

**“Designing a Funding Mechanism in a Government R&D
Organization: Applying the Intellectual Capital Lens”**

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Abstract

This paper sets out to make a distinction between R&D on the one hand and innovation on the other as well as mapping the value creation dynamics of R&D through the lens of the resource-based view of the firm and intellectual capital thinking. The purpose of this paper is to let this theoretical background feed into the design of an internal R&D funding mechanism in a government organization. We review the constraints experienced by governmental organizations in general and governmental R&D organizations in particular in terms of the pressure to disclose performance results as well as budget restrictions. The paper concludes with an in principal design of an internal funding mechanism for a government R&D organization using the intellectual capital language.

Keywords: Research and development, innovation, intellectual capital, public sector, funding.

Introduction

Trends such as the growing significance of global markets together with increasing competitive pressures as well as a shortening of product lifecycles, all imply that the effective and efficient management of research and development activities is becoming more important for firms and originations across the world (Völker and Kasper, 2004). Increasing the potential for innovation and achieving outstanding performance in Research and Development (R&D) represent some of the biggest challenges for many firms (Boer, 1999). Research and development organizations need to enhance their strategic management in order to become goal-directed communities for innovation (Judge et al, 1997) and allocate their resources consistent with their overall R&D strategy (Harrison et al, 1993).

It is now widely acknowledged that intangible resources are key drivers of innovation and organizational value in R&D organizations (Coombs, 1996; Del Canto and Gonzalez, 1999; Bounfour, 2003, Pike et al., 2005). The appropriate allocation and deployment of these intellectual capital resources is an important strategic decision for organizations in general and for R&D organizations in particular (Halliday et al, 1997). However, Knott et al. (2003) and Dierickx and Cool (1989) conclude that the accumulation process of intangible assets per se is not an isolating mechanism for increased R&D performance. It is the effective management of the available resources, tangible and intangible, that determines differences in R&D performance (Del Canto and Gonzalez, 1999).

This paper sets out to make a distinction between R&D on the one hand and innovation on the other as well as mapping the value creation dynamics of R&D through the lens of the resource-based view of the firm (e.g. Penrose, 1959; Wernerfelt, 1989, Barney, 1991) and intellectual capital thinking as devised by e.g. Roos and Roos (1997), Roos et al. (2005) and Pike et al. (2006). The purpose of this paper is to let this theoretical background feed into the design of an internal R&D funding mechanism in a government organization.

We start off by briefly reviewing the nature of R&D and then turn to innovation in order subsequently to compare and contrast the two. We explore the particularities of R&D in the public sector as well as the importance of intellectual capital thinking in an R&D value creation. Last, aspects around funding of R&D are described before we go on to devise a principle funding mechanism expressed in intellectual capital language.

The nature of Research and Development

The reinvention of innovation and knowledge is fundamental to the increasing shift toward a knowledge-based economy. In this context, R&D is an organized way to develop a 'knowledge base' and 'innovation potential'. In the last few decades the organization of R&D has witnessed a series of transformations resulting in several 'R&D generations'. The first and second generations focused on linear knowledge generation (Bush, 1947) which until the 1950s was based on the concept of 'intellectual curiosity'. In the 1950s and 1960s, R&D activities primarily concerned the principles of project

management. In the 1970s and 1980s the (industrial) research and development landscape increasingly focused itself on firm objectives and strategies with increased attention given to the element of risk management.

Since the 1990s, an increase in non-linear information flows within R&D can be witnessed primarily due to a large number of alliances between R&D customers and suppliers. Consequently, the forth generation of R&D can be characterized as follows:

- The process of R&D is a managed one (e.g. according to project management principles);
- The risk involved is spread over several projects which are run in parallel, linked by a long-term strategy and are bundled in portfolios (portfolio management);
- Collaboration between governments, universities and industry is increasingly important for R&D efforts to be successful;
- High risk research is to be linked with regional development goals and implemented in small networks and partnerships.

Consequently, these trends imply that the fundamentals for research can to a lesser extent be based around an individual researcher system and instead research activities increasingly need to be based on inter-disciplinary teams driven by customer and user requirements (Gupta, 1996; Germeraad, 2001; Edler, 2002).

R&D activities typically entail different development stages. The management direction in these development stages is a widely accepted approach (Boer, 1999, 22). According to the, Oslo Manual' (OECD, 1997) the technological innovation of a product/process consists of the following activities:

- Research and development;
- Selection of suitable technologies;
- Industrial product development;
- Design;
- Commencement of production and
- Marketing, optimization and training.

Innovation

Innovation is often claimed to be a cornerstone of competitiveness (Denton, 1999; Jägge, 1999; Johannessen et al., 1999; Neely and Hii, 1998) and in some cases also profitability (Bose et al., 2002 ; Roberts, 1999). The role of innovation in a firm's strategy is further said to contribute to competitive advantage (Johannessen et al., 2001), organizational performance (Yamin et al. 1999) and market share (Robinson, 1990).

Innovation is a more comprehensive term which goes beyond the R&D concept, covering all steps from the generation of ideas to the first economic conversion into a new marketable product, procedure or service (Grünbuch der Innovation, Europäische Kommission 1995; 5). Prior to R&D is the idea identification, post-R&D is the technology transition and market introduction (which is often more difficult than the technological R&D itself). Innovation processes are described as open, dynamic and non-linear, and are therefore hard to predict and to control (Roste, 2005). Yet there are some basic conditions and general patterns that often occur in innovation processes. The “innovation journey” (Van de Ven et al. 1999) presents a road map of how innovation processes typically unfold. Innovation processes are understood as occurring in three phases: the initiation period, the development period and the implementation/termination period.

Innovation research does not deliver a comprehensive approach nor a generally accepted definition of innovation (Lehner, 1998; 9). The OECD definition as defined in the Oslo Manual, (OECD, 1997) focuses on the innovation process (how is innovation defined in individual stages?) whereby the organization of innovation within and around the firm is of significance.

A further analytical distinction can be made by the differences between process innovation (which allows for productivity gains by improved production methods and organization) and product innovation (new or improved products). In practice process and product innovation frequently overlap.

R&D vs. innovation

At this stage it is worth pointing out that there are some clear differences between R&D and innovation. While R&D can occur within the realm of a single discipline and also within the boundaries of a designated R&D department, real innovation typically requires the joint efforts of several departments and functions and often even parties external to the organization (Burns and Stalker, 1961; Rothwell et al. 1974; Wang 1997; Miyazaki, 1995, Nonaka and Tekecuchi, 1995; Iansiti, 1997). Innovation takes place in a system consisting of individuals, firms and institutions and within a certain cultural and regulatory framework. Innovation is not the result of a linear process starting out in universities and government laboratories and then transferred through companies to the market. Accordingly, innovations – be they new or improved products, processes or services – are not normally born as ideas in institutions of basic science. Rather, most innovation processes start within companies trying to solve certain problems. Through this learning process the company will make use of various sources of competences and knowledge in the innovation system, being those customers, suppliers, consultancies, patents, or various research institutions (Røste, 2005).

The above is a *holistic* view of innovation (Roste, 2005). The profit-maximizing model generally applied in neoclassical economy is too limited to understand the processes of innovation. To be able to understand and explain innovations all important elements

shaping and influencing the dynamic of the systems must be taken into account. These are not restricted to economic elements, but also organizational, institutional, social and political factors, mechanisms and relations. The legal conditions and the norms and cultures in the institutional context represent important incentives and constraints to innovation. Through their activities, companies establish relations with other companies like suppliers and competitors, with customers and with other financial, technological and marketing partners. These relations and their institutional contexts make a complex map of the company's interaction with sources of knowledge and technology and the potential for learning and cooperation. This cumulative accumulation of knowledge and skills, i.e. the learning process, is crucial for innovation (ibid). This is not to say that R&D can do completely without such a network – it may certainly be enhanced by it – but it is not as crucial for creating R&D value as it is for creating innovation value.

Considering the value dimension, we fall onto another significant difference between R&D and innovation. The value of innovation can typically be measured in monetary entities while it is not as straightforward with R&D. Put very simply, R&D is about transforming money into knowledge, while innovation is about transforming knowledge into money as illustrated in figure X. Innovation should hence have a more direct impact on revenue generation whereas R&D may or may not have it have it long term. A number of studies consider the role of technology and research and development as contributors to innovation (Aghion and Tirole, 1994; d'Aspremont et al., 2000; Gans and Stern, 2003, Hull and Azumi, 1991; du Pre Gauntt, 2004).

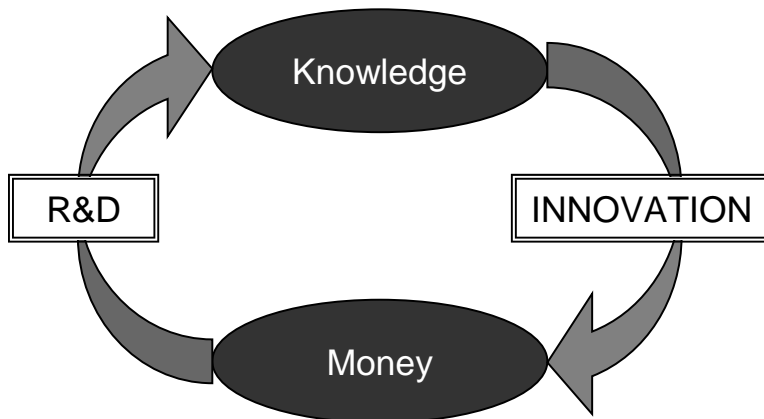


Figure 1 The difference between R&D and innovation

Having made that distinction, this paper really concerns R&D, and not innovation, in a public sector environment. The public sector focus also gives that R&D gets measured predominantly in social benefit terms.

R&D in the public sector

As mentioned in the introductory section of this paper, we will use the resource-based view of the firm together with intellectual capital thinking in order to design the principles for a funding mechanism in a public sector R&D organization. At this stage, it is therefore worth examining the particularities and prerequisites brought about by a governmental context.

With increasing globalization, countries need to foster innovation and R&D in order to stay competitive on a global scale. To Western countries in particular, this is a pressing issue since they cannot compete with low cost labour provided by countries such as China and India. Governmental R&D organizations are hence important players in the technological development of economy and society and contribute to the competitiveness of nations (Rudolph and Leitner, 2002). Most research organizations are linked in national and international university-, industrial- and public networks and thus fulfill important functions within the knowledge transfer from the basic research to the development and implementation of new technologies.

Characterized by different owners, different legal status, missions, organizational structures and outputs, the sector is very heterogeneous and formed by the national context. Contract Research Organizations, Research Technology Organizations, Joint Research Centers, Competence Centers and Large-scale Facility Centers are typical organizational forms, with public as well as also private owners, which are mainly publicly, but also privately funded. The majority of the organizations are non-profit, they often have missions and aims strongly influenced or set by the science and technology policy and are also producers of public goods (ibid).

In a knowledge-based world, a national economy's maintenance of the competitive edge increasingly depends on the management of ideas and innovation. As governments and their employees embrace the 'knowledge age', the value of, and demand for, government information and services will increase significantly (OECD, 1999). Given that governmental R&D output cannot readily be measured in money, these organizations usually face an issue around the justification of its existence and benefit of the society and economy that they serve. Measuring and managing intangible resources thus seems to have a huge potential for research organizations, because firstly, their most important resources are obviously intangible ones and their major output is knowledge, and, the traditional accounting system does clearly not deliver information for investment decisions and the strategic management of the knowledge based resources (Rudolph and Leitner, 2002).

This need for justification has taken the form of disclosure of numerous performance measures of varying usefulness. The pressure to disclose performance information has in many Western countries been reinforced by a stream of thinking under the umbrella term of 'new public management' (NPM), reforming public sector organizations towards a managerialist philosophy and the virtues of economic rationalism (Jones, Guthrie and Steane, 2001, p.5). With the implementation of NPM reforms and the transition towards

the market model of governance, modes of public sector management have increasingly emphasized quantitative performance measurement. This has predominantly comprised a shift towards the application of accrual accounting and reporting techniques (Guthrie, Carlin and Yongvanich, 2004). In addition, representations of government agency output have been increasingly specified in financial and nonfinancial measures of organizational activity. Indeed, even in such traditionally qualitatively assessed areas as social welfare, professionals and managers alike found their activities being increasingly represented and subject to scrutiny in terms of quantitative performance indicators, invariably expressed in accounting terms (English, Guthrie and Parker, 2005).

Resource provision determined through annual budget cycles is limited to the achievement of performance targets within corresponding short- to medium-term time-frames, a practice commonly referred to as accrual output-based budgeting (Carlin, 2003). Adopting a longer-term view to the organization is arguably more difficult given these impositions and circumstances. Indeed, the imposition of accrual accounting based reporting and budgeting frameworks risks damaging the long-term sustainability and value creation capacity of public-sector organizations, given that strategically important intellectual capital resources are not accounted for in these performance reporting regimes (Guthrie et al., 2005).

R&D value creation

Earlier in this paper we briefly discussed the difference in what type of value innovation and R&D create respectively. Looking more closely at R&D value creation there is clearly a need to understand how it happens in order to know how to manage and fund R&D activities.

As Pike et al. (2005) note, much of the work on resource allocation in R&D organizations is focused on financial resources and staffing (Harrison et al, 1993; Scholefield, 1994). Little research has concentrated on how to best deploy and utilize intangible resources within R&D organizations. At the same time, R&D companies often struggle with causal ambiguity and a strong interconnectedness of assets (Dierickx and Cool, 1989). This means that R&D organizations often do not understand how resources rely on each other to create value, which leads to an R&D process that is often stochastic and discontinuous (Dierickx and Cool, 1989). Without a solid understanding of the key value drivers and their dynamic interaction, it is difficult to strategically manage and effectively allocate resources.

This section looks at the dynamic value creation of resources in R&D organizations with specific focus on the importance of intellectual capital resources. This is done through the lens of the resource-based view of the firm (Wernerfelt, 1984; Dierickx and Cool, 1989; Prahalad and Hamel, 1990; Barney, 1991; Grant, 1991; Peteraf, 1993). This view of innovation-based competition, increasing marginal returns and development of strategic competence was first framed by Edith Penrose (1959) and then later picked up by Birger Wernerfelt (1984) and Richard P. Rumelt (1984), who are seen as developers of the modern resource-based view of the firm (Foss, 1997). The resource-based view

concentrates on the antecedent role of internal resources and understands firms as heterogeneous entities characterized by their unique resource bases (Nelson and Winter, 1982) with different distinctive competencies (Selznick, 1957). Firms need to strategically deploy and utilize their resources in order to gain a competitive advantage (Peteraf, 1993).

According to the resource-based view, sustainable competitive advantage results from resources that are inimitable, not substitutable, tacit in nature, and synergistic (Wernerfelt, 1984; Barney, 1991; Rumelt, 1984; Teece et al, 1997). Therefore, managers need to understand what are the key resources and drivers of performance and value in their organizations. Traditionally, those resources were physical, such as land and machines, or financial capital. In later years, intangible assets have been identified as key resources and driver of organizational performance and value creation (Itami, 1987; Teece, 2000; Nahapiet and Ghoshal, 1998; McGaughey, 2002; Delios and Beamish, 2001; Roos and Roos, 1997) and it holds especially true for organizations involved in R&D (Henderson and Cockburn, 1994; Quelin, 2000; Del Canto and Gonzalez, 1999).

Itami (1987) was one of the first to articulate the notion of intangible assets such as technology, accumulated consumer information, brand name, reputation, and corporate culture as the critical resources of firms and sources of competitive power. Since then, scholars and practitioners alike have come up with a plethora of various definitions and classifications of intangible resources (e.g. Hall, 1992; Edvinsson, 1997; Roos and Roos, 1997; Sveiby, 1997). Multiple taxonomies of intangibles have been suggested over the past decade, however, it seems that the distinction between human resources, organizational resources, and relational resources are the most commonly accepted categories (Bainbridge, Jacobsen and Roos, 2001; Pike and Roos, 2001). These are explored in some more detail below.

Intellectual capital resources are most commonly categorized into three main groups - human, organizational, and relational (e.g. Pike et al., 2006), albeit some use different but equivalent terms. To these are added the two familiar tangible resource groups of the firm namely physical and monetary resources.

Human resources naturally make up a core asset for R&D firms as they rely on highly educated and trained scientists and technicians with know-how in the relevant areas. Human resources include the experience, knowledge, judgment, abilities and skills of individuals associated with the firm (Barney, 1991). Research suggests that in R&D environments, university degrees, diversity of backgrounds, as well as knowledge depths are strongly associated with innovation (Souitaris, 2002; Carroll, 1967; Devar and Dutton, 1986).

Organizational resources include brand, intellectual property (IP), strategy, culture, reputation and image of an R&D firm. Teece (1986) shows that such commercial resources can become important for the suitable exploitation of R&D activities. Furthermore, research suggests that in an R&D context a strong market orientation improves innovative capacity (Rothwell, 1992) and organizational culture is a critical success factor (Damanpour, 1992; Pearson, 1989).

Relational resources for an R&D organization are made up of partnering agreements with suppliers, external subject matter experts, research centers, or universities as well as relationships with regulatory bodies. Quelin (2000) finds that by nurturing relationships with external research laboratories and universities, R&D organizations can develop and nurture their competencies. Similarly, Henderson and Cockburn (1994) find that encouraging and maintaining flows of knowledge across the boundaries of the firm and across scientific disciplines leads to more productive R&D efforts. In addition, Chung and Kim (2003) find that higher level of supplier involvement has positive effects on R&D performance.

Physical resources include land, buildings, IT, equipment, materials and products of an R&D organization. Results in R&D organizations often depend on highly valuable and specialized equipment, tools or software applications. Del Canto and Gonzalez (1999) confirm that successfully carrying out R&D activities often requires highly sophisticated equipment and technology, which is added to the productive system of the firm.

Monetary resources in the R&D context include any financial assets, which are equivalent to or can be converted into cash. Cash flow generated by the firm make future R&D activities possible (Baysinger and Hoskisson, 1989; Goolsbee and Klenow) and in turn R&D activities generate future cash flow (Mansfield, 1965; Minasian, 1969).

As mentioned above, the mere presence of resources is not enough for value creation to realize. The resources need to interact for this to happen as set out in the next section.

As argued by Penrose, it is never resources themselves that create value, but the services that the resources can render (Penrose, 1959 p. 25). Resources are not just static assets but they dynamically interact with each other to be transformed into value (Teece *et al*, 1997; Roos and Roos 1997; Roos, Roos, Dragonetti and Edvinsson, 1997). Dierickx and Cool (1989) talk about interconnectedness of asset stocks and argue that asset accumulation might depend on the level of stocks of other assets. The example they give is new product development, which often finds its origin in customer requests or suggest and that it may be harder to develop technological know-how for firms without an extensive service network. It is also argued for time compression diseconomies (Dierickx and Cool, 1989), for example, that the existence of a superior stock of R&D know-how puts firms in a better position to make further breakthroughs and add to their existing stock of knowledge.

The issue of R&D justification was brought up by Klein *et al* (1998) discussing the interactions and relationships between core competencies and skills in R&D environments. They state that understanding and visualizing a network of interacting core competencies can be useful for firms to understand and characterize and hence justify R&D. Research is usually considered to be an iterative process whereby knowledge is increased by developing and extending that which is already known. Even the seemingly most radical changes have been attributed to this process. The process of extending knowledge, codifying it and having it taken up by others which in turn leads to new avenues of research makes research an essentially cyclical process and many have described it in such terms (Boisot, 1997).

In business terms, this process has a parallel in the value creation logics described by Stabell and Fjeldstad (1998). They described two value creation logics alternative to the Porterian value chain: the value shop and the value network. The former is a problem solving logic, particularly applicable to engineering, various advisory services and, naturally, to R&D. The process of the value shop is depicted in Figure 2.

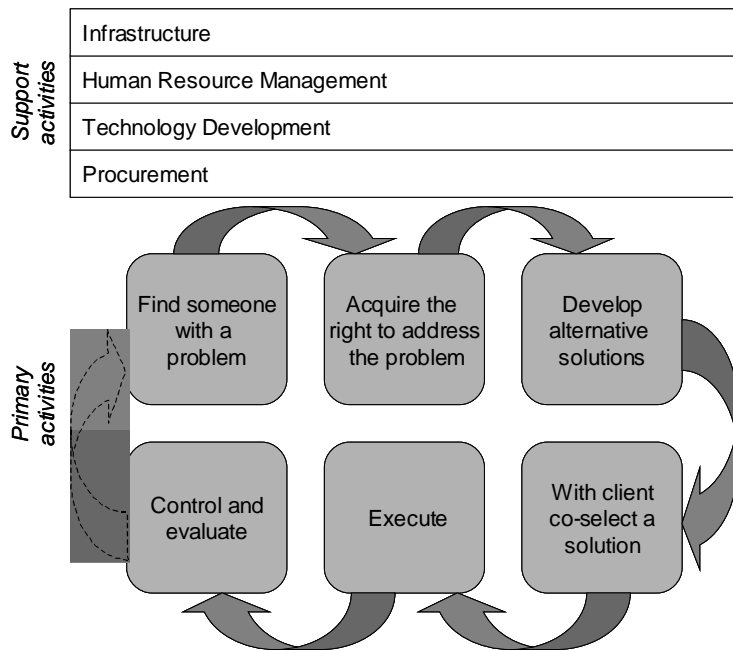


Figure 2 The Value Shop. Stabell and Fjeldstad, 1998 adapted by Roos in Chatzkel, 2002.

The value shop process starts with a problem that is discovered or acquired. Then possible solutions to the problem are identified. Subsequently, the most appropriate solution is selected and executed. Finally, the outcome of the execution is evaluated and learning takes place. Post-execution evaluation can then feed back into a new problem definition and a new problem-finding activity.

The value shop process shows clear parallels with the scientific method and R&D activities (Pike et al. 2005), which may start with the observation of a phenomenon followed by the development of a hypothesis. The hypothesis is then tested to see whether it can predict the outcome of further experiments. At this stage, the hypothesis can be codified. It is then tested by others to ascertain its match with reality. If it fails to match real-world experiments then the hypothesis is modified and the process starts again.

In resource terms, this process can be expressed as the use of cognitive abilities (human resource) to generate new hypotheses, which are tested and then codified (organizational capital) (Pike et al. 2005). Testing is carried out in the real world with real client

problems and the evaluation generates the need for a new cycle (relational capital). The testing of the hypothesis will also lead to internally generated modifications to the hypothesis, before it is tested in the real world. This is a transformation of organizational capital into human capital. Human resources will influence organizational resources, which will, in turn, influence relational resources. Both relational and organizational resource will influence human resources in the next round of thinking. Stabell and Fjeldstad (1998) continue the argument by adding that success breeds success, creating a virtuous cycle. Dierickx and Cool (1989) show that this is especially true for the R&D process. Best people attract best projects, which attract the best people, which successfully solve the problems, which creates success and reputation. The above outlined dynamic interactions are depicted in Figure 3.

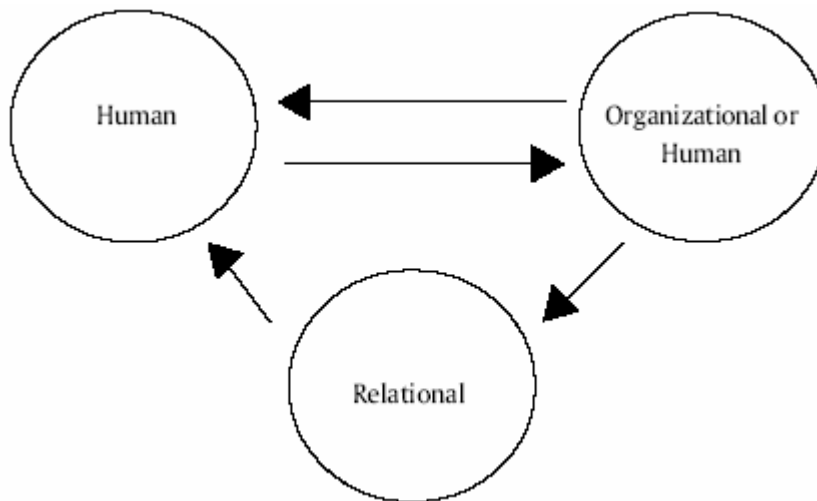


Figure 3 R&D dynamics. Source: Pike et al. 2005

A way to depict the interactions between resources is through the intellectual capital navigator (e.g. Roos et al., 1997, Roos et al., 2005). In the diagram in figure 4, the size of the circles represents the importance of the resources, the arrows represent the transformations between resources, and the thickness of the arrow represents the importance of the transformation. Note that there are no bi-directional arrows since the meaning of transformations from resource A to resource B is entirely different from and not reciprocal to a transformation from resource B to resource A. Figure X shows such a map, depicting the R&D division of a large pharmaceutical company (Fernstrom et al., 2004).

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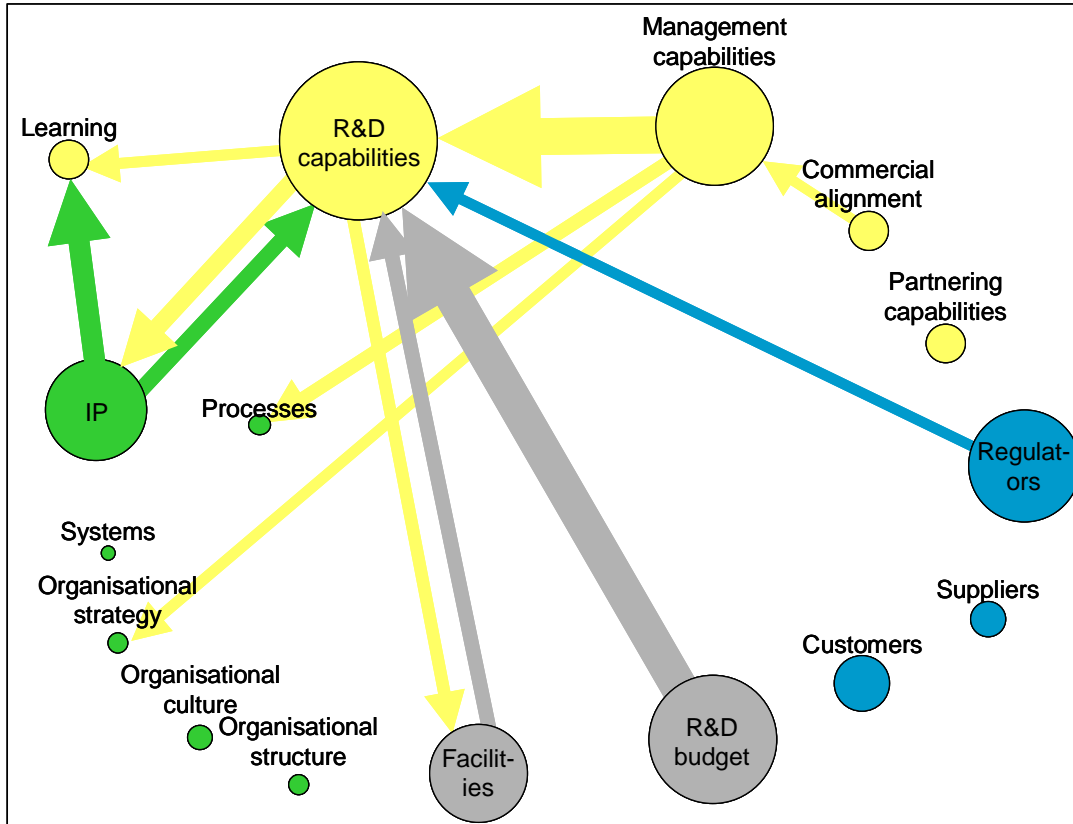


Figure 4 The intellectual capital navigator of an R&D division. Source: Fernstrom et al., 2004

Judging from the IC-navigator model in figure 4, the division's strategic logic is based on a value shop model (Stabell and Fjeldstad, 1998), which is to be expected from an R&D organization. The division's attempts, successful or not, leads to learning which contributes to the next experimental cycle. There is a reliance on blockbuster drugs, which creates an insular triad of IP, learning and R&D, i.e. the scientists carry out research, directed by a capable management until a new and promising candidate appears. Currently, there is some input from "commercial alignment" but the influence of "partners" and "customers" (including other parts of the division) is negligible. This is noteworthy, as an effective and efficient value shop architecture takes its stimulus from outside the organization, whereas in the model of the division, stimulus is taken from internal management direction rather than from external demand. The division is thus divorcing the R&D capability to an extent from the outside world and signals for change that may arise there, which is a clear sign of inefficiency. Once again, should the blockbuster model be questioned or augmented with a secondary mechanism, the links from customer and partner organizations will have to be strengthened. Furthermore, the navigator reveals that regulators are key external influence and not customers or suppliers. In addition, the organizational resources of structure, culture and strategy play very little part in the running of the R&D company. Thus, they may be technically excellent but they are insular, since the only direct external influence seems to come from

regulators, and independent since strategy, culture and structure seems to have no influence on the management of the R&D division.

Another example of this is illustrated with the division's R&D Budget. No company can afford to allocate funds to a cost centre and not have some concern that the money is being spent efficiently, effectively and economically. Research performance and management by objectives have always tended to relegate science to simple work against milestones which can be met rather than encourage the approaches that have a higher intrinsic failure rate but do offer the best prospect of discovering the blockbuster required by the Company's current model of operation. What is required of this and any other cost centre is a mechanism by which the achievements can be published, either inside or outside the Company and in such a way that senior budget holders see value (even potential value) in the research that is done. In the IC-navigator, this would be reflected in links in which IP, R&D capability, academia and customers influence budget holders who in turn, influence the R&D budget (Fernstrom et al. 2004).

R&D funding

Having set the scene of how resources create value in an R&D setting we turn back to the context of the public sector and more precisely to funding R&D in a government organization.

Resource allocation problems are of particular importance in R&D management. According to Foster (1986) the need to 'appropriately' allocate scarce resources (funds, competences, skills, IP etc.) is of particular relevance here (see also Engwall and Jerbrant, 2003). Resource allocation can be distinguished according to two organizational types:

- hierarchical allocation
- market allocation

The discussion around the advantages and disadvantages of the two allocation types can be traced back to Williamson (1975) and Halal et al. (1993).

Reorganization of resources is of utmost importance in scientific R&D in order to optimize the innovation potential of the organization. A framework found here includes 'learning organizations' amongst others (March, 1991; Senge, 1990). Decisions are to be taken in those organizational units where the required knowledge is available (decentralisation).

According to a definition by Spremann (1998), the term "internal markets" refers to the entirety of a firm's internal allocation systems, including cash flows and non-financial resources, across a range of projects or business divisions within the firm. Klein (1998) describes internal markets as a platform from which internal scarce resources are exchanged while Völker and Kasper (2004) describe them as follows: instead of assigning the budget directly to internal units, the budgets are assigned to operational units (customers) who are then in the position to purchase products and services both

internally or externally. Internal suppliers then enjoy the freedom of offering their efforts to external as well as internal customers (e.g. Halal et al., 1993; Malone, 2004).

With regards to the advantages and disadvantages of resource allocation via internal markets, Williamson (1975) recognized that the allocation of funds via internal markets is more efficient (e.g. lower transaction costs associated with internal markets over external markets) in diversified firms. Fazzari et al. (1988) published the empirical proof of the cost benefits associated with internal capital markets. Stein (1997) concluded that internal markets are superior to external markets as the firm management both owns and manages the assets of divisions and therefore can pick the winners and losers (with regards to advantages of internal markets see Lamont, 1997; Shin et al., 1998; Gertner et al., 1994; Hubbard et al., 1998; Khanna et al., 2000). The principle problems of internal markets include the Principle-Agent-Problem, information asymmetries and power grabbing (Palia, 1999; Rajan et al., 2001; Meyer et al., 1992; Scharfstein et al., 2000; Shin et al., 1998).

Three principle elements of internal markets are (Lehmann, 2002):

- providing employees with comprehensive decision-making powers (empowerment);
- the promotion of direct linkages and processes between the involved units and
- the widespread avoidance of detailed controls and interventions by hierarchical higher units.

Designing an effective funding model

To the above backdrop, this section sets out the principles for designing an effective funding mechanism in a governmental R&D organization, taking the intellectual capital aspect into consideration.

First of all, from the intellectual capital resource discussion above, we can deduce that there are a number of resources that need to be in place for the funding model to be effective. The most important of these are outlined in figure 5.

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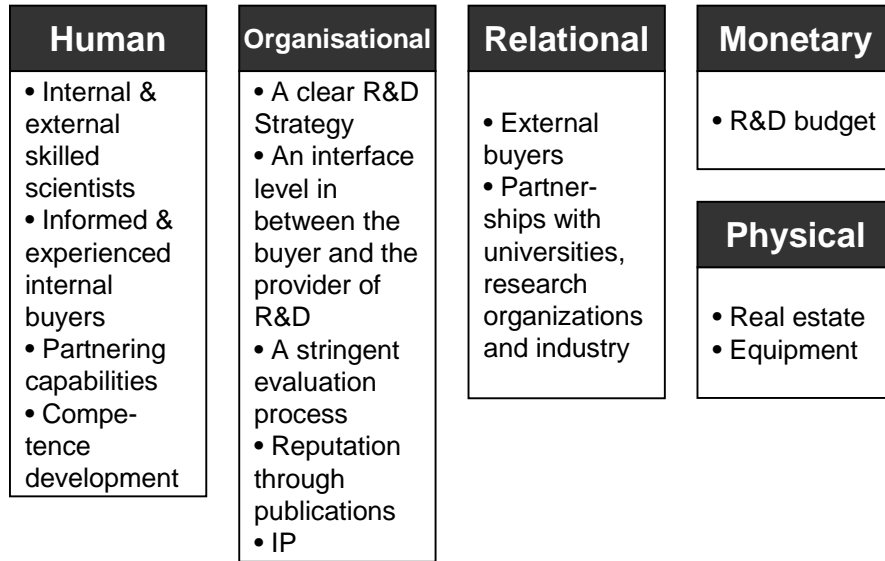


Figure 5 Resources needed for an effective funding mechanism in a governmental R&D organization.

Some of the resources in figure 5 are rather self-explanatory as why they are there, such as skilled scientists, partnering capabilities, competence development (human), reputation and IP (organizational), partnerships (relational) as well as a budget (monetary) and real estate and equipment (physical). Others merit a bit more explanation.

Full basic funding of R&D usually does not deliver the required and desired outcomes and impact, due to lack of efficiency. So for a R&D organization to function efficiently and utilize its scientific potential, it does not suffice with internal buyers, but demanding **external buyers**/customers are needed. This is also confirmed by the clear international trend seeing Government research organizations go from receiving full basic funding towards more market orientation with external funding through contract research.

To the same end, in order to keep the organization at pace with its peers, it needs to have informed and experienced **internal buyers**, people with senior scientific background, who understand the nature and dynamics of R&D and who are able to prioritize according to the **R&D strategy**. The strategy, informed by policy, is crucial for the long time perspective setting the guidelines, direction, and priorities for R&D activities, competence development, partnerships and strategic capital investments.

In order to further ensure transparency, predictability, and adherence to policy and strategy, an **interface level** in between the buyer and the provider of R&D is needed. This takes the form of a formalized conference in which R&D proposals are compared. As discussed earlier, there is increasing pressure on government organizations to justify their activities and benefit to society, thus, a stringent **evaluation process** is an integral part of the funding model. This evaluation encompasses outcome evaluation, impact

evaluation and scientific quality evaluation and will help the organization to demonstrate its value and contributions to public good.

Not only should these resources be in place but a certain interaction between them also needs to be enabled. This interaction is once again illustrated through an intellectual capital navigator (see figure 6). The arrows represent the main transformations of importance from a funding point view. The budget is spent first and foremost on funding R&D projects in line with the strategy (monetary->organizational) but also on investment in equipment (monetary->physical) and in competence development (monetary->human). Human resources in turn convert into R&D project proposals and documented and published results and findings (human -> organizational) as well as to relationships with external parties such as customers, universities, research institutes, relevant international research bodies, industry (human -> relational). External customers contribute to the budget through commissioning of R&D projects (relational -> monetary) and sometimes, external parties engage in joint project proposals (relational -> organizational). Finally, published research and the reputation of the organization help maintain and develop relationships with external parties (organizational -> relational). Noteworthy is that monetary resources clearly make up a value source (transformations in<transformations out) since money is spent on R&D with non-monetary output. Meanwhile, organizational resources, being the principal output of the organization, clearly constitute a value sink (transformations in>transformations out).

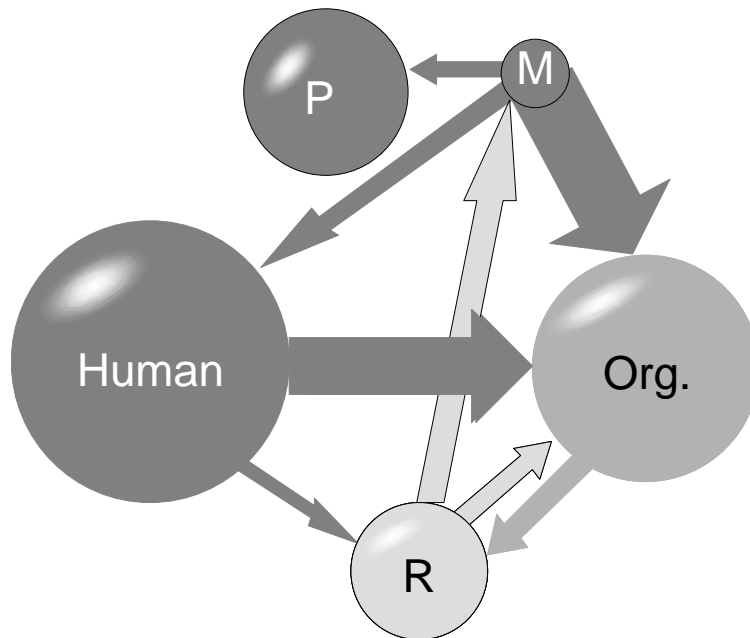


Figure 6 A principal intellectual capital navigator depicting the funding mechanism in a governmental R&D organization.

Conclusions

In this paper, we established some clear distinctions between R&D on the one hand and innovation on the other in order to further explore the value creation dynamics of R&D. We grounded our research in the resource-based view of the firm and emphasized the importance of intellectual capital resources as value drivers in the R&D process. We then highlighted the dynamic nature of resources in the R&D context and used a theoretical model, the intellectual capital navigator, for mapping how intellectual capital resources dynamically interact to deliver value. We then reviewed the constraints experienced by governmental organizations in general and governmental R&D organizations in particular in terms of the pressure to disclose performance results as well as budget restrictions. From here, we set out the principles for an internal funding mechanism using the intellectual capital language and taking all the above into account.

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