How does the Technology Innovation Agency (TIA) evaluate the relationship between Universities of Technology and SMMEs for Technology Transfer: A Case Study of the Technology Stations Programme

by

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Declaration of Master's Report

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How does the Technology Innovation Agency (TIA) evaluate the relationship between Universities of Technology and SMMEs for Technology Transfer: A Case Study of the Technology Stations Programme.

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(b) that this submission conforms to the guidelines for presentation set out in the relevant documentation.

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Acknowledgements

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Abstract

Increasingly, innovation through technology transfer is seen as a mechanism through which economic growth can be spurred. The South African National Innovation System (NIS) is built on this premise, leading to the emergence of Technology Transfer Organizations (TTOs) such as the Technology Innovation Agency's (TIA's) Technology Stations Programme. The Technology Stations Programme addresses, and attempts to alleviate, the slow overall decline of South African industrial sectors through innovation work for industrialization. It is not clear, however, how the TIA monitors and evaluates, and hence measures the economic and socio-economic outcomes of the Technology Stations Programme. This is because the relationship between the strategic objectives of the programme, and the performance indicators used for impact assessment is not clear. This study identifies the use of the Science, Engineering, Technology and Innovation (SETI) Scorecard of indicators as the framework for performance reporting at the Technology Stations Programme. The study describes the SETI framework and then evaluates it, finding that it is not well defined and lacks the properties required of a framework of indicators to make it an adequate tool for performance reporting. Other problems compromising the reporting on the Technology Stations Programme have to do with the seemingly incomplete nature of reports, occasional incoherence and seeming carelessness where there are graphic errors in the reporting. This inadequate monitoring and evaluation, and performance reporting is concerning because interview work suggests that the Technology Stations Programme is highly successful in supporting SMMEs and offering them technology related services that contribute to industrial policy through innovation work. The failure to have a SETI Scorecard of indicators that is functional enough to make these outcomes in the Technology Stations Programme visible in formal reporting is concerning as programme evaluation should make known the effects of policies. In the case of the Technology Stations Programme these effects are crucial as the technology transfer taking place in the programme is anticipated to achieve grand objectives in the way of economic value adding and industrial expansion. This necessitates the need to capture the outcomes related to these objectives, and make future decisions on the Technology Stations Programme as well as other technology transfer programmes.

List of Abbreviations

DST – Department for Science and Technology

KPI(s) – Key Performance Indicator(s)

SETI – Science, Engineering, Technology and Innovation

SMME – Small Micro and Medium Enterprises

TIA – Technology Innovation Agency

TTO – Technology Transfer Organization

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Chapter 1 – Introduction

1.1 Background

The economic performance of the South African economy remains below what is desired by the government, and a variety of sector policies are geared towards addressing this (Economic Development Department; 2014). In response, domestic industrial policy seeks to stimulate the economy using a number of measures, one of which is the strengthening of the South African innovation base through technology transfer initiatives (DST; 2007). The Technology Innovation Agency (TIA) runs the Technology Stations Programme which links Small Medium and Micro Enterprises (SMMEs) with universities of technology to improve the industrial capabilities of these SMMEs, contributing to industrial progress by offering them research, development and technology services.

Initial Strategic Context and History of the Technology Stations Programme

The network of technical expertise that has been built over the years is the result of the initial idea from the Department of Science and Technology (DST)[1] to develop a technology demonstration centre in the year 2000 (TIA; 2013). The demand for something more than just a technology demonstration centre led to a bilateral agreement with Germany to implement the Technology Stations Programme, which was based on the German "Steinbeis Principle" for technology transfer and application. The term "Steinbeis Principle" encompasses the idea of the successful transfer of "tangible", "market-based" knowledge and technology (Reinhardt and Steinbeis-Stiftung; 2009). The German Steinbeis centres create bridges between science, academia, trade and industry (Reinhardt and Steinbeis-Stiftung; 2009). Their portfolio of services offers: consulting, research and development, training and employee development, as well as evaluation and expert services (Reinhardt and Steinbeis-Stiftung; 2009). The concept of making the expertise and infrastructure of universities of technology available to industry and society is accepted as the so-called "third academic mission" of universities. The DST (then called the Department of Arts, Culture, Technology and Science, DACTS, at the inception of the

[1] The abbreviations in the text were kept to a limit of only five abbreviations for ease of reading. This is why the "DST" is abbreviated (as it was an important title, used frequently), while the Department of Economic Development, for example, was not abbreviated. Various other titles that could have been abbreviated were not for this reason.

Technology Stations Programme) developed, and modeled the Technology Stations Programme after the "Steinbeis Principle" and Steinbeis centres, with the objective of strengthening technological innovation activities (TIA; 2013). The aim was (and remains) to increase the relative competitiveness of existing technology based SMMEs in targeted sectors, in the regional, national and global markets (TIA; 2013).

1.2 Problem Statement

The Economic Development Department's reference to the sluggish growth of the South African economy has much to do with industrial sectors in particular experiencing a slow overall decline (especially in manufacturing, a key industrial sector) (Tregenna; 2008). Most literature blames the decline on failed structural transformation as a result of: poor Macroeconomic policy (e.g. inappropriate trade liberalization), outdated technology and constrained input access, rising global competition, poor skills, etc. (Takala-Greenish; 2008). Part of the solution to this decline has to do with expanding the South African innovation base to fully optimize the supposed 'knowledge-economy' through a state-industry-university relationship (DST; 2013). This is at least according to policy statements. The Technology Stations Programme therefore arises in the context of "innovation to stimulate industrial growth" and exists to achieve this by providing technology support and skills upgrading to SMMEs (through the provision of: tests, analysis, training, technology demonstrations and product design) (TIA; 2014). The programme brings together SMMEs (industry), and academics (who work in Technology Stations located on the campuses of universities of technology) to cooperatively produce innovation for industrial and economic value. Beyond this cooperation between SMMEs and academics, South African innovation policy for industrial work is further cooperative because of its multi-departmental nature, where part of the Department of Trade and Industry's Industrial Policy Action Plan (IPAP) is to facilitate the growth and the strengthening of SMMEs by working closely with the DST to bring science and technology products and services into the market place (DTI; 2013). The DST's TIA, in other words, supports the Department of Trade and Industry's intention (with respect to science and technology for economic value) through the technology transfer taking place from the universities of technology to the SMMEs in the Technology Stations Programme.

It is not clear, however, how exactly the outcomes of the relationship between the Technology Stations and SMMEs are measured and then evaluated by the TIA insofar as it achieves the agency's stipulated strategic innovation aims for creating economic value. In other words, the relationship between performance indicators and strategic objectives is not explicit; making it difficult to concretely identify what the Technology Stations Programme has achieved.

1.3 Purpose of the Study

This study aims to achieve a clearer understanding of what the Technology Stations Programme achieves towards industrial policy through innovation work, and how the TIA evaluates these achievements. It is hence concerned with the coherence between indicators for evaluation and the set of strategic objectives assigned to the Technology Stations Programme. The need to understand how evaluation happens and what the indicators used are arises in the light of the difficulty associated with monitoring and evaluating any programme.

1.4 Research Questions

To achieve the aim of this study as articulated above, the broad research question answered in the study is: "What value does the TIA find in the relationship between SMMEs and the Technology Stations?; What does the Technology Stations Programme achieve?; and How does the TIA measure and evaluate the outcomes of the engagement between SMMEs and Technology Stations for its objectives towards industrialization?"

In order to answer this broad question, the following sub-questions will be used to guide the findings and analysis of this study.

Sub-questions:

1. "What indicators are used to measure the achievement of the Technology Stations Programme's objectives?

2. What is the relationship between the indicators applied to measure this achievement, and the strategic economic objectives of the Technology Stations Programme for industrialization?;
3. And then is, or are the indicators(s) adequate? (In other words, is there a clear relationship between indicators and objectives?; making the indicators of a good quality)"

1.5 Importance of the Study

This study is organized (through the "Problem Statement", "Purpose of the Study" and "Research Questions") to present a highly relevant and current discussion in South Africa, where the "knowledge economy" is spoken of highly, and eagerly pursued under the theme "innovation for industrial stimulation". To pursue the "knowledge economy" for "innovation for industrial stimulation", the South African government positions the notion of 'technology transfer' within a 'super system' that requires overlapping interactions between a number of government agencies and departments (e.g. the DST, Department of Trade and Industry, Department of Higher Education and Training, National Research Foundation, etc.). The system is an elaborate one, to which high expectations are attached (such as alleviating science and technology challenges in various sector (TIA; 2012)).

Monitoring and evaluation is a part of all governments' policy cycles and is often pointed out as problematic because of issues around: data collection and use, the difficulty of sorting between cause and effect, and sorting between short and long term effects among other difficulties (Coglianese; 2012). Policy evaluation is conducted so as to make known and understood the effects of policies once they are implemented, assessing them in terms of: efficiency, validity and hence, necessity (U.S Department of State; 2013). Very often, however, it does not do this. Adequate evaluation is crucial as it enables governments to improve the policy planning and implementation process; ensuring that limited state funding and other resources are put to their best use.

This study can aid the South African government in better understanding its procedures for monitoring and evaluation of the Technology Stations Programme and performance reporting, as well as their adequacy or lack thereof. It therefore has the potential to contribute to better formulated evaluation policy and future policy planning.

Chapter 2: Literature Review

In order to identify previous research on this topic, locate the topic in current research and develop a conceptual framework to assess the TIA's evaluation policy regarding the outcomes of technology transfer in the Technology Stations Programme, the key concepts presented in this literature review are: the 'knowledge economy' and the 'capitalization of knowledge', the 'Triple Helix Model', the 'entrepreneurial state' and 'entrepreneurial university', 'industrial policy and innovation'; and lastly "best practice in the evaluation of TTOs". The importance of TTOs for boosting innovative performance has been highlighted by both literature and empirical research (Kodama, 2008), making them a relevant and current area of research because of what is anticipated they can achieve industrially. Whether the TIA, through the Technology Stations Programme is an effective TTO rests on its achievement of the strategic objectives geared towards closing the South African innovation chasm and stimulating industrialization. This necessitates adequate evaluation so that where there are shortcomings, these may be addressed and policy may be adjusted to achieve successful outcomes.

For a programme as important as the Technology Stations Programme, adequate evaluation that captures the effects on industrial sectors should be carried out. The findings of evaluations should also be publicly availed, and transparently so through both the TIA and DST - making clear the evaluation policy that brings the TIA to its final reports on the outcomes of the Technology Stations Programme. The literature that follows situates this issue in the context of the aforementioned key concepts and current literature, mapping out the current landscape of technology transfer.

2.1 The Knowledge *Economy*

When states actively pursue a 'knowledge economy' (as many claim to do in policy statements), they buy into the need for innovation if such an economy is to flourish (Amidon, 1997). Innovation is required if economies want to survive in the very competitive global knowledge economy (Lundvall; 2010). Current literature on knowledge economies suggests that the belief in the nature of modern economies being more about intangible capital (and in particular, intellectual capital such as knowledge) is widely accepted (Lin and Edvinsson, 2011; Lopes et al., 2005). Livingstone and Guile point out that as a result, popular discourse and opinion accepts the existence (or potential existence for countries lagging) of a 'knowledge economy' without question (2012: 13). "We start by noting that the existence of a 'knowledge-based economy' is widely taken for granted by governments, mass media, public opinion, and most scholars today." (Livingstone and Guile; 2012: 13). To point out the global transition towards knowledge economies, it is said that changes from earlier economies (which were characterized by industrial and mass production, as well as service sectors; (Chandler; 1992)) began around the late 1960s, where knowledge creation and accumulation gained strong momentum (through changes in knowledge instruments like information and communication technologies (ICTs) and the internet) (Powell and Snellman; 2004). This history of the use of knowledge instruments such as information and communication technologies is in line with the claim that: "Contemporary advocates of knowledge-based economies have tended to focus on cognitive, rationalist, formalist aspects of knowledge and their relevance for the production of new knowledge-intensive commodities." (Livingstone and Guile; 2012: 14). Stam and Garnsey assert that the emergence of a knowledge economy is not confined to high technology and information and communication technologies, but rather, knowledge economies engage science and technology and "knowledge of practice" across all sectors of market economies (Stam and Garnsey; 2007). Ideas around using knowledge to generate economic added value make what is the theory of the 'Capitalization of Knowledge' (Viale, R. and Etzkowitz, H.; 2010) – where economic value can be direct (i.e. through sale of the knowledge for a financial, material gain or other gain) or indirect (leading to the production of material or service goods for sale) (Viale; 2010). These ideas of knowledge for innovation and economic value through the capitalization of knowledge inform the emergence of Technology Transfer Organizations (TTOs) such as the TIA's Technology Stations Programme, which is part of the drive to improve South Africa's innovation

base (Pretorius and Oerlemans; 2006). These ideas are also part of the global notion of 'Mode 2 knowledge production' where knowledge or research is carried out for application through the direct influence of societal needs on the knowledge production (Tuunainen; 2002).

The Department of Higher Education and Training (DHET) says in the White Paper of 2013 that it wishes to increase research and innovation through funding and the alignment of skills development with national priorities (2013: xvi). This presents issues around what type of knowledge is useful, changing occupational and skills structures to privilege certain kinds of knowledge production and knowledge workers (generally in the sciences and technologies) in a potential knowledge economy (NSW Board of Vocational Education and Training: 2000). In a critique against these ideas, Allais writes that the idea of a knowledge economy is problematic because it conceptually shrinks the definition of knowledge, equating it with 'information' or 'fact' (2014: 140). In another paper Allais goes on to say that economic problems are redefined as having to do with the need for "useful" knowledge and skills in the context of developing human capital (2011: 1). Brinkley explains that it was argued (and implicitly predicted) at one point that the information and communication technology revolution would allow firms to exploit scientific and technical knowledge bases, giving them a competitive edge and changing employment relations to make knowledge workers "self-employed", "free-lance" type workers – but instead the "dot.com" crash led to the opposite of this prediction (2006: 5). Brinkley says that this failure led to the belief that perhaps the "new and emerging knowledge economy" was not in fact emerging – leading many to question whether a knowledge economy is coming or exists at all (2006: 5). Some knowledge economy theorists argue that all human economies are in fact knowledge based anyway – that the 'knowledge economy' is not a new idea. To support this, it is argued that over the course of history, our species has gathered information from its environment, processing it into useful knowledge to cope effectively with changes (Chang; 2010).

The tensions discussed in the literature corroborate what Livingstone and Guile argue - that the problems with the idea of a 'knowledge economy' mean that there is little clarity or consistency in debates in economics or sociology around the extent of the move into a knowledge economy (Livingstone and Guile; 2012). This therefore means that policy formulation that arises to

stimulate the knowledge economy may be troublesome when there is no clarity on the idea of the knowledge economy itself, let alone what can be done with it for innovation work in industrial policy. What this means for the TIA's evaluation of the Technology Stations Programme is that relating evaluation indicators to strategic objectives may be difficult because of the problem of defining what indicators point to a movement towards a knowledge economy that effectively and productively exploits innovation for economic value.

2.2 Theoretical Framework: Triple Helix Model

While it is unclear whether a knowledge economy exists or not, the South African government has set out to align its policies with what is consistent with a drive towards a knowledge economy. The idea of a knowledge economy leads to the hybridization of, and integration between organizations, creating TTOs such as the TIA's Technology Stations Programme. TTOs can be organized in a number of ways, being either public or private in nature (European Commission, 2004). They are for example incubators, science parks, research laboratories, etc. According to Comacchio and Bonesso, their mission is to provide knowledge intensive services to firms in different phases of their innovation process and to be part of the knowledge transfer infrastructure that promotes and facilitates networking activities between firms and research institutions (2012: 127). The emergence of TTOs stems from the 'Triple Helix' model.

'Triple Helix' initiatives involve academia, government and industry, and have (since the 1970s in the USA, and the 1980s in Europe) spurred the birth of a number of actors whose task it is to facilitate the transfer of scientific knowledge from universities to firms (Bradley et al; 2013). The key concepts presented in the Bradley et al framework are: 'technology transfer', 'intellectual property', 'patents', 'innovation' and 'commercialization' (2013: 3). The 'intellectual property' and 'patents' items will be used in this research such that they explain the features of an innovation system when 'knowledge goods' are exchanged during knowledge or technology transfer for market use (i.e. knowledge capitalization). Evolving innovation systems have led to debates around which path may be deemed most appropriate for state-university-industry relationships, leading to varying institutional arrangements of a 'Triple-Helix' nature (Etzkowitz and Leydesdorff; 2000). The Bradley et al. framework used here is by no means the only existing 'Triple-Helix' arrangement as state-industry-university relationships have been configured in a

variety of ways over the course of history (Farinha and Ferreira; 2012). Tuunainen suggests that the 'Triple-Helix' framework is problematic as it glosses over vital conceptual insights such as the distinction between theoretical, methodological and applied dimensions of research programmes (2002: 1). These contradictions arise when universities must commercialize research and cause potential failures in creating a hybrid community between academia and industry (primarily because of a clash of values), etc. (2002: 1).

Figure 2.1 illustrates the Bradley et al model. The solid black arrows indicate the processes of technology transfer, while the gray dashed arrows indicate factors that influence these processes (Bradley et al; 2013). The process begins with a scientific discovery where the inventor may be a university scientist, graduate student or research team (Bradley et al; 2013). Also indicated in the beginning of this heuristic are the possible funding sources that facilitate discovery (e.g. government grants, corporate contracts, donations, venture capital funds, etc.) (Bradley; 2013). Transfer takes off such that the academic may or may not choose to disclose his invention to the TTO in the model below (Bradley et al; 2013).

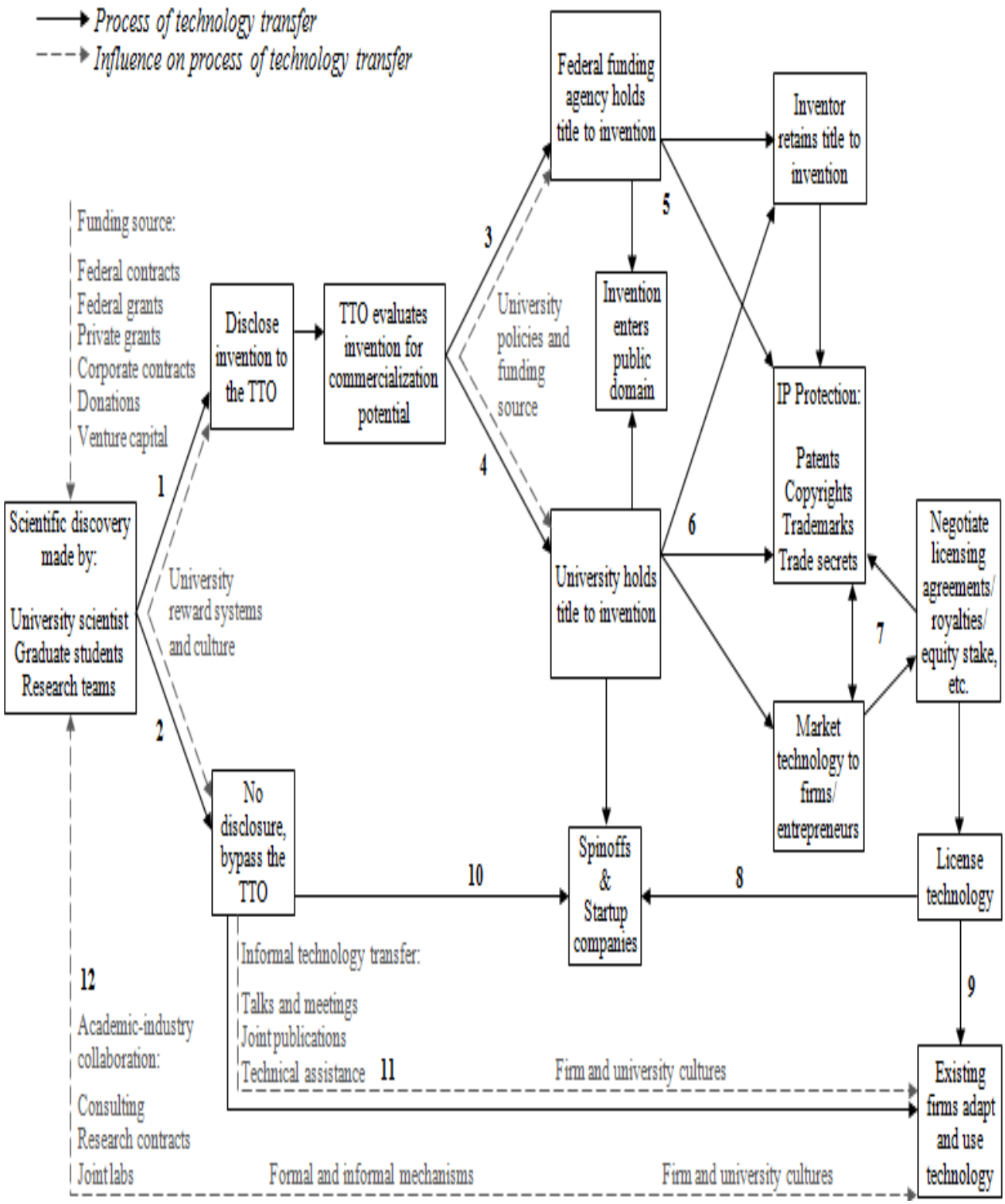

Figure 2.1: Revised Triple Helix Model

In light of the above model, the theoretical underpinnings of this research will be derived from the notion of the 'Entrepreneurial State' and 'Entrepreneurial University' required for a 'Triple Helix' model. Schumpeter's work of 1911 in "The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest and the Business Cycle" defines the concept of the "entrepreneur as innovator" as a key concept fostering economic development because innovative activities lead to "creative destruction", leading to the kind of disturbances that rebalance the economic system and lead to opportunities for wealth creation (Wong et al., 2005 and Kim et al., 2011). In this research, these theories of the 'Entrepreneurial State' and 'Entrepreneurial University' will define and describe the current face of South African government (i.e. the DST and TIA) and universities of technology involved in expanding the innovation base through the Technology Stations Programme - explaining their behaviour, the capabilities required of them for technology transfer, as well as how and why they capitalize knowledge. The next section explains these theories of the state and university further:

2.2.1 Entrepreneurial University - Higher education has evolved because of its position in the context of globalization, neo-liberal politics, modern culture, and the multiplicity of institutional changes resulting from these trends (Bullard; 2007). The trends destabilize the traditional patterns of the academic profession and place faculty directly in the market place (to innovate for industry) (Bullard; 2007). The evolution of academia has had to do with the state cutting down on the funds put towards higher education. Fairweather (1988) points to the need for universities to partner with industry, turning their focus toward innovative product development to create a new stream of revenue for themselves. An entrepreneurial university achieves: entrepreneurial (productive) research, and productive technology transfer offices. Further, it aids the establishment of new firms, and has strong networks of innovation (Rothaermel et al.; 2007). Universities are grappling to define what 'social responsiveness' means (where 'social responsiveness' is at the crux of being an entrepreneurial university), and what strategic and systemic changes are taking place – or should take place – to realize new visions (Hall; 2010). Entrepreneurial universities operate in complex environments where industries can accrue power, allowing them to shape university curricula e.g. standardizing and routinizing faculty

work, one of the many disadvantages associated with the university-industry partnership (Gumport and Pusser; 1995).

The pressure to be 'socially responsive' explains the impetus behind the involvement of South African universities of technology in the Technology Stations Programme. This pressure has the capacity to influence the outcomes desired by these academic institutions and the way in which they evaluate the value that they take from the programme given the pros and cons of academic entrepreneurialism.

2.2.2 Entrepreneurial State - The technology transfer process between universities and SMMEs can be stifled because independent university-industry linkages imply high search costs, since firms need to invest much time and resources in seeking and assessing potential academic partners (Comacchio and Bonesso; 2012). This necessitates state intervention for technology transfer initiatives, where the state creates a 'space' or 'system' for industry and university to meet – reducing transaction costs (Adams; 2006). This may be referred to as a 'super system' because it is often elaborate in terms of the number and types of stakeholders involved, and the interactions between them. Mazzucato emphasizes the need for such a 'super system' in knowledge transfer (2011: 15). "Innovation is far more likely to happen when it is commissioned via a multitude of contracts for particular advances or technological solutions, rather than by — for example — providing tax credits for general research and development, or badgering the banks to lend more to certain parts of the economy." (Mazzucato; 2011: 15). In response to a blog in 'The Economist' for the article "Schumpeter: The Entrepreneurial State", Mazzucato clarifies that states are not necessarily entrepreneurial, but "CAN" be (The Economist; 2013). She says in her comment that the example of Silicon Valley demonstrates that 'bottom-up' innovation efforts, that are dynamic, coordinated in a more de-centralized manner through ministries and well-funded state agencies, are more successful that 'top-down efforts' (The Economist; 2013).

The common neoclassical misconception is that the state's role should merely be to incentivize the private sector to innovate (Karagiannis and Zagros; 2007). Mazzucato, however, calls on the

state to be proactive, targeted, risk-taking, and hence entrepreneurial – creating a highly networked system of actors harnessing the best of the private sector for the medium and long-term national economic good (2011: 20). Such a state would fund the most uncertain phase of the research, which the private sector is too risk-averse to engage with; seeking and commissioning further developments, and even overseeing the commercialisation process (Mazzucato; 2011). This was the nature of the state when the USA established the Orphan Drug Act (ODA), making it possible for small, dedicated biotech firms (through subsidies, fast tracked drug approval, etc.) to break into the market (Mazzucato; 2011). This was the case too in the exemplary East Asian states after the 1960's (Amsden; 1991).

This theory will be used to establish the types of capabilities (e.g. political will, flexibility, etc.) required of an 'entrepreneurial state' that pursues technology transfer policy; using this lens to identify the function of the South African state at the point of evaluation in the Technology Stations Programme for industrialization through innovation work.

2.3 South African Industrial Policy in the Context of Innovation Work

The work on 'Triple-Helix' engagement discussed above is located in the industrial context of a country, in this case South Africa. In the globalized context, an institutional model of late industrialization can be said to be taking shape conceptually across the world, influencing domestic industrial policy in various late-industrializers (Steinfeld, 2004; Veloso and Soto, 2001). This late industrialization can be characterized in the following way: "Whereas industrialization in the eighteenth and nineteenth centuries was propelled by new products and processes, late industrialization is being driven by borrowing technology or "learning."" (Amsden; 1991: 285). Recent research has highlighted the importance of technology strategies in influencing the economic performance of firms in developing countries, which often are late-industrializers. Attention has been focused on two types of technology strategies. The first involves adopting technologies developed elsewhere without undertaking any modifications, while the second involves investing in such technologies but adapting them to suit firm-specific needs and circumstances (Deraniyagala; 2001). Research shows that firms adopting Strategy 2 have higher levels of efficiency (Deraniyagala; 2001). Deraniyagala's study, provides strong support for the argument that productivity enhancement in developing country firms is not

merely a straightforward process of purchasing new technologies, but requires considerable in-house effort to operationalize these technologies (2001: 23). It would seem that the TIA's work in developing the South African innovation base for industrial policy is in line with this view.

The Department of Trade and Industry's policy for industrialisation is comprehensively set out in the Industrial Policy Action Plan, which outlines the transversal and sector specific programmes and interventions that the department has committed to for economic growth. The Industrial Policy Action Plan is informed by the National Development Plan; which lies in the country's vision for an equitable society (Department of Trade and Industry; 2013). "Government policy set out in the Industrial Policy Action Plan and other documents seek to ensure a restructuring of the economy to set it on a more value-adding, labour-intensive and environmentally sustainable growth path." (Department of Trade and Industry; 2013: 11). To do this the Department of Trade and Industry strives to: promote diversification beyond traditional and non-tradable goods and services to compete in export markets; improve the African continent's productive capacity and ensure long term intensification of South Africa's industrialisation process and movement towards a knowledge economy; etc. (2013: 11). The Industrial Policy Action Plan identifies, among other constraints on industrialisation, a skills deficit and mismatch as well as dwindling private sector investment in research and development (Department of Trade and Industry; 2013). The latter is identified as a constraint on expanding the South African innovation base. The next section discusses innovation for industrialization. Innovation work, as expressed by the Department of Higher Education and Training (DHET) (in the Ten-Year Innovation Plan of 2007) can help realize the aims of the National Development Plan, the New growth Path, and the Industrial Policy Action Plan (2013: 34).

2.3.1 Innovation for Industrialization at the DST - The Department of Trade and Industry's stance on innovation for industrialisation is that there are gaps and opportunities for a stronger support mechanism for commercialisation of innovation and new technologies to improve local manufacturing capabilities for South African competitiveness (2013: 40). The DST (through the National Research and Development Strategy), with its associated science councils and research institutes oversees South African innovation strategy (DTI; 2013). Its work on innovation in the context of industrialization is informed by the Industrial Policy Action Plan. The Department of

Trade and Industry states for example that: "Government has a target of increasing and sustaining research and development expenditure to at least 1% of GDP." (Department of Trade and Industry; 2013: 65); and the DST implements strategies to contribute to achieving this goal. With the DST partnering with the Department of Trade and Industry, the TIA emerges as an entity reporting directly to the DST.

While the literature on the economics of innovation often assumes a direct causal link between research and development, and innovation, and between innovation and economic growth, there are very few studies which prove that innovation carried out by large or small firms actually increases their growth performance. Some company level studies have found a positive impact of innovation on growth; others observe no significant impact, or instead observe a negative one (Mazzucato; 2011). Given this uncertainty, it is essential that the evaluation of innovation strategies at the Technology Stations Programme be assessed to find what the results are given firm and country specifics. More uncertainty surrounds firms, particularly SMMEs in knowledge transfer.

2.4 Small Medium and Micro Enterprises (SMMEs)

As the literature on South African industrial policy points out, the South African work on innovation for industrial policy has a particular focus on SMMEs. The idea that engagement between SMMEs and academic research institutions is productive for the South African economy comes from work such as the South African "Economic Outlook" review, which stated that during 2012 South Africa had 2.8 million SMMEs, contributing to 52%-57% of national GDP (National Treasury; 2012). Other work by the South African National Treasury has also previously suggested that during 2007 SMMEs provided 60% of jobs in the country and made up roughly 40% of the country's remuneration (2008). Further research by the National Treasury highlights that big corporate firms are shedding jobs in South Africa, and that international trends (in East Asia during the late 1990s and early 2000s) suggest that economic booms in middle-income countries have largely been thanks to the existence of a strong SMME sector (2012). While the story is more complex than this when it comes to South African SMMEs (where generally 76% of South African SMMEs fail in their first 2 years (Financial Mail; 2014), and the informal sector is where most "entrepreneurship" takes place), there is the belief that

access to credit, and now access to world class technologies may be the solution to the problem of failing SMMEs and a lack of SMMEs in the right sectors (Independent Evaluation Group, World Bank; 2013). Many, it would seem, buy into the power of the SMME, so much so that the South African government has introduced a ministry dedicated solely to SMMEs (i.e the Department of Small Business Development). The World Bank promotes SMMEs as entities that play the "competitive" game differently from big corporate firms, making their approach "nimble" and "efficiency and productivity" achieving – and hence setting them apart (N.D. : 1, 28). Despite this positive outlook, the South African SMME Business Confidence Index in the fourth quarter of 2014 declined (possibly because of a decline in SMMEs' confidence in industrial and trade sectors of the economy) (African Growth Institute; 2014).

While SMMEs are continually prioritized for economic gains (e.g. the Department of Trade and Industry prioritizes SMMEs to advance entrepreneurship by creating demand for inputs from SMMEs in various sectors, generating employment for the less skilled, etc. (Berry et al 2002)); Branco identifies a number of problems with the SMME argument for development - two of which are particularly significant for this study. "First, the concept of SMMEs is not clear as definitions are arbitrary and vary significantly according to different stages of economic development, economic structures..." (2003: 1). Ndabeni writes that the term 'SMME' in South Africa is used to describe activities that differ in size, formality, structure and sector (2010: 2). This is of interest because it is not clear what the selection criteria for SMMEs that will collaborate with the Technology Stations Programme are either (shown later in the findings of this study). Also, if SMMEs are ill-defined; it is difficult to forecast what they can deliver (Branco; 2003). Second, Branco speaks on the many arguments around SMMEs, which mean that there is no clarity as to what exactly SMMEs can deliver for economic growth (2003: 4). "If SMMEs are not specifically defined with respect to more decisive development goals, then there is no set of policies that adequately addresses the SMME issue." (Branco; 2013).

One finding by Mazzucato, namely that the impact of innovation on growth is varying for different types of firms, has important implications for the commonly held assumption that 'small firms' such as SMMEs matter (for growth and innovation) (2011: 37). "The hype around small firms arises mainly from the confusion between size and growth." (Mazzucato; 2011: 37).

According to Mazzucato, the most robust evidence is not on the role of small firms in the economy, but the role of *young,* high growth firms (2011: 37). While many high growth firms are small, many small firms are not necessarily high growth (Mazzucato; 2011).

The "SMME" is therefore a "slippery" concept, and for the TIA and Technology Stations Programme to make it a focus, and the vehicle through which innovation will be translated into economic gains necessitates that the entities be clear on what kind of SMMEs they're looking for. Extensive thought must be given to the sort of characteristics that these SMMEs must have in order for them to have the propensity to produce the desired economic value post "technology assimilation", and post the development of their "innovative capacity" through the Technology Stations Programme.

2.5 Evaluating Knowledge Transfer

Each of the key areas discussed in this review build up to the need for well formulated monitoring and evaluation that views technology transfer as a 'work in progress' needing further definition and consideration (which can only happen through monitoring and evaluation as manifestations are observed) particularly in developing countries where it's newly adopted. This is why it is essential that the TIA undertake adequate evaluation of the Technology Stations Programme, identifying the right indicators so that the costs and benefits associated with the programme are clearly visible and can be objectively judged. Trochim defines evaluation policy as: "...any rule or principle that a group or organization uses to guide its decisions and actions when doing evaluation." (Trochim; 2009: 13). With regard to knowledge transfer programmes and their performances, it is important to identify appropriate proxy variables in evaluation (World Bank; 2004). For medium income countries, data relating to the evolution of the patenting activity (including deposits in national regimes), levels of business research and development, the capacity of retention of educated workforces, and the rates of the creation and growth of new firms, are highly relevant (World Bank; 2004: 30).

During the last decade, European institutions have sponsored initiatives to identify methodologies that will support TTOs in defining their objectives (Comacchio and Bonnesso;

2012). The initiatives also assess the way these objectives are being fulfilled and set up permanent monitoring systems that can guarantee the evaluation of performance over time (European Commission, 2009; Guy, 1996). Comacchio and Bonesso discuss the many attempts towards some definition of an evaluation system for TTOs and how they've encountered a number of difficulties due to the characteristics of TTOs (e.g. their broad mission statements and wide range of aims that are difficult to identify, monitor and evaluate) (2012: 136). This is particularly clear for the TIA, which largely adopts the aims of the Industrial Policy Action Plan. The Industrial Policy Action Plan itself presents broad economic objectives such as diversifying the economy, creating sustainable jobs, etc. Furthermore, the strategies and the subsequent business models implemented by the TIA (like most TTOs) are determined by multiple stakeholders, not just the DST and Department of Trade and Industry. This is evident when on the one hand, local institutions aim to obtain an objective approach to measure the returns from allocated resources and plan future investments; and on the other, firms want to obtain a performance appraisal tool that enables them to compare TTOs and select the effective partner to involve in their innovation process (Bigliardi et al., 2006). Other challenges include the problem that TTOs do not produce instant results, or that measurement of results must be both at the micro and macro level (generating problems in terms of isolating the results that are firm specific versus regional in impact (Gardner et al., 2010; Guy, 1996).). The broad services portfolios of TTOs also mean that the outcome of each service requires a different indicator.

This literature for monitoring and evaluating knowledge transfer seeks to simplify, and clearly mark out the process of evaluation (known to be difficult) for organizations with interactions that take place on a large scale and between a number of stakeholders. This gives some idea as to the challenges that the TIA must navigate to adequately monitor and evaluate the Technology Stations Programme.

2.6 Conceptual Framework

According to Ben-Arieh and Fiones, dictionaries define indicators as something denoting something, a pointing or directing device - and indicators may refer to the state of the present (2011: 462). Ben-Arieh and Fornes emphasize that indicators interact with measurement techniques and tools and the choice of measurements influences the form and content of

indicators (2011: 462). The process has specific nodes or subfields: the unit of observation; the source of information; and whether the indicators are direct or indirect (Ben-Arieh and Fornes; 2011: 469). Because policy-makers and social services planners increasingly rely on economic and social indicators to bridge goals and practical action, as well as guide social policies, the quality of indicators is critical (Ben-Arieh and Frones; 2011). "Quality refers not only to the validity of indicators, their reliability or technical standard, but also to the framework of understanding, and theory on which they implicitly or explicitly rest." (Ben-Arieh and Frones; 2011: 460). Using Franceschini et al's taxonomy of indicators' properties as a framework, an analysis of the TIA's indicators for the strategic objectives attached to the Technology Stations Programme will be carried out according to the: general properties of indicators (consistency with the representation target, level of detail, simplicity of use, etc.), properties of sets of indicators (exhaustiveness and non-redundancy), and properties of derived indicators (monotony and compensation) (2007). This framework guides the process of developing indicators, providing a structure for quality assessment in indicators and will be further described in the **Data Analysis** section of the **Methodology** in **Chapter 3**.

This conceptual framework will both describe and facilitate an initial evaluation of the indicators for monitoring and evaluation applied by the TIA to the Technology Stations Programme. The analysis enables readers to better observe whether the indicators applied for reporting demonstrate what the Technology Stations Programme does and does not achieve for South African innovation in industrialization, and does so through a systematic description and evaluation of their properties.

2.7 Conclusion

It can be concluded then that the knowledge gap lies in the lack of available knowledge regarding the TIA's process of evaluation and what leads it to the final reports produced on the outcomes of the Technology Stations Programme. This gap is of concern give not only the money spent on the Technology Stations Programme and the known difficulties often anticipated in monitoring and evaluating any programme – but the DST has almost "leapt" into technology transfer work in an abrupt and grand way (through a massive inter-departmental National System of innovation) despite the shakiness (given the various debates in the literature) of technology

transfer, suggesting either that it remains highly optimistic about outcomes of technology transfer despite the debates, or that it lacks a full and complete awareness of the dynamics of the technology transfer landscape. This is further concerning as developing countries are new implementers of technology transfer initiatives and one would expect a more gradual entry into the space.

Capturing these issues, this study presents an analysis of the Technology Stations Programmes monitoring and evaluation approach. As such, it provides additional insight into evaluation work in technology transfer and the need to understand a multiplicity of factors for the South African National Innovation System, and does so by unpacking the various properties of the indicators used to report on economic and socio-economic outcomes of the Technology Stations Programmes. The analytic contribution enables an understanding of the ideas with which the TIA would have to grapple with to facilitate and produce adequate evaluation policy (using functional indicators) that is coherent, accurate and useful in further policy work.

Chapter 3 - Methodology

3.1 Approach

The type of research that was conducted was descriptive research, as it primarily described phenomena in the TIA's evaluation system as they exist. It was an initial (not very in-depth) evaluation itself. Using the case study of the Technology Stations Programme, the research assessed the South African government's evaluation process for technology transfer aligned with industrial policy. Because the research took the form of an evaluation itself, it judged the coherence in the TIA's evaluation policy, approach and methodology. The study presents the TIA's evaluation framework for the Technology Stations Programme and the notion of "coherence" is used in relation to the alignment between indicators and objectives in the Technology Stations Programme (as part of Industrial Policy and the National System of Innovation). In other words, the research looks at the TIA's evaluation framework given that its objectives are informed by innovation policy and industrial policy, such that the Technology Stations Programme's performance will be assessed based on outcomes that contribute to "innovation for industrial policy".

The work is qualitative, answering questions regarding how evaluation takes place at the TIA as well as which indicators are used and how they're defined. It further describes how exactly the indicators are used, and presented in the TIA's final reports. Qualitative research methods are especially useful in discovering the meaning that people give to events they experience (Bogdan and Biklen, 2003; Denzin and Lincoln, 2000). Moreover, qualitative research is warranted when the nature of the research question requires exploration (Stake; 1995), where qualitative research questions often begin with "how" or "what" (Patton, 1978; Seidman, 1991).

3.2 Data Collection

The method of data collection was systematic (with a separation between data sets to be discussed later). The base work for the study took the form of 'desk-top' research, making use of official documents including: TIA annual reports; DST annual reports, the 10 Year Innovation Plan paper; the National Innovation Survey, and other related publications by the Human Sciences Research Council's Centre for Science, Technology, and Innovation Indicators. These documents enabled the researcher to situate the work of the TIA within the context of the 'super system' that is the National System for Innovation to close the innovation chasm in South Africa, illustrating the various points at which the many departments and other state entities each inform the TIA's evaluation approach for Technology Stations. Field research, conducted through semi-structured interviews, was planned with the key stakeholders that were: government (the DST and TIA), industry (the relevant SMMEs) and the academic institutions (universities of technology).

3.3 The Process of Securing Interviews

Obtaining interviews and data through the TIA and the Technology Stations was relatively easy. The organizations and their stakeholders were eager to participate and avail what information they could to achieve this study. Interviews were secured through e-mail and telephone conversations. The interview with the consultant (from the TIA's consulting affiliates in

Germany – not mentioned for the sake of anonymity) was organized through the TIA, where the consultant shared the new work taking place in the area of impact assessment at the SMME level.

To detail the failure to reach the DST, through interviews it was established that a particular individual was understood by all stakeholders to be the person to talk to at the DST about performance monitoring and evaluation for impact assessment. An attempt was made at reaching the individual via e-mail and telephone. The reply obtained by email said that the individual did not understand what was being asked of him for this study. The research question was more clearly explained, as well as the aims of this report – again, both via e-mail and telephone. The researcher got in contact with a second individual through multiple telephone calls and emails after failing to secure an interview with individual 1. Contacting individual 2 (who initially referred the researcher back to individual 1) also yielded no interview. A last attempt was again made to reach individual 1 before the researcher had to move on with the study given time constraints.

3.4 Data Obtained

The data put together for this study presents a work that is both "systems analysis" (looking at the framework and methodology for impact assessment), and "stories" (through interviews that brought to the fore the reality of policy implementation and the deviations from policy statements that these illustrate). The data obtained can be divided into 3 data sets. **Data set 1** is the selection of documents that was sourced from research participants who were interviewed. Those items cannot be specified here for the purpose of confidentiality. **Data set 2** is what is publicly available performance reporting related to the DST's innovation projects, the TIA's work as an agency, and the Technology Stations Programme as a project within the greater National Innovation System (i.e. DST's Annual Report of 2013/2014, and the TIA's Annual Reports of 2011/2012, 2012/2013 and 2013/2014 – with only one report being used from the DST as it does not report on the Technology Stations Programme in detail). Lastly, **Data set 3** is what was obtained through interview responses to the semi-structured interviews in **Appendix 4**.

The initial desktop research established what is, and is not available in the public domain regarding impact assessment for the Technology Stations Programme, and informed the choice of interview questions that served to fill the gaps on the missing information. With the discussions from the interviews (**Data set 3**), and the information availed in the documents from **Data set 1**, key concepts and ideas came to the fore, facilitating a second round of desktop research. The importance of having the right key words (i.e. key concepts and ideas) has to do with their value in enabling the researcher to search effectively for documents online. However, the need to conduct interviews to learn of these key words is troubling as it shows how elaborate the National Innovation System if one cannot easily identify the system's core ideas and concepts from reading independently. The system is complex, and what is not easily understood is how certain key words become relevant and important at certain points in the system and between certain stakeholders. The next section will describe each data set (i.e. **Data sets 1**, **2** and **3**).

Data Set 1: Data Acquired Through Stakeholders Interviewed

The documents acquired through stakeholders are confidential. They are internal documents that map out various regulations, processes and agreements for the operations of the Technology Stations Programme, and the monitoring and evaluation process.

Data Set 2: Publicly Available Performance Reporting Documents

The items here are available online and were sourced via Internet. They are: the Thsumisano Trust's Performance Reporting (before the institution was done away with and the TIA emerged), the National Innovation Survey, the TIA's Annual Reports of 2011/2012, 2012/2013 and 2013/2014, the DST's Annual Report of 2013/2024, and the European Union's Innovation Scoreboard of 2014. While there exists a Department of Performance, Monitoring and Evaluation, which aims to improve service delivery through monitoring and evaluation, it has not thus far produced anything in regard to the Technology Stations Programme (at least not so it can be accessed online). As a result, work does not feature in this study. The researcher could not

interview this department due to time constraints and the need to focus on the reporting at the immediate level of the TIA.

Data Set 3: A Description of the Interview Data (6 Interviews in total)

The chosen interviewees for this study were only those directly involved in the monitoring and evaluation of the Technology Stations Programme as this study is only a mini-dissertation that needed to remain tightly focused on establishing responses that would speak directly to the research questions. Moreover, the interviews conducted were only one aspect of the data work as document analysis was also undertaken.

1. The TIA - The first interview was an informal meeting. An overview of the Technology Stations Programme and its history were the focus of the interview. Out of this came further direction on what to potentially expect in the findings of this study i.e. how there had never really been any impact assessment before. The next interview was around the more technical aspects of monitoring and evaluation, and the theory that informs the choice of indicators used to report on the Technology Stations Programme's outcomes (i.e. Science, Engineering, Technology and Innovation best practice).

2. Consultant of the TIA's affiliate consulting organization – The consultant who had done impact assessment on the Technology Stations Programme presented findings on impact for SMME clients. The work was useful because he had access to the SMMEs that are involved in the Technology Stations Programme, access that could not be obtained by the researcher for this study. The findings express whether the SMME clients are happy or not with what they get out of the Technology Stations Programme (in **Appendix 3**).

3. Technology Stations - Four interviews were conducted with the sampled Technology Stations from the Gauteng region. These stations were chosen because the researcher had

no budget to meet with stakeholders in the Technology Stations outside of Gauteng. The aim of the questionnaires used during these interviews was not to obtain any technical information on the monitoring and evaluation process, but to establish what the interaction between the Technology Stations, and the TIA and DST is during the monitoring and evaluation process, and then also to get a sense of the attitudes of the stakeholders in the stations towards the process. What also came out were crucial stories of successes and challenges that, surprisingly, were not relayed in the performance reports publicly available online.

3.5 Data Analysis

This study concerns itself with the quality of the indicators used to produce reports on the Technology Stations Programmes. This requires a look at the relationship between the indicators used, and the objectives of the Technology Stations Programme. The Franceschini et al. conceptual framework introduced in the literature review of this study is used to demonstrate the quality of the indicators used for reporting on the Technology Stations Programme using properties defined in the framework to capture these relationships between indicators and objectives. The taxonomy for indicators presented by Franceshini et al. defines properties of indictors as follows:

This taxonomy separates indicators into two typologies before beginning to unpack them for the reader, namely: “Indicators (individual indicators) and sets of indicators (where more than one indicator covers various process points)”, and “Objective (impartial) and subjective (particular to the individual item, person or event) indicators” (where all indicators for this study are objective) (2007: 139). Moreover, Franceschini’s taxonomy identifies “basic” versus “derived indicators”. “Basic indicators are obtained from a direct observation of an empirical system (for example the “number of defectives on a product line”...). Derived (or aggregated) indicators are obtained by combining the information of one or more “sub-indicators” (basic, or other derived), which are then aggregated and synthesized.” (Franceschini et al.; 2007: 140). The same set of indicators (for a target) can be arranged in a number of ways, potentially leading to the ‘wrong’ results” if

improperly carried out (Roy and Bouyssou; 1993). Therefore, the aggregation of a derived indicator from several indicators is never easy (Franceschini; 2007). The taxonomy by Franceschini et al. goes further and classifies the properties of indicators as "properties of derived indicators", "properties of sets of indicators", "general" and "accessory" indicators (2007: 140). The paper on the taxonomy says: "These properties can represent a useful tool to select and evaluate performance indicators in different contexts." (Franceschini et al.; 2007: 140). Sets of indicators need to represent the real dimensions of a process without omissions or redundancy – i.e. they need to be "exhaustive" and have "non-redundancy". A set is non-exhaustive when it fails to refer to one, or more specific dimensions of a process. If indicators do not discriminate two process states when empirical manifestations from state 1 can be distinguished from those of state 2, it is said that the set of indicators is incomplete (Franceschini; 2007).

Figure 3.1: Franceschini et al. Taxonomy for Indicators' Properties (2006).

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Category	Properties	Short description
Properties of *sets* of indicators $S = \{I_i, I_j, I_k\}$	Exhaustiveness	Indicators should properly represent all the system dimensions, without omissions
	Non-redundancy	Indicators set should not include redundant indicators
Properties of derived indicators $(I_i, I_j, I_k) \Rightarrow I_{TOT}$	Monotony	Increase/decrease of one of the aggregated indicators should be associated with a corresponding increase/decrease of the derived indicator
	Compensation	Changes of different aggregated indicators may compensate one another, without making the derived indicator change
General properties	Consistency with the representation-target	The indicator should properly represent the representation-target
	Level of detail	The indicator should not provide more than the required information
	Non-counter-productivity	Indicators should not create incentives for counter-productive acts
	Economic impact	Each indicator should be defined considering the expenses to collect the information needed
	Simplicity of use	The indicator should be easy to understand and use
Accessory properties	Long-term goals	Indicators should encourage the achievement of process long-term goals
	Customer-oriented	Indicators should represent the process dimensions which most impact on customer satisfaction

Table I.
Proposed taxonomy of indicators properties

Source: Franceschini *et al.* (2006)

In **Chapter 4 – Findings and Analysis** a few examples are presented using this taxonomy to establish the types of indicators that those used for the Technology Stations Programme can be classified as, what properties they should therefore have, and how adequate the indicators then are (based on an observation of the properties) for clearly articulating their relationship to the listed objectives at the Technology Stations Programme to produce impact assessment. The ability to carry out such a systematic analysis using the taxonomy makes it a key component leading to the conclusion of this study. The taxonomy allows a systematic look at the "definitions" of the indicators (based on the properties of the indicators), whereas when the DST

speaks on indicators it does not systematically present these definitions through a discussion on the properties of the indictors. This is pointed out also in **Chapter 4**.

3.6 Scope and Limitations of the Study

TTOs can take a number of forms (e.g. public research organizations, incubators, etc.), not just that of government laboratories such as the TIA. These differences between TTOs mean that such organizations have differing forms of interaction between state, university and industry, as well as differing aims and outcomes. The findings of this research will therefore speak to the TIA as a TTO that is specifically mandated to supply qualified services of research and development, as well as analysis and testing to client firms. This scope means that the assessment of evaluation policy in the TIA cannot be generalized across all types of TTOs, but will be limited to laboratory type organizations. Furthermore, each framework (whether theoretical or conceptual) for evaluating knowledge transfer has its strengths and limitations, and this study will bare this in mind; not presenting any of those used for this paper as any sort of 'panacea'.

This study will focus on economic and socio-economic impact assessment of the Technology Stations Programme resulting from monitoring and evaluation. Therefore financial and other types of reporting will not feature in the study. Moreover, the paper will in some cases show awareness of other outcomes in the Technology Stations Programme (e.g. the strain that the need to expand the South African innovation base places, for instance, on the traditional culture within universities), but will not explore these further outside of their relevance for economic and socio-economic impact assessment in monitoring and evaluation.

Lastly, the inability to secure an interview with the DST may also mean that this report presents incomplete information and may lack answers to certain aspects of the research problem.

Chapter 4 –Findings and Analysis

The methodology presented above can be extended slightly to introduce what came out in the findings of this study, especially because of the varying data sets used and what they meant for difficulties that then arose during the organizing of this chapter. Recall that this study is the result of a mix of both desktop research, and interview work. The findings are organized so as to make the content as coherent as possible. The result is that the research questions are not answered in the order that they were presented in **Chapter 1**. This is because the findings were acquired from a variety of sources that make a "patch-work" of sources. Furthermore, the findings answering the research questions don't always speak directly to the research question, or in a manner that is clear and final. The discussion is therefore pulling together answers that are both explicitly and implicitly expressed, using the "patch-work" of sources to establish one train of argumentation.

To give a brief background on the monitoring and evaluation process at the Technology Stations Programme, monitoring and evaluation is known to have its difficulties, and the Technology Stations Programme is no exception. Nonetheless, the state is obliged to produce performance reporting to relay to the public what the returns were on the public expenditure allocated to the Technology Stations Programme. The state also must have some sense, however rough, of what does and does not work in the programme if it is to effectively support innovation. Early findings suggested that the Technology Stations Programme is not monitored and evaluated as well as it could be (Technology Stations Stakeholders; 2014). One interview revelation suggested that the Technology Stations Programme is 'perceived' as a smaller project relative to others housed in various agencies of the DST, receiving a substantially smaller amount of funding (Technology Stations Stakeholders; 2014). This was viewed as a possible suggestion as to why the programme then may not receive priority when it comes to monitoring and evaluation. That said, the attitudes of the DST towards the Technology Stations Programme came up a number of times during the interview process – influencing the attitudes of stakeholders towards the monitoring and evaluation process. These perceptions give the impression that some stakeholders feel that the monitoring and evaluation that takes place in the Technology Stations Programme is more a "rubber stamp" than a real effort to understand the economic and socio-economic outcomes, or

impact of the programme. This was an important finding as it was an early pointing to potentially weak monitoring and evaluation that stakeholders did not necessarily view as useful to achieve what monitoring and evaluation should so as to facilitate the decisions on the future of the programme (Technology Stations Stakeholders; 2014). This also suggests, already, that the measuring of outcomes to establish what the Technology Stations Programme achieves is not working well to allow the TIA to show what the Technology Stations Programme achieves if the outcomes are viewed as "not useful".

4.1 Where does monitoring and evaluation begin for the Technology Stations Programme?

To begin detailing the findings presented during the initial interview sessions and answering the question of how the TIA monitors and evaluates the outcomes of the Technology Stations Programme, this section will take a brief look at where the evaluation work begins in the context of the National System for Innovation.

Inevitably, monitoring and evaluation of such a large and inter-departmental nature is highly complex. The finding regarding this process was that because of the inter-departmental nature of the Technology Stations Programme and the TIA, and the national level at which the National System for Innovation is established, all innovation work within this national system is first underpinned by its location in the National Treasury's Regulatory Framework for reporting on all state entities and their programmes. Comacchio and Bonesso talk in **Chapter 2** about the difficulties associated with trying to define an evaluation system for technology transfer, particularly because TTOs tend to have broad mission statements and wide ranges of aims that are difficult to identify, let alone monitor and evaluate (2012: 136). Because the TIA and Technology Stations Programme sit within the National System for Innovation, their objectives tend to be broad and aimed at aligning the work of the entities with national priorities. The TIA's vision sums up that the work carried out ultimately seeks to stimulate and support technological innovation to improve the quality of life of South Africans (TIA; 2014). The DST also makes reference to this broad objective (of using science and technology to address socio-economic needs) in a number of its reports and other work. It certainly is not very clear what the immediate

relationship between stimulating the competitiveness of SMMEs and improving people's quality of life through innovation work is, neither do the DST or TIA go any further in their reports to try and unpack this intention (through a discussion of the anticipated mechanisms of "trickle-down" effect, or attempts at forecasting the size of the impact on the quality of lives of South Africans resulting from science and technology work).

What became clear very quickly is that the TIA's monitoring and evaluation methodology and guide emerges through the National Treasury produced framework for monitoring performance (TIA; 2013). The Technology Stations each input information about SMME clients (as they come into stations for technology related services) in a "Client Information Management System" linked via network to the TIA and DST for information sharing. Information is then organized according to the national framework, in which key concepts are outlined and defined – giving guidance on the collecting, organizing and reporting of performance information in public entities (TIA; 2013). Treasury regulations call upon state entities to carry out performance reporting according to Regulation 53 of the Treasury Regulations with Sections 27(4) and 36(5) of the Public Finance Management Act (TIA; 2013), establishing procedures for quarterly reporting. This is to facilitate effective monitoring, evaluation and, if required, "corrective action" or remedy (TIA; 2013). This already begins to address the title of this paper, which asks how the TIA evaluates the Technology Stations Programme. The agency begins by putting in place systems to secure the required data and then follows the national guide on reporting, adhering to national standards. The considerations that go into the national framework are: defining indicators, discussing titles and definitions of indicators, sources of data, the type of indicator, the responsibility or function of the indicator, the baseline indicator from the previous year, etc. (National Treausry; 2013).

All programmes of state entities have their performance information guided by this framework, enabling national tracking and a comparison between national projects. This is necessary because of the broad mission statements attached to programmes that are part of national systems. In one annex of the DST's Annual Report of 2013/2014 (on page 102) a table is presented titled "Adjusted targets as per National Treasury Prescripts" (DST; 2014). In the table there is one

example of an annual target change arising through the National Treasury, where the target goes from requiring that the Technology Stations assist 2300 SMME clients during that year, to requiring that they assist only 2000 (DST; 2014). This is visible in **Appendix 2.**

This illustrates that the TIA's evaluation approach comes from above first (i.e. it is a top-down approach), before it is an internal approach. The top-down approach is also the way in which "innovation" and "technology transfer" specific indicators applied by the TIA to evaluate the Technology Stations are established. In other words, there is the national framework for monitoring and evaluation discussed above, and it is used to establish the "innovation" and "technology transfer" specific (i.e. specifically for work in the science and technology spaces) indicators used for, and seen in reporting for the Technology Stations Programme. This "top-down" theme is important because it says the TIA's indicators are externally produced and then applied.

4.2 What are the technology transfer specific indicators used to report the Technology Stations Programme's outcomes?

Given the formal place of the indicators methodology at the national level, the next major finding for this study was firstly, that the indicators of choice for the Technology Stations Programme are the DST's SETI Scorecard of (Key Performance Indicators) KPIs. These "innovation" and "technology transfer" specific indicators are the formal indicator framework applied for the monitoring and evaluation of the Technology Stations Programme. This SETI Scorecard determines how indicators are defined for the Technology Stations Programme with a focus on the type of data acquired for projects in the SETI and innovation space. However, although the SETI indicators are referenced by the DST as the tool used to report on innovation programmes such as the Technology Stations Programme, there has never been any real economic and socio-economic impact assessment carried out using these SETI indicators.

The TIA makes use of the SETI Scorecard for the Technology Stations Programme along with other stakeholders in the SETI space such as the Council for Scientific and Industrial Research (CSIR) and the National Research Foundation (NRF) for example. To give a background on the SETI indicators, the SETI indicators emerge from the work of the Human Sciences Research

Council's Centre for Science, Technology and Innovation Indicators. "The Centre for Science, Technology and Innovation Indicators was established to undertake national R&D innovation surveys on behalf of the Department of Science and Technology and to produce national indicators from the survey results to provide inputs for policy makers and a basis for international comparison." (Human Science Research Council; 2014). The National Innovation Survey is part of the DST's effort to establish baseline indicators to be used for monitoring, reporting on and fine-tuning the National System of Innovation (Human Sciences Research Council, CSTII; 2014). The survey is modeled after the European Union's work (referred to by the Centre for Science, Technology and Innovation Indicators as "best practice"), and presents findings over the period 2005 – 2007 (Centre for Science, Technology and Innovation Indicators; 2011). It attempts to replicate itself after the European Union's "Community Innovation Survey". The data in the European Union's survey sets out a methodology used to establish "composite indicators" (which rest on a theoretical framework or definition, allowing individual indicators or variables to be selected, combined and weighted to reflect the phenomena being measured). It explicitly presents and defines 25 indicators, and using them, categorizes states as innovation leaders, followers, moderate innovators and modest innovators (European Union; 2014).

Attempting to replicate itself after the European Union's work, the South African National Innovation Survey of 2008 asks questions to firms categorized according to: 1. General information about the firm; 2. Product (goods or services) innovation; 3. Process Innovation; etc. (Centre for Science, Technology and Innovation Indicators; 2008). The results presented discuss the items such as the total number of enterprises that participated in the survey, how many had innovation activity, the firm's turnover, etc. (Council for Science, technology and Innovation Indicators; 2011). Unlike the European Union's work, no finite number of indicators comes out of the South African National Innovation survey with the sort of definitions, use of variables and weighting presented in the European Union's 25 indictors. The National Innovation Survey therefore seemingly falls short of really lifting the results out of the survey to produce the required baseline of indicators that the DST mandates it to produce. The National Innovation System is hence far from being as sophisticated and detailed as the European Union's system of indicators. There is essentially little clarity on what the South African SETI Scorecard consists of (despite policy reports referring to the National Innovation Survey as the work from which a

baseline of SETI indicators is established). It would seem the term "SETI Scorecard" is loosely used to hide behind a lack of functional monitoring and evaluation methodology for technology transfer, explaining the lack of real economic and socio-economic impact assessment thus far (where **one confidential document** showed an example of SETI Performance Reporting from when the Technology Stations Programme was with the Tshumisano Trust, with the "Social Impact" column left completely blank). The attempts at impact assessment (through perception surveys and interviews conducted with the Technology Stations Programme's SMME clients) have been initial attempts at producing impact assessment, needing further development still. The results of the impact assessment carried out on SMME clients are in **Appendix 3** and show that more needs to be done to produce output on what "regional or sectoral economic impact" was in response to the cost cutting experienced by SMMEs in the Technology Stations Programme. Later, an analysis using the Franceschini et al. taxonomy of indicators will demonstrate that the SETI indicators seem "empty" (lack the required properties) and may be unable to facilitate impact assessment, possibly contributing to this lack of impact assessment.

Of further concern is that the work that is publicly available on performance reporting doesn't make reference to these frameworks (the SETI Scorecard and the National Innovation Survey) in direct discussion about the TIA and the Technology Stations Programme (although it does for older SETI programmes or entities such as the Centre for Scientific and Industrial Research). Recall that the "Problem Statement" for this study has to do with the lack of publicly available information explicitly outlining how the outcomes of the Technology Stations Programme are measured, and the theory or framework that informs the relationship between indicators and objectives (in other words, a guide on how the TIA gets to the results that it publishes in its reports). It was through the data acquired during the interview process that it was established that the SETI indicators are used for the Technology Stations Programme and that the reports visible online are informed by the SETI Scorecard that is a product of the National Innovation Survey. **Chapter 2** emphasizes the Triple Helix model for technology transfer projects. What it does not point out is that often the Triple Helix engagement involves both a variety of stakeholders, and a variety of projects falling under numerous government departments and agencies (in other words the system of engagement can get more complex than what the Triple Helix Model suggests –

where unlike the diagram, arrows of interaction between stakeholders can move in both directions). In this case, the DST mandates the Centre for Sciences, Technology and Innovation Indicators at the Human Sciences Research Council to carry out innovation surveys that then provide a baseline of indicators for Science, Engineering, Technology and Innovation programmes. The work on indicators then goes back through the DST to take a top-down approach of feeding these indicators into agencies such as the TIA for the performance monitoring of their programmes. This relationship between and across entities and agencies is difficult to track with no background information as the DST website does not neatly direct individuals between entities and agencies, or mention the SETI Scorecard clearly enough to make known where it comes from and which entities create it, and use it.

This information allows us to conclude that the TIA uses SETI indicators, but that with them no real impact assessment has been carried out. This is an important finding because it leads to questions on why the impact assessment hasn't been there if the indicators exist. Why then are the SETI indicators used for reporting? Why were they deemed "adequate" to achieve impact assessment by the Centre for Science, Technology and Innovation Indicators? And if there hasn't been any impact assessment, can it be said that the TIA fully knows what the outcomes of the Technology Stations Programme in fact are?

These questions sit together to answer the question on how the TIA measures the outcomes of the Technology Stations Programme, and how it concludes on what the programme has achieved. The answers to these questions determine future funding of the Technology Stations Programme, and also very crucially tell us whether technology transfer and innovation work is achieving what the state so eagerly and enthusiastically suggests it is going to achieve for industrial policy. Are the Department of Trade and Industry's desires (e.g. diversification of the domestic economy, competitiveness, etc.) being achieved?

4.3 What does the Technology Stations Programmes end reporting look like?

The framework discussed above leads to the TIA's information reporting, and use of the SETI Scorecard indicators to express the outcomes of the Technology Stations Programme. It was found that the final reports visible online (and attached in **Appendix 1**) lack detail, definition of indicators and are seemingly incomplete, with errors in some instances even. To unpack the manner in which the SETI indicators are used to deliver reports, the TIA's Annual Report of 2013/14 discusses the Technology Stations Programme on page 58. Two to three short paragraphs are presented discussing four (strategic component) items: 1. Support for small, medium and micro enterprises; 2. Skills and capacity building; 3. Institutional learning; and 4. Socio-economic impact and smart industries (TIA; 2014). While this point of discussion is in no way detailed (which is fine as it's a broad summary), the one that follows is seemingly incoherent, and skips back to an overall TIA report where the 6 strategic objectives (in the document referred to as "SO 1,....SO 6") of the TIA as a whole are presented. Some examples of the 6 are: 1. "To stimulate the development, and commercialisation of technology-based services, processes, and products"; 2. "To support the establishment and development of technology based commercially viable enterprises"; 3. "To leverage TIA funds for co-investments";etc. (TIA; 2014). Under each strategic objective are: "KPI", "Target", "Actual Performance", and "Comments and reasons for variances" (TI; 2014). To give example of the level of detail that follows each strategic objective and the outcomes, Strategic Objective 1 (SO 1) has its fourth KPI listed as "Number of new technology products/processes/services developed with TIA funding", where the "Annual Target 2011/2012" was to develop "22 New technology products, processes, or services", and the "Actual Performance 2011/2012" was that "751...products and process improvements for SMMEs that utilize the TIA Technology Stations and Platforms" were achieved (TIA; 2014). In the "Comments and reasons for variances" column it is said that: "The target was exceeded in the TIA's first year of operations indicating a higher than projected demand for the TIA's services, going forward the actual performance will serve as a baseline for future performance." (DST; 2014: 65).

This information found in the TIA's Annual Report of 2013/2014, while it attempts to display the SETI indicators at work, lacks programme specific detail. The TIA oversees a number of projects or programmes, not just the Technology Stations Programme. Therefore, a discussion on

indicators used for each individual project or programme is required. In other words, there's a need to discuss each project or programme by saying for example: "the Technology Stations Programme achieves these things, and here is 'x' number of indicators demonstrating those achievements. Next, 'Programme y' achieves these things, and 'y' number of indicators demonstrates those achievements, etc." The way that reporting happens instead (visible in **Appendix 1**) is that the TIA lists its 6 strategic objectives, and then under each objective presents the projects or programmes that speak to that objective and the related KPIs. This is fine for illustrating the links across projects that create the system for technology transfer and innovation work within the TIA. However, each programme or project is organized individually, with an individual strategic plan and objectives (the Technology Stations Programme has its own strategic plan and objectives, separate from the next project or programme), and each is funded individually, based on whether or not its objectives are met. This necessitates individual programme reporting.

The next section addresses what crucial findings were established through the interview processes, which were not visible in the TIA's annual reports. These were the "real" stories that demonstrated the successes towards, and deviations from policy aims. The stories that the Centre for Science, Technology, and Innovation Indicators' SETI indicators are struggling to articulate because of their contribution to the TIA's incomplete reporting. These problems hinder the ability of the TIA to really capture what is happening in the Technology Stations Programme and pull out the outcomes to make them visible to the public.

4.4 What does the reporting on the Technology Stations Programme fail to tell us?

The shallow kind of performance reporting illustrated in the above section means that the real story about the outcomes at the Technology Stations Programme is not visible. One manager, at Technology Station B (2014), felt that a lot of the information documented for monitoring and evaluation really was not all that useful and couldn't speak directly to the targets of the TIA and DST, or to the true impact that the Technology Stations Programme is having on clients. The

Technology Stations Programme is a unique, high impact project, which one might argue is even under-rated because of the failure of performance reporting to fully articulate what it achieves.

The Technology Stations Programme manages to give SMMEs access to technologies that other firms in their relevant sectors have no access to (either because of monetary constraints, or issues around law and legislation) and provides these SMMEs with a competitive edge and advantaged they would otherwise have never afforded for themselves (Technology Stations Stakeholders; 2014). The staff in the stations are enthusiastic and value their work, admittedly expressing that they feel the programme adds to the South African economy in ways that other programmes have failed to do. The programme, based on their stories, is at the very forefront of innovation in South Africa and the SMMEs that receive assistance have felt and seen tangible changes in their firms (as expressed by the impact assessment of SMMEs carried out in **Appendix 3**), further legitimating the evident fact that the programme would leave a large gap to be filled if ever it were discontinued. The involved stakeholders at the Technology Stations believe the programme has been of such value that there are milestones that a number of SMMEs would not have otherwise achieved had they not experienced the engagement they had with the technology stations. This comes particularly from individuals who have been a part of the Technology Stations Programme for years, some over a decade, who know the Technology Stations Programme exceptionally well.

4.4.1 What are the successes that reporting fails to draw out?

The various successes of the Technology Stations Programme have been visible all the way through the existence of the Technology Stations Programme, from the days of the Tshumisano Trust in the early 2000s – despite their seeming absence in reporting. According to the Tshumisano Trust, the clothing industry in the Western Cape in the financial year 2004/2005 experienced a rapid appraisal of the value chain as well as innovation activity that year (Tshumisano Trust; 2005). Visiting experts in the industry introduced new expertise and technologies in the industry, resulting in significant improvements in productivity and competitiveness for selected firms (Tshumisano Trust; 2005). Other highlights reported during

the days of the "Tshumisano Trust" were the cooperation between Nelson Mandela Metropolitan University (NMMU) and FH Esslingen in integrity car structures. The results were improved capacity and competence (Tshumisano Trust; 2005).

The manager at Technology Station A could confidently say that the equipment at Technology Station A is some of the best in the world and that some of it is similar to, or the same as, what is used by massive science and technology institutions such as NASA (National Aeronautics and Space Administration) - so that the station can produce items that the likes of NASA produces. Technology Station A also has the biggest additive manufacturing hub in the Southern Hemisphere, producing the biggest statues in South Africa (e.g. the Nelson Mandela statue in Sandton) through robotic milling (Technology Station Manager A). Only five entities in the world are able to carry out this robotic milling work and Technology Station A is one of the five. None of this appears in the reports of the TIA or the DST, except through brief sentences often headed "Highlights" and not related to the indicators and objectives in the formal performance report tables. Other brief mentions around the international competitiveness and breaking into new export markets of 647 new SMMEs in the financial year 2011/2012, or how the programme assisted 329 clients to access new markets also appear haphazardly and not in the context of indicators (TIA; 2012). The reporting quite evidently fails to fully articulate the magnitude of the successes in Technology Stations.

More good in the Technology Stations Programme comes from how stations make their services to SMME clients exceptionally affordable, promoting cost cutting, and hence competitiveness within these firms. For example one milling project at Technology Station A cost R2,5 million in total – but the SMME client in this case was only charged a total of R50 000. The manager at Technology Station A firmly believes that had the technology station not played a role in this particular project, the work would have been contracted to a firm oversees because the SMMEs in the South African space could not have otherwise had access to the technologies that made the project possible at such a low, and hence competitive cost. Also a number of the materials used may have needed to be imported, working against import-substitution policy attempts (as

highlighted in the Industrial Policy Action Plan and other documents that are part of industrial policy). The TIA's reports do not use the SETI indicators to articulate findings this way; in the context of industrial policy, despite the Technology Stations Programme existing to stimulate industrialization. For this particular SMME's example, localization of the manufacturing of certain industrial parts for the relevant sectors potentially squeezes imports out at certain stages of the manufacturing process, creating jobs locally through production and maintenance services (Technology Station Manager A; 2014). Surprisingly, this impact is not made visible in performance reports. The station manager at Technology Station A felt that the low charges at which the Technology Station offered services also enabled its impact to ripple through various areas of the economy. "The clients working with the station are able to make large amounts of money because the station makes very little turnover for itself to enable this." (Technology Station Manager A; 2014).

There is also Technology Station C, which has broken SMME businesses into new export markets in Switzerland, trading in olive oil there (2014). This is particularly pleasing because olive oil is linked to agriculture and the use of low-skilled labour. It then also links to light manufacturing with the processing of the olive oil which stands out as literature suggests de-industrialization in South Africa has to do with the attempt to leap-frog past light industries, towards heavy ones (Tragenna; 2008). At the same Technology Station another SMME client is producing cost-saving bio-fuel (by a 5% reduction in costs), which then feeds into other firms cutting their costs too through linkages (Technology Station C; 2014).

These "wins" are impressive and not to be taken lightly, and it is strange that the TIA's reporting overlooks them. They pull out and show how the Technology Stations Programme works to achieve some of the goals presented in the Industrial Policy Action Plan. Also of relevance is that they occur under sometimes difficult circumstances given the top-down nature of the National System of Innovation and its location in a large national context (i.e. the National Treasury Framework, the inter-departmental relations between the DST and various other

departments and state entities). Various stakeholders assign some of the challenges in the Technology Stations Programme to the sometimes political nature of the national work.

Before moving on, this section clearly illustrates that the work coming out of the Technology Stations is characteristic of the "entrepreneurial university. The use of a network so that the Technology Stations located on the campuses of the universities of technology create productive relationships with SMMEs demonstrates "social responsiveness" to the needs of industry and the economy. My limited research suggests that the staff in the Technology Stations behave in a creative, and innovative manner to facilitate the pragmatic implementation of research and development so that it offers solutions to the hurdles stifling the industrial success of industry.

4.4.2 What are the challenges that reporting fails to make evident?

For an initiative the size of the National System of Innovation, the state's role cannot be anything but complex. One interview finding was that until recently, the South African government didn't know that there was a South African electronics sector and only since recently does industrial policy speak on it in the Industrial Policy Action Plan 2013/14-2015/16 (Technology Stations Stakeholder; 2014). Because of this perception, a massive contract with the move of the national broadcaster from analogue to digital (set up box) antenna almost overlooked the domestic electronics sector, and sourced imports to carry out the project – but the state was met with resistance from the local sector (Technology Station B; 2014). This major oversight by the South African state points to the lack of full capacity of the state to stay abreast of the happenings in the economy, much less in the elaborate system it has set up for innovation. This is worrying because to carry out a task as big as a "Triple Helix" arrangement that is multi-sectoral requires strong institutions that will allow the state to effectively oversee all sectors, and then monitor and evaluate them. This is where the concept of the "entrepreneurial state" becomes relevant so that the available industry resources within the electronics sector could have been assessed and the necessary coordination timeously carried out by the state. This should then have been followed by targeted action facilitated by the state. The reports on the Technology Stations need to present

more such stories to make known the challenges in the programme and how they stifle industrial objectives and can be addressed.

This and one statement in the TIA's report of 2011/2012 are of concern. The statement presents an inconsistency by suggesting that the Technology Stations Programme should prioritize repeat SMME clients if it wants to achieve a real impact on economic growth. Stakeholders interviewed in the Technology Stations, however, all seem to understand that the TIA wants 2000 new SMME clients each year and wants Technology Stations to prioritize new clients over repeat clients, contradicting the statement from the report of 2011/2012 (Technology Stations Stakeholders; 2014). The DST's Annual Report of 2013/2014, where targets are changed as per the National Treasury's instruction also explicitly says that the TIA requires 2000 new SMME clients from Technology Stations per annum (DST; 2014). This inconsistency is a significant one, saying that there's a lack of clarity on targets – which then says there can't be clarity in terms of indicators (as they are a function of targets). This definitional inconsistency likely has to do with the largeness of this project and the result, which is "broken-telephone" type communication across stakeholders. The issue further is likely to arise as a result of the lack of clarity on what SMMEs achieve growth, as discussed in **Chapter 2**. In other words, it looks as though the Technology Stations are pressured to help as many SMMEs as possible, rather than focus on a select and specific few with certain "growth-engine" type characteristics. Another stakeholder (Technology Stations Stakeholders; 2014) felt that any business could tell you that the bulk of its revenue comes from repeat clients with which relationships had been established, and that the grant agreement signed by the Technology Stations states that Technology Stations need to behave and perform "business-like" (and businesses would prioritize repeat clients). Recall that in an "entrepreneurial university" the priority is for the institution to generate revenue. This would explain the importance of repeat clients for revenue. In this case, the stakeholder suggested that "dumping" the Technology Stations in a university made this revenue pursuit difficult, again speaking to the issue of the differing processes and objectives of business-like entities versus those of academic institutions (Technology Stations Stakeholder; 2014). The Technology Stations are also subject to university rules and processes (Technology Stations Stakeholder; 2014). One stakeholder said that buying a new item such as a laptop through the

university's channels requires that the Technology Station liaise with the relevant university authorities i.e. fill out a form, etc. (Technology Stations Stakeholder; 2014). Conversely, he expresses that doing work for industry is generally very urgent and for more core activities, having to follow various processes at the academic institution can result in money losses (because of failures to perform at industry pace) for clients, compromising the speed at which the Technology Station is able to deliver services to SMMEs (2014). Stakeholders expressed that as much as there is a need to engage industry with academics, the geographical location of Technology Stations (where some are in townships, away from business districts relevant to the Technology Station) as well as the processes within academic institutions, often get in the way of industry objectives. Therefore, the manner in which the Technology Stations Programme is organized geographically was not the most conducive way to achieve Triple-Helix work, adding to issues related to the size of the National System of Innovation, inconsistencies in targets, etc.

To look at another issue, most stakeholders interviewed at Technology Station B still understand the primary aim of the Technology Stations Programme from the days of the Tshumisano Trust (before any socio-economic objectives are taken into account, as he says) to be around bringing new technologies into South Africa and making them available and accessible to SMMEs at affordable rates (Technology Stations Stakeholders; 2014). Stakeholders expressed that the socio-economic objectives of the Technology Stations Programme and TIA are seemingly "for show", that they couldn't really occur in a programme for sectors in the sciences and technologies, in which previously disadvantaged and marginalized groups are not very active (Technology Stations Stakeholders; 2014). The TIA's Annual Report of 2011/2012, says: "The Technology Stations initiative is aimed at cultivating an entrepreneurial spirit within the country and addresses mainly pressing socio-economic goals of the government, by empowering previously disadvantaged individuals (PDI) and female owned enterprises. This is accomplished by providing a package of comprehensive solutions for complex challenges within the relevant industry sector." (TIA; 2012). This quote stands out because previously disadvantaged people are not necessarily close to the SETI spaces, supporting the stakeholders' view that socio-economic objectives are difficult to achieve in the Technology Stations Programme. Interview data proves the point that previously disadvantaged individuals (PDI) are not always close to the SETI

spaces. In the electronics space, female business owners are few (Technology Station B; 2014). It's a sector in which women are not very active and the manager estimates that in his ten years at the station, he has met only about three female business owners in the space (2014). Another Technology Station, Technology Station D (in metals), had the same challenges with finding previously disadvantaged individuals in its space (2014). Also in Technology Station C, the agro-processing spaces are estimated by the manager to be 90% white, stifling the attainment of Broad Based Black Economic Empowerment (BBBEE) quotas. In other words, the socio-economic achievements listed as objectives at the Technology Stations Programme are sometimes achieved with great difficulty and often not organically when it is clear for 3 of the 4 stations interviewed that marginalized groups are not very active in their spaces.

Moreover, when socio-economic items do appear in the TIA's reporting, they're haphazardly thrown into the text. For example in the TIA's Annual Report of 2011/2012, under "Socio-economic impact and smart industries", it reads: "All programme activities strive to meet equity targets of at least 55 percent black people, 34 percent women and 8 percent people with disabilities...the programme assisted at least 717 black people, 461 women and 16 projects linked to people with disabilities." (TIA; 2012: 58). This is all that is said in the way of socio-economic work, suggesting that the Technology Stations Programme is not really geared towards such items. Again there is no linking to the SETI indicators and this doesn't tell us what these achievements mean. If more work went into measuring the impact of the Technology Stations Programme on people's quality of life using, for example, "Mercer's Quality of Life Survey" (where 60 areas are looked at to assess quality of water, education, green-economy, etc. (Mercer; 2014)) in a separate "Socio-economic Impact" section for reporting – then that might disprove what the stakeholders say about these objectives being "for show". Without being an expert, a broad objective such as improving the quality of lives of South Africans (which the DST and TIA highlight in every report) can be achieved in a variety of ways. To give an example, while driving to a Technology Station in Sebokeng, it was clear that the area was underdeveloped and that the presence of an academic institution and the Technology Station attracting industry players could elevate the image of the community as well as the perceptions among community members regarding the prospects of their livelihood. Sen's capabilities highlight people's self-

esteem as a facet of social development and having institutions in the area that create the sort of "traffic" that the Technology Station in Sebokeng does, undoubtedly adds to a community's profile and the residents' perceptions about opportunities (1993). The fact that no effort is made in any of the TIA's reports to express such relationships suggests one of two things. Either, those who carry out the reporting and interpretation of the data are lazy and don't want to carry out the labour involved with interpreting social impact for the many strategic components of each programme, or they aren't clear on what the relationship between indicators and objectives is – making them unable to articulate effectively the results in impact assessment. The example just presented required no special expertise, just an extra amount of time thinking through the relationships between activities and their potential impact on communities. Instead no real attempt is made by the TIA to draw the relationship between innovation work outcomes and the impact on quality of life using the SETI indicators.

This complexity around reporting on the socio-economic, and then establishing what it means for the performance of Technology Stations affects the funding of stations (which rests on their performance) (Technology Stations Stakeholders; 2014). Poor performance in both economic and socio-economic areas determines the future funding of stations. This raises concern as there should be a focus on the primary SETI objectives lined up with innovation for economic outcomes, at least such that they are the only tool used to determine the future funding of a Technology Station. The issue of having to meet socio-economic objectives only encourages behaviour to meet targets at any cost (i.e shirking). Stakeholders expressed that the targets set for the station are so far unreachable sometimes that the station must 'make the numbers work' i.e. "cook the books" (2014). At each Technology Station, clients fill in a "client form" expressing who they are (i.e. name, date of birth, gender, race, etc.), what service they're looking for from the Technology Station, and in what capacity. Stakeholders pointed out that the researcher for this study, who was made to fill in a client form as well, was a great client because she was young, black and female. She would be counted as an equity target. It is clear that stations are under pressure to create the appearance of socio-economic impact even where it may not present itself. The Technology Stations Programme however does exceptional work in terms of innovation for purely economic objectives such as competitiveness, and this should perhaps be

all that is required of it. This and work from the Centre for Science, Technology and Innovation Indicators to strengthen the SETI indicators so that they can articulate clearly and fully this exceptional innovation work in terms of its economic impact are what's most needed to aid the TIA in capturing and articulating the outcomes of the Technology Stations Programme.

Two last problems arise in the way the DST organizes itself and its agencies. The TIA, technology stations managers and a DST representative meet once a year (at an annual TIA forum) to discuss reporting results, successes, challenges, and any required changes (Technology Stations Stakeholders; 2014). Stakeholders however have found this forum futile and view the Technology Stations Programme as taken for granted by the DST. One stakeholder went as far as saying that the DST does not even know the managers in the Technology Stations, and that the challenges that came up during interviews have been voiced year on year, with no real action taken to address them (Technology Stations Stakeholder; 2014). Effective monitoring and evaluation should pick up these issues and set out to alleviate them. But the DST seems inaccessible even to those working within its agencies. Moreover, the researcher (a Masters student) also could not access the DST or gain enough information to figure out how to navigate the institution to secure an interview for this study. If both stakeholders on the inside and "educated" people struggle to wrestle such a big institution, how does the DST think previously disadvantaged or marginalized individuals will even begin to approach and understand how to use the relevant channels that are supposedly made available to "improve their quality of life"? The institution is large and highly impermeable, with staff in the Department also seeming unclear on which agency forms part of which programme. Recall individual 1 at the DST (discussed in **Chapter 3**) with whom no interview was secured. He said he could not assist with this study as he only works with "indicators" and is "just a funder" of the Technology Stations Programme. Even after the researcher had explained that she had understood his responsibilities to include "strategic oversight of the Technology Stations Programme", hoping he might briefly explain how he "strategically oversees" and is part of funding decisions for the programme (as this responsibility suggests he does work in the line of indicators for impact assessment) that he suggests he cannot speak on regarding impact assessment. The DST is inaccessible and confusing for an interview alone, monitoring and evaluating its 'super system' for innovation is

imaginably more complex despite the national framework for reporting, the Triple Helix attempt and the attempt to replicate European Union indicators to track occurrences in its Technology Stations Programme's technology transfer arrangement.

Lastly, the Triple Helix arrangement has problems at the SMME level because of state-level misunderstandings. At one point the TIA did not recognize individuals (i.e. sole proprietors) and focused only on small businesses as "SMMEs" according to station managers (2014). The problem here, according to the station manager at Technology Station B, is that if an individual comes to the station to develop a product that can then allow him/her to launch a business, there is a long chain of processes that must take place before a business can emerge (2014). In other words, SMMEs are started by individuals and to disregard them at the initial stage is to defeat the attempt to achieve employment creation later. Another manager asked the DST (at the annual meeting) if someone that came in for 5 minutes could be counted as a client and invoiced R0 – and the DST representative replied yes (2014); counting this client towards the new 2000 SMME clients that should be helped per annum, as per the TIA targets. The problem arises when such a meeting (of 5 minutes) counts or holds equal weight as a project that takes over six months, helping an SMME make tens of thousands or even millions of rand (Technology Stations Stakeholder; 2014). The impact from the two is expansively different, but seems to be viewed as having the same value by the DST. Also, one document by the Tshumisano Trust (because no TIA documents tell us who the SMME clients worked with are) reads: "The programme (TSP) has thus far assisted hundreds of SMMEs since the year 2000. The SMMEs assisted range from third tier suppliers to OEM's such as Daimler Chrysler, Flat, VW SA, Audi, Engineering firms, chemicals manufacturers, inventors, the Regional Cricket Board, clothing retailers and processing technologies." (Tshumisano Trust; 2005: 23). "Audi" is not an SMME. Does this mean that the TIA struggles to find real SMMEs or that it does not in fact believe in them being engines of growth? Are these the kind of supposed "SMMEs" made mention of in performance reporting? One station manager felt that the TIA does not in fact prioritize SMMEs despite this showing up in policy statements (Technology Stations Stakeholder; 2014). SETI indicators used by the TIA do not define SMMEs – these indicators are incomplete and allow much to "slip through the cracks" in reporting work because of a lack of definitions. Moreover, Technology Station A's manager pointed out that the definitions of clients and SMMEs are different across

stakeholders and that each Technology Station manager must, before helping a client, identify what type of client he is dealing with (2014). The station manager at Technology Station B feels that if an individual comes to the station requiring certain services, it's not his place to decide whether the SMME can be a success or not (2014). Recall from **Chapter 2** that 76% of SMMEs fail in the first 2 years, and station managers are being asked to ascertain which SMMEs have the propensity to succeed. This should not be the job of station managers (all of whom are engineers, scientists, and technologists). Their concern should only extends as far as the technologies are concerned. The stations job is only to ask what the technology required by the SMME must have in it, what functions it must perform, how much it'll cost to develop, and then move on from there (Technology Stations Stakeholders; 2014). Because of the extended responsibilities of managers into business relations, 3 of the 4 interviewed were studying towards or had commerce and entrepreneurship qualifications as well (2014).

To conclude the two sections on what reporting does not tell us, it can be said that the indicators used to monitor and evaluate the Technology Stations Programme inadequately present the outcomes of the programme – both good and bad. They fail to draw out the stories discussed here. These are the stories that the TIA needs to be bringing forward when discussing the outcomes in the programme, what it achieves and the value it adds in the context of innovation for industrialization. The next section will illustrate how this inadequacy in reporting results from a lack of detail and definition of indicators (among other missing properties), as well as the incomplete nature of the indicators.

4.5 What are the Properties of the SETI Indicators for Technology Stations?

To extend the discussion above and try to establish why the stories uncovered through interview work do not come out in the TIA's reports, this section looks at the relationship between the SETI indicators and the objectives of the Technology Stations Programme. Through an analysis of the properties of the SETI indicators, this relationship is observed and the quality and adequacy of the indicators is established.

It cannot be said that the indicators used to monitor and evaluate the Technology Stations Programme are adequate precisely because the various properties that should make the SETI indicators functional for reporting outcomes in the Technology Stations Programme (by drawing a relationship between indicators and objectives) are lacking. The relationship between indicators is often unclear because they need further definition or explanation, possess incomplete derived indicators, have potential redundancies, stifle long term goal reporting, etc. This will be illustrated by way of analysis using the Franceschini et al. taxonomy for indicators. Ben-Arieh and Fiones (2010) say in the literature that indicators should show the state of the present, which those applied to the Technology Stations Programme do not (because we've just seen how they fail to capture the real stories).

The manner in which information is delivered in reports comes across as deficient. Although there is clarity on the use of the SETI Scorecard for indicators, nothing is obvious about what this scorecard is made of. In other words, each indicator in the TIA's Annual Reports that are publically availed should be unpacked to briefly explain to the reader what they are reading and where in the picture of objectives each indicator fits in. While the DST's reporting will of course provide lesser details as it must deliver information on numerous programmes, the TIA's reporting on the Technology Stations is not very comprehensive either - leaving the reader with questions as to what the information presented means. Again, the DST may aggregate performance at a very high level, but the TIA's reporting should work to complement the DST's report – filling in the necessary blanks.

It would seem the first problem with the SETI indicators is that there is no complete list of SETI indicators (at least not available for public viewing). We do not know how many indicators there are. Because the reporting that is publicly available is in bits and pieces, and very aggregated, not producing detail on each indicator, this presents difficulty in answering the second sub-research question - "What is the relationship between indicators and the strategic objectives of the Technology Stations Programme?". For the sub-research question "What indicators are used to measure the achievement of objectives?", it is clear that SETI indicators are used. It is not,

however, enough to answer the second question (regarding the relationship between indicators and objectives) by merely saying that the SETI Scorecard presents a relationship between indicators and objectives because it does not, at least not clearly. The SETI Scorecard lacks detail and definition, which this study requires to produce a descriptive account of the methodology behind the indicators used, detailing the properties that led the DST to settle on SETI indicators as indicators of "quality". This says that the SETI indicators are inadequate in quality as they do not demonstrate a clear and sound relationship to objectives, otherwise they would make the stories discussed in the previous section visible and link them (using SETI indicators) to industrial policy.

The next problem in the reports is with the lack of introduction of indicators. The SETI indicators in the TIA's reports are not introduced to the reader to say for example that this report is for "impact assessment" (as we know there are other types of assessments, e.g. Financial Performance) and looks at indicators specifically for "economic" and "socio-economic" outcomes, which primarily have to do with "economy" and "equity" items, where there is a relationship between "economy" and "equity" particularly given South Africa's history. This is evident in the TIA's previous reporting of 2012/2013, where the opening statement says that objectives were met with a score of 86% (TIA; 2013). There is no introduction provided in the report explicitly introducing indicators through some detail or definition. The statement (regarding the score of 86%) is immediately and abruptly followed by a table providing the reporting results for the financial year 2013/2014 – all in Section 4 of the report.

The next section will take the analysis a step further using Franceschini et al's taxonomy of indicators to assess the properties of the indicators that are in the reporting of the Technology Stations Programme by the TIA.

4.6 What is the quality of the SETI indicators based on their properties?

In response to problems with the SETI indicators and reporting, the DST and National Research Foundation highlight that the assessment of social impact of research represents uncharted territory (2014: 2). Moreover the DST expresses that:

"Progress in improving the functioning of the National System of Innovation remains hampered by the absence of an assigned responsibility for ensuring the availability, collation, maintenance, (and even analysis) of the SETI indicators, both quantitative and qualitative, needed for monitoring and evaluation, and for planning and management of the National System of Innovation as a whole...there is no comprehensive synopsis available, in conception that reflects the need to "see" the system in its totality, and assess how it might fulfill its contribution to national development." (DST; 2012: 47). Further comment in response to the work happening through the annual National Surveys of Research and Development at the Human Sciences Research Council and the Centre for Science, Technology and Innovation Indicators, says that: "It should be noted, however, that many indicators are not fully 'unpacked' in the published survey reports, nor are they sufficiently meta-analyzed to yield their true worth" (DST; 2012: 47).

This and other items in this discussion point to the fact that impact assessment is a work in progress, and that the SETI Scorecard has not yet been "fleshed-out" to work for the South African case. This is fine, as long as it is acknowledged and addressed. The above quotes from the DST and National Research Foundation are one of the few (if not the only ones) in which the DST explicitly says that the SETI work on indicators in South Africa is nowhere near complete, or capable of providing the required information to discuss the impact of technology transfer and innovation work in the country. Reports do not however tell this to readers in the immediate text – something necessary given the high expectations awaited from technology transfer. Telling the public that the achievement of these expectations may not necessarily be accurately measured at this point is of importance. Because of this inability to measure outcomes fully and accurately,

how do we know that industrial improvements are taking place, and know the size of these improvements in industrial sectors?

Using the Franceschini et al. taxonomy illustrates the lack of clear definition and detail in the SETI indicators, leading to potential redundancies, and incomplete sets of indicators to clearly present processes involved in achieving objectives. Other problems in the reporting are around graphical errors, and again cases of incoherence and seemingly shallow representations of programme outcomes. It can be assumed that the KPIs in the TIA report are "derived" (as each target or strategic objective has under it a set of indicators that speak to the process that achieves an objective) in their properties. In the TIA's report of 2013/14 numbering has been done incorrectly, moving from "Strategic Objective 2" to "4" and leaving out "Strategic Objective 3". The report introduces four strategic objectives, while other documents to do with the TIA present five strategic objectives – leading to questions on whether the statement that 86% of objectives were met is in fact valid, or flawed as a result of this error. In the next paragraph, an examination of each strategic objective and the indicators set out beneath it will show that the indicators for reporting impact assessment of the Technology Stations Programme are inadequate tools for reporting the information required to point out the successes and failures of the Technology Stations Programme.

Looking first at "Strategic Objective 1: To stimulate the development and demonstration of technology-based products, processes and services", 7 indicators are used to report on its outcomes. These make the attempt to represent all dimensions of the process of stimulating the development and demonstration of technology-based items. There is a lack of detail in that there is no definition or differentiation between what it means for products to be "developed or improved" versus "supported". From the 7 indicators, indicator 1.3 reads: "Number of technology-based products/processes developed or improved through Technology Stations", and indicator 1.7 reads: "Number of knowledge, innovation products supported: Patents, prototypes, technology demonstrations and technology transfer packages" (TIA; 2014). The Farnceschini et al. taxonomy highlights that indicators should not give more than the required information, or

less of it. In this case the indicators that speak to the strategic objective are not fully defined. How does product "support" differ from product "development and improvement"? While reading from another document, or more interview work may clarify the definitions and differences between the two activities, such detail for reporting should be presented in the immediate document such that complete information is provided, making it clear to the reader what the terms used mean. A brief explanation could state in brackets that, "Product support refers to a, b, c, etc. while product development and improvement refer to e, f, g, etc.". For publicly availed documents, it cannot be assumed that the reader has detailed enough knowledge about technology transfer work to differentiate between terms that are seemingly so close to one another. The example explanation provided here demonstrates that a brief elaboration on the terms used can clear up issues that stifle understanding. Recall that level of detail is a "General Property" of the Franceschini et al. taxonomy. Kahn defines "product development" as the process of designing, creating and marketing new products. Prototyping often can involve marketing and selling the item at prototype stage as well. These two sentences illustrate the potential overlap between product "development and improvement", and product "support". Lastly, if there is in fact no difference between product "development and improvement" and product "support", this may also be confused with "redundancy" – a violation of the properties of sets of indicators in the Franceschini et al. taxonomy (2007: 139).

To consider now "Strategic objective 2: To support the commercialization of technology innovations", 4 indicators are used to unpack the objective. The European Union's Innovation Scoreboard points out revenue from commercialized products as part of the measure of successfully commercializing technology-based products. The Technology Stations' reporting presents nothing on revenue, suggesting that this area of reporting is incomplete – failing to speak to economic impact in monetary terms. Also, commercialization may get complex because of issues to do with lag-time (as Gardner et al., 2010 and Guy, 1996 highlight in the literature), especially if reporting does goes as far as measuring the income generated from the commercialization of technology-based products. Moreover, the process is a long one and requires measures such as the "number of patent applications", then a discussion on how many were successful before looking at the income generated (Gulbrandsen; 2008). Derived indicators

serve this very purpose, to track the process in achieving an objective. This brings up the need for additional indicators that will measure intermediate successes on the path to full commercialization. The derived indicators under this objective therefore do not cover all processes involved in achieving the objective of commercialization – in other words, they're not "exhaustive". Some literature identifies indicators as being "direct" and "indirect", and then also "intermediate" as well. Such separation between indicators can assist with creating derived indicators that are exhaustive. This is lacking in the reporting by the TIA for the Technology Stations Programme.

Lastly, in "Strategic objective 5: To facilitate the development of innovation skills to support technology innovation and commercialization", 8 indicators are applied. Indicator 5.4 is "Number of interns placed on an accredited programme for work place exposure". The target was 220, but the outcome was that 90 candidates completed business skills training and another 90, skills training. Again there is the question of the difference between the two types of training (business skills training versus skills training), but more than that – 180 interns in total completed the two programmes, meaning the deviation from the target was 40 and not 21 as the report says. Each indicator, after discussing its targets and actual outcomes gets a rating of either "Achieved" (A) or "Not Achieved" (N). This particular indicator is classified as "Achieved". Is the incorrect deviation of 21 a graphical error? Or is it a real mis-calaculation? What does that mean for the rating of the indicator? Can it be rated as "Achieved" still, or not? And can the report, in light of this, still claim that the Technology Stations Programme has met its objectives with a score of 86% - or would the scoring change? This oversight leads to a number of questions on whether the reporting is drastically inaccurate as a result of this mis-calculation.

To make one further point (not using the Franceschini et al. taxonomy now), indicator 1.5 in the TIA report is "Number of green technologies supported" and is haphazardly added to the end of "Strategic Objective 1" (to stimulate the development and demonstration of technology-based items). Given that interview work highlights the wave of "green" ideas, work and technology from the German Technical Cooperation Agency (GTZ), it seems inadequate to speak in such

passing about green, or environmentally conscious work at the Technology Stations. Environmental or green work also is heavily focused on giving people the appropriate quality of life that comes from living in a healthy environment. This necessitates that more be said on this point and that the report expand on it in terms of socio-economic impact.

This section has used the Franceschini et al. taxonomy to conduct a brief and initial analysis of the properties of the SETI indicators used to report on the Technology Stations Programme. Because the indicators do not possess the properties required to make them functional, it would seem that they fail to adequately relate to objectives to illustrate whether they have been met or not. The indicators are incomplete, they lack detail and definition, and there are graphical errors in the reporting, as well as what seems to be careless or haphazard skimming over certain items. This contributes to the lack of overall completeness and coherence in the TIA's performance reports. These issues possibly explain or contribute to there being no adequate impact assessment of the Technology Stations Programme in the past as these SETI indicators are not necessarily well enough developed to facilitate impact assessment.

Chapter 5 – Conclusion

To conclude and answer the bigger research question on what outcomes the TIA identifies in the Technology Stations Programme, it is clear what the Technology Stations Programme is supposed to achieve as part of the National Innovation System and the drive towards economic objectives such as competitiveness and breaking into new export markets. The work in the Technology Stations Programme is consistent with the themes visible in the literature review i.e. "Triple helix engagement for innovation in Industrial Policy", "Education, knowledge and economy" and "SMMEs as engines of growth". The industry-university engagement in the programme speaks to Schumpeter's notion of academics (in an entrepreneurial university) acting with the SMMEs as innovators and achieving productive technology transfer. The South African government's policy statements (e.g. the Industrial Policy Action Plan 2013/14 – 2015/16) speak on the "knowledge economy" with conviction and certainty that a knowledge economy is attainable through the right measures (Department of Trade and Industry; 2013). The Department

of Trade and Industry stresses that shocks including low profitability, low investment in productivity enhancement, poor product and process innovation and obsolete capital equipment are the structural challenges faced by South Africa's industrial sectors (2013: 41). These very issues are addressed by the Technology Stations Programme, and "Mode 2 knowledge production" (Tuunainen; 2002) as well as knowledge capitalization (Viale and Etzkowitz; 2010) are visible in the Technology Stations Programme.

The problem is that the indicators applied for monitoring and evaluation do not demonstrate the outcomes of the Technology Stations Programme (i.e. the many successes and challenges presented in **Chapter 4).** Like stakeholders suggested initially, the perception is that the Technology Stations Programme is relatively small, and it hence looks as though the DST does not prioritize it when it comes to monitoring and evaluation. This exacerbates the clear problem that the SETI Scorecard as it exists now and as it is applied for reporting on the Technology Stations Programme fails to tell the story of the programme's various outcomes because the indicators lack the properties required to make them an effective tool to monitor and evaluate the Technology Stations Programme, and then produce information regarding impact assessment. These issues in the indicators likely begin with the "top-down" nature of the making of indicators right from the National Treasury level, to their "imposition" on the TIA through the Centre for Science, Technology and Innovation Indicators and DST. The relationship between the indicators and objectives is unclear as the indicators are incomplete and lack detail and definition, requiring that the Centre for Science, Technology and Innovation Indicators develop them further so that they enable agencies to better report on programme outcomes. The result of the weak indicators is shallow, incomplete reporting that in some cases is incoherent. Seeming carelessness also leads to errors in reporting. The Annual Report of 2013/2014 by the DST says that R9 488 000 was spent on developing Science and Technology indicators that will report on the achievement of SETI objectives (DST; 2014). This investment however has not produced solid, functional indicators to report on the impact of innovation work through SETI programmes. It is imperative that adequate reporting be produced for technology transfer programmes given the high expectations attached to them and their location in large national systems.

There is also the seemingly forced attachment of socio-economic objectives to the Technology Stations Programme (seemingly for political appeal). The TIA's vision is to be a world-class technology innovation agency that will stimulate and support technological innovation to improve the quality of life of all South Africans through the mission that is to facilitate the translation of South Africa's knowledge resources into sustainable commercial opportunities (TIA; 2015). This says that the work of the TIA through programmes such as the Technology Stations Programme is two-pronged (i.e. economic and socio-economic), when interview data and reports suggest that it is in fact not. The SETI indicators are not solid or functional enough to work first to report on the direct (economic) impact, and primary, innovation-related impact of the Technology Stations Programme. If there is a need to look at the more indirect (socio-economic) impact of the Technology Stations Programme, it should be done at a secondary level. The two agendas (direct versus indirect) need to be reported on separately with clear statements showing that the economic, innovation-related impact is the primary objective, while the socio-economic impact is secondary. Focusing on these socio-economic aspects makes the Technology Stations Programme look as though it's failing in that area (because previously disadvantaged groups are not very active in the SETI spaces), when this is not its priority area. The result is compromised funding for the Technology Stations going forward. Between this perceived failure, and the inadequately captured successes in the Technology Stations Programme, it looks as though the Technology Stations Programme achieves less than what it does (as we've seen through stories from the interviews); like it's not stimulating industrial expansion when it is according to informal data.

To give a last word on the role of the state, it can be said that the DST (as the potential "entrepreneurial state") is effectively reducing the transaction costs of academic-industry engagement, and making access to technologies coming in from Germany substantially cheaper for SMMEs (which struggle to gain credit to access such items to stimulate their competitiveness) using a "bottom-up", "de-centralized" approached (Mazzucato; 2014). The state is "targeted" and "pro-active" in this sense, as an entrepreneurial state should be (Mazzucato; 2014). Moreover, through the Technology Stations Programme, South African SMMEs are using technology from abroad in a way adapted for the needs of local firms as the

literature suggests is the most productive way of employing international technologies (Derianiyagala; 2001). Moreover, the Technology Stations programme works in line with the Industrial Policy Action Plan's "sectoral" approach by having each Technology Station focus on a specific sector. Here the relationship between the DST's work and that of the Department of Trade and Industry as an inter-departmental effort is visible. The "entrepreneurial" nature of the state is also visible as it is investing in research and development itself, and taking the risks needed to achieve the desired economic impact. These successes are worth noting given the size of the South African National Innovation System. The size of the system, however, is also a hindrance (affecting monitoring and evaluation) at various levels as has been demonstrated in **Chapter 4** with the lack of knowledge on the existence of the electronics sector among other oversights and inconsistencies. The grievances and challenges discussed with stakeholders during interviews (also in **Chapter 4)** should also come up if monitoring and evaluation is effective and works well to communicate what is and is not working, what facilitates and what stifles innovation work. This is what should be discussed when remedial steps are proposed in response to the finding of performance reports. It seems the DST needs to re-look at the location of programmes such as the Technology Stations in its bigger National Innovation System. The system is extravagantly large and leads to confusion for everyone (for the DST's staff, staff in its agencies, and the public who are trying to understand and access the institution), making it difficult to monitor and evaluate.

This study has shown that there is a framework and a system for monitoring and evaluation in place through the SETI work, it just needs the makers of the SETI indicators and those who report on monitoring and evaluation to really commit to making the SETI Scorecard indicators a more robust tool that will enable the TIA to demonstrate the Technology Stations Programme's outcomes. There also needs to be more thought around how to best to organize results so that they are useful and tell a clear story. The DST further needs to re-organize the National System of Innovation so that it is better manageable, no longer has inconsistencies and misunderstandings across stakeholders and addresses the challenges (as they arise in monitoring and evaluation) stifling the highly impactful work in the Technology Stations Programme.

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