

A framework, process and tool for managing technology-based assets

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Technology organisations centre their business on the development of new technology-based offerings (i.e. products and services). The strategic management of technology-based assets is therefore crucial for these organisations as an imperative for business success. However, these assets are often intangible and reflect future rather than current value and are therefore difficult to manage when using traditional managerial concepts. This study investigates integrative mechanisms addressing the management of technology-based assets and offerings in a technology organisation. The approach taken was to study the views and practices regarding the management of technology-based assets in a number of strategic units of a technology organisation (CSIR, South Africa). The study maintains that the management of technology-based assets and offerings requires clear strategic management of the process of technological innovation with special emphasis on the management of the intellectual capital (IC) and the intellectual property (IP) of the organisation. The study describes a framework linking the core processes supporting the management of technology-based assets and offerings with other organisational elements such as leadership, strategy, and culture. Specific key links between the core process of innovation and the strategic management of investment in technology-based assets using a portfolio approach are discussed.

1. Introduction

In many sectors of the global economy an increasing number of firms are centring their business on the development of new technology-based offerings (products and services). The strategic management of technology-based assets has therefore become crucial in gaining competitive advantage. A number of studies emphasise the importance of technology-based innovation processes as an imperative for business success (Hamel and Prahalad, 1990; Jolly *et al.*, 1997; Matheson and Matheson, 1998; Roussel *et al.*, 1991). However, the integration of technology/innovation management practices with conventional (traditional) organisational strategic thinking and decision-making presents a significant challenge (Matheson and Matheson, 1998; Stewart, 1998). Hamilton (1997) emphasises the creation of common language and frameworks as part of the managerial challenges and choices presented to firms aiming at employing

technology as a strategic asset. In addition, organisations do not engage in learning about managing their technology-based assets in a financially rigorous way. This could constitute a significant organisational risk where the core business of the organisation is knowledge-intensive.

The firm's technology-based assets are often intangible and reflect future rather than current value and, as such, constitute a different category of assets, which is difficult to manage as an integral component of the overall strategy of the organisation (Stewart, 1998). Because income of many technology-based firms is either gained or paid in licensing with increased penalties related to litigation (in many parts of the world), the management of technology-based assets is becoming a major concern (Carayannis and Alexander, 1999). In many cases the key to managing technology-based assets is the strategic management of the intellectual capital (associated with, or) embedded in these assets. A recent benchmarking study

(involving 21 companies in high-tech and chemical industries in the USA) indicated that companies are increasingly paying greater attention to the strategic management of their intellectual property, with special emphasis on patents (Ransley and Gaffney, 1997).

The strategic management of technology-based assets is addressed in this study. The study calls for the introduction of a new innovative approach to technology undertakings. The study uses a case study approach and provides a framework for the strategic management, as well as processes and systems supporting the management of technology-based assets and offerings.

2. The CSIR

The CSIR is a South African statutory organisation with an autonomous status. The CSIR is the largest technology organisation on the African continent with a staff complement of over 3000 and a turnover per annum of about US\$ 150 million. The CSIR undertakes contract research and development programmes and provides technology and specialist consultancy services to a variety of local, other African and international users (Basson, 1996; CSIR, 1990–98; De Wet, 1997).

During the mid-80s the CSIR's core operating philosophy underwent major re-thinking due to external and internal environmental constraints. The change resulted in the establishment of a new operating philosophy with clear business objectives. In 1986, the CSIR was restructured into a market-driven, autonomous organisation with a number of strategic units (divisions) addressing different market segments. The CSIR's objectives are to be market-driven and to increase external earnings in real terms through meeting the needs of all its clients and stakeholders. It currently earns about 60% of its annual turnover from external contracts, originating from the public and private sectors, and from international contract

research. Income from other African countries and other parts of the world is growing steadily (CSIR, 1998).

The CSIR conducts its activities in a business-like manner and has clear key performance indicators and measures addressing the effectiveness and efficacy of its investment, financial status, and its position in the local and the global market. This includes measures such as return on investment, growth in external income (external contracts), royalty income and income due to new offerings as a percentage of external income, customer satisfaction, quality based indicators (benchmarking), specific impact measure per market segment (including a global and a local view), cash flow from operations and margin before non-operational income as well as net margin. The CSIR publishes, annually, its financial statements and report on its activities to all its stakeholders and clients via an annual report.

A brief overview of the nine strategic units of the CSIR is given in Table 1. The CSIR has a strong knowledge base in materials and primary processing technology. This strong base is utilised in conjunction with other technologies to serve different market needs. All strategic units offer the market technology-based offerings, including the sale of technology, services (e.g. contract R&D, specialised consultancy) and products (e.g. hard products and software systems). However, the units differ in volume and balance of the above offerings.

3. Strategic management of technology-based assets and offerings

The core business of the CSIR is innovation, which is centred on the sale of technology-based offerings. These offerings are heavily dependent on the technology-based assets of the organisation. Technology-based assets consist of the Intellectual Capital (IC), and the Intellectual Property (IP) of the organisation.

Table 1. The CSIR's strategic units of their characteristics.

Strategic unit of technology	Core technology	Market sector
Building	Infrastructural and materials	Central and local government, construction industry
Water, environment and forestry	Environmental assessment and management	Public and private sectors, industrial development sector
Defence	Materials and information	Defence, security industry
Biochemical and food	Bio-science and biotechnology	Agriculture, food, pharmaceutical industry
Material and manufacturing	Materials and industrial process	Manufacturing industry
Information and communication	Information	Public and private sectors
Mining	Materials processing	Mining industry
Textile	Natural materials	Textile industry
Roads and transport	Infrastructural and materials	Public sector

IC can be defined as the know-how and knowledge embodied in the human capital of the organisation. IC is used to develop, apply and sell different forms of IP.

The CSIR has developed a portfolio management approach that supports the core business of technological innovation. The organisation has about 80 strategic portfolios where each portfolio represents an organisational knowledge entity, linking focused market needs to the organisational core competences and embedding core IC and IP into technology-based offerings. Each strategic portfolio mirrors the core business of the organisation i.e. innovation, and reflects the notion of ‘market to mind to market’ supporting the full innovation cycle from idea generation to delivery of offerings.

4. An innovative business process and an enabling software tool for managing the organisation technology-based assets and offerings

The CSIR investment process supports its portfolio management approach. The process aims at maximising benefits and improving the efficacy and the effectiveness of the organisation’s deployment of the Parliamentary Grant (the annual grant provided by the South African government) that is viewed and treated by the CSIR as an investment fund. Three major themes underpin this investment process i.e., the direct link to market needs as a basis for the development of technology-based offerings, the notion of portfolio management and the indirect ties between the investments in competence development (science and technology) and specific offerings (products and services).

Years of organisational learning facilitated the current understanding of portfolio management. The core concept underpinning this understanding is that in order to maximise returns on investment, the investment process should be centred around portfolios of offerings. This indicates a clear move from a previous

‘product life cycle’ approach which was widely practiced in the organisation.

This insight facilitated the birth of a new entity i.e. the portfolio (Figure 1). Indirect ties between investments in competence development and offerings (products and services) link investment and income within a portfolio. The portfolio has become the organisational knowledge entity that ties focused market needs to the organisational core competences of knowledge acquisition, development, deployment and transfer. A portfolio represents a group of related offerings at different stages of development. An offering is defined as a product or a service offered by the CSIR to the market. The CSIR offerings are developed in accordance with market needs through the utilisation of the organisation’s unique competences. The development of offerings requires investments to create different components of organisational competence as summarised in Table 2.

In conjunction with its investment business process the CSIR has developed a software tool, namely *KnowledgeWise*© – portfolio management for innovation. The tool supports investment decision-making and allows on-line planning, management and evaluation of investments funds and investment outcomes at various levels within the organisation. Both investment history and future cash flows are captured. In addition to providing a logical framework for planning, strategy development and implementation management, it also functions as the organisation’s knowledge warehouse, allowing data aggregation, data analysis and trend analysis.

KnowledgeWise© consists of a number of closely linked planning modules addressing topics such as market needs, market position, offering description, technology maturity, needed competence, investment and income scenarios, technological and commercial risk (at an offering and a portfolio level), and short-, medium- and long-term investment plans. In addition to these planning modules, the tool has a unique implementation module (the balance sheet sub-tool)

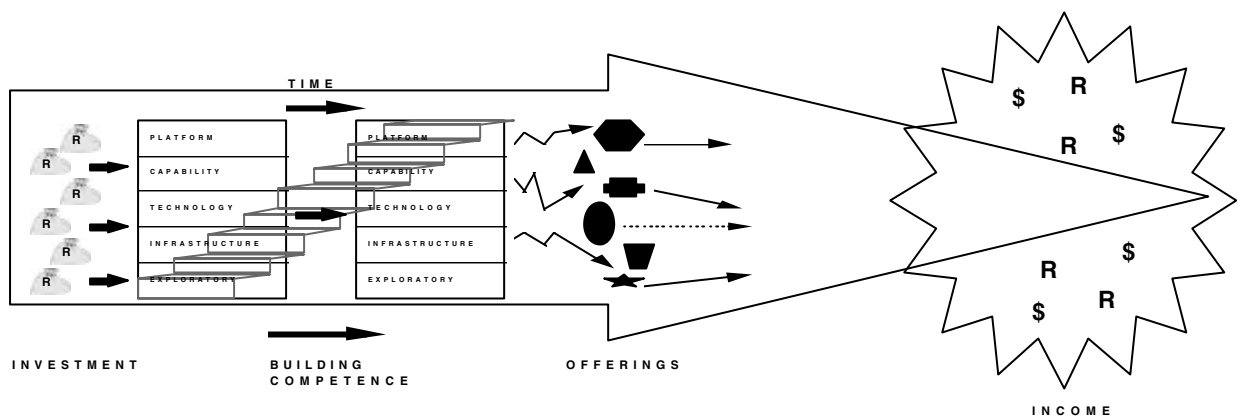


Figure 1. A strategic portfolio of technology-based assets and offerings.

Table 2. Different components of organisational competence.

Components of competence building	Description
Exploratory Infrastructure	At this level, new concepts, technologies and markets are explored The provision of required infrastructure such as research facilities and information technology systems and structures. At this level, the investment is mostly internal and the direct marketable outputs are limited
Technology	At this level core know-how and skills (i.e. intellectual property) are developed. The offerings at this level of competence are aimed at a market with advanced science and technology needs, e.g. commercial partners, clients with well developed in-house technological knowledge and clients who out-source non-core technologies
Capability	The ability to mobilise know-how and know-ware into a problem-solving mode, i.e. effective knowledge transfer. The capabilities developed at this level could be used to provide knowledge-based services to specific market segments, e.g. value-adding decision support and specialist consulting services
Platform	At this level advanced packaging of knowledge (i.e. knowledge-based core services and products) is developed. These core services and products are 'self-standing' (prepackaged) and may serve a wide range of market segments that have limited or no technological know-how

supporting the deployment of the investment into appropriate implementation projects and recording all linked investment and income projects.

5. Assessing utilisation and effectiveness of investment – the balance sheet approach

The implementation stage of the investment process is managed using the balance sheet sub-tool. This sub-tool records investment projects and income projects which relate to a specific portfolio and facilitates the analysis of the investment portfolio as presented in Figure 2. Investments are designated into five generic categories, i.e. 'income generators' (exploited investments which bear income), 'sleeping beauties' (dormant investments), 'infrastructure' (investments aimed at building infrastructure which will not bear income), 'exploratory' (investments in new technology and market exploration) and 'dead ducks' (written off investments). The breakdown of the total investment into the categories mentioned above provides a

framework for analysing and assessing investment efficacy. The data can be presented at different levels of aggregation and trend analyses can be derived using cumulative data. Examples of four different investment trends are given in Figure 3.

As shown in Figure 3, each Unit has utilised its investment differently. To analyse Unit efficacy in context, the breakdown and trend analyses shown in Figure 3 should be related to the nature of the business of each Unit and its market dynamics. It is also of the utmost importance to understand how this efficacy relates to its effectiveness. The balance sheet approach provides this analysis by calculating an index of return on exploited investment. Examples representing four different trends of effectiveness are given in Figure 4.

6. Key stages linking the investment process to the process of technological innovation

As shown in Table 2, the portfolio approach emphasises investments in building of technology-based assets

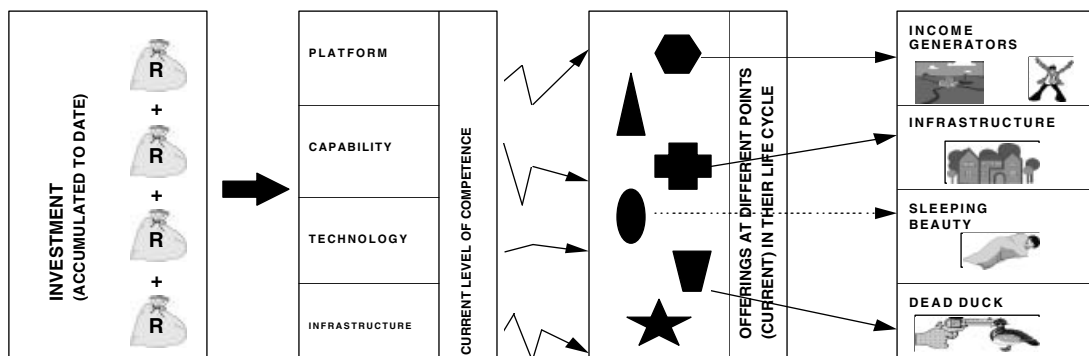


Figure 2. A portfolio balance sheet.

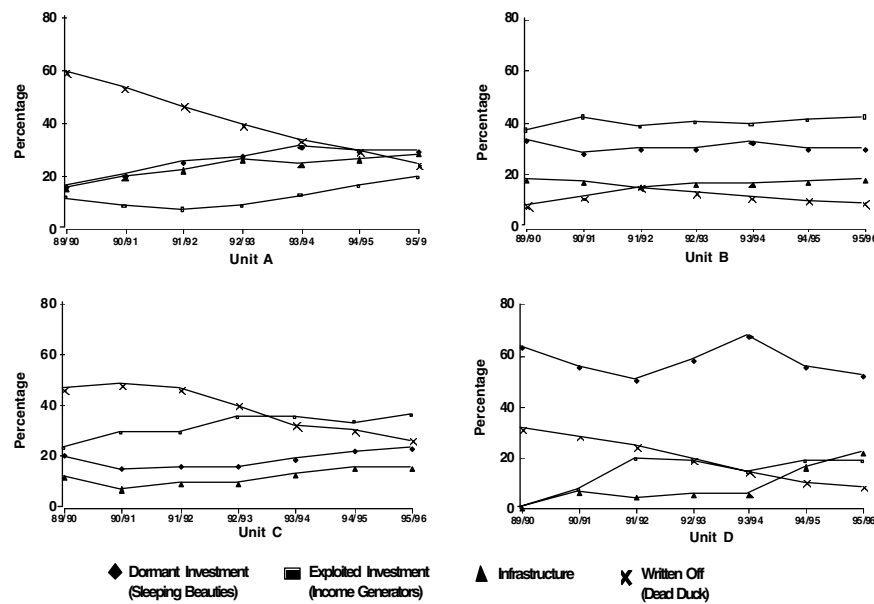


Figure 3. Trend analysis of investment utilisation (Cumulative data collected for four different Units over a period of seven years).

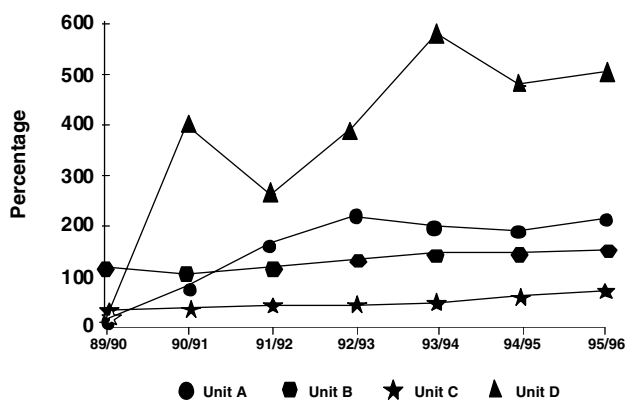


Figure 4. Trend analysis of the effectiveness of investment (Cumulative data collected for the same four Units over a period of seven years).

at different levels of competences. Each level of competence will result in development of different kinds of technology-based offerings and will require different strategic management of the IC and IP embedded in the relevant technology-based assets. The different levels of competence required to build the organisation technology-based assets and offerings (Table 2) are directly related to the core business of innovation.

There are three clear major investment stages related to development and deployment of technology-based assets as described below:

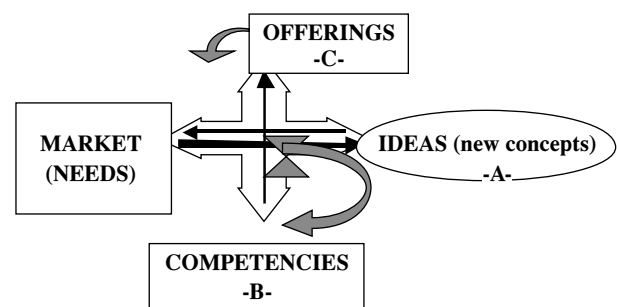
- Exploration Stage (A) – where the organisation invests in its IC and builds its intellectual infrastructure and exploratory research;
- Competence Building/Translation Stage (B) – at this stage the organisation invests in building the

- appropriate level of competence to allow the translation of the idea into a saleable offering;
- Offering Commercialisation and Delivery Stage (C) – at this stage the organisation invests in the commercialisation and marketing of its offerings.

The CSIR's portfolio management approach aims at maximising the benefits and improving the efficacy and the effectiveness of the organisation's deployment of its investment in the development of technology-based offerings (products and services) (Paterson and Kfir, 1997).

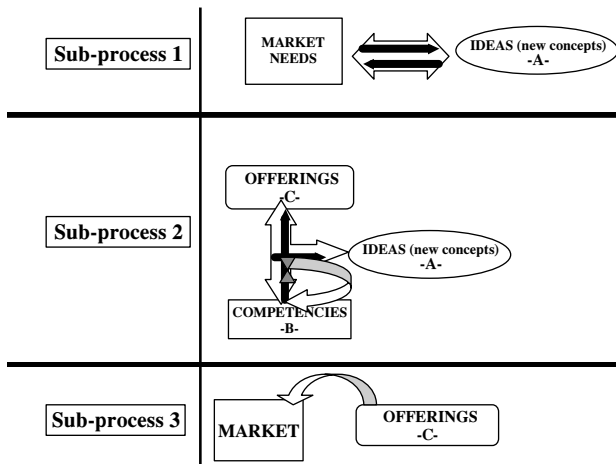
7. The innovation process

As indicated above, the core business process of a technology organisation is the technology innovation process (Figure 5).



(A-C: investment process stages: A – the exploration stage; B – the competence building/translation stage; C – the offering commercialisation and delivery stage)

Figure 5. An overview of the technology innovation process.



(A–C: investment process stages: A – the exploration stage; B – the competence building/translation stage; C – the offering commercialisation and delivery stage)

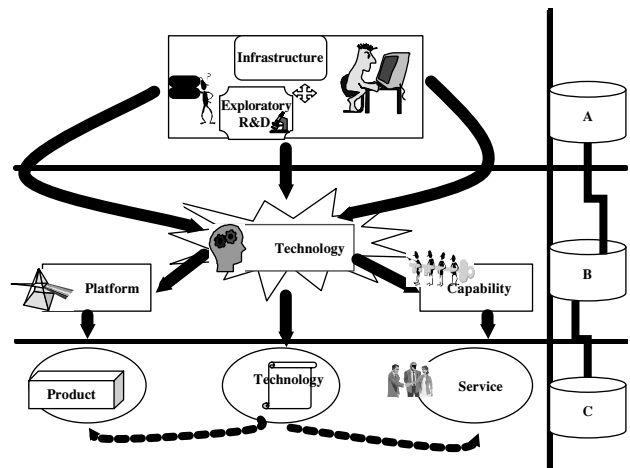
Figure 6. The sub-processes of the technology innovation process of a technology organisation.

This process is rooted in both business and technology strategies as it links market needs to the sale of offerings (Figures 1 and 5). This innovation process is closely linked to the notion of portfolio management of technology-based assets and offering and its supportive investment process and tool. The three investment stages are closely linked to the core process of innovation as presented in Figure 5. The innovation process is a non-linear process consisting of three major sub-processes:

- *Sub-process 1* addresses the relationship between market needs and idea generation. While idea (or new offering concept) generation is triggered by explicit market needs, there is also a clear link between new concepts originating from within the organisation, which may create explicit market needs when the market's implicit needs are addressed. This sub-process is associated with stage A of the investment process (investment stage A – the exploration stage, Figure 6);
- *Sub-process 2* forms the link between the new idea and the organisation's competence base. This link facilitates the formation of new or improved offerings. This sub-process is linked to stage B of the investment process (investment stage B – the competence building/translation stage, Figure 6);
- *Sub-process 3* is where the new offering is presented, delivered (i.e., sold) to the market. This sub-process relates to stage C of the investment process (investment stage C – the offering commercialisation and delivery stage, Figure 6).

8. Strategic management of intellectual capital

This study maintains that there is a close link between the strategic management of innovation and the level



(A – the exploration stage; B – the competence building/translation stage; C – the offering commercialisation and delivery stage)

Figure 7. A model for strategic management of technology-based assets and offerings.

of competence embedded in any specific technology-based asset and offering. Figure 7 presents a model for the above with special emphasis on management of IC at the various levels of competence (Table 2). As presented in Figure 6, the model also indicates clear links to the three major stages of investment in the development of technology-based assets and offerings (Figure 5). At the exploration stage, exploratory research is done and basic development of the intellectual infrastructure (human capital) takes place. At this stage offering concepts are explored but no offerings are sold. The technology assets developed at this stage are mainly in the form of IC. The management of these IC-based assets is related directly to issues of leadership and culture (see Section 9 and Figure 8).

The competence building/translation stage (Stage B) is where competences, required for the translation of the new ideas into saleable offerings, are acquired. The level of competences differs with the type of target offering. Three different levels of competences are shown in Figure 3, i.e., technology, capability and platform (Table 2).

The technology level forms the basis for the other two levels of competences. At this level of competence, the organisation has a technology asset in a form of IP.

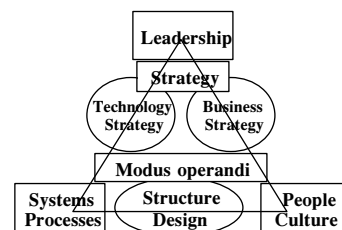


Figure 8. A framework linking the organisation's core elements with the management of technology-based assets and offerings.

The organisation may choose to sell this IP direct as a technology. The direct sale of technology will coincide with all issues that relate to the traditional protection of IP (e.g. patents, licensing, trademarks, copyrights and other related issues). Alternatively, the organisation may prefer to develop this technology to a capability or a platform level of competence. In both these levels the technology assets of the organisation are in the form of a complex combination of IP and IC.

At a capability level the organisation offers the market either contract R&D or specialised consultancy services (Stage C – the offering commercialisation and delivery stage, Figures 5 and 6). This kind of offering requires high investment into the development and the protection of the organisational IC. At platform level the technology is embedded in a hard or a soft product and IP forms the major component of the technology asset. At stages B and C the organisation can choose between an in-house development and sale or a joint venture route. Thus, the management of the technology-based asset will differ accordingly and issues such as legal ownership of IP, trade secrets and secrecy agreements will need to be addressed.

9. A framework linking the management of technology-based assets with core management elements

As discussed above, the strategic management of innovation with a special emphasis on the management of IC is crucial for technology-based organisations. The model linking the core process of innovation with specific investment stages (Figures 3 and 4) provides a strategic framework for managing technology-based assets and offerings. However, the modus operandi, and practices (generic type of business, processes and frameworks) of technology organisations call for a wider integrative model where the organisation's core business of technology innovation will be integrated with other key strategic elements. Other studies addressing this issue also stress the need to view and manage technology-based assets as a business imperative (Hamilton, 1997; McConnachie, 1998). By using a systems view this study aims to provide a technology organisation with a high level integrative framework for strategic management of technology-based assets and offerings as shown in Figure 8.

Figure 8 presents an overview of the core elements essential to the management of innovation within the framework of management of a portfolio of technology-based assets and offerings. The integration of the strategic management of technology-based assets and offerings is represented in the wide-system view by the close link between the business and technology strategies. The triangular structure and the position of the various elements relative to each other are of great significance.

All key elements are strongly inter-dependent and a change in any element may result in an overall 'distinctive shift' in the wide system. The three core elements of leadership, systems and processes, people and culture form the triangular base onto which the other elements are anchored. Appropriate and conducive leadership and culture supported by the appropriate processes and systems are essential for the strategic management of innovation. This will include IC issues that relate to creativity, and IP and IC issues relating to incentive schemes and IP ownership.

The CSIR case presents an example where core business processes are used by an organisation to mirror the organisational intent. It is evident that both the innovation core business process and the supporting investment process have greatly improved the contribution of the organisation to its clients and stakeholders in both the public and the private sectors. The CSIR case also presents a good example where a positive reinforcing relationship was established between the business process and the corresponding IT component as illustrated by the effectiveness of the supportive software tool, namely *Knowledge Wise*©.

10. Conclusion

In summary, the system-wide view, the innovation process and its sub-processes, the model linking the strategic management of technology-based assets and offerings with the innovation supportive investment processes form a holistic framework. This framework is based on the notion of managing portfolios of technology-based assets and offerings. This framework addresses two major strategic themes i.e., the types of technology assets the organisation is building to support its innovation process and the level of competence at which the organisation chooses to sell its offerings. A clear, strategic understanding of the above will facilitate the appropriate strategic and operational management of IP and IC as an integrative part of managing the organisation's portfolio of knowledge-based technology assets and offerings. It is also suggested that technology organisations utilise this framework in conjunction with other supporting tools that will allow ongoing operational management of investment into the development of portfolio of technology-based assets and offerings which will enhance the maximisation of return on investment.

In addition, the CSIR case presented here emphasises the importance of business processes and tools that enable the viable integration of technology and innovation management into the overall organisational business at both strategic and operational levels.

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