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OF BUSINESS SCIENCE
University of Pretoria

The impact of institutions on the innovations of firms belonging to an emerging versus a mature industry in a developing country, South Africa

Indranil Bandyopadhyay

29603112

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Abstract

This study describes how institutions in a developing country, South Africa influence the salient characteristics and patterns of innovation in firms belonging to an emerging versus a mature industry. The patterns and characteristics of innovation in firms belonging to industries in different phases of their life cycles are influenced by various factors. Because of the wide range of factors and often due to the endogenous relationships between them, empirical studies in describing these patterns remain inconclusive. This research describes the patterns and the significant innovation characteristics of the firms through the lens of institutions. Special attention is paid to the institutional frameworks influencing innovation in firms at national and regional levels. These frameworks are often referred to as National and Regional Innovation Systems. The central argument of this study is that these innovation systems are expected to influence the characteristics of innovation in different ways when firms are situated in developed versus the developing countries. In this regard, this study attempts to contribute to the innovation knowledge-base of developing countries.

The salient characteristics discussed in this study are types, institutional support (government), centre of knowledge and geographical locations of innovations. Chi-square, t-tests and stepwise logistic regressions were run on the responses of the firms regarding the chosen characteristics. The results suggest that in most cases these characteristics were different in firms belonging to an emerging versus a mature industry. Also the patterns of innovation were mostly dissimilar from the expectations of the studies based in the developed world. A logistic model was built to explain the relationships between the individual characteristics and the firms belonging to the two phases of the industry life cycle. The model, formulated on the salient characteristics of innovation discussed could successfully predict if a firm belonged to a mature industry or not.

Keywords

Innovation

Industry life cycle

National innovation system

Regional innovation system

South Africa

Declaration

I declare that this research project is my own work. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration at the Gordon Institute of Business Science, University of Pretoria. It has not been submitted before for any degree or examination in any other University. I further declare that I have obtained the necessary authorisation and consent to carry out this research.

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1. Introduction

1.1 The impact of institutions on the innovations of firms belonging to an emerging versus a mature industry in a developing country, South Africa

Societal norms, rules, conventions, habits and values constitute institutions (Hollingsworth, 2000) which are supported by three pillars, namely regulative, normative and cultural-cognitive pillars (Scott, 2008).These components and pillars of institutions influence the characteristics, behaviour and evolution of the organisations operating in a particular society within the geographical boundary of a nation or a region.

One of the features of an organisation or a firm is to innovate to enter, grow or maintain dominance within an industry. The characteristics and patterns of innovation differ among firms belonging to the emerging or mature stage of the industry lifecycle. This research attempts to describe how institutions in a developing country like South Africa influence the salient characteristics and patterns of innovation in firms belonging to an emerging versus a mature industry.

1.2 Introduction to the research problem: country, industry life cycle and system of innovation

1.2.1 Country and Innovation

The long term economic growth of a country is dependent on the creation of an environment which is conducive to innovation and application of new technologies. Economic growth and productivity is a measure of national competitiveness, hence innovation is a major determinant of the modes and characteristics of the competitive advantage of a country (Atun, Harvey & Wild, 2007).

Porter (1990) suggested that countries evolve through three stages of economic growth. In the first *factor driven stage* a country's competitive advantage is based on the availability of labour and natural resources; the efficiency for standard products and services drive the second *investment driven stage* and the third *innovation driven stage* is dependent on the ability to produce and use innovative products and services.

The 2010-2011 Global Competitiveness Report ranked South Africa 54th in the world. The competitiveness of the country could be enhanced by reducing costs to business caused by violence (ranked 137th), better hiring and firing practices (ranked 135th), better labour-employer relations (132nd) and flexibility in wage determination (ranked 131st). It was observed that for South Africa to move to an *innovation driven economy*, the main pillar of improvement would be innovation (a score of 3.5; the lowest score among the twelve pillars of the Global Competitiveness Index) (Schwab, 2010).

The ability of countries to innovate is largely dependent on their “innovation systems” and countries are often ranked to distinguish between “winners” and “losers” (Rutten & Boekema, 2005, p.1132). South Africa was one of the first developing countries to introduce the national systems of innovation (NSI) in its policy making; however the National Research and Development Strategy found the lack of input of resources to NSI to be a major weakness (Rooks & Oerlemans, 2005). They also commented on the depleting R&D expenditure of South Africa in both the private and public sectors as being a cause of low innovative activities.

It can thus far be seen that innovation is an important driver towards a country’s competitiveness and long term economic growth. However, this macro level innovativeness of a country is built by the innovation activities at a much lower, firm level. The macro level infrastructure and micro level activities influence each other.

1.2.2 Firms, industry life cycle and Innovation

Industry or firm level studies point at differing innovative activities within a country and between countries. In their seminal paper, Dasgupta and Stiglitz (1980) demonstrated a positive relationship between competition and innovation. Competition encourages innovation and compels a firm to improve the cost and functionality of their products and services. Higher competition increases the risk of failure; in order to improve efficiency and to ensure survival, firms engage in innovative activities (Aghion & Howitt, 1998; Haskel & Sanchis, 1995). Firms from emerging industries with low concentration and intense competition, characterised by *creative destruction* (Schumpeter Mark I model), get involved in innovative activities to develop differentiated products and services and maintain market share (Atun, Harvey & Wild, 2007). During the early stages of the industry life cycle, there is a high amount of innovative activity and new and smaller enterprises tend to conduct the relative innovation advantage. During the mature stages of the industry life cycle however, there tends to be less (product) innovative activity, and established large enterprises tend to engage in innovative activities (Audretsch & Feldman, 1996). Additionally, Klepper (1996) suggested that the diversity of competing versions of the product and the number of major product innovations tend to reach a peak during the growth in the number of producers and then fall over time. Over time, producers devote increasing effort to process relative to product innovation.

This view is challenged by the Schumpeterian Mark II approach characterised by *creative accumulation* which concludes that innovation and growth decline with competition. Increased competition may reduce innovation and the gains from innovation are quickly consumed. This results in discouragement in innovative spending. Also, the negative relationship between competition and innovation is supported by other studies that show that firms from more concentrated and mature industries have a lower risk of bankruptcy and are therefore better positioned to finance innovation activities that in turn enhance their dominant position (Atun, Harvey & Wild, 2007).

During the last fifty years, studies were done which aimed to empirically verify the two patterns. The studies were focused on firm size, market structure and the rate of innovation, but produced inconclusive results. These results were due to the neglected role of opportunity and appropriability in the various industries, as well as the endogenous relationship between the firm size, concentration and technological change (Malerba, 2005).

It is apparent that patterns and characteristics of innovation among firms belonging to industries in different phases of their life cycles are influenced by various factors. This is why it is often difficult to come up with conclusive or generalised results in this regard. Amongst others, one factor of influence on innovation in firms is the institutional framework. Recognition of this fact has given rise to the concept of system of innovation.

1.2.3 System of Innovation

Edquist (2001, p.2) defined the System of Innovation (SI) based on cross-disciplinary studies of institutional and innovation theories as “all important economic, social, political, organisational and other factors that influence the development, diffusion and use of innovations”. The concept of SI evolved during the last two decades, after the seminal work of Freeman, Lundvall and Nelson. Johnson & Jacobsson (2003) suggested SI as a framework to analyse and evaluate the dynamics of an innovation system among firms belonging to a particular stage of evolution in an industry life-cycle.

Fagerberg, Mowery & Verspagen (2008) reasoned that the emergence and evolution of SI was based on a co-evolutionary process in which the development of firms and industries interacted with and affected national public research infrastructures, policies and institutions. They further suggested that these processes gave rise to path-dependencies of various sorts that systematically favoured some type of activities, while constraining others. In a broader sense, the set of habits, routines, rules, norms, and laws, along with private firms, universities, government laboratories and other public agencies within a national boundary, constitutes the National System of Innovation (NSI). NSI is also known as National Innovation System (NIS). These elements of NIS cause financial, human and knowledge flows among private and non-private organisations. “A national system of innovation consists of firms in many different sectors operating within a common (national) ‘knowledge infrastructure’ and a common institutional framework” (Fagerberg *et al.,* 2008, p.3).

This *national knowledge* and common institutional frameworks differ from country to country. The co-evolutionary process between firms and national institutions which influences the development of innovation has rarely been studied in developing countries. In addition, the nature of innovation changes with the maturity of the industries. These characteristics of innovation have mainly been empirically studied in developed countries.

In order for a developing country like South Africa to move towards an *innovation driven economy*, it is critical that one understands the characteristics of innovation among firms, how it differs within the industry life cycle and how these characteristics are influenced by institutional factors.

This research intends to shed some light in that regard – describing the differing salient characteristics and patterns of innovation between firms belonging to an emerging versus a mature industry in South Africa. It also attempts to build a predictive model whereby the selected characteristics of innovation in a firm will predict the odds of a firm belonging to a mature industry or an emerging one.

1.3 Rationale of the Research

The purpose of this research is to make an academic contribution to the body of knowledge of the characteristics of innovation in firms belonging to industries at various stages of their life cycles.

This knowledge will assist policy makers, entrepreneurs, academics and other stakeholders associated with the development of the economy of a developing country, to work on the challenges and beneficially utilise the opportunities that exist. This contribution will also assist strategists in a firm to devise tactics to either play along the expected innovation characteristics of the firm depending on the stage of the life cycle of the industry, or to break out of it and create a new development path.

The research report begins by reviewing the theory from the existing available literature on institutional theory, innovation, innovation systems (national and regional) and the innovation patterns among firms belonging to industries at various stages of their life cycle. Next, the salient features from the literature review are analysed to come up with the research questions. After this, the research methodology used for the study and the findings of the study are discussed. This is followed by a discussion on the findings. Finally, some conclusions and recommendations for policy makers, entrepreneurs, academics and business managers are proposed.

2. Theory and Literature review

2.1 Institutional theory

North (1990, p.3) defined the term 'institution' as the "rules of the game in a society". He argued that institutions were constraints which shaped human interaction and the way that society evolved through time. However, Schotter (1981, p.155) regarded institutions as the behaviour that followed from rules and argued that they were "not the rules of the game". He was more interested in what actors did with the rules and not what the rules were.

Another challenge in institutional literature is the relationship between institutions and organisations. North (1990) argued that institutions and organisations were separate entities. He further went on to say that organisations' evolution was influenced by society's rules and norms (institutions). On the other hand, the proponents of 'new institutionalism' argue that societal rules and norms, along with organisations, co-evolve and reflect and influence each other (Hollingsworth, 2000). Liang, Saraf, Hu, and Xue (2007) argued that the structural and behavioural changes in organisations were determined less by competition and the desire for efficiency, and more by the need for institutional factors like organisational legitimacy. "Institutional set-up is seen as a structure that shapes the productive and the innovative activities within the firms" (Eparvier, 2005, p.567) and constrain the firms' (organisations') behaviour (Hodgson, 1998; Khalil, 1995).

Scott (2008) defined institutions as a social structure that gives organisations lines of actions or orientations, but at the same time controlling and constraining them. Institutions then "represent constraints on the options that individuals and collectives are likely to exercise, albeit constraints that are open to modification over time" (Barley & Tolbert, 1997, p.94).

The concept of institutional pillars was proposed by Scott (2008). According to Scott the three institutional pillars are:

- Regulative (coercive) pillar – Coercion as tests of strength and fear of sanction explains how institutions constrain and regularise the behaviour of the actors.
- Normative pillar – This is based on agents' social obligations which are observable through values and norms.
- Cultural-cognitive pillar – In a context of uncertainty, organisations will imitate other organisations they consider leaders.

Hollingsworth (2000) attempted to define institutional theory from a configuration point of view. He came up with five components (levels) in descending order of permanence, stability, endurance and persistence:

- Institutions as norms, rules, conventions, habits and values.
- Institutional arrangements as markets, states, corporate hierarchies, networks, associations and communities.
- Institutional sectors as financial systems, systems of education, business systems and systems of research.
- Organisations.
- Outputs and performances as statuses, administrative decisions, the nature, quantity and the quality of industrial products.

Thus, there remains heterogeneity of approach towards the concept of institutions. Looking at the various approaches from the abstractness and societal rule based concept of North to the analytical approach of Scott and the configuration based approach of the institutional level of Hollingsworth, the commonalities in institutional theory are around the mutual interactions between societal rules and norms, and organisations often associated with production, controls and constraints.

2.2 Innovation

Innovation is critical in terms of corporate survival, growth and renewal processes (Bessant, Lamming, Noke & Phillips, 2005; Zahra & Covin, 1994). New products and services, new processes and new organisational forms constitute the most common types of innovation (Ettlie & Reza, 1992). Damanpour and Schneider (2006) suggested that innovation was studied and defined from different perspectives. Baregheh, Rowley and Sambrook (2009, p.1334) were of the opinion that there was a lack of common definition on innovation and suggested the following:

"Innovation is the multistage process whereby organisations transform ideas into new/improved products, services or processes, in order to advance, compete and differentiate themselves successfully in their marketplace."

Contrary to the narrow conception of innovation as technological innovation, the broad conception encompasses everything that increases the efficiency of resources, considering the satisfaction of market needs (Dinis, 2006). This conception supports Schumpeter's view of five types of innovation:

- (i) Modifications to existing products, as well as
- (ii) Development of new products,
- (iii) Market sourcing,
- (iv) Organisational innovation, and
- (v) Process innovation (Dinis, 2006).

The European Commission (2003) stressed that early adopters do not necessarily capture international markets, but rather fast followers contribute towards the expansion of international markets in a more significant way. Thus in a broader sense, innovation is not about invention only, it is also about imitation and adoption.

For developing countries it would be damaging to equate innovation to invention only. Rather, the broad definition that encompasses innovation as a continuous learning process that improves product design and quality, changes organisation and management routines, encourages creativity in marketing and modifications to production process, is of major importance to firms in developing countries (Mytelka, 2000).

2.3 Innovation systems

Innovation systems are borne out of the cross disciplinary studies between institutional (section 2.1) and innovation theories (section 2.2). Joseph (2009) looked at innovation beyond the narrow context of product and process innovation and highlighted the non-linearity of innovation where institutions play an important role. This approach, commonly known as innovations systems, placed innovations at micro, meso and macro levels (Lundvall, Vang, Joseph & Chaminade, 2009). The initial work on innovation systems was done by Freeman, Lundvall and Nelson at the national level; this led the way for a variety of more fine-grained approaches, e.g. regional innovation systems by Asheim and Gertler, sectoral innovation systems by Malerba, technological innovation systems by Carlsson and Stankiewitz and corporate level innovation systems by Granstrand (Lundvall *et al.,* 2009).

This research concentrates on the National Innovation System and certain characteristics of the regional innovation system based in a developing country, South Africa.

2.3.1 National Innovation System (NIS)

NIS as a concept is rooted in history – the starting point of the idea can be traced back to Adam Smith and Freidrich List, with Freeman, Nelson and Lundvall subsequently popularising the concept (Lundvall, Johnson, Andersen & Dalum, 2002).

The set of inter-connected institutions form a framework within which governments implement policies to influence the development and diffusion of new technologies (innovation process) (Sharif, 2006). This set of institutions which influence innovation and create and use knowledge for economic purposes can be termed NIS. NIS is the interactive system of existing institutions, private and public firms, universities and government agencies, aiming at innovating within national borders (Intarakumnerd, Chairatana & Tangchitpiboon, 2002).

Box 2-1: Definitions of NIS

"...The network of institutions in the public- and private-sectors whose activities and interactions initiate, import, modify and diffuse **new technologies**" (Freeman, 1987)

"...The elements and relationships which interact in the production, diffusion and use of new and economically useful knowledge...and are either located within or rooted inside the borders of a nation state" (Lundvall, 1992)

"...The set of **institutions** whose interactions determine the innovative performance of national firms" (Nelson & Rosenberg, 1993)

"...The national system of innovation is constituted by the **institutions** and economic structures affecting the rate and direction of **technological change** in the society" (Edquist & Lundvall, 1993)

"...A national system of innovation is the system of interacting private and public firms (either large or small), universities, and government agencies aiming at the production of **science and technology** within national borders. Interaction among these units may be **technical**, commercial, legal, social and financial, in as much as the goal of the interaction is the development, protection, financing or regulation of new science and technology" (Niosi *et al*., 1993)

"...The national **institutions**, their incentive structures and their competencies, that determine the rate and direction of **technological learning** (or the volume and composition of change generating activities) in a country" (Patel & Pavitt, 1994)

"...That set of distinct institutions which jointly and individually contribute to the development and diffusion of **new technologies** and which provides the framework within which governments form and implement policies to influence the innovation process. As such it is a system of interconnected **institutions** to create, store and transfer the knowledge, skills and artefacts which define **new technologies**" (Metcalfe, 1995)

Source: Niosi (2002, p 292)

From the definitions above it is observed that the commonality among all these points of view is around reference to *institutions* and *technology*. These points of view are mainly based on historically developed countries where technology and new products and processes were the bases of innovation (*sensu stricto*). Viotti (2002) argued that innovation should be reserved for developed countries. He went on to say that in developing countries, incremental innovation, diffusion and learning might take place, but not innovation. Policy makers and scholars have often used this narrow understanding of the concept of NIS that is focussed on science-based innovation and formal technological infrastructure and in policies aimed exclusively at R&D efforts (Lundvall, 2007).

Lundvall *et al*. (2009) did not buy in to Viotti's argument and proposed a much wider view of NIS, which is more appropriate for developing countries. Table 2-1 illustrates the emphasis of the innovation system approach:

Table 2-1: Innovation System Approach

	Allocation	Innovation
Choice making	Standard neo-classical	Project Management
Learning	Austrian Economics	Innovation systems

Source: Lundvall (2007)

As per the table above, the innovation system focuses toward a combination of innovation and learning. The underlying theory of innovation is about learning processes involving skilful but imperfectly rational agents and organisations (Lundvall, 2007). Lundvall (2007) further suggested that agents have a capability to enhance their competence through searching and learning, and do so in interaction with other agents, the outcome being new innovations and competencies.

Based on the above, Lundvall *et al*. (2009, p.6) defined NIS as below:

"The national innovation system is an open, evolving and complex system that encompasses **relationships within and between organisations, institutions and socio-economic structures** which determine the rate and direction of innovation and **competence-building** emanating from processes of science-based and experience-based **learning**".

The three major focus points of the above definition are – relationships within and between organisations, institutions and socio-economic structures, competence building and learning. These features constitute a broad definition of NIS as compared to the historical narrow one which was based on research and development efforts and science and technology alone (Fagerberg *et al*., 2008; Lundvall, 2009).

2.3.1.1 Components of NIS

Components are the operating part of the system. *Organisations* and *institutions* constitute the main components of NIS. These organisations include firms such as suppliers, customers, competitors etc, or non-firm entities such as universities, schools and government ministries. Institutions are constituted of laws, rules, norms and routines. Institutions impact on the behaviour of organisations and vice versa, creating a co-evolutionary process. Such co-evolutionary processes might give rise to *path-dependencies* of various sorts, acting as incentives and obstacles for innovation (Fagerberg *et al*., 2008). Fagerberg *et al*. (2008) further pointed out that firms did not normally innovate in isolation but in collaboration and interdependence with other organisations. The relations between organisations and institutions and within themselves are crucial for innovation activities and for the operations of the system of innovation (Edquist, 2001).

Developing countries are less developed in terms of institutional compositions, sophistication of scientific and technological activities, and linkages between organisational units (Kayal, 2008). Thus NIS in these countries will play a different role compared to developed countries.

2.3.1.2 Dimensions of NIS

Traditionally in developed countries there was a focus on the dimensions of innovation systems that could easily be measured – the formal elements. These elements were made up of R&D efforts and patents. The informal elements like the quality of the relationships between customers and suppliers, the degree of trust, educational systems and labour markets were neglected. Table 2-2 below summarises the major dimensions of innovation systems:

Table 2-2: Dimensions of Innovation Systems

	Narrow	Broad
Formal	(1) Science and Technology organisations, institutions and formal networks -- Functioning of universities and research institutions -- Patents and publications of technology policy and programmes	(2) Organisations supporting innovation in general, institutions and formal networks -- Educational and financial system -- Environmental competition and policy -- Labour market and other organisations
Informal	(3) S&T informal institutions and informal networks -- Willingness of firms to co-operate -- Closeness of relationships between companies and technology policy	(4) Informal institutions influencing innovation and informal networks -- Quality of relationships between customers and suppliers -- Degree of trust in society

Source: Lundvall *et al.* (2009)

The traditional focus of systems research and innovation policies has been on formal and narrow definitions. But the various dimensions (1-4 as explained above) are highly interdependent and impact the overall innovation performance (Lundvall *et al*., 2009). This is particularly true for innovation in developing countries; however it does not mean that broad and informal definitions are irrelevant for developed countries. For example the developed Nordic countries like Norway and Denmark, in spite of their small size and rather weak knowledge base, perform well in terms of innovation. The high level of trust, capability to absorb ideas from abroad, transparency and absence of corruption are some of the causes which are broad and informal and have impacted the formal dimensions of the innovation system to produce good results. The reality of most developing countries is quite different from the Nordic model though. "In less-developed countries offering general access to modest forms of education, health and service and food for all children without regard of social and ethnic origin might be a kind of reform that would contribute to generalised trust that can spill over to the innovation system" (Lundvall *et al*., 2009, p.12). A case in point is that of Korea, a developing country that succeeded in developing its informal innovation system by way of agrarian reform and an all encompassing education system.

2.3.1.3 Determinants of NIS

A system can also be defined in terms of what it does (it's functions). Edquist (2001) argued that the determinants of the system of innovation were more important than the consequences (in terms of growth, quantity of employment, working conditions etc) of the systems. He further commented that it was important to note what the organisations (firms and non-firms) did in relation to the innovation process, how institutions constrained or stimulated innovative activities in organisation and what roles the relations between the components in the system play for innovation processes. Johnson and Jacobsson (2003) suggested a list of five determinants or functions of SI as the systems level explanatory factors which support firm entry, variety and formation of niche markets in the emerging phase of industry and market expansion and the supply of resources to exploit the market in the mature phase. Similar determinants have been suggested by authors of *functional approach* like Liu and White (2001), Rickne (2000), Edquist (2004) and Hekkert, Suurs, Negro, Kuhlmann and Smits (2007).

Edquist (2001) clarified that the functions or determinants of the systems were similar in all systems, but they were performed by different organisations (firms and non-firms) in the context of different institutions differently. Edquist (2004) argued that because of the complexity of the task, an exhaustive list of all the functions or determinants of innovation would be impossible. However, he suggested that there were good reasons to develop theories about relations between these determinants and innovation.

Lundvall *et al*. (2009) counter-argued that agreeing on a list of functions to create rigour and scientific progress might not be correct. However, they agreed that some of the functions or determinants would perform differently in different national systems.

Table 2-3 summarises the functions or determinants as viewed by the different functional authors.

Table 2-3: Determinants of NIS

Liu and White (2000)	Johnson	Rickne (2000)	Edquist (2004)
1. Research (basic, developmental, engineering)	1. To create new knowledge	1. To create human capital	1. R&D
2. Implementation (manufacturing)	2. To guide the direction of the search process	2.To create and diffuse technological opportunities	2. Competence building
3. End-use (customers of the product or process outputs)	3. To supply resources, i.e. capital, competence and other resources	3. To create and diffuse products	3. Formation of new product markets
4. Linkage (bringing together complementary knowledge)	4. To facilitate the creation of positive external economies (in the form of an exchange of information, knowleadge and visions)	4. To incubate in order to provide facilities, equipment and administrative support	4. Articulation of user needs
5. Education	5. To facilitate the formation of markets	5. To facilitate regulation for technologies, materials and products that may enlarge the market and enhance market access	5. Creation and change of organisation
		6. To legitimise technology and firms	6. Networking around knowledge
		7. To create markets and diffuse market knowledge	7. Creating and changing institutions
		8. To enhance networking	8. Incubating activities
		9. To direct technology, market and partner research	9. Financing innovation
		10. To facilitate financing	10. Consultancy services
		11. To create a labour market that the NTBF can	

Three functions were found to be common among the functions suggested by various authors above (see the colour coding). They are as follows:

- Research – creation of new knowledge.
- Supply of resources – especially competence building.

- Creation of positive external economies – exchange of information, knowledge and vision from external sources.

One interesting observation from the contents of Table 2-3 is that functions like R&D, creation of new knowledge, education, and technological opportunities are very much applicable to developed countries. Even functions like competence building, networking around knowledge and facilitating financing have very different meanings in the context of developing and developed countries.

In summary, it is apparent that the characteristics of the components, dimensions and determinants of NIS discussed above were mainly based on the knowledge from developed countries. In some instances, a passing mention was made that some components and dimensions of NIS in developing countries were different from that of the developed countries. A detailed look in that regard will be made in the following sections. It is worth mentioning that each developing country is embedded in a specific institutional context and just imitating innovation policies practised in other countries is unlikely to deliver the desired results (Chaminade *et al*., 2009).

2.3.2 NIS in developing countries

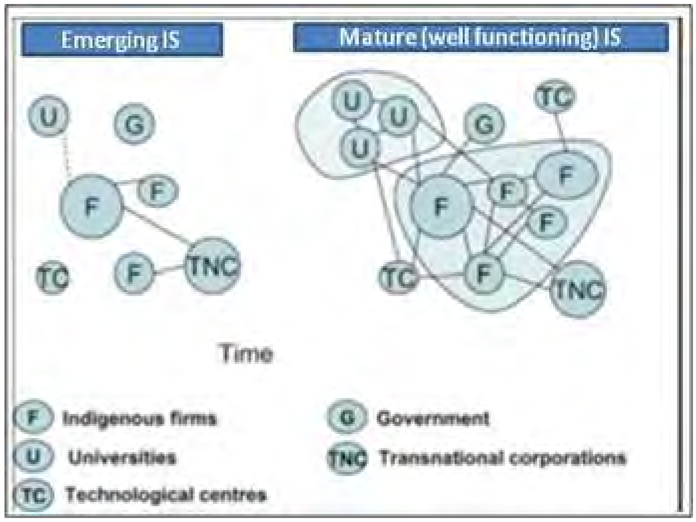
NIS in a broad sense (see section 2.3.1 for definition by Lundvall *et al*., 2009), which encompasses innovation, learning and competence, is crucial for the economic growth and competitiveness of a developing country. Innovation in this system encompasses two forms of learning – the STI (Science, Technology and Innovation) and DUI (Doing, Using and Interacting). The STI approach is the narrow approach of learning through laboratory experimentation, codified knowledge and formal processes of learning - R&D being its major creator. The DUI model, which focuses on interactive learning through structures, relationships and through external customers, is a broad approach to learning and innovation systems.

Historically, the concept of NIS was mainly used in rich, developed countries. Intarakumnerd *et al.* (2002) suggested the need for studies done in less-technologically successful, developing countries in terms of using empirical data to analyse the relationships between social absorptive capacity, NIS and economic performance in developing countries. However, interest in NIS is growing in developing countries and the idea of institutions is being more generally accepted (Lundvall *et al*., 2002). Lundvall *et al*. (2002) argued that a broadened, deepened and more dynamic NIS would be able to adapt to developing countries in a way that does not result in a negative effect on their development strategies, but rather help to stimulate the policy of learning.

Most innovations in a developing country are *new to the firm* and related to absorption of technology and competence building (Chaminade, Lundvall, Vang & Joseph, 2009; Viotti, 2002). These types of innovations are important for development and *catching-up* in a developing country (Chaminade *et al*., 2009).

A well-functioning innovation system based on intense interactive learning is conspicuous by its absence in a developing country (Chaminade *et al*., 2009). The following diagrammatic presentation differentiates between innovation systems in an emerging and developed country. A system of innovation in the context of a developing or emerging country is evolutionary in nature and characterised by the presence of some building blocks of innovation systems; the interactions among the blocks are still in formation and fragmented in nature (Chaminade & Vang, 2008).

Diagram 2-1: Emerging versus Mature IS



Source: Chaminade and Vang (2008)

Unlike in the case of developed countries, Galli and Teubal (1997) suggested that the innovation systems in emerging countries had weak inter-sectoral links; there was an absence of interface units between the various organisations and especially universities, which mainly supplied manpower and not innovative knowledge. An interesting observation from the above diagram is the role of government – it seems that it is practically non-existent in the case of emerging innovation systems. Such systems are also weak in terms of both DUI and STI forms of learning. Chaminade *et al*. (2009) argued that this is due to low competencies of users, a lack of trust and a low level of research capabilities.

The following discussion attempts to identify the important elements and relationships which are critical in understanding the innovation system of developing countries.

a) Capabilities

Most of the literature on innovation in developing countries argues that the crucial capabilities of the innovation system in an emerging country are those related to *absorption* and *adaptation* of technology from external sources of knowledge (Chaminade *et al*., 2009).

Absorption of technology is fundamental in the earlier stage of development in the system typical of a developing country. Firms focus on the acquisition of *managerial competencies* only in the mature stage when certain technical levels are achieved (Chaminade & Vang, 2008). A case in point is that of Sasol in South Africa which started to look at managerial competencies and practices like process improvements ten years after its founding (Barnard, Bromfield & Cantwell, 2009).

Chaminade *et al*. (2009) argued that the lack of STI *research capabilities* in developing countries should not be considered as an important constraint for the development of innovation. It becomes crucial only in the mature stage of economic development.

Jensen, Johnson, Lorenz and Lundvall (2007) stated that independent of the stage of development, the combination of interactive learning through STI (learning through Science and Technology) and DUI (on the job learning and interaction with users) were critical in terms of enhancing innovation in firms. The lack of learning organisations and the low level of skills, education systems and knowledge infrastructure in developing countries are major deterrents in this regard (Chaminade *et al*., 2009).

b) Network

A lack of local competencies and knowledge resources often make the local firms dependent on the holding transnational corporations (TNC) for STI and DUI knowledge and capital (Cozzens & Kaplinsky, 2009). The literature on direct and indirect spillovers from TNCs to local firms demonstrate that the TNCs (international users) are often reluctant to engage in interactive learning with the local firms due to a lack of absorptive capacity on the part of the latter, fear of losing knowledge and the lack of differentiation of firms and the goods they supply (Marin & Arza, 2009). This is why Chaminade *et al*. (2009) stressed the importance of the accumulation of local capabilities to boost interactive learning between local and TNC firms.

Although absorbing knowledge from abroad is a significant element of an emerging NIS, the role of local users - particularly for DUI forms of learning - cannot be neglected. The role of domestic users might be more relevant for larger developing countries like Brazil, India and China (Chaminade *et al*., 2009). The development of the nanocar (India), the Lilliput computer (China) and sugarcane fuels (Brazil) are some examples of the role of local users in stimulating innovation.

Interactions with universities are significant in the STI mode of learning. In a developing country the lack of advanced research capabilities in universities is a problem. Here, universities supply trained academic personnel to be absorbed in meaningful employment and less on research and development (R&D) activities (Lundvall, 2007). However, this lack of university-generated research is not the biggest issue for an emerging innovation system. This only becomes critical when firms start moving to more advanced and mature activities in the value chain (Chaminade *et al*., 2009).

c) <u>Institutional links in NIS</u>

D'costa (2006) argued that innovation systems in developing countries were characterised by a low degree of institutional thickness and thus weak inactive learning. Also, the links between formal and informal elements seem to be weak. The existence of innovation-friendly business regulations, a regulatory labour market and a reliable intellectual property regime (IPR) are crucial for economic development (Fagerberg & Srholec, 2009).

The existence of a lack of business regulations, weak or non-existing IPR, and high levels of corruption or of social exclusions, are the major impediments for the prosperity of innovation in developing countries (Chaminade *et al*., 2009).

Thus, in a developing country some of the elements of an innovation system are present, however the interactive learning between an organisation and capabilities are lacking because of weak institutions and the link between organisations.

In summary, it is argued that the characteristics, elements and determinants of a National Innovation System differ widely among developing and developed countries. Also, the impact of NIS on the innovation activities of firms differs in the context of the respective countries. It is a daunting task to identify characteristics of an innovation system in developing countries because of the heterogeneity in the configuration of the systems among the countries. This difficulty compounds even further because of the limited studies done on developing countries in this regard.

However, based on the above literature review, Table 2-4 (below) summarises the various aspects of the innovation systems in developing countries which will be used as a basis to analyse the innovation characteristics of firms in South Africa. The table is not exhaustive however the intent is to illustrate the major innovation system characteristics of developing countries based on the existing literature. Some of the characteristics of the developed countries are mentioned for contrasting and comparison purposes only.

Table 2-4: Comparison of NIS of a Developed Country and a Developing Country

	NIS of a developed country	NIS of a developing country	
1. Components of NIS	Strong institutional set up High level of business regulation and IPR	Low degree of institutional thickness Lack of business regulation, weak or non-existing IPR High level of corruption	D'costa (2006) Fagerberg and Srholec (2009) Chaminade *et al.* (2009)
	Linkages between firms and organisations are well developed	In formation stage and fragmented in nature Weak inter-sectoral links Absence of interface units	
2. Dimensions of NIS	Mainly narrow and formal but inclusive of broad and informal	The broad dimensions including formal and informal elements is a better framework for explaining emerging innovation system	Lundvall *et al.* (2009)
3.Determinants of NIS	Creation of new knowledge	Absorption and adoption of knowledge	Chaminade *et al*. (2009) Lundvall (2007)
	R&D and S&T based	Weak R&D	
	Better education system	Education -- Universities are supplier of man-power and not research	
	High internal competence building and absorptive capacity Superior networking around knowledge	Knowledge dependant on external and foreign sources	
4. Learning mode	Mainly STI but inclusive of DUI	Weak STI and DUI learning. STI learning relatively weaker	Chaminade *et al*. (2009)
	Intense interactive learning	Weak interactive learning between firms, universities etc	
5. Types of innovation	Mainly 'new to market' and 'new to world'	Mainly 'new to firm'	Chaminade *et al.* (2009) Viotti(2002)
	Creation of technology	Absorption of technology	
6. Capabilities	Evolved -- inventional capabilities; managerial competencies; research capabilities	Evolving -- Mainly absorption and adoption, lack of STI research and managerial capabilities Low competences of users, lack of trust and low level of research capabilities	Chaminade *et al.* (2009) Chaminade and Vang (2008)
7. Network	Developed network -- evolved interactions with other indigenous firms, universities, research institutes , government and technological centres. University-industry link is strong	Fragmented network -- Dependant on international knowledge spill-overs, low interactions with other firms, universities, government University-government-industry link weak	Galli and Teubal (1997)

The important themes emanating from this summary are those of a low degree of institutional environment characterised by weak inter-sectoral links, knowledge dependence on external sources (including TNCs), low competence, weak interactive learning and reliance on regional frameworks (i.e. a weak national set-up).

2.3.3 NIS in South Africa

The NIS of South Africa has its own characteristics. It is important to note the extent of the similarity of the generic characteristics, elements and determinants of NIS between the developing countries (illustrated in Table 2-4) and South Africa.

Rooks *et al.* (2005) opined that research was needed to open the black box of South Africa's innovation system. Comparing innovations systems is problematic as the use of aggregate statistics may hide institutional inefficiencies (Niosi, 2002).

Rooks and Oerlemans (2005) developed a descriptive model based on the knowledge flows, financial capital flows, human capital flows and regulatory flows in South Africa. The following are their major findings:

2.3.3.1 Knowledge flows

South African firms, compared to their EU counterparts, have relatively more technological alliances, and their partnerships are mainly with foreign firms. Based on the South African Innovation Survey (2001), companies indicated that in terms of usage of external knowledge flow, they utilised the following group in order of use (Oerlemans, Pretorius, Buys & Rooks, 2003):

- Business network comprised of competitors, buyers and suppliers.
- Professional knowledge channel comprised of professional literature and exhibitions.
- Public and private knowledge infrastructure comprised of research laboratories, universities and innovation centres (hardly used).

The nature of innovation is also characterised by imitation and reverse engineering. Rooks and Oerlemans (2005) found that the majority of innovation projects encountered problems due to a lack of information or unfamiliarity with technology.

2.3.3.2 Financial capital flows

Rooks and Oerlemans (2005) claimed that one in five innovating firms did not start an innovation project because of a lack of capital and the projects were often delayed and abandoned compared to the developed European counterparts. As per the South

African Innovation Survey (2001), only 7% of South African firms made use of government innovation funds. This low utilisation could be due to limited budgets of government funds, lack of trust in government, bureaucratic procedures or lack of accessibility to funds (Rooks & Oerlemans, 2005).

2.3.3.3 Human capital flows

It is observed in the discussion above that the South African innovation system is fuelled by an external knowledge source. The capability to absorb this knowledge is critical for the success of the firms. Education and training improves this absorptive capability.

However, South African firms are handicapped by a lack of qualified personnel. The reasons for this are due to HIV/AIDS issues, a sub standard education system and the phenomenon of *brain drain,* whereby professionals are leaving the country (Rooks & Oerlemans, 2005).

2.3.3.4 Regulatory flows

South Africa has made efforts to improve the alignment of NSI with national objectives (Kaplan, 2004). However, the National Research and Development Strategy (2002) expressed concern around the absence of a policy framework for intellectual property and the fragmentation of government departments in terms of S&T programmes. In addition, restrictive regulations hinder innovation projects in South Africa (Rooks & Oerlemans, 2005).

Table 2-5 below summarises the characteristics of the innovation systems in South Africa and the similarities with the generic characteristics of innovation systems in developing countries. The common themes again centred on a low degree of national institutional frameworks, characterised by weak government support, innovation based on absorption of knowledge, domestic and international partnerships, a lack of qualified personnel and a low level of education.

In the absence of a strong national institutional framework and the compulsion of firms to look externally for innovative activities, interactions and interactive learning among organisations and institutional support becomes localised and region based. The following section will look at some of the characteristics of the regional innovation system with an intention to discover the significant local characteristics of innovation among the firms. This along with the information regarding the NIS in South Africa (discussed above) is envisaged to aid in developing a framework of patterns and salient characteristics of innovation in firms belonging to an emerging and a mature industry.

Table 2-5: Comparison of NIS of Developing Countries and South Africa

	NIS of a developing country	NIS of South Africa
1. Components of NIS	Low degree of institutional thickness Lack of business regulation, weak or non-existing IPR High level of corruption	Absence of policy framework for IP Fragmentation of government departments in terms of S&T programmes
	In formation stage and fragmented in nature Weak inter-sectoral links Absence of interface units	Problems occur in innovation projects due to restrictive public or governmental regulations Fragementation of government departments in terms of S&T programmes
2. Dimensions of NIS	The broad dimensions including formal and informal elements is a better framework for explaining emerging innovation system	High level of utilisation of business network -- competitors, buyers and suppliers.
3.Determinants of NIS	Absorption and adoption of knowledge	The innovation is fuelled by absorption of knowledge from business network and professional knowledge channels
	Weak R&D	
	Education -- Universities are supplier of man-power and not research	Public and and private knowledge infrastructure -- research lab, universities, innovation centres are not used widely for innovative purposes
	Weak internal capability and dependence on external financing	Partnership mainly from foreign firms
	Knowledge dependant on external and foreign sources	Partnership mainly from foreign firms Fewer partnership with domestic firms
4. Learning mode	Weak STI and DUI learning. STI learning relatively weaker	Problems during innovation project due to lack of information/familiarity with technology and low learning ability
	Weak interactive learning between firms, universities etc	Public and and private knowledge infrastructure -- research lab, universities, innovation centres are not used widely for innovative purposes
5. Types of innovation	Mainly 'new to firm'	The nature of innovations is characterised by imitation and reverse engineering and absorptive in nature
	Absorption of technology	
6. Capabilities	Evolving -- Mainly absorption and adoption, lack of STI research and manegerial capabilities. Low competences of users, lack of trust and low level of research capabilities	Problems occur in innovation projects due to lack of qualified personnel Low level of education system
7. Network	Fragmented network -- Dependant on international knowledge spill-overs, low intercations with other firms, universities, government. University-government-industry link weak	Public and and private knowledge infrastructure -- research lab, universities, innovation centres are not used widely for innovative purposes. 7% of firms utilise government fundings

2.3.4 Regional Innovation System (RIS)

At a sub-national level, the innovation system literature which has caused the greatest policy impact is that on the Regional Innovation System (RIS) (Nuur, Gustavvson & Laestadius, 2009). RIS is defined as a "constellation of *industrial clusters* surrounded by innovation supporting organisations" (Asheim & Coenen, 2005). Porter (1998) referred to *industrial clusters* as the geographic concentration of firms in the same or related industries. The concept of RIS was inspired by successful regions like Silicon Valley, Baden Wurttemberg and the Third Italy, and was based on the fact that knowledge formation (and communication) processes were not perfectly mobile. Localised learning processes benefit from at least some physical closeness (Nuur *et al*., 2009). This creates tension between the global/national and local/regional, out of which several forms of RIS emerged (Asheim & Gertler, 2005).

The RIS concept was based on the NIS concept and it is inspired by similar logic that emphasises a territorially based innovation system (Asheim, 2007). The uneven distribution of innovation at national level is one of the reasons for the *regionalisation* of innovation activities (Nuur *et al*., 2009). Thus, the various components, dimensions, learning modes and determinants which are important at national level (NIS) can all have strong regional dimensions. These dimensions are based on *sticky* knowledge and localised learning within the region. "The RIS can be thought of as the institutional infrastructure supporting innovation within the productive structure of the region" (Asheim, 2007).

2.3.4.1 Types of RIS

Asheim (2007) distinguished between three types of RISs.

The first type was denoted as *territorially embedded regional innovation systems.* Cook (1998) described this type as *grassroots RIS.* In this type of RIS, firms' innovation activities are based on localised, inter-firm learning processes stimulated by the conjunction of geographical and relational proximity without much direct interaction with knowledge-generating organisations (R&D institutes and universities). The direction of innovation here is determined by the demand factor. This type of RIS is envisaged to be present in developing countries.

The second type is the *regionally networked innovation system.* This system is characterised by the intentional strengthening of the region's institutional infrastructure which in turn enables localised interactive learning. Cook (1998) called this type of RIS, *network RIS.* This approach is prevalent in developed countries like Germany, Austria and the Nordic countries. The direction of innovation is determined by mixed supply/demand interaction.

Finally, the third type of RIS is the *regionalised national innovation system.* The major difference of this system compared to the other two is as follows:

- Here, innovation activity takes place primarily in co-operation with actors outside the region – tightly integrated with a national or international innovation system.
- The collaboration between organisations is based on formal analytical scientific knowledge e.g. science parks.

Cooke (1998) described this as *dirigiste RIS,* reflecting a narrow definition of the innovation system based on a science/supply driven model in which exogenous actors and relationships play a major role. This type of RIS is envisaged to be prevalent mainly in developed countries.

2.3.4.1 RIS and life cycle of industries

Porter's original cluster concept indicates that "a nation's successful industries are usually linked through vertical (buyer/supplier) or horizontal (common customers, technology etc) relationships" (Porter, 1990, p.149). He further suggested that clusters were geographic concentrations of interconnected companies and institutions in a particular field. It "encompassed an array of linked industries and other entities important to competition" (Porter, 1998, p.78). The concept of RIS is an extension of the firm's interaction concept of the *cluster.* It is a concept which includes much wider actors and may be defined as "co-operation in innovation activity between firms and knowledge creating and diffusing organisations, such as universities, colleges, training organisations, R&D institutes, technology transfer agencies, business associations, finance institutions etc" (Isaksen, 2001, p.107).

The interaction and relationship between the cluster concept and RIS can be explained systematically with the help of various stages of the industry life cycles. In the case of the mature industries, RIS are built on 'pure' clusters structured to support innovation based on existing knowledge prevalent in already established industries; while new knowledge, clusters and RIS interact in the case of emerging industries (Asheim, 2007).

In a territorially embedded innovation system, the importance lies in the localised, path-dependent, inter-firm learning processes based on synthetic knowledge (innovation based on existing knowledge). This system is often found in mature industries (Asheim, 2007). In the case of regionalised national innovation systems however, R&D and scientific research take a much more prominent role based on analytical knowledge (innovation based on new knowledge). Asheim (2007) suggested that this system is more prevalent in emerging industries.

The following Table 2-6 summarises the relationships between types of knowledge, types of RIS and life cycle of the industry:

Table 2-6: Types of RIS and Knowledge: Life Cycle of Industries

	Type of knowledge	
Types of RIS	Analytical (new knowledge)	Synthetic (existing knowledge)
Territorially Embedded System		Mature Industry
Regionalised National Innovation System	Emerging industry	

Although from the above generic relationship it is apparent that firms belonging to mature industries also operate under RIS, the empirical background of territorial agglomeration and networking is based on small to medium sized enterprises (Asheim, 2000). Generally in emerging industries where competition among firms is higher, the sizes of the firms are relatively smaller. The size of the firms grows with time as the industry becomes more concentrated and the barriers of entry become higher. Thus one may develop a viewpoint that firms in the emerging industries have more incentive to participate in a RIS than those in mature industries.

Asheim (2000) supported this view by arguing for the creation of *industrial districts* (territorial systems). In general the creation of RIS was based on the creation of external economies of scale - economies that were external to firms but internal to the area. This provides a competitive advantage for the smaller firms belonging to an emerging industry relative to the internal economies of scale of the incumbent firms. Additionally, most findings on triple helix collaborations (industry-government-university) in regional dynamics which originated from the emergent industries at the start of their life cycles (Coenen & Moodysson, 2009), strengthen the viewpoint of the relative incentive for the regional participation of firms belonging to emerging industries.

In summary, RIS is not NIS at a sub-national level. The study of how an embedded learning process takes place in a NIS sometimes becomes problematic. This problem is often resolved by "focussing on specific, important and innovative sectors in the national economy which in turn are often regionally concentrated" (Coenen &

Moodysson, 2009). RIS is an interactive localised innovation process between the various actors – firms, government, and knowledge diffusing and creating organisations. The various types of RIS and the associated interplay between the types of knowledge and firms belonging to different phases of the industry life cycle, give rise to the various dimensions of RIS. Finally, it seems that the firms belonging to the emerging industries may have more incentive to take advantage of the dynamics of the RIS.

2.3.5 RIS in developing countries

In section 2.3.4 (above), the traits and characteristics of RIS were discussed mainly in the context of developed countries. As mentioned previously the concept of RIS was developed from the inspiration of successful regions and clusters such as Silicon Valley, Baden Wurttemberg and the Third Italy (all from developed countries). It seems however, that there are no 'best practice' lessons that can be learnt from these or any other successful regions. This is mainly due to the fact that these regions followed highly diverse industrialisation, development and upgrading paths (Padilla-Perez, Vang & Chaminade, 2009). Padilla-Pereze, *et al*. (2009) further emphasised that the region's innovation system was influenced by the human, social, financial endowment, policy and intervention strategies of the country it belonged to. This has encouraged scholars like Lundvall, Chaminade, Vang, Asheim, Yeung, Pietroballi and Rabellotti to re-theorise, re-conceptualise and adapt the original ideas of RIS and clusters to the context and specificities of the developing countries.

RISs are conceived as *ex post* rationalisations of the aforementioned success cases in the well functioning regions of developed countries (Padilla-Perez *et al*., 2009). Chaminade and Vang (2008) claimed that existing literature was generic and ignored the specificities of firms located in the RIS in developing countries. It would not be far-fetched to extend this claim of ignorance towards specificities of firms belonging to industries in different phases of their life cycle. RISs in developed and developing countries shape innovation in fundamentally different ways because of the influence of the national institutional frameworks. Thus, in this research the localised characteristics (influenced by RIS) of innovation in firms belonging to the emerging and mature industries are looked through the lens of NIS of an emerging country, South Africa.

The RIS in developing countries is characterised by weak indigenous formal institutions and *catching up,* as opposed to being the first movers (Padilla-Perez *et al*., 2009). This innovation system often relies on external capital and knowledge originating not just outside the firms and sub-national regional borders, but also from outside the country (Amin, 2004; Loebis & Schmitz, 2005; Pietrobelli & Rabellotti, 2006; Scmitz, 2006) compared to the relative self-sustenance of RIS in a developed country. The following section describes some of the characteristics of RIS in developing countries. The structure is based on the findings of Padilla-Perez *et al*. (2009).

2.3.5.1 Integration and interaction in regional innovations systems in developing countries

This thesis, as mentioned previously, defines innovation systems in a broad way contrary to the narrow definition of scientific research – the SI is about integration and interaction among various actors in the system. RIS focuses on the localised nature of these interactions, emphasising the tacit component of knowledge facilitated by local proximity (Padilla-Perez *et al*., 2009). In developing countries, unlike the developed countries there is an absence of intensive interactions between the various elements in the system. In this sense, RIS in a developing country may be termed as 'immature RIS', where the interaction among the elements is fragmented and still in formation (Chaminade & Vang, 2008). Padilla-Perez *et al*. (2009) claimed that a high degree of integration and interaction among the elements of RIS was necessary for advanced firm-level technological capabilities in the developing countries.

2.3.5.2Transnational Corporations (TNCs) and the RIS

As mentioned before, developing countries lack local resources and are dependent on external sources of knowledge. Hence so-called global-local linkages have come to the forefront of RIS studies in developing countries (Padilla-Perez *et al*., 2009). It is important to note that international linkages do not guarantee positive results and are dependent, amongst other factors, on the subsidiaries' local embeddedness, and the R&D mandate (the decision making structure of the TNC) ; in general they are dependent on the industry, institutional and firm specific characteristics (Pack & Saggi, 1997;Padilla-Perez, 2008). Padilla-Perez *et al*. (2009) suggested that the interaction between foreign subsidiaries and locally owned firms was important in RIS of developing countries, yet it was not automatic.

2.3.5.3 State or governmental intervention in RIS of developing countries

The NIS approach gives importance to the role of the national government in creating an environment for effective innovation in firms, while RIS emphasises the role of local government in constructing and supporting innovation systems at the local level (Asheim, Isaksen, Nauwelaers & Toedtling, 2003). 'Italian district literature' described the role of state (local government) extensively. The major contributors in this regard are scholars like Beccatini, Bagansco, Brusco and Trigilia. Most of them place emphasis on the importance of interactive learning and facilitation of innovation with the support of the local government. Padilla-Perez *et al*. (2009) argued that local state intervention was instrumental in RIS to upgrade firms' technological capabilities.

In summary, although the localisation of interaction between the different elements of the innovation system is common among the developed and developing countries, some of the characteristics of RIS in a developing country differ from that of a developed country. The RIS of a developing country is characterised by weak indigenous formal institutions and a lack of resources, thereby depending on either external sources or local governmental support. Table 2-7 (below) summarises the salient features of the RIS in a developing country. The characteristics of the developed countries are used for contrasting purpose.

Table 2-7: RIS characteristics of Developed and Developing countries

	RIS in developed country	RIS in developing country
Types	• Mainly, Regionally networked and Regionalised National innovation system • 'First mover'	• Mainly ,Territorially embedded regional innovation system. • 'Catching up'
Source of Capital and Knowledge	Self sustenance in terms of capital and knowledge	External reliance on capital and knowledge
Integration	Higher degree of integration and interaction amomg the elements of RIS	Weak integration and interaction among the elements.
Types of Knowledge	Mainly based on analytical (new) knowledge	Mainly based on synthetic (existing) knowledge
Support	Support from both local and national innovation framework	Support mainly based on local frameworks

Now that the background and themes of NIS and RIS existent in a developing country are understood, the details of characteristics of the industry life cycle is looked into in the following section. The aim is to juxtapose the themes of the innovation system and the innovation patterns of the industry life cycle and come up with a generic innovation framework for the firms belonging to an emerging and a mature industry.

2.4 Industry Life cycle (ILC)

The theory of the product life cycle originally presented by Utterback-Aberanthy and subsequently by Porter gave impetus to the studies of the Industry Life Cycle (ILC) (Argyres & Bigelow, 2007). Subsequently, Klepper (1996) popularised the concept. According to this concept, firms rapidly enter the early stage of the industry evolution called the emerging or development stage. The net entry of the number of firms reduces over time giving rise to a mature stage, where the more efficient firms manage to survive, with the exit or absorption of the less efficient ones.

2.4.1 Characteristics of innovations at different stages of ILC – product, process and firm entry rates

The two major theories in illustrating the characteristics of ILC are the Vernon-Abernathy-Utterback (V-A-U) model and the Klepper model. The V-A-U model based on the dominant design concept predicts the incentive of firms to enter and exit the market at various stages of the industry life cycle, while Klepper's model does that based on accumulated process innovations.

Vernon-Abernathy-Utterback model

This model is based on the *dominant design* concept. The early phase (*emerging* or *developing*) of an industry is characterised by uncertainty – consumer tastes, potential size of the market, technical constraints and solutions (Windrum, 2005). These uncertainties give rise to product innovation and experimentation among competing firms. Each firm tries to design the products/solutions differently to capture market share. The number of firms entering the industry in this phase is high. The entry of firms reduces with time when the industry shake-out occurs with the emergence of a dominant design. The developer of the dominant design has the competitive advantage in this phase.

Once a dominant design is established, the competition among firms is based on cost and price (Argyres & Bigelow, 2007). Also the nature of innovation changes from product to process. The firms which do not have economies of scale and process efficiency exit the industry giving rise to the *mature* stage of the industry. Subsequently, once the process efficiency is stabilised, the competitive advantage moves towards the wage cost, frequently causing relocation of production to developing countries (Windrum, 2005).

Klepper's Model

Klepper's model is based on the learning to do (process) R&D capacities of firms rather than the emergence of the dominant design concept; it assumes that the return to process R&D is a direct function of the firm size (Windrum, 2005). As per Klepper (1996), the new entrants in the industry were relatively smaller in size and were involved with incremental product innovation. Thus the *developing* phase of the industry is characterised by the entry of firms that are heterogeneous in their product innovation capability (Argyres & Bigelow, 2007). However this entry becomes increasingly difficult with time due to increasing start-up costs (associated with accumulated process innovations) (Windrum, 2005). This is why Klepper argued that the number of net entry of firms reduced over the course of the ILC. He also claimed that in the mature phase of the ILC, successful firms backed by process innovation, economies of scale and better efficiency managed to reduce the unit cost, thus increasing their competitiveness. This implied that the less efficient firms exited the industry.

The Vernon-Abernathy-Utterback model and Klepper's model differ regarding the primary drivers of the characteristics of ILC – competitive advantage, innovation and shake-outs. However, they concur on the essential phenomenology of innovation over the ILC (Windrum, 2005). As per Klepper (1996), the following are some of the characteristics of the ILC:

- The number of new entrants may rise or decline initially, but eventually it will decline to zero.
- The number of net firms in the industry rises in the initial phase of ILC but eventually it will decline.
- The rate of change of market share of the incumbent will eventually slow.

- The number of product innovations decline as industries mature through the phases of ILC.
- Process related innovations increase with the maturity of the ILC.
- Entrant firms will be more innovative on average compared to the incumbents.

Empirical studies in terms of the characteristics of ILC by Christensen (1997) , Cohen and Klepper (1996), Henderson (1993), Klepper (2002), and Klepper and Graddy (1990) agree with some of the claims as described above (Argyres & Bigelow, 2007; McGahan & Silverman, 2001). In most of these studies however, relatively little cross-sectional analysis was used and they were based on intra-industry dynamics (McGahan & Silverman, 2001).

McGahan and Silverman (2001) did an empirical analysis on the characteristics of innovation during the phases of ILC on inter-industry data of US firms from the early 1980s to the mid-1990s. They used the number of patents as a measure of innovative activities and concluded with the following findings which were contradictory to some of Klepper's claims:

- There was no evidence of less innovative activity in mature industries than in emerging industries i.e. innovative activities were not higher in emerging industries than mature industries.
- There was no evidence of more process innovation in mature industries than in emerging or declining industries i.e. the process innovation in emerging industries was as high as those of mature industries.
- There was no evidence that mature industry leaders were less innovative than emerging industry leaders i.e. the leaders in mature industries participated as much in innovation activities as the leaders of emerging industries.

Windrum (2005) also refuted Klepper's model and the generalised claims in terms of characteristics of innovations during the different life cycles of an industry. He concluded the following in terms of his study on the amateur camera industry based on companies in Europe and Japan:

- Major product innovations were not concentrated in the early phase of the lifecycle.
- The number of new entrants did not peak in the early phase of the lifecycle.
- The introduction of new radical product designs took place in the mature phase of the lifecycle.
- A series of shake-outs took place in the camera industry.
- New technology entrants could out-compete mature incumbents.
- The strict product-process sequence of innovations was not found in the camera industry.

Barras (1990) suggested a *reverse lifecycle* in service industries, refuting the conventional product to process innovation sequence as well. He found the adoption of Information and Communications Technology (ICT) in banking, insurance and accounting industries prompted an improvement of back-office processes, and only in the mature stage were new financial products developed. Barras (1990) went ahead and claimed that the reverse lifecycle existed in service industries while the conventional lifecycle existed in manufacturing industries. However, the stylised facts in the amateur camera industry by Windrum (2005) raised doubt on the existence of the conventional life-cycle in the manufacturing industry as well.

In conclusion, there remain heterogeneous viewpoints so far as the relative total innovativeness, and specific product and process innovativeness among firms belonging to emerging versus mature industries. Klepper’s claim of higher total innovativeness and product innovativeness in firms belonging to an emerging industry, and higher process innovativeness in firms belonging to a mature industry, has been challenged by the likes of McGahan & Silverman, Windrum and Barras. In this research, these viewpoints of the characteristics of innovation in firms will be tested in the context of a developing country.

2.4.2 Stages of ILC – R&D and knowledge flow

It is observed in section 2.3.1 that learning is a critical factor for successful innovation activities. Learning is closely related to knowledge, which acts as input to the process of generating innovative activities. Some of the key factors of generating knowledge are a high degree of human capital, a skilled labour force, the high presence of scientists and engineers, and research and development (Audretsch, 1998).

The knowledge production function has traditionally been used to illustrate the impact of knowledge (flow) on innovation. This function links inputs in the innovation process to innovative outputs. R&D, which is a good proxy for source of knowledge especially in developed countries, is used as a primary source and input to the production function. Thus the innovative outputs explained by this function (defined below) are based on a fairly narrow definition.

$$I_{si} = IRD^{\beta_1} * UR_{si}^{\beta_2} * (UR_{si} * GC_{si}^{\beta_3}) * \varepsilon_{si}$$

I = innovative output, IRD= corporate expenditures on R&D, UR= research expenditure in universities, GC=geographic coincidence between university and corporate research. The unit of observation is at spatial level = s, a state and at industry level i.

This raises a question about how small firms entering the emerging phase of the ILC manage to be innovative in spite of their low R&D capability. One possible answer to this is via knowledge spillover from other firms or through universities' research institutes (Audretsch, 1998).

Audretsch and Feldman (1996) went on to claim that innovative activity should take place in regions where (i) the direct knowledge generating inputs are greatest and (ii) where knowledge spillovers are more prevalent. They further suggested that *tacit knowledge* played a much more significant role in the emerging phase of the ILC compared to the mature phase. In this context, large firms belonging to mature industries are more adept at knowledge created in their own laboratories, while the smaller counterparts from emerging industries were better at exploiting spillovers from university laboratories (Audretsch, 1998). Thus firms in emerging industries seem to be dependent on research and development knowledge spillovers from external agents compared to those of mature industries.

In summary, based on the formal knowledge (the flow of R&D in research laboratories and universities in the developed countries), firms in emerging industries are expected to use external knowledge from sources like universities while the firms in the mature industries are expected to use internal technical knowledge. A fallacy in these expectations is the assumption that knowledge is formal and based on scientific R&D only. Also, the expectations cannot be generalised based on the learning of the developed countries. On the contrary, it may be argued that because of the weak institutional links and fragmented interface units to the external world in developing countries, the firms in emerging industries may be forced to look inward and compete on the basis of the internal-to-firm innovation activities and its external interaction may be limited to the localised elements, while the firms in the mature industries may be in a better position to exploit external knowledge, based on the international connections developed over time.

Given the characteristics of the NIS and RIS in a developing country and the innovation patterns of the firms belonging to the different phases of the industry life cycle, the following is a summary of the expected patterns and characteristics of innovation among firms belonging to an emerging industry or a mature industry (the details of the analysis and reasoning is discussed in the following section).

Table 2-8: Innovation Characteristics during the ILC

`	Emerging Industry	Mature Industry
Innovativeness	More innovation	Less innovation
Product v/s process	More product innovation; less process innovation	Less product innovation;more process innovation
Knowledge flow	More internal-to-firm	More dependent on external agent
Institutional (government) support	Less support	More support
	More local support	More national support
Innovation activities	Based on local elements	Based on international elements

2.5 Impact of NIS, RIS and ILC characteristics on the innovation of firms

As observed in the literature review so far, there is a lack of innovation studies done in less technologically successful, developing countries (Intarakumnerd *et al*., 2002). Also, the empirical studies on the characteristics of innovation at various life cycle stages of industries have mainly been done in developed countries.

This study attempts to predict the differing salient characteristics of innovation in firms belonging to an emerging versus a mature industry in South Africa. The predictions are based on the juxtaposition of the features of the national innovation system based on the institutional setup (as explained in section 2.3.1-2.3.3), significant characteristics of the regional innovation system (as explained in section 2.3.4 and 2.3.5) and general characteristics of innovations in firms belonging to an emerging and a mature industry (as explained in section 2.4) in the context of a developing country, South Africa.

Table 2-9 below summarises the characteristics of NIS in column 1 (C1), the characteristics of RIS in column 2 (C2), the characteristics of firms belonging to different stages of industry life cycles in column 3 (C3) in a developing country, and the summary of the juxtaposition and analysis of these characteristics (from C1 to C3) to come up with the suggested innovation characteristics among firms belonging to the emerging and mature industries in column 4 (C4).

This is followed by the description of the rationale behind the four major hypotheses built on the basis of the analyses of the juxtaposition of the elements of NIS, RIS and innovation characteristics of the ILC (as summarised in Table 2-9).

Table 2-9: Analysis: Cross Reference of NIS, RIS and Innovation Characteristics during ILC

	NIS characteristics of a developing country(C1)	RIS characteristics(C2)	ILC characteristics(C3)	Juxtaposition and Analysis(C4)
1	• Weak R&D • Low competence • Low education • Lack of STI research		• Number of innovation in emerging industry > mature industry (Klepper) • Number of innovation in emerging industry not higher than mature industry (McGahan,Silverman)	McGahan and Silverman's claim is based on R&D(patents) in developed countries. The institutional environment related to innovation in developing countries -- weak R&D, lack of STI research (see C1) is different in developing countries from the developed countries. Thus it is expected that that McGahan's claim may not be true in developing countries. While Kleppers' claim of higher innovativeness in emerging industry may be true.
1a	• Absorption of technology • Lack of managerial capability		• Product innovation > process innovation in emerging industry (Klepper) • Product innovation not more than process innovation in emerging industry (Barras, Windrum)	Again Barass and Windrum's claims are based on developed countries. Absorption of technology (noted in C1) is fundamental in the product innovation in firms belonging to the early life-cycle stage of an industry in a developing country; while managerial competencies (noted in C2) like process improvement comes with maturity of industry in a developing country. Thus Kleppers claim of more product innovation in emerging industries and more process innovation in mature industries seem to be more relevant in developing countries.
1b	• Absorption of technology • Lack of managerial capability		• Process innovation > product innovation in mature industry (Klepper) • No evidence that mature industry has more process innovation (McGahan and Silverman)	As per the analysis in point 1a (above).

	NIS characteristics of a developing country(C1)	RIS characteristics(C2)	ILC characteristics(C3)	Juxtaposition and Analysis(C4)
2	• Low degree of institutional thickness • Weak inter-sectoral links • Absence of interface units • Fragmentation of government departments in terms of innovation programs.		The age of firms in mature industry is higher than those in emerging industry	Because of the age of the firms in mature industries they make the most of the low degree and fragmented governmental support (see C1) based on its relationships with the governements supplemented by greater contribution to GDP.
2a		• RIS emphasizes the role of local government in constructing and supporting innovation systems at local level in a developing country (Ashiem, Isaksen, Nauwelaers & Toedtling) • The local state intervention was instrumental in RIS to upgrade firms' technological capabilities (Padilla-Perez *et al.*)	Concentration of firms in emerging industry in a particular region e.g. concentration of software firms in the *industrial district* of Gauteng.	The importance of RIS in terms of local governmental support (see C2) combined with the concentration of the software (emerging) industry in Gauteng (see C3) suggests that the firms belonging to the emerging industry can be expected to have more local governmental support.
2b	• Low degree of institutional thickness • Fragmentation of government departments in terms of innovation programs		The higher age of mature firms and greater contribution to GDP.	The higher age and greater contribution to GDP aids in building relationship with national institutions (government). Thus it may be expected that firms in mature industries get more national governmental support.

	NIS characteristics of a developing country(C1)	RIS characteristics(C2)	ILC characteristics(C3)	Juxtaposition and Analysis(C4)
3	• Weak inter-sectoral links • Absence of interface units • Low interaction with other firms, universities etc • Dependency on external sources of knowledge		The firms in mature industry by virtue of being around longer has better relationships with external agents compared to the firms in the emerging industry	The weak intersectoral links, absence of interface units (see C1) and younger age (see C2) of emerging industry makes it more inside focussed.
4a	• Weak interactive learning between firms, universities etc • Fragmented network -- Dependant on international knowledge spill-over, low interactions with other firms, universities, government • University-government-industry link weak • Weak internal capability and dependence on external financing	• Padilla-Perez *et al*. claimed that high degree of integration and interaction among the local elements of IS was necessary for advanced firm-level technological capabilities in the developing countries. • Most findings on triple helix collaboration (industry-government-university) in regional dynamics originated from the emergent industries at the start of their life cycles (Coenen & Moodysson)	Concentration of firms belonging to emerging industries in a region.	The concentration of the firms belonging to an emerging industry in a region (see C3) and the relatively higher incentive to use the localised elements of the innovation systems(see C2) in the context of weak national institutions (see C1) suggests firms in emerging industries to engage in relatively more innovation based on local activity.
4b	• Weak interactive learning between firms, universities etc • Fragmented network -- Dependant on international knowledge spill-over, low interactions with other firms, universities, government • University-government-industry link weak • Weak internal capability and dependence on external financing	Padilla-Perez *et al*. suggested that the interaction between foreign subsidiaries and locally owned firms was important in RIS of developing countries, yet it was not automatic.		Complementary reasoning to point 4 above -- mature industry in a developing country because of weak and fragmented national learning framework (see C1) has to look externally (see C2) for innovation activities. However because of its age and size it is expected to establish external international relationships.

2.5.1 Rationale behind the four major hypotheses

Hypothesis 1: Are firms in an emerging industry (software) more innovative than those in a mature industry (automotive)?

Klepper (1996) claimed that the numbers of innovations in firms belonging to an emerging phase of the industry are greater than in the mature phase. McGahan and Silverman (2001) challenged this claim. However, their empirical study was based on the number of patents as the measure of innovations.

It is observed in the literature review that there is a lack of research and development capability in developing countries (Lundvall, 2007) like South Africa. Hence the narrow definition of innovation based on patents is not relevant here. Firms in emerging industries, in order to be competitive, will innovate until a dominant design is established. Also, they may want to imitate and absorb and thereby take advantage of the lack of business regulation and weak institutions such as ineffective patent systems in developing countries (Chaminade *et al*., 2009; D'costa, 2006).

Thus, Hypothesis 1 states that the innovativeness in firms belonging to an emerging industry is greater than those of firms belonging to a mature industry.

With regards to types of innovation, Klepper (1996) proposed that there were more product innovations in firms belonging to an emerging industry than those of a mature industry, while there were more process innovations in firms belonging to a mature industry than in an emerging industry.

McGahan and Silverman (2001) and Windrum (2005) refuted Klepper's claims. However, McGahan and Silverman used patents as a measure of innovations and Windrum's claims were based on the camera industry in Japan and Europe (developed countries).

In the context of developing countries, absorption of technology is fundamental in the early stages of the development of the industry. Only when a technical level is achieved do firms start focusing on managerial competencies like process improvement (Chaminde & Vang, 2008; Barnard *et al*., 2009).

Thus the sub-hypotheses under the main hypothesis 1 state that product innovativeness is higher in an emerging industry, while process innovativeness is higher in a mature industry.

<u>Hypothesis 2: Does Government support firms in a mature industry (automotive) more than those in an emerging industry (software)?</u>

Innovation systems in a developing country are characterised by fragmented networks; the government-industry link is weak (Chaminade & Vang, 2008; Galli & Teubal, 1997). This is true in South Africa as well – only 7% of South African firms made use of government innovation funds (South African Innovation Survey, 2001). This low utilisation could be due to lack of government funds, bureaucratic red-tape or a lack of trust in government (Rooks & Oerlemans, 2005).

Firms belonging to a mature industry have existed longer than those in an emerging industry. Also, they often contribute more towards the GDP of a country. There is a higher possibility of mature firms having a better relationship with government, better accessibility to funds and increased mutual trust.

Thus, hypothesis 2 states that the governmental support to foster innovation is higher in firms belonging to a mature industry as compared to those in an emerging industry.

As observed so far, the innovation system in a developing country is characterised by a fragmented network, the absence of interface units, and weak industry-government linkages; and in general a low degree of institutional thickness. However, in the absence of local resources within firms in a developing country, innovation activities are dependent on external sources - especially national and local institutions like government. In the triple-helix collaboration (industry-government-university), government plays an important role in setting up an environment of interactive learning and facilitation of innovation.

Asheim, *et al*., (2003) emphasised the role of local government in constructing and supporting innovation systems at local level. At local level, the concentration of firms is often in the emerging industries. This provides a competitive advantage for the smaller firms belonging to an emerging industry to develop external economies of scale. The finding of the triple-helix collaboration based on firms in emergent industries (Coenen & Moodysson, 2009) also supports this view. Thus, given the importance of the role of local government in constructing an innovation system and the incentive for firms belonging to the emerging industries to take advantage of this support, it is expected that the firms belonging to an emerging industry will get more local governmental support.

Like any other organisation in a developing country, the firms belonging to a mature industry need institutional support from the government as well. These firms, because of their relatively higher age and contribution to the national GDP, develop better relationships with government at the national level and have more incentive to take advantage (because of their larger scale of support) of the national institutions, compared to the firms in an emerging industry. Hence it is expected that the firms in a mature industry will enjoy more national governmental support.

Thus the sub-hypotheses under hypothesis 2 state that the local governmental support for firms is higher in an emerging industry, while national governmental support for firms is higher in a mature industry.

Hypothesis 3: Do firms in an emerging industry (software) innovate more based on internal-to-firm knowledge than those in a mature industry (automotive) (hypothesis 3)?

The innovation system in developing countries is dependent on external sources (Chaminade *et al*., 2009; Lundvall, 2007). The situation in South Africa is very similar. As per the South African Innovation Survey (2001), innovative firms utilise external sources like business networks and professional knowledge channels in comparison to private knowledge infrastructure.

Audretsch and Feldman (1996) and Audretsch (1998) claimed that firms in emerging industries are more reliant on external agents than mature industries. However, this claim was based on research and development activities. The underlying assumption was that mature firms had better internal R&D facilities compared to emerging firms.

Developing countries have a very weak R&D structure (Lundvall, 2007). Hence the above claim may not hold well in the context of a developing country. On the contrary, given the weak inter-sectoral link, the absence of interface units and a low degree of institutional thickness in developing countries, the firms belonging to an emerging industry may need to innovate with internal sources relatively more than those in a mature industry.The firms belonging to a mature industry by virtue of relatively stronger external links (developed over time) will be in a better position to absorb external knowledge.

Thus, hypothesis 3 states that the innovations based internal to firms are higher in firms belonging to an emerging industry as compared to those in a mature industry.

Hypothesis 4: Is there any pattern of local and international innovation activities between the firms in an emerging industry (software) and a mature industry (automotive)?

Innovations in a developing country are often characterised by weak R&D systems, nearly absent links between university-government-organisation, feeble internal capability and knowledge dependent on external activities (Chaminde *et al*., 2009). However, it is also true that firms – particularly those belonging to an emerging industry - are forced to be involved with internal to firm innovations (see Hypothesis 3). Thus, although in a developing country the firms in general engage in innovation activities based on external resources, there is a certain amount of internal to firm innovation activities also happening. Irrespective of internal or external to firm innovation activities, the geographic location of the activities may be local or international.

The empirical background of territorial (local) agglomeration points to the fact that the firms belonging to an emerging industry seem to be utilising the local elements of the region more than those belonging to a mature industry. The fact that the most findings on triple helix collaboration (industry-government-university) in regional dynamics originated from the emergent industries at the start of their life cycles (Coenen & Moodysson, 2009) also supports this argument. Thus it may be expected that the innovation based on local activities (internal and external) is higher in firms belonging to an emerging industry that those of a mature industry.

In contrast, the firms belonging to a mature industry existed longer than the emergent firms. Hence they have the advantage of having built relationships with their suppliers, clients and competitors based abroad, and they may be expected to innovate based on the activities from international sources (internal and external).

Thus, hypothesis 4 states that the innovations based on local activities are higher in firms belonging to an emerging industry and innovation based on international activities is higher in firms belonging to a mature industry.

The next chapter summarises the research questions, in particular the proposed hypotheses based on the analysis and the context of the various characteristics of institutional theory, innovation systems and industry life cycle discussed so far.

3. Research Hypothesis

From the review of literature, it is apparent that the characteristics of innovations among firms belonging to different life cycles of an industry – emerging and mature stage differ. Additionally these characteristics are somewhat different in firms belonging to a developed country versus a developing country. It is argued in this study that this is primarily due to the institutional impact of the NIS and RIS on the innovation activities of the firm.

The focus of this research is to describe **how institutions in a developing country like South Africa influence the differing salient characteristics and patterns of innovation in firms belonging to an emerging versus a mature industry**. Four main hypotheses have been formulated with respect to this research question.

Hypothesis 1:

$H1_A$: The innovativeness in firms belonging to an emerging industry is greater than those belonging to a mature industry.

The two sub-hypotheses under hypothesis 1 are as below:

Sub-hypothesis 1a and 1b:

$H1a_A$: The product innovativeness in firms belonging to an emerging industry is greater than those in a mature industry.

$H1b_A$: The process innovativeness in firms belonging to a mature industry is greater than those in an emerging industry.

<u>Hypothesis 2</u>:

$H2_A$: The governmental support to foster innovation is higher in firms belonging to a mature industry than those in an emerging industry.

The two sub-hypotheses under hypothesis 2 are as below:

<u>Sub-hypothesis 2a and 2b:</u>

$H2a_A$: The local governmental support for firms belonging to an emerging industry is greater than those in a mature industry.

$H2b_A$: The national governmental support for firms belonging to a mature industry is greater than those in an emerging industry.

<u>Hypothesis 3</u>:

$H3_A$: The innovations based on internal-to-firm knowledge are higher in firms belonging to an emerging industry as compared to those in a mature industry.

<u>Hypothesis 4</u>:

$H4a_A$: The innovation based on local activities in firms belonging to an emerging industry is greater than those in a mature industry.

$H4b_A$: The innovation based on international activities in firms belonging to a mature industry is greater than those in an emerging industry.

The next chapter discusses the research methodology used to test the above propositions.

4. Research Methodology

4.1 Choice of methodology

The choice of methodology for the research was quantitative and descriptive in nature. Descriptive research describes the characteristics of a population or a phenomenon (Zikmund, 2003). Zikmund (2003) suggested that descriptive research answers questions like who, what, when, where and how, and are based on some previous understanding of the nature of the research problem. The intention of this research was to find *how* characteristics and patterns of innovation varied among firms belonging to a mature or an emerging industry. This research drew on the previous understanding of theories of innovation, institutions and industry life cycles, and in some respects drew from relevant empirical studies in developed countries.

4.2 Population of relevance

Zikmund (2003) defined target populations as the complete group of specific population elements relevant to the research project. In this research, all firms belonging to emerging and mature industries in South Africa constituted the target population.

4.3 Sampling frame and sample

The sampling frame is the list of elements from which a sample can be drawn; it also provides the list that can be worked with operationally (Zikmund, 2003). The sampling frame for this research was made up of firms belonging to the software (the proxy for emerging industries) and the automotive industry (the proxy for mature industries) in South Africa. Going forward, the terms ‘emerging industry’ and ‘software industry’, and the terms ‘mature industry’ and ‘automotive industry’ will be used interchangeably.

The database of the National Association of Automotive Component and Allied Manufacturers (NAACAM) and the Computer Society of South Africa (CSSA) were used to identify the firms belonging to the automotive and software sectors respectively.

4.4 Unit of analysis

The unit of analysis was the firm.

4.5 Data Collection Instrument - design

The data was based on the questionnaire developed as part of a larger international project under the University of Lund in Sweden. The original questionnaire was developed in Sweden with inputs from Chinese and Indian counterparts working on this project.

The questionnaire was adapted for South Africa in a workshop in South Africa in May 2008. Local academics and industry experts (automotive and software) gave their inputs as well. The questionnaire constituted of several questions and had the following broad categories:

- Company background
- Strategy to access local and foreign markets
- Resources of innovation
- Type and importance of innovation
- Linkages and channels

Copies of the questionnaires are included in Appendix 1(software) and Appendix 2 (automobile).

Every objective of this research had at least one question related to it in the questionnaire.

Automotive

The database of NAACAM comprising of 174 automotive firms was used as sampling frame. These firms constitute almost the entire population of active firms in the automotive sector of South Africa.

Software

The software industry is an emerging industry, thus the firms are not very well organised in terms of industry associations and/or directories. The Johannesburg Centre for Software Engineering was approached for a database of active software firms. This database did not include some of the big banks and telecommunication companies as software firms since their core business was not software. This is why the Computer Society of South Africa (CSSA) was approached. CSSA supports and recognises individuals who work in the software industry. The individual members are generally not opposed to disclosing their affiliations to the companies they work for. Thus 355 software firms were identified as a sampling frame using a bottom-up approach.

4.6 Data Collection

Automotive

The students doing a Masters of Engineering Management course at the Graduate School of Technology (University of Pretoria) assisted with the data collection for the automotive industry. The purpose of the questionnaire and the interview techniques were explained to the students in a training session prior to starting the field work. Each student conducted 10 to 15 interviews in person at the automotive firms. The students did not target specific persons with titles for responses. They identified appropriate respondents by taking the suggestion of the person in charge of innovation, process development or new product development. In some instances, the data was cross-referenced with other respondents at the respective companies. Once all the data was gathered centrally, a faculty member familiar with the automotive industry reviewed the consistency of coding.

Software

A different approach was used for the software firms. A recent graduate was appointed to gather responses from the firms in the software industry. The interviewer was trained in the purpose of the questionnaire and telephonic interview techniques. He contacted the companies telephonically and identified appropriate respondents by taking suggestions from the individuals who had membership at CSSA. In the cases of large organisations where multiple members were present in an organisation, a random method was used to contact one of them for the recommendation of an appropriate respondent. One advantage of having a single interviewer was the consistency in terms of the interpretation of the questions and coding.

4.7 Data Analysis

4.7.1 Independent variables

The data from the questionnaire was characterised into nine independent variables representing the sub-elements of the various hypotheses. Only some of the relevant questions from the questionnaire were used for this purpose. The responses gathered from the questions were translated into these nine variables.

The variables are identified in Table 4-1 with a cross-reference to the questions in the questionnaire.

Table 4-1: Variable Descriptions

Variable	Variable description	Questionnaire
x1	Total innovativeness of firms	Q24.1,Q24.2,Q24.3,Q24.4
x1a	Product innovativeness	Q24.1, Q24.2
x1b	Process innovativeness	Q24.3,Q24.4
x2	Overall governmental support to foster innovation	Q30.1 - Q30.10
x2a	Local governmental support to foster innovation	Q30.1 - Q30.10
x2b	National governmental support to foster innovation	Q30.1 - Q30.10
x3	Firms involved with internal-to-firm innovations	Q25
x4a	Innovations based on local activities	Q26.1-26.5
x4b	Innovations based on international activities	Q26.1-26.5

The variables x1, x1a, x1b, x2, x2a, x2b, x4a, and x4b (with the exception of variable x3, based on a single question) were created by giving equal weight to the responses given by each sub-question. For example Q24.1, Q24.2, Q24.3 and Q24.4 represented innovations in terms of goods, services, methods of manufacturing and logistics respectively. Responses from all these innovation categories were given equal weight and combined to create the variable innovativeness of firms (x1).

4.7.2 Data Coding

The responses to the questions needed to be statistically analysed. In order to do this a code was developed to translate the responses into numeric format.

Table 4-2 below is the summary of the codification of the responses to the questions.

Table 4-2: Question Code Tables

Question 24.1	Improved goods
0*	No innovation
1*	New to the firm
2*	New to the domestic market
3*	New to the world

Question 24.2	Improved services	Aggregated index Q24.1-24.2 Product innovations
0*	No innovation	0-6
1*	New to the firm	
2*	New to the domestic market	
3*	New to the world	

Question 24.3	Improved methods
0*	No innovation
1*	New to the firm
2*	New to the domestic market
3*	New to the world

Question 24.4	Improved logistics	Aggregated index Q24.3-24.4 Process innovations	Aggregated index Q24.1-24.4 Total innovations
0*	No innovation	0-6	0-12
1*	New to the firm		
2*	New to the domestic market		
3*	New to the world		

Question 26.1	Intramural R&D
1*	Local
2*	Domestic
3*	International

Question 26.2	Extramural R&D
1*	Local
2*	Domestic
3*	International

Question 26.3	Acquistion of machine & equipment
1*	Local
2*	Domestic
3*	International

Question 26.4	Acquisition of other external knowledge
1*	Local
2*	Domestic
3*	International

Question 26.5	Training	Aggregated index
1*	Local	0-5
2*	Domestic	0-5
3*	International	0-5

Question 30.1	Tax incentive
0*	Local Government
1*	National government

Question 30.2	Funds
0*	Local Government
1*	National government

Question 30.3	Export support
0*	Local Government
1*	National government

Question 30.4	Technological support
0*	Local Government
1*	National government

Question 30.5	Other	Aggregated index	Aggregated index Total support
0*	Local Government	0-5	0-10
1*	National government	0-5	

Question 25	Source of innovation
0*	No contribution
1*	Mainly the own unit
2*	Unit with other companies
3*	Unit with university and research centre
4*	Other

* Coded value

The elements from the Table 4-2 that are worth noting are as follows:

- In terms of types of innovation, ‘new to world’ was given the highest weight (3) because of its span of influence and impact beyond national boundaries. For the same reason ‘new to the firm’ innovation was given the least weight (1).
- Also, an aggregated index for total innovativeness (Questions 24.1 to 24.4) was created by adding the codes from the responses to the type of innovative activities (improved goods, services, methods and logistics) a firm was engaged with. Thus if firms did not engage in any of the activities it would have an aggregated index value of 0, while if a firm engaged in new to the world innovative activity for all types of innovation it would have a value of 12 (3+3+3+3). For any other combination it would have a value between and including 1 and 11.
- With regards to activities supporting innovation – R&D, acquisition of machines, knowledge, training etc (Questions 26.1 to 26.5) - the aggregated index was created by grouping the local, domestic and international activities. For example, if a firm did not participate in any of the activities sourced from local resources it would have an aggregated index of 0 for local group, while if it participated in all activities sourced from local resources it would have a value of 5 (1+1+1+1+1). For any other combination it would have a value between and including 1 and 4. Similar values were assigned for the domestic and international groups.
- A similar strategy was adapted for government support (Questions 30.1 to 30.5). The only additional point here is that local and national governmental support was combined to the aggregated index of overall governmental support. In that case, each of the local and national integrated indices would have a value between and including 0 and 5. When the overall support was calculated adding the local and national indices, it would have a value between and including 0 and 10.

4.7.3 Test of difference

In order to test the hypotheses that the software industry and the automotive industry differ with respect to measures on variables (details in Table 4-1), a proper test of difference between two groups (software industry and automotive industry) with respect to types of innovation, institutional (government) support towards innovations, innovation based on knowledge internal or external to firms and geographic location of innovation activities, was needed. Zikmund (2003, p.520) suggested that a good starting point for discussing testing of differences was to compare the distribution of one group with the distribution of another group. In statistical analyses this is often achieved by setting up a contingency table (RxC, where R = row and C = column). A chi-square test is conducted to test for significance in the analysis of an RxC contingency table – it allows us to test for differences in two groups' distributions (columns) across categories (rows).

Thus, the chosen test of difference was the chi-square test. To run the chi-square test, firstly the contingency tables were created where the columns represented the software and automotive industries, while the rows represented the types, sources and channels of innovation.

The cells represented the relevant frequencies. Next, chi-square tests were run on the contingency tables to establish if there was a statistically significant difference between the groups of industries in relation to the types, sources and channels of innovation, which in common terms signifies if there was an overall difference in terms of responses to each sub question between the two groups of industries.

Once a pattern was established in terms of difference between the two groups with respect to the various sub-types and sub-determinants of innovation, it was necessary to find out if the groups differed with respect to the aggregated sub-types and sub-determinants, e.g.

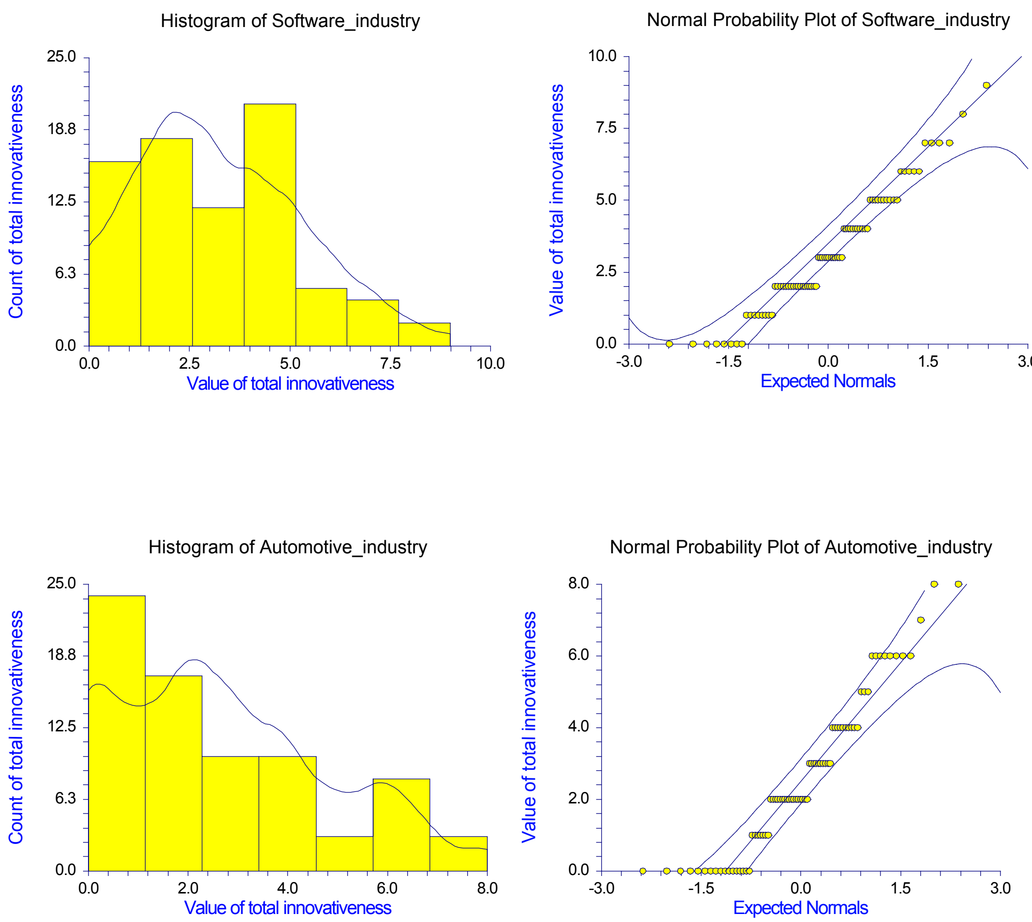
the chi-square test gave the pattern of differences between the two groups in terms of sub-types - products (goods), products (services), process (methods) and process (logistics) individually. At this stage it was interesting to see if the two groups differed taking all the sub-types into consideration i.e. if there was an overall difference between the groups in terms of total innovativeness.

In order to achieve this big picture view, interval scale variables in the form of aggregated indices were calculated by combining the responses of the sub-questions (see Table 4-2 for details). The comparison of means of the aggregated indices between the groups would give the overall difference between the groups with respect to the types, sources and channels of innovation.

Zikmund (2003) suggested the t-test as a technique to test the hypothesis that the mean scores on some interval-scaled variables were significantly different for two independent samples or groups. It is used when the population standard deviation is unknown and the sample size is small. Zikmund (2003) further suggested that to use the t-test for difference of means it was assumed that the two samples were drawn from normal distribution and also the variances of the two populations or groups were equal (*homoscedacity*).

In terms of the characteristics of the sample data, the interval between the values of the aggregated indices were equally spaced, thus the indices were treated as interval-scaled variables. Also, the sample sizes for the software industry and automotive industry were 78 and 76 respectively (greater than 30), which is why the samples were assumed to be drawn from normal distributions. The following plot section is illustration of distributions of some of the aggregated indices which show normal distribution in terms of the distribution of sample data along the dimension of innovation.

Diagram 4-1: Illustration of Distributions of Chosen Aggregated Indices



Next, tests were run to compare the variances between the groups. If the variances were equal between the groups, an Equal Variance t-test was run, alternately Aspin-Welch Unequal-Variance tests were run to find if the differences between the means of the software and automotive industries were significantly different. These tests could either confirm or disconfirm the alternate hypotheses, thereby assisting in empirically describing the characteristics of the innovation in emerging and mature firms of South Africa.

4.7.4 A predictive model – logistic regression

Further to this, a model was built to predict whether a firm would belong to a mature industry (or otherwise, an emerging industry) given the chosen characteristics of innovation (explanatory variables).

Logistic regression was used to build this model. It is a technique for analysing problems in which there are one or more independent variables (x1 to x4b) that determine a non-continuous outcome (whether or not the firm belonged to a mature industry). The outcome was measured with a dichotomous variable (y; with value of 1 if the firm belonged to a mature industry – automotive, and 0 if the firm belonged to an emerging industry – software).

As observed in Table 4-1, the variables x1 (total innovativeness) and x2 (overall governmental support) have two sub variables each – x1a (product innovativeness) and x1b (process innovativeness), and x2a (local governmental support) and x2b (national governmental support). In order to make the model more granular in terms of the predictive role of the independent variables, the sub-variables (x1a, x1b, x2a, x2b) along with the rest of independent variables x3, x4a and x4b were used and not the aggregated composite variables (x1 and x2). This follows the principle of adding more characteristics (variables) in the equation to reduce the deviance and thereby improve the fit of the model (see section 5.4 in the next chapter for the details and validity of the claim).

Standardisation of the independent variables was not found to be necessary because of the following reasons:

- In order to not lose the informational value of the data.
- The logistic regression was used to choose the statistically significant independent variables which would increase or decrease the odds of a firm belonging to a mature or an emerging industry. The primary intention was not to compare the coefficients of the equation.
- The presence of a categorical variable in the equation.
- The step-wise regression (forward and backward steps) executed by the statistical package gives an indication of the relative importance of the independent variables in the model using Wald statistic or -2Log likelihood. Unlike the Ordinary Least Square regression, the beta (coefficient) of the model or even the Exp (beta) is not used for explaining the relative importance of the independent variables.

The following equation explains the logistic or (also termed logit) function:

$$\text{logit}(y) = b_0 + b_1\,x1a + b_2\,x1b + b_3\,x2a + b_4\,x2b + b_5\,x3 + b_6\,x4a + b_7\,x4b$$

where y = the probability of presence of a firm in the automotive industry. The logit transformation is defined as logged odds:

Odds = y/ (1-y) = probability of firm belonging to the automotive industry/probability of firms belonging to the software industry and

Logit(y) = ln (y/ (1-y).

In other words, the $y/(1-y) = e^{(b0 + b1.\,x1a + b2.\,x1b + b3.\,x2a + b4.\,x2b + b5.\,x3 + b6.\,x4a + b7.\,x4b)}$

Or, y = probability of presence of a firm in the automotive industry =

$$e^{(b0 + b1.\,x1a + b2.\,x1b + b3.\,x2a + b4.\,x2b + b5.\,x3 + b6.\,x4a + b7.\,x4b)}/(1+ e^{b0 + b1.\,x1a + b2.\,x1b + b3.\,x2a + b4.\,x2b + b5.\,x3 + b6.\,x4a + b7.\,x4b})$$

The aim of this regression function was to come up with a model which predicted the odds and thereby the probability of a firm belonging to an automotive industry. In order to do this

(i) An *initial* model was built with all the independent variables (as mentioned above). The various characteristics of the model were looked into – the Wald statistic, Likelihood ratio test, goodness of fit for the overall model, usefulness of the independent variables in predicting the dependant variable, and discrimination. Finally, the model was assessed to determine it's validity in terms of the statistical significance and the log likelihood of each independent variable.

(ii) If some of the response variables in the initial model were found to be statistically insignificant an optimal adjusted model needed to be built. Stepwise logistic regression was used for this purpose. This regression technique is designed to find the most parsimonious set of predictors that are most effective in predicting the dependent variable. Variables are added to the logistic regression equation one at a time, using the statistical criterion (e.g. reduction of the -2 Log Likelihood) for the included variables. After each variable is entered, each of the included variables is tested to see if the model would be better off if the variables were excluded. This does not happen often. The process of adding more variables stops when all of the available variables have been included or when it is not possible to make a statistically significant reduction in the statistical error using any of the variables not yet included. The order of entry of the variables is often used to measure the relative importance of the variables in the model.

Two algorithms – Wald and the Likelihood ratio - were used for this purpose.

(a) Wald Statistic test

The Wald statistic is an alternative test which is commonly used to test the significance of individual logistic regression coefficients for each independent variable (that is, to test the null hypothesis in logistic regression that a particular logit (effect) coefficient is zero). The Wald statistic is the squared ratio of the un-standardised logistic coefficient to its standard error. One may well want to drop independents from the model when their effect is not significant by the Wald statistic.

(b) Likelihood ratio test

In this test, as a starter, comparison is made between the deviance statistics of just the constant (intercept only) null-model to the deviance statistics when the new predictor has been added. The difference between these two deviance statistic values is often referred to as G for goodness of fit. The deviance statistic is called -2LL (log likelihood). It is expected that the -2LL value will decrease with the addition of a statistically significant predictor to the model. The other predictors are taken through similar steps - the null-model being the latest model from the previous step. This process continues until no statistically significant improvement can be made in terms of the -2LL statistic.

4.8 Research limitations

Limitations based on the intended scope and the design of the research is acknowledged as following:

- Non-response and response bias in terms of the data collection for the questionnaire.
- Several data collectors were used for the firms in the automotive industry. This gave rise to challenges around consistency of understanding of the questions and codification of the responses. However, to mitigate this risk the data was extensively checked by an industry expert.
- The study focused only on the software and automotive industries as proxies for emerging and mature industries. Several other firms belonging to emerging and mature industries need to be included in the scope of the future research to make a better generalisation of the findings.

In the next chapter, the results of the study will be discussed based on the above methodology.

5. Results

This section firstly describes the participant responses, followed by some salient findings in terms of the background of the software and the automotive industry in South Africa. These characteristics were discovered from the responses of the firms to the various questions of the questionnaire. It then goes on to describe in more depth the types, institutional support, centre and flow of knowledge and location of innovation activities in the two industries. Finally these factors of innovations are linked to the hypotheses of this research.

In order to describe these factors the data was analysed in the following broad steps:

(i) The first step was the descriptive analysis of the data. This was done by analysing the frequency tables constructed from the responses of the firms to the various questions in the questionnaire. The outcome of this step was to establish if there was any existent pattern of differences in terms of the various characteristics of innovation between the two industries.

(ii) The second step was to run the chi-square tests and t-tests per characteristic or factor of innovation. The associated histograms and box plots assisted in visualising the probability distribution and the percentile distribution of the data respectively, while the chi-square values and the associated probability in the t-tests confirmed if the pattern observed in step 1 was statistically significant.

This step also established if individually each characteristic of innovation had any relationship with the two types of industries.

(iii) Finally, a step-wise logistic regression was run on all the characteristics of innovation found in step 2, showing a pattern which was found to be statistically significant individually. This step was to find jointly how the various factors/characteristics of innovation differed between the two industries. This model took the interdependency of all the characteristics into account. Also, this step confirmed if it was possible to accurately predict if a firm would belong to the automotive or software industry (dependent variable) by knowing the various characteristics of innovation (independent variables).

5.1 Participant response and background

5.1.1 Participant response

78 out of 355 firms belonging to the software industry responded to the questionnaire with a response rate of 21.97%, which is somewhat low in absolute terms. 76 out of 174 firms in the automotive industry with a response rate of 43.67% responded to the questionnaire.

Baruch and Holtom (2008) studied the response rates of the various studies from 17 refereed management and behavioural science journals, 12 first-tier journals and five second-tier journals. The study revealed that the average response rates of organisations (in 2005) were 35% with a standard deviation of 18.2.

Thus a response rate of 43.67% in the automotive industry is more than acceptable while the response rate of 21.97% in the software industry is less than the mean of 35%, but falls within one standard deviation from the mean. The relatively low response from the software industry could be attributed to the fact that it is an emerging industry. The firms might have been reluctant to reveal the details regarding their innovation which is the basis of their competitiveness.

With an increase of the sample size (n), sampling error and uncertainty decrease. "...if n is reasonably large, there is about 95% chance that the magnitude of the sampling error will be no more than 2 standard errors" (Albright, Winston & Zappe, 2009, p.417). With increasing n which implies greater degrees of freedom (larger than 30), the sample distribution is expected to adequately approximate the population distribution (Albright *et al.*, 2009, p.435).

For a multivariate analysis, the degrees of freedom (df) is defined as:

$$df = n - k - 1$$

Where n = number of data points, k = number of variables.

Here, in the case of the software industry, df=78-9-1=68 greater than 30.

and, in case of the automotive industry, df = 76-9-1=66 greater than 30.

Thus the sample size is good enough so that the sample distribution approximates the population distribution adequately.

5.1.2 Background of the software and automotive industries

The software and automotive industries have contrasting backgrounds in South Africa – the former is much younger than the latter. The average age of the firms in the software industry (13 years) was found to be less than half of those in the automotive industry (31 years). This is in line with the worldwide trend of the existence of the automotive industry much before the software industry and confirms the appropriateness of the use of the two industries as proxies for a 'mature' and 'emerging' industry. Most of the software firms were units on their own while the automotive firms were mainly subsidiaries to enterprise groups. The majority of the headquarters of the automotive industry resided outside of South Africa. Hence the majority of the source of capital in this industry came from foreign companies, while the capital in the software industry was sourced predominantly from local sources. Following the same pattern, the foreign sales and foreign suppliers were higher in the automotive industry compared to the software industry.

In terms of locations, the automotive industry was mainly based in the cities or towns located inland and on the coastal line of South Africa – Johannesburg, Pretoria, Roodepoort, Benoni, Port Elizabeth, Durban, Cape Town and Pietermaritzburg - to name a few. The software industry was mainly based in Johannesburg, the business hub of South Africa. Being a labour intensive industry, the automotive industry on average was bigger in size and employed staff ranging in number from 100 to 249. The software industry, which is mainly based on intellectual property, on average employed staff which ranged between 10 and 49 people. Also, in terms of turnover, the automotive industry was larger – the average total sales of an automotive industry was between 10 and 50 million US dollars, while the software industry on an average sold products worth less than 2 million US dollars.

The following Table 5-1 is the summary of the demographics of the software and automotive industry:

Table 5-1: Summary of Demographics

		Software	Automobile
Types of firm		Mainly Indepenedent units	Mainly subsidiaries
Location of firms		Concentrated in Johannesburg	Spread in various coastal towns and cities
Average Age		13.03 years	30.84 years
Ownership	Percentage of domestic capital (%)	92.97%	42.27
	Percentage of foreign capital (%)	7.03%	57.73
Source of capital		Mainly domestic	Mainly international
Average Number of employees		10-49	100-249
Average Total sales (in million)		Less tha $ 2 million	Between $10 million and $50 million.
Destination of sales(%)	Domestic market	85.85%	65.32%
	North America (US and Canada)	1.01%	6.13%
	Western Europe	4.67%	26.00%
	Asia/Africa (except domestic)	7.40%	0.79%
	Other	1.07%	1.76%
Origin of suppliers(%)	Domestic market	62.71%	57.98%
	North America (US and Canada)	24.14%	3.41%
	Western Europe[1]	4.52%	24.56%
	Asia/Africa[2] (except domestic)	3.97%	6.00%
	Other	4.66%	14.00%

5.2 Types, institutional (government) support, centre of knowledge and location of innovation in the software and automotive industry

The main objective of this research is to find how characteristics of innovation differ between an emerging (software) and a mature (automotive) industry. This section describes each of the sub-characteristics of innovation as found from the results of the different statistical tests run on the responses of the firms to the relevant questions (as described in section 4).

5.2.1 Types of innovations

The major types of innovation considered in this research were product and process innovations. Significantly improved goods and services were the major components of product innovation, while new or significantly improved methods and logistics were the components of process innovation. For each of these components innovations could be new to the firm, new to the domestic market or new to the world, depending on the span of the newness of the innovations.

Analysis of the statistical tests on these responses of the firms pointed to the fact that there were specific patterns of differences between the software and the automotive industry in terms of the types of innovations. The following sections describe the results and findings in detail:

5.2.1.1 Test for difference in product and process innovations (variables x1a and x1b)

In order to find if there was a difference between the software industry and automotive industry so far as types of innovations were concerned, comparisons of the distributions of the responses between the two industries were made. Table 5-2 is the summary of the contingency table created to do these comparisons.

Both in new or significantly improved goods and services (product type of innovation) there is a clear pattern – the involvement of number of firms (frequencies) in such innovations in the software industry was greater than those in the automotive industry. This trend is exactly opposite when one looks at the new or significantly improved methods and logistics (process type of innovation) – the involvement of a number of firms in such innovations in the automotive industry was greater than those in the software industry.

Table 5-2: Types of Innovation

	Types of innovation	Product (New or significantly improved goods)*			Product (New or significantly improved services)*			Process (New or significantly improved methods)*			Process (New or significantly improved logistics)*		
	Industry	Software	Automotive	Total	Software	Automotive	Total	Software	Automotive	Total	Software	Automotive	Total
New to the firm	Frequency	21	17	38	19	7	26	19	22	41	13	15	28
	Percent	13.64	11.04	24.68	12.34	4.55	16.88	12.34	14.29	26.62	8.44	9.74	18.18
	Row Pct	55.26	44.74		73.08	26.92		46.34	53.66		46.43	53.57	
	Column Pct	26.92	22.37		24.36	9.21		24.36	28.95		16.67	19.74	
New to the domestic market	Frequency	25	15	40	25	7	32	5	20	25	2	8	10
	Percent	16.23	9.74	25.97	16.23	4.55	20.78	3.25	12.99	16.23	1.3	5.19	6.49
	Row Pct	62.5	37.5		78.13	21.88		20	80		20	80	
	Column Pct	32.05	19.74		32.05	9.21		6.41	26.32		2.56	10.53	
New to the world	Frequency	13	5	18	8	3	11	0	5	5	0	3	3
	Percent	8.44	3.25	11.69	5.19	1.95	7.14	0	3.25	3.25	0	1.95	1.95
	Row Pct	72.22	27.78		72.73	27.27		0	100		0	100	
	Column Pct	16.67	6.58		10.26	3.95		0	6.58		0	3.95	
No innovation	Frequency	19	39	58	26	59	85	54	29	83	63	50	113
	Percent	12.34	25.32	37.66	16.88	38.31	55.19	35.06	18.83	53.9	40.91	32.47	73.38
	Row Pct	32.76	67.24		30.59	69.41		65.06	34.94		55.75	44.25	
	Column Pct	24.36	51.32		33.33	77.63		69.23	38.16		80.77	65.79	
	Total	78	76	154	78	76	154	78	76	154	78	76	154
		50.65	49.35	100	50.65	49.35	100	50.65	49.35	100	50.65	49.35	100
Statistic		**DF**	**Value**	**Prob**	**DF**	**Value**	**Prob**	**DF**	**Value**	**Prob**	**DF**	**Value**	**Prob**
Chi square		3	13.349	0.0039	3	30.7272	<.0001	3	21.7273	<.0001	3	8.2138	0.0418

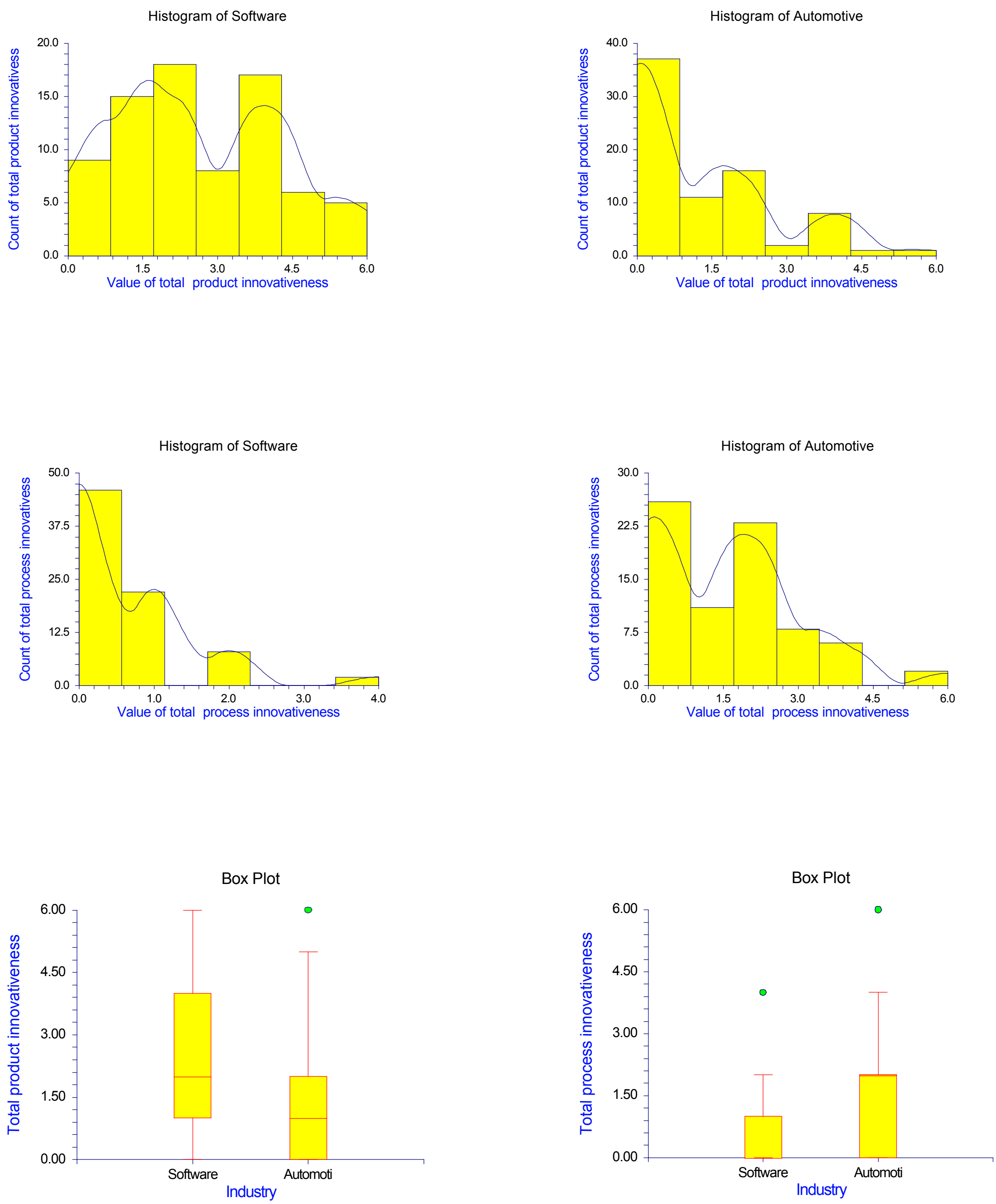
* p<0.05 -- the difference between the industries are statistically significant

The bottom section of Table 5-2 shows the corresponding degrees of freedom, chi-square values and the associated probability. Both product (goods and services) and process (methods and logistics) types of innovation for all categories (new to firm, new to the domestic market and new to the world), have a p-value of less than 0.05, thus confirming that the pattern of differences between the industries so far as types of innovations were concerned was statistically significant.

Though individually the sub-types of innovation - the goods and services (product), and methods and logistics (process) - showed consistent trends, overall product and process innovativeness was tested by running t-tests on the aggregated product index and the aggregated process index. As mentioned in sub-section 4.7.2, these aggregated indices were created by adding the code of responses to types of innovative activities (new to the firm, domestic market and new to the world) for the product and process innovations respectively.

The histograms and box plots in Diagram 5-1 (below) corresponding to the aggregated indices give an indication that the average product innovativeness in the software industry was possibly higher compared to the automotive industry, while the average process innovativeness in the automotive industry was possibly higher than that of the software industry.

Diagram 5-1: Plot Section of Product and Process Innovativeness



Further, from the Two Sample T-Test Reports (Box 5-1 and 5-2) it is observed that the mean value, in other words the average of the variable product innovativeness (x1a) of the software industry (2.60), was higher than those of the automotive industry (1.21). Also, the average of the variable process innovativeness (x1b) of the automotive industry (1.54) was higher than that of the software industry (0.59). The corresponding p-values were less than 0.05. Thus, the difference between the two industries in overall product and process innovativeness was statistically significant.

Box 5-1: T-Test Report for Product Innovativeness

Descriptive Statistics Section

Variable	Count	Mean	Standard Deviation	Standard Error	95.0% LCL of Mean	95.0% UCL of Mean
Software	78	2.602564	1.738336	0.1968278	2.21063	2.994498
Automotive	76	1.210526	1.508339	0.1730184	0.865856	1.555197

Note: T-alpha (Software) = 1.9913, T-alpha (Automotive) = 1.9921

Confidence-Limits of Difference Section

Variance Assumption	DF	Mean Difference	Standard Deviation	Standard Error	95.0% LCL Difference	95.0% UCL Difference
Equal	152	1.392038	1.628914	0.2625455	0.8733283	1.910747
Unequal	150.01	1.392038	2.301499	0.2620621	0.8742283	1.909847

Note: T-alpha (Equal) = 1.9757, T-alpha (Unequal) = 1.9759

Equal-Variance T-Test Section

Alternative Hypothesis	T-Value	Prob Level	Reject H0 at .050	Power (Alpha=.050)	Power (Alpha=.010)
Difference <> 0	5.3021	0.000000	Yes	0.999531	0.996184
Difference < 0	5.3021	1.000000	No	0.000000	0.000000
Difference > 0	5.3021	0.000000	Yes	0.999860	0.998295

Difference: (Software)-(Automotive)

Tests of Assumptions Section

Assumption	Value	Probability	Decision(.050)
Variance-Ratio Equal-Variance Test	1.3282	0.218986	Cannot reject equal variances
Modified-Levene Equal-Variance Test	2.4853	0.116997	Cannot reject equal variances

Box 5-2: T-Test Report for Process Innovativeness

Descriptive Statistics Section

Variable	Count	Mean	Standard Deviation	Standard Error	95.0% LCL of Mean	95.0% UCL of Mean
Software	78	0.5897436	0.8743962	9.900588E-02	0.3925977	0.7868895
Automotive	76	1.539474	1.473687	0.1690435	1.202722	1.876226

Note: T-alpha (Software) = 1.9913, T-alpha (Automotive) = 1.9921

Confidence-Limits of Difference Section

Variance Assumption	DF	Mean Difference	Standard Deviation	Standard Error	95.0% LCL Difference	95.0% UCL Difference
Equal	152	-0.9497301	1.207851	0.1946792	-1.334357	-0.5651035
Unequal	121.37	-0.9497301	1.71357	0.1959027	-1.337559	-0.5619009

Note: T-alpha (Equal) = 1.9757, T-alpha (Unequal) = 1.9797

Aspin-Welch Unequal-Variance Test Section

Alternative Hypothesis	T-Value	Prob Level	Reject H0 at .050	Power (Alpha=.050)	Power (Alpha=.010)
Difference <> 0	-4.8480	0.000004	Yes	0.997809	0.986286
Difference < 0	-4.8480	0.000002	Yes	0.999253	0.993190
Difference > 0	-4.8480	0.999998	No	0.000000	0.000000

Difference: (Software)-(Automotive)

Tests of Assumptions Section

Assumption	Value	Probability	Decision(.050)
Variance-Ratio Equal-Variance Test	2.8405	0.000009	Reject equal variances
Modified-Levene Equal-Variance Test	16.7576	0.000069	Reject equal variances

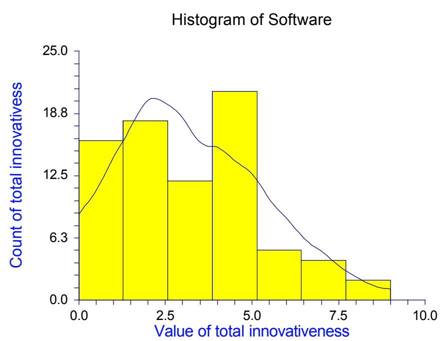
The removal of the outliers from the datasets made no difference to the outcome as described above.

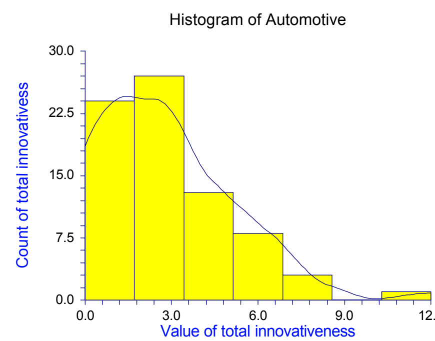
It was observed from the various tests that the software industry was more innovative in product innovations, while the automotive industry was more innovative in process innovations. At this stage a relevant question arises - what does this mean in terms of the total innovativeness of the two industries?

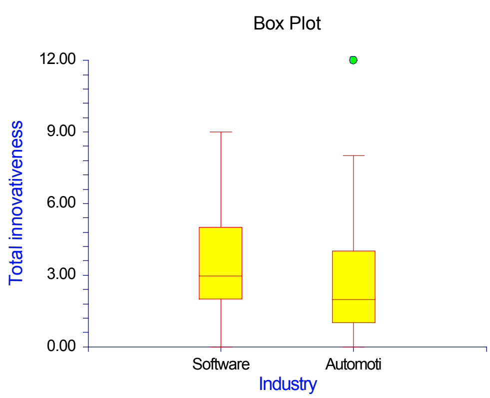
5.2.1.2 Test for difference in total innovativeness (variable x1)

To answer this question of total innovativeness, aggregated indices were created by adding the codes from the responses of firms towards the various product and process types of innovation. These indices included improved goods, services, methods and logistics (see sub-section 4.7.2 for details).. The following section details the descriptive statistics and t-test run on the aggregated indices to find if there was a statistically significant difference between the total innovativeness of the firms.

<u>Diagram 5-2: Plot Section of Total innovativeness</u>







The histograms, and more specifically the box plots, in Diagram 5-2 (above) gives an indication that the average innovativeness of software firms was possibly greater than the automotive firms. The presence of an outlier (value= 12) is also observed (belonging to an automotive firm).

From the Two Sample T-Test Report (Box 5-3) it is observed that the mean value, in other words the average of the variable total innovativeness (x1) of software firms (3.19), was higher than those of automotive firms (2.75). However, this difference was not statistically significant as observed by the T-value of 1.2158 and a p-value which is greater than 0.05.

Box 5-3: T-Test Report for Total innovativeness

Descriptive Statistics Section

Variable	Count	Mean	Standard Deviation	Standard Error	95.0% LCL of Mean	95.0% UCL of Mean
Software	78	3.192308	2.101686	0.2379691	2.718451	3.666165
Automotive	76	2.75	2.406242	0.2760149	2.20015	3.29985

Note: T-alpha (Software) = 1.9913, T-alpha (Automotive) = 1.9921

Confidence-Limits of Difference Section

Variance Assumption	DF	Mean Difference	Standard Deviation	Standard Error	95.0% LCL Difference	95.0% UCL Difference
Equal	152	0.4423077	2.257102	0.3637956	-0.2764411	1.161056
Unequal	148.19	0.4423077	3.194853	0.3644358	-0.2778547	1.16247

Note: T-alpha (Equal) = 1.9757, T-alpha (Unequal) = 1.9761

Equal-Variance T-Test Section

Alternative Hypothesis	T-Value	Prob Level	Reject H0 at .050	Power (Alpha=.050)	Power (Alpha=.010)
Difference <> 0	1.2158	0.225941	No	0.226846	0.084919
Difference < 0	1.2158	0.887030	No	0.002150	0.000207
Difference > 0	1.2158	0.112970	No	0.331981	0.131074

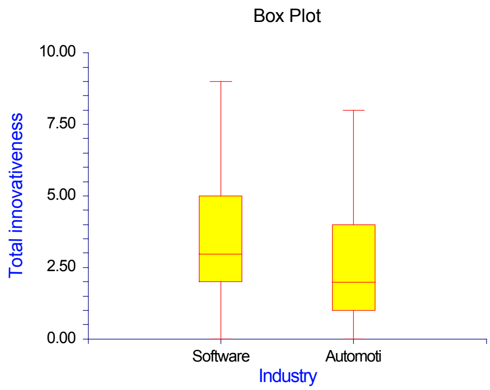
Difference: (Software)-(Automotive)

Tests of Assumptions Section

Assumption	Value	Probability	Decision(.050)
Variance-Ratio Equal-Variance Test	1.3108	0.239718	Cannot reject equal variances
Modified-Levene Equal-Variance Test	0.3780	0.539590	Cannot reject equal variances

The presence of an outlier was mentioned earlier on. A very interesting result was observed if this outlier was removed from the dataset of firms' responses:

Diagram 5-3: Plot Section of Total innovativeness (without outlier)



Box 5-4: T-Test Report for Total innovativeness (without outlier)

Descriptive Statistics Section

Variable	Count	Mean	Standard Deviation	Standard Error	95.0% LCL of Mean	95.0% UCL of Mean
Software	78	3.192308	2.101686	0.2379691	2.718451	3.666165
Automotive	75	2.626667	2.167159	0.2502419	2.128049	3.125285

Note: T-alpha (Software) = 1.9913, T-alpha (Automotive) = 1.9925

Equal-Variance T-Test Section

Alternative Hypothesis	T-Value	Prob Level	Reject H0 at .050	Power (Alpha=.050)	Power (Alpha=.010)
Difference <> 0	1.6390	0.103299	No	0.370336	0.169853
Difference < 0	1.6390	0.948351	No	0.000525	0.000039
Difference > 0	1.6390	0.051649	No	0.494726	0.241331

Difference: (Software)-(Automotive)

Tests of Assumptions Section

Assumption	Value	Probability	Decision(.050)
Variance-Ratio Equal-Variance Test	1.0633	0.789328	Cannot reject equal variances
Modified-Levene Equal-Variance Test	0.0341	0.853799	Cannot reject equal variances

The difference of mean (average total innovativeness) between the software industry and the automotive industry became marginally significant at 95% confidence level (T-value = 1.6390, p=0.051649) when the outlier was removed.

In summary, it was established that the firms belonging to the software industry were statistically more innovative in product innovations, while the firms belonging to the automotive industry were statistically more innovative in process innovations. Although there was suggestive evidence that the software industry was more innovative overall, the data and associated statistics did not provide significant statistical evidence to conclude that the total innovativeness of the firms belonging to an emerging industry (software) was substantially different to a mature industry (automotive).

5.2.2 Governmental support towards innovation

For the purpose of this research, government support was measured through tax incentives, funds to develop new products and acquire new technologies, export support and providing information on technological opportunities. Also, the support was divided into local and national government.

Analysis of the statistical tests on the responses of the firms towards governmental support points to the fact that both the software and the automotive industry relied very little on local government support. However, there was some pattern of difference between the industries in terms of national government support. The following sections describe the results and findings in details:

5.2.2.1 Test for difference in local and national government support (variables x2a and x2b)

Comparisons of the distributions of the firms' responses towards governmental support were done to find if there was a difference between the industries so far as local and national government support was concerned. Tables 5-3 and 5-4 are the summaries of the contingency table created in order to do these comparisons.

Local government support for the software industry was very limited, but still higher than that of the automotive industry. This pattern was evident in the majority of dimensions of government support (except export support where the frequencies were equal). The trend was exactly opposite in the case of national government support. In this case, the majority of dimensions (except information on technological opportunities) of national government support were used more by firms belonging to the automotive industry than those from the software industry.

As evident from Table 5-3 for local government support, only in the case of '*information on technological opportunities'*, was the p-value less than 0.05. For the rest of the local government support constituents the p-values were greater than 0.05, thus it cannot be confirmed with statistical significance that the local governmental support to the firms belonging to the software industry was higher than that of the automotive industry. In the case of national government support to firms, as observed from Table 5-4 , the *'export support'* and '*other support'* categories (support from organisations like Manufacturing, Engineering and Related Services, Automotive Industry Development Centre and Sector Education and Training Authority) had a p-value less than 0.05. So far as '*tax incentives'* was concerned, the p-value was 0.06, thus making this category marginally significant. In the rest of the national government support constituents the p-values were greater than 0.05.Thus at this stage, it cannot be confirmed with statistical significance that the national government support to the firms belonging to the automotive industry was higher than that of the software industry.

Table 5-3: Local governmental support

		Tax incentives#			Funds to develop new products and acquire technology#			Export support#			Information on technological opportunities*			Other#		
		Software	Automotive	Total	Software	Automotive	Total	Software	Automotive	Total	Software	Automotive	Total	Software	Automotive	Total
Local government supported innovation	Frequency	5	1	6	4	1	5	3	3	6	6	0	6	0	1	1
	Percent	3.25	0.65	3.9	2.6	0.65	3.25	1.95	1.95	3.9	3.9	0	3.9	0	0.65	0.65
	Row Pct	83.33	16.67		80	20		50	50		100	0		0	100	
	Column Pct	6.41	1.32		5.13	1.32		3.85	3.95		7.69	0		0	1.32	
No support	Frequency	73	75	148	74	75	149	75	73	148	72	76	148	78	75	153
	Percent	47.4	48.7	96.1	48.05	48.7	96.75	48.7	47.4	96.1	46.75	49.35	96.1	50.65	48.7	99.35
	Row Pct	49.32	50.68		49.66	50.34		50.68	49.32		48.65	51.35		50.98	49.02	
	Column Pct	93.59	98.68		94.87	98.68		96.15	96.05		92.31	100		100	98.68	
	Total	78	76	154	78	76	154	78	76	154	78	76	154	78	76	154
		50.65	49.35	100	50.65	49.35	100	50.65	49.35	100	50.65	49.35	100	50.65	49.35	100
Statistic		**DF**	**Value**	**Prob**	**DF**	**Value**	**Prob**	**DF**	**Value**	**Prob**	**DF**	**Value**	**Prob**	**DF**	**Value**	**Prob**
Chi square		1	2.6682	0.1	1	1.781	0.182	1	0.0011	0.9741	1	6.0832	0.014	1	1.033	0.3094

* $p<0.05$ -- the difference between the industries are statistically significant

\# $p>0.05$ -- the difference between the industries are not statistically significant

Table 5-4: National Governmental Support

		Tax incentives#			Funds to develop new products and acquire technology#			Export support*			Information on technological opportunities#			Other*		
		Software	Automotive	Total	Software	Automotive	Total	Software	Automotive	Total	Software	Automotive	Total	Software	Automotive	Total
National government supported innovation	Frequency	5	12	17	6	7	13	2	26	28	3	3	6	1	12	13
	Percent	3.25	7.79	11	3.9	4.55	8.44	1.3	16.88	18.18	1.95	1.95	3.9	0.65	7.79	8.44
	Row Pct	29.41	70.59		46.15	53.85		7.14	92.86		50	50		7.69	92.31	
	Column Pct	6.41	15.79		7.69	9.21		2.56	34.21		3.85	3.95		1.28	15.79	
No support	Frequency	73	64	137	72	69	141	76	50	126	75	73	148	77	64	141
	Percent	47.4	41.56	89	46.75	44.81	91.56	49.35	32.47	81.82	48.7	47.4	96.1	50	41.56	91.56
	Row Pct	53.28	46.72		51.06	48.94		60.32	39.68		50.68	49.32		54.61	45.39	
	Column Pct	93.59	84.21		92.31	90.79		97.44	65.79		96.15	96.05		98.72	84.21	
	Total	78	76	154	78	76	154	78	76	154	78	76	154	78	76	154
		50.65	49.35	100	50.65	49.35	100	50.65	49.35	100	50.65	49.35	100	50.65	49.35	100
Statistic		**DF**	**Value**	**Prob**	**DF**	**Value**	**Prob**	**DF**	**Value**	**Prob**	**DF**	**Value**	**Prob**	**DF**	**Value**	**Prob**
Chi square		1	3.4482	0.06	1	0.1148	0.735	1	25.9149	<0.001	1	0.0011	0.974	1	10.4821	0.0012

* p<0.05 -- the difference between the industries are statistically significant

#p >0.05 -- the difference between the industries are not statistically significant

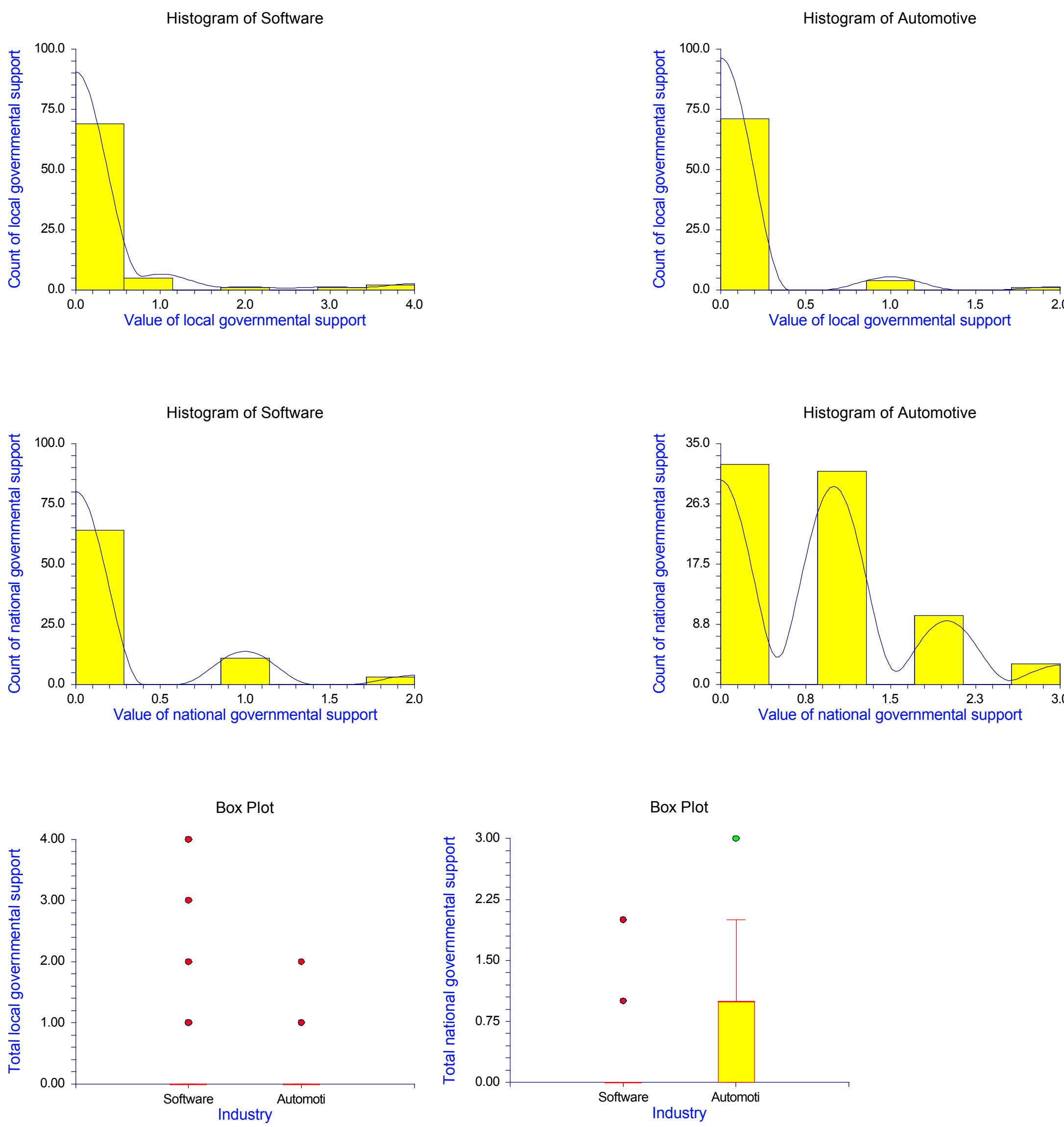
So far it can be observed from the contingency tables and results of the chi-square tests that the respective dimensions of local and national government support showed some trends but were not all statistically significant. Thus to have a clearer view, the aggregated indices for the respective local and national government support were created by combining the responses of all the dimensions of support (see sub-section 4.7.2 for details).

The histograms and box plots in Diagram 5-4 (below) corresponding to the aggregated indices gives an indication that national government support to the firms in the automotive industry was possibly higher compared to that of the software industry, while there seems to be no significant difference so far as local government support was concerned.

Also, from the Two Sample T-Test Report (Box 5-4 and 5-5) it is observed that the mean value of the variable, local government support (x2a) to software firms (0.23) was higher than that of automotive firms (0.079). This difference is almost statistically significant at 95% confidence level (T-value of 1.5896 and a p-value = 0.057). Also, the mean value of the variable national government support (x2b) to the automotive firms (0.79) was higher than that of the software firms (0.22). This difference is statistically significant (T-value of -5.1967 and a p-value less than 0.05).

The removal of outliers from the datasets made no difference to the outcome as described above.

Diagram 5-4: Plot Section of Local and National Governmental Support



Box 5-4: T-Test Report for Local Governmental Support

Descriptive Statistics Section

Variable	Count	Mean	Standard Deviation	Standard Error	95.0% LCL of Mean	95.0% UCL of Mean
Software	78	0.2307692	0.7716246	8.736929E-02	5.679476E-02	0.4047437
Automotive	76	7.894737E-02	0.3167821	3.633739E-02	6.559566E-03	0.1513352

Note: T-alpha (Software) = 1.9913, T-alpha (Automotive) = 1.9921

Confidence-Limits of Difference Section

Variance Assumption	DF	Mean Difference	Standard Deviation	Standard Error	95.0% LCL Difference	95.0% UCL Difference
Equal	152	0.1518219	0.5925662	9.550874E-02	-3.687418E-02	0.3405179
Unequal	102.79	0.1518219	0.8341196	9.462451E-02	-3.584821E-02	0.3394919

Note: T-alpha (Equal) = 1.9757, T-alpha (Unequal) = 1.9833

Equal-Variance T-Test Section

Alternative Hypothesis	T-Value	Prob Level	Reject H0 at .050	Power (Alpha=.050)	Power (Alpha=.010)
Difference <> 0	1.5896	0.114000	No	0.352027	0.157824
Difference < 0	1.5896	0.943000	No	0.000625	0.000048
Difference > 0	1.5896	0.057000	No	0.475154	0.226368

Difference: (Software)-(Automotive)

Aspin-Welch Unequal-Variance Test Section

Alternative Hypothesis	T-Value	Prob Level	Reject H0 at .050	Power (Alpha=.050)	Power (Alpha=.010)
Difference <> 0	1.6045	0.111680	No	0.355704	0.159365
Difference < 0	1.6045	0.944160	No	0.000600	0.000046
Difference > 0	1.6045	0.055840	No	0.479680	0.228757

Difference: (Software)-(Automotive)

Tests of Assumptions Section

Assumption	Value	Probability	Decision(.050)
Variance-Ratio Equal-Variance Test	5.9332	0.000000	Reject equal variances
Modified-Levene Equal-Variance Test	2.5269	0.114000	Cannot reject equal variances

Box 5-5: T-Test Report for National Governmental Support

Descriptive Statistics Section

Variable	Count	Mean	Standard Deviation	Standard Error	95.0% LCL of Mean	95.0% UCL of Mean
IT	78	0.2179487	0.5005824	0.0566798	0.1050848	0.3308126
Automotive	76	0.7894737	0.8216372	9.424825E-02	0.6017215	0.9772258

Note: T-alpha (IT) = 1.9913, T-alpha (Automotive) = 1.9921

Confidence-Limits of Difference Section

Variance Assumption	DF	Mean Difference	Standard Deviation	Standard Error	95.0% LCL Difference	95.0% UCL Difference
Equal	152	-0.571525	0.6782643	0.1093214	-0.7875106	-0.3555393
Unequal	123.35	-0.571525	0.9621177	0.1099788	-0.7892151	-0.3538348

Note: T-alpha (Equal) = 1.9757, T-alpha (Unequal) = 1.9794

Aspin-Welch Unequal-Variance Test Section

Alternative Hypothesis	T-Value	Prob Level	Reject H0 at .050	Power (Alpha=.050)	Power (Alpha=.010)
Difference <> 0	-5.1967	0.000001	Yes	0.999303	0.994620
Difference < 0	-5.1967	0.000000	Yes	0.999787	0.997545
Difference > 0	-5.1967	1.000000	No	0.000000	0.000000

Difference: (IT)-(Automotive)

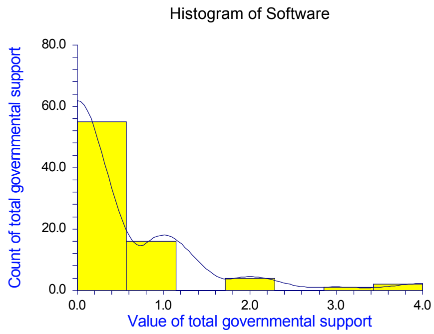
Tests of Assumptions Section

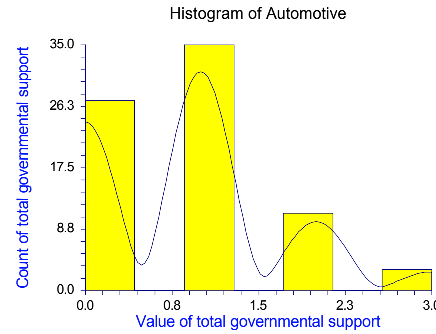
Assumption	Value	Probability	Decision(.050)
Variance-Ratio Equal-Variance Test	2.6941	0.000023	Reject equal variances
Modified-Levene Equal-Variance Test	23.2916	0.000003	Reject equal variances

5.2.2.2 Test for difference in overall governmental support (variable x2)

Since governmental support for all firms is very low and local government support was not statistically significant, the combined index of all the dimensions of both local and national government support may be able to more clearly highlight the pattern. To achieve this, the two industries' aggregated indices were created by adding the codes from the responses of firms towards both local and national government support they received (see sub-section 4.7.2 for details). The following section details the descriptive statistics and t-test run on the aggregated indices to find if there was a statistical significant difference between the overall governmental support to the firms belonging to the two industries.

Diagram 5-5: Plot Section of Overall Governmental Support





The histograms in Diagram 5-5 give some idea about higher governmental support towards the automotive industry.

From the Two Sample T-Test Report (Box 5-6), it is further observed that the mean value, in other words, the average of the variable, governmental support (x2) to the automotive firms (0.87), was higher than that of the software firms (0.45). The low average value also points to the fact that on an average, firms received very little governmental support. This difference of overall governmental support between the software and automotive industries was also statistically significant as observed by the T-value of -3.1185 and a p-value less than 0.05 in the Equal Variance T-Test Section.

Box 5-6: T-Test Report for Overall Governmental Support

Descriptive Statistics Section

Variable	Count	Mean	Standard Deviation	Standard Error	95.0% LCL of Mean	95.0% UCL of Mean
Software	78	0.448718	0.862606	9.767091E-02	0.2542303	0.6432056
Automotive	76	0.8684211	0.8056816	9.241802E-02	0.6843149	1.052527

Note: T-alpha (Software) = 1.9913, T-alpha (Automotive) = 1.9921

Confidence-Limits of Difference Section

Variance Assumption	DF	Mean Difference	Standard Deviation	Standard Error	95.0% LCL Difference	95.0% UCL Difference
Equal	152	-0.4197031	0.8350035	0.1345844	-0.6856006	-0.1538056
Unequal	151.73	-0.4197031	1.180344	0.1344645	-0.6853675	-0.1540387

Note: T-alpha (Equal) = 1.9757, T-alpha (Unequal) = 1.9757

Equal-Variance T-Test Section

Alternative Hypothesis	T-Value	Prob Level	Reject H0 at .050	Power (Alpha=.050)	Power (Alpha=.010)
Difference <> 0	-3.1185	0.002175	Yes	0.872604	0.694488
Difference < 0	-3.1185	0.001087	Yes	0.927818	0.777671
Difference > 0	-3.1185	0.998913	No	0.000001	0.000000

Difference: (Software)-(Automotive)

Tests of Assumptions Section

Assumption	Value	Probability	Decision(.050)
Variance-Ratio Equal-Variance Test	1.1463	0.554025	Cannot reject equal variances
Modified-Levene Equal-Variance Test	1.2128	0.272522	Cannot reject equal variances

In summary, it was observed that the overall governmental support to firms belonging to both the software and automotive industries was very low. However, in this environment of low governmental support, the firms belonging to the automotive industry received significantly higher support than those in the software industry. Also, the firms belonging to software industry were somewhat more likely to benefit from their local government, while the firms belonging to the automotive industry was significantly more likely to benefit from national government interventions.

5.2.3 Where is the innovation knowledge centred – internal or external to firms?

Next we look at the location of where innovation knowledge is centred – internal or external to the firm. Analysis of the statistical tests on the responses of the firms point to the fact that there were specific patterns of differences between the software and the automotive industries in terms of innovations based internal to the firms. The following sections describe the results and findings in detail.

5.2.3.1 Test for difference in innovations based on knowledge internal to the firms (variable x3)

In order to find a pattern of differences regarding the innovations based on knowledge internal to firms between the two groups of industries, comparisons of the distributions of the responses between the two industries were made. The comparisons showed a consistent pattern for internal-to-firm innovations. Table 5-5 is the summary of the relevant frequencies.

It is clear from the table that innovations internal to firms were higher in software industries compared to the automotive industry.

Table 5-5: Innovation Knowledge—Internal or External to Firms

		Source of innovation*		
		Software	Automotive	Total
Own unit	Frequency	46	34	80
	Percent	29.87	22.08	51.95
	Row Pct	57.5	42.5	
	Column Pct	58.97	44.74	
Unit together with other companies	Frequency	21	12	33
	Percent	13.64	7.79	21.43
	Row Pct	63.64	36.36	
	Column Pct	26.92	15.79	
Unit together with research centre/university	Frequency	3	4	7
	Percent	1.95	2.6	4.55
	Row Pct	42.86	57.14	
	Column Pct	3.85	5.26	
Other	Frequency	0	11	11
	Percent	0	7.14	7.14
	Row Pct	0	100	
	Column Pct	0	14.47	
No contribution	Frequency	8	15	23
	Percent	5.19	9.74	14.94
	Row Pct	34.78	65.22	
	Column Pct	10.26	19.74	
	Total	78	76	154
		50.65	49.35	100
Statistic		**DF**	**Value**	**Prob**
Chi square		4	17.5048	0.0015

* p<0.05 -- the difference between the industries are statistically significant

In order to understand if the patterns of difference between the two industries were statistically significant, chi-square tests were run. The p-value was less than 0.05 and this confirmed that the difference in internal-to-firm innovations among firms between the industries was statistically significant.

This trend of the higher usage of the internal-to-firm knowledge among firms in the software industry was also supported by the frequency of the firms engaged in intramural R&D (internal knowledge source) in Table 5-6 (see the next section, left-most column).

The average of the variable number of firms engaged in innovation based on internal-to-firm knowledge (x3) was 0.59 (59%) for the software industry, while that of the automotive industry was 0.45 (45%).

In summary, the data and the chi-square tests provided significant statistical evidence to conclude that firms in the software industry were involved with more innovations based on internal-to-firm knowledge compared to those in the automotive industry.

5.2.4 Geographical location of innovation activities

The geographical location of innovative activities in firms rounds up the characteristics of innovations this research looks into. Intramural and extramural research, acquisition of technology, machinery and knowledge and training are the major innovative activities considered in this regard.

The statistical analysis of data from the responses of firms indicated that there were specific patterns of differences between the software and automotive industry so far as local and international innovation activities were concerned. The following sections describe the results and findings in details:

5.2.4.1 Test for difference in local and international innovation activities (variables x4a and x4b)

Table 5-6 summarises the contingency table used to compare the local and international innovation activities of the firms belonging to the software and automotive industries. It is evident from the table that local activities were higher in firms belonging to the software industry and international activities were higher in firms belonging to the automotive industry. Also, with the exception of international R&D activities, all other frequencies for the various components of innovation activities showed this pattern consistently.

Table 5-6: Location of Innovation Activities – Local, Domestic and International

		Company engaged in intramural research and development activities *			Company engaged in extramural research and development activities #			Company engaged in acquisition of machinery and equipments *			Company engaged in acquisition of other external knowledge *			Internal or external training *		
		Software	Automotive	Total	Software	Automotive	Total	Software	Automotive	Total	Software	Automotive	Total	Software	Automotive	Total
Local	Frequency	31	16	47	9	3	12	33	4	37	14	5	19	32	22	54
	Percent	20.13	10.39	30.52	5.84	1.95	7.79	21.43	2.6	24.03	9.09	3.25	12.34	20.78	14.29	35.07
	Row Pct	65.96	34.04		75	25		89.19	10.81		73.68	26.32		59.26	40.74	
	Column Pct	39.74	21.05		11.54	3.95		42.31	5.26		17.95	6.58		41.02	28.95	
Domestic	Frequency	10	5	15	5	6	11	4	11	15	15	5	20	12	12	24
	Percent	6.49	3.25	9.74	3.25	3.9	7.14	2.6	7.14	9.74	9.74	3.25	12.99	7.79	7.79	15.58
	Row Pct	66.67	33.33		45.45	54.55		26.67	73.33		75	25		50	50	
	Column Pct	12.82	6.58		6.41	7.89		5.13	14.47		19.23	6.58		15.38	15.79	
International	Frequency	12	10	22	8	8	16	10	34	44	17	23	40	10	24	34
	Percent	7.79	6.49	14.29	5.19	5.19	10.39	6.49	22.08	28.57	11.04	14.94	25.97	6.49	15.58	22.07
	Row Pct	54.55	45.45		50	50		22.73	77.27		42.5	57.5		29.41	70.59	
	Column Pct	15.38	13.16		10.26	10.53		12.82	44.74		21.79	30.26		12.82	31.56	
No engagement	Frequency	25	45	70	56	59	115	31	27	58	32	43	75	24	18	42
	Percent	16.23	29.22	45.45	36.36	38.31	74.68	20.13	17.53	37.66	20.78	27.92	48.7	15.58	11.69	27.27
	Row Pct	35.71	64.29		48.7	51.3		53.45	46.55		42.67	57.33		57.14	42.86	
	Column Pct	32.05	59.21		71.79	77.63		39.74	35.53		41.03	56.58		30.77	23.68	
	Total	78	76	154	78	76	154	78	76	154	78	76	154	78	76	154
		50.65	49.35	100	50.65	49.35	100	50.65	49.35	100	50.65	49.35	100	50.65	49.35	100
Statistic		**DF**	**Value**	**Prob**	**DF**	**Value**	**Prob**	**DF**	**Value**	**Prob**	**DF**	**Value**	**Prob**	**DF**	**Value**	**Prob**
Chi square		3	12.3261	0.0063	3	3.1437	0.3700	3	39.3438	<.0001	3	11.7525	0.0083	3	8.44915	0.03786

* $p<0.05$ -- the difference between the industries are statistically significant

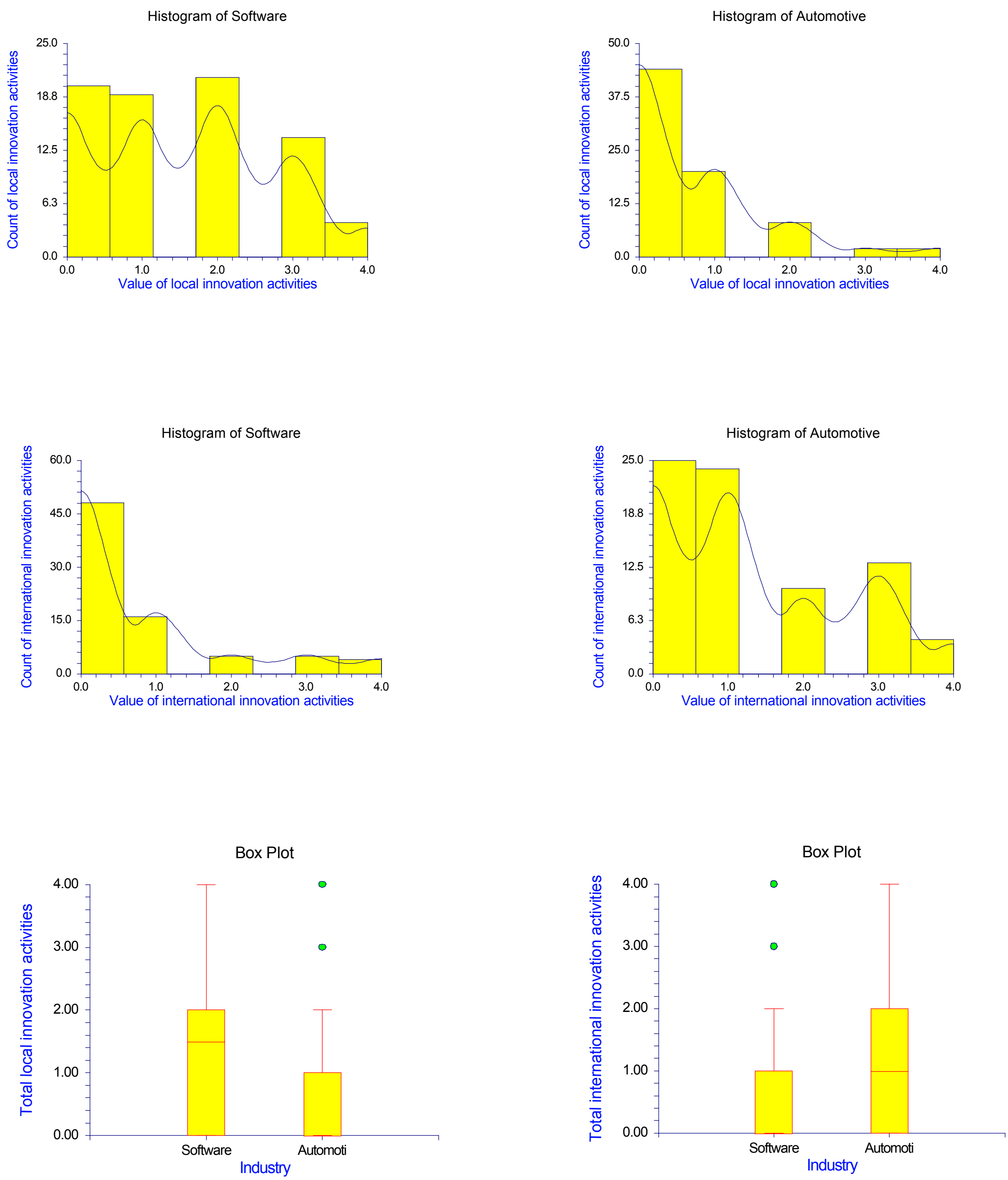
$p>0.05$ -- the difference between the industries are not statistically significant

With the exception of extramural R&D, all other components constituting the majority of the innovation activities had chi-square values and a corresponding p-value of less than 0.05. Thus the pattern of differences between the industries so far as local and international innovation activities were concerned was found to be statistically significant.

An aggregated index was created by adding the codes from the responses to various components of the innovation activities (see sub-section 4.7.2 for details). This was done to find the pattern of differences for the overall local and international innovation activities in the software and automotive industry.

The following section details the descriptive statistics and t-test run on the aggregated indices to find if there was a statistically significant difference between the geographical location (local and national) of innovation activities in the firms belonging to the two industries.

Diagram 5-6: Plot Section of Local and International Innovation Activities



The histograms, and more specifically the box plots, in Diagram 5-6 suggest that the average local innovation activities of the software industry were possibly higher than those of the automotive industry, while the average national innovation activities of the automotive industry were possibly higher than those of the software industry. The presence of two outliers is also observed.

From the Two Sample T-Test Report (Box 5-7 and 5-8) it was observed that the mean value, in other words the average of the variable innovations based on local activities (x4a) of the software industry (1.53), was higher than that of the automotive industry (0.66), while the average of the variable innovations based on international activities (x4b) of the automotive industry (1.30) was higher than that of the software industry (0.73). The pattern of this difference is statistically significant since the corresponding p-values were less than 0.05.

Box 5-7: T-Test Report for Local Innovation Activities

Descriptive Statistics Section

Variable	Count	Mean	Standard Deviation	Standard Error	95.0% LCL of Mean	95.0% UCL of Mean
Software	78	1.525641	1.203074	0.1362213	1.25439	1.796892
Automotive	76	0.6578947	0.9598976	0.1101078	0.4385487	0.8772408

Note: T-alpha (Software) = 1.9913, T-alpha (Automotive) = 1.9921

Confidence-Limits of Difference Section

Variance Assumption	DF	Mean Difference	Standard Deviation	Standard Error	95.0% LCL Difference	95.0% UCL Difference
Equal	152	0.8677463	1.089888	0.1756661	0.5206838	1.214809
Unequal	146.35	0.8677463	1.539087	0.175157	0.5215825	1.21391

Note: T-alpha (Equal) = 1.9757, T-alpha (Unequal) = 1.9763

Equal-Variance T-Test Section

Alternative Hypothesis	T-Value	Prob Level	Reject H0 at .050	Power (Alpha=.050)	Power (Alpha=.010)
Difference <> 0	4.9397	0.000002	Yes	0.998403	0.989547
Difference < 0	4.9397	0.999999	No	0.000000	0.000000
Difference > 0	4.9397	0.000001	Yes	0.999467	0.994902

Difference: (Software)-(Automotive)

Aspin-Welch Unequal-Variance Test Section

Alternative Hypothesis	T-Value	Prob Level	Reject H0 at .050	Power (Alpha=.050)	Power (Alpha=.010)
Difference <> 0	4.9541	0.000002	Yes	0.998469	0.989877
Difference < 0	4.9541	0.999999	No	0.000000	0.000000
Difference > 0	4.9541	0.000001	Yes	0.999492	0.995083

Difference: (Software)-(Automotive)

Tests of Assumptions Section

Assumption	Value	Probability	Decision(.050)
Variance-Ratio Equal-Variance Test	1.5708	0.051083	Cannot reject equal variances
Modified-Levene Equal-Variance Test	8.7824	0.003532	Reject equal variances

Box 5-8: T-Test Report for International Innovation Activities

Descriptive Statistics Section

Variable	Count	Mean	Standard Deviation	Standard Error	95.0% LCL of Mean	95.0% UCL of Mean
Software	78	0.7307692	1.158515	0.131176	0.4695644	0.9919741
Automotive	76	1.302632	1.243862	0.1426808	1.018397	1.586866

Note: T-alpha (Software) = 1.9913, T-alpha (Automotive) = 1.9921

Confidence-Limits of Difference Section

Variance Assumption	DF	Mean Difference	Standard Deviation	Standard Error	95.0% LCL Difference	95.0% UCL Difference
Equal	152	-0.5718623	1.201385	0.1936371	-0.95443	-0.1892947
Unequal	150.58	-0.5718623	1.699809	0.1938168	-0.954814	-0.1889107

Note: T-alpha (Equal) = 1.9757, T-alpha (Unequal) = 1.9758

Equal-Variance T-Test Section

Alternative Hypothesis	T-Value	Prob Level	Reject H0 at .050	Power (Alpha=.050)	Power (Alpha=.010)
Difference <> 0	-2.9533	0.003644	Yes	0.835120	0.635023
Difference < 0	-2.9533	0.001822	Yes	0.902380	0.725943
Difference > 0	-2.9533	0.998178	No	0.000002	0.000000

Difference: (Software)-(Automotive)

Tests of Assumptions Section

Assumption	Value	Probability	Decision(.050)
Variance-Ratio Equal-Variance Test	1.1528	0.536226	Cannot reject equal variances
Modified-Levene Equal-Variance Test	1.9770	0.161746	Cannot reject equal variances

The removal of the outliers from the dataset made no difference to the outcomes as described above.

In summary, it was established that the firms belonging to the software industry engaged in more local innovation activities than those of the automotive industry, while the firms belonging to the automotive industry practised more international innovation activities than those of the software industry. These differences were statistically significant.

5.3 Summary of the patterns regarding characteristics of innovation in the software and automotive industry

The following are the patterns in terms of the characteristics of innovations between the firms belonging to an emerging industry (software) and a mature industry (automotive) established so far.

5.3.1 Are firms in an emerging industry (software) more innovative than those in a mature industry (automotive) (hypothesis 1)?

There is suggestive evidence that the firms belonging to an emerging industry (software industry) were more innovative than those belonging to a mature industry (automotive industry). However, this evidence is inconclusive so far as statistical significance is concerned. So far as product innovations are concerned, there is conclusive evidence that the firms belonging to an emerging industry (software industry) were more innovative than those belonging to a mature industry (automotive industry). In terms of process innovations this trend was exactly opposite and the firms belonging to a mature industry (automotive industry) were conclusively more innovative than those of the software industry.

5.3.2 Does Government support firms in a mature industry (automotive) more than those in an emerging industry (software) (hypothesis 2)?

Although the governmental support to the firms in both industries was very limited, the overall governmental support to firms belonging to a mature industry (automotive industry) was significantly higher compared to those of an emerging industry (software industry). Local government support was very low and there was suggestive evidence that the firms belonging to an emerging industry (software industry) received more local support than those of a mature industry (automotive industry). In terms of national government support, the firms belonging to a mature industry (automotive industry) benefited more than those of an emerging industry (software industry).

5.3.3 Do firms in an emerging industry (software) innovate more based on internal-to-firm knowledge than those in a mature industry (automotive) (hypothesis 3)?

The firms belonging to an emerging industry (software industry) were involved with significantly more innovations based on internal-to-firm knowledge than those in a mature industry (automotive industry).

5.3.4 Is there any pattern of local and international innovation activities between the firms in an emerging industry (software) and a mature industry (automotive) (hypothesis 4)?

There were definite patterns among the industries in terms of local and international innovation activities. The firms belonging to an emerging industry (software industry) engaged significantly more in local innovative activities compared to those in a mature industry (automotive industry), while the firms belonging to a mature industry (automotive industry) engaged significantly more in international innovation activities than those of an emerging industry (software industry).

The following Table 5-7 summarises the descriptive statistics of the various characteristics of innovation found in the two industries.

Table 5-7: Summary of Descriptive Statistics

	Software industry			Automobile industry				T-test	
	Mean	Std. Dev	Std. Error	Mean	Std. Dev	Std. Error	Mean difference	T-value	Prob. level
1.Overall innovativeness(x1)	3.19	2.1	0.24	2.63	2.17	0.25	0.56	1.6390	0.051649
a.Product innovativeness(x1a)	2.60	1.74	0.20	1.21	1.51	0.17	1.39	5.3021	0.000000
b.Process innovativeness(x1b)	0.59	0.87	0.10	1.54	1.47	0.17	-0.95	-4.8480	0.000002
2.Total governmental support(x2)	0.45	0.86	0.10	0.87	0.81	0.09	-0.42	-3.1185	0.001087
a.Local support(x2a)	0.23	0.77	0.09	0.08	0.32	0.04	0.15	1.5896	0.057000
b.National support(x2b)	0.22	0.50	0.06	0.79	0.82	0.09	-0.57	-5.1967	0.000000
3. Innovation internal to firms(x3)	0.59	-	-	0.45	-	-	-	17.5048*	0.001500
4. Innovation based on local activities(x4a)	1.53	1.20	0.14	0.66	0.96	0.11	0.87	4.9397	0.000001
5. Innovation based on international activities(x4b)	0.73	1.16	0.13	1.30	1.24	0.14	-0.57	-2.9533	0.001822

*Chi-square value

5.4 What do these patterns mean when they are combined together?

The innovation characteristics explained above describe the basic patterns among the firms belonging to the software and the automotive industries. Additionally, these patterns explain the relationships between the individual characteristics and the firms belonging to the two industries. However, there may be interdependencies between the different elements when all these characteristics are combined. This raises the question, which characteristics are significant in explaining these relationships and to what extent?

In order to answer these questions, a number of models were built to get to the one which fits the data the best and is also superior in terms of predictability of the innovation characteristics-industry type relationship. In this regard, the comparison between the two step-wise models one with the composite variables -- x1 and x2 and the other without -- x1a, x1b, x2a and x2b is worth mentioning. Table 5-8 below describes some of the salient statistics of the models.

Table 5-8: Summary of Comparative Statistics of the Two Models

Model	R^2 value	Predicatability
1. With composite variable	0.271	70.80%
2. Without composite varaible	0.616	81.20%

Clearly the second model that does not use the composite variables but rather uses the sub-variables (x1a, x1b, x2a and x2b) were found to be superior in terms of data-fit and predictability. Thus the chosen model of this research is the second model and sub-section 5.4.1 details the same.

The composition of the chosen model was found to be identical in terms of both the Wald and the Likelihood ratio tests. However, the discussion below is based on the Likelihood ratio test, which is generally considered to be superior to the Wald test. Some Wald statistics are mentioned where appropriate.

5.4.1 Overall summary of the model

Table 5-9 (below) shows the details of the various steps of the stepwise regression. The last line of the table gives the coefficients for the independent variables in the model.

Table 5-9: Iteration History of the Forward Stepwise Logistic Regression [a,b,c,d,e,f]

Iteration		-2 Log likelihood	Coefficients					
			Constant	product. innovativeness	process. innovativeness	national.govt. support	innovation.on. local.activity	innovation.on. international. activity
Step 1	1	188.125	.833	-.448				
	2	187.742	.922	-.512				
	3	187.741	.925	-.515				
	4	187.741	.925	-.515				
Step 2	1	159.012	.241	-.479	.615			
	2	152.993	.334	-.692	.928			
	3	152.567	.367	-.767	1.043			
	4	152.564	.369	-.774	1.054			
	5	152.564	.369	-.774	1.054			
Step 3	1	146.034	-.191	-.416	.555	.748		
	2	136.671	-.256	-.632	.882	1.144		
	3	135.709	-.280	-.727	1.033	1.318		
	4	135.693	-.283	-.742	1.056	1.342		
	5	135.693	-.283	-.742	1.057	1.342		
Step 4	1	138.972	.126	-.347	.534	.675	-.356	
	2	126.887	.184	-.555	.914	1.051	-.520	
	3	124.929	.215	-.668	1.154	1.272	-.616	
	4	124.846	.225	-.696	1.218	1.328	-.641	
	5	124.845	.226	-.698	1.222	1.330	-.643	
	6	124.845	.226	-.698	1.222	1.330	-.643	
Step 5	1	136.538	-.035	-.375	.491	.659	-.296	.200
	2	123.261	-.054	-.602	.869	1.030	-.446	.301
	3	120.745	-.063	-.740	1.138	1.260	-.544	.366
	4	120.593	-.063	-.783	1.228	1.328	-.577	.387
	5	120.592	-.062	-.786	1.235	1.332	-.579	.389
	6	120.592	-.062	-.786	1.235	1.332	-.579	.389

a. Method: Forward Stepwise (Likelihood Ratio)

b. Constant is included in the model.

c. Initial -2 Log Likelihood: 213.463

d. Estimation terminated at iteration number 4 because parameter estimates changed by less than .001.

e. Estimation terminated at iteration number 5 because parameter estimates changed by less than .001.

f. Estimation terminated at iteration number 6 because parameter estimates changed by less than .001.

Table 5-10: Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	25.722	1	.000
	Block	25.722	1	.000
	Model	25.722	1	.000
Step 2	Step	35.177	1	.000
	Block	60.900	2	.000
	Model	60.900	2	.000
Step 3	Step	16.871	1	.000
	Block	77.770	3	.000
	Model	77.770	3	.000
Step 4	Step	10.848	1	.001
	Block	88.618	4	.000
	Model	88.618	4	.000
Step 5	Step	4.253	1	.039
	Block	92.871	5	.000
	Model	92.871	5	.000

The large chi-square value (92.871) with the corresponding p-value (0.000) in the model row of the Omnibus test indicates that the industry types (automotive and software) are significantly associated with the independent variables, either individually or in combination.

5.4.2 Goodness of fit of the model

Table 5-11: Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	187.741[a]	.154	.205
2	152.564[b]	.327	.436
3	135.693[b]	.396	.529
4	124.845[c]	.438	.583
5	120.592[c]	.453	.604

a. Estimation terminated at iteration number 4 because parameter estimates changed by less than .001.

b. Estimation terminated at iteration number 5 because parameter estimates changed by less than .001.

c. Estimation terminated at iteration number 6 because parameter estimates changed by less than .001.

The values of .453 (Cox and Snell R^2) and .604 (Nagelkerke R^2) indicate the model is useful in predicting the odds of a firm belonging to an automotive industry.

Table 5-12: Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	7.031	4	.134
2	6.906	7	.439
3	12.748	8	.121
4	9.370	8	.312
5	12.404	8	.134

Table 5-13: Classification Table[a]

			Predicted		
			automobile		Percentage Correct
Observed			.00	1.00	
Step 1	automobile	.00	54	24	69.2
		1.00	28	48	63.2
	Overall Percentage				66.2
Step 2	automobile	.00	57	21	73.1
		1.00	20	56	73.7
	Overall Percentage				73.4
Step 3	automobile	.00	62	16	79.5
		1.00	17	59	77.6
	Overall Percentage				78.6
Step 4	automobile	.00	61	17	78.2
		1.00	19	57	75.0
	Overall Percentage				76.6
Step 5	automobile	.00	68	10	87.2
		1.00	19	57	75.0
	Overall Percentage				81.2

a. The cut value is .500

It is also evident from the chi-square value (from the Table 5-12) of 12.404 and a corresponding p-value greater than 0.05 that the model fits the data well. Also, the classification Table 5-13 (above) indicates that in 87.2% of cases the model can predict the odds of a firm belonging to the software industry correctly, and in 75% of cases it can predict the odds of the firm belonging to the automotive industry. Overall the model can predict the odds of a firm belonging to the software or automotive industry correctly at 81.2%. Thus this model is more than useful in this regard.

The following diagram 5-1explains the high predictability of the model in a visual manner. All the 1s to the right and 0s to the left of the cut-off point (0.5) are instances of correct prediction by the model.

Diagram 5-1: Observed Groups and Predicted Probabilities

```
      16 +                                                                                                    +
         |                                                                                                    |
         |                                                                                                    |
F        |                                                                                                    |
R     12 +                                                                                                    +
E        |                                                                                                   1|
Q        |                                                                                                   1|
U        |                                                                                                   1|
E      8 +0                                               1                                                 11+
N        |0                                               1                                                 11|
C        |0                                               1                                                 11|
Y        |0   0                                           0                                                 11|
       4 +0 0 0    00                  1                  0                             1                  111+
         |0 0 0    00     1  0        11     1            0                             1              1 1 111|
         |0 0 00   00  1  1 10    0  0001 0  0    0    1  0   1    1        1 1  1     11   1 1   1 1  1 11111|
         |000000 00000000011000 0 010000010 000   010000 10  10 0  00    0  1 10 10 1  01  11 0 11110  1111111|
Predicted ---------+---------+---------+---------+---------+---------+---------+---------+---------+----------
  Prob:   0        .1        .2        .3        .4        .5        .6        .7        .8        .9         1
  Group:  0000000000000000000000000000000000000000000000000011111111111111111111111111111111111111111111111111

          Predicted Probability is of Membership for 1.00
          The Cut Value is .50
          Symbols: 0 - .00
                   1 - 1.00
          Each Symbol Represents 1 Case.
```

5.4.3 Statistical test of the individual predictor of the model

The following Table 5-14 explains the characteristics of the individual predictors of the model and what they mean for predicting the odds of the firms belonging to the automotive industry.

Table 5-14: Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
								Lower	Upper
Step 1[a]	product.innovativeness	-.515	.112	21.098	1	.000	.597	.480	.744
	Constant	.925	.263	12.416	1	.000	2.522		
Step 2[b]	product.innovativeness	-.774	.152	25.793	1	.000	.461	.342	.622
	process.innovativeness	1.054	.221	22.702	1	.000	2.870	1.860	4.429
	Constant	.369	.299	1.531	1	.216	1.447		
Step 3[c]	product.innovativeness	-.742	.158	21.964	1	.000	.476	.349	.649
	process.innovativeness	1.057	.231	20.990	1	.000	2.877	1.831	4.522
	national.govt.support	1.342	.365	13.518	1	.000	3.828	1.871	7.829
	Constant	-.283	.353	.642	1	.423	.753		
Step 4[d]	innovation.on.local.activity	-.643	.207	9.625	1	.002	.526	.350	.789
	product.innovativeness	-.698	.167	17.523	1	.000	.498	.359	.690
	process.innovativeness	1.222	.274	19.876	1	.000	3.393	1.983	5.806
	national.govt.support	1.330	.394	11.377	1	.001	3.783	1.746	8.195
	Constant	.226	.399	.321	1	.571	1.253		
Step 5[e]	innovation.on. international.activity	.389	.191	4.129	1	.042	1.475	1.014	2.145
	innovation.on.local.activity	-.579	.215	7.232	1	.007	.560	.367	.855
	product.innovativeness	-.786	.182	18.747	1	.000	.456	.319	.650
	process.innovativeness	1.235	.291	17.978	1	.000	3.439	1.943	6.088
	national.govt.support	1.332	.406	10.759	1	.001	3.790	1.710	8.403
	Constant	-.062	.433	.021	1	.885	.939		

a. Variable(s) entered on step 1: product.innovativeness.

b. Variable(s) entered on step 2: process.innovativeness.

c. Variable(s) entered on step 3: national.govt.support.

d. Variable(s) entered on step 4: innovation.on.local.activity.

e. Variable(s) entered on step 5: innovation.on.international.activity.

The salient features to be noted from the table above are as follows:

- In terms of the importance of the variables in the model the sequence is product innovativeness, process innovativeness, national government support, innovation based on local activity followed by innovation based on international activity. This is as per the sequence of the variables that entered the model.

- The p-values corresponding to the Wald value of the variables were less than 0.05, thus making them all statistically significant.
- The variables dropped from the model are – local government support and innovation internal to firms.
- The model can be expressed as

In(odds of a firm belonging to an automotive industry)

= -0.062 -.786(product innovativeness) + 1.235 (process innovativeness) + 1.332 (national government support) -.579 (innovation based on local activity) + .389 (innovation based on international activity)

The odd's ratio (OR) -- Exp(B) explains to what extent the independent variables increase or decrease the prediction of odds of a firm belonging to the software or automotive industry:

Assuming that the values of all other variables stay constant;

- The OR of product innovativeness is 0.456. This implies that for 1 unit increase of product innovativeness, the odds of a firm belonging to the software industry increases by 2.19 times (1/0.456 = 2.19).
- The OR of process innovativeness is 3.439. This implies that for 1 unit increase of process innovativeness, the odds of a firm belonging to the automotive industry increases by 3.44 times.
- The OR of national governmental support is 3.790. This implies that for 1 unit increase of national governmental support, the odds of a firm belonging to the automotive industry increases by 3.79 times.

- The OR of innovation based on local activity is 0.56. This implies that for 1 unit increase of innovation based on local activity, the odds of a firm belonging to the software industry increases by 79% (1/0.56 = 1.79).
- The OR of innovation based on international activity is 1.475, thus for an increase of 1 unit of this innovation activity in a firm, the odds of belonging to the automotive industry is increased by 47.5%.

The correlation matrix below confirms that there is no multicollinearity among the independent variables in the predictive model.

Table 5-15: Correlation Matrix

		1	2	3	4	5	6
1	Constant	1.000					
2	innovation.on.international .activity	-.313	1.000				
3	innovation.on.local.activity	-.394	.110	1.000			
4	product.innovativeness	-.279	-.333	.010	1.000		
5	process.innovativeness	-.111	.103	-.305	-.509	1.000	
6	national.govt.support	-.363	.045	-.079	-.105	.199	1.000

In summary, the salient innovation characteristics that are statistically different in firms belonging to an emerging industry (software) and a mature industry (automotive) are product innovativeness, process innovativeness, national governmental support, and innovation based on local activity and international activity. These characteristics also contribute significantly in predicting whether a firm will belong to an automotive industry or not (software industry).

Two other characteristics showed close association of differences in firms belonging to the two industries:

(i) Innovation based on internal to firm was statistically significant when dealt with independently, while it became statistically insignificant when all the independent variables were taken together in the regression model.

(ii) Local governmental support showed suggestive evidence of difference and was also dropped in the regression model.

Lastly, it may be recalled that the two characteristics (composite variables) – total innovativeness and overall government support decreased the goodness of fit when they were used in the regression model as opposed to their constituent variables (product-process innovativeness and local-national governmental support). Hence they were not considered in the predictive model. However, total innovativeness showed suggestive evidence and overall government support showed statistically significant difference when dealt with independently.

5.5 Conclusion of the hypothesis testing

The table below summarises the conclusion of the proposed hypotheses testing of this study:

Table 5-15: Summary of the Hypotheses Testing

	Main Hypothesis	Null hypothesis	Test variable	Reject H0 at .05 significance level?	Probability	Included in the model?*
1	The innovativeness in firms in an emerging industry (software) is higher than those of a mature industry(automotive)	The innovativeness in firms belonging to an emerging industry is less than or equal a mature industry	x1	Inconclusive	0.011;0.052#	N/A
	Sub Hypotheses					
a	o The product innovations in firms is higher in an emerging industry (software) than those in a mature industry (automotive)	The product innovativeness in firms belonging to an emerging industry is less than or equal a mature industry	x1a	Yes	<0.0001	Yes(1)
b	o The process innovations in firms is higher in a mature industry (automotive) than those in an emerging industry (software)	The process innovativeness in firms belonging to a mature industry is less than or equal an emerging industry	x1b	Yes	<0.0001	Yes(2)
2	The governmental support towards firms in a mature (automotive) is higher than those in an emerging industry(software).	The governmental support to firms in a mature industry is less than or equal an emerging industry	x2	Yes	0.001	N/A
	Sub Hypotheses					
a	o The local government support to firms is higher in an emerging industry (software) than those in a mature industry (automotive)	The local governmental support to firm in an emerging industry is less than or equal mature industry	x2a	Inconclusive	0.057	No
b	o The national government support to firms is higher in a mature industry (automotive) than those in an emerging industry (software)	The national governmental support to firms in a mature industry is less than or equal emerging industry	x2b	Yes	<0.0001	Yes(3)
3	The innovations based on internal-to-firm knowledge are higher in firms belonging to an emerging industry (software) as compared to those in a mature industry(automotive)	The innovations based internal to firms in an emerging industry is less than or equal a mature industry	x3	Yes	0.0015	No
4	The innovation based on local activities in firms is higher in an emerging industry (software) than those in a mature industry(automotive)	The innovation based on local activities in firms belonging to an emerging industry is less than or equal a mature industry	x4a	Yes	<0.0001	Yes(4)
	The innovation based on international activities in firms is higher in a mature industry (automotive) than those in an emerging industry (software)	The innovation based on international activities in firms belonging to a mature industry is less than or equal an emerging industry	x4b	Yes	0.0018	Yes(5)

* Yes(x), where x=importance of the variable in the model

After the removal of the outlier

The next chapter discusses and interprets the findings from the results above.

6. Findings and Interpretations

The current literature on the characteristics and patterns of innovation in firms belonging to an emerging and a mature industry is mainly based on the studies done in developed countries. The central argument of this study is that these characteristics of innovation are expected to be different in a developing country like South Africa. The underlying logic for this expectation is that the institutional environment, both at a national and regional level, impacts the patterns of innovation in firms and there are fundamental differences in terms of the institutional environments between developing countries (like South Africa) and developed countries. The findings of this research found conclusive evidence regarding patterns of differences between firms belonging to an emerging industry and a mature industry so far as types, government support, centres of innovation-knowledge and geographical locations were concerned. So far as the product, process and total innovativeness among firms are concerned, this research agrees with some of the claims and disagrees with others that were based on studies in developed countries. It is argued that so far as total innovativeness is concerned, the underlying principles for the similarities in this study versus those in developed countries are different. However the driving forces behind product and process innovativeness among firms are very similar across developed and developing countries. In terms of the local and international government support, internal-to-firm innovations, and local and international innovation activities, the findings of this study differ from the viewpoints based on developed countries.

Additionally, the high percentage (81.2%) of correctness in the predictability of a firm belonging to an emerging or a mature industry by the model built in this research points to the appropriateness of choice of the innovation characteristics dealt with in this study.

The following sections describe the findings and interpretation of the major results.

6.1 General Characteristics

Every industry goes through a life cycle often known as industry life cycle, a term popularised by Porter and Klepper (Argyres & Bigelow, 2007). The concept of the life cycle of an industry was based on the product life cycle originally presented by Utterback-Aberanthy. An emerging industry is characterised by an increasing net entry of firms in the industry, and thus are relatively young and made up of small firms, while a mature industry is characterised by a decreasing net entry of firms, and are thus relatively older and made up of bigger firms. The examples of an emerging and a mature industry used in this study were the software and automotive industries respectively. The appropriateness of using the two industries as examples was borne out by the fact that the average age of the firms belonging to the software industry (13 years) was less than half of those in the automotive industry (31 years). This was also true for size – the average number of employees and total sales in firms belonging to the software industry was found to be significantly smaller when compared to those belonging to the automotive industry. In the case of the software industry, a firm on average employed between 10 and 49 employees, while the firms in the automotive industry employed on average between 100 and 249 employees. The average total turnover in a software firm was found to be less than $2 million, while that of an automotive firm was between $10 million and $50 million.

The geographical clustering or concentration of interconnected firms belonging to an industry is often based on localised inter-firm learning processes and exchange of knowledge due to the relational proximity of the firms (Asheim, 2007). This exchange of knowledge often gives rise to co-operative innovation activities among these firms and other local actors, giving rise to the concept of a Regional Innovation System . Asheim

(2007) argued that the participation of both emerging and mature industries in this RIS was primarily built on analytical (new) and synthetic (existing) knowledge respectively. Neither the existing literature nor Asheim was explicit in terms of any difference in incentives to participate in RIS among the firms belonging to the emerging industries versus the mature industries. However, there is empirical evidence of territorial agglomeration of RIS centring on small to medium size enterprises based on external economies of scale – external to firms but internal to the area (Asheim, 2000). Extending the underlying logic of the empirical evidence, this study argues that since the size of the firms is relatively smaller in the emerging industries (confirmed by the findings of this study as well), there is a higher incentive for firms belonging to the emerging industries to be geographically concentrated and participate in the RIS.

The argument is supported by the findings whereby the firms belonging to the software industry were found to be concentrated in the business city of Johannesburg, while the firms belonging to the automotive industry were spread across various towns and cities. If the locations of the automotive firms were only in the coastal towns and cities one could have argued that this phenomenon was because of ease of export and import, but the locations of these firms included inland and coastal towns and cities – in fact the proportion of the inland locations was higher than the coastal ones.

The source of capital, destination of sales and origin of supplier showed the same trend of local involvement among the firms belonging to the software industry compared to those belonging to the automotive industry. The source of capital was mainly domestic for the software firms, while it was international for the automotive firms. The software firms were more engaged with other local firms in the supply chain (buyers – 85.85% domestic; suppliers – 62.71%) compared to the automotive firms (buyers – 65.32%; suppliers – 57.98%).

6.2 Are firms in an emerging industry (software) more innovative than those in a mature industry (automotive)?

During their early stage of industry life cycle, firms in emerging industries are often characterised by *creative destruction* and high competition, resulting in an increased amount of innovative activities (Aghion & Howitt, 1998; Atun, Harvey & Wild, 2007; Dasgupta & Stiglitz, 1980). During the mature stages of an industry life cycle there tends to be less innovation (Audretsch & Feldman, 1996). These claims are mainly based on innovation characteristics of firms in developed countries. This study validates these claims among firms based in a developing country, South Africa. The total innovativeness in this study is made up of product and process innovations activities in firms. Klepper (1996) claimed that firms in emerging industries would be involved with more product innovations and those in mature industries would be involved with more process innovations.

The major findings in this regard were that there was conclusive evidence that the product innovativeness of firms in an emerging industry (software) was higher than that in a mature industry (automotive) and the process innovativeness of firms in a mature industry was higher than that in an emerging industry. However, it was inconclusive that the total innovativeness of firms in an emerging industry was higher than those in a mature industry.

Thus this study reconfirms the conventional characteristics of product-process innovations during the life-cycle of industries (based on the studies done mainly in developed countries) as claimed by Christensen (1997), Cohen and Klepper (1996), Henderson (1993), and Klepper and Graddy (1990) and refutes the *reverse lifecycle* claims of the likes of Barras (1990), McGahan and Silverman (2001) and Windrum (2005). The similar pattern in both developed and developing countries in this regard are because even in a developing country characterised by a weak institutional set up, firms belonging to the emerging industries go through a phase of uncertainty regarding consumer tastes, potential size of market, technical constraints and solutions (Windrum, 2005). Each firm tries to take advantage of this uncertainty by way of innovating, experimenting and designing new products to capture market share. In time, the firms who develop the *dominant design* (Vernon-Abernathy-Utterback model) have the competitive edge. The emerging industry phase of the firms is characterised by the entry of firms, however this entry becomes increasingly difficult with time due to an increase of barriers to entry often associated with accumulated process innovations (Windrum, 2005). The firms in mature industries increase their competitiveness by better process innovations, which give rise to increased efficiency and reduction of unit costs. The accumulated process innovations in firms belonging to the mature industries become even more relevant in the context of a developing country. In a developing country characterised by weak institutions and property rights, copying of products is easy, however process effectiveness and efficiency runs deep into the culture of an organisation which is relatively difficult to copy and acts as a better barrier to entry towards any firm interested in entering an industry. Thus the firms in a mature industry have more incentive to engage in process innovation when compared to firms in the emerging phase.

As far as total innovativeness is concerned, the study rejects the claims of Klepper (1996), i.e. this research found no conclusive proof that the total innovativeness in firms belonging to an emerging industry was higher than those of a mature industry. This finding tends to agree with McGahan and Silverman's (2001) study based on number of patents. It is interesting to note that this study, which was based on the broad definition of innovation in a developing country like South Africa, produced the same result as found by McGahan and Silverman. However, the underlying principles and interpretation of the findings are different.

In this study, in order for firms belonging to an emerging industry to be considered more innovative, the sum of their product and process innovativeness needed to be significantly higher than those of a mature industry, which was not found to be the case. Also, the product innovativeness among firms in one industry (emerging - software) was higher than those of the other (mature – automotive), but the trend for process innovativeness was found to be exactly opposite. The opposing trends negated the relative advantage of higher innovativeness of one industry over the other. The interpretation of these findings point to the fact that:

(a) The difference of product innovativeness between firms in an emerging industry and a mature industry was not big enough to make the overall comparative innovativeness of the emerging firms conclusively higher than those of mature firms.
(b) Conversely, the difference of process innovativeness between a mature industry and an emerging one was big enough to make the overall comparative innovativeness of the mature firms not conclusively lower than those in emerging firms.

In summary it is argued that there is no runaway relative advantage of product innovativeness for firms in an emerging industry, while there is a significant relative advantage of process innovativeness in the firms belonging to a mature industry.

A developing country like South Africa is characterised by institutional inefficiencies (Niosi, 2002), an absence of policy frameworks for intellectual property, weak R&D structures and the fragmentation of inter-sectoral links among the components of the innovation system

(Rooks & Oerlemans, 2005). Unlike developed countries, under such circumstances of weak property rights the nature of product innovation is mainly based on imitation and reverse engineering (Oerlemans *et al.*, 2003) - new products are often copied due to weak patent laws. Thus, firms in an emerging industry have a low incentive for product innovation based on R&D, since such gains of innovation are quickly consumed. Besides, Rooks and Oerlemans (2005) claimed that one in five innovating firms did not start an innovation project (in the strict sense of new products and invention) because of lack of capital and projects were often delayed and abandoned. It may thus be argued that one component of product innovation – invention - is either missing or severely challenged in a developing country. This trend may explain why the product innovativeness among firms in an emerging industry is not high enough to foster a clear advantage in terms of total innovativeness over the firms belonging to a mature industry.

On the contrary, firms in a mature industry create barriers to entry through greater efficiency backed by process innovation. Firms on the basis of only their *dominant design* cannot sustain their competitiveness. This is even more relevant in developing countries where the gains of new products are quickly consumed by imitation. Thus, process innovation, which is relatively difficult to copy, becomes the source of sustainable competitive advantage for mature firms. In addition, due to the price sensitive nature of the markets in developing countries, the reduction of unit cost becomes critical. This is often achieved via efficiency brought in by process innovations. These innovations and related efficiencies are gained over time in mature firms. Thus the incentives and advantages of the mature firms may explain the wide difference of process innovativeness between the firms in a mature industry and an emerging industry.Also, in a developing country like South Africa where lack of capital is a major hindrance towards innovation activities (Rooks & Oerlemans, 2005), firms in a mature industry - because of their size and turnover

- have a lesser risk of financial failure and a greater appetite to finance innovation activities that enhance their dominant position (Atun, Harvey & Wild, 2007).

In summary, the conventional product-process innovation patterns based mainly on the firms in developed countries, i.e. dominance of product innovation in firms belonging to an emerging industry and process innovation in firms belonging to a mature industry, were found to be true in the context of the weak institutional setup of a developing country as well. This was due to the presence of the same driving factors in both the environments – the search for the *dominant product design* among firms in the early phase of the industry, and the usage of increased efficiency backed by process innovation as a barrier to entry to maintain the dominant position of incumbent firms in a mature industry. However, it is argued that unlike developed countries, developing countries are characterised by the presence of a low level of research, a weak linkage between firms and industries, a low level of skills, a poor education system and knowledge infrastructure, and weak property rights. This gives little incentive to an invention type of innovation among firms from an emerging industry, thus reducing the gap of relative innovativeness between the firms in an emerging industry and a mature industry. The gap is further reduced by a higher relative process innovativeness of firms belonging to a mature industry for very similar reasons. These arguments, when combined, explain why there was no conclusive evidence of firms in an emerging industry being more innovative than those in a mature industry. In this regard, the findings in this study were different from some of the claims made on total innovativeness during the different phases of ILC based on developed countries.

6.3 Does Government support firms in a mature industry (automotive) more than those in an emerging industry (software)?

Innovation systems in a developing country are characterised by fragmented networks, giving rise to weak government-industry link (Chaminade & Vang, 2008; Galli & Teubal, 1997). This study supports this view – on an average only 4.48% of the firms in an emerging industry (software) and 8.68% of the firms in the mature industry (automotive) received government support in South Africa. This low utilisation of government support could be due to a lack of government funds, bureaucratic red-tape or a lack of trust in government (Rooks & Oerlemans, 2005).

The major findings of this study in this regard were that greater overall governmental support was accessed by firms belonging to a mature industry than those in an emerging industry. Additionally, there was suggestive evidence of greater local support for firms belonging to an emerging industry and of greater national support for firms belonging to a mature industry.

This is in contrast to the claims made based on studies done in developed countries. In the context of the developed world there were fair distributions of governmental supports to firms belonging to either phase of the ILC. Romijn and Allaladejo (2002) claimed that innovation and technology counsellors funded by the national government in the UK visited and supported all firms irrespective of the stage of the ILC they belonged to. They further explained how some of the firms in the emerging industries would not have survived without the government support. Their findings concurred with other research based in developed countries that pointed to the strong local network linkages (government-industry-university) contributing to the success of the small technology based emerging firms.

However, in the current study based on a developing country it is argued that firms in a mature industry manage to receive more overall governmental support. As discussed earlier, this may be due to their sizes, impact on GDP, export potential and being older than the firms in an emerging industry that have helped develop a closer relationships with government both at a local and national level. Based on the empirical background of territorial agglomeration and networking of small to medium sized enterprises (Asheim, 2000), and on most findings on triple helix collaboration (industry-government-university) in regional dynamics (Coenen & Moodyson, 2009), it is further argued that the firms in an emerging industry may have superior incentive to receive higher local governmental support. This study provided suggestive evidence in this regard.

One interesting observation in this regard was that the firms in an emerging industry showed relative strength in acquiring local governmental support in the areas of tax incentives, funds for product development and information on technological opportunities. But there was no such advantage in terms of export support. This could be due to the fact that local governments have less power in terms of supporting export activities than national governments. Hence, a clear advantage in this regard for the firms in an emerging industry was not visible.

Looking into these two trends of local and national government support, i.e. the inconclusive advantage of firms in an emerging industry regarding local government support and the conclusive advantage of firms in a mature industry regarding national government support, it logically follows that the overall government support to firms belonging to a mature industry is higher than that of an emerging industry. In this context, it may additionally be argued that in a developing country like South Africa the connection between politics and the economy is crucial. The relationship developed over time between firms in a mature industry and the previous governments cannot be ignored. Thus firms in a mature industry are already in a relatively better position in terms of government-industry relationships. The current government, although ideologically different from the previous ones, has little choice but to maintain these relationships. This is because of the influence that mature firms have over the national economy – export and imports, foreign direct investments, employment and the overall influence on national GDP. As a custodian of the national economy the government has mutually beneficial relationships with these mature firms. However, emerging industries represent the economic powerhouses of the future, and the weak links between those industries and government are therefore troubling.

In summary, unlike in developed countries, government support to firms for innovative activities was found to be low. Firms in a mature industry in a developing country like South Africa receive higher national and overall governmental support, primarily because of their relationships with the government which have developed over time and their higher impact on the national GDP. Unlike the substantial governmental support towards emerging firms in a developed country, firms in an emerging industry in South Africa receive nominal local governmental support.

6.4 Do firms in an emerging industry (software) innovate more based on internal-to-firm knowledge than those in a mature industry (automotive)?

Audretsch and Feldman (1996) created a production function of innovation which linked the inputs of innovation to innovative outputs. A primary input to this function was R&D – in the context of a developed country, a good proxy for source of knowledge. This raises a question about the internal-to-firm innovativeness of firms with limited R&D capabilities in an emerging industry. This problem becomes even more critical in a developing country which is characterised by low research capability, challenges in creation of knowledge and a lack of learning organisations. One possible answer is that firms in an emerging industry innovate via knowledge spillovers from external sources like universities, other firms, research institutes and TNCs (Audretsch, 1998).

The findings of this study refute this reasoning and finds conclusive evidence that the firms belonging to an emerging industry innovate more based on internal-to-firm knowledge. This is counterintuitive and goes against the claims of Audretsch (1998). In this connection, it may be noted that Audretsch's claims were based on formal knowledge (STI learning) and in the context of developed countries.

It may be argued that the counterintuitive findings in this study are influenced by certain characteristics of NIS in a developing country. Jensen *et al.* (2007) claimed that firms involved with the invention of new products connected to formal scientific knowledge are based on STI learning. As discussed earlier, firms, especially those belonging to an emerging industry operating in an innovation system of a developing country, have less incentive to be involved in invention-based new product development. Thus, the DUI model, which focuses on interactive learning based on informal knowledge sharing, is critical in a developing country. Therefore the limited R&D capability of firms in an emerging industry does not pose as great a threat to internal-to-firm innovation as expected by Audretsch (1998).

The weak inter-sectoral links between the different elements of the NIS in a developing country – firms, universities, government, technological centres and TNCs – arguably pose relatively more challenges to firms in an emerging industry than those in a mature industry. This is because unlike emerging firms, companies in a mature industry develop some sort of relationship between the various elements of the IS and benefit from knowledge spillovers from external sources. Marin and Arza (2009) suggested that in the context of a

NIS in a developing country, multinational corporation (MNC) subsidiaries were better positioned to benefit from knowledge creation and diffusion at the interface of two systems of knowledge: global (created via their links with MNCs and other international agents) and national. It may be noted that several firms constituting the automotive industry (mature industry) were found to be MNC subsidiaries and owned by foreign capital, thereby positioning themselves better for external-to-firm innovation activities based on external knowledge spillovers than those in the software industry (emerging industry).

In summary, the firms in an emerging industry, in spite of relatively low internal R&D capability, manage to be more innovative based on their internal-to-firm knowledge. This internal-to-firm knowledge is based on the knowledge flow within the firms' structures and relationships. Due to very weak relationships between firms in an emerging industry and external agents, these companies are forced to use their internal-to-firm knowledge to be innovative and therefore compete in an emerging market. In contrast, firms in a mature industry are better positioned to innovate by exploiting the knowledge external to firms, especially at the national and international level. These findings were found to be different to the claims made in this regard in the context of developed countries.

6.5 Is there any pattern of local and international innovation activities between firms in an emerging industry (software) and a mature industry (automotive)?

Asheim (2007) argued that a *regionalised national innovation system* characterised by innovation activities taking place primarily in co-operation with actors outside the region were often found among firms in an emerging industry. In contrast, *territorially embedded systems* characterised by innovation activities based on localised inter-firm learning process were often found among firms in a mature industry. Asheim's claims, like most of the literature in this regard, are based on a fairly narrow definition of innovation based on R&D and scientific research in developed countries.

However the findings of this study suggest otherwise – there was conclusive evidence that firms in an emerging (software) industry were more involved in local innovation activities, while firms in a mature (automotive) industry were more involved in international innovation activities. This study once again suggests that the predictions made in terms of the patterns of innovation based on developed countries can be found to be untrue in the context of developing countries.

Given the earlier discussion around weak and formative NIS and RIS, it is quite logical that contrary to Asheim's claims, firms in an emerging industry operate in the *territorially embedded regional innovation system.* Under this system, firms are locally stimulated by an informal knowledge flow within a geographical and regional proximity without much interaction with knowledge generating organisations (universities and R&D institutes). As noted in the discussions under sections 6.3 and 6.4, it is argued that the firms in an emerging industry possibly have more incentive to be localised than those in a mature industry. In contrast, firms in a mature industry have better national and international knowledge flows and relationships.

In this regard, the findings of this study are in line with the claims of Marin and Arza (2009). They noted that TNCs were often reluctant to engage in interactive learning with the emerging (local) firms due to a lack of absorptive capacity on the part of the latter, a fear of losing knowledge and the lack of differentiation between firms and the goods they supply. Padilla-Perez *et al.* (2009) suggested that although the relationships between local emerging firms and international agents were important, they were not automatic but rather dependent on industry, institutional and firm-specific characteristics.

In contrast, given the institutional characteristics of a developing country and the characteristics of firms in a mature industry, it was not surprising that the firms in a mature industry were more involved in international innovation activities. Unlike Asheim's (2007) suggestion, this study argues that it made more sense for firms in a mature industry in the context of a developing country to be involved with a *regionalised national innovation system.* Under this system firms are expected to be involved with innovation activities with exogenous factors – a national and international innovation system. As noted under section 6.4, firms in a mature industry are better positioned to be involved with international relationships and thereby engage in international innovation activities.

One interesting observation in this regard was that the above trend of local and international innovation activities was consistent among the different sub-activities such as acquisition of machinery, equipment, knowledge and training, with the exception of international R&D. In this case, the involvements were nearly equal. It is expected that firms in an emerging industry will have low involvement in international R&D activities because of their inclination towards local relationships and internal-to-firm innovation activities (as discussed under section 6.3 and 6.4). For firms in a mature industry, the absence of relatively more involvement in R&D with international agents was a *prima facie* surprise, considering the international relationships between these firms and the TNCs.

One possible reason in this regard could be due to the relative less power of the TNC subsidiaries and other firms in the developing countries in relation to the head-offices situated overseas (mostly in developed countries). Firms in developing countries are often treated as the cheap manufacturer and seller of the products designed and created in developed countries. TNCs are averse to engage in interactive learning with firms in a developing country, which implies in most cases hierarchical or quasi-hierarchical relationships (D'costa, 2006). This view is supported by the findings that in the categories of international acquisition of knowledge, machinery and equipment, and training (acquiring of already developed concepts, know-how and products) there was a clear and conclusive trend of superior involvement of firms in a mature industry while no such trend existed for R&D involvement (development of new concept and product).

In summary, the firms in a mature industry are at an advantageous position by virtue of having better international relationships. Thus mature firms are involved with more international activities. In the absence of these international relationships among firms in an emerging industry, they innovate based on informal localised learning within a geographical and regional proximity. It is to be noted that this finding is in contrast to Asheim's (2007) expectations of these firms' innovative behaviour in terms of local and international activities (when set in the context of the fairly narrow definition of innovation based on R&D and scientific research) often based on developed countries.

6.6 What do these innovation patterns mean for the various stakeholders of an organisation?

The various stakeholders of an organisation considered in this regard are the governments (policy makers), shareholders, managers, universities, research institutes and TNCs situated overseas.

It is pertinent for stakeholders to understand the advantages and challenges of a National Innovation System. Innovation has a direct link with the economy and it's competitiveness. It distinguishes between "winners" and "losers" (Rutten & Boekema, 2005, p.1132). The innovation pattern and characteristics discussed in this study will hopefully help the various stakeholders to understand the nuances of innovation among firms belonging to different stages of the industry life cycle. This will aid them to develop policies and strategies to develop innovation activities backed by flow of capital, information and knowledge within and between firms, government, universities, research institutes and TNCs.

The next chapter discusses the specific recommendations in this regard along with the discussion of the main findings of this study and future research.

7. Conclusion and Recommendations

7.1 Conclusion

As per the Global Competitive Report of 2010-2011, South Africa has slipped from an overall competitive ranking of 45th (2009) to 54th (2010) (Schwab, 2010). The two major areas where South Africa needs the most improvement in terms of bettering its competitiveness and thereby enhancing the chances of moving from an *efficiency driven* economy to a higher state of an *innovation driven* economy, are technological readiness and innovation (both were scored at 3.5; the lowest score among the twelve pillars of the Global Competitive Index). Technological readiness is also influenced by innovation, therefore if there is a single focus point for South Africa, it is innovation.

Macro level national innovativeness cannot be achieved without innovation activities at a micro level – within firms. Thus it is important to understand the characteristics of innovation activities in firms and how these activities are influenced by the rules and norms of society and vice versa. This insight will help in developing an environment conducive to innovation at both a micro and macro level, thereby contributing positively towards the long term economic growth of the country.

Firms are driven to innovate by *creative destruction* and *creative accumulation* (Schumpeter Mark I and II models). These driving factors vary with the various stages of industry life cycles (emerging and mature stages) and give rise to differing characteristics of innovations. These differing characteristics have mainly been studied from the point of views of firm size, market structure and industry concentration, with the aim of establishing a pattern. Additionally, the context of these studies has mainly been developed countries and often based on a fairly narrow definition of innovation – invention, R&D, and the STI mode of learning. However they produced inconclusive results due to the endogenous relationship between firm size, concentration and technological changes (Malerba, 2005).

This study attempts to describe how institutions in a developing country like South Africa influence the differing salient characteristics and patterns of innovation in firms belonging to an emerging versus a mature industry. The central argument of this research is that the institutional impact on the innovation characteristics of firms differs between a developing country and a developed country. This becomes even more prominent when the broader definition of innovation, which includes invention, imitation and reengineering, as well as STI and DUI modes of leanings, is used. Thus, some of the patterns of innovation among firms belonging to the different stages of the ILC are expected to be different in a developing country like South Africa than those studied extensively in developed countries.

North (1990, p.3) defined institutions as, “rules of the game in a society”. Hollingsworth (2000) added norms, conventions, habits and values at a macro level, followed by micro level constituents -- markets, states, networks, systems of education and research and organisations among others. Scott (2008) argued that institutions were supported by regulative, normative and cultural-cognitive pillars.

In order to come up with the different salient characteristics of innovation in firms belonging to an emerging industry versus a mature industry, the framework of system of innovation was used. Johnson and Jacobsson (2003) suggested this framework as a tool to analyse and evaluate the characteristics of an innovation system among firms belonging to the various stages of ILC. For this study, the set of institutions which influences innovations within the national boundary of South Africa (NIS) and within regional boundaries of territorial agglomeration (RIS) were considered.

The theory of industry life cycle in terms of firm behaviour was juxtaposed within the NIS and RIS frameworks to come up with the following set of salient innovation features which characteristically differ in firms belonging to an emerging versus a mature industry:

a) Types of innovation

The product innovativeness of firms belonging to an emerging industry was higher than those in a mature industry, while the process innovativeness of firms belonging to a mature industry was higher than those in an emerging industry. Contrary to the majority of claims made in the existing literature based on developed countries, there was no conclusive evidence that the total innovativeness in firms belonging to an emerging industry was higher than those in a mature industry.

b) Government support

Overall government support was found to be very limited among firms - irrespective of their belonging to an emerging or a mature industry. This is in contrast to what is found in the developed world. There was no conclusive evidence of greater local government support to firms in an emerging industry, while there was significant evidence of greater national and overall government support for firms belonging to a mature industry. No such differing patterns are expected in the existing literature based in developed countries –the overall government support is expected to be fairly distributed and consistent across all firms irrespective of the phase of the industry they belong to. If anything these studies are beset with success stories of local government -small and medium enterprises/emerging firms relationships.

c) Centre of innovation activities

Firms belonging to an emerging industry were found to be involved in higher internal-to-firm innovations than those in a mature industry. This finding was also in sharp contrast to the developed world's expectations of firms in an emerging industry to innovate via knowledge spillover from external sources like universities, other firms, research institutes and TNCs.

d) Geographical location of innovation

Firms in an emerging industry were found to be involved with more local innovative activities, while those in a mature industry were involved with more international innovation activities. This was again found to be counterintuitive to the findings of the studies done in the context of the developed world.

It may be noted that the appropriateness of the choice of these different salient innovation features was justified by the high rate of success (81.2%) in predicting if a firm belonged to a mature industry or not (i.e. emerging industry) by the model developed in this study.

7.2 Recommendations to stakeholders

The following describes the various recommendations to some of the major stakeholders in view of the findings of this research.

a) Government/policy makers

The findings of this study clearly indicate that the characteristics of innovation differ between firms belonging to industries in the various stages of their life-cycles. Also, these characteristics were often different from the expectations developed in studies based in developed countries. It is recommended that these nuances be observed and internalised by the government. This will help develop a national environment of innovation which will be supportive to not only the firms in mature industries, but also to the small and medium enterprises belonging to emerging industries. Additionally, it is expected that the government and policy makers understand the context set out in this study in terms of the characteristics of the

NIS and RIS in South Africa. This will aid in creating a national and regional framework where the different elements of the innovation systems – firms, government, universities, external research institutes and TNCs will be well connected in terms of knowledge and capital flow. A starting point in this regard could be a closer relation within the triple helix structure of university, industry and government. Such a relationship will boost innovation activities in all sectors. In particular, firms in the emerging industries will no longer be handicapped by weak inter-sectoral links which force them to look inwards all the time.

b) Shareholders

Shareholders often look for growth in a firm's share prices and their invested capital. This growth is often related to the growth of the firm in terms of profitability and market share, which is normally the feature of companies belonging to emerging industries. Firms in mature industries are usually stable and holding on to their market share is their main objective. It is recommended to shareholders that before buying or selling shares in a firm, in addition to the conventional outlook of a firm's financial situation and market conditions, the innovation characteristics of the firms discussed in this study also be considered. This will give an indication if the firm is in its growth stage or has stagnated in a mature stage. This view will help in understanding the future standing of the firm in terms of development of new products and services, as well as how it will create a barrier to entry for other firms wanting to enter the industry.

c) Managers

It is recommended that managers and leaders of firms internalise these patterns of innovation, along with the characteristics of NIS and RIS discussed in this study. This will assist them to develop an understanding of what characteristics of innovation a firm of its stature may be expected to be involved with. In addition to this it will also give information regarding the landscape it is operating within. These insights will be crucial for the future strategy of the firm. Managers and leaders will either want to execute the general innovation characteristics applicable for a firm belonging to the same stage of industry life cycle it belongs to – this is more of a follower strategy. However a firm may as well start a new *sigmoid* curve of growth by choosing certain innovation characteristics based on the stage of the industry life cycle it envisages to operate in – this is more of a leader strategy.

d) University and external research institutes

Universities and external research institutes are important elements of an innovation system. They generate knowledge and provide resources for innovation activities. In South Africa, the knowledge flow between firms and research institutes is generally weak. Thus it is recommended that universities and research institutes understand the challenges faced by companies, especially those belonging to the emerging industries that are constrained by internal-to-firm innovation activities. It is suggested that the universities get involved in more entrepreneurial activities by being more innovative, encouraging more knowledge flow between them and firms, and not just being a supplier of resources to companies for employment. Public-private partnerships in terms of developing world class research institutes are also strongly recommended.

e) TNCs

As noted in this study there is apathy when it comes to TNCs being involved with firms in emerging industries. Also, they do not encourage partnership in research with local firms. TNCs use companies in developing countries as cheap manufacturers and distributors of products designed and created in developed countries. It is recommended that TNCs look in depth into this practice, much as Immelt did in the case of GE. He encouraged the design and development of products in developing markets like India and China and marketed them in developed countries (*reverse innovation*). The idea is not to compromise on quality in pursuit of making the products cost-effective, which is an order qualifying criterion in a price sensitive developing market. It is also suggested that TNCs have more trust in local small and medium enterprises. This may give TNCs the added advantage of working with the nimbleness associated with relatively smaller firms in an emerging industry.

7.3 Recommendations for future research

The recommendations for future research are as follows:

a) This study was constrained in terms of using only a single example each for an emerging industry and a mature industry. It is recommended that for a better generalisation, firms from other sectors in emerging industries and mature industries be used.
b) The research tried to explain the salient innovation characteristics of firms in the context of a developing country like South Africa. Again, in order for better generalisation, similar studies in other developing countries like India, China, Brazil and Russia are recommended.
c) It is also suggested that some other important differing innovation characteristics between firms in emerging and mature industries be researched and introduced in the model developed in this research, so that the predictability of the model becomes even better. For example, unlike this study where new to firm, domestic market and global market innovations have been aggregated; it is suggested to use these characteristics on their own to find if any significant pattern of differences exist. In addition, sources of technology and knowledge (like employees, parent companies, clients, competitors, universities and public research), level of

education within a firm and organisational innovation may also be looked at to find any existent pattern.

d) It would also be interesting to extend the research to firms belonging to industries in the declining stage of their life-cycles. Some industries which may be considered are print media, traditional CD/DVD manufacturer and retailer (including rentals), and wired telecommunication provider.

8. Reference List

Aghion, P. & Howitt, P. (1998). *Endogenous Growth Theory*. Cambridge, MA: MIT Press.

Argyres, N., & Bigelow, L. (2007). Does transaction misalignment matter for firm survival at all stages of the industry life cycle? *Management Science, 53*(8), 1332-1344.

Albright, S.C., Winston, W.L., & Zappe, C.J. (2009) *Data Analysis & Decision Making.* Mason: South-Western Cengage Learning.

Amin, A. (2004). Regions unbound: towards a new politics and place. *Geografiska Annaler,*86(1), 31-42.

Asheim, B.(2000), Industrial districts: The contributions of Marshall and beyond, in Clark, G., Feldman, M. & Gertler, M. (eds), *The Oxford Handbook of Economic Geography, Oxford*, Oxford University Press, 413-431.

Asheim, B. (2007). Differentiated knowledge bases and varieties of regional innovation systems. *Innovation: The European Journal of Social Sciences, 20*(3), 223-241. doi:10.1080/13511610701722846.

Asheim, B.,& Coenen, L. (2005). Knowledge bases and regional innovation systems: comparing Nordic clusters. *Research Policy,*34(8),1173.

Asheim, B. and Gertler, M. (2005) The geography of innovation: regional innovation systems, in: J. Fagerberg, D. C. Mowery & R. R. Nelson (Eds). *The Oxford Handbook of Innovation*, 291–317.

Asheim, B., Isaksen, A., Nauwelaers, C., & Toedtling, F. (2003). *Regional Innovation Policy for Small-medium Enterprises*. Cheltenham, UK and Northampton, MA, USA.

Atun, R. A., Harvey, I., & Wild, J. (2007). Innovation, patents and economic growth. *International Journal of Innovation Management, 11*(2), 279-297.

Audretsch, D.B. (1998) Agglomeration and the location of innovative activity. *Oxford review of economic policy,* 14(2), 18-29.

Audretsch, D.B. & Feldman, M.P. (1996) Innovative Clusters and the Industry Life Cycle. *Review of Industrial Organization,* 11, 253-257.

Baregheh, A., Rowley, J., & Sambrook, S. (2009). Towards a multidisciplinary definition of innovation. *Management Decision, 47*(8), 1323-1339. doi:10.1108/00251740910984578

Barley, S.R. and Tolbert, P.S. (1997). Institutionalization and Structuration: Studying the links between action and institution. *Organization Studies, 18*(1), 93–117.

Barnard, H., Bromfield T. & Cantwell, J. (2009) The role of indigenous firms in innovation systems in developing countries: the developmental implications of national champion firms' response to underdeveloped national innovation systems. In: Lundvall B., Joseph, K., Chaminade, C., & Vang, J.(eds). *Handbook of Innovation Systems and Developing Countries,* 241-279.

Barras, R. (1990). Interactive innovation in financial and business services: the vanguard of service revolution. *Research Policy,19,* 215-237.

Bessant, J., Lamming, R., Noke, H., & Phillips, W. (2005), Managing innovation beyond the steady state.*Technovation*, 25(12), 1366-1376.

Breschi, S., Malerba, F., & Orsenigo, L., 2000. Technological regimes and Schumpeterian patterns of innovation. *Economic Journal*, 110, 338–410.

Chaminade, C., & Vang, J. (2008). Globalisation of knowledge production and regional innovation policy: Supporting specialized hubs in the bangalore software industry. *Research Policy, 37*(10), 1684-1696. doi:DOI: 10.1016/j.respol.2008.08.014

Chaminade, C., Lundvall, B., Vang J., & Joseph, K.J. (2009). Designing innovation policies for development; towards a systemic experimentation-based approach. In: Lundvall B., Joseph, K., Chaminade, C., & Vang, J. (eds). *Handbook of Innovation Systems and Developing Countries,* 360-379.

Coenen, L., & Moodysson, J. (2009). Putting constructed regional advantage into swedish practice. *European Planning Studies, 17*(4), 587-604. doi:10.1080/09654310802682180

Cooke, P. (1998), Introduction: origins of the concept. In Braczyk, H., Cooke, P. & Heidenreich, M.(eds), *Regional Innovation Systems*, London, UCL Press, 2-25.

Cozzens, S.E., & Kaplinsky, R. (2009). Innovation, poverty and inequality: cause, coincidence, or co-evolution? In: Lundvall B., Joseph, K., Chaminade, C., & Vang, J. (eds). *Handbook of Innovation Systems and Developing Countries,* 57-82.

Damanpour, F., & Schneider, M. (2006), Phases of the adoption of innovation in organizations: effects of environment, organization and top managers, *British Journal of Management*, 17(3) , 215-236.

Dasgupta, P., & J Stiglitz (1980). Industrial-structure and the nature of innovative activity.*Economic Journal*, 90(358), 266–293.

Davis, L. & North, D. (1971). *Institutional Change and American Economic Growth.*Cambridge: Cambridge University Press.

D'Costa, A. (2006). Exports, university-industry linkages, and innovation challenges in Bangalore, India. *World Bank Policy Research Paper (WPS 3887),* available at www.worldbank.org (accessed 24/03/10).

Department of Trade and Industry (2003). *Innovation Report. Competing in the global economy*: *The innovation challenge*. London.

Dinis, A. (2006). Marketing and innovation: Useful tools for competitiveness in rural and peripheral areas. *European Planning Studies, 14*(1), 9-22. doi:10.1080=09654310500339083

Edquist, C. (2004). Systems of innovation: perspectives and challenges.. In: Fagerberg. J., Nelson, R., & Mowrey, D.(eds). *The Oxford Handbook of Innovation.* Oxford : Oxford university press, 181-208.

Edquist, C. (2001). The systems of innovation approach and innovation policy: an account of the state of art. *Paper for DRUID's conference -- National systems of innovation, institutions and public policy*. Aalborg.

Eparvier, P. (2005). Methods of evolutionism and rivalry with neoclassical analysis. the example of the national system of innovation concept. *Journal of Economic Methodology, 12*(4), 563-579. doi:10.1080/13501780500343664

Ernst, D. (2000). Global production networks and the changing geography of innovation systems: Implications for developing countries. *East–West Center Working Papers Economic Series*, No. 9.

Ettlie, J.E., & Reza, E.M. (1992).Organizational integration and process innovation. *Academy of Management Journal*, 35(4), 795-827.

European Commission (2003) *Innovation Policy: Updating the Union's approach in the Context of the Lisbon Strategy.* Brussels. COM(2003).

Fagerberg,J., Mowery, D., & Verspagen, B. (2008). Innovations-systems, path dependency and policy: the co-evolution of science, technology and innovation policy and industrial structure in a small, resource-based economy. *Paper presented at the Prime-Latin America Conference in Mexico City, 24-26 September.*

Fagerberg, J., & Srholec, M. (2009). Innovation systems, technology and development: unpacking the relationships. In: Lundvall B., Joseph, K., Chaminade, C., & Vang, J. (eds). *Handbook of Innovation Systems and Developing Countries,* 83-118.

Galli, R., & Teubal, M. (1997). Paradigmatic shifts in national innovation systems. In Edquist, C (ed). *Systems of innovation, technologies, Institutions and Organisations.* London. Routledge.

Haskel, J & A Sanchis (1995). Privatisation and X-inefficiency: A bargaining approach.*Journal of Industrial Economics*, 43(3), 301–321.

Hekkert, M. P., Suurs, R. A. A., Negro, S. O., Kuhlmann, S., & Smits, R. E. H. M. (2007). Functions of innovation systems: A new approach for analysing technological change. *Technological Forecasting and Social Change, 74*(4), 413-432. doi:DOI: 10.1016/j.techfore.2006.03.002

Hodgson, G.M. (1998) The Approach of Institutional Economics. *Journal Of Economic Literature, 36(1),*59-87.

Hollingsworth, J. R. (2000). Doing institutional analysis: Implications for the study of innovations. *Review of International Political Economy, 7*(4)

Intarakumnerd, P., Chairatana, P., & Tangchitpiboon, T. (2002). National innovation system in less successful developing countries: The case of thailand. *Research Policy, 31*(8-9), 1445-1457. doi:DOI: 10.1016/S0048-7333(02)00074-4

Isaksen, A. (2001) Building regional innovation systems: is endogenous industrial development possible in the global economy? *Canadian Journal of Regional Science*, 24(1), 101–120.

Jensen, M. B., Johnson, B., Lorenz, E., & Lundvall, B. Å. (2007). Forms of knowledge and modes of innovation. *Research Policy, 36*(5), 680-693. doi:DOI: 10.1016/j.respol.2007.01.006

Johnson, A. (2001). Functions in Innovation System Approaches. *Paper for DRUID's Nelson-Winter Conference*. Aalborg, Denmark .

Johnson, A., & Jacobsson, S. (2003). The emergence of a growth industry : a comparative analysis of the German, Dutch and Swedish wind turbine industries . In : Metclafe S., & Cantner, U. (eds). *Transformation and Development: Schumpeterian perspectives.* Heidelberg:Physica/Springer .

Joseph, K.J. (2009) Sectoral innovation systems in developing countries: the case of ICT in India. In: Lundvall B., Joseph, K., Chaminade, C., & Vang, J. (eds). *Handbook of innovation systems and developing countries,* 183-213.

Kaplan, D. (2004) Technology and the growth of manufactured exports: Assessing South Africa's performance and policy. *Paper presented at the DRUID Conference on Industrial Dynamics, Innovation and Development.* Elsinore, Denmark.

Kayal, A. (2008) National innovation systems a proposed framework for developing countries. *Int.J. Entrepreneurship and Innovation Management,* 8(1), 74-86.

Khalil, E. L. (1995). Institutional theory of the firm? extension and limitation. *Review of Political Economy, 7*(1), 43.

Klepper, S. (1997). Industry life cycles. *Industrial & Corporate Change, 6*(1), 119-143.

Klepper, S. (1996). Entry, exit, growth, and innovation over the product life cycle. *American Economic Review, 86*(3), 562-583.

Liang, H.G., Saraf, N.,Hu, Q., & Xue, Y.J. (2007) Assimilation of Enterprise Systems: The Effect of institutional pressures and the mediating role of the top management. *MIS Quarterly, 31*(1)*,* 59-87*.*

Liu, X., & White, S. (2001). Comparing Innovation Systems: A Framework and

application to China's Transitional Context. *Research Policy, 30(7),* 1091-114*.*

Loebis, L., & Schmitz, H. (2005). Java furniture makers: winners of losers from globalisation? *Development and Practice,15*(3-4), 514-21

Lundvall, B., Johnson, B., Andersen, E. S., & Dalum, B. (2002). National systems of production, innovation and competence building. *Research Policy, 31*(2), 213-231. doi:DOI: 10.1016/S0048-7333(01)00137-8

Lundvall, B. (2007). Innovation system research Where it came from and where it might go. *The Global Network for Economics of Learning, Innovation, and Competence Building System.*

Lundvall, B., Vang J., Joseph, K.J. & Chaminade, C. (2009) Innovation system research and developing countries. In: Lundvall B., Joseph, K., Chaminade, C., & Vang, J. (eds).*Handbook of Innovation Systems and Developing Countries,* 1-30.

Malerba, F. (2002). Sectoral systems of innovation and production. *Research Policy, 31*(2), 247.

Malerba, F. (2005). Sectoral systems of innovation: A framework for linking innovation to the knowledge base, structure and dynamics of sectors. *Economics of Innovation & New Technology, 14*(1), 63-82. doi:10.1080/1043859042000228688

Malerba, F., & Orsenigo, L. (1997). Technological regimes and sectoral patterns of innovative activities. *Industrial & Corporate Change, 6*(1), 83-117.

Marin, A., & Arza, V. (2009). The role of multinational corporations in national innovation systems in developing countries: from technology diffusion to international involvement. In: Lundvall B., Joseph, K., Chaminade, C., & Vang, J. (eds).*Handbook of innovation systems and developing countries,* 280-310.

McGahan, A. M., & Silverman, B. S. (2001). How does innovative activity change as industries mature? *International Journal of Industrial Organization, 19*(7), 1141.

Metcalfe, S., & Ramlogan, R. (2008). Innovation systems and the competitive process in developing economies. *The Quarterly Review of Economics and Finance, 48*(2), 433-446. doi:DOI: 10.1016/j.qref.2006.12.021

Mytelka, L. (2000). Local systems of innovation in a globalized world economy. *Industry and Innovation*, *7*(1), 15–32.

Nuur, C., Gustavsson, L., & Laestadius, S. (2009). Promoting regional innovation systems in a global context. *Industry & Innovation, 16*(1), 123-139. doi:10.1080/13662710902728142

North, D. (1991) *Institutions, Institutional Change and Economic Performance.*Cambridge and New York: Cambridge University Press.

Niosi, J. (2002). National systems of innovations are 'x-efficient' (and x-effective) why some are slow learners. *Research Policy, 31*(2), 291.

OECD (2003). *The Sources of Economic Growth in the OECD Countries*. Paris: OECD

Oerlemans, L., Pretorius M., Buys, A., & Rooks, G. (2003) South African Innovation Survey 2001.*Department of Engineering and Technology Management.*Pretoria.

Pack, H., & Saggi, K. (1997). Inflows of foreign technology and indigenous technological development. *Review of Development Economics, 1*(1), 81-98.

Padilla-Perez, R. (2008). A regional approach to study technology transfer through foreign direct investment: the electronics industry in two Mexican regions. *research Policy, 37*(5), 849-60.

Padilla-Perez, R.,Vang J., & Chaminade, C. (2009). Regional innovation systems in developing countries : integrating micros and meso level capabilities. In: Lundvall B., Joseph, K., Chaminade, C., & Vang, J. (eds). *Handbook of Innovation Systems and Developing Countries,* 140-182.

Pietrobelli, C., & Rabellotti, R. (2006). Upgrading to Complete: Global Value Chains, Clusters, and SMEs in Latin America. *Inter-American development Bank.* David Rockefeller Center for latin American Studies, Harvard University.

Porter, M. (1990). *The Competitive Advantage of Nations.*London: Macmillan

Porter, M. (1998). Clusters and the new economics of competition. *Harvard Business Review,76*(6),77-90.

Rickne, Annika (2000). New Technology-Based Firms and Industrial Dynamics: Evidence from the Technological Systems of Biomaterials in Sweden, Ohio and Massachusetts, *Department of Industrial dynamics, Chalmers University of Technology*.

Romijn, H., & Albaladejo, M. (2002). Determinants of innovation capability in small electronics and software firms in southeast England. *Research Policy, 31*(7), 1053-1067. doi:DOI: 10.1016/S0048-7333(01)00176-7

Rooks, G., & Oerlemans, L. (2005). South africa: A rising star? assessing the X-effectiveness of south africa's national system of innovation. *European Planning Studies, 13*(8), 1205-1226. doi:10.1080/09654310500336584

Rooks, G., Oerlemans, L., Buys, A., & Pretorius, T. (2005). Industrial innovation in south africa:A comparative study. *South African Journal of Science, 101*(3), 149-150.

Rutten, R., & Boekema, F. (2005). *Innovation, policy and economic growth: Theory and cases* Routledge. doi:10.1080/09654310500336436

Schmitz, H. (2006). Regional systems and global chains. *Paper presented at the Fifth International conference on Industrial Clustering and regional Development.*

Schoser, C. (1999). The institutions defining national systems of innovation: a new taxonomy to analyse the the impact of globalisation. *Annual conference of the European Association of Evolutionary Political Economy.* Prague.

Schotter, A. (1981) *The Economic Theory of Social Institutions.* Cambridge and New York: Cambridge University Press.

Schwab, K. (2010) The Global Competitive Report. Geneva : World Economic Forum. Available from http://www3.weforum.org/docs/WEF_GlobalCompetitivenessReport_2010-11.pdf (accessed 24/10/2010).

Scott, W.R. (2008). *Institutional and Organizations – Ideas and interests*. Thousand Oaks: Sage.

Sharif, N. (2006). Emergence and development of the national innovation systems concept. *Research Policy, 35*(5), 745-766. doi:DOI: 10.1016/j.respol.2006.04.001

Vang, J., & Asheim, B. (2006). Regions, absorptive capacity and strategic coupling with high tech TNCs; lessons from India and China. *Science Technology & Society,11*(1), 39.

Viotti, E. B. (2002). National learning systems: A new approach on technological change in late industrializing economies and evidences from the cases of Brazil and South Korea. *Technological Forecasting and Social Change, 69*(7), 653-680. doi:DOI: 10.1016/S0040-1625(01)00167-6

Webster, E. (2004). Firms' decisions to innovate and innovation routines. *Economics of Innovation & New Technology, 13*(8), 733-745. doi:10.1080/10438590410001686824

Weerakkody, V., Dwivedi, Y. K., & Irani, Z. (2009). The diffusion and use of institutional theory: A cross-disciplinary longitudinal literature survey. *Journal of Information Technology (Palgrave Macmillan), 24*(4), 354-368.

Windrum, P. (2005). Heterogeneous preferences and new innovation cycles in mature industries: The amateur camera industry 1955-1974. *Industrial & Corporate Change, 14*(6), 1043-1074. doi:10.1093/icc/dth069

Zahra, S.A., Covin, J.G. (1994), The financial implications of fit between competitive strategy and innovation types and sources, *The Journal of High Technology Management Research*, *5*(2), 183-211

Zikmund, W. (2003) *Business Research Methods*. United States of America: South-Western Cengage Learning.

9. Appendix

Appendix 1: Software Questionnaire

C I R C L E

Insert logo of partner institution here

QUESTIONNAIRE FOR FIRMS

"INNOVATION-BASED STRATEGIES FOR GLOBALIZATION"

Questionnaire for "SOFTWARE"

(SOUTH AFRICA)

Person that makes the interview__________________________________

Date of the interview____

Project – South Africa SOFTWARE

I. COMPANY BACKGROUND

1. Company name ____________________

2. Is this unit....

☐ A single plant firm
☐ Part of an enterprise group[1] . If part of an enterprise group, this unit is
☐ The head office ☐ One of the subsidiaries
In which country is the head office of your group located?____________________

For companies that are part of an enterprise group, please answer all further questions only for this plant in South Africa. Do not include results from parent enterprises outside of South Africa. All questions refer to the year 2007.

3. Year of establishment in South Africa	
4. Location city of this unit	
5. Located in a special zone?[2]	
6. Web site	

7. Ownership

☐ Percentage of domestic capital _____%
☐ Percentage of foreign capital _____%

8. Number of employees (average full-time equivalent for 2007)

☐ 1-10 ☐ 50-99 ☐ 250-499 ☐ 1000-2499
☐ 10-49 ☐ 100-249 ☐ 500-999 ☐ More than 2500

9. Please indicate the total sales (in 2007)

Estimation of total sales in RAND ____________________

Or, alternatively[3]:

☐ Less than 2 million US$ ☐ Between 10-50 million US$ ☐ More than 100 million US$
☐ Between 2-10 million US$ ☐ Between 50-100 million US$

10. Please indicate the direct destination of your sales (percentage of sales in 2007). In case your products go to a domestic firm that will further export them to international markets please estimate the final destination (percentage of re-export in 2007)

Destination	% direct sales	% re-exports
Domestic market		
North America (US)		
Western Europe[4]		
Eastern Europe		
Asia		
Latin America		
Africa (except domestic)		
Other		

Please indicate the country of your unit's three top clients in terms of sales
1.
2.
3.

1

11. Origin of suppliers in the last year 2007 (percentages of purchases)

Origin	% purchases
Domestic market	
North America (US)	
Western Europe[5]	
Eastern Europe	
Asia	
Latin America	
Africa (except domestic)	
Other	

Please indicate the country of your unit's three top suppliers in terms of purchases
1.
2.
3.

12. Please indicate in which segment of the software industry you operate. Insert 1 beside the most important segment, 2 beside the second and 3 beside the third, etc.

a) By sub-industry (Segment)

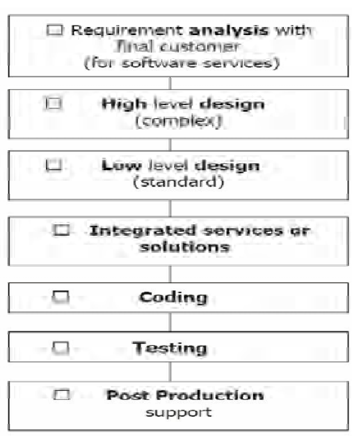
Rank	
	Packaged software
	Software services
	Embedded software
	Application software
	Other, specify____________

b) By the market the unit serves

Rank	
	Solutions to industry
	Entertainment and games
	Film animation
	Other, specify____________
	Other, specify____________

13. Please describe the highest value product, process or service of your firm (2007)[6]

14. In the software industry, which of these activities in the value chain did your unit perform in 2007? (check in the graph all that apply)



2

II. STRATEGY TO ACCESS LOCAL AND FOREIGN MARKETS

15. In case your unit is a subsidiary, what was the role of the unit in the global strategy of the multinational in 2007? (check all that apply)

☐ Access to low cost resources (land, labour)
☐ Access to South African market
☐ Access to third markets:
  ☐ Rest of Africa
  ☐ Other markets
☐ Other (please specify).........................

☐ Access to specialized resources (highly qualified personnel, research, etc)
☐ Access to specific suppliers

16. In case your unit used in 2007 any of the following strategies to access international or domestic markets, please indicate the degree of importance:

1. Extremely important
2. Important
3. Average
4. Not so important
5. Not relevant at all

Strategy	Domestic market	Rest of Africa	North America	EU countries	Asia	Latin America	Other
Quality							
Cost-based strategy							
Delivery time							
Innovative products/services							
After-sale services							
Flexibility							
Brand management							
Value chain management							
Other (fill in)							
Other (fill in)							

III. RESOURCES

17. a. Is your machinery and equipment behind or ahead the average of the industry in South Africa?

☐ Ahead ☐ Behind ☐ Average ☐ Not known

b. For how many years (ahead or behind)?

18. a. How many patents per employee had your unit in 2007? ____

18. b Of the total number of patents, what was the % of international patents?
____%

19. In 2007, what was the estimated proportion of employees in each of the following categories?

a. By position	**%**
Shop floor	
Supporting staff'	
Managers	

b. By education	**%**
No schooling or elementary school	
High school	
Technical education/training	
University degree	
Postgraduate studies	

3

20. a. What is the highest qualification of the CEO or top manager? Please indicate **ES** for Elementary School/ **HS** for high school/ **TE** for technical education/ **U** for university degree/ **PS** for post graduate studies

____

b. Where did he/she get the highest qualification? (university, master, PhD)
Please name institution and location. E.g. University of Pretoria, Pretoria

____

21. Does your unit have any of the following systems of production organization?

Quality control systems	☐ Yes	☐ No
Just in time	☐ Yes	☐ No
Continuous improvement	☐ Yes	☐ No
Quality circles, team work	☐ Yes	☐ No
Internal manuals	☐ Yes	☐ No
Other (please specify)	☐ Yes	☐ No

22. Does your unit have any quality certification? If so, which one and in which year was awarded?

☐ ISO, year _____
☐ Other, please specify__________________, year _____
☐ Other, please specify__________________, year _____

23. Do you have an R&D department?

☐ No ☐ Yes, how many employees in the R&D dept as a percentage of total staff?_____ %

IV. TYPE AND IMPORTANCE OF INNOVATION

Product innovation[8] and Process innovation[9]

	24. During 2007, did your unit introduce any of the following innovations? Mark with an X what corresponds. If the answer is Yes, please mark the degree of novelty	No	New to global market[10]	New to domestic market[11]	New to the firm[12]
Product	P1. New or significantly improved goods. (Exclude the simple resale of new goods purchased from other enterprises and changes of a solely aesthetic nature.)				
	P2. New or significantly improved services.				
Process	PR1. New or significantly improved methods of manufacturing or producing goods or services				
	PR2. New or significantly improved logistics, delivery or distribution methods for your inputs, goods or services				
	PR3. New or significantly improved supporting activities for your processes, such as maintenance systems or operations for purchasing, accounting, or computing				
Organnizational	O1.Marketing for innovative products or services: Activities for the market introduction of your new or significantly improved goods and services, including market research and launch advertising				
	O2. New business practices for organising work or procedures (i.e. supply chain management, business re-engineering, lean production, quality management, education/training systems, etc)				
	O3. New knowledge management systems to better use or exchange information, knowledge and skills within your enterprise or to collect and interpret information from outside your enterprise				
	O4. New methods of workplace organisation for distributing responsibilities and decision making (i.e. first use of team work, de-centralization, integration or de-integration of departments, etc)				
	O5. New methods of organising external relations with other firms or public institutions (i.e. first use of alliances, partnerships, outsourcing or sub-contracting, etc.)				

25. Who developed this product, process or organizational innovation? Please select the most appropriate option. Cross the box that is most appropriate

	Product	Process	Organiz.
Mainly your unit			
Mainly your enterprise group			
Your unit together with other companies. Please indicate the country(s) of origin of those companies..			
Your unit together with a university or research center			
Mainly other companies			
Mainly the university or the research centre			
Your unit in collaboration with a consultancy company			
Other (please specify)			

5

Innovation activities

26. **During 2007, for companies engaged in the following innovation activities, please indicate if it was locally, provincially, domestically and/or internationally.** If you did not, leave the box blank.	**Local**	**Provincial**	**Domestic**	**International**
Intramural R&D: Creative work undertaken within your enterprise to increase the stock of knowledge and its use to devise new and improved products and processes (including software development)				
Extramural R&D: Same activities as above, but performed by other companies (including other enterprises within your group) or by public or private research organisations and purchased by your enterprise				
Acquisition of machinery and equipment: Acquisition of advanced machinery, equipment and computer hardware or software to produce new or significantly improved products and processes				
Acquisition of other external knowledge: Purchase or licensing of patents and non-patented inventions, know-how, and other types of knowledge from other enterprises or organisations				
Training: Internal or external training for your personnel **specifically** for the development and/or introduction of new or significantly improved products and processes (that is, training related to new products or processes, not training in general)				

27. Indicate **how important product/process/organizational innovations are in pursuing all of your relevant business strategies (as selected in question 16).** Please indicate the degree of importance

1. Extremely important
2. Important
3. Average
4. Not so important
5. Not relevant at all

Strategy	Product innovation	Process innovation	Organizational
Quality			
Cost-based strategy			
Delivery time			
Innovative products/services			
After-sale services			
Flexibility			
Brand management			
Value chain management			
Other (fill in)			
Other (fill in)			

V. LINKAGES AND CHANNELS

Sources of technology and knowledge

28. Please indicate how important have been in the last three years these **local, provincial, domestic or international sources of technology & knowledge for your innovation products/processes.** Insert: 1. Extremely important 2. Important 3. Average 4. Not so important 5. Not relevant at all	**Importance**			
	Local	**Provincial**	**Domestic**	**International**
Employees (excluding returnees)				
South African returnees from abroad				
Recruitment of highly qualified personnel				
Suppliers of equipment and inputs				
Parent company (for subsidiaries)				
Licensing/patents				
Clients				
Competitors				
Consultancy companies				
Fairs, exhibitions, conferences or congresses				
Chambers of commerce and industry associations				
Academic publications				
Other publications (specialized journals, etc)				
Universities and Public research centers				
Financial entities				
Government[13]				
Other (please specify)				

Content of the collaboration

29. For companies that collaborated **with local, provincial, domestic or international universities** or research centers in 2007, how important are the following activities for your unit? Insert: 1. Extremely important 2. Important 3. Average 4. Not so important 5. Not relevant at all	**Importance**			
	Local	**Provincial**	**Domestic**	**International**
General training				
Company specific training				
Students specific placement				
Exchange programs with professors and other experts				
Collaborative research projects				
Technical assistance				
Recruitment of qualified human resources				
Curriculum alignment/design				
Licensing/patents				
Other (please specify)________				

30. For companies that benefited in 2007 from any the following supporting schemes to foster innovation or technology dissemination, please indicate the importance of that support for your company's innovation projects.

1. Extremely important
2. Important
3. Average
4. Not so important
5. Not relevant at all

	Supporting schemes from		
	From local government	From national government	International funding
Training			
Tax incentives			
Funds to develop new products			
Export support[14]			
Technology upgrading			
Information on technological opportunities			
Other (please specify)			

31. From whom do you get the technical specifications/other requirements to develop your product or provide your service?

☐ Specifications from the parent company (for subsidiaries)
☐ Specifications from the company that has subcontracted you
☐ Specifications from the final client
☐ Specifications from the supplier
☐ Own design
☐ Designed in cooperation with other companies
☐ Other (please specify)

32. For *subsidiaries/local companies*, which kind of technical assistance (TA) do you commonly receive from the parent company either in your country or abroad?
For *parent companies*, what kind of technical assistance do you commonly provide to the subsidiaries?

☐ TA related to product specifications
☐ TA related to process or organization
☐ Purchase of machinery and equipment
☐ TA related to quality control
☐ TA for market strategy
☐ Training of engineers and technicians
☐ TA for procurement of components and materials
☐ I do not receive any assistance
☐ I do not provide any assistance
☐ Other (please specify)..............

33. For companies that interacted in 2007 with other local, provincial, domestic or international firms, please indicate the importance of the transactions. Insert: 1. Extremely important 2. Important 3. Average 4. Not so important 5. Not relevant at all	**Importance**			
	Local	**Provincial**	**Domestic**	**International**
We buy inputs from them				
We acquire machinery from them				
We outsource part of our production				
We sell our products to them (we provide intermediate inputs)				
We collaborate for the creation of common strategies				
Other________________				

34. a. What kind of **products or services do you buy from local firms?** **b.** If none, please explain why

35. a. What kind of **products or services do you outsource to local firms?** **b.** If none, please explain why

THANK YOU VERY MUCH FOR YOUR PARTICIPATION. WE ARE VERY GRATEFUL!

Person we should contact if there are any queries regarding the form (please fill the form or attach business card):

Name: ______________________________
Job title: ______________________________
Organisation: ______________________________
Phone: ______________________________
Fax: ______________________________
E-mail: ______________________________

[1] A group consists of two or more legally defined enterprises under common ownership. Each enterprise in the group may serve different markets, as with national or regional subsidiaries, or serve different product markets. The head office is also part of an enterprise group.
[2] Indicate if it is a Science Park, Technology Park, Special tax zone, etc.
[3] Rand should be converted in US dollar on the basis of 31st December 2007 rate.
[4] Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Italy, Ireland, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovenia, Slovakia, Switzerland, Turkey, Spain, Sweden and the United Kingdom.

Appendix 2 : Automotive Questionnaire

CIRCLE

Insert logo of partner institution here

QUESTIONNAIRE FOR FIRMS

"INNOVATION-BASED STRATEGIES FOR GLOBALIZATION"

Questionnaire for "AUTOMOTIVE COMPONENT"

(SOUTH AFRICA)

Person that makes the interview________________________________

Date of the interview____

I. COMPANY BACKGROUND

1. Company name ____________________

2. Is this unit....

☐ A single plant firm
☐ Part of an enterprise group[1] . If part of an enterprise group, this unit is
☐ The head office ☐ One of the subsidiaries
In which country is the head office of your group located?_______________

For companies that are part of an enterprise group, please answer all further questions <u>only</u> for this plant in South Africa. Do not include results from parent enterprises outside of South Africa. All questions refer to the year 2007.

3. Year of establishment in South Africa
4. Location city of this unit
5. Located in a special zone?[2]
6. Web site

7. Ownership

☐ Percentage of domestic capital _____%
☐ Percentage of foreign capital _____%

8. Number of employees (average full-time equivalent for 2007)

☐ 1-10 ☐ 50-99 ☐ 250-499 ☐ 1000-2499
☐ 10-49 ☐ 100-249 ☐ 500-999 ☐ More than 2500

9. a. Please indicate the total sales (in 2007)

☐ Estimation of total sales in RAND _________________ Or, alternatively[3]:

☐ Less than 2 million US$ ☐ Between 10-50 million US$ ☐ More than 100 million US$
☐ Between 2-10 million US$ ☐ Between 50-100 million US$

9. b. For companies that produce components for other industries, please estimate what percentage of your total sales goes to the automotive industry

☐ Percentage on total sales _____%

10. Please indicate the direct destination of your sales (percentage of sales in 2007). In case your products go to a domestic firm that will further export them to international markets please estimate the final destination (percentage of re-export in 2007)

Destination	% direct sales	% re-exports
Domestic market		
North America (US)		
Western Europe[4]		
Eastern Europe		
Asia		
Latin America		
Africa (except domestic)		
Other		

Please indicate the country of your unit's three top clients in terms of sales
1.
2.
3.

1

11. Origin of suppliers in the last year 2007 (percentages of purchases)

Origin	% purchases
Domestic market	
North America (US)	
Western Europe[5]	
Eastern Europe	
Asia	
Latin America	
Africa (except domestic)	
Other	

Please indicate the country of your unit's three top suppliers in terms of purchases
1.
2.
3.

12. Please indicate in which segment in the automotive industry you supply your main product. Insert 1 beside the most important segment, 2 beside the second and 3 beside the third, etc.

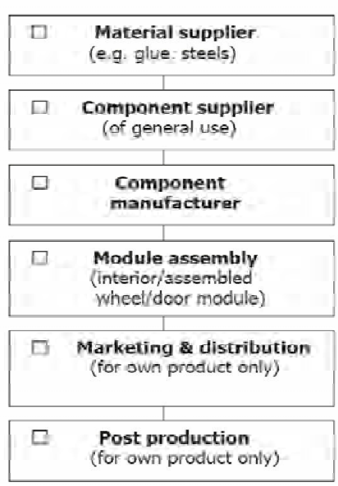
Rank	**Light vehicles**
	Passenger cars
	Commercial vehicles

Rank	**High commercial vehicles**
	Medium-heavy commercial vehicles
	Heavy trucks
	Buses and coaches

13. Please describe the highest value product, process or activity of your firm (2007)[6]

14.a. In the automotive component industry, which of these activities in the value chain did your unit perform in 2007? (check in the graph all that apply)

Graph I: AUTOMOTIVE COMPONENT INDUSTRY VALUE CHAIN



2

14.b. As a supplier of automotive components, please indicate if you are:
☐ First tier supplier ☐ Second tier supplier ☐ Third tier supplier ☐ Other ____________

II. STRATEGY TO ACCESS LOCAL AND FOREIGN MARKETS

15. In case your unit is a subsidiary, what was the role of the unit in the global strategy of the multinational in 2007? (check all that apply)

☐ Access to low cost resources (land, labour)
☐ Access to South African market
☐ Access to third markets:
  ☐ Rest of Africa
  ☐ Other markets
☐ Other (please specify)..........................
☐ Access to specialized resources (highly qualified personnel, research, etc)
☐ Access to specific suppliers

16. In case your unit used in 2007 any of the following strategies to access international or domestic markets, please indicate the degree of importance:

1. Extremely important
2. Important
3. Average
4. Not so important
5. Not relevant at all

Strategy	Domestic market	Rest of Africa	North America	EU countries	Asia	Latin America	Other
Quality							
Cost-based strategy							
Delivery time							
Innovative products/services							
After-sale services							
Flexibility							
Brand management							
Value chain management							
Other (fill in)							
Other (fill in)							

III. RESOURCES

17. a. Is your machinery and equipment behind or ahead the average of the industry in South Africa?

☐ Ahead ☐ Behind ☐ Average ☐ Not known

b. For how many years (ahead or behind)? ____

18. a. How many patents per employee had your unit in 2007? ____

18. b. Of the total number of patents, what was the % of international patents? ____%

19. In 2007, what was the estimated proportion of employees in each of the following categories?

a. By position	%
Shop floor	
Supporting staff[7]	
Managers	

b. By education	%
No schooling or elementary school	
High school	
Technical education/training	
University degree	
Postgraduate studies	

20. a. What is the highest qualification of the CEO or top manager? Please indicate **ES** for Elementary School/ **HS** for high school/ **TE** for technical education/ **U** for university degree/ **PS** for post graduate studies

____

b. Where did he/she get the highest qualification? (university, master, PhD) Please name institution and location. E.g. University of Pretoria, Pretoria

____

21. Does your unit have any of the following systems of production organization?

Quality control systems	☐ Yes	☐ No
Just in time	☐ Yes	☐ No
Continuous improvement	☐ Yes	☐ No
Quality circles, team work	☐ Yes	☐ No
Internal manuals	☐ Yes	☐ No
Other (please specify)	☐ Yes	☐ No

22. Does your unit have any quality certification? If so, which one and in which year was awarded?

☐ ISO, year _____ ☐ QS (automotive), year _____ ☐ CMM (Software), year ______

23. Do you have an R&D department?

☐ No ☐ Yes, how many employees in the R&D dept as a percentage of total staff?_____ %

IV. TYPE AND IMPORTANCE OF INNOVATION

Product innovation[8] and Process innovation[9]

	24. During 2007, did your unit introduce any of the following innovations? Mark with an X what corresponds. If the answer is Yes, please mark the degree of novelty	No	New to global market[10]	New to domestic market[11]	New to the firm[12]
Product	P1. New or significantly improved goods. (Exclude the simple resale of new goods purchased from other enterprises and changes of a solely aesthetic nature.)				
	P2. New or significantly improved services.				
Process	PR1. New or significantly improved methods of manufacturing or producing goods or services				
	PR2. New or significantly improved logistics, delivery or distribution methods for your inputs, goods or services				
	PR3. New or significantly improved supporting activities for your processes, such as maintenance systems or operations for purchasing, accounting, or computing				
Organnizational	O1.Marketing for innovative products or services: Activities for the market introduction of your new or significantly improved goods and services, including market research and launch advertising				
	O2. New business practices for organising work or procedures (i.e. supply chain management, business re-engineering, lean production, quality management, education/training systems, etc)				
	O3. New knowledge management systems to better use or exchange information, knowledge and skills within your enterprise or to collect and interpret information from outside your enterprise				
	O4. New methods of workplace organisation for distributing responsibilities and decision making (i.e. first use of team work, de-centralization, integration or de-integration of departments, etc)				
	O5. New methods of organising external relations with other firms or public institutions (i.e. first use of alliances, partnerships, outsourcing or sub-contracting, etc.)				

25. Who developed this product, process or organizational innovation? Please select the most appropriate option. Cross the box that is most appropriate

	Product	Process	Organiz.
Mainly your unit			
Mainly your enterprise group			
Your unit together with other companies. Please indicate the country(s) of origin of those companies..			
Your unit together with a university or research center			
Mainly other companies			
Mainly the university or the research centre			
Your unit in collaboration with a consultancy company			
Other (please specify)			

Innovation activities

26. During 2007, for companies engaged in the following innovation activities, please indicate if it was locally, provincially, domestically and/or internationally. If you did not, leave the box blank.	**Local**	**Provincial**	**Domestic**	**International**
Intramural R&D: Creative work undertaken within your enterprise to increase the stock of knowledge and its use to devise new and improved products and processes (including software development)				
Extramural R&D: Same activities as above, but performed by other companies (including other enterprises within your group) or by public or private research organisations and purchased by your enterprise				
Acquisition of machinery and equipment: Acquisition of advanced machinery, equipment and computer hardware or software to produce new or significantly improved products and processes				
Acquisition of other external knowledge: Purchase or licensing of patents and non-patented inventions, know-how, and other types of knowledge from other enterprises or organisations				
Training: Internal or external training for your personnel **specifically** for the development and/or introduction of new or significantly improved products and processes (that is, training related to new products or processes, not training in general)				

27. Indicate **how important product/process/organizational innovations are in pursuing all of your relevant business strategies (as selected in question 16).** Please indicate the degree of importance

1. Extremely important
2. Important
3. Average
4. Not so important
5. Not relevant at all

Strategy	Product innovation	Process innovation	Organizational
Quality			
Cost-based strategy			
Delivery time			
Innovative products/services			
After-sale services			
Flexibility			
Brand management			
Value chain management			
Other (fill in)			
Other (fill in)			

V. LINKAGES AND CHANNELS

Sources of technology and knowledge

28. Please indicate how important have been in the last three years these **local, provincial, domestic or international sources of technology & knowledge for your innovation products/processes.** Insert: 1. Extremely important 2. Important 3. Average 4. Not so important 5. Not relevant at all	**Importance**			
	Local	**Provincial**	**Domestic**	**International**
Employees (excluding returnees)				
South African returnees from abroad				
Recruitment of highly qualified personnel				
Suppliers of equipment and inputs				
Parent company (for subsidiaries)				
Licensing/patents				
Clients				
Competitors				
Consultancy companies				
Fairs, exhibitions, conferences or congresses				
Chambers of commerce and industry associations				
Academic publications				
Other publications (specialized journals, etc)				
Universities and Public research centers				
Financial entities				
Government[13]				
Other (please specify)				

Content of the collaboration

29. For companies that collaborated **with local, provincial, domestic or international universities** or research centers in 2007, how important are the following activities for your unit? Insert: 1. Extremely important 2. Important 3. Average 4. Not so important 5. Not relevant at all	**Importance**			
	Local	**Provincial**	**Domestic**	**International**
General training				
Company specific training				
Students work placement				
Exchange programs with professors and other experts				
Collaborative research projects				
Technical assistance				
Recruitment of qualified human resources				
Curriculum alignment/design				
Licensing/patents				
Other (please specify)____________				

30. For companies that benefited in 2007 from any of the following supporting schemes to foster innovation or technology dissemination, please indicate the importance of that support for your company's innovation projects.

1. Extremely important
2. Important
3. Average
4. Not so important
5. Not relevant at all

	Supporting schemes from		
	From local government	From national government	International funding
Training			
Tax incentives			
Funds to develop new products			
Export support[14]			
Technology upgrading			
Information on technological opportunities			
Other (please specify)			

31. From whom do you get the main technical specifications/other requirements to assemble or manufacture your product or provide your service?

☐ Specifications from the parent company (for subsidiaries)
☐ Specifications from the company that has subcontracted you
☐ Specifications from the final client
☐ Specifications from the supplier
☐ Own design
☐ Designed in cooperation with other companies
☐ Other (please specify)

32. For *subsidiaries/local companies*, which kind of technical assistance (TA) do you commonly receive from the parent company either in your country or abroad?

For *parent companies*, what kind of technical assistance do you commonly provide to the subsidiaries?

☐ TA related to product specifications
☐ TA related to process or organization
☐ Purchase of machinery and equipment
☐ TA related to quality control
☐ TA for market strategy
☐ Training of engineers and technicians
☐ TA for procurement of components and materials
☐ I do not receive any assistance
☐ I do not provide any assistance
☐ Other (please specify)...............

33. For companies that interacted in 2007 with other local, provincial, domestic or international firms, please indicate the importance of the transactions. Insert: 1. Extremely important 2. Important 3. Average 4. Not so important 5. Not relevant at all	**Importance**			
	Local	**Provincial**	**Domestic**	**International**
We buy inputs from them				
We acquire machinery from them				
We outsource part of our production				
We sell our products to them (we provide intermediate inputs)				
We collaborate for the creation of common strategies				
Other_______________				

8

34. a. What kind of **products or services do you buy from local firms? b.** If none, please explain why

35. a. What kind of **products or services do you outsource to local firms? b.** If none, please explain why

THANK YOU VERY MUCH FOR YOUR PARTICIPATION. WE ARE VERY GRATEFUL!

Person we should contact if there are any queries regarding the form (please fill the form or attach business card):

Name: ______________________________
Job title: ______________________________
Organisation: ______________________________
Phone: ______________________________
Fax: ______________________________
E-mail: ______________________________

[1] A group consists of two or more legally defined enterprises under common ownership. Each enterprise in the group may serve different markets, as with national or regional subsidiaries, or serve different product markets. The head office is also part of an enterprise group.
[2] Indicate if it is a Science Park, Technology Park, Special tax zone, etc.
[3] Rand should be converted in US dollar on the basis of 31st December 2007 rate.
[4] Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Italy, Ireland, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovenia, Slovakia, Switzerland, Turkey, Spain, Sweden and the United Kingdom.
[5] Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Italy, Ireland, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovenia, Slovakia, Switzerland, Turkey, Spain, Sweden and the United Kingdom.

Appendix 3: Consistency Matrix

Hypotheses	Literature Review	Data Collection Tool	Analysis
Hypothesis 1 The innovativeness in firms belonging to an emerging industry is greater than those belonging to a mature industry.	Argyres & Bigelow (2007) Barras (1990) Chaminade *et al*. (2009) D'costa (2006) Klepper(1996) Lundvall(2007) McGahan & Silverman (2001)	Questions 24.1-24.4	T-tests were done on aggregated indices to find the difference of average total innovativeness between the two industries.
Sub-Hypotheses 1a and 1b **1a:**The product innovativeness in firms belonging to an emerging industry is greater than those in a mature industry. **1b**:The process innovativeness in firms belonging to a mature industry is greater than those in an emerging industry.	Argyres & Bigelow (2007) Barnard *et al*.(2009) Barras (1990) Chaminde & Vang (2008) McGahan & Silverman (2001) Windrum(2005)	Questions 24.1 and 24.2 Questions 24.3 and 24.4	Chi-square tests were done to test for differences in terms of various types of product and process innovativeness between the two industries. T-tests were done on aggregated indices to find the difference of average product and process innovativeness between the two industries.

Hypotheses	Literature Review	Data Collection Tool	Analysis
Hypothesis 2 The governmental support to foster innovation is higher in firms belonging to a mature industry than those in an emerging industry	Ashiem *et al. (* 2003) Chaminade & Vang (2008) Fagerberg and Srholec (2009) Galli & Teubal (1997) Rooks & Oerlemans (2005)	Questions 30.1-30.5	T-tests were done on aggregated indices to find the difference of average total government support between the two industries.
Sub-Hypotheses 2a and 2b **2a:**The local governmental support for firms belonging to an emerging industry is greater than those in a mature industry. **2b**:The national governmental support for firms belonging to a mature industry is greater than those in an emerging industry.	Ashiem *et al. (* 2003) Chaminade & Vang (2008) Fagerberg and Srholec (2009) Galli & Teubal (1997) Rooks & Oerlemans (2005)	Questions 30.1 -30.5 (coded value=0) Questions 30.1 -30.5 (coded value=1)	Chi-square tests were done to test for differences in terms of various types of local and national government support towards the two industries. T-tests were done on aggregated indices to find the difference of average local and national government support towards the two industries.

Hypotheses	Literature Review	Data Collection Tool	Analysis
Hypothesis 3 The innovations based on internal-to-firm knowledge are higher in firms belonging to an emerging industry as compared to those in a mature industry.	Audretsch (1998) Audretch and Feldman (1996) Chaminade *et al*. (2009) Edquist (2001) Edquist (2004) Lundvall (2007) Rooks & Oerlemans (2005) Schoser (1999)	Question 25	Chi-square tests were done to test for differences in terms of innovations based internal to firms between the two industries.
Hypotheses 4a and 4b **4a:**The innovation based on local activities in firms belonging to an emerging industry is greater than those in a mature industry. 4**b**:The innovation based on international activities in firms belonging to a mature industry is greater than those in an emerging industry.	Ashiem *et al.* (2003) Chaminade *et al*. (2009) Coenen and Moodysson (2009) Edquist (2001) Edquist (2004) Marin & Arza (2009) Rooks & Oerlemans (2005)	Questions 26.1 -26.5 (coded value=1) Questions 26.1 -26.5 (coded value=3)	Chi-square tests were done to test for differences in terms of various types of local and international innovation activities between the two industries. T-tests were done on aggregated indices to find the difference of average local and international innovation activities between the two industries.