

Creating and Justifying Research and Development Value: Scope, Scale, Skill and Social Networking of R&D

Aard J. Groen, Petra C. de Weerd-Nederhof,
Inge C. Kerssens-van Drongelen,
Rob A.J. Badoux and Gerard P.H. Olthuis

In this paper we describe a framework for analysing the creation and justification of Research & Development. The 4S framework is developed for analysing the scope, scale, skills and social network aspects of Research & Development value. The framework is based on social system theory, a process contingency model, and recent Research & Development metrics.

We present a first empirical assessment based on a workshop using the 4S framework for leveraging Research & Development. Results that assist in the assessment of value creation utilising R & D within networks are very relevant in high tech industries. The multi-dimensional process approach of this framework seems promising for understanding and managing R&D value creation, but needs further operationalisation. Case studies are described and a Dutch network on leveraging R&D has been initiated.

Introduction

It is increasingly argued that the management of Research & Development is becoming more complex. Market developments including globalisation, mass-customisation, changing dynamics in demand (Kotler 2000, Volberda, 1996) combine with technology demands such as shorter technology life cycles, virtualisation of research and global standards to accentuate this process. (Teece et al., 1997). There are concerns to make innovation more market oriented, more network related and to apply the newest project management techniques, thus increasing the complexity of the process. Balancing Research & Development investments is increasingly difficult. Firms can fall in the renewal trap by investing too much in Research & Development without clear direction of development (for example 3M according to Volberda, 1996, 1998). On the other hand firms fall into the competence trap (Levinthal & March, 1993) by relying too much on routines. Core competencies become core rigidities (Leonard-Barton, 1992). The balance between cutting current costs and gambling on long term gains with Research and Develop-

ment goes to the heart of the strategic flexibility discussion. Furthermore, the growing competition in many technology intensive markets adds to the pressure on Research & Development management to justify Research & Development investments (Kerssens-Van Drongelen, 2000).

In large firms Research & Development managers often are not able to determine by themselves in which direction and to what extent Research & Development projects are started, continued or ended. More often this is an interaction process with general management. They discuss the issue of how much and where to invest in Research & Development in integral decision making processes using input from several internal and external sources (Griffin, 1997; Wood, 1998). Understanding these decision-making processes is a prerequisite for Research & Development managers to be able to use relevant indicators of value creation when justifying Research & Development expenditures. This implies a thorough insight in firm strategy making processes, where networks of internal and external actors influence processes of decision making.

Not only strategic aspects of justifying research and development expenditures demand more insight in research and development value creation processes short and long term. The management of the value creation process itself would gain from this. The growing multi-disciplinarity of technological innovation on the one hand and the necessity to specialise due to fast technological development on the other, mean that Research & Development activities are more often carried out in heterogeneous networks of large and small firms, universities and other knowledge institutes (Rip & Groen, 2001; Klein Woolthuis, 1999; Huff, 2000). Creative combination of new and already existing different techniques, technological strategies and distributed bodies of knowledge might open up promising fields for application and the creation of new markets. The speed of development in high tech fields, such as ICT, biotech, micro technologies, and medical technologies, also generates many new start-up firms. The need for efficient and effective processes of shared knowledge development in networks of SMEs, knowledge institutes and large firms, is high in these fields. Changing institutionalised patterns of technological regimes (Rip *et al.*, 1995) and existing dominant designs within those regimes asks for elaborate insight into the networks of actors and institutions. Using the metaphor of Rip and Groen (2001) 'many visible hands' construct new knowledge, technologies, and products. For the manager it is important to have sufficient insight on which of those 'hands' are relevant, and what kind of contribution they could make for his own value creation process.

In this article we present a multiple faceted framework for analysis of value creation and justification of research and development in a network perspective, based on a combination of earlier academic and practical work of the authors. This framework is the basis of a series of ongoing projects in several Dutch companies in a network on leveraging R & D. The first results of discussing this framework with the participating academics and practitioners in a workshop revealed the relevance of this approach.

Assessing Value and Justifying Research & Development Performance

To analyse value creation of Research & Development from a network perspective, we developed a framework inspired by multi-dimensional social system theory derived

from classical sociological theory on the functional analysis of social systems (Groen, 1994, 2000). Furthermore, to specify organisational aspects and functional requirements we build upon the process-based contingency model tailored to New Product Development (NPD) (De Weerd-Nederhof, 1998). The third inspiration basis first helps us in defining the problem of current methods for performance measurement systems in a networked economy. Secondly, it is a source of definition and selection of metrics to assess Research & Development performance. This is based on earlier work of Kerssens-van Drongelen (1998) and Kerssens-van Drongelen *et al.* (2000). In this article we do not deductively define a new theory, but we do give a description of the background of the models and construct a framework to assess the value of R & D in a multi-dimensional way. We specifically address the tensions between operational effectiveness and strategic flexibility. Furthermore, we will not address other strands of literature on assessment models for R & D, although we are aware of other approaches, some of which are dedicated to R & D (e.g. Chiesa *et al.*, 1996), others are more general (e.g. EFMD-model of total quality, Balanced scorecard from Kaplan & Norton, 1996). Instead we choose here to describe this method in development and we will address these two issues elsewhere. First, we will describe elements of theory erecting the 4S-framework. After that we will describe the analytical framework we constructed for analysing the value of research and development and some first operational sets of indicators to build up a performance measurement system.

Analysis of Value of Research and Development

As stated above a source of inspiration is found in the work of Parsons (1964, 1977; Groen, 1994). The starting point of the set of assumptions we use, is that actors act purposefully in interaction with other actors (see also Granovetter, 1992). A social system originally was defined as:

'...a social system consists in a plurality of individual actors interacting with each other in a situation which has at least a physical or environmental aspect, actors who are motivated in terms of a tendency to the "optimization of gratification" and whose relation to their situations, including each other, is defined and mediated in terms of culturally structured and shared symbols' (Parsons, 1964, pp. 5–6)

Four mechanisms are embedded in this definition: interaction between actors, striving

for goal attainment, optimisation of processes, and maintaining patterns of culturally structured and shared symbols. Each of these mechanisms produces its own type of processes and within those processes its own type of capital

- *goal attainment processes establishing the scope of the actions use (or result in) strategic capital which is based on power or authority* (Simon, 1976).

Actors are motivated to do certain things. This determines the desired *scope* of the social system. The nature of goals and ability (by power or authority) to influence behaviour of other actors in alignment with these goals leads to *strategic capital*. Having explicit strategic goals, power bases, authority or influence bases together lead to an indication of strategic capital of an actor in his network (a.o. Simon, 1976; Etzioni, 1988).

It is important to know about the goals and power basis of actors in the research and development context. In order for example, to be able to estimate cooperation or conflict based on communalities or differences of goals of actors involved in the Research & Development process. Furthermore, to be able to estimate differences in power or authority of the actors involved. The estimation of the contribution of Research & Development to the strategic capital of the own company, or to a strategic alliance partner may be a strong indication for value of Research & Development.

- *economic optimization (seeking the efficient scale) is performed using financial capital (money)*.

Actors strive for optimization of the situation. We see this as striving for economically efficient behaviour. Optimisation of costs and gains lead to more or less monetary *economic capital* of the actor. Important questions here are related to the necessary scale of an operation: How can more efficient production of Research & Development products be realised, and what kind of financial contribution can be expected, and for who?

- *pattern maintenance is fed with cultural capital based on closeness to societal norms, knowledge, skills and experience*,

Knowing how to do things in a more or less effective and efficient way leads to relatively fixed patterns of *skills*. To maintain these patterns is also a basic mechanism in a social system. However, actors are capable of learning (Parsons, 1977). So

successful practice leads to institutionalisation of that patterns of behaviour. Continuous evaluation of the situation (think of changing technology, or market circumstances) leads to adaptations in the patterns. Knowledge and experience with successful behavioural patterns lead to *cultural capital*. Note that successful patterns might have their origin in long standing traditions or in new practices just applied for the first time. Closeness to societal values and norms of the social system indicates ability to build upon earlier traditions (Bourdieu, 1973). Another part of cultural capital is based on knowledge and experience of new technologies. Knowledge management is an important process in this respect. Capital in this dimension relates to the 'absorptive capacity' (Cohen & Levinthal, 1990) of a firm, and builds on explicit and tacit knowledge.

- *the interaction mechanism needs social capital which is based on positional and cohesive relations of actors in social networks*

Only in interaction with other actors can individual actors exist. Interaction with other actors leads to the integration of actions in the larger system and to mutual adjustment of actions. The kind of mutual adjustments depend on the specific characteristics of the actors and the processes they are involved in. The ability of actors to interact with other actors leads to *social capital*. Network relations can be described in relational patterns or positional analysis. Relational aspects are, for example, the intensity of the relation, multiplexity of the relation, meaning how many types of content (roles) are embodied in one relation (for example friend, consultant, controller), or look at the range of a network. Structural positional analysis looks at aspects such as equivalency of position (for example two competitors often have similar networks, but no relation with each other). Also aspects such as hierarchy, brokerage relations, or analysing the redundancy of networks (for example searching structural holes which are unique positions without any redundant relations) can be evaluated using network theory (Burt, 1982, 1992; Granovetter, 1973, 1985, 1992). For Research & Development management this leads to questions about the use and improvement of networks of the company by interacting (co-operating) with certain actors in or outside their own company. Assessing the relational and structural position is possible in its own right (showing redundancies, holes, or specific

cliques in the network), but its relevance is determined by the content of the interaction. Therefore, interaction patterns get meaning through the *social integration of scope, scale and skills* of the actor (see figure 1).

All four mechanisms work concurrently and influence the outcomes of a social system in a structured, but not deterministic, way. Actors develop positions using resources in interaction with others. In interaction actors use these capitals more or less successful, which leads to recursive relations between capital use in one situation and possibilities later in time.

Each actor acts in a space in which physical and environmental constraints apply. One consequence of these constraints is found in the assumption of bounded rationality (Simon, 1976). Therefore, actors may behave sub-optimally due to bounded rationality, and although a social system might look stable when looked at from a high level of analysis, in specific interaction processes they need not be in stable balance. The interesting point of the original version of Parsons is the explicit attention for multi-dimensionality of social system interaction and the approach of multi-level analysis. The basic hypothesis in social system theory is that only when all four mechanisms are developed sufficiently, can a social

system last. Concentration on only one dimension will lead to losing of functionality. An example of such concentration on one mechanism is the focus of many managers on reducing costs, *Hamel and Prahalad* labelled that as managerial anorexia and showed that results are very often disastrous. Also Etzioni (1988) in his famous work 'The Moral Dimension' warns about a monolithic attention on economic efficiency. We assume that this is valid for each of the dimensions, so also a monolithic focus on culture, networks or strategy/politics will lead to the same kind of problems.

In our view this concurs with practical experiences in R & D management. Goal attainment, patterns of culture and knowledge, economics and interaction in networks all are important facets on multiple aggregation levels of analysis such as the level of the R&D department, the firm, and the networks in and around the firms. However, to make this more operational for the R & D setting we have to define in an R & D context how we can assess the four mechanisms and the gains or losses of capital in the four dimensions. In the process contingency model we found several possible specifications.

The process contingency model

The second inspiration described here is the process-based contingency model. It focuses

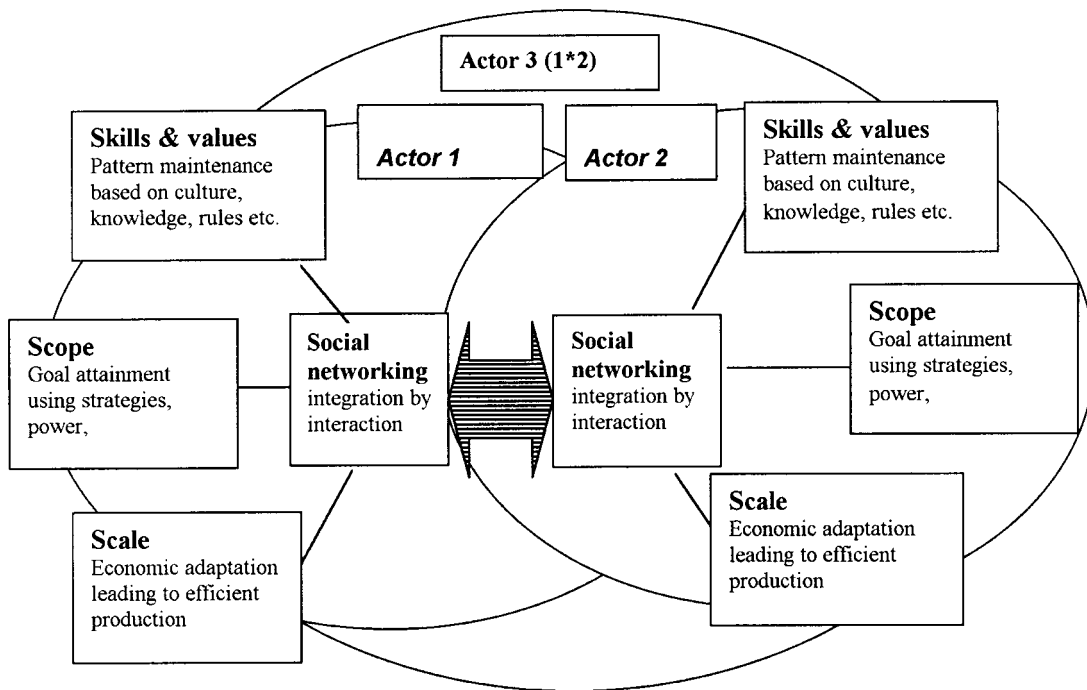


Figure 1. Two Actor Model of Network of Actors in Social System Perspective

on organisations as actors. Like the social systems model, it too treats organisations as purposeful systems of people and resources which, using multiple technologies, together perform certain 'activities' or 'processes' to transform inputs into outputs (Boer & Krabendam, 1991). The main assumption underlying the model explicitly refers to the link between effectiveness and configuration; an organisation is supposed to be effective if the constituent elements of the organisation are compatible with each other and with the environment. So this theory focuses on the organisation as unit, relations to the environment are developed in a more ad hoc fashion, but on a number of dimensions the process contingency approach specifies important elements for assessing value of research and development.

The operationalisation of the process-based contingency model is tailored to NPD (de Weerd-Nederhof, 1998). It contains separate mapping tools for the description of goals (strategic, adaptive and operational) (defining scope), processes (primary, management and support) (defining scale and elements of pattern maintenance), people (NPD workers and managers), tools & techniques (techniques, IT, equipment), and organisational arrangements (all three elements of skill / pattern maintenance). Organisational arrangements are described in a multi-level way: at the individual (jobs, roles), group (teams, procedures) and organisational (structure, culture) level.

Analysis of this NPD system is facilitated by assessing performance fit as well as configurational fit, both in terms of the performance dimensions Operational Effectiveness and Strategic Flexibility. Operational Effectiveness refers to the effectiveness of today's work: the degree to which NPD contributes to realising goals set by the organisation. Strategic flexibility refers to the readiness of the NPD system to adapt to, anticipate or even create future performance requirements (tomorrow's innovation) (de Weerd-Nederhof, 1998). These two performance dimensions offer an evaluation scheme, which is not at hand in the social system view, but which is very relevant in the context of R & D as described in the introduction.

Performance fit is the degree to which the strategic, adaptive and operational goals set for the product concept performance (fit with market demands and firm competencies) and the NPD process performance (speed, productivity, flexibility) match with actual performance at both performance dimensions. *Configurational fit* is determined by identifying the features of the NPD configuration which contribute to the matches (or cause the

gaps) in the performance fit. Note that the concept of fit is *dynamic*, meaning that it should be possible to deal with (continuous) changes in Operational Effectiveness and Strategic Flexibility issues. In fact, it is stressed that NPD management is an act of balancing short- and long-term issues as well as finding a balance in satisfying internal and external stakeholders. In line with this, shortcomings in one configurational element can be dynamically combined with and balance strengths in another. For example it was found that badly designed horizontal linkages hindering in-depth contacts between members of cross functional teams representing the same business function, may – especially in small organisations – be overcome and balanced by an innovative climate and strong leadership (de Weerd-Nederhof, 1998).

In earlier work on the use of performance indicators (a.o. Chiesa *et al.*, 1996) it was shown that performance measurement should distinguish between process and product oriented performance analysis. Using the process based contingency model it was shown that not only management control of product development output functions are important, but also learning and alignment with primary objectives expressed in NPD strategy should be monitored (Kerssens-van Drongelen & de Weerd-Nederhof, 1999). Operational Effectiveness and Strategic Flexibility are considered as basic elements (performance dimensions) of a solid NPD/Research & Development strategy. From case studies we know that many Research & Development managers consider their strategic flexibility as especially problematic. More insight in learning processes is necessary to manage and justify on the basis of enhancing Strategic Flexibility.

Essential points from the process based contingency model are twofold here: first the concept of dynamic fit and the connected view on balancing short term and long term issues, directs the Research & Development manager to address the timeline of Research & Development value creation and to align justification with that. Furthermore, it confirms that fit is not a linear concept for which one could state an end-goal. Instead dynamic fit is created in interaction between actors' alignment of goals, cultures, economies and networks. In learning processes fit is constantly re-assessed. This brings us to the second point: the focus on learning processes calls for extra attention on assessing learning in Research & Development context. This is coherent with our interpretation of social system theory, specifically changes in cultural capital indicate learning.

Research & Development value justification metrics

The third source of inspiration for the 4S framework was found in Research & Development performance indicator literature (a.o. Kerssens-van Drongelen, 1999). On the one hand we find a method of designing a performance measurement system, and on the other an overview of existing practices and the related problems were described in this work (see also Kerssens van Drongelen *et al.*, 2000)

Many of the developed metrics focus on economic assessment of Research & Development. Quinn in 1960 has already mentioned: 'Research & Development output in terms of expected economic value compared to costs and eventual profits obtained from technologies actually adopted by the business.' The widely used Brown and Svenson framework (1988) also focussed on economical value of the processing Research & Development system, leading to patents, products, processes, publications, facts / knowledge. Furthermore, they consider outcomes from the receiving system (marketing, business planning, manufacturing, engineering and operations) such as cost reduction, sales improvement, product improvements and capital avoidance. These kind of indicators still are important, but as shown in the discussion based on the process contingency model short term and long term balancing complicates this very much. Thus a strategic dimension is necessary. Furthermore, the organisational learning aspects are discarded too often. The social system model accommodates the economic and strategic dimension and adds the cultural pattern maintenance as a dimension for systematically treating learning and maintaining experience on multiple levels of aggregation level. For the organisational level some indicators are developed in the process based contingency model (e.g. descriptors of organisational arrangements).

Next it seems that many assessment tools take the firm as unit of analysis (e.g. Brown & Svenson, 1988; Chiesa *et al.*, 1996), where the assessment of network complexity is underdeveloped. Via the network dimension the 4S assessment explicitly addresses this. However, to develop metrics to assess network characteristics is not an easy task. Although many network measurement methods and techniques exist (see a.o., for quantitative models Burt, 1982, 1992 or for a more qualitative approach Håkansson & Snehota, 1995) it will take considerable work to develop metrics to assess the value of certain network structures and relational interaction patterns in a quantitative way. Network

assessment using qualitative instruments is part of the 4S approach. Assessing the nature of the scope, skill and scale effects through social links is possible. Furthermore, elements of network theory can be used for example to assess redundancy of relations, brokerage effects, clustering of cliques and equivalency of positions of competitors.

It is important to note that due to several types of measurement problems it is difficult to accurately isolate the contribution of Research & Development to company performance. To mention some problems: time lag of cause and effect might be large (e.g. Papas & Remer, 1985); politics might interfere; value is created in intertwined teams (Hodge, 1963). The intertwined effort made inside companies to realise market performance is already difficult to disentangle. In complex networks of firms, universities, co-developers, even competitors working together in knowledge intensive Research & Development, this is even more difficult. Subjective measurement on an ordinal scale might be the maximum reachable measurement level. We see this as a fact, that does not take away the potential usefulness of such measurement. Depending on the level of openness in a network, discussing Research & Development value creation and justification in the network (or parts of it) can contribute to understanding each others position. The role of trust and openness in such processes can not be overestimated (see Klein Woolthuis, 1999; Nixon, 1998) (for a more elaborate discussion of measurement problems see Brockhoff *et al.*, 2000, pp. 267–270)

The use of good measurement theory is very important in such cases: to be able to define as clear as possible how the complexity can be unravelled to discuss in what way cause and effect of Research & Development value creation are justifiable. This is the aspect our contribution is focussing on.

Our approach can be characterised as a process oriented, predominantly (inter-) subjective and qualitative approach. However, this does not mean that part of the value creation and justification assessment is not quantitative or based on objective numbers. Important in our view is to generate discussion on what value is and how it best can be created to enhance learning processes. In our view it is not automatic that often mentioned general performance indicators such as innovativeness (Bolwijn & Kumpe, 1990), time-to-market, quality; productivity, cost, and quantity (Gerritsma & Omta, 1998) are used in an assessment. Although in general these concepts have much face value it depends on the firms strategy, skills, scale

and social position to what extent which indicator is relevant. Where one recognises the co-evolutionary aspects of technology and social developments general concepts such as quality or costs are in themselves multi-dimensional and should be operationalised using a coherent multi-dimensional theory.

Towards a framework for leveraging Research and Development

Combining the basic ideas of the three strands of literature above leads us to a multi-dimensional framework for analysis of value creation and justification of research and development. As discussed above we do not claim to be able to make a general applicable set of specific indicators, but in stead we propose a process-oriented method of defining and assessing Research & Development

efforts. The aim of this process is twofold: first it aims to support Research & Development managers in defining how they can create value, and second how they can justify their claims on assets of the firm and/or of other actors in their Research & Development oriented network.

The four mechanisms described in social system theory are used as a starting point for analysing the need of information on value of research and development. For each of those mechanisms we use earlier work on mapping tools for assessing new product development systems (de Weerd-Nederhof, 1998), and other auxiliary theory. For each of the dimensions we will recapitulate the mechanism; define the type of capital; and construct a set of mapping tools to analyse a networked research and development unit. In table 1 we describe the first set of mapping tools per dimension. This

Table 1. 4S Mapping Tools for Research & Development Assessment

Social networking

- Mechanism: Actors interact with other actors occupying network positions and filling the relation(s) in a multiplex way, and are dependent on other actor's actions.
- Capital: Social capital relates to available relations and network position in network structure.
- Mapping tool: Which actors are relevant to a certain research or development (short and long term)?
Define units of analysis: what aggregation level is important for the development?
What position in networks of knowledge, power or economy are actors in?
Type of relations: who is interacting with whom how frequent, duration, intensity, strength of ties?
Analyse positional structures, who is equivalent? How redundant / unique are relations?

Scope / goal attainment

- Mechanism: Actors set goals and try to attain them, but they are also constraint by goals of other actors.
- Capital: Strategic capital relates to power, authority and influence of actors involved.
- Mapping tool: Which goals do actors involve have on strategic, adaptive and operational levels (short term and long term)?
Establish a map of power, authority and influence distribution in the relevant network?
Map dynamics of goal attainment to assess the role of research and development output in it.
What is the contribution to realising short and long term goals of actors involved?

Skills & values / pattern maintenance

- Mechanism: Actors maintain patterns of behaviour and value patterns (but are influenced by patterns of others).
- Capital: Cultural capital relates to experience and knowledge accumulation and cultural values and to how the current processes are maintained.
- Mapping tool: How are people selected, trained, and appraised on technical, administrative and social skills?
What (short and long term) contribution is made to technical and organisational /network knowledge?
What kind of hardware and software is maintained?
Compare informal practices and formal procedures.
Attitudes towards important network goals (e.g. innovation, entrepreneurial orientation).

Scale / efficiency adaptation

- Mechanism: Actors adapt their processes to work as efficient as possible, but have to use or compete for production systems of others too (make or buy / competition).
- Capital: Financial capital is money.
- Mapping tool: What is the expected net present value of the output of R&D?
Map speed and productivity performance.
Which sources of economic income are generated (sales, licensing, subsidies)?

set of questions is used as point of departure for discussion in workshops and case studies for analysis of both operational effectiveness and strategic flexibility.

In the remainder of this article we will describe the first attempts to find more explicit indicators for assessing the value of R&D. This was done in a workshop labelled as a small event on creating and justifying value of Research and Development.

First Assessment of Empirical Relevance

Introduction

To assess relevance of this topic and framework we organised a small event (workshop) in January 2001. 25 participants from 11 different companies came together to discuss leveraging Research & Development. Table 2 shows the sort of company and the field the company works in. The participants came from a wide variety of companies. About 25% of the participants possess a general management function and 50% work as R&D managers, the other 25% were consultants or researchers. The desired outcome of this event was a first evaluation of the 4S framework in aiding Research & Development managers to steer value creation and to justify claims on scarce resources.

As preparation for this small event we constructed a framework as depicted in appendix 1. We gave a description of leveraging Research and Development issues (including an earlier version of this paper). Furthermore, they received a set of basic questions as shown in table 1 and we asked the participants to prepare a first analysis of their value creation and justification R & D system. They could

use table 2 as a sort of reporting tool. With three of these companies we had an interview to introduce the framework. The rest only received explanations in writing. Seven of the eleven companies delivered such a first analysis. Two of seven only used the columns of operational effectiveness and strategic flexibility and did not fill in the column on measurements. In the workshop, in presentations and discussions the indicators were mentioned. At the end of the workshop we evaluated the presented framework on relevance. We will start with this last topic as it shows some broad relevance indications. This will be followed by a short description of the outcomes from self-assessments made by the participants. This will lead us to the conclusions and further developments in the last part of this paper.

Relevance and current availability of mapping tools

On the relevance of the topic we asked a few questions about the importance of leveraging R & D in each of the 4 S dimensions. Furthermore we asked them if they already had indicators on the dimensions in place. The scores in general showed that each of the dimensions were evaluated as important (see table 3). However, the availability of indicators was not so homogeneous. Economical aspects of R & D value are measured in 90% of the firms, and the firms who did not do this do not do formal R & D (two consultants). Knowledge aspects and strategic aspects were measured explicitly by 60% of the firms. In other words approximately a third of the firms who did measure economic value of Research and Development did not measure the strategic or cultural value of research and

Table 2. List of Participating Companies

Sort of company	Field
Large companies	Chemical Energy IT Electronics Medical
Consultancy companies	Accountancy Environment
Technology transfer institutes	Project management Energy / environment
Small firms	Industrial equipment

Table 3. Importance and Use of Indicators of Aspects of R & D Value in Companies

	Importance of these aspects on a 1–5 scale	Percentage of firms who use indicators for these aspects
– strategic aspects (scope)	4.3	60%
– network aspects (social networking)	4.2	20%
– economical aspects (scale)	4.3	90%
– knowledge aspects (skill)	4.2	60%

development, although they seem to find these aspects and economic issues of equal importance. Even more noticeable is the discrepancy between the felt importance of network issues, which is also high, and the availability of indicators of network aspects in only 20% of the cases. We might conclude that the participants became more aware of strategic, cultural and social value of research and development in this workshop. This was corroborated by statements of participants. Furthermore, four participants granted access to students performing a case study on their organisations, showing interest in going deeper into the question of how to create and justify research and development value.

Results of self-analysis

In the following part of the article we will describe per dimension which kind of indicators are in use in the companies. The results of the inventarisation of the firms shall be given in this part for every social system dimension on the performance dimensions operational effectiveness and strategic flexibility. We give examples of reasoning of different firms of the issues they think are

important. This will show some of the heterogeneity of the outcomes.

Strategy / Scope

Almost all respondents could give insights in strategic issues, only two companies left the performance dimension Operational Effectiveness blank and a different company left the field on strategic flexibility blank.

Goals to be attained by Research and Development in the performance dimension operational effectiveness can be summarised as matching current market demands. This was worded different giving some ideas about different sets of justification indicators. The medical technology company mentioned very explicitly matching the patent portfolio to the product road map for the coming years. Others just spoke in general terms about 'license to operate', and improvement of efficiency.

For the performance dimension strategic flexibility the chemical company mentioned 'Re-establish technological leadership in the market' and the medical company 'provisioning of new technologies an architectural concepts to enable leadership'. Also 'product/patent portfolio' was mentioned more often.

Table 4a. Results workshop

	Monitoring added value creation		Proof of added value
	Operational effectiveness	Strategic flexibility	Measurement
Strategy / Scope Which strategic goals are to be attained? What contribution to strategic capital (power base of company) is made?	<ul style="list-style-type: none"> – better matching of technology, patent and publication portfolios to product roadmaps – Maintaining 'licence to operate' – Improvement of efficiency 	<ul style="list-style-type: none"> – Enhancing market value by technological developments – Technological leadership – Sustaining a product / process portfolio 	<ul style="list-style-type: none"> – nr. of patents and licenses – business opportunity rating – strategic compatibility of Research & Development

Table 4b. Results Workshop

	Monitoring added value creation		Proof of added value
	Operational effectiveness	Strategic flexibility	Measurement
Social networks Which position and relational contacts are used/useable? What contribution is made to social capital?	<ul style="list-style-type: none"> - Network with local knowledge institutes, - Using contacts from symposia, conferences etc. in projects - Providing knowledge & reputation to other departments 	<ul style="list-style-type: none"> - Future access to knowledge networks - Networking around core competence areas - Rapid receipt of new developments - Enhance the positive image 	No indicators mentioned

The energy company wrote about this 'The work performed by Research & Development supports the policy and strategic goals of the company. Research & Development provides the company with innovation and technical knowledge in order to enhance the market value of natural gas'.

Social network

Most of the companies had little experience in making their network position explicit. Only four companies gave a result for the performance dimension, Operational Effectiveness. With the performance dimension Strategic Flexibility more response occurred. The electronic company showed in their contribution to the small event, called 'the networking company', that they think that this is an important dimension in the 4S-model.

Three of the four companies had described a result in the operational effectiveness dimension that can be summarised as 'the development and maintaining of networks'. The IT company describes this as 'creating access to local knowledge (institutes) to the benefits of the company'. The environmental consultant wrote down 'networking by participating in symposia and congresses and using these networks inside the companies for projects and participation'. The energy / environment technology transfer company describe this as 'developing and maintaining networks'. The energy company looked in a different way at the social network. They looked at how the Research & Development department could give added value to the social network and not as the other three to get something (mostly information) from the social network. They describe this as 'Experts from Research & Development lend their expertise in dealings that other departments

have with external organizations. In this fashion Research & Development lends significant additional weight to company argument'.

The results on the dimension Strategic Flexibility can in most of the situations be characterised as 'network development'. But the purpose of developing these networks is rather vague. The IT company describes this as 'enable future access to local knowledge (institutes) to the benefit of the company'. While the medical company say that they 'aim at building knowledge for core areas'. The environment consultant says that 'the knowledge within the network makes the company more flexible'. The Energy / environment technology transfer company does not give a goal for developing a network and only give as result 'developing and maintaining network'. Also in the dimension of strategic flexibility the energy company looked from a different point of view at the social network. The energy company describes this as 'The interaction of researchers in their various networks results both in rapid receipt of new information ('sensor function') and its ability to influence the outside parties in the network. Furthermore, the respect that Research & Development has earned and continues to earn based on its expertise enhances the positive image of the company'. In network theory terminology we see that the responses relate to the network from a 'ego-network' point of view: dependencies on other actors, possible effects of network structures, redundancies or holes are not addressed issues here.

Skills, Competencies & Values

Most of the companies had big difficulties with assessing human/cultural capital and

especially in the dimension of operational effectiveness. Only three companies filled in a result in this performance dimension. In the dimension of strategic flexibility the results diverged strongly. Two of the seven companies made a distinction by separating this dimension in human capital and cultural capital. The management technology transfer company stated that 'the human capital expresses itself in the other three dimensions'.

Two companies filled in a result which had to do with 'response'. The IT company said 'to be able to respond to specific innovative questions from the market and customers (strategic market support). While the medical company, who made a distinction between human and cultural capital, mentioned under cultural capital 'regular reviews of projects to check response conditions and progress'. The chemical and the medical company, both made a distinction between human and cultural capital, described as human capital: The chemical company mentioned 'focus teams for know-how transfer (technical, commercial) in all countries involved'. While the medical company made two remarks 'concentrate on core skills and knowledge' and 'improved ways of working by improving: employability and working conditions/environment'. Two different kind of results can be recognised in these responses. The first can be summarised as 'focus on know-how' and was seen by both. While the second only seen by the medical company can be summarised as 'improving ways of working'.

Within the strategic flexibility dimension the results were not quite clear. The chemical company described as cultural capital the 'core

project team (involving all functional areas) with strong support from senior management' and for human capital as only the 'core project team (involving all functional areas)'. While the IT company sees as indicator for this dimension 'To develop competencies that allow the right products for the company group in the future' and 'To create an innovative image in the (labour) market to attract the people of choice'. The energy company wrote down as 'Research & Development is an environment in which young people can learn various facets of the business as well as sharpening their analytical skills. Both aspects enhance their value to the organization upon being transferred'. The medical company was the second company that made a distinction between human and cultural capital. They had three remarks on human capital 'value people as vital assets', 'image to be the employer of choice for a high-tech career' and 'act as a knowledge base'. On cultural capital they made two remarks 'always striving for clear definitions of research' and 'always setting business objective as a prime objective'. The environment consultant mentioned about this that 'Research & Development is attractive for higher educated employers' and 'many people from Research & Development flow into different parts of the organization'. While the energy / environment technology transfer company said about this 'developing market orientation of researchers'. Two results can be abstracted out of these diverge results. The first can be summarized as 'education'. The IT, energy and environment consultant noticed this. The medical company and environment consultant noticed

Table 4c. Results Workshop

	Monitoring added value creation		Proof of added value
	Operational effectiveness	Strategic flexibility	Measurement
Skills, competencies and values How and which patterns are to be maintained (adaptive goals)? What contribution is made to cultural and human capital?	<ul style="list-style-type: none"> – Regular reviews of projects – Focus teams on knowledge sharing – Improve employability and working conditions 	<ul style="list-style-type: none"> – Maintain interdisciplinary development team across functional areas – R & D contributes to core competence – more attractive for higher educated employees also for rest of company 	<ul style="list-style-type: none"> – project quality – sharing volume of facts and knowledge – satisfaction with education/ training – growth technical level – planning quality – clear roles and procedures – team cohesiveness – spin-out of personnel to rest organisation

Table 4d. Results Workshop

	Monitoring added value creation		Proof of added value
	Operational effectiveness	Strategic flexibility	Measurement
Scale / economic efficiency Which economic scale is necessary? (operational goals) What contribution can be expected to economic capital?	<ul style="list-style-type: none"> - Working more efficient - Budget & timing control - Enhancing ROI 	<ul style="list-style-type: none"> - Enhancing performance on ROI, time to market, return on knowledge, developing new products 	<ul style="list-style-type: none"> - NPV of projects - Sales and profits generated - Licensing income / year - Investment/year - Time till completion

the second result. They noticed that Research & Development makes a company more attractive for higher educated people

Scale / economic efficiency

In this dimension most of the companies did not have a problem with giving results, which we expected already. In most companies the added value of Research & Development is predominantly justified on this dimension.

Two sorts of results could be recognised in the dimension of operational effectiveness. The first can be called 'control'. The chemical company described this as 'budget and timing control'. While the medical company mentioned 'clear measurement contribution to business effects'. The environment consultant said just 'budget control'. The other sort of result can be described as 'working more efficient'. The energy company described this as 'the work performed by Research & Development department allows the company to use their resources with higher efficiency. Higher efficiency enables the company to reduce operating costs'. The management technology transfer company described this in terms of better ROI, time-to-market and return-on-knowledge. While the Energy / environment technology transfer company describes this as 'effective use of government subsidies'.

In the dimension strategic flexibility two groups of results can be recognised. The first group can be summarised as 'better performance'. The chemical company describes this as 'SupDi-toolkit, a new approach for colour formulation process'. The energy company mentioned 'the work performed by Research & Development allows the company to manage their processes in a better way. Better management enables the company to reduce operating costs'. The medical company describes this as 'maximize sustainable profit-

ability'. While the management technology transfer institute describe this as 'better ROI, time-to-market and ROK'. The second group that could be recognised is 'developing new products'. The IT company describes this as 'To develop technology that allows the company group to develop the right products in the future. The environment consultant said this as 'Making developments that enables the company to make successful (advice) products'. While the Energy / environment technology transfer company wrote this down as 'securing continuity by generating income for future development.

Conclusion

First of all it is clear that leveraging R & D is an important issue for R & D managers. However, the creation and explicit justification of added value of R & D in relation to scope, skill, scale and social networking is not yet common practice. First indications from the workshop are that it is promising to develop this method further. Clearly further operationalisation of this framework is necessary to come to a practical instrument. The fact that three companies after an interview on the use of this framework were better able to use it shows that clarification is necessary and useful. Furthermore, the basic assumptions of the approach, placing value creation explicitly in a network perspective, is not only theoretical of importance, but is also in practical sense an useful addition. The observation that the importance of network aspects as seen by the managers in the workshop was high, but the use of explicit network analytical tools is low, supports this.

Scientifically this approach combines in a systematic way internal and external developments and mechanisms to influence value

creation. The combination of social system theory and elements of the process based contingency theory and the metrics developed in that perspective lead to a fruitful framework. The process orientation, combination of qualitative and quantitative analysis, multi-dimensionality and multi-level analysis, lead to a complex model of value creation in R&D. We conclude that the complex situation of R&D in high tech fields corresponds with this complexity.

Further development is necessary to develop the theory from a predominantly analysis tool to a management tool. Therefore further operationalisation is necessary. First steps to do so are taken, four case studies are begun and also the R&D network will continue its activities. The case studies address complementary issues: one case study focuses on the interactions between the four basic mechanisms, three R & D units of companies present in the workshop are analysed in more depth on this topic. One other case study is an in depth study of an industrial network in which an innovation is introduced. In the case study an assessment tool of this network is made, leading to pointers for marketing and portfolio management in R&D. Recently two case studies began analysing the internal and external networks of research and development units in automotive and electronics firms. In a later paper we will come back to the results of these case studies and the feedback we will get from the leveraging R & D network in which coming events will be used to present and evaluate these cases. Using a design oriented approach (Kerssens-van Drongelen, 1999) we expect to construct a design method of an assessment tool for value creation and value justification in research and development systems. This method will enable network-oriented assessment in a multiple dimensional way revealing value for scope scale and skill of actors active in these networks.

Note

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Aard J. Groen is associate professor of Entrepreneurship and is director of NIKOS: the Dutch Institute for Knowledge Intensive Entrepreneurship at the University of Twente, The Netherlands. Inge Kerssens-van Drongelen is management consultant at Cap Gemini Ernst & Young in Utrecht, the Netherlands, and assistant professor at the Faculty of Technology and Management at the University of Twente, Enschede, the Netherlands. Petra C. de Weerd-Nederhof is associate professor New Product Development at the faculty of Technology and Management, University of Twente, The Netherlands. Rob Badoux is currently Program Director for the Natural Gas Strategy Course at Gastransport Services, The Netherlands. Before this he was Manager of R&D Services at Gasunie Research, The Netherlands. Gerard P.H. Olthuis was technology officer at Philips International, Eindhoven, The Netherlands. He retired in 2001.

Appendix 1: 4 S framework

	Monitoring added value creation		Proof of added value
	Operational effectiveness	Strategic flexibility	Measurement
Strategy / Scope Which strategic goals are to be attained? What contribution to strategic capital (power base of company) is made?	–	–	–
Social networks Which position and relational contacts are used/useable? What contribution is made to social capital?	–	–	–
Skills, competencies and values How and which patterns are to be maintained (adaptive goals)? What contribution is made to cultural and human capital?	–	–	–
Scale / economic efficiency Which economic scale is necessary? (operational goals) What contribution can be expected to economic capital?			–