both the tangible and intangible benefits of SPI.

- Calculate the trade-off between the financial outlay in terms of training, appraisal and the total gains in terms improved quality, less defects, increased productivity, on-time releases as well as increased revenue.
- The financial outlay will include ongoing annual support costs and therefore the ROI calculations should be run at least on annual timelines.
- Benefits can be quantified both in terms of value as well as effort saved (e.g. the cost of poor quality).
- The results of the ROI should therefore be communicated back to the team to ensure a common understanding of the program benefits.

7.2.4 Identifying and mitigating the risks of adopting CMMI®

The risks faced when adopting CMMI® in South Africa fall into three categories:

- Risks relating to people and organisational issues such as participation, leadership and communication
- Risks relating to the impact on resources such as time, funds and skilled people
- Risks relating to the adoption factors such as the implementation methodology.

It is interesting that one of the primary risks faced when adopting CMMI® appears not to be technical, but rather one that relates to people. A lack of senior management support for the adoption process seriously affects how the process changes are accepted and implemented. Senior management would possibly support the process more if they regarded the long-term benefits of adopting CMMI® as strategic and an opportunity to improve business value. With their support, the necessary resources in terms of funds, time and people can be unlocked to deliver on potential. The adoption needs to ensure that people come before the process. Without ensuring that staff are involved and participate in the

process, it makes it more difficult for them to see the value of the whole CMMI® adoption process. Change cannot be imposed and therefore, just like any other change implementation, it should be carefully planned, possibly piloted first and allowed to have a medium to long term period to mature.

Costs more than time and skilled resources are regarded as hindering factors facing CMMI® adoption. The costs of the appraisal and training, although localised through the JCSE, are still regarded as expensive. This stance reflects two interesting perspectives, firstly, that cost should be related to value, either through improved efficiencies or through the ability to win new business or both, and secondly, that CMMI® is still not widely accepted in South Africa, both in terms of demand and supply. Therefore cheaper standards such as ISO dominate and, until local clients demand it, only organisations that compete internationally or in niche industries such as defence will fully adopt it.

Another risk factor around cost is the applicability of CMMI® for smaller organisations which, although they have an advantage in terms of managing change, do not have the necessary deeper specialisation of resources and face the challenge of having individuals performing multiple tasks. In this scenario, the role of quality or process leader cannot be played by a single person.

A third key area of risk relates to how much attention is paid to "what activities to implement" instead of "how to implement" the activities. Part of the hard work in getting SPI working in practice is related to how CMMI® is adopted, namely the methodology and approach. Effort and resources are required to ensure that the adoption of CMMI® is not a half-hearted effort as this will cause more harm than good.

Finally, it was highlighted as part of the research that it is not possible to implement CMMI alone. This raised the important role government plays. In other parts of the world such as India and Ireland, the government provides an enormous amount of support for the ICTE industries. Therefore to ensure that the South African ICT industry can compete internationally, further intervention is required by the South African government to raise the awareness, importance and demand for quality standards locally.

7.2.5 Assessing progress and measuring the impact of CMMI®

Assessing performance when adopting CMMI® can take place in the follow two key areas. At a corporate level, a balanced scorecard (Kaplan and Norton, 1986) format assists with measuring the attainment of organisational goals and can be used to track the impact of adopting CMMI®. Measuring the impact on internal business processes and efficiencies resulting from the adoption of CMMI® leads to improved customer satisfaction and financial returns such as an improved ability to compete for new business and lower organisational costs. Improvements in performance that are visible to shareholders and customers include:

- reduced time to market
- increased ability to compete for new business
- increased revenue from sales
- improved customer satisfaction ratings.

The least important area of impact on the balanced scorecard appears to be employee learning and growth and this remains an area of debate: does or can process come before people? This will remain a challenge in the South African environment for three reasons – the generic nature of South African IT professionals who often have a variety of abilities, such as programming languages, secondly, the hero-type mentality that is very much a part of the work culture, and

finally, the limited number of IT skills which, in a high demand environment, have to be nurtured.

At a project level, process management through the adoption of CMMI® needs to be measured through positive process outcomes. The use of the CMMI® framework assists organisations to identify gaps in their existing processes, to improve the quality of the plans and estimates and to improve quality through less defects. Defining more streamlined, end-to-end processes has assisted organisations through improved productivity.

Process improvement has also affected the organisational culture in a more intangible but profound manner. The structure provided by the adoption of CMMI® provides for a defined process which firstly offers benefits such as the elimination of hero culture within a project environment and secondly, counteracts any business interference with the software process activities. In some cased it resulted in increased job satisfaction and retention through a structured work environment.

Improvements in running the business include price-to-performance ratios, lessening risk as well as:

- improved product quality
- reduced cost of development
- increased productivity
- reduced cost of rework
- reduced organisational costs.

7.3 Recommendations for management

As software process improvement initiatives and quality standards such as CMMI® become increasingly prevalent globally, the software development organisations in

the South African market will no longer face the question of whether or not a company should adopt SPI using CMMI® but when. The business case framework discussed in Section 7:2 highlights the benefits and costs of CMMI® implementation in South Africa. The key findings of this research were brought together and are represented as an overview model illustrated in Figure 7:1. The key areas of the model are:

- the objective of the adoption (operations or strategic)
- organisational factors
- environmental independent factors
- South African environmental dependent factors
- performance factors
- controls and mechanisms
- costs and benefits.

Each area is discussed in detail below Figure 7:1.

In addition, further recommendations for management are included in Section 7.4.8 and recommendations for other stakeholders, including government, are included in Section 7.4.9.

Figure 7:1 Overview of assessment model

(Adapted from: Rous and Putterill, 2003; Guerrer and Eterovic, 2004)

7.3.1 The objective of the adoption

It appears that there are two clear motivations in adopting CMMI® in South Africa – firstly, improvement in running the business which is more internally focused on operations and secondly, growing the business which is more externally and strategically focused. While CMMI® is an activity that adds value both internally and externally as highlighted in this report, the adoption of CMMI® can also be seen as an input and output process flow, with the process activities responsible for the transformation.

In this regard, it is recommended that to achieve the desired outcomes from CMMI®, the effort needs initially to focus on improving efficiencies in running the business as focusing on operational issues leads to improved quality. The aim of using the certification to increase the ability of the firm to win new business and reach international markets cannot be achieved without the necessary inputs and transformation.

7.3.2 Organisational factors

Organisational factors are regarded as those factors that are applicable to each organisation individually and directly and include the following:

- *Goals and objectives*: As outlined above, each organisation has its own reasons for adopting CMMI®. These goals must, however, be grounded in the fact that CMMI® is not a short-term objective and that there will be significant organisational change.
- *Types of industries or systems*: As highlighted by the research, the adoption of CMMI® is more prevalent in those industries and projects where quality comes before schedule and price, for example defence, aerospace and mining.

Organisations that develop large-scale systems that are mission critical should also consider CMMI® as a tool with which to ensure quality, guarantee performance and minimise risk. In these scenarios CMMI® would be an order qualifier. Organisations that are not in such industries or only develop smaller solutions could consider CMMI® as an order winner by first improving the operations of their business.

- *Organisation size*: It does appear that larger organisations are better equipped to manage the CMMI® adoption by having dedicated resources available. However, it also depends on the nature of the smaller organisation and who is driving the CMMI® process.
- *Budget and resources*: As highlighted in the research, CMMI® adoption, implementation and support is costly, both financially and in terms of time and effort. It is worth nothing that the adoption cannot be a half-hearted effort as this will cause more harm than good. Organisations must therefore clearly define expectations before the process starts, understand the costs involved upfront as well as the timing of the returns and the level of risk.
- *Age and experience level of staff*: One of the benefits of adopting a process-led approach is the elimination of the hero culture in organisations. As many organisations employ senior IT professionals who they cannot afford to lose, the impact of the change must be carefully considered.
- *Organisational structure*: Quality initiatives are often driven centrally through a quality team or department. For the adoption of CMMI® to make an impact, programme and project managers and team leaders must be involved and be responsible for the process.

It is recommended that organisations take note of how they measure-up to each of the organisational factors outlined above prior to adopting CMMI®. Each will have a

material affect on the nature and level of success of the adoption of CMMI® process.

7.3.3 Environmental independent factors

Environmental independent factors apply to all organisations who are considering adopting CMMI®. Two key areas to highlight here include firstly, the need for senior management commitment, both in supporting the programme as well as being accountable for its delivery and secondly, being aware of the changes that are going to take place in the organisation and proactively managing those changes. As an example, the Senior Management of one organisation participating in the South African CMMI® pilot went to the extent of hiring an external change management consultant to advise and prepare the organisation for the change process. This has been recognised as one of the reasons for the success of CMMI® in that organisation.

It is recommended that CMMI adoption process becomes a strategic board level initiative and that performance outcomes from the adoption are not supported by senior management by are directly linked to their individual performance deliverables and targets.

7.3.4 South African environmental dependent factors

In what way does South Africa differ from other countries in their adoption of CMMI® and what would hinder or support its success? Unlike countries such as India and Israel, the software development sector has not been significantly supported by the government. Possibly due to the cost of adopting CMMI® and the potential for it to support an export drive, many South African organisations are expecting further government commitment in terms of funds and resources. Initially, funding from the DTI supported the programme, but this is not sustainable

and it does not appear that there will be direct government funding in the future. Organisations will have to decide for themselves if they want the CMMI® "ticket to play the game", in which case they will have to fund it themselves.

Questions also exist in terms of the effectiveness of the local support through the JCSE. Organisations are concerned about its current capacity and long-term sustainability. However, having the JCSE in South Africa as a registered SEI partner is a first for Africa and offers a unique opportunity for organisations rather to partner with the JCSE than just regard it as another service provider.

The adoption of CMMI® together with South Africa's IT skills shortage is a double-edged sword. On the one hand, the adoption process eliminates the hero culture and allows for best practice to be implemented in a process arrangement, thereby eliminating the dependence on specific people. On the other hand, South Africa has limited skills in IT and there will therefore always be a certain amount of dependence on such individuals. It will be difficult to enforce a process change on them without running the risk of losing them.

Finally, and the most serious challenge facing the adoption of CMMI® in South Africa, is the cost that is influenced by the dollar-based pricing and the exchange rate. It is perceived that even at local rates obtained through the JCSE, the training and appraisals are expensive. Therefore, based on the previous point regarding budgets, organisations need to understand the costs involved upfront as well as the timing of the returns and the level of risk.

It is recommended that South African organisations that intend competing internationally, or those that operate in niche industries, recognise the importance of SPI using CMMI®, not only as part of their own growth strategy but is also to

benefit the entire South African software sector. Organisations need to form a community of practice around CMMI as an industry, and assist each other raising the awareness of CMMI and importance of quality across the industry.

7.3.5 Performance measurement factors

Performance measurement factors such as the balanced scorecard can assist with translating business strategy into actionable process improvements in an organisation. Monitoring the status of an organisation's balanced scorecard can be a straightforward way of ensuring that process improvements contribute to overall business value. As an example, the balanced scorecard framework provides a clear way of categorising and understanding business goals, the factors which affect achievement and common measures:

- *Financial*: business revenue, operational cost and market share
- *Customer satisfaction*: level of satisfaction, number of customers and depth of involvement with customers
- *Internal business processes*: practices and methods to develop, maintain and deliver products and services, as well as manage people in the organisation
- *Learning and growth*: people-related capabilities of the organisation such as technical skills of the staff, number of staff, level of domain knowledge, personnel retention and morale.

It is recommended that to fully benefit from improvements in process efficiency and quality initiatives such as CMMI, the outputs must be linked directly to the businesses performance measurements. The Balanced Scorecard provides a suitable framework to translate such process improvements into related financial, customer and learning and growth benefits.

7.3.6 Controls and mechanisms

Controls are defined as those aspects which guide or regulate the adoption process, whereas mechanisms include the systems, people and tools used to perform the process changes. Controls translate into performance standards such as a reduction in the number of defects or customer satisfaction surveys that need to be measured. Mechanisms translate into implementation and adoption plans, including the methodology for change management plans that need to be constantly evaluated.

It is recommended that the in adoption of CMMI clearly defined benefits and targets / goals are specific within each organisation. The monitored and tracked results must be presented back to the team to make them aware of the improvements and to ensure a common understanding of the program benefits within the organisation.

7.3.7 Assessing all benefits and costs

As outlined in the body of this research, there are both tangible and intangible benefits as well as costs involved in the adoption of CMMI®. Calculating total costs and benefits also needs to take into account the timing. How long will it take to start seeing the benefits or incur costs? A time/cost analysis therefore needs to be considered as well as the risk factor – how likely is it that the actual future benefits will vary from what they are projected to be?

Measuring both the benefits and the costs of adopting CMMI® is difficult, however, without the numbers on costs and benefits it's impossible to decide if it's worthwhile and value adding. It is recommended that a pragmatic approach is used to calculate ROI, one that involves all the various stakeholders within an

organisation in order to calculate a trade-off between the all the costs and benefits and obtain an ROI number to be used for communication purposes.

7.3.8 Further recommendations for management

Other recommendations for management regarding the assessment of the business value of adopting CMMI® include the following:

- A long-term success strategy for SPI entails that the right type of process innovation be applied to the right project, supported by appropriate training and deployed with realistic expectations.
- Half-hearted process improvement is extremely damaging as it undermines future improvement attempts.
- There are reasons to work towards the maturity level grading for larger organisations, those competing internationally or in niche industries. However, it is important to encourage process-led, quality-improvement thinking, rather than a focus on obtaining the certification.
- Having streamlined, efficient processes does not replace people. Even in CMMI® Level 5 organisations skilled people are regarded as valuable resources.
- Never underestimate the impact of organisational change so greater emphasis must be placed on how the SPI model is implemented.

It is recommended that the above factors be considered to achieve the best possible results from the CMMI® adoption process; it is important to note that organisations recognise that CMMI® is a framework and it needs to be interpreted and tailored to the individual needs of each organisation. It should only serve as a guide and not an exact model to be followed.

7.3.9 Recommendations for other stakeholders (government)

As highlighted by Wills *et al*. (2005) as well as by Heeks and Nicholson (2004), South Africa is at disadvantage in comparison to other countries such as India, Ireland and Israel, where clear government support has prioritised their software sectors, addressed the issue of fragmentation in their industries and developed more coherent strategies. When addressing the lack of quality and performance standards, the South African government could further assist the ICT industry by:

- providing long-term funding for organisations such as the JCSE to build its capacity to support the uptake of CMMI® in South Africa as well as address the fragmentation in the South African sector by developing an industry cluster
- ensuring that quality standards become key criteria in all the ICT tenders for government. This will ensure that there is a demand for CMMI® and will ensure that there is more awareness regarding quality standards among interested service providers.

As a result of the research, it was recognised that the South African software sector has expectations from the form of financial support for CMMI from the government. It is recommended that stakeholders, such as government, from a much closer working relationship with the South African software sector around areas such as building awareness around quality standards, supporting niche industries, developing skills and increasing the international competitiveness of the South African software sector.

7.4 Recommendations for further research

As explained in Section 1.2.1, without addressing the need for quality and process improvement it will be difficult for South African software companies to stay

competitive. In 2007, South African based software companies agreed to participate in the CMMI® pilot programme which has been supported by industry, government and academia. In a context where there is a greater demand for higher quality and improved delivery as well as a drive for greater organisational efficiencies and performance, there is a need to understand what role quality standards and process methodologies such as CMMI® can play, particularly in developing countries such as South Africa. In this regard, the following can be considered for future areas of research:

- To explore fully the impact and value of adopting CMMI® in South Africa, the research would have to take place over a period of time. This type of research would address a limitation of this research paper of only being a cross-sectional study. An in-depth longitudinal study could be made of the pilot organisation at various stages throughout the pilot phase over a period of three years. The results of such a study could be used to compare and contrast the findings of international studies with organisations based in South Africa. It would verify whether South African results are congruent with global industry related results.
- Culture was raised as a possible hindrance to the adoption of CMMI® in South Africa. Research could be done into the role culture plays, particularly in the South African environment, in light of the global phenomenon of commoditisation, industrialisation and standardisation of process in software development as well as other business functions.
- India, and more recently Russia and China, have become the emerging giants in software development and services. Research could explore what lessons South African organisations could learn from their success and how they have implemented, adopted and adapted international quality standards and process methodologies such as CMMI®. The effect of different implementation

and adoption strategies employed by different organisations can also be considered.

- This research was targeted at senior managerial (sponsors) and professional staff (project managers). Research targeting different work groups, project teams and different levels in the organisation could identify more areas affected by the adoption of CMMI® that can be explored to gain a better understanding of the adoption process. The effect of having a skills shortage and, in some areas, an aging workforce can also be considered.

7.5 Conclusion

The main aim of this study was to gain an understanding of how organisations in the South African software development sector are achieving business value from adopting and implementing a software process initiative using CMMI®. Four research questions were answered by the study. Results showed organisations are primarily adopting CMMI® either to improve the running and efficiency of the business or to grow the business through international expansion. It was found that the adoption of CMMI® had numerous positive impacts on the organisations. From an external perspective, it provided an opportunity to raise South Africa's profile to compete or export internationally. From an internal perspective, it protected the software development process from immediate business pressures. There were, however, also negative aspects, including a lack of local demand or awareness of CMMI® certifications.

The research also identified various tangible and intangible benefits and costs in adopting CMMI®. The adoption of CMMI® appears to have positively and tangibly impacted the organisations in terms of customer, financial and organisational improvement, process improvement and quality benefits. The adoption also carries

implementation costs and it confirmed that ROI along with other financial metrics is being used as a means of assessing the business case for adopting CMMI®.

Issues such as change management, applicability to the South African organisational culture and lack of senior management commitment are risks facing the adoption of CMMI® from an organisational perspective, while cost and limited local and government support are factors preventing the widespread adoption in South Africa.

These findings together with insights gleaned from the literature review were then used to suggest a high-level model to assist in achieving business value from the adoption of CMMI® for organisations in South Africa. Having conducted the research across a limited number of South African software development institutions, recommendations for future research were also made.

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9 ANNEXURES

9.1 Annexure A: List of research respondents

Name	Organisation	Position / Role
Alok Goswami	Nedbank	Process Portfolio Manager
Andre February	Fujitsu	Managing Consultant: Business Consulting Division
Antoinette Venter	Accenture	QPI Liaison for Application Outsourcing
Dale Thoma	Saab Tactical Communications	Software Engineer
Daleen Ilsley	SITA	Senior Business Analyst: SITA Quality Management
Dimitri Vratsanos	Psybergate	Head of Software Development and Analyst Competency
DJ Hewson	Cell C	Software Engineer Technical Solutions Team
Ferny Menezies	ADS	Manager of Quality Services
Francina Botha	Nedbank	COE, SOA Implementation Head
Gary Stocks	Business Systems Group (Africa)	Executive Director
Janiene Du Plessis	Accenture	Senior Manager QPI Liaison
Jurgens van Rooyen	Accenture (previously Nedbank)	Project Manager: Software Development
Lance Steward	Joburg Centre for Software Engineering	Project Manager "Bringing CMMI® to SA" programme / SCAMPI Assessor
Louw Stewart	Fujitsu	Enterprise Architect
Lungile Mdletshe	Business Systems Group (Africa)	Strategy Manager / Process Improvement
Nadia Nortje	Department of Trade and Industry	Assistant Director - Electrotechnical Unit Enterprise and Industry Development Division
Quinton Anderson	SEAD	Owner / Partner
Tryna Koekemoer	GijimaAst	PPQM Manager GMSI

9.2 Annexure B: Copy of email requesting interview

Dear _____

I obtained your details from Lance Stewart and Prof Barry Dwolatzky from the Joburg Centre for Software Engineering (JCSE) who are involved in the "Bringing CMMI® to South Africa" programme.

I am currently researching the adoption of software process improvement using the Capability Maturity Model Integration (CMMI®) by organisations in South Africa as part of my MBA studies at the Gordon Institute of Business Science. I am hoping that the findings of the research will be used to understand the business case of CMMI® adoption better and assist future managerial decisions in translating what value CMMI® as a software quality and process improvement standard can bring to the South African environment.

Based on your exposure to and/or knowledge surrounding CMMI®, I would very much like to arrange a short interview with you, which will be used to inform this research. The interview will only take about 45 minutes and I will gladly work around your availability and convenience in order to come and meet with you.

If this is not an option, it can be done telephonically.

Please note as this is only exploratory research, no names of respondents or organisations are required and all answers will be kept confidential as per the ethical standards of the University of Pretoria.

Your assistance will be greatly appreciated and I am looking forward to hearing from you soon to arrange a meeting or a time for the interview within the next few weeks.If you are unable to help, please reply and let me know or contact me of you have any other concerns.

Regards
Douglas Cohen
082 458 1272
douglas.cohen@gmail.com

Student No. 27485073
(A copy of the research will be made available to you when completed.)

9.3 Annexure C: Consent letter

I am conducting exploratory research on the adoption of software process improvement (SPI) using the Capability Maturity Model Integration (CMMI®) by organisations in South Africa. Findings of the research will be used to understand the business case of CMMI® adoption to assist future managerial decisions in translating what business value CMMI® as a software quality and process improvement standard can bring within the South African environment. Our interview is expected to last one hour where I will ask a series of questions relating to your experience regarding the adoption CMMI®. Your participation is voluntary and you can withdraw at any time without penalty.

Please note that no names of respondents are required and that while part of the interview may be recorded for research purposes, the anonymity of all respondents shall be respected and all answers will be kept confidential. I would be happy to provide you with a copy of the resulting research findings.

If you do have any concerns, please contact my research supervisor or myself directly. Our details are provided below:

Douglas Cohen
douglas.cohen@gmail.com
+27 82 458 1272

Dr. Peter Tobin
tobinp@gibs.co.za
+27 11 771 4000

Signature of Participant: _____

Date_____

Signature of Researcher_____

Date: _____

9.4 Annexure D: Interview guide

The researcher introduces himself and provides a five minute introduction, explaining the research and the purpose and structure of the interview. (It will be highlighted that the responses to this questionnaire will be treated as strictly confidential.)
Opening: 5 minutes
Section One: Open-ended questions: 30 minutes
Section Two: Closed-ended question: 20 minutes
Closing: 5 minutes

9.4.1 Section one: Open questions

- Before we start and for formal interviewing purposes, could you please state your name, the organisation you work for / represent and your position and role in the organisation.
- Briefly describe the purpose and nature of your organisation, including what kind of work your organisation does, the types of clients / customers you service, the size (people) and structure of the organisation.

1 Describe your current software development capabilities.
2 Describe the types of projects your organisation delivers on.
3 What is the scope (projects, business units / areas) of CMMI® adoption within your organisation?
4 Describe what level of exposure you or any of your employees have had to CMMI®.
5 What exposure have you or any of your employees had to any other software process improvement methodologies, for example ISO 9000, ITIL, Six Sigma, Cobit, other?
6 Do you feel that CMMI® has made or will make any difference (positive or negative) to your capacity to deliver projects? Why? Why not?
7 How will / does adopting CMMI® add value to your organisation?
8 Would you recommend / welcome CMMI® if you moved to another organisation? If so, why? Why not?
9 Do you think there will be an uptake of CMMI® locally? If so, to what extent? If not, why?
10 Do you have any other comments with regards to the adoption of CMMI® drawing on your own experiences?

To ensure answers are fully explored, when necessary, follow up questions with phrases like: "What makes you say that?" / "What evidence do you have to support that?"

9.5 Annexure E: Questionnaire

9.5.1 Section two

Section two consists of 10 questions and is divided into parts. There are two types of questions:

Ticking of boxes

Indexes and Rating Scales.

Question 11

What are your main reasons / motivations for adopting CMMI®?

Tick the relevant box/es that apply:

Reason	☑		
Company philosophy			
Competitive advantage			
Competitive pressures			
Customer/s require it			
Ensuring predictable results			
Expected process improvement			
Improve customer satisfaction			
Improve productivity			
Improve public image / marketing			
Improve service / product quality			
Increase internal controls			
Increase profit			
Reduce cost of development			
Reduce time to develop			
Other			
Other			

From your selection above, please select your top three.

Question 12

What goals and measures would you track in achieving the above motivation/s for adopting CMMI®?

Tick the relevant box/es that apply:

Performance area	Goals and measures	☑
Financial	Reduced organisation costs (e.g. total cost of ownership)	
	Increased revenue from sales, ongoing support, license fees	
	Increased market share	
	Ability to compete for new business	
Customer (internal/ external) satisfaction	Improved satisfaction ratings (e.g. customer survey results)	
	Reduced problem reports (e.g. number of complaints)	
	Reduced support effort (e.g. support hours charged to a customer)	
	Improvements to specific customer concerns (e.g. response time)	
Internal business processes	Reduced cycle time, time to market	
	Reduced cost of rework	
	Improved product quality	
Learning and growth	Improvements in experience level (e.g. years of experience)	
	Increased retention rates for staff	
	Improved employee satisfaction ratings	

Question 13

What impact has the adoption of CMMI® had on the following criteria in terms of <u>tangible benefits</u>?

Tick the relevant box to indicate the following ratings:

(1) Very positive impact
(2) Somewhat positive impact
(3) Somewhat negative impact
(4) Very negative impact
(5) Don't know

Benefit category	Defined by	Rating				
Customer	Improved customer satisfaction	1	2	3	4	5
	Decrease in the number of defects in post release / go live	1	2	3	4	5
	Reduced number of customer complaints	1	2	3	4	5
	Increase in on-time delivery	1	2	3	4	5
Financial	Reduced project costs	1	2	3	4	5
	Increased opportunity of winning contracts	1	2	3	4	5
	Increased bargaining power	1	2	3	4	5
	Increased ROI of projects	1	2	3	4	5
Organisational improvement	Increased organisational competitiveness	1	2	3	4	5
	Increased organisational productivity	1	2	3	4	5
	Improved organisational reputation	1	2	3	4	5
Process improvements	Increased efficiency of development process	1	2	3	4	5
	Improved capacity of project monitoring	1	2	3	4	5
	Reduced redundant work	1	2	3	4	5
	Improved effective resource allocation	1	2	3	4	5
Quality	Improved product/system functionality	1	2	3	4	5
	Improved product/system reliability	1	2	3	4	5
	Improved product/system usability	1	2	3	4	5
	Improved product/system efficiency (lower failure rate)	1	2	3	4	5
	Improved product/system maintainability	1	2	3	4	5
	Improved requirement satisfaction	1	2	3	4	5
	Early detection of defects	1	2	3	4	5

Question 14a and 14b

What impact has the adoption of CMMI® had on the following criteria in terms of <u>tangible costs</u>? Where there is a cost, was it worth it?

Tick the relevant box to indicate the following ratings:
(1) No cost (there is no change from current costs / as is)
(2) Some cost (the cost has been identified and budgeted for)
(3) Substantial cost (the cost has been identified but was significantly more than budgeted)

(Y) It was worth the cost (N) It wasn't worth the cost

Cost category	Defined by	Rating				Y / N	
Cost of Performance	Generating plans	1	2	3		Y	N
	Developing requirements	1	2	3		Y	N
	Developing designs	1	2	3		Y	N
	Developing software	1	2	3		Y	N
	Developing documentation	1	2	3		Y	N
	Developing tests	1	2	3		Y	N
	Establishing deployment environments	1	2	3		Y	N
Cost of prevention	Conducting formal work product reviews	1	2	3		Y	N
	Conducting informal work product reviews	1	2	3		Y	N
	Running tests (unit, module, integration, system, acceptance)	1	2	3		Y	N
Cost of appraisal (cost of review)	Training people	1	2	3		Y	N
	Defining and maintaining processes, procedures and other assets	1	2	3		Y	N
	Installing and maintaining tools	1	2	3		Y	N
	Gathering and analysing data	1	2	3		Y	N
	Performing quality (process and product) assurance	1	2	3		Y	N
Cost of non-conformance to the model (cost of rework)	Fixing defects in software and other work products	1	2	3		Y	N
	Re-reviewing the work	1	2	3		Y	N
	Re-running tests	1	2	3		Y	N
	Building and deploying patches and update releases	1	2	3		Y	N
	Staffing a help desk for customer support	1	2	3		Y	N
	Re-developing a product that missed the customer needs (penalties and fines)	1	2	3		Y	N

Question 15

What impact has the adoption of CMMI® had on the following criteria in terms of <u>intangible benefits</u>?

Tick the relevant box to indicate the following ratings:

(1) Very positive impact
(2) Somewhat positive impact
(3) Somewhat negative impact
(4) Very negative impact
(5) Don't know

Benefit category	Defined by	Rating				
Improved quality of work life / working conditions	More stable work environment	1	2	3	4	5
	Fewer problems / crises	1	2	3	4	5
	Less stress / pressure	1	2	3	4	5
	Increased levels of confidence	1	2	3	4	5
	Fewer overtime hours	1	2	3	4	5
Improved organisational communications	Improved communications upwards to management	1	2	3	4	5
	Improved communications downwards from management	1	2	3	4	5
	Improved communications across projects / teams	1	2	3	4	5
Improved organisational learning and efficiencies	Improved ability to educate / train software professionals	1	2	3	4	5
	Improved understanding of how the organisation develops / implements software	1	2	3	4	5
	Improved portability of people across projects / teams	1	2	3	4	5
	Improved ability to change	1	2	3	4	5
	Enhanced awareness of quality within organisation	1	2	3	4	5
Improved ability to attract, retain and develop software professionals	Improved ability to recruit new staff	1	2	3	4	5
	Fewer resignations	1	2	3	4	5
	Better opportunities for promotion and development	1	2	3	4	5
	Richer career path for employees	1	2	3	4	5
More coherent organisational culture	Improved understanding of the organisation's mission and vision	1	2	3	4	5
	Shared sense of pride	1	2	3	4	5
	Participation in process improvement activities	1	2	3	4	5
	Improved morale / employee satisfaction	1	2	3	4	5

Question 16a and 16b

What impact has the adoption of CMMI® had on the following criteria in terms of <u>intangible costs</u>? Where there is a cost, was it worth it?

Tick the relevant box to indicate the following ratings:

(1) No cost (there is no change from current costs / as is)
(2) Some cost (the cost has been identified and budgeted for)
(3) Substantial cost (the cost has been identified but was significantly more than budgeted)

(Y) It was worth the cost (N) It wasn't worth the cost

Cost category	Defined by	Rating				Y/N	
Implementation costs	Hours of staff effort dedicated to developing and documenting new processes, meetings and checklists	1	2	3		Y	N
	Effort to prepare and conduct kick-off meetings to announce the changes and answer questions.	1	2	3		Y	N
	Dissemination and training costs	1	2	3		Y	N
	Communication and motivation costs	1	2	3		Y	N
Support costs	Additional assistance for on-going consulting and support	1	2	3		Y	N
	Verification and enforcement costs	1	2	3		Y	N

Question 17a and 17b

Questions	Rating			
To what extent are you measuring the above benefits?	1	2	3	4
To what extent are you measuring the above costs?	1	2	3	4

Tick the relevant box to indicate the following ratings:

(1) To a great extent
(2) To some extent
(3) Very little
(4) Not at all

Question 18a, 18b and 18c

Which of the following techniques is most appropriate for evaluating the business value of adopting CMMI®?

Tick the relevant box/es that apply:
Are you using this method?

(Y) Yes (N) No

Method	☑		Y/N	
Break-even point			Y	N
Internal rate of return			Y	N
Net present value			Y	N
Payback period			Y	N
Return on investment			Y	N
None / Not applicable			Y	N
Other			Y	N

In terms of timing, when would you expect to achieve the business goals from adopting CMMI®?

Tick the relevant box that applies:

Time periods	☑
< 1 year	
1 – 2 years	
3 – 5 years	
> 5 years	
Never	

Question 19

What are the key risks faced by organisations in adopting CMMI®?

Tick the relevant box/es that apply:

Risks	☑		
Impact of organisational change management required			
Impact on day-to-day operations (negatively)			
Lack of senior management commitment			
Lack of staff involvement and participation (seeing the value)			
Lack of skilled staff			
Lack of process action teams			
Lack of ongoing data collection and feedback			
Lack of awareness of implementation			
Lack of training and mentoring			
Lack of awareness with regards to roles and responsibilities			
Lack of formal implementation methodology			
Lack of prototyping / piloting			
Lack of resources (funds, tools and people)			
Lack of review processes and monitoring			
Lack of staff time			
Lack of simplicity			
Lack of support (internally or externally)			
Presence of organisational politics			

From your selection above, please select your top three.

Question 20

What factors would prevent the widespread adoption of CMMI® in South Africa?

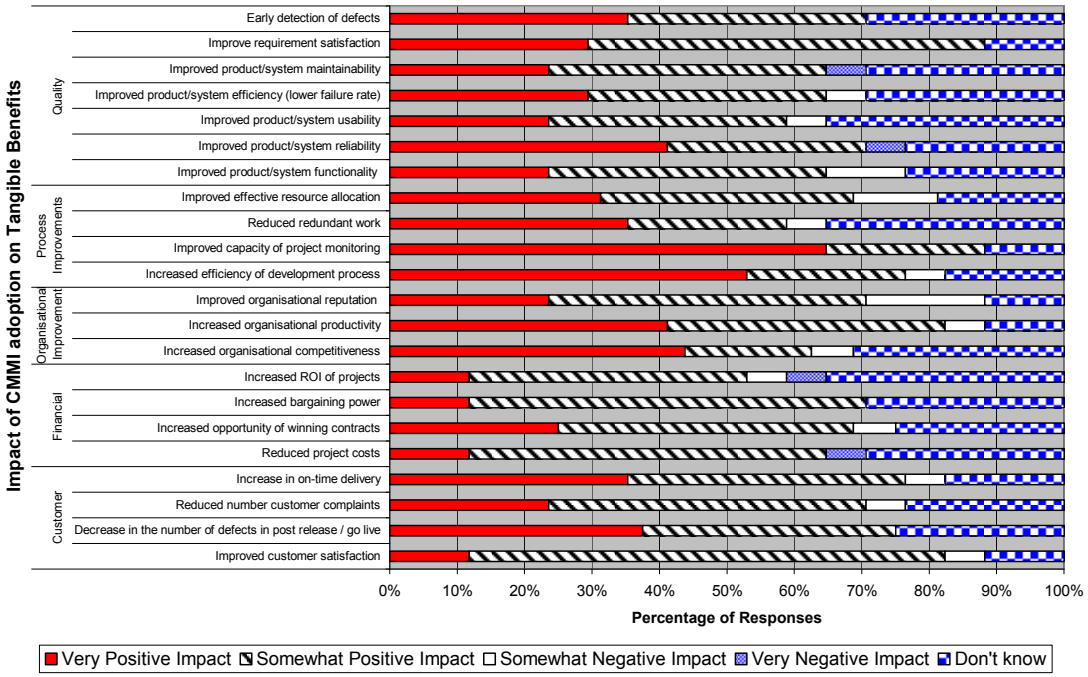
Tick the relevant box/es that apply:

Factors	☑		
Ability to work effectively with current process limitations (bad processes)			
Lack of funds			
Lack of skilled people			
Lack of time			
Lack of tools			
Not applicable to their specific projects			
No customer demand for quality and/or process certification			
Use of other software process improvement initiatives such as: ISO 9000 ITIL COBIT Six Sigma PM-POK PRINCE Other _____			
No clear benefits			
Potential benefits not wanted			
Unaware of CMMI®			
Risk of poor certification damaging business			
Small organisation			
Too costly			
Other			
Other			

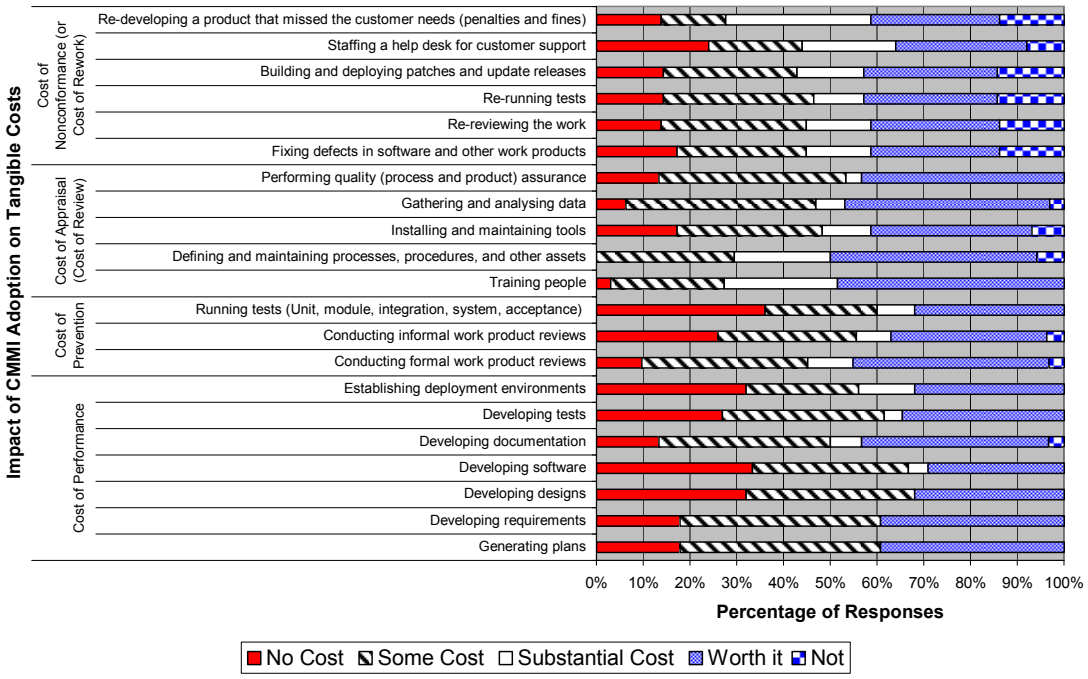
From your selection above, please select your top three.

9.6 Annexure F: Representation of results

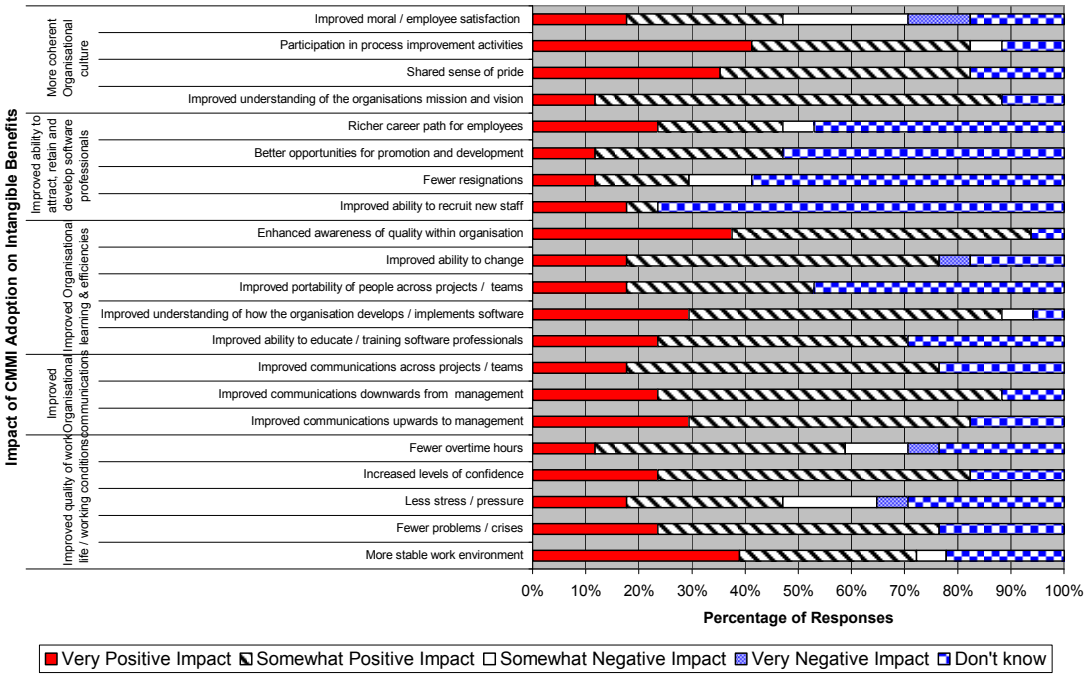
9.6.1 Question 13: Impact of CMMI® adoption on tangible benefits



9.6.2 Question 14: Impact of CMMI® adoption on tangible costs



9.6.3 Question 15: Impact of CMMI® adoption on intangible benefits



9.6.4 Question 15: Impact of CMMI® adoption on intangible costs