CHOICE OF TECHNOLOGY ACQUISITION MODES WITHIN A BUSINESS CYCLE

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Abstract
The purpose of this study is to link the value chain and business cycle to the choice of technology acquisition mode. Although this area has been studied extensively within the electronics industry there is a gap in the body of knowledge within the mining industry. Previous research has been fragmented with only a few of the abovementioned areas being studied at a specific time for appropriate modes. Theory does not link all of these aspects together, but it is important to understand the mining context, because of the increasing pressures to improve management outputs to remain globally competitive. Hence, this study suggests a conceptual framework within which the selection of technology acquisition modes changes during the business cycle and impacts on specific areas of the company's value chain.

Survey questionnaire responses from all of the ferrochrome producers in South Africa were analysed to test associations distinguishing the three technology acquisition modes, e.g. in-house development, technology purchasing and collaborative development. Results show that technology acquisition modes change over a business cycle, and that technologies are developed mostly for key area (processes) and support area (process systems), followed then by management innovation.

Keywords: acquisition modes, ferrochrome, value chain, business cycle.

Introduction

Throughout history economics has proven to be volatile and unpredictable. Cyclical markets are not uncommon in the mining industry, and the cycles are unique for each commodity. The slightest fluctuations in end-markets as a result of a country's political and economic stability, or an economic recession results in what is called the bullwhip effect (Jaipuria and Mahapatra, 2014: 13), and can cause large oscillations in the mining industry supply chain (Alajoutsijärvi *et al.*, 2012: 294). During recessions the mining sector is at the mercy of the exchange and merchants to sell their produce at minimal costs. Management of sustainable operations throughout the market troughs are imperative for individual mining houses to remain profitable.

South Africa contains some of the world's largest mineral reserves in platinum group metals (PGMs), manganese, chrome, vanadium and gold. The distribution amongst precious and non-ferrous metals makes the South African market competitive and a large prospect for foreign investments.

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China is the major consumer of chrome ore produced worldwide, and South Africa's ore supply into this market has risen significantly from 36% in 2010 to 60% in 2014 of total Chinese chrome ore imports (Fowkes, 2014: 5). China holds control over the demand of both ferrochrome and chrome ore (chromite) from South Africa (Fowkes, 2014: 2). The market depreciates the value of the ferrochrome by demanding lower prices and is willing to pay higher prices for chrome ore. The SA industry meets the chrome ore demands and loses out on beneficiation of ferrochrome. The high import of chrome ore by China has resulted in driving the ferrochrome prices down and a depressed ferrochrome market. The South African ferrochrome producers further faced higher electricity costs, electricity supply complications and a stronger local exchange currency rate since 2009.

Chromium is one of the fundamental metals used in modern steelmaking which has no adequate substitute for corrosion resistance and is regarded as a commodity of critical and strategic importance (Murthy et al, 2011: 326). Stainless steel markets have been growing at a rate of 6% per annum on average since the 2009 recession till 2014, see Figure 1.

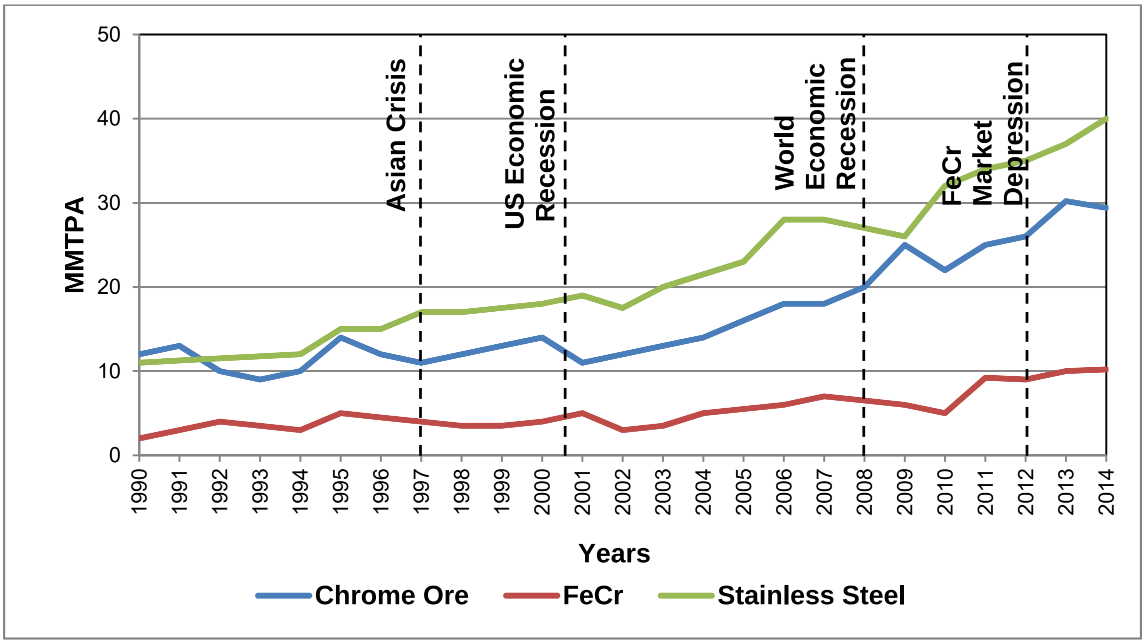

Figure 1: World production of stainless steel, chrome ore and ferrochrome (FeCr) for the period 1990-2014 (Kleynhans, 2011: 15, Richard, 2015: 7, I.F.M., 2013: 5)

The South African ferrochrome industry needs more effective technology management which will drive the industry's global competitive advantage and make the industry sustainable throughout a business cycle. An important part of technology management is selecting an appropriate technology acquisition mode which will contribute positively on a company's performance. However, the links within the mining industry's value chain and the technology acquisition modes are unknown.

Background

Ferrochrome market

The overall ferrochrome production capacity has increased within South Africa since 2004 in order to fulfill the anticipated increase in demand. However, the ferrochrome production capacity remains unexploited due to the industry's chrome ore sales balancing act as seen in Table 1.

Table 1: South African ferrochrome sales and production capacity (D.T.I., 2014, Beukes et al., 2010, Jones et al., 2011)

Ferrochrome local and export sales	**2004**	**2009**	**2013**
South African Global Export (million mt/a)	2.4	2.9	2.9
South African Local Sales (million mt/a)	0.5	0.4	0.4
South African Total Production Capacity (million mt/a)	3.4	4.7	4.8
Ferrochrome Capacity Distribution per South African Ferrochrome Producer	**2004**	**2009**	**2013**
Glencore Chrome	47%	42%	41%
Samancor Chrome	29%	23%	26%
Hernic Ferrochrome	8%	9%	9%
ASA Ferrochrome	3%	8%	8%
Assmang Chrome	10%	7%	5%
IFM	-	6%	6%
Tata Ferrochrome	-	3%	3%
Mogale Alloys	3%	2%	2%

South African ferrochrome competitiveness

South Africa was always considered a world leader in ferrochrome production, due to an abundance of good quality raw materials (ore, reductants and fluxes), adequate infrastructure and fairly low-cost capital (Basson *et al.*, 2007). However, the complexity of the ferrochrome industry has threatened the overall competitiveness of the South African producers in more recent years. Some of the challenges, of which some are directly linked to the production costs, are discussed briefly:

- *Electricity:* South Africa's electricity demand has exceeded the electricity-generating capacity (Eskom, 2014). This has led to dramatic increases in electricity prices in the past few years and is set to continue for the foreseeable future. Electricity costs are the largest cost component in ferrochrome production (Fowkes, 2013: 5, Biermann *et al.*, 2012: 302). Government has also pushed for a decreased carbon footprint and are imposing carbon taxes in order to curb the environmental impact created by smelters (Kleynhans, 2011: 8). This implies that ferrochrome producers must form a technology strategy regarding controlling electricity consumption, reductant consumption and using alternative fuel sources.

- *Employment:* In comparison to the overall employment within the mining industry of South Africa the chrome industry only employs approximately 3.7% of the total mining employees. The power struggle amongst rival unions, Association of Mineworkers and Construction Union (AMCU) and National Union of Metalworkers of South Africa (NUMSA), brought the country into an economic slowdown, because of the six month long strike in the PGMs sector. The same power battle filtered into the chrome sector where wildcat strikes occurred in 2013 and impacted employment and mining operations at both Samancor and Glencore (Burkhardt, 2014). Mosiane (2007: 28) stated that for an average capacity of 700 tonnes ferrochrome per worker, 410 kt of ferrochrome would create 587 employment opportunities per annum. This employment opportunity, however, has not materialized because of the increased export sales of chrome ore.
- *Chrome ore export:* It is believed that a country rich in mineral reserves is cursed with slow growth, because of its inability to maximise productivity potential of its reserves (Coxhead, 2007). Countries with large mineral reserves do not correlate to being the countries with a high Gross Domestic Product, in fact they tend to correlate with either developing or undeveloped countries. The peak of the economic cycle (2003 – 2008) was both longer than usual and presented significant growths in mineral prices. These growths were due to high demands from China, and the lower availability of mineral reserves and partially processed minerals (Filippou and King, 2011, Humphreys, 2001). China holds control over the demand of both ferrochrome and chrome ore from South Africa (Fowkes, 2014: 2). The market depreciates the value of the ferrochrome by demanding lower prices and is willing to pay higher prices for chrome ore, which results in the South African ferrochrome industry meeting the demands and loses out on beneficiation and job creation.
- *Business cycle:* Industry specific business cycles have four phases being: boom, recession, depression and recovery. The analysis of a typical business cycle from the view point of a technology provider is depicted in Figure 2. Business cycles are a consequence of either a large sole cause or smaller events in the market such as the sub-prime crisis (2009 recession) or capital projects (Roberts, 2009: 87). The end consumption of the ferrochrome mining industry is dependent on demands for increased activities, such as construction and automotive manufacturing. Inventories tend to grow during recessions and shrink during booms which reflects on both consumption and market price (Vinell, 1997). The sub-prime crisis put strain on many mining companies, where most had made price reductions, others limited operations, and others postponed capital projects. Expansions and projects within the mining industry are dependent on mineral prices as they influence the volatility of the project cash flows. One of the main purposes of predictive models for commodities is to aid the appraisal process and justify risk versus returns. Doing any mine or smelter expansions requires a sound knowledge of the mine life, costs of the minerals during its life time, and understanding of the specific mineral demand (Shafiee and Topal, 2010, Crowson, 2001). Investors tend to flock to commodity markets to avoid unpredictability thus reducing overall portfolio risks (Shafiee and Topal, 2010, Batten *et al.*, 2010). Ferrochrome, however, is not seen to be a stable commodity in the market and has not been studied to the same extent as the PGMs sector.

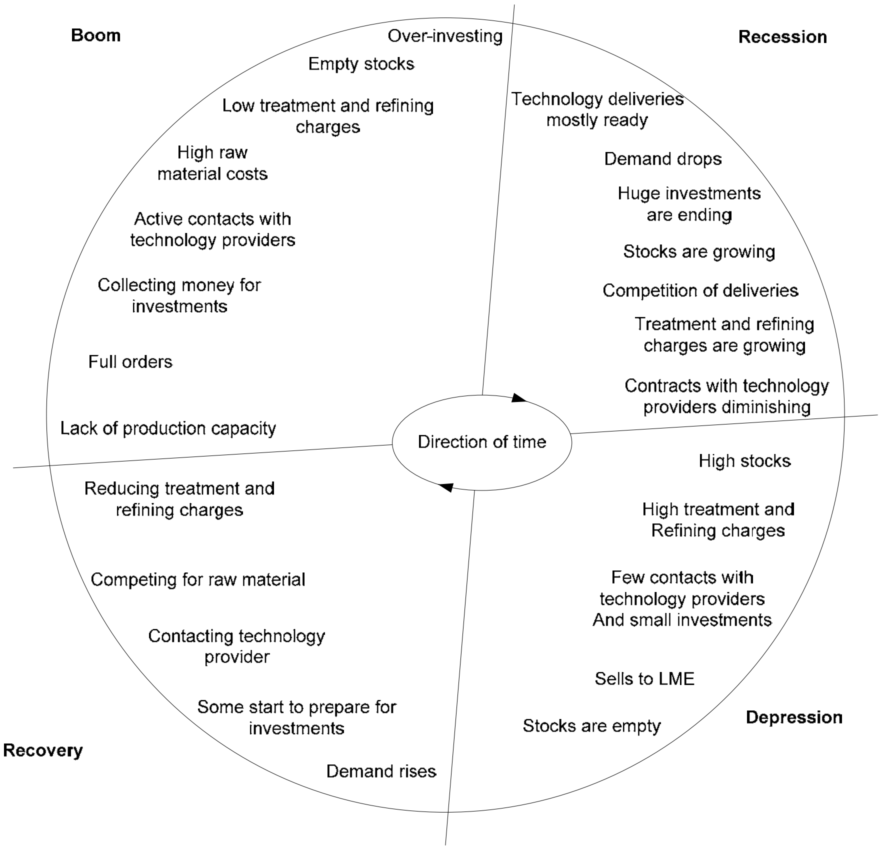

Figure 2: The key activities and events during different phases of the business cycle in the mining industry pertaining to smelters (Alajoutsijärvi et al., 2012: 296).

Technology acquisition modes (TAMs)

Historically, the mining industry conducted in-house research and development (R&D) for new exploration methods (geology, geochemistry, and geophysics), innovative mining technologies, and metallurgical techniques. Hitzman (2002: 64) states that industry's sponsoring had overtaken the US government for R&D but that many company research centers have been terminated along with declining numbers of US graduate programs in mining engineering and economic geology.

Internal R&D has emerged once more as a response to lower costs of organising inside a firm compared to acquiring innovations. Companies with significant investment in R&D could develop various organisational structures to streamline innovative processes and become a technology provider themselves. Companies that do so, could gain economies of scale and scope for their R&D (Dahlander, 2010: 701).

Even though the mining industry showed large increases in profitability, from 2003 through 2008, there is still an unyielding decrease in R&D spend. This trend started to develop in the early 1980's (Filippou and King, 2011: 276, Hitzman, 2002: 63).

The decline of R&D investing decreased significantly within companies where mergers and acquisitions occurred (Bartos, 2007). Major downsizing of R&D in both BHP and Rio Tinto occurred where both in-house laboratories were closed down, even Alcoa reduced staff and exploration groups, but this was not only a common trend amongst the large players, smaller companies literally cut all funding out of their budgets (La Nauze and Shodde, 2004). This observation highlights a point of interest within the proposed research in the ferrochrome industry.

Technology in the eyes of the mining industry is the significant increase in the degree of automation, providing larger and more efficient equipment, furnaces and beneficiation plants (Bartos, 2007, Filippou and King, 2011). There are more innovations occurring within the mining industry than glass and cement industries, but the measure is insignificant to the microcomputer industry (Filippou and King, 2011).

Key issues facing managers include understanding the link between technology and corporate strategy, technology diversification and technology acquisition. Ultimately, managers are appointed with determining the most effective and efficient methods for meeting the technology development challenges necessary to survive in their particular industry (Jones *et al.*, 2001: 258).

Technology acquisition strategy is seen as the process of selecting acquisition modes by using technical and non-technical capabilities, and an integration of the selected technology into the value chain (Burgelman, 2004: 253, Cho and Pyung- Il, 2000: 692). Many scholars have analyzed the reasons why a technology acquisition mode is selected, but this study is concerned with one influencing element; the impact of the business cycle on the mode of technology acquisition selected and the downstream impacts thereof (Cánez *et al.*, 2000: 1313, Cho and Pyung-Il, 2000: 691, Narula, 2001: 365, Jafari *et al.*, 2011: 309, Hung and Tang, 2008: 551).

Cho and Pyung-Il (2000: 693) used the integrated framework set out in Figure 3 to investigate how firms acquire needed technology with an integrated approach on the basis of previous studies. Previous studies (Lowe and Taylor, 1998: 263, Tyler and Steensma, 1995: 70) used three characteristics to categorize influential factors being: internal, external and technologic-specific. This categorisation is used to reflect perspectives within the industry within the framework.

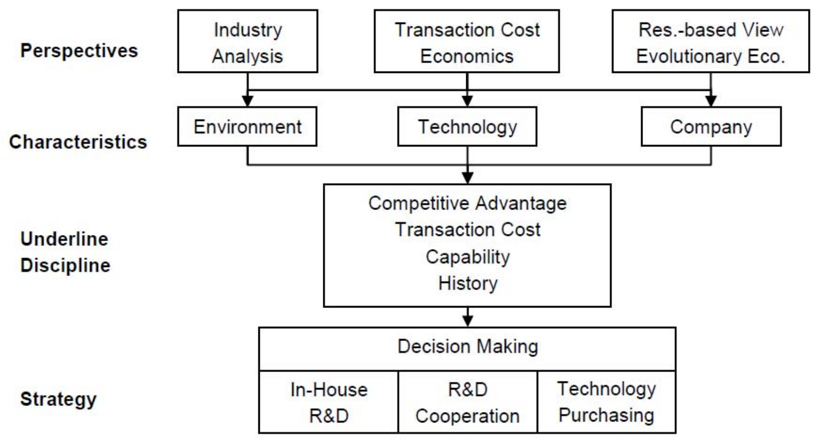

Figure 3: Adapted integrated framework for technology acquisition modes (Cho and Pyung-Il, 2000: 693)

There are various types of acquisition modes but in general, *in-house development* and *technology purchasing* is the umbrella terms used to describe a whole range of acquisition modes. A third mode which requires the involvement of both internal and external capabilities, being development *collaboration,* is considered within this study.

In-house development is defined as the execution of development as a task within the existing structures of the organization, namely a R&D department (Cho and Pyung-Il, 2000: 692). Some of the advantages of in-house development according to Schlorke (2011: 13) include: tacit knowledge gain, developed technology becomes the property of the developer, competitive advantage becomes exclusive to the developer, and opportunity to increase revenues by the sale or licensing of the developed technology. The disadvantages of in-house development are: long development times, increased costs to develop, potential disruption to production, and possible lack of resources existing internally to complete the development.

Technology purchasing is broadly defined as acquiring technologies by contracts, licensing or simply purchasing from a provider. This mode neither utilises internal capabilities or requires any technical collaboration (Cho and Pyung-Il, 2000: 692). The advantages of technology purchasing are possible reduced cost, lower risks and decreased time to implementation (Schlorke, 2011: 14). However, the purchasing of technology does not guarantee a competitive advantage and there is usually no valuable exchange of tacit knowledge within the process. Although sourcing technologies externally may reduce the need to sustain internal technical capabilities, it can also speed up the implementation of products and processes (Tsai and Wang, 2008: 104).

Collaborative development can be defined as the complimenting of internal resources in the innovation process, enhancing both the innovation input and output measured by the realization of innovations (Becker and Dietz, 2004: 209).

Simatupang (2006: 43) found that few studies in the practices and characteristics of the technology acquisition process for companies in developing countries have been conducted. Most of the current studies were conducted in the developed nations, such as the USA, UK, and Japan where competitiveness is driven by technology development. Schlorke (2011: 10) provides the most recent study to link technology acquisition and product development processes within the South African electronics industry. The studies conducted in the different countries all involve the electronics industry that focuses on product development and program management unlike the ferrochrome industry that focuses on operations and efficiency.

Research objectives

As the activities of a smelter fall within the boundaries of a generic value chain, it is assumed that a decision made for technology acquisition will have an impact on one or more activities in the value chain. Studies have not explored in depth variations of technology acquisition based on the actual area of development in the value chain, because they focused on high technology industries and not beneficiation.

The main objective of this study is to determine whether methods of technology acquisition used in various parts of the ferrochrome smelter value chain have an impact on the company throughout a business cycle. Other objectives of this study includes to determine whether there is a preference for a specific acquisition within an explicit part of the value chain, whether companies prefer local or global institutions for collaborative development, and methods used by companies to protect their technologies.

Conceptual Framework

Ford (1988: 85) states that it is important to evaluate the company's level of knowledge of its own technologies and emerging technologies. This evaluation must be understood across the value chain from upstream development to downstream activities of marketing and aftermarket services. The conceptual framework to investigate the relationships in the ferrochrome smelting industry includes the variables, TAMs and the smelter product value chain areas (VCAs). A longitudinal study was conducted in order to assess the changes of these modes throughout a business cycle. Linking TAMs to the VCAs and the business cycle are depicted within the framework in Figure 4 below and the research questions are provided hereunder.

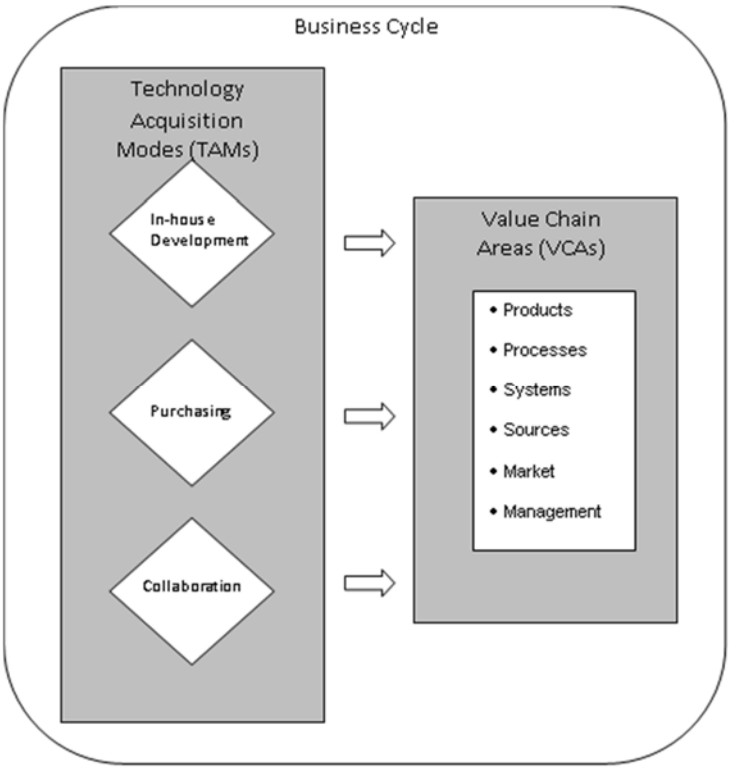

Figure 4: Integrated conceptual framework

The following research questions were identified:

- **RQ$_1$**: Do technology acquisition modes used by the ferrochrome industry change during different business cycles?

- **RQ_2**: Will a higher focus for specific key process areas result in a higher preference for in-house development?
- **RQ_3**: Will a higher focus for the support process areas result in a higher preference for technology purchasing?
- **RQ_4**: If the focus on management innovation is higher, will the preference be for in-house development?
- **RQ_5**: Does the South African ferrochrome industry rather approach local institutions, such as science councils, universities and consultants, than global institutions when conducting a collaborative development?
- **RQ_6**: Do the ferrochrome industry make use of protection methods to safeguard its distinctive technologies?

Research Methodology

To address the research objectives, the research design combines qualitative and quantitative analyses methods to non-experimental (i.e. no variables are controlled) research. The qualitative methods consist of electronic based surveys and follow up telephonic interviews with management of the ferrochrome producers. Of the variety of survey methods a one-to-one method was selected where an electronic based survey is the primary form of data collection and telephonic interviews is the secondary form. The research questions asked in the survey are related to the conceptual framework described and are designed to answer the research problem by avoiding bias. The quantitative methods followed included assessment of open source data such production figures and high-level market share values published in annual reports of the various ferrochrome producers and government reports.

There are 14 ferrochrome smelters in South Africa, representing eight different companies, as indicated in Table 2. 75% of ferrochrome companies in SA are publicly listed. Although quantitative data will not be available for the privately owned companies the correlations observed in the study provide a good indication of the impacts of the market conditions on the industry itself.

Responses for the surveys were received from managers from all eight companies (26 respondents) within the population. The responses are summarized to the respective company by assigning weights to the position and experience of the respondent. The population is stratified into publicly listed and privately owned companies because of the limited quantitative data available for the private companies.

Table 2: Description of ferrochrome producers in South Africa (2014)

Company	Total Capacity (kt/a)	Company Structure
Glencore Chrome	2335	Publi c
Samancor Chrome	1330	Private
Hernic	420	Private
Sinosteel ASA Metals	370	Private-State Owned
Assmang	250	Publi c
IFM	267	Publi c
Tata Steel KZN	150	Publi c
Mogale	110	Publi c

Results and Discussion

TAMs and the business cycle

This section reports on how modes of acquisition change throughout a business cycle. Gaps in the body of knowledge exist regarding the actual impact of business cycles on the preference of technology acquisition mode. Many theories describe various factors affecting the mode selection (Cho and Pyung-Il, 2000: 693, Kurokawa, 1997: 132, Schlorke, 2011: 14) but none have highlighted the business cycle which is important for a commodity producer, such as the ferrochrome industry, as this is what drives demand for the product. The ferrochrome industry is vulnerable to many factors and requires consistent adaptation to changes, and especially in developed countries, difficulties are experienced in sustaining technology management strategies.

Table 3 shows the results of different business cycles on technology acquisition modes. Technology purchasing was the predominant acquisition mode during the boom period. The overall trend of diminishing technology purchasing as the business cycle moves from boom to recession followed by depression is confirmed. As soon as the recession hits, investments become small, which leads to a focus on internal capabilities driving the technology development. Collaborative development is only preferred over purchasing during a depression. This means that consultants and institutions should have more opportunities during this time within the context of ferrochrome smelters.

The trend quoted by Alajoutsijärvi et al. (2012: 296) confirms changes in technology strategies throughout the business cycle in the context of ferrochrome smelters. The preference for in-house development appears to be independent of in-house capabilities but rather of the business cycle.

Table 3: Phase of the business cycle and modes of technology acquisition.

Period of Business Cycle	Acquisition Mode			
	In-house development	Technology purchasing	Collaborative development	Total
Boom (2004-2007)	37%	50%	13%	100%
Recession (2008-2009)	62%	25%	13%	100%
Depression (2012-Present)	62%	13%	25%	100%

Regarding the company's preferred TAM in 2015 (depression stage), the results indicated that a total of 53% of the companies preference is for in-house development, 28% for purchasing of technology, and 19% prefer the collaborative development approach. Public companies tend to rather conduct in-house development, whereas private companies have a slightly higher preference for purchasing and collaborative development of technology, see Figure 5.

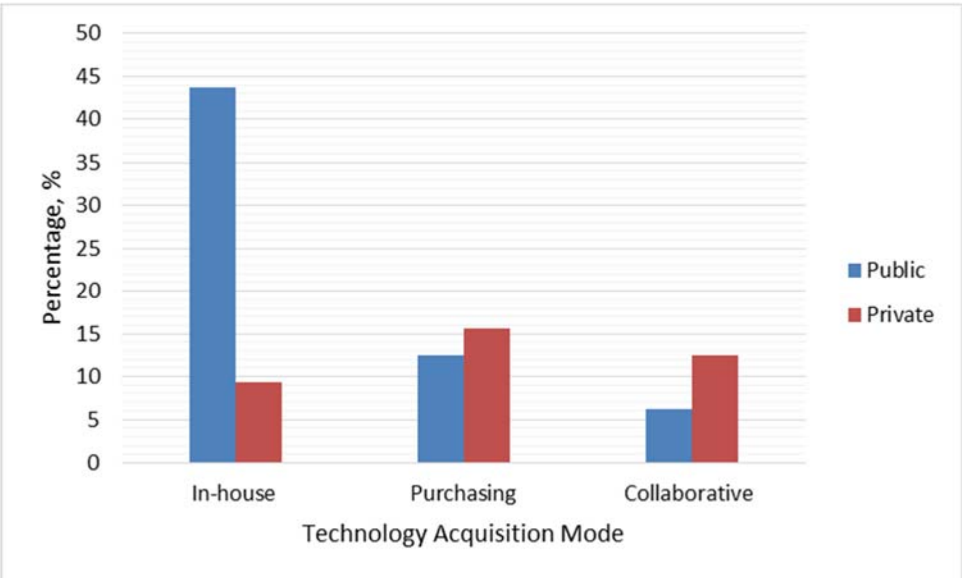

Figure 5: Preferred TAMs for public and private ferrochrome companies.

Responsible department and TAMs

Each ferrochrome producer has a different organogram wherein the management functions. This means that technology management and thus acquisition mode selection is performed by specific functional groups within the business. The responsible department (e.g. technology, capital projects, maintenance, controls and instruments, production, business integration systems) was identified at the onset of the questionnaire, as well as their preferred mode of technology acquisition. The distribution between department(s) responsible for technological innovation in the South African ferrochrome industry, during a depression period, is shown in Table 4. The overall distribution of innovation responsibility is relatively evenly distributed between the departments in the industry as a whole, except for lower values for the technology– and capital projects departments. Within the private sector, a slightly higher assignment resulted for the business integration system (BIS) department to develop technologies, whereas a slightly lower assignment was found for the technology department (Figure 6). For public companies the distribution was relatively equal between the different departments with technology-, maintenance- and production departments slightly higher. The primary focus of the responsible departments is not isolated to a single dimension as shown in the results of Figure 7. Private as well as public companies, focus mainly on increased productivity, profit, and improved quality.

Table 4: Responsible department for technology management and technology acquisition modes.

Responsible Department	Average distribution (%)
Technology department	13
Capital Projects	13
Maintenance	20
Controls and Instrumentation	17
Production	20
Business Integration Systems (BIS)	17

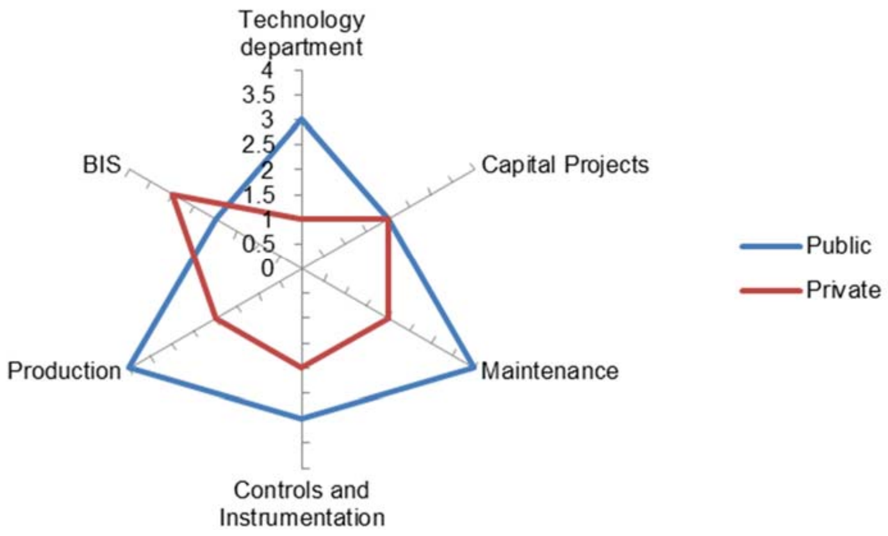

Figure 6: Departments responsible for technological innovation within the company.

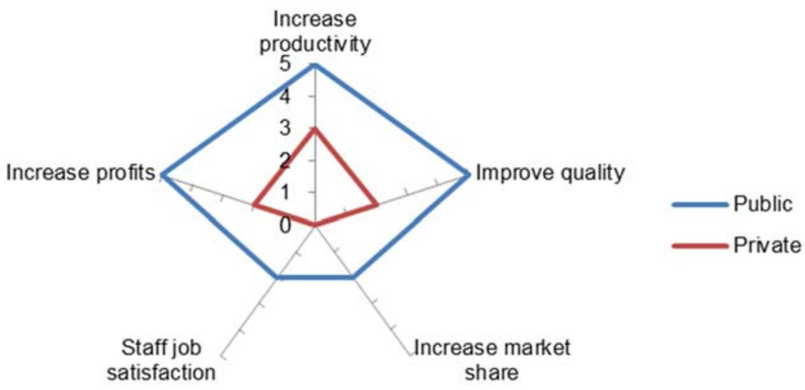

Figure 7: Focus of the department responsible for technological innovation within the organization.

TAMs and the VCAs

Table 5 shows that technologies are developed mostly for key area (processes) and support area (systems), followed then by management innovation. In conjunction with the results of the previous section, it is clear that Maintenance and Production departments, whose primary focus is the key process area, show a preference in developing processes and systems using technological innovation during a depression in the business cycle. Further, for key area (processes) and support area (systems), the preferred TAM is technology purchasing, followed by similar results for the TAMs in-house development and collaborative development. On the other hand, management innovation's preferred TAMs are in-house development and collaborative development with lowest score for technology purchasing.

Table 5: Focus areas of the value chain and modes of technology acquisition

Focus Area			Acquisition Mode		
			In-house development	**Technology purchasing**	**Collaborative development**
Key	Products	18%	21%	12%	22%
	Processes	32%	33%	41%	30%
	Sources	-	-	-	4%
Support	Systems	27%	29%	41%	30%
Management	Market	-	4%	-	-
	Management	23%	13%	6%	13%
Total		**100%**	**100%**	**100%**	**100%**

Lastly, the value chain is understood well within the industry and each area of the value chain is managed accordingly. It is clear that these relationships have not been investigated in an integrated way in the past because of confusion as to who manages technology development within the company. It is unlikely that a software engineer manages technological innovation in the key process area and that production departments manage innovations in the finance department. For these reasons, and because the body of knowledge is still very vague, it is not deemed pragmatic to address the relationship between TAMs and the value chain within an integrated framework.

Collaborations and technology protection preferences

The South African ferrochrome industry has an inclination to collaborate with local institutions, see Figure 8. The majority of the collaborative work are conducted with SA science councils, followed by consultants and then universities. Global institutions constitute to less than 20% of the TAM collaborative development.

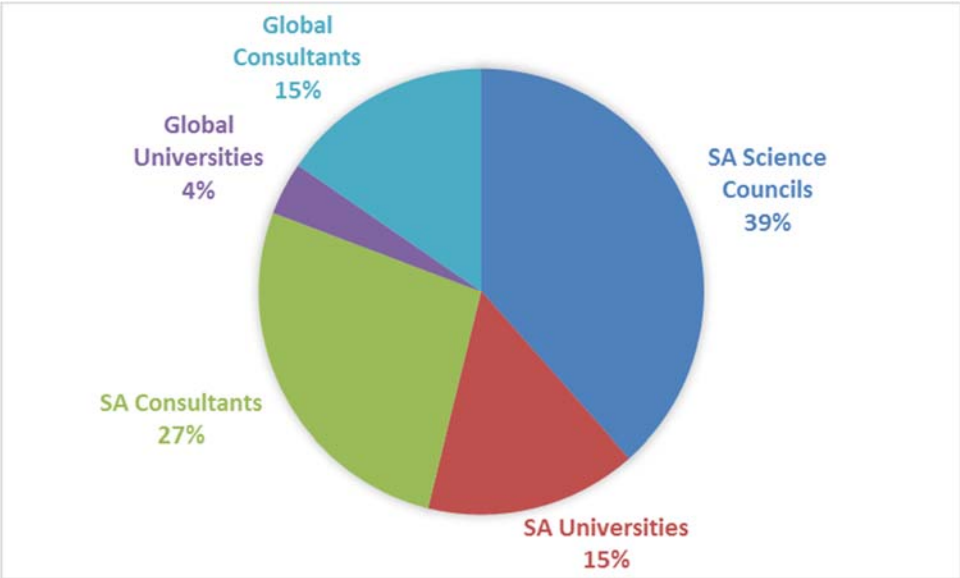

Figure 8: Results indicating the collaborative development preference with global and local institutions.

The South African ferrochrome industry are in general very protective of its technologies and make use of various methods to protect it as shown in Figure 9. Confidentiality policies followed by retaining know-how in-house appeared to be the foremost means of protecting the companies' technologies. Legal protections methods such as patenting and licensing are also often employed in this sector. Interesting to note is that no company indicating the use of trademarks as a protection mode for its technologies.

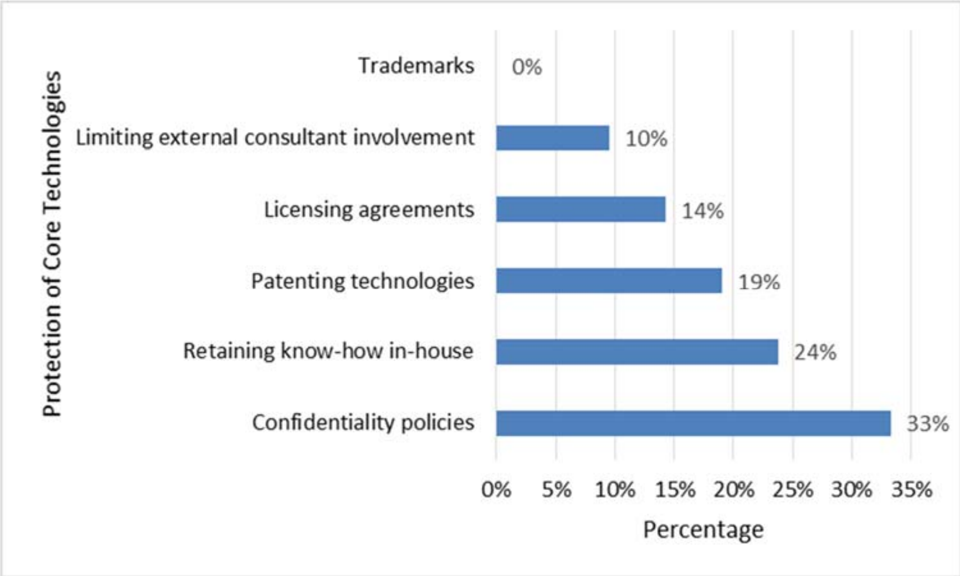

Figure 9: Protection methods used by ferrochrome industry.

Conclusions

The investigation showed no definite differences in management behaviour between public and privately owned ferrochrome producers. Most of the companies assign the responsibility of technology development to the maintenance and production departments, but there is a general consensus that all departments are responsible for technology development.

Production and maintenance departments have the largest influence on key process areas of the value chain meaning that most innovations are geared towards processes. Results showed that support areas such as systems are prioritized similarly to processes.

TAM preferences are linked to a definite focus area. This link means that in-house development is the preferred method of acquisition for processes, specifically during a recession and depression of the business cycle.

Regarding the research questions:

- **RQ_1**: Do technology acquisition modes used by the ferrochrome industry change during different business cycles? The TAM technology purchasing was the predominant acquisition mode during the boom period, whereas collaborative development is only preferred over purchasing during a depression.
- **RQ_2**: Will a higher focus for a specific key process areas result in a higher the preference for in-house development? The focus areas with highest score did not indicate a preference for TAM in-house development, but rather for TAM technology purchasing.
- **RQ_3**: Will a higher focus for the support process areas result in a higher preference for technology purchasing? The results indicated that this is true and that the TAM technology purchasing is the preferred TAM for support process areas.

- **RQ4**: If the focus on management innovation is higher, the preference will be for in-house development? In-house development is one of the most important TAMs for management innovation but cannot be singled out.
- **RQ5**: Does the South African ferrochrome industry rather approach local institutions, such as science councils, universities and consultants, than global institutions when conducting a collaborative development? The SA ferrochrome industry favourite local institutions for collaborative development.
- **RQ6**: Do the ferrochrome industry make use of protection methods to safeguard its distinctive technologies? Yes, the industry often make use of protection methods such as policies, retaining in-house know-how, patents and licences.

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