INTERNATIONAL DESIGN CONFERENCE - DESIGN 2012
Dubrovnik - Croatia, May 21 - 24, 2012.

IS THERE A NEED FOR DECISION SUPPORT IN SUSTAINABLE R&D PORTFOLIO MANAGEMENT?

C. J. Decouttere and N. J. Vandaele

Keywords: R&D portfolio,sustainable R&D, group decision making, user experience

1. Introduction

This work seminated from an observed industry need in Flanders of how to introduce sustainability in the R&D portfolio decision. During the preparation, the conduct and the follow-up of various R&D projects in the industry, it was striking to observe how several particular issues related to decision support came back over and over again. This urged for a coalition between a research intermediary (Flanders InShape) and a university (KU Leuven) to go together for a quest to provide an answer to these industrial concerns and turn them into clear and outlined research questions. This paper covers the industrial problem setting related to incorporate sustainability in the R&D portfolio decision making, the delineation of the first research topics and a first proof of answer. The latter is illustrated with two real-life examples from industry, an industrial supplier of raw materials on the one hand and a producer of consumer products on the other hand.

2. The need for decision support

2.1 Description of the problem context

Today's innovation strength is more than ever determined by a company's ability to differentiate from the competition in delivering customer delight at the pace of the market, applying the best available technology. Sustainable innovation results in profitable, people oriented, and planet-minded products and services. It is a great challenge for innovation and R&D managers to permanently assure that R&D budgets are allocated to the best set of R&D projects in order to reach the innovation targets on both the shorter and the longer term [Cooper 1998]. Factors with a traditionally strong influence on strategic innovation decision making, such as the business opportunity and the feasibility of a project, do not necessarily predict project success [Moenaert 2010]. From the latter study, competitiveness reveals to be a strong predictor for success. Competitiveness consists of the following three elements: a competitive answer to a threat or an opportunity, the size of the advantage over the competition (incremental or game changing) and the sustainability of the innovation.
Competitiveness is linked with differentiation and added value as perceived by the customer. In order to create a sustainable advantage there is a need for non-imitable features, such as non-technological, intangible aspects leading to product/service experience and meaning, in line with the brand experience and corporate identity [Borja de Mozota 2003]. This holds both for incremental as well as for radical innovations. However, the latter cannot be derived from actual user and market research, since they create new markets and envision the user of the future in a future context. Radical innovations, based on new technology, or addressing new user needs or creating new markets, are hard to evaluate, especially in the early phases of New Product Development (NPD). There are many

uncertainties and risks on all three types of innovation aspects: technology, economies and values, as shown in Figure 1. We define "values" as the ethical, societal and personal values and perceptions leading to a product experience. Radical and incremental innovations differ dramatically in the availability of information on opportunities and risks. They are difficult to compare and equally serve the goals set by the business and innovation strategy. Industry practice shows that a separate approach in budget allocation and R&D organization for radical innovations is usually applied. This, however, does not solve the problem of evaluating the radical innovation projects. Optimal R&D budget allocation according to the innovation strategy requires incremental and radical innovations to be evaluated simultaneously.

Sustainability, as defined by the Brundtland Commission in 1987, was translated into the triple bottom line (people, planet, profit), and adopted by many companies through their mission statement and innovation strategy. However, the societal (people) and ecological (planet) dimension of sustainability are difficult to incorporate in formal decision making policies and decision support systems.

From a short term perspective, designing for user experience can lead to differentiation and innovation success and thus economic benefits. When embedded into a long term company strategy, aiming for "customer delight" involves human-centered design and experience innovation and leads to both incrementally and radically new products and services addressing today's and tomorrow's user needs. However, the economic benefits resulting from "user experience" are hard to estimate in the early phases of NPD. Moreover, the amount in which an innovation contributes to a user experience represents a completely different type of benefit for the company than the direct and short term economic consequences.

Ecology and human (or user) related aspects are part of the earlier defined 'values', since they both involve ethical values, which can be commonly shared by a group of customers or they can be individually perceived. Values cannot be translated into monetary figures without loss of information. They can be very different, even conflicting in their nature and value. For instance an innovation idea can lead to a very high user experience but low ecological contribution. They will therefore be treated as separate dimensions in the decision support for strategic innovation decisions.

R&D managers are in search of a consistent way to translate the innovation strategy into an R&D portfolio, taking into account all three dimensions of the sustainability concept. Available decision policies and supporting tools for strategic innovation decision making are not well capable of handling the intangible aspects of customer delight and ecology; they are too slow to respond to changes in both endogenous and exogenous factors. They favor incremental innovation versus radical innovations, especially when these originate from a user oriented perspective.

As a result, mainly the technological and financial aspects prevail in the ranking and selection of projects at the strategic level, defining the R&D project portfolio. The disability to evaluate a projects' performance level on the value-based aspects, and to evaluate its overall performance on technological, financial and value-based aspects forces ad hoc, subjective and informal decision making. This prevents a consistent value-based innovation strategy and R&D portfolio.

Innovation processes such as the widespread stage-gate® process, have many benefits for managing risks and monitoring KPI's along the innovation funnel. However, the sequential process is not a reflection of the real-life, parallel and iterative innovation activity, and it has a tendency of favoring projects who are in their later phases of development [Repenning 2001].

Next to adequate decision support models and processes, the implementation of a sustainable R&D strategy requires a new mindset, reconciling an analytic with an intuitive approach. Decision makers will face less certainty and will have to manage more risks and must be open to creative, intangible inputs during the R&D process. This will require a behavioral change in the decision making teams. In order to gain trust amongst the decision makers, it is of utmost importance to maintain transparency and consistency in the decision making, with a strong emphasis on communication based on the visualization of the data and results. This is a cornerstone of the "Design Thinking" way of R&D management, in which a holistic approach is applied and which involves rapid visualization of an idea and validation of each concept [Lockwood 2009]. The decision support system aimed for should be capable to support Design Thinking on the strategic innovation level and therefore, besides

transparency in the data, the system will have to possess quick recalculation functionalities and needs to provide an intuitive visualization of the model results.

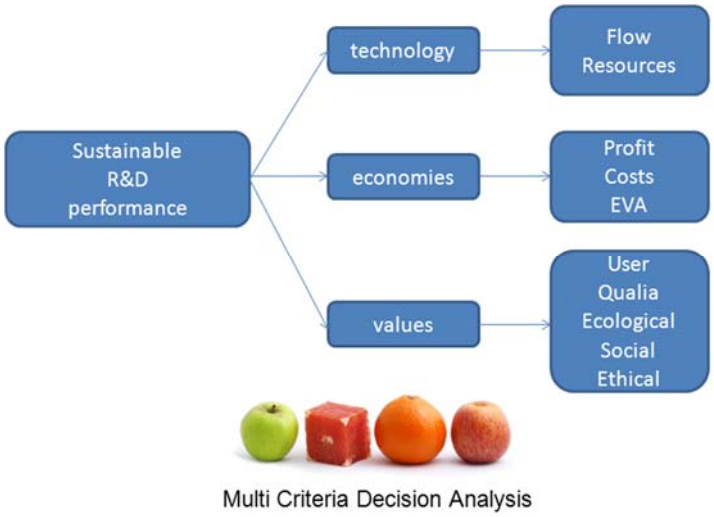

Figure 1. The multi criteria nature of R&D portfolio assessment

Our approach is in line with findings in the literature, were it is observed that product success is not only dependent on the technological and economical characteristics, but also relies on the experience of the product. Radical innovation design practice, based on product experience, has for instance been developed by Hekkert et al. [Hekkert 2011] through the ViP design methodology, in which user experience and contextual factors determine the innovation requirements. The R&D portfolio dimensions corresponding to product experience, are part of the "values" in Figure 1.

2.2 Results from an industry review in Flanders

The first step in our research related to decision support for sustainability in R&D portfolio assessment, was a multilayered scan on how Flemish companies managed their R&D portfolio. Several ways were adopted to reveal the relevance of the business process named 'R&D portfolio management' whereof portfolio assessment is a crucial part: systematic audits and interviews (100+ companies), focus groups, discussion networks with industry captains, in-depth interviews and dedicated workshops. From this review, we were able to undoubtedly conclude on the real need for R&D assessment decision support in general and more specifically on the lack for a corresponding assessment model with the sustainability - and more broadly the value aspects - embedded in a decision support tool. It turned out that from a decision support point of view, the problem of R&D portfolio assessment encompasses:

- A low success ratio for **radical innovations** mainly due to failing **user acceptance,** and consequently a low ratio of radical innovation investments vs. incremental innovation investments.
- A **priority setting gap** between technology driven, and market driven R&D entities leading to **long decision cycles** and **inefficient R&D management**
- The direct labeling of **strategic directions** on individual projects causes overruling of the scoring models in place. These projects are hardly questioned during the course of R&D assessment because they were imposed by another decision authority and are outside the formal decision process.
- Unclear link between **KPI's** for R&D and the **portfolio selection criteria**, miss the opportunity to drive improvement actions and target setting
- **Sustainability** seems to be difficult to integrate in the formal decision process, it is either put forward as a strategic direction and is materialized in a few strategic projects, or it is found at the end of the development process where mainly incremental improvements can be expected.

- **Input data** based on human evaluations, used for score calculation, are not consistent. Sometimes different viewpoints, contexts or definitions are interpreted.
- R&D portfolio decisions are mainly made based on **economic figures**: NPV, ROI and other monetary metrics.
- **Intangibles** and **value-based arguments** are difficult to deal with for idea selection and project ranking and are not taken into account.
- Need for **dynamic** portfolio management tool allowing what-if analysis for changing external conditions with adequate frequency of updating.
- **Behavioral aspects** in decision making play an important role; shortcoming in visualization impedes good communication, the interpretation of the data differs between the members of the decision making group.

2.3 The industrial practice related to R&D portfolio assessment

The industry review revealed several decision support tools in use today. Besides scoring models, the major characteristic of all these is that they are descriptive, leaving a huge opportunity for subjective inclusion of arguments and opinions. R&D managers state frequently that in this way consistency is hard to preserve whilst various stakeholders in the R&D assessment feel uncomfortable with the personal weight individuals can embed in the process. *"It is very difficult to objectively evaluate a promising technology driven research project, of which the economic value is based on estimations, against an incremental innovation project for a product segment in a prosperous market segment. Actual sales figures or a customer's request have more weight than a future potential."* The portfolio management goals, derived from the innovation strategy, can be diverse: to maximize project efficiency, to maintain a balanced portfolio or to aim for highest success ratio. They require different types of portfolio assessment tools and visualizations (e.g. portfolio mapping and bubble graphs which allow for immediate recalculation and very suitable for what-if analysis).
These tools have a low analytic content in the sense that they mainly try to map the data at hand. For the matter of decision support, they remain subject to personal opinions, power games, colored interpretations as well as they only rely on a partial analysis and thus limited view. However, our survey turned out that these decision support tools are quite popular and widespread. This is mainly due to two important and powerful features: visualization and communication. As a consequence, these two observations put a necessary condition on the newly proposed decision support tool for R&D portfolio assessment.

3. Two examplary case studies

Based on the multi-layered scan of Flemish industry, two typical case studies out of the set of companies reviewed to test and validate our approach are chosen. They have been selected based on their urgent need for scientifically based decision support in the area of R&D portfolio assessment, their reasonable availability of suitable data and a willingness to join into a case based research path and to go along with the suggested mathematical modeling. In Figure 2, we list (part of) the information from the industry survey. The companies are clustered according to their position in the value chain, based on the observation that the inclusion of the user/value dimension is one of the key determinants for successfully integrating sustainability in the R&D portfolio. For this paper two cases are selected along this axis: one global company active in the B2B material research area and another more local company active in the B2C end-product mass market. Both companies have expressed substantial interest in the decision support model for R&D portfolio assessment, but each one had its own specific emphasized interests related to sustainability:

- The B2B company is characterized by the additional challenging feature of consolidating the R&D portfolio's of several business units. Here the idea is neither to miss nor to overemphasize the sustainability issues over all existing and future business units.
- The B2C company faced a different challenge as the R&D portfolio is mixed up with incremental projects originating from both process and product improvement. Analogously, sustainability issues may be overwhelmed by incremental, and thus shorter term, concerns.

	B2B Material research	B2B Platform technology	B2B End product Professional market	B2C End product Mass market
Position in value chain				
Innovation drivers	1. technology 2. market (customers)	1. Technology 2. Market (customers)	1 Market (few customers)	1 Market (users & customers)
(end)User experience and interest	Sensory aspects: touch, visual, functional: weight, strength, cost	Functionality, cognitive & sensory	Functionality Multisensory	Multisensory Functionality
(end)User involvement in innovation	Scientific relation between multisensory experience and material properties	Indirectly Limited impact on decisions	Lead users From early stage of NPD	Market research: Usage and attitude studies User research for incremental innovation in later stages of NPD
strengths	Discovery of radically new possibilities from technology Awareness of ecology/trends/regulations	Technology driven radical innovations Ecodesign	Experience with lead user innovation	Experience with market and user research
weaknesses	Communication with future clients on user needs (incl qualia) and benefits from material properties	Add qualia to user needs and match with technical possibilities to beat competition Make better portfolio choices	Early detection of radically new technological opportunities relevant to future users	Early detection of radically new technological opportunities relevant to future users

Case 1 Case 2

Figure 2. Company categories based on the value chain position

DEA is chosen as the basic methodology to develop a decision support system for R&D portfolio assessment. Data Envelopment Analysis (DEA) is a generally accepted methodology for multi-attribute relative performance assessment [Charnes 1978]. For our purposes, where the units are the various projects to be assessed, more details and respective models can be found in [Vandaele 2011].
For the purposes of this paper, where the units are the various projects to be assessed, it offers not only nice features for portfolio assessment and ranking, but it also turns out basic insights for portfolio selection, for portfolio management, the construction of technology roadmaps and even some possibilities for technology forecasting. In this paper the focus is on the issues of assessment and ranking. From various sources in literature, the following can be recalled:

1. DEA is suitable for datasets with heterogeneous dimensions; as described in section 1, the overall assessment of a R&D portfolio boils down to technological, economical and value based performance measures, each stated in their respective measurement units. Note that value based performance measures may likely be expressed by scale or ordinal data; however, also some technological and economical measurements (e.g. risk assessment) may be described by ordinal data (Likert scales).
2. Once the DEA model is agreed upon, it provides rapid (re)calculation. This is utmost welcome as several dimensions in the R&D portfolio assessment are volatile and subject to internal and external dynamics (for instance delivered test results, regulation changes, market/user reactions, competitive moves, ...). Also, as some of R&D measurements are based on opinions, expert knowledge, risk orientation and some kind of forecasting, rapid calculation is very useful to conduct what-if scenario's and sensitivity analysis. Rapid (re)calculation is also important if the methodology is used in a group decision making context, for instance in the format of the R&D portfolio meetings.
3. Provided appropriate choice of measurements and reliable data, DEA is able to give insight in the R&D portfolio. It points to (in)consistency in the data, it assesses the relevance of the measured dimensions, it may reveal clusters of projects and points to (in)balances in the R&D portfolio related to the overall risk content of the portfolio, the balance between radical and incremental projects, a shift in competitive position, etc.
4. By the adequate choice of performance criteria the DEA model can support both strategy fulfilment and project performance. In this way a connection is preserved with the strategic vision with respect to sustainability and emphasis of the company on the one hand, and tactical and operational R&D management decisions on the other hand. As described in section 1.2, this is a major reason why current R&D portfolio assessment tools fail.

Due to confidentiality reasons, neither the company details nor the portfolio data can be disclosed. However, we report on the outcome of the case based research trajectory.

3.1 The case of a B2B company

This section describes a multi-national, B2B material manufacturer in the plastic and foam industry. The company employs a centralized R&D portfolio covering different business units, among which some are active in rather mature markets whereas others are active in growing markets. The portfolio reviews research projects for new materials, new applications and new markets. However, alongside the case based research path, it became clear that particular incremental innovation projects for applications in growing markets with strong business units behind them, were systematically favored over radical innovation projects for new markets for which a new business unit needed to be created. This application of strategic buckets, in which R&D budgets were allocated according to the market evolution erruled somehow any assessment and ranking.

It is important to know that this company has developed and used an elaborated R&D portfolio management system in the past. Relevant for this paper, it is worth to mention some of the main characteristics:

- it was based on a weighted scoring approach
- it was prone to manipulation: the different dimensions were given a weight which was utmost easy to adjust the projects were visualized using radar graphs; these graphs do not only become pretty cumbersome with an increasing number of dimensions, but also lack the ability to rank the projects in a consistent and correct way
- visualization was always myopic: only three dimensions were visualized separately (the system consisted of several two-dimensional bubble graphs); in this way a holistic and complete view/assessment on the portfolio was never possible
- the system was based on many characteristics; there was no means available to limit the number of criteria (for instance if they were highly correlated); consequently, the amount of data to be collected was huge and envisioned resistance in many occasions

This elaborate R&D portfolio management system was abandoned due to its complexity and shrinking buy-in by the users of the system. In-transparency and blurred visualization added to this growing lack of interest.

Nevertheless, the company expressed its concern and belief that trends like sustainability in general and ecology in particular have to be incorporated in the R&D portfolio management agenda. Related to this is a growing concern about user perception of the companies' chemical and potentially hazardous reputation. On the other hand, the unique user experience potential, due to new material properties give rise to numerous new applications, which seem promising for those involved in R&D. However, the potential is difficult to put in numbers in the early stages of product development and the actual decision support system is not able to reflect this potential.

With the available data (see Figure 3) we performed several DEA analyses which gave insight in the performance of the various innovation project types. It became clear that estimated parameters, such as "environmental strength", should be evaluated as detailed as possible in order to produce discriminating results. On the other hand, even if the data are rough estimations, every difference between projects is valuable information. The fact that the data can be easily updated and the model can be re-run when new information gets available, lowers the anxiousness for early phase estimations. Due to the large amount of projects in the portfolio, we were able to work with 4 inputs and 8 output variables, which included the full pallet of sustainable R&D portfolio: economic, technical and value aspects. Some left out variables will need to be measured or estimated in a more detailed way than the currently used 3- and 5-point Likert scales, other parameters did not justify further investigation, because they contained no new information or they revealed not to contribute to the ranking of the projects. Overall, the amount of work for data collection and data processing will be significantly reduced for a far better result. A challenge is here how to create room in the R&D environment in order to develop new businesses, from the research projects which have no proven market success yet but have a future potential due to value based aspects. This is done by adding criteria which are able to reflect the future potential based on the value aspects.

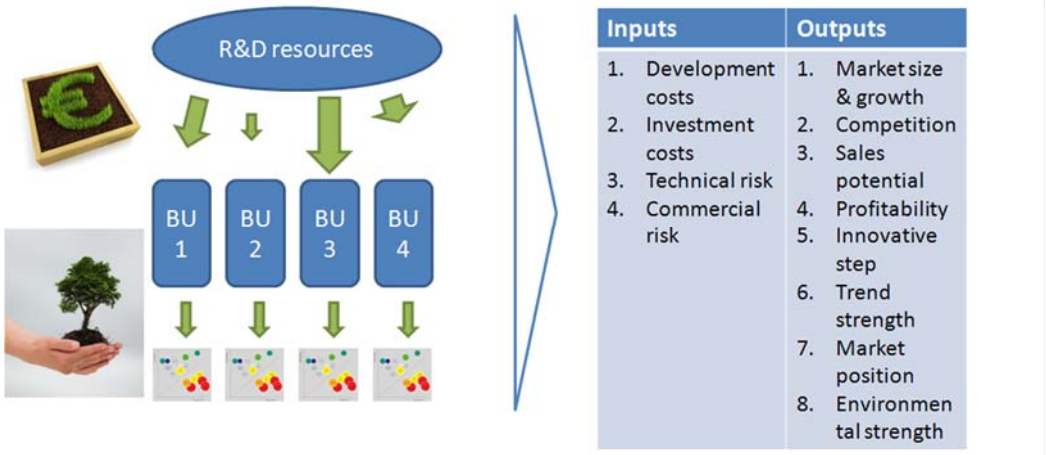

Figure 3. DEA application in the B2B case

Another challenge is to evaluate projects in early-phase idea stage against concepts and nearly developed products. Figure 4 shows an example of a merged portfolio representation of R&D projects of different business units.

A 2D bubble graph (see Figure 4) representing only two 'tangible' dimensions proved already in practice to influence the decision making process for project selection towards more focus on the overall corporate R&D company mission, and flexibility towards the strategic buckets. When more intangible dimensions are chosen, such as environmental strength and user perceived value, it enables the decision makers to better capture early phase projects in terms of their benefits, risks and position in the portfolio, and to put them alongside the clear and well documented late stage development projects.

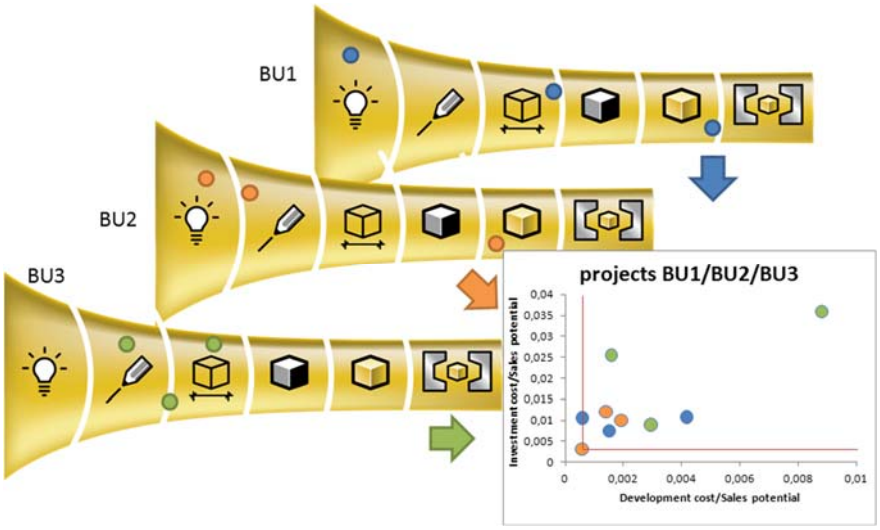

Figure 4. Merged R&D portfolios with DEA

3.2 The case of a B2C company

The company used a quantitative scoring model and a qualitative checklist. The scoring model was based on both calculations and human estimations. However, they were mainly economically driven. The checklist provides detailed project information on all sustainability dimensions, in total 28 parameters are estimated per project. The two datasets were not linked for portfolio assessment, only the inputs for the scoring model were used.

Sustainability and user experience are main focus areas in the company's strategy. User insights and user involvement are of very high quality in the company. On strategic level however, the new product ideas resulting from user insights and radically new co-developed concepts are not able to gain attention next to incremental business driven innovations. Reactive projects, responding to a change in

competitive environment, were systematically earmarked as "strategic", overruling the scoring model and the checklists. The company's mission and innovation strategy was to be a leader, but the portfolio was constructed for a follower. The aspect of ecology was considered as very important, but was not reflected in the decision support. This is a criterion which will be captured in the future to include in the DEA analysis. DEA analysis revealed a potential for reducing data collection of double measured, overlapping, correlated and inconsistent parameters and posed the right questions about the strategically earmarked projects (see Figure 5). The 5-point Likert scale which was applied for many qualitative parameters will be refined and less parameters will be used.

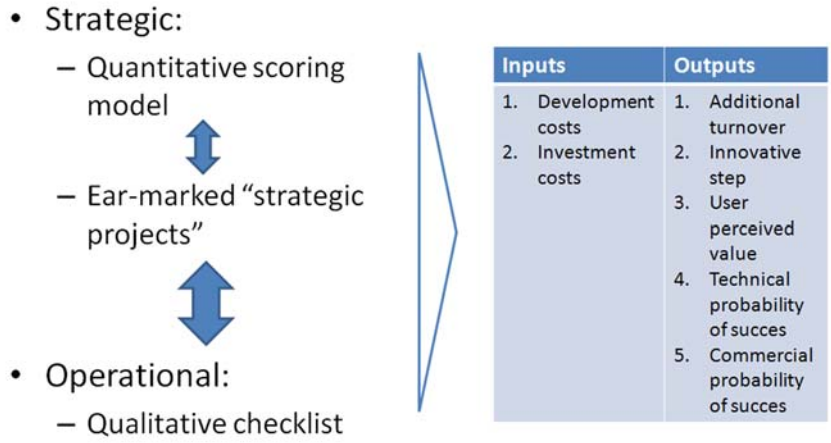

Figure 5. Case B2C company

4. Conclusion

As sustainability gets mixed with the other performance criteria, it imposes challenges on both the methodological and the practical side. From a methodological point of view, many of the value based criteria are descriptive and qualitative. Turning them into numbers is not trivial. Likert scales and categories have shown not to be that promising whilst the additional insight and value of these complicated models is questionable. Therefore, based on the two examplary case studies revealed in this paper, we suggest to model the value based criteria as much as possible as continuous cardinal criteria. From the practical point of view, establishing good continuous cardinal measures for value based criteria is not obvious. The quest for good metrics, which are in line with the strategic mission and options, must be intensified and appropriate data collection processes have to be set up. As far as the output from the decision support system is concerned, the visualization of the results turned out to be a key success factor. This is the solid base for proper and profound insight creation which serves on its turn as the fundament for clear and concise communication. As the R&D portfolio assessment process is a typical group decision exercise, the decision support tool has to fit this setting.

Data Envelopment Analysis turned out to be a suitable methodology for R&D portfolio assessment, including the value based criteria. The main advantages are the fact that is complete (it summarizes the multiple criteria into one assessment and ranking), transparent (the assessment results can be justified and explained) and consistent (the methodology neutralizes subjectivity and circumstances). In a group decision process, it definitely takes care of the analytic part of the R&D portfolio game. Based on this analytic part, all other considerations can be added in order to come to a solid, well-thought decision.

As far as future research is concerned, extensions on the proposed R&D portfolio assessment approach are to be formulated in the direction of project selection under constraints, the formulation of roadmaps and multi-project planning and to exploit the possibilities for portfolio follow-up and control.

Acknowledgement

The authors like to thank the many anonymous companies for their contribution to this research.

References

Akyol, D.E., De Koster, M.B.M., "Non-Dominated Time-Window Policies in City Distribution." 23rd European Conference on Operational Research, Bonn, Germany, 2009.

Ayag, Z., R.G. Ozdemir. "A hybrid approach to concept selection through fuzzy analytic network process", Computers & Industrial Engineering Vol. 56, 2009, pp 368–379.

Borja de Mozota B., "Design management: using design to build brand value and corporate innovation", Allworth Communications Inc., 2003

Charnes, A., W. W Cooper, E. Rhodes., "Measuring the efficiency of decision making units", European Journal of Operational Research Vol. 2, No. 6, 1978, pp 429-44.

Cooper, R.G., S.J. Edgett, E.J. Kleinschmidt. 1998. "Portfolio management for new products" Perseus Books, Massachusetts, 1998

Hekkert, P., Van Dijk, M., "Vision in Product Design: Handbook for Innovators" Amsterdam: BIS Publishers, Amsterdam, 2011.

Lockwood, T., "Design thinking: integrating innovation, customer experience and brand value", Allworth Communications Inc., 2009

Moenaert, Rudy K., et al., "Strategic Innovation Decisions: What you foresee is not what you get", Journal of Product Innovation Management, Vol. 27, 2010, pp 840-855.

Repenning, N.P., "Understanding fire fighting in new product development", Journal of Product Innovation Management Vol. 18, 2001, pp 285–300.

Vandaele N, Decouttere C, " Sustainable R&D portfolio assessment", KBI_1128, KU Leuven, 2011

Ir. Catherine Decouttere
Coordinator research program
Flanders InShape and Katholieke Universiteit Leuven
Etienne Sabbelaan 51, 8500 Kortrijk, Belgium
Telephone: +32 56 28 28 43
Telefax: +32 56 28 28 50
Email: catherine.decouttere@flandersinshape.be and catherine.decouttere@kuleuven-kortrijk.be
URL: http://www.flandersinshape.be