Globelics

Knowledge-intensive university spin-off firms in South Africa: fragile network alignment?[i]

Glenda Kruss[1]

INTRODUCTION

Sustaining knowledge-intensive university spin-off firms in South Africa?

A small number of South African universities and public research institutes have created spin-off companies over the past decade. Such commercialization of knowledge is facilitated by a new government policy framework, and a range of government initiatives including funding programmes, technology incubators in key sectors identified for development, and 'technology stations' focused on SMEs at the new technological universities. These initiatives, and others, indicate that the South African economy is moving towards the policy goal of knowledge intensification.

The research literature suggests that in general, starting or creating a high technology company may be possible for university-based academics. However, sustaining and growing a successful spin-off company over an extended period of time is a major challenge (Franklin et al 2001, Wright et al 2006, Pries and Guild 2007, Mustar et al 2006). Knowledge intensification requires strong institutional networks to support increased knowledge diffusion across national systems of innovation. Despite the encouraging trends in South Africa, there is concern that such institutional networks are not yet sufficiently developed in the national system of innovation (OECD 2007).

The paper aims to problematise the specific forms these challenges take in the South African context. It does so through an empirical analysis of three cases of university-industry interaction that aimed to create spin-off companies in South Africa. A 'network alignment' approach to national systems of innovation (von Tunzelman 2007) was adopted. The analysis investigated whether and how the degree of network alignment within and between the sub-systems of South Africa's national technological system and its industrial system is likely to create the conditions to support competitive knowledge-intensive spin-off firms over time, to realize national policy goals.

The following two sub-sections describe the 'network alignment' framework and the methodology employed in the empirical research, before presenting an outline of the argument.

[1] Chief Research Specialist. Education, Science and Skills Development research programme Human Sciences Research Council South Africa. Email: gkruss@hsrc.ac.za

A 'network alignment' framework

The research was framed in terms of Von Tunzelmann's (2007) conceptualisation of a 'network alignment' approach, which analyses the interlocking complementarities or overarching links that are present or absent within and between networks in production, innovation and knowledge systems. The task of network alignment is to assess the consistency between multiple and heterogeneous networks, in terms of their ability to contribute towards the attainment of the developmental goals defined for a system (see also Lee and Von Tunzelmann 2005, Wang and von Tunzelmann 2000, von Tunzelmann and Wang 2003).

This model of the national system of innovation places firms and their industrial sectors at the fulcrum of analysis (Figure 1). It has imported a model to explain competitive advantage, drawing on Porter's (1990) 'diamond', alongside the more typical model of the national technological system (the structures and networks of government, education systems and public research institutes). The 'diamond' represents four attributes that shape the environment in which firms compete that may facilitate or constrain competitive advantage. These relate to the strategy and structure of the firm itself, the factor conditions, the demand conditions, and the related and supporting industries. These determinants are mutually reinforcing, and the effect of one attribute is contingent on the state of the others. Weakness in any one determinant will constrain the potential for an industry to upgrade and gain advantage. Government plays a role in influencing the four determinants of the diamond, and can be influenced by each of the four, positively or negatively. Government can reinforce underlying determinants of innovation, but it cannot *create* advantage.

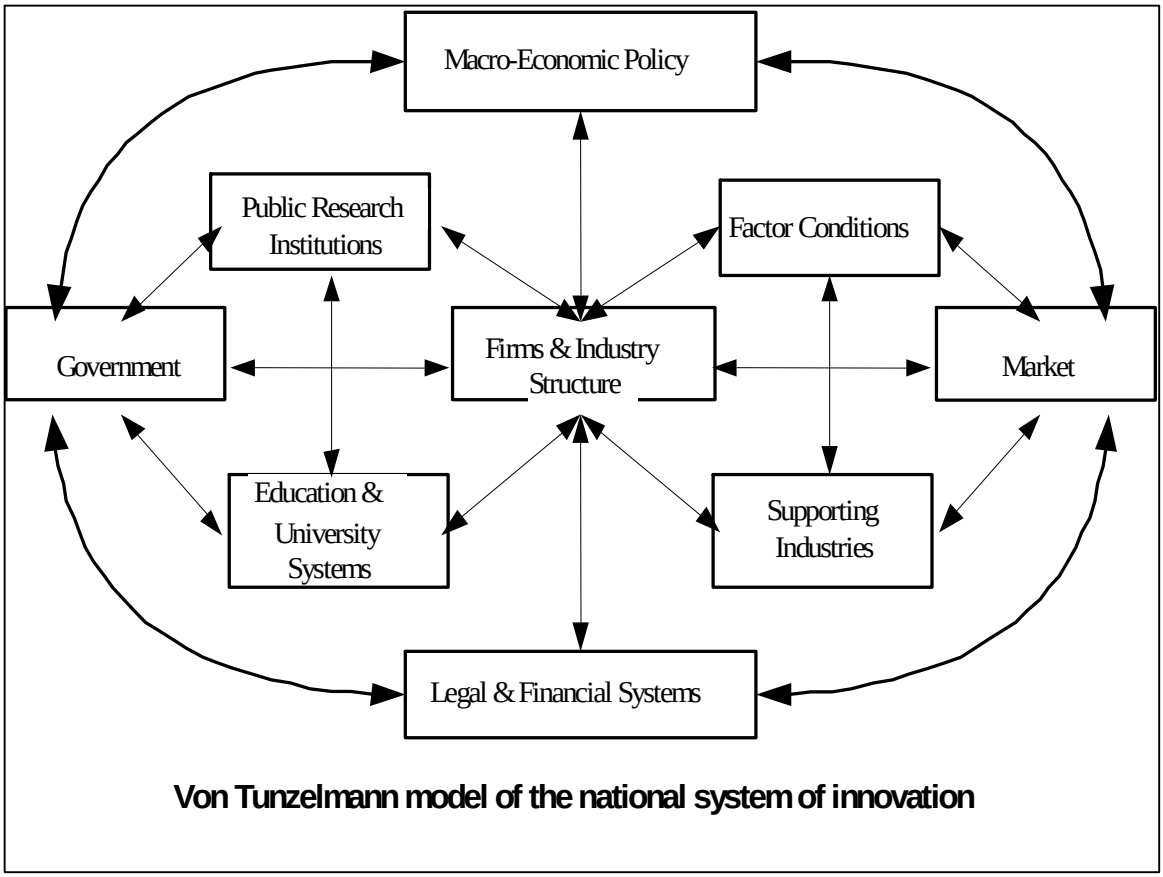

Figure 1. Von Tunzelmann(2007) model of the national system of innovation

Von Tunzelmann (2007) proposes that successful production in a firm is the simultaneous outcome of its internal functional structure and their external relationships, its resource structure and their external relationships, and the spatial structure of governance modes that it fits into (global, national and local). The functional networks intersect in many-to-many fashion with the resource networks and the spatial networks. That is, empirical research needs to observe multiple agents interacting in both functional and resource networks in differing spatial contexts.

Thus, the model proposes that for firms, network alignment requires that there are complementarities in at least three dimensions:

1. in the firm's internal functional networks (linking the four functions of technology, production process, products [marketing] and finance - all coordinated by management and entrepreneurship)
2. in the firm's external resource networks (supply chains/networks of various types, relevant to the full range of resource flows, including capital, skilled labour, knowledge and technology)
3. in the firm's geographical networks (the local, national and/or global levels at which the firm's activities are coordinated).

Networks between the national technological system and the industrial system, or within the firm and its industrial sector, may be misaligned in a range of ways. Networks may

exist, but not sufficiently widely across the system, or they may not function effectively, or the networks in one sub-system or function of a firm may have conflicting goals (von Tunzelmann 2007).

The case studies presented in Sections One to Three below explore the forms of network (mis) alignment that militate against or facilitate competitive university spin-off companies in South Africa. The problem in South Africa, it will be demonstrated, relates to unevenness and inequalities in interactive capability within and across the national technological system, which impact on the depth and extent of network alignment possible – and hence, on firm and sectoral progress towards knowledge intensification.

Methodology

In November 2003, a set of eleven case studies of 'technology cooperation networks' were conducted, in an attempt to understand their creation, structure and dynamics (Kruss 2006a, 2006b). Such collaborative, knowledge-intensive interactions between universities, firms and public research institutes 'facilitate the acquisition of product design and production technology, enable joint production and process development, and permit generic scientific knowledge and research and development to be shared' (Castells 1996: 191).

Three cases were selected for longitudinal follow up in August 2007. The cases were in the ICT sector broadly defined, focused on innovation of product, and oriented to a specialized niche, high technology customer base. The most 'classic' ICT case was a software development network centred on a virtual reality authoring tool. A second case was a bioinformatics network, at the cusp of biotechnology and ICT, to develop tools to analyse the human genome. The third case intersected the communications technology sub-sector and space science, to develop an imager for a micro-satellite.

For each case, a set of qualitative in-depth semi-structured interviews were conducted with key firm technology and general managers, and university-based researchers. In addition, data on each firm and technology cooperation network was collected from web-based searches and secondary sources. The initial objective was to establish 'outcomes' four years later - whether the specific goals had been achieved, whether the technology cooperation network had been sustained in any way, and whether there had been successful commercialisation or the spin-off firm had remained competitive. The second objective was to explain this 'outcome', using the framework of network alignment. Such analysis allows identification of some of the ways in which innovation policy in South Africa is appropriate to current conditions.

In 2003, two cases – the bioinformatics and micro-satellite networks - involved university research groups in collaboration with small firms that had their origins as spin-off companies commercializing previous university research. The prospects for long-term mutual benefit were favourable, and the spin-off firm seemed likely to be sustainable and competitive. The virtual environment software network was at an earlier research stage, and prospects for successful commercialization did not look promising. The range of

potential outcomes suggested it would be possible to analyse instances of network alignment and misalignment.

The paper

The 2007 case studies confirmed the negative expectations of the virtual environment software network. The project was successfully completed in terms of the research group's academic goals, but it did not result in commercialization, primarily because of the lack of interactive capability and the absence of networks between the university and the industrial sector, and between the industrial sector and government support agencies.

The genomics case in contrast was extremely successful precisely because of networks between the university and the biotechnology sector facilitated by government. But contrary to expectations, this success was short-lived, given misalignment between the firm and global market conditions, and in the co-ordination of key functional networks within the firm itself, that left it vulnerable and unable to achieve competitive advantage when capital resource flow networks were disrupted.

The micro-satellite case displayed alignment within the firm, in terms of effective coordination of functions, and in terms of the integration of knowledge resource flows from the university research group. Here too a degree of misalignment in the networks between the firm and a key supporting industry impacted on the networks between the firm and the market and exacerbated weaknesses in the home demand, threatening turnover and the future viability of the firm. The firm was in strong alignment with government strategic priorities. However, fragility in the horizontal networks between government departments and between government agencies and the firm meant that it was not certain that government or the university would intervene to support the firm and ensure its future viability, despite considerable investment of public funds.

Sections One to Three will attempt to explain the challenges faced in each of the cases, in support of the analysis presented here in broad outline.

SECTION 1. VE TOOLS: MISALIGNMENT AND NETWORK FAILURE

The VE Tools technology cooperation network was at an early stage of research and technology development aimed at commercialisation. The network was based at a strong well-established historically white research university that adopted a managerial strategy of 'harnessing innovation potential' (Kruss 2005). It was funded by a government programme aimed to promote commercialization, the Innovation Fund (Letseka 2005, HSRC 2003). However, in 2003, there were already indications of potential misalignment. Once the funded research project was completed in 2004, the research products were not commercialized, and the network ceased to function.

The case displayed significant network failure, in particular, a lack of interactive capability. Key networks did not exist, and as the following sub-sections shall demonstrate, there was evidence of conflicting goals that contributed to misalignment.

The network in 2003

The network was established to produce an authoring tool for virtual environments that was user-friendly, versatile and had greater 'presence' for the end-user. The key product proposed was virtual environment authoring tool software. In addition, a hardware platform was being developed, alongside a codified methodology and three model scenarios that could demonstrate the potential of the software.

The Innovation Fund mandated consortium initially consisted of a laboratory based at the lead university, a strong partner research university, a public science council, two firms, and an applications partner, a cultural archive based at the university. Within two years, the consortium was depleted, with in effect two active partners based at the lead university, and varying degrees of interest from individual agents within the two firms. By 2003, there was in effect no technology cooperation network supporting the project. The research proceeded under the guidance of the academic project leader and a paid project manager, and with a well-paid lead programmer. It primarily operated as a very large complex traditional academic research and technology development project within a single research group at a single university.

A lack of common goals and network failure

A strong cause of network failure lies in the lack of congruence between the goals of the university researchers and those of the firms involved. Initial interest in the network lay with individual managers, and as each firm was subject to a series of 'buy-outs' by larger companies, these individuals either left or lost their position of authority. Neither of the two firms had a substantive financial interest invested in the project, nor was the innovation central to their core technology and products, nor were the firms involved in the knowledge generation or technology development process in any substantive way. Participation in the network was seen as low risk, placing the firms in a preferential position to acquire shares in any commercial venture that might evolve out of the potentially innovative research.

The absence of an industry partner that had a shared developmental goal and immediate demand for the commercial application of the new technology laid the conditions that militated against the creation of a spin-off company to commercialise the research product.

The reluctance of firms to invest in radical innovation, carrying high risk and uncertainty, is directly linked to the nature of the ICT industrial sector, particularly the software sub-sector, in South Africa (Paterson 2005). The industry tends to import solutions instead of developing its own products. Multi-national companies that operate in South Africa tend to concentrate R&D in the home base. Small firms tend to be driven by the personal interest of the founder, and typically do not have the capital to support university research (see Manuel 2007 for further analysis of current trends). In the context of these market

and factor conditions, there was no meaningful incentive for firms to interact with university research groups.

Misalignment in the national technological system
Network failure was at the same time related to misalignment within the national technological system.

Strong reputational competition (Whitley 2000, 2003) between the two universities and to some extent the science council hindered collaboration in research and development. The research functions of each potentially strong consortium partner were not defined in a sufficiently complementary manner, creating competition and tension within the team. The partner university withdrew at an early stage, and the science council remained only formally involved with no active participation. The cultural archive remained involved as it had a direct interest in what VE technology could offer, and complementary expertise.

The network was also affected by misalignment in the national university system, in terms of the inability to produce and retain a critical mass of future researchers in ICT (SAITIS 2000 and 2002). The severity of the software development skills shortage in the region (Manuel 2007: 6-7) was a critical factor condition in this industrial sub-sector. ICT is an industry subject to the global mobility of staff with scarce high-level skills, and the negative effects were felt acutely in the project initially.

Conditions within the university did not promote interactive capability effectively. The extent to which knowledge of the university's innovation policy and incentive or support mechanisms had permeated through the institutional systems was uneven. The project relied on the academic leader of the consortium, who lacked the tacit knowledge required to manage the network, and admitted that it was an overwhelming task, at odds with his previous academic experience and roles.

Unsuccessful commercialization by 2007
By the end of 2004, the research and development project was successfully completed. It was technically a success. All the deliverables were successfully produced, and the applications were well received. The research was at the stage of proof of concept with an executable prototype, but there was not yet a developed product. Hence, the project output could not be directly commercialised, and required support for marketing, patenting and further research and development to create reliable software. Given the absence of a technology cooperation network - in particular, active involvement of the firms - when it came time to commercialise the prototype, in effect the process started from scratch.

Despite considerable efforts, commercialization did not succeed. The required resource flows were not easily available from government or from within the university, particularly venture capital, funding for technology development and legal support for patenting, nor was it possible to access markets that might have provided private sector resources.

Misalignment of markets

The project leader was aware that the home market for the software was non-existent, and that marketing needed emphasis and expertise, given that the field was globalised and dominated by large foreign players, which made it difficult for new entrants (Anon 2004: 39). Nevertheless, it was argued that the VE Tools products had good export market potential. Numerous attempts were made to access markets in Europe and America, through strategic partnerships with other firms, but the team could not find a complementary partner with the required marketing ability. The early misalignment that led to network failure continued to militate against the resource flows that could support the formation of a spin-off company.

Misalignment in public 'technology-push' programmes

At the same time, the project leader pursued public funding. There was a gap within the Innovation Fund, the government funding programme, as then constituted: that is, there was no provision to fund and support the transition from executable prototype to developed product. The project leader applied to use unspent funds to bridge the gap, which was initially sympathetically received. Bridging funding did not materialize, reportedly due to a change in officials managing the funding programme. An academic-bureaucratic conflict ensued, and descended into an antagonistic personal conflict, signalling the end of the relationship between the Innovation Fund and the research group. The required resource flows and networks between government and the research group did not exist at that point.

Network misalignment within the university as an organisation

Nor could the project find the required capital resource flows and networks for bridging support from within the university. The university's support for commercialization was not as strong as it had been earlier, given a change in senior research management, which shifted the direction of organisational focus more towards a 'laissez faire traditional' position (Kruss 2005). Change in key personnel in the university's innovation office and the absence of venture capital closed one promising avenue. The lack of specialized expertise in pursuing ICT patents, together with the high cost involved closed a second possibility.

The role of academic agents?

Finally, it was noted that the project leader displayed weak interactive capability, and was not an 'academic entrepreneur'. After the failure of commercialization, he retreated into the typical position of a reputationally competitive academic conducting basic research:

> I am now 55, I am a full professor. A project like VE Tools is too much hassle for too little reward. Now I want to pursue what interests me for its own sake. If there was a better support structure, I would think of it (Interview, project leader).

This attitude meant that the drive to build networks to pursue commercialization was not strong enough to overcome the absence of critical links and complementarities in the national innovation and knowledge systems.

SECTION 2. GENOMICS INC: MISALIGNMENT OF MARKETS AND THE MARKETING FUNCTION

An unexpected rapid demise

In 2003, Genomics Inc was a successful small spin off company that had been operating for 6 years. It grew from a young bioinformatics research and teaching centre based at a historically disadvantaged university. The firm had early successes with its bioinformatics software, with reports that one of its products was being adopted by genomic researchers internationally as a standard for analyzing gene expression states (Versweyveld 2003).

The research centre was a textbook example of the benefits of 'brain circulation', in that it was established by a South African academic returning from an extensive period of study and work (including in Silicon Valley) in the United States. The goal was to establish an academic base to develop bioinformatics capacity and research infrastructure in South Africa. The research centre was integrally involved in national and regional government initiated networks to develop biotechnology (see NBN 2006).

In 2004, the firm was pursuing an exit strategy, in the form of a sale to a larger international company, a typical goal of biotechnology start-up firms in order to realize the initial investment. The firm did not have a large patent portfolio, and needed increased funds for marketing. As Von Tunzelmann and Wang (2003) point out, to develop producer-led packaged software, initially R&D costs are very high, but then marketing costs rise rapidly. Thus, to become competitive in the ICT software sector depends in large part on a firm's marketing strategy, and on the dynamic appropriability of up-to-date versions of the firm's products – which require continuous innovation.

Genomics Inc was negotiating strategic deals with two companies, initially in the form of formal marketing collaborations, but with a view to future partnerships. At the same time, they were negotiating with two government funding agencies. Yet, by March 2005, the firm was forced to retrench all their staff, and in effect close down. By 2007, it remained active in name only, as a shell for small scale consulting work by the former CEO.

Network failure in this case can be explained primarily by the absence of home demand, which led to misalignment between the marketing, technical development and production functional networks within the firm, exacerbated by ineffective coordination of management within the firm. The firm was thus vulnerable, and a subsequent disruption of its capital and knowledge resource network flows forced it to close down. These claims will be substantiated below.

Network alignment in the national technology system

Government policy mechanisms and funding

The biotechnology sector in South Africa was prioritized for public investment and development in the first national foresight studies (DACST 1999). Considerable public research funding was earmarked for the sector through a range of direct and indirect mechanisms (DACST 2002a, NACI 2006, DST 2007, Campbell 2006a, 2007a, DST and eGoli 2004). Such funding created a set of positive conditions in the national technology system to facilitate alignment between the goals of government and firms in the sector. Early stage funding for biotechnology start-up companies remained limited and high-risk. For a number of years, Genomics Inc benefited directly from public and private capital resource flows.

The research group and the university

The university was able to leverage its previously historically disadvantaged position and its past oppositional political stance, to attract a commitment from scientists to grow research capacity in niche areas, accompanied by relatively high levels of public funds. The '*laissez faire* aspirational' managerial style of this small university facilitated a number of bottom-up initiatives that were supported by central management, in that they enhanced the reputation of the university (Kruss 2005).

Genomics Inc had an extremely close relationship with the research centre, based on personal ties, shared premises and computing equipment, and shared intellectual property. Tensions existed, in the need to compromise to balance the value the academics involved placed on scientific reputation, publishing and open source software, and the values of the company to generate value and register intellectual property. The firm claimed that as a result, they were pioneers in new business models and Open Source business strategies. The firm received a vote of confidence from a private sector biotechnology venture fund, which invested one eighth of its total investment portfolio in 2003.

Relationships with suppliers were never a problem, as the main resource flow was knowledge capital from the research centre. Instead, the firm concentrated on inserting their product as an integral part of other supply chains, through global biotechnology companies.

Network misalignment: markets and firm coordination

Misalignment between the firm and the local market

Porter (1990) postulates that the composition of demand, the mix, character and sophistication of local needs is key to shape the attention and priorities of firms that will equip them to enter global markets. Genomics Inc sold its products to pharmaceutical companies, health researchers, and biotechnology firms who required computational software to analyse genomic databases. There was no sophisticated home market in South Africa for such a specialized niche area. All of the customers were based internationally, which had a direct impact on innovation and on the development of new products. The

software development was slower, as the programmers were not familiar with the demands and requirements of the global market. It was not possible to send more staff more often to meet with international clients, because of high travel costs and the cost in time. As a result, the firm had to work smarter in terms of what it chose to develop, in order to simply 'keep up'.

Misalignment in coordinating the four functions of the firm

In terms of the firm's internal functional networks, the fact that the primary market for the product was at a major distance geographically created significant problems in the coordination of marketing with the functions of techniques, production and administration. It was a constant battle to retain appropriate marketing and sales staff. A 'head office' was established in the USA, and the sales staff was based there, but this was difficult to manage from a distance. The CEO personally participated in the closure of all deals, and relied on personal networks. At the same time, there were difficulties experienced in finding competent skilled human resources in bioinformatics, a global scarcity. Software programmers had to be inducted into the bioinformatics field, which created pressures on management. The firm became too thinly 'stretched' in terms of management expertise.

The fact that the CEO traveled extensively created resentment amongst senior technical staff, which iterated with a perceived general mistrust of management. The CEO, an American, identified an assumption that management can only operate in a top-down manner as a peculiarly South African cultural barrier. Despite a flat organizational structure and considerable autonomy, the cultural barrier meant that staff was not able to participate effectively in a start-up environment. One instance of lack of coordination of the functions of the firm was a constant tension with a senior technical software developer. The result was a level of technological mistrust in the CEO's reputation and ability in the market place. The two managers reported that they struggled to find a way to manage the firm and create the team environment required. Hence, circumstances within the firm militated against the translation of the considerable scientific and managerial competence into effective interactive capability.

Misaligned legal frameworks

The immediate series of events that led to the collapse of Genomics Inc related to a legal dispute over intellectual property rights with the senior technical software developer, who had left to work at a publicly funded research network. The levels of mistrust within the functional networks of the firm left it vulnerable to such exploitation. A poor grasp of IPR is a common cause of conflict and disputes between collaborators, resulting in misalignment in the knowledge resource flow networks between academic research centres and firms in South Africa. A national Intellectual Property Rights framework is not well developed, legislation is outdated, and a draft bill to create a new framework for the private use of publicly funded research tabled in 2006 has received negative comment (Wolson 2003, 2007). Many universities have operated in an *ad hoc* manner, only recently developing internal IPR policies and coherent management strategies.

Disruption of capital resource flow networks
The private sector venture capital company spent a large sum of money on legal fees, in an attempt to protect its investment in Genomics Inc. The end result was an out of court settlement, mediated by a government department, but the settlement was not in favour of the firm. Further public investment did not materialize, and the proposed strategic partnership deals with the global firms collapsed. Even attempts to sell the existing intellectual property were unsuccessful, given the legal dispute. The firm gave the university the intellectual property rights in exchange for its investment, but the private sector venture capital firm and the Innovation Fund lost their equity and had no return on their investment. As with the VE case, the director of the research centre (who had been involved in the spin-off company but did not hold equity or shares), turned his attention to strengthen reputational competitiveness and capacity building programmes within the university.

SECTION 3. SATELLITES INC: MISALIGNMENT BETWEEN THE FIRM AND SUPPORTING INDUSTRIES

The final case particularly illustrates the complexity of sustaining university spin-off companies in high technology sectors in transitional economies. In 2003, the spin-off company, Satellites Inc had experienced successful sales of its first micro-satellite, and had been voted a top South African SME in a national competition, for a few years in a row. It was expected that this case would provide an appropriate instance to analyse the alignment that leads to a sustainable and competitive firm.

In 2007 the ultimate outcome remained uncertain. The firm had grown substantially from a small to a medium sized company of approximately 90 staff, it had matured organizationally and it had developed a wider range of products and services. However, in their own words, the firm was experiencing extremely 'tough' trading conditions that meant it was not turning a profit, and that impacted on its future viability and continued existence. The following sub-sections analyse why the situation was so precarious.

Misalignment in supporting industries

The micro-satellite sub-sector
Satellites have become key to monitoring weather, agriculture, global disasters and mapping, amongst many possible applications. Government support is a requirement inherent to the nature of the market, and clients are typically government organisations. Globally, the micro-satellite sector is highly commercialized and competitive, with the advent of private aerospace companies (Alexander 2002). The potential advantages of building a sustainable space industry that could lead to high value-added exports from South Africa were promoted over the past five years (Anon 2003, Campbell 2005). The space sub-sector in South Africa remained small and highly concentrated, based strongly on apartheid defence R&D capability, and firms tended to be inter-linked with one another for complementary competences (South African Space Portal).

The nature of the micro-satellite sub-sector was by definition uneven and high-risk, given that it is a 'shipyard' type of enterprise. When it has no new projects, the company has to bear all the costs of maintaining a high technology firm, particularly the core of specialised engineers. There may be influences or dependencies over which a firm has no control, which impact on the signing of new projects. In 2007, Satellites Inc was in one of these crisis periods, caught in an impasse beyond its direct control.

Misalignment in the networks with suppliers of launch services

The firm had a sound marketing strategy, with three sequential phases that aimed to build on one another. Satellites Inc planned to use the first 'training and know-how' market to open up the operational market, and in turn, to open up the commercial market. The firm needed a track record of producing operational small satellites to build market confidence, which was scheduled to be proven by 2004.

However, the firm had a major problem in its supplier value chain, that is, micro-satellite launch services. South Africa does not have the capacity and the expertise required to launch micro-satellites. The first satellite was launched free by NASA as a secondary launch to another paying satellite, as a developmental exercise for the university. Hence, the satellite was placed in a non-ideal orbit, which might have contributed to its failure after two years in space (Campbell 2005). This was prior to 1994, building on South Africa's long history of involvement in satellite technology and tracking in collaboration with international agencies since the 1950s.

By 2007, Russia had cornered the market for launching micro-satellites (Campbell 2007b). In 2004, Satellites Inc's first operational satellite was delivered to the Russians to be launched, again, as the secondary satellite on a rocket. This launch was delayed for the past three years. Thus, the firm organized a dedicated, funded launch as the primary load for their next satellite, commissioned by the South African government. Unfortunately, this launch too has been delayed, with no specific date set (Anon 2006b, Campbell 2006b, 2007c).

Satellites Inc had enormous dependence for its marketing strategy in the expanded commercial market hinging on a successful launch. The fact that there was no operational reference for customers created extremely 'tough' business conditions. The delay directly caused misalignment between the determinants of competitive advantage for this firm. The firm attributed the impasse to 'geopolitical risk' over which they had no control, as any intervention had to proceed through high-level government channels. Porter may refer to this as an instance of 'chance', but it is perhaps not as significant as global warfare or a crash in world markets. There is misalignment at the global level within the network between the firm and the supplier of a crucial service in the micro-satellite value chain.

Tough times, but a firm foundation?

The firm kept afloat by selling knowledge services, in the form of training of future satellite engineers. The question was how long it could continue to do so, and how likely it was that there would be support interventions, on the part of government or the university. The firm was not as vulnerable as Genomics Inc. There was no evidence of major misalignment within the functions of the firm itself, and in relation to its industrial sector. Satellites Inc was also in stronger alignment with government and the university, although there were indications that these networks did not function as effectively as they could. Each of these will be examined in turn briefly.

Strong network alignment within the firm

The four functions of production, marketing, techniques and administration operated well in alignment with one another, through a networked structure co-ordinated by an effective management system. Production and technology development were totally interlinked, with no mass production. The firm designed a system and subcontracted out parts; but also designed and built most of the components and integrated each piece of the electronics, the mechanics and the optics in-house, and then integrated the final product. The internal network matrix structure of the firm was adopted from the model of state armaments firms in the apartheid era. There was no evidence of an alignment problem within the functions of this 'learning' firm, which operated internally through network modes of governance.

Satellites Inc was also becoming more established as a commercial company run by a board of directors. It had taken on a Black Economic Empowerment (BEE) partner, a consortium of telecommunications, ICT and financial interests, as well as a group of engineers employed in the company (Engelbrecht 2007). The partnership was in line with government and business attempts to shift the racially unequal ownership structure of the South African economy. The BEE partnership venture was critical to the future of the company in the current political environment, particularly for the networking credentials of a spin-off firm from a historically white and conservative university, in a sector with past links to the apartheid defence R&D system.

Less intense alignment with the university

With maturation of the firm and shifts in ownership, it was evident that the network connections between Satellites Inc and the university were not as intense as previously. The university remained as a shareholder, but most of the original founders were no longer directly involved in the firm's operations. The knowledge-intensive resource link was not as tight, because of budgetary constraints that prevented the firm from funding more fundamental research. Nevertheless, the long-established nature of the research network and the close financial, knowledge and personal linkages meant that the knowledge flows remained available as a key resource for the firm.

The depth of alignment between the firm and government policy and funding?

Involvement in frontier cutting-edge space science was seen as key to the international technological standing of a transitional country like South Africa, and to its leadership

position in Africa (Anon 2006a). Government prioritized space science as a focus area of 'big science', from the time of the national Research and Development Strategy (DST 2002b: 45). This commitment has been taking more concrete form in the five years since (Mangena 2005b, 2006a, DST 2007). The goals of Satellites Inc were in close alignment with the goals of government space initiatives, and specific networks existed between the firm and government agencies (Mangena 2005a, Alexander 2002:2, Campbell 2006b, Mangena 2006b, SAASTA 2006, Campbell 2007c). However, the depth of this alignment in practice, and the extent to which networks worked effectively, appeared to be fragile, to lack trust and to be easily vulnerable to rupture.

The coordinator of the National Working Group on Space Science and Technology claimed that 'the Satellites Inc project was conducted in a policy vacuum' given the lack of a co-ordinating agency, the lack of a single space budget and the lack of government support to follow up and build on what had been achieved (Campbell 2005). Although the need for consolidating around a single space agency was increasingly recognized (Mangena 2005a, Mangena 2006b, Mangena 2007, Naidu 2005), the absence of strategic coordination at the time of research was a constraint on Satellites Inc. It was evident that the existing networks between the firm and government agencies were fragile, and not functioning as effectively as they should. A similar lack of continuity and loss of institutional memory in government bureaucracy that impacted on VE Tools came into play. Linkages relied on individual agents, and network interaction was not yet entrenched sufficiently in the organization and institutions of the state bureaucracy as a form of governance.

Government financial and human resources may be spread too thin over too many priority areas, to support the firm in its impasse. A senior manager of Satellites Inc argued that given the high-risk nature of the sub-sector, and particularly in facing an impasse such as the launch crisis, the firm needed government involvement to absorb some of the technology risk. Government had no direct investment in Satellites Inc; government had invested extensively in direct technology development, but not sufficient to maintain business indefinitely; and government was not committed to buy products as a 'preferred customer'. One may debate how much government should invest in a single firm (DST 2007: 6). However, the potential risk to the considerable financial and scientific investment in Satellites Inc needed to be carefully evaluated as part of a coordinated strategic policy intervention.

CONCLUSION

In general, the case studies demonstrated that the intellectual capacity to develop cutting edge high technology products exists within some South African universities, that there is a degree of entrepreneurial and interactive capability that can create spin-off firms, and that there is a degree of government funded support for such initiatives. However, the empirical analysis showed that despite a favourable policy and funding context, it is extremely difficult and complex to sustain a competitive knowledge-intensive university spin-off firm in South Africa. The three cases illustrated a continuum of challenges: the

VE Tools case illustrated the failure to create a spin-off, Genomics Inc illustrated the failure to sustain a spin-off, and Satellites Inc illustrated the challenge to remain competitive. In order to explain these outcomes, the paper analysed the ways in which functional networks intersect with resource networks in the differing spatial contexts of each firm, in relation to its links and complementarities with the national technological system, particularly government and the university.

The VE Tools case illustrated misalignment between the software industrial sector and the national technology system, and within the national technology system, that shaped the failure to proceed to commercialization. A lack of common goals between the research group and firms in the ICT software sub-sector, reputational competition between research groups based at different universities and science councils, and a lack of interactive capability on the part of the project leader meant network failure at an early point. The functional networks and human and capital resources flows that could bring the macro and micro levels of innovation and production together were not present. Numerous attempts to build new links with firms, and to strengthen existing links with government funding agencies and within the university thus failed to create conditions to support the ongoing R&D required to proceed towards commercialization.

In contrast, conditions of alignment within the national technology system were more extensive to support the creation of Genomics Inc and Satellites Inc. However, in these cases, inter-locking complementarities in geographical networks (particularly coordination of marketing activities on the global level) were absent, exacerbated variously by weak interaction in the functional and resource networks of the firm and of government.

For Genomics Inc, misalignment of the firm in relation to the national market and global demand for bioinformatics, and ineffective coordination of the functional networks within the firm itself meant that the company was left vulnerable to disruption of the capital resource flow networks it required to put a new business strategy in place.

Satellites Inc had strong internal alignment of its functions and management, and it had good knowledge resource flows with the university. However, a major misalignment in its supplier value chain impacted on its ability to access global markets, and its competitiveness. Its goals were in strong alignment with government's goals and strategic priorities, which meant that government could intervene to support the firm. However, there were indications that functional networks within government and resource networks between government and the firm may be too fragile to support the firm to enable it to weather the 'tough' times.

The analysis identified a range of critical points of misalignment, which could inform strategic policy prioritization and future interventions – in terms of bridging funds, IPR frameworks, supporting access to global markets, and building interactive capability within universities and government departments, to highlight but a few options. However, it highlights a more fundamental issue that could undermine any future strategic interventions. That is, the depth and extent of network alignment within and between the

sub-systems of the national technological system and the industrial sub-sectors in South Africa is not yet able to support knowledge-intensification adequately. Indeed, the thin layer of capacity of key government agents, and a lack of will to provide decisive leadership in policy implementation has been identified as one of the binding constraints on growth and development in South Africa in general (Presidency 2006: 3-4). Stronger, wider and deeper complementarities and overarching linkages within firms, within government and within universities, and between government agencies, universities and firms, could support the achievement of shared developmental goals more effectively. Policy interventions need to build in mechanisms that specifically take into account the fragile network alignment in the South African national system of innovation.

References

Primary sources

Anon. (2003), 'African satellites in orbit', *Science in Africa,* October. [www.scienceinafrica.co.za/2003/October/satellite.htm]

Anon. (2004), Final Report to the Innovation Fund. VE Tools, Cape Town, December.

Anon.(2006a),'SA heads towards the final frontier',*South Africa.The Good News,*28 July.

Anon. (2006b), 'SA Microsatellite departs for Russia', *Creamers' Engineering News,* 7 December.

Alexander, M. (2002), 'Blast from the past. South Africa in space', *Carte Blanche Interactive,* 19 May.

Campbell, K. (2005), 'Last in space?' *Creamer's Engineering News,* 13 May.

Campbell, K. (2006a), 'SA wins major international science facility', *Creamer's Engineering News,* 15 December.

Campbell, K. (2006b), 'SA satellite programme could give Christmas present to the nation', *Creamer's Engineering News,* 6 October.

Campbell, K. (2007a), 'SA accelerates development of cutting-edge biotech research', *Creamers Engineering News,* 20 August.

Campbell, K. (2007b), 'SA, Russia seek to deepen space relationship', *Creamers Engineering News,* 6 April.

Campbell, K. (2007c), 'Second SA satellite to launch in June', *Creamer's Engineering News,* 20 April 2007.

Department of Arts, Culture, Science and Technology. South Africa. (DACST). (1999), Foresight summary report: *Dawn of the African Century: A nation at work through science and technology for a better future,* Government Printer, Pretoria.

Department of Arts, Culture, Science and Technology. South Africa. (DACST). (2002a), *A National Biotechnology Strategy for South Africa,* Government Printer, Pretoria.

Department of Arts, Culture, Science and Technology, South Africa. (DACST). (2002b), *South Africa's Research and Development Strategy,*Government Printer, Pretoria.

Department of Science and Technology. South Africa. (DST). (2007), 'Innovation towards a knowledge-based economy. Ten-Year Plan for South Africa (2008-2018)', Draft document for discussion, 10 July.

Department of Science and Technology. South Africa (DST) and eGoli. (2004), *South African National Biotechnology Audit, January 2003,* DST, Pretoria.

Engelbrecht, L. (2007), 'BEE group takes Satellite Inc stake', *ITWeb,* Johannesburg, 26 January.

Mangena, M. (2005a), 'Budget vote address by the Honourable Minister of Science and Technology, Mosibudi Mangena', 7 April 2005.

Mangena, M. (2005b), 'Address by Minister Mosibudi Mangena, Minister of Science and Technology of the Republic of South Afria, at the International Space Conference."Space and Science" session', Brussels, Belgium, 17 February.

Mangena, M. (2006a), 'Space Science and Technology in South Africa: - Reviving our leadership position in Space Technology'.

Mangena, M. (2006b), 'South African Low earth orbiting micro-satellite. Address at the announcement of the South African micro-satellite', Department of Science and Technology, Pretoria, 31 July.

Mangena, M. (2007), 'Budget vote speech by the Minister of Science and Technology, honourable Mosibudi Mangena', Parliament, Cape Town, 25 May.

Manuel, V. (2007), CITI's Software Engineering Colloquium. Post Event Report, 8 May, Cape Information Technology Initiative, Cape Town.

Naidu, E. (2005), 'National Space Agency will bid for cutting edge tenders', *Sunday Independent,* 1 May 2005.

National Bioinformatics Network. (NBN). South Africa. (2006), NBN Policies and procedures [http://www.nbn.ac.za]

Presidency. (2006), *Accelerated and Shared Growth Initiative. AsgiSA, Annual Report 2006*. [http://www.info.gov.za/asgisa]

South African Agency for Science and Technology Advancement. SAASTA. (2006), 'World Space Week. Space for Saving Lives', Media Release, 4 October.

SAITIS (South African Information Technology Industry Strategy). (2000), *South African ICT Sector Development Framework.* [http://www.thedti.gov.za/saitis/]

SAITIS (South African Information Technology Industry Strategy). (2002), *ICT diffusion and ICT applications in usage sectors.* [http://www.thedti.gov.za/saitis/]

Versweyveld, L. (2003), 'Genomics Inc Corporation releases eVoke gene expression ontology toolkit', *Virtual Medical Worlds,* 15 August.

Secondary sources

Castells, M. (1996), *The rise of the network society. The information age: Economy, society and culture,* Blackwell, Oxford.

Franklin, S. Wright, M. and Lockett, A. (2001), 'Academic and surrogate entrepreneurs in university spin-out companies' *Journal of Technology Transfer,* Vol 26, No 1-2, pp 127-141.

HSRC. (2003), *Government incentivisation of higher education-indsutry partnerships in South Africa. An audit of THRIP and the Innovation Fund,* HSRC Publishers, Cape Town.

Kruss, G. (2005), *Financial or Intellectual imperatives. Working partnerships in higher education, industry and innovation,* HSRC Press, Cape Town.

Kruss, G. (2006a), 'Working partnerships: the challenge of creating mutual partnerships for academics and industry', *Perspectives in Education,* Vol 24, No 3, pp 1-13.

Kruss, G.ed. (2006b), *Creating knowledge networks*, HSRC publishers, Cape Town.

Lee, T-L. and von Tunzelmann, N. (2005), 'A dynamic analytic approach to national innovation systems: The IC industry in Taiwan', *Research Policy,* Vol 34, pp 425-440.

Letseka, M. (2005), 'Government incentivisation of partnership in South Africa: an audit of THRIP and the Innovation Fund', *Industry and Higher Education*, Vol 19, No 2, pp 161-168.

Mustar, P., Renault, M., Colombo, M., Piva, E., Fontes, M., Lockett, A., Wright, M., Clarysse, B. and Moray, N. (2006), 'Conceptualising the heterogeneity of research-based spin-offs: A multi-dimensional taxonomy', *Research Policy,* Vol 35, pp 289-308.

National Advisory Council on Innovation (NACI). (2006), *The South African National System of Innovation: Structures, Policies and Performance. Background report to the OECD Country Review of South Africa's National System of Innovation*, National Advisory Council on Innovation (NACI), Pretoria.

OECD. (2007), *Review of the South Africa's Innovation Policy,* Directorate for Science, Technology and Industry, OECD, Paris.

Paterson, A. (2005), 'Articulation of industrial R&D with higher education in the telecommunications sector in South Africa' *Industry and Higher Education*, Vol 19, No 2, pp 179-188.

Pries, F. and Guild, P. (2007), 'Commercial exploitation of new technologies arising from university research: start-ups and markets for technology', *R&D Management*, Vol 37, No 4, pp 319-328.

Porter, M. (1990), *The competitive advantage of nations,* The Free Press, New York.

Von Tunzelmann, N. (2007). Approaching network alignment, Unpublished report for U-Know consortium, Understanding the relationship between knowledge and competitiveness in the enlarging European Union.

Von Tunzelmann, N. and Wang, Q. (2003) 'An evolutionary view of dynamic capabilities', *Economie Appliquee*, Vol 56, No 3, pp 33-64.

Wang, Q. and Von Tunzelmann, N. (2000), 'Complexity and the functions of the firm: breadth and depth', *Research Policy,* Vol 29, No 7-8, pp 805-818.

Whitley, R. (2003), 'Competition and pluralism in the public sciences: the impact of institutional frameworks on the organization of academic science', *Research Policy,* Vol 32, pp 1015 – 1029.

Whitley, R. (2000), *The intellectual and social organisation of the sciences,* Oxford University Press, Oxford.

Wolson, R. (2003), 'Intellectual property management in South African higher education institutions: some policy issues', *Proceedings of the CHE colloquium: Building relationships between higher education and the private and public sectors and contributing to their high-level person power and knowledge needs,* Council on Higher Education, Pretoria.

Wolson, R. (2007), 'The role of technology transfer offices in building the South African biotechnology sector: an assessment of policies, practices and impact', *Journal of Technology Transfer,* Vol 32, pp 343-365.

Wright, M., Lockett, A. Clarysse, B. and Binks, M. (2006), 'University spin-out companies and venture capital', *Research Policy,* Vol 35, No 4, pp 481-501.

[i] The research on which the paper is based was partially financed by the European Union Commission, in Framework Programme 6, Priority 7 on "Citizens and Governance in a knowledge based society", contract nr CIT5-028519. The author is solely responsible for the contents which might not represent the opinion of the Community. The Community is not responsible for any use that might be made of data appearing in this publication. The paper will be published in *Industry and Higher Education* 2008,22(4): 1-11.