THE INFLUENCE OF SUPPLY CHAIN SOURCES OF TECHNOLOGY AND KNOWLEDGE ON INNOVATION IN DEVELOPING COUNTRY AUTOMOTIVE COMPONENT MANUFACTURING

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ABSTRACT

This study seeks to establish the influence that supply chain sources of knowledge have on innovation within developing country automotive component manufacturing. Innovation research indicates that most firms learn from external parties as part of their innovation initiatives. Learning occurs due to knowledge deficits resulting from an elevated level of innovation the firm is aiming to achieve or uncertainty facing the firm, whilst an important source of learning is from within the supply chain viz. suppliers, competitors and clients. Understanding these relationships can significantly increase the chances of innovation and could assist policymakers in improving the effectiveness of innovation support schemes.

Data from a 2009 study was used, where semi-structured interviews were held with automotive component manufacturers in the Pune area in India, Beijing area in China and in South Africa. An updated survey was conducted with manufacturers in the Durban area. The hypotheses were tested using chi-squared testing to establish association and multinomial logistic regression analysis to determine correlation. The differences between the three regions are discussed as a guide to firms, particularly in South Africa and other lesser developed economies, on what can be learnt from successes of firms in the automotive component manufacturing sector in more advanced developing countries. Statistical analysis of the secondary data corroborates four of the proposed hypotheses for at least one country, illustrating that the supply chain sources of technology and knowledge do indeed have some influence on innovation.

Key words: Innovation, Innovation process, Supply chain learning, Automotive component manufacturing.

INTRODUCTION

Innovation has received much attention in recent times and the processes related to achieving innovation has seen growing interest from the scientific community since the 1970's (Utterback, 1974; Von Hippel, 1988). Firms are innovating intensively to improve their competitiveness by decreasing their time to market and differentiating their products or services, granting them access to new markets and the ability to achieve a higher perceived value for their customers. This has become even more important since the dawn of the knowledge economy. The driving force behind this knowledge economy is innovation and the networks in which it pervades (Dutta, 2013).

Recent studies have determined that most firms that innovate collaborate with external parties (Amara & Landry, 2005; Fritsch & Lukas, 2001; Tether, 2002). This concept is referred to as the innovation/collaborative network. Tether (2002) highlights that in today's market, companies cannot innovate in isolation but instead must draw on information within its networks to innovate. Technological innovations are becoming increasingly complex and costly, leading companies to diversify the associated risks (Fritsch & Lukas, 2001). Therefore, companies seeking to innovate in their products or processes are more likely to source knowledge externally (Fritsch & Lukas, 2001; Tether, 2002) whilst those seeking a higher degree of novelty of innovation are more likely to have a wider network of external knowledge sources from which to draw (Amara & Landry, 2005; Nieto & Santamaría, 2007)

Innovation and learning

Innovation has historically been thought of as a linear process, i.e.: from the Research and Development (R&D) lab to production to market. However, Kline and Rosenberg (1986) contend that innovation need not only be confined to internal R&D units, rather it incorporates interactive relationships amongst different parties within the firm's operating environment. Innovation is also characterised by the process of learning which is in turn determined by the absorptive capacity of companies (Cohen & Levinthal, 1990). Absorptive capacity refers to the firm's ability to value new, externally sourced knowledge, assimilate it on multiple levels of the organisation's structure and apply it for its economic benefit. It is highly dependent on the firm's prior knowledge, be it a common language or skills to the most recent scientific and technological developments in the relevant arena. Nonetheless, learning can occur from internal or external sources and forms a critical part of technical competencies (Cetindamar et al., 2010). Moreover, innovations are not governed by isolated instances of learning but rather by social processes of exchange in a knowledge generating systems, referred to as innovation systems or clusters (Cooke, 2001; Lorentzen & Barnes, 2004; Lundvall, 1988; Roper et al., 2006)

Novelty of innovation and knowledge deficits

As innovation has become the norm rather than the exception, shifting market focus to what is the degree of novelty of the innovation (Amara & Landry, 2005). Amara et al. (2008) mention that innovation and degree of novelty of innovations are linked to four categories of knowledge deficits:

i. Technological uncertainty indicates deficit in product development or production process knowledge.

ii. Technical inexperience indicates deficit in required skills and equipment for product development or production process.

iii. Business inexperience indicates deficit in business practices/organisational processes.

iv. Technology costs indicates deficit in required investment for acquisition of knowledge embodied in equipment.

Improving the ability to learn enables the firm to achieve higher levels of novelty of innovation in their products and processes (Amara et al., 2008). In the context of innovation, learning is defined as: "the acquisition and use of existing knowledge and/or the creation of new knowledge with the purpose of improving economic performance." (Boerner et al., 2001). In this process of learning,

companies form formal and informal linkages with clients, suppliers, industry associations, research organisations and governmental agencies. These collaborations provide access to knowledge that would otherwise not have been available, improving its access to information about markets, technologies, technical assistance research and technical knowledge. Amara and Landry (2005) also found that the degree of novelty of innovation is directly dependant on a larger variety of interaction sources. In this regard (Tether, 2002) states that amongst the sample of surveyed firms in the UK: *"*Suppliers and customers were the most widely engaged co-operation partners, but significant proportions also engaged competitors,".

Developing Country Automotive Manufacturing

Its mature supply chain relationships in the automotive manufacturing industry in developed economies create both opportunities and challenges for suppliers in developing countries. Automotive component manufacturers and policy makers in developing countries need to understand how supply chain knowledge sourcing influence resultant innovation in the context of their economic environment. The automotive industry also represents a significant proportion of the manufacturing sector, contributing nearly 7% to the South African (NAAMSA, 2012) and Indian GDP (Klink et al., 2013), with similar percentages for total national employment. China recently became the world's largest manufacturer of automobiles (OICA, 2013) making it the most significant automotive manufacturing industry in the world.

South Africa's automotive industry can historically be seen in two distinct phases with the second, current phase following on the advent of democracy in 1994. This resulted in opening of international trade opportunities and the 1995 introduction of the Motor Industry Development Plan (MIDP). Prior to the transition, the Apartheid government protected the local industry with high import tariffs, as much as 115%, to ensure sheltered growth and almost exclusive supply to the domestic market (Lorentzen et al., 2005). Domestic manufacturers produced substandard vehicles in a variety of models that reached some 300 000 – 350 000 units in the early 1990s (Lorentzen & Barnes, 2004). This approach meant that although the industry was quite profitable (due to the anti-competitive market), South African manufacturers were inefficient and technologically stagnant, missing out on operational revolutions that occurred in the 1970s and 1980s such as lean manufacturing (Stijger, 2009). With the introduction of the democratic government and its new market liberalisation strategy, the MIDP sought to increase the international competitiveness of the industry by reducing import tariffs and shifting focus to export production (Lorentzen et al., 2005). It did so by encouraging Original Equipment Manufacturers (OEM) to invest in South Africa and integrate their domestic operations into their global supply chains. The MIDP, along with the export and productivity success, also meant that smaller firms had to either align themselves with these global supply chains or risk irrelevance (Lorentzen & Barnes, 2004). Multinational OEMs now dominate the local manufacturing scene, with design and innovation often located outside of the country. Due to the advent of global design standards and vehicle platforms, these OEMs would rather source components from local subsidiaries of multinational component manufacturers with whom they have existing relationships and partnerships with in their home countries (Lorentzen & Barnes, 2004). Therefore, firms in developing countries are likely to lose their design and engineering capabilities resulting in a dearth of locally based innovations.

In East Asia stiff competition was enforced amongst local producers even though the fledgling manufacturing base was protected against import competition (Lorentzen & Barnes, 2004). In the Pune region, there are Indian OEMs such as Mahindra and Tata Motors along with subsidiaries of multinational OEMs like Volkswagen and General Motors. Here the focus of the Indian OEMs is to design and develop vehicles for the domestic and emerging markets differing from South Africa's foreign owned OEMs producing vehicles aimed primarily at industrialised nations' markets. This alone would suggest that the potential for innovation would be higher amongst Indian manufacturers as compared to those in South Africa. In fact, Sutton (2004) observed that in response to the challenge of competition from international manufacturers, domestic manufacturers in India raised their productivity and quality. Other factors that facilitated innovation included cost competition and environmental legislation for fuel efficiencies and pollution emissions (Vermaak & Steyn, 2013). With a liberalised market and favourable policy regime in India, many of the major international component manufacturers have manufacturing operations there.

China, in the meanwhile has rapidly become the largest automotive manufacturing country seeing very high growth over the last 25 years. Sutton (2004) reports that in 1991 China produced 81 000 vehicles and by 2013, was the largest automotive manufacturer in the world producing more than 18 million passenger vehicles. Although the Chinese auto industry is highly fragmented with more than 100 manufacturers, just five major manufacturers dominate and account for more than 70% of the market (Sardy & Fetscherin, 2009). All five manufacturers have joint ventures with other multinational OEMs. China's production explosion can be attributed to the change in policy from a protectionist regime to a more liberalised regime after joining the World Trade Organisation (WTO) in 2002. The new strategy had done away with local content regulations, forcing Chinese component manufacturers to become more competitive and much like the South African case, join the global value chain, or risk irrelevance. However, Holweg et al. (2009) state that even though component manufacturers have become more globally competitive (mainly through reduced costs, while quality still lags the more established nations), they still lack product development capabilities, buying in their product development designs.

Research Objectives

The objective of the research is to determine the influence sources of knowledge and information that firms use from their supply chains and assess the impact these sources have on innovation within the developing country and newly developed country context. The differences between the three regions are discussed as a guide to firms, particularly in South Africa and other lesser developed economies, on what can be learnt from successes of firms in the automotive component manufacturing sector in more advanced developing countries. Understanding these relationships should assist in the management of innovation in firms and could assist policymakers in improving the effectiveness of innovation support schemes. Knowing where to find the right technology and knowledge should increase the chances of a successful innovation. Research questions arising from the literature on sources and effect of knowledge are:

i. What type of knowledge is sourced from suppliers and for what purpose?

ii. What type of knowledge is sourced from clients and for what purpose?

iii. What type of knowledge is sourced from competitors and for what purpose?

CONCEPTUAL FRAMEWORK

Theories of innovation

The idea of innovation has evolved from linear problem solving (Katila & Ahuja, 2002), to an interactive definition (Kline & Rosenberg, 1986), to one that incorporates learning (Lundvall, 1988; Von Hippel, 1988) and finally to a process that encompasses a knowledge generating system (Cooke, 2001).

The above four idea categories have heavily influenced the four common theories of innovation. These four theories stem from the knowledge bases that are deemed important viz. knowledge-based innovations derived from science, market participant linkages, technological networks and social networks (Amara & Landry, 2005). The first is the linear *'engineering theory'* of innovation. This is the more traditional idea of innovation where R&D is the primary source of new knowledge. However, innovation does not occur through R&D alone (Kline & Rosenberg, 1986), but rather also through the process of external learning. Nonetheless, having an internal R&D unit enhances the absorptive capacity or the ability to learn from external sources (Cohen & Levinthal, 1990). Secondly, the '*inter-firm network theory'* of innovation, considers the role of external sources of information specifically from users or clients (Von Hippel, 1986) and suppliers. The third theory highlights the '*technological network'* where innovation is facilitated through strategic alliances, collaborative R&D arrangements and consortia with competitors. The theorists include organised systems of innovation under this category (Cooke, 2001). Finally, the '*social network theory'* on innovation includes the additional insight that knowledge plays a critical role in the development of innovations (Amara & Landry, 2005). Firms are required to invest in the formation of these networks to build up their social capital (Dodgson et al., 2008).

All of the above theories entail learning in some form or the other, which occurs as a result of knowledge deficits that the firms are presented with. The deficits are a strategic consequence of the degree of novelty of innovation that the firm is aiming to achieve. Dodgson et al. (2008) aptly state "the greater uncertainties facing firms, the greater will be the need for learning." From a supply chain perspective, learning primarily occurs in the 'learning by interacting' mode (Amara et al., 2008).

Supply chain learning

Tether (2002) notes that: "Suppliers and customers were the most widely engaged co-operation partners, but significant proportions also engaged competitors," with regard to co-operation arrangements for innovation. These interactions have a number of advantages in that they improve market access information, technologies, technical assistance, research and technical knowledge.

Knowledge sourcing from users/clients

The importance of caucusing customers within the innovation process cannot be understated. Reducing the risk of failed market introduction and defining the scope of the innovation has been highlighted as motives for involving customers since the 1970's (Utterback, 1974). Fritsch and Lukas (2001) found in their study of German manufacturers that the most common type of knowledge sourcing for innovation occurred from customers. The same authors also state that client collaboration is associated with product related innovation activities whilst other studies have found

that those firms aiming at a higher degree of novelty of innovation (new to market/world) frequently use clients as sources of information (Amara & Landry, 2005; Tether, 2002) since market acceptance tends to be more conservative with regard to radical innovations. Roper et al. (2006) findings suggest that forward knowledge sourcing, with reference to customers, had a positive influence on product innovation and innovation success increasing the probability of each by approximately 11%. Further reasons include reducing the risk associated with high cost of innovation. Since the technology is new, firms can in effect include customers to reduce the market exposure (Tether, 2002).

Knowledge sourcing from suppliers

The relationship with suppliers have been widely scrutinised within the strategic 'make-or-buy' debate. Incidentally, innovation with suppliers drew special attention during the 1980's out of success in the Japanese automotive industry (Tether, 2002). Fritsch and Lukas (2001) and Tether (2002) concur that firms whose innovation efforts are aimed at cost reduction in their processes are not likely to have collaborated with any partners, except with suppliers. Research studies from Europe also suggest that suppliers were sources of technology and know-how (process) and had a positive influence on innovation (Tödtling et al., 2009). Dodgson et al. (2008) refer to many other studies that have found that process innovators specifically draw knowledge from suppliers. Interestingly, Tether (2002) claims that for the development of non-standard technologies, firms are most likely to collaborate with suppliers due to the high risk and significant information flow associated with them. The non-standard technology developments relate directly to high levels of technology acquisition and expenditure on machinery, equipment and other technologies. Firms will work closely with suppliers in order to understand and utilize the full potential of new technologies (Dodgson et al., 2008).

Knowledge sourcing from competitors

Competitors mostly co-operate when innovations related to their competitive advantages are not at stake. Tether (2002) notes that competitors will cooperate for standard setting where both firms and the market in general may benefit, or to learn more about their competitors' competencies by cooperating in non-competing markets and competencies and lastly, when they face a common problem for example, to innovate in response to regulatory changes within their operating environment. Firms will also cooperate with competitors to reduce the risk associated with high cost of innovation owing to new technology and greater resource requirements (Tether, 2002). Incidentally, low-technology firms were found to be more likely to collaborate with competitors indicating that the knowledge sourcing is more process based (Tether, 2002). A local study found that most of the innovations in South Africa were imitations (Knoben & Oerlemans, 2010). Tether (2002, p. 948) also found similar results in the UK where most innovations where imitations 'new to firm'.

Conceptual model

Innovation strategy

Innovation is shaped by the strategy that the firm adopts, together with its enabling factors. The risk appetite is governed by the extent to which its innovation strategy creates knowledge deficits. In other words, the more ambitious a firm is with its strategy, pushing its limits of resources and skills to execute the strategy, the greater the risk incurred (and potential for innovation). The business strategy would identify key technologies and markets that management believe would represent the best value for the firm. It is proposed that the strategy a firm pursues influences the sources of technology and knowledge that a firm accesses in order to bridge the deficit/s it perceives. For example, those firms seeking a reduction of costs of manufacturing and production would likely collaborate with their suppliers. Similarly, those seeking new products or services would most probably engage users/clients in their development process.

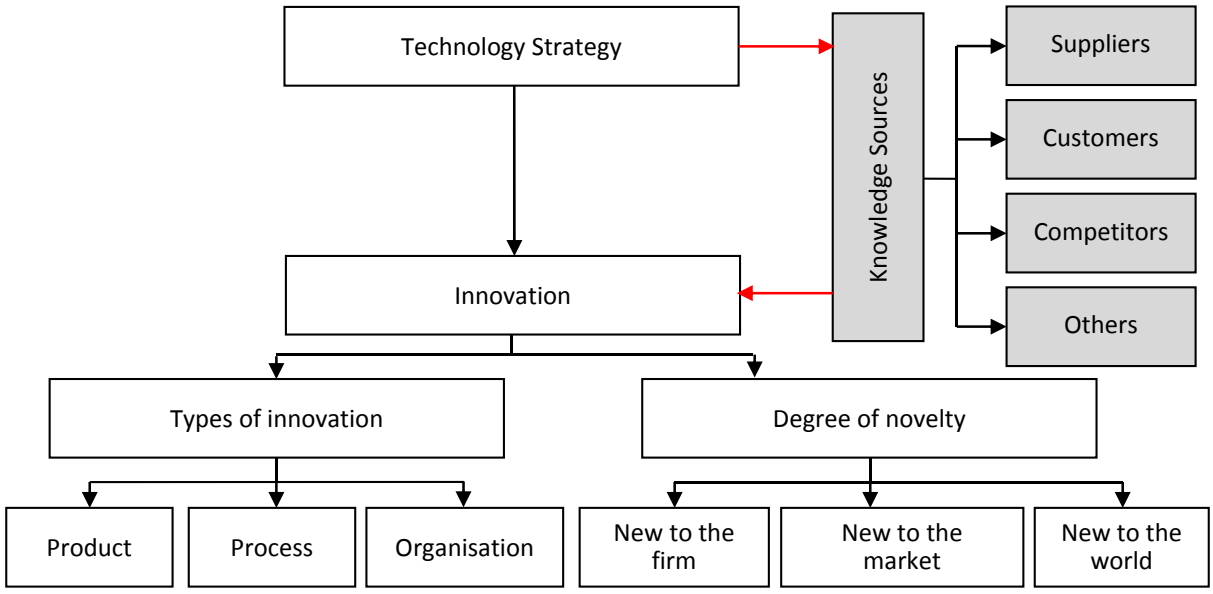

Figure 1: Proposed conceptual framework

Innovation classification

The degree of novelty of innovation refers to newness or impact of innovation. Degree of novelty of innovation is generally typified in two ways, in market terms and by technical variables. How new an innovation is and being able to increase this, is considered more important than if a company is innovating or not, as the degree of novelty of innovation determines the competitive advantage and market attention that a company could achieve (Amara et al., 2008). In market terms the first definition and most impactful is a 'new to the world' innovation, which is an innovation that is first on the market at a global level. The second is 'new to the market/country' where a company would have beaten its competitors and other companies in the introduction of an innovation in a particular market. The last and probably least impactful is 'new to the firm', which is a development that exists in the market but is introduced into the company for the first time. The technical variables used to categorise innovation are product or process innovations. Organisational innovation is added referring to innovation within management or organisational practices of the firm.

Methods

The conceptual method uses knowledge sources as independent variables viz. suppliers, clients and competitors whilst dependant variables are type of innovation and degree of novelty of innovation, since the study is seeking to establish the influence of these supply chain sources of knowledge on innovation. The hypotheses derived to assess the research problem are listed below:

H1. Knowledge sourcing from suppliers is associated with acquisition of machinery and equipment as innovation activity and transactions.

H2. The more knowledge is sourced from clients the more innovation is new to the market.

H3. The more knowledge is sourced from competitors, the more innovation is new to the firm.

H4. The more knowledge is sourced from clients, the more innovation is in product or service.

H5. The more knowledge is sourced from competitors, the more innovation is new manufacturing methods.

H6. The more knowledge is sourced from suppliers, the more innovation is new manufacturing methods.

RESEARCH METHODOLOGY

The analysis consisted of two parts, viz. quantitative and qualitative. The quantitative research used the data collected in a 2009 survey, which was part of an international research project with universities and researchers in the EU and some of the most important developing economies in the world. The survey employed fixed format questionnaires facilitated by graduate students or other staff, who had undergone prior interview training to improve data validity. To ensure that the respondents understood the complex concepts and questions, the interviews were held in person or by telephone. Steyn et al. (2011) explain that the advantages of this methodology include firstly that supplementary (perhaps tacit) information could be gathered, secondly that interviews would likely be completed or reasons could be given for incomplete questionnaires and that the workload and costs of the data collection were distributed. One of the challenges with interactive interviews is the possibility of interviewer bias, though the training aided in the mitigation thereof.

This existing secondary data was supported empirically by obtaining primary data using semi-structured interviews with automotive component manufacturing firms in the Durban area of South Africa, situated in the KwaZulu-Natal province (KZN). Having the interviews and questionnaires in fixed format also improves the repeatability of the results and validity by minimising interviewer bias whilst still affording the researcher to gather knowledge on practical and contextual information. Thus, the qualitative information complemented the quantitative analysis. The sampling included randomly chosen companies belonging to the National Association of Automotive Component and Allied Manufacturers (NAACAM) from KZN. NAACAM has the majority of the component manufacturers in the country in its membership and can therefore be deemed representative of the local automotive component industry.

The hypotheses were tested using a chi-squared test to establish association and multinomial logistic regression analysis to determine correlation. Data from the three developing countries was also compared to determine differences or trends that may be apparent. The differences between the

three regions are discussed as a guide to firms, particularly in South Africa and other lesser developed economies, on what can be learnt from successes of firms in the automotive component manufacturing sector in more advanced developing countries.

RESULTS

Primary data collection

Eight firms from the KZN region responded positively to the request for interview. The respondents were either senior executives of their companies or at least managing directors of their firms/units. Five companies were wholly locally owned whilst two companies were completely foreign owned subsidiary companies of German based automotive component manufacturers. The other company interviewed was split between 75% local and 25% foreign capital, the foreign equity held by a large multinational component manufacturer. The majority of the sales comprised of either manufacturing under OEM specifications or 'Original Design Manufacturing' (ODM) referring to products that are developed and designed by the companies according to requirements of buyers. Only two companies developed and designed their own products and sold it under their own brand, though even this accounted for a marginal percentage, 10% and 2% of sales at those companies. Generally, companies were not export orientated with only two companies reporting more than 30% sales outside of the country. The rest of the companies supplied local OEMs directly or 1st tier suppliers. From a supplier perspective, the situation is very much similar with only two companies reporting imports of more than 30%. All of the interviewed component manufacturers were either 1st or 2nd tier suppliers with only one manufacturer being an approved OEM aftermarket only supplier.

All of the firms reported some innovation activity, with a clear bias towards improved manufacturing methods (PR1) as well as organisational innovation by introducing new internal management practices (O1). Product innovations (P1) were common; however, some new products may just amount to existing components modified to refit new vehicle models without significantly upgrading the product itself. None of the companies interviewed introduced new services (P2), whilst only a few reported introduction of improved logistics (PR2) or new methods of organising external relations (O2).

Table 1: Number of innovation activities reported

	P1	P2	PR1	PR2	O1	O2	Total
New to the Firm	2	0	4	2	7	3	18
New to Market	2	0	3	0	0	0	5
New to the World	1	0	0	0	0	0	1

P1 - New or significantly improved goods — *P2 - New or significantly improved services.*
PR1 - New or significantly improved methods of manufacturing — *PR2 - New or significantly improved logistics*
O1 - New internal management practices — *O2 - New methods of organising external relations*

Table 1 also lists reported innovations according to the degree of novelty of innovation. Only one firm had reported a world first product innovation, which may have been influenced by the fact that this specific company, being mostly export orientated (95% export) to Europe especially, would have had the opportunity to feed into the global designs of the major European OEMs or at least their

major 1st tier suppliers. Again, of the 5 companies that reported new to the market innovations, 4 are significantly exposed to international markets through either export orientation or foreign capitalisation. The majority, 18 of 24 reported innovations, were new to the firm whilst also being heavily skewed toward process and organisational innovation. This finding is consistent with other studies done locally (Knoben & Oerlemans, 2010) and internationally (Tether, 2002) indicating that firms mostly learn from imitation of their market rivals or supply chain collaborators. Table 2 highlights the sources of technology and knowledge employed by the companies.

Table 2: Sources of technology and knowledge for innovation

	Employees	Returning Employees	Suppliers	Clients	Competitors	Consultants	Universities	Government	Other	Total
Local	6	1	1	2	0	2	1	0	0	13
Domestic	1	0	1	3	0	3	2	3	0	13
International	1	0	4	2	1	1	1	0	0	10
Total	8	1	6	7	1	6	4	3	0	

Expectedly, after internal employees as a source of technology and knowledge, supply chain actors feature significantly. Again, this is consistent still with other studies that had found similar results (Dodgson et al., 2008; Fritsch & Lukas, 2001; Tether, 2002). The exception here is competitors as a knowledge source; companies seem to perceive little value in cooperating with competitors. However, in the case of this sample set, the companies used consultants and universities quite a bit more than had previously been found. Six out of eight companies had engaged with consultants as a source of innovation whilst half of the companies engaged with universities. Government as a source of technology and knowledge was also reported by three companies, notably the Council for Scientific and Industrial Research (CSIR) was a key partner, which companies engaged as part of the CSIR industry support initiatives. From a geographic perspective, the sources were rather evenly split between local and domestic with international sources of technology and knowledge lagging slightly. Interestingly, although most of the companies reported having mainly local suppliers, international suppliers comprised the bulk of the technology and knowledge sourcing reported. A possible explanation is that the local suppliers would probably account for the bulk of the supply spend through raw materials and consumables in the manufacturing process, however international suppliers would be sought for machinery and process knowledge.

Secondary data analysis

Descriptive statistics

As discussed above the quantitative analysis was conducted on survey data collected in 2009 as part of international research into the automotive sector. Altogether, 538 observations were recorded with 75 companies from South Africa, 190 companies from China and 273 companies from India responding to the survey. Vermaak and Steyn (2013) reported that an overall response rate of 40%

was achieved whilst Steyn et al. (2011) confirmed that common method variance[1] does not exist within this data set.

Interestingly, the South African motor industry seems to be significantly older than its Chinese and Indian counterparts are. This could possibly be due to the recent rapid industrialisation of those countries and expansive growth of the domestic automotive markets, encouraging the proliferation of small component manufacturers to make up the demand. As far as ownership is concerned South Africa is very much dominated by foreign owned firms and multinational OEMs as compared to China and India. For the responding South African firms, domestic capitalisation averaged at 43% and foreign equity making up the balance with an average of 57%. China and India reported significantly lower levels of foreign ownership at averages of 16% and 2% respectively. This is also manifest in the sales strategies employed by South African firms. Table 3 presents the distribution of sales categories broken down per country.

Table 3: Percentage distribution of sales categories

	Original Equipment Manufacturing	Original Design Manufacturing	Original Brand Manufacturing	Other
South Africa	63%	16%	17%	4%
China	19%	30%	51%	0%
India	82%	17%	2%	0%

The OEM sales model i.e. supplying components as per design and specification from OEMs, without conducting any product design, dominates South African component manufacturing. ODM and OBM, Original Brand Manufacturing which is designing, producing and marketing of the companies own brand of products, are less prominent each accounting for less than 20 % of reported sales. Conversely, in China, component manufacturers do not primarily subscribe to the OEM model but instead prefer the OBM strategy with an average of 51% of sales. This could explain the highly fragmented nature of the automotive industry in China as found by Sardy and Fetscherin (2009), with each manufacturer conducting its own product design and brand marketing. The capacity for design amongst Chinese firms appears to be quite strong as ODM, designing products according to OEM specifications, is also popular. The OBM strategy is almost non-existent amongst Indian component manufacturers featuring at just 2%. However, in India the OEM approach accounts for the majority of manufacturing at over 80%. A possible explanation for this observation could be that due to the high number of local OEMs manufacturing vehicles specifically for the Indian domestic market, a high percentage of parts are designed within these automotive houses and subsequently specified to component manufacturers as opposed to component manufacturers needing to design or market their own products and brands. The Indian automotive industry is very much an enclosed system from a supply chain perspective. The majority of sales and suppliers are located within the country with very little orientation towards exports and even less so for imports. China follows a similar approach with the bulk of the supply originating from and production remaining within the country. South Africa, on the other hand, is quite different exporting and importing considerably

[1] Variance due to dependant and independent variables collected using the same survey instrument

more than either China or India. A third of domestic production goes overseas mainly to Europe and a substantial 43% of suppliers are based internationally, again mainly in Europe.

Innovation activities

In Table 4, the reported degree of novelty of innovation in market terms and innovation category are cross tabulated. The prevalence of new to the firm innovations, at more than two thirds, mirrors the results found in the primary data as well as numerous other innovation studies, that most innovations are imitations of other successful innovations. Between the countries, firms in China were consistently found to have a higher degree of innovation as compared to those in South Africa and much more than those in India. The data seems to correlate with that presented in Table 3 where more alignment with the OEM sales model resulted in lower degree of novelty of innovation. In following the ODM and OBM strategies, firms in China are able to leverage their design and marketing capabilities to innovate at a higher degree of novelty.

Table 4: Cross tabulation of reported innovation categories

	Product	Process	Organisation	South Africa	China	India	Total
New to the Firm	66%	60%	75%	56%	49%	84%	67%
New to Market	29%	34%	22%	31%	45%	14%	28%
New to the World	5%	6%	3%	13%	6%	2%	5%
South Africa	29%	38%	33%				
China	35%	31%	33%				
India	50%	21%	29%				
Total	42%	27%	31%				

The innovation categories are differentiated between product, process and organisational innovations. China can be seen to be innovating relatively equally across these three categories whilst South Africa favours process innovation over newly developed products, symptomatic of the prevailing OEM sales model. India was found to have relatively high levels of product innovation, despite the dominance of the OEM system. However, these innovations were new to the firm products consistent with the low levels of design activity.

Sources of technology and knowledge

Not surprisingly,

Table 5 shows that the three supply chain actors, viz. suppliers, clients and competitors, were the most significant external sources caucused by automotive component manufacturers. Employees, suppliers and competitors were each engaged by more than half of responding firms with almost 80% of firms indicating that they considered clients to have been an important source of knowledge in their product/process innovation. Geographically, local sources made up the bulk of collaborations at 52%, domestic sources accounting for 39% of interactions with international sources at 9%.

Table 5: Sources of technology and knowledge amongst component manufacturers

	Employees	Returning Employees	Suppliers	Clients	Competitors	Consultants	Universities	Government	Other	Percentage
Local	199	26	115	214	153	41	17	56	3	52%
Domestic	74	20	138	169	101	41	37	40	1	39%
International	20	14	30	44	18	3	3	0	2	9%
Percentage of firms	54%	11%	53%	79%	51%	16%	11%	18%	1%	

Hypotheses testing

Table 6: Multinomial logistic regression test results

Country		**South Africa**		**China**		**India**	
Hypothesis	**Knowledge Source**	**Wald Chi-Square**	**Pr > ChiSq**	**Wald Chi-Square**	**Pr > ChiSq**	**Wald Chi-Square**	**Pr > ChiSq**
H1a	Suppliers	3.99	**0.046***	7.69	**0.006***	34.47	**<.001***
H1b	Suppliers	2.47	0.116	0.07	0.793	4.51	**0.034***
H2	Clients	3.07	0.080	2.33	0.127	1.36	0.243
H3	Competitors	0.31	0.576	3.66	0.056	0.30	0.587
H4	Clients	8.85	**0.003***	14.92	**<.001***	0.69	0.406
H5	Competitors	0.05	0.816	8.53	**0.004***	12.39	**<.001***
H6	Suppliers	2.04	0.153	9.05	**0.003***	22.34	**<.001***

**Significance level p-value <0.05*

The results from the multinomial logistic regression analysis are presented in Table 6, and show that the relationships analysed are statistically significant for at least one of the countries with the exception of H2 and H3. The analysis for H2 and H3 indicate p-values which are >0.05 the significance level for all three countries. Thus the null hypotheses $H_{0\text{-}2}$ and $H_{0\text{-}3}$ cannot be rejected, i.e. the hypotheses that 'the more knowledge is sourced from clients the more innovation is new to the market' and 'the more knowledge is sourced from competitors, the more innovation is new to the firm' are rejected for all three countries.

The rest of the hypotheses analysed exhibit a significant Wald Chi-Square for at least one of the surveyed countries, indicating that the independent variables are significant predictors of the dependant variables. Hypothesis 1a displays a p-value <0.05 for all three countries, therefore 'Knowledge sourcing from suppliers is associated with acquisition of machinery and equipment as innovation activity' can be accepted across all three regions. Hypothesis 1b that 'Knowledge sourcing from suppliers is associated with acquisition of machinery and equipment as transactions' can be accepted for only for Indian automotive component manufacturers and is rejected for the South African and Chinese cases. 'The more knowledge is sourced from clients, the more innovation is in

product or service' which is Hypothesis 4, is precisely the opposite where it can be accepted for South Africa and China with p-values of 0.003 and <0.001 respectively, whilst with a p-value of 0.406 it is rejected for India. For Hypotheses 5 and 6 there is consensus between Indian and Chinese data where the propositions 'the more knowledge is sourced from competitors, the more innovation is new manufacturing methods' and 'the more knowledge is sourced from suppliers, the more innovation is new manufacturing methods' can be accepted. For South Africa, on the other hand this is not the case, where p-values of 0.816 and 0.153 for H5 and H6 respectively, mean that the null hypotheses cannot be rejected.

CONCLUSIONS AND RECOMMENDATIONS

The literature analysis indicates that there could be an influence between sources of technology and knowledge on innovation, whilst this study aimed at determining the influence of supply chain sources on innovation in the context of developing country automotive component manufacturers. Statistical analysis of the secondary data corroborates four of the proposed hypotheses for at least one country, illustrating that the supply chain sources of technology and knowledge do indeed have some influence on innovation.

Knowledge sourcing from suppliers was found to be associated with acquisition of machinery and equipment as innovation activity across the three countries (H1a), implying that automotive component manufacturers tend to rely on their suppliers for process knowledge embedded in the machinery and equipment they purchase. This could also be a case of not reinventing the wheel, as firms tend to substitute their own innovation efforts in co-operation with suppliers (Fritsch & Lukas, 2001). Knowledge sourcing from suppliers was found to be associated with acquisition of machinery and equipment as transactions for Indian automotive component manufacturers (H1b) indicating that, in the South African and Chinese context the knowledge activity of acquisition of machinery and equipment consisted of more than just transactions or that the time delay from acquiring knowledge to transacting extended beyond the year of the study. Moreover, innovation in new manufacturing methods were observed to positively correlate with knowledge sourcing from suppliers in China and India (H6) echoing the finding that firms work closely with suppliers in order to understand and utilize the full potential of new technologies (Dodgson et al., 2008). This was not the case for South African automotive component manufacturers where knowledge sourcing from suppliers did not correlate with innovations in new manufacturing methods. South Africa reported more than 50% of its knowledge sourcing from suppliers as being international and considering the results from Hypothesis 1 and the dominance of multinational component manufacturers, this knowledge sourcing is likely to have been acquisition of machinery and equipment rather than pure process or manufacturing knowledge.

The analysis also revealed that in all three countries, knowledge sourcing from clients does not correlate to new to the market innovations (H2). Firms who develop new to firm innovations also engage clients in their innovation processes even though those aiming for a higher degree of novelty would probably be more likely to use clients as found in other studies (Amara & Landry, 2005; Tether, 2002). Sourcing knowledge from clients does not predispose firms to achieve a higher degree of novelty of innovation. However, amongst South African and Chinese firms, knowledge sourcing form clients was found to positively correlate to product or service innovations (H4). Clients often have intimate knowledge of the products and services they use, along with the invaluable insight of

what they desire in new products. It is this insight that holds that attraction for innovative firms. Clients are engaged early on in the innovation process to assess market requirements and increase chances and rate of acceptance. This correlation was not found in Indian firms, clients as a source of technology and knowledge did not influence product or service innovations or even result in a higher degree of novelty of innovation. From Table 3 it can be seen that firms in India did report the highest percentage of product innovations and innovation new to the firm. This appears to point to in-house development to OEM specification.

Knowledge sourcing from competitors also did not show a relationship with innovation that is new to the firm for all three countries (H3). More than two thirds of innovations observed (67%) were new to the firm, though are not necessarily associated with sourcing knowledge from competitors. It seems that firms may use information sourced from competitors in combination with other sources to introduce something new to the market, whilst collaborating with competitors does not confine the innovation to a low degree of novelty. Collaboration with competitors can be quite difficult to assess as most competitors interact largely on an informal basis. Nonetheless, automotive component manufacturers in China and India did collaborate with competitors with regard to new manufacturing methods (H5). Sourcing knowledge from competitors positively correlated with new manufacturing methods. Firms will engage competitors when the risk of losing its competitive advantage is low, indicating that within those component manufacturing industries, process innovations do not present a competitive advantage since the industry is fairly established. South African firms seem not see any benefit from collaborating with competitors in general or value their manufacturing methods as their competitive advantage so neglect to constructively interact with competitors. The primary data corroborates this finding in that only one of the interviewed firms used a competitor as a source of technology and knowledge and predictably, this was an international competitor that operated outside of the company's direct markets.

South Africa is well poised in that it has an established automotive industry on which to build. Collaborations and learning for innovation could be done more effectively and the country may benefit from building these improvement interventions into incentive schemes. Supply chain learning, from competitors especially, have a lot of room for improvements but would require a paradigm shift away from the OEM dominant state that now prevails.

The general mode of innovation in South Africa is aptly described by de Wet (1999), wherein he describes some developing countries as technology colonies who rely on externally licensed technologies. South Africa consistently showed higher levels of international technology and knowledge sourcing than either China or India, again commensurate with the prevalence of multinational component manufacturers and foreign owned OEMs. Interestingly, China showed a significant prevalence of domestic knowledge sourcing activity, illustrative of the vast geographic resources and burgeoning economy supportive of it's widely distributed (though fragmented) manufacturing base. Indian automotive component manufacturers from Pune displayed a peculiar autarky (self-reliance), almost operating as a closed system both in terms of their supply chain and their knowledge sourcing activities. The majority of India's knowledge sourcing occurred locally. It would be interesting to investigate the reasons for this self-containment and the success thereof.

The results present opportunities for further research to identify those sources of technology and knowledge that have the most influence on the success of certain innovations. A follow up study

could also be useful to determine if any changes in the innovation process have occurred since the original survey, and to include other successful developing countries.

ACKNOWLEDGEMENTS

The data of Chinese and Indian companies were collected as part of the project "Emerging Trends in Asia: From low-cost providers to Innovators" financed by the Swedish Research Council (project 421-2006-2332). The project was coordinated by Prof. Cristina Chaminade, Lund University, Sweden. Dr Legesse Debusho and Mrs Joyce Jordaan of the Department of Statistics, University of Pretoria supported the statistical analysis.

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