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# Balancing incentives in thematic priority-setting for collaborative innovation networks

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**Abstract:** In collaborative innovation networks, foresight activities for the development of thematic R&D priorities may be expected to serve different objectives that place different requirements on the foresight process. Demands for novelty, for instance, may best attained by elaborating bold ideas and by promoting wide-ranging and open-ended discussions; but the immediate needs of decision making may be best served by generating actionable and less contestable recommendations. In this paper, we analyze such complementary objectives in relation to the methodological design of the foresight process. Specifically, we discuss them in the light of a priority-setting process that was conducted for the Association of Packaging Technology and Research (PTR) in Finland. This exercise was novel in that an interactive decision support tool RPM-Explorer© was employed to support the development of thematic priorities at the Board level.

**Keywords:** Participatory foresight, innovation networks, innovation management, R&D priority-setting, Robust Portfolio Modeling, RPM-Screening, group decision support, packaging industry

## 1 Introduction

The development of thematic R&D priorities is widely regarded as one of the key objectives of participatory foresight activities (see e.g., Martin and Irvine, 1989; Salo and Salmenkaita, 2002). By fostering future-orientation, broad stakeholder participation, multiple perspectives and mutual learning (e.g., Irvine and Martin, 1984; Könnölä et al., 2007), foresight may mitigate the risks of establishing priorities based on considerations that are either too narrow in scope or too present-oriented in terms of planning horizons. Moreover, foresight may also contribute to the structural re-shaping of the innovation system, for example by building new collaborative networks or creating new patterns of knowledge diffusion among the stakeholders (e.g., Barré, 2002).

Participatory methods are suitable for the development of thematic R&D priorities in collaborative innovation networks which are characterized by many-faceted links to different kinds of organizations and

which seek to re-structure themselves in response to technological advances and societal changes (e.g., Wissema and Euser, 1991; Van Aken and Weggeman, 2002; see also Brummer et al., 2009). Arguably, such networks can be best assisted by methodologies that help the network participants identify opportunities for collaborative efforts and promote the diffusion of knowledge within their respective organizations (e.g. Faucheux and Hue, 2001; Jochem and Edelgard, 2007; Salerno et al., 2008; Brummer et al., 2008, 2009; Könnölä et al., 2009). It is particularly when pressures arising from changes in the innovation environment call for a reconfiguration of the network, (e.g. Jarimo et al., 2005) that the broader consultation of stakeholders can help synthesize inputs from multiple sources of expertise into well-founded visions for joint actions. Furthermore, if the networked organizations follow dissimilar routines when pursuing partly over-lapping objectives, agreements on the shaping of these routines must be based on an appraisal of these routines by the network participants who know them best (e.g. Reger, 2001). Participatory approaches may be suitable here as well.

While participatory foresight activities can bring multiple perspectives to the consideration of prospective research priorities, the use of foresight methodologies for R&D priority-setting can be challenging. Some methods are not ideally suited for this purpose (Salmenkaita and Salo, 2004): for instance, while the Delphi method (e.g. Linstone and Turoff, 1975) yields information on alternative states of future, it may be difficult to translate this information into actionable recommendations (see e.g. van der Meulen et al., 2003; see also Salo et al., 2004). Even expert workshops–which enable intensive communication among the stakeholders–may fail to yield recommendations for the decisions that the foresight process may have been expected to support (see e.g. Hjelt et al., 2001; Salo et al., 2004).

The close engagement of decision makers in the foresight process is likely to increase the chances of producing actionable results (Weber et al., 2008). Senior decision makers, in particular, may look for consensual foresight results that suggest defensible R&D priorities that are aligned with their short and mid-term objectives (Weber et al., 2008). But this demand is not necessarily fully aligned with the other expectations that the stakeholders and organizations may place on foresight: for example, attempts to enhance the competitiveness of innovation networks may call for other kinds of results, such as novel ideas that incite the participants to pursue the development of innovations.

In this paper, we argue that the above tensions can be addressed through methodological choices that seek to balance the requirements that different stakeholders place on the foresight process. Specifically, we report a foresight process that was sponsored by the Association of Packaging Technology and Research (PTR) in Finland with the aim of developing thematic R&D priorities for the packaging industry. We discuss how some of these requirements were met through methodological choices, such as the coherent application of multiple evaluation criteria to comparable 'units of analysis'; the use of interactive decision aiding tools; and the involvement of senior decision makers in the very earliest phases of the project.

From the methodological point of view, this foresight process is of interest due to the increasingly tight linkages that the packaging industry has with other industries and research fields. The packaging industry is presently in an exceptionally turbulent development phase due to recent technological developments (e.g., RFID technology), shifting consumer values (e.g., importance of environmental concerns) and more stringent regulatory demands (e.g., traceability of products). Because analogous developments characterize innovation activities increasingly in other industries as well, it appears that experiences from this process are relevant to other industries as well.

The rest of the paper is organized as follows. Section 2 discusses the use of participatory foresight activities for the development of R&D priorities setting in innovation networks and considers requirements that different stakeholders may place on the foresight exercise. Section 3 presents a case study where novel decision support tools of were deployed. Experiences from the case study and their broader relevance are addressed in Section 4. Section 5 concludes.

## 2 Balancing incentives and requirements of participatory foresight in innovation networks

### 2.1 Participatory foresight in supporting thematic R&D priority-setting in innovation networks

Collaborative innovation networks are at the heart of innovation systems (e.g. Van Aken and Weggeman, 2002; Bullinger et al., 2004). New products and services are increasingly multi-technological (Narula, 2004), which creates a demand for collaboration forms that facilitate the planning and implementation of joint efforts of firms and research organizations. Moreover, as the success of new technologies, products and services depends on the joint actions taken by public funding agencies, regulators and policy makers, there is a need for practices that

help synchronize the strategies and actions of the stakeholders that operate in these networks (e.g. Smits and Kuhlmann, 2004).

Thematic R&D priority setting is one of the central tools for managing innovation networks (e.g. Bullinger et al., 2004). On one hand, priority setting activities may provide relatively loose guidelines that help stakeholders and organizations synchronize their medium and long term development activities. On the other hand, they may suggest specific topics to which specific resources and efforts are devoted with the aim of harnessing potential synergies. The identification of joint actions can often be stimulated by eliciting forward-looking ideas about prospective product and process innovations (e.g. Salo et al., 2003; Keenan, 2003).

### 2.2 Incentives and requirements of foresight

Several authors have addressed questions of how participatory foresight activities can best support thematic S&T priority-setting and what objectives and interest groups such activities can best serve (see e.g. Stewart, 1995; Salo, 2001; Weber et al., 2008). Stewart (1995), for example, analyzes priority-setting activities from three perspectives, distinguishing between priority-setting activities that are driven by (i) the needs of the users in industry or society (the user based model), (ii) the rewards for broader involvement of the community (the institutional model), and (iii) present political aims (the political model). Weber et al. (2008) analyze what implications the involvement of stakeholders can have on foresight outcomes. They argue that the more extensively the decisions makers are engaged in the foresight exercise, the greater number of concrete outcomes and initiatives may be–albeit at a possible loss of novelty and creativity.

Further perspectives can be offered by examining how the objectives, incentives and constraints of different stakeholders relate to methodological choices in foresight for innovation networks. Here, we consider three specific aspects of innovation networks:

- The objectives that the *participating organizations* place on the process provide a starting point for the design of foresight activities (Salo et al., 2004). Apart from priority-setting, there may be other objectives that can be pursued by facilitating open-ended discussions on the possibilities for enhancing the competitiveness of the network, by increasing the awareness of S&T opportunities and challenges and by fostering mutual learning at large (see also 'variety'; Rip, 2003; 'involvement and creativity'; Rask, 2008).
- *Foresight participants* (i.e., the researchers, industrialist and other stakeholders who contribute to the process) typically devote only a relatively modest amount of their time and effort to foresight activities. Moreover, if there are new participants who do not have prior experience on foresight benefits, there may be a need to clarify what these benefits are and how the inputs from the participants are harnessed in the development of R&D priorities, for instance. This requires for transparent methodologies (Salo, 2001).
- Also *decision makers* who use foresight results are concerned with the time and effort that they invest in the process. This may mean that foresight results should, if possible, contain readily interpretable and actionable decision recommendations (Azzonea and Manzini, 2007; for an example of a policy document STPC, 2006). Overall, decision makers may be more prone to make use of actionable, consensual and risk-averse foresight results that synthesize viewpoints into aggregate funding priorities or suggestions for concrete R&D policy measures (e.g., development of strategic alliances; Weber et al., 2008; Salmenkaita and Salo, 2004).

### 2.3 Need for balance

Many authors note that there is typically no single objective that foresight is expected to serve; rather, they recognize multiple tensions (Salmenkaita and Salo, 2004), balances (Salo et al., 2008; Rask, 2009) and trade-offs (Rip, 2003) among different objectives. In innovation networks, the methodological design of participatory foresight processes can be even more challenging due to the possibly conflicting requirements that may apply. These requirements span concerns such as the following:

- *Strict management vs. creativity* (see also 'Daphne Dilemma'; Van Aken and Weggeman, 2002): The demand for transparency and the limited availability of time that the participants can dedicate to foresight activities imply that the process should have a well-defined focus and structure. In effect, a clear process design is a precondition for transparency, because otherwise it can be very difficult to communicate how and by whom the foresight results have been developed and what assumptions they are based on. Furthermore, a clear design helps the participants understand what they are expected to do while it also facilitates the uptake of foresight results in subsequent decision making. This notwithstanding, too rigid a structure may stifle creativity if it does not allow the participants to debate openly S&T opportunities, challenges and solutions.

- *Diversity vs. usability of the foresight results:* In foresight, diversity can be understood as a characteristic of the number and disparity of foresight conclusions (see also Stirling, 2007). Diversity is relevant in priority-setting (see e.g. Könnölä et al., 2007; Kemp, 1996; Schot, 1992; Weitzman, 1992): specifically, if the innovation network is being adjusted due to internal or external pressures, or if it is preparing for technological discontinues, the foresight process should facilitate broad-ranging discussion on S&T opportunities, threats and solutions (Könnölä et al., 2007). Yet, if the foresight results contain contradictory recommendations, it may be hard to adopt them in consensual decision making processes that seek to gain acceptance for immediately actionable results.
- *Establishment of new themes vs. validation of earlier ones* (see also Salmenkaita and Salo, 2004): Foresight may lend support for priorities that are readily accepted in the light of available knowledge and existing collaboration patterns. But foresight may also be expected to offer pave way for joint actions towards innovations whose potential is contested and which embody elements that are new to the network. These two objectives may be hard to fulfil at the same time, especially if the decision making bodies are dominated by experts who represent influential organizations and who may be keen on preserving some of the existing priorities.

## 3 Developing joint R&D priorities for the Finnish packaging industry

Our case study was conducted for the packaging industry which consists mostly of firms that are engaged in the coordinated manufacturing of products for transportation, distribution, storage, retailing and end use, among others. In a broader sense, the industry spans both vertical (i.e. value chain) and horizontal (i.e. other industries, socio-economic aspects, consumer behaviour, etc) dimensions. Relevant R&D activities take place in materials, logistics, printing, design and marketing, among others. Policy makers and regulators, too, shape the packaging industry through legislation and S&T and environmental policies, among others.

Apart from its broad span, one of the defining features of the packaging industry is its fragmentation because packing forms but a relatively small part of the business and R&D activities of many firms. For example, food industry has shared interests with the packaging industry (design and brand, food safety, sustainability, etc.). Yet both industries address issues that do not relate to the other.

In recent years, changes due to technological advances and consumers' attitudes have altered the business environment of the packaging industry. For example, information and communication technologies (ICT) have become essential in logistics, manufacturing and retail. Moreover, due to increased environmental awareness, companies need to identify, understand and address issues that affect the sustainability of packaging (Vachon and Klassen, 2006; Lewis, 2005). As a result, there is a need to adjust R&D activities in response to new topics in behavioural and social sciences. This also means that new organizations need to be involved in the development of thematic R&D priorities.

Against this background, the Association of Packaging Technology in Finland (PTR) decided to organize a foresight exercise in order to build the basis for a future research program on packaging. Earlier on, PTR had commissioned several studies in the course of which also workshops attended by end-user consumers were organized, with the aim of developing a new research strategy for the Finnish packaging industry. From the viewpoint of the PTR Board, however, these studies did not offer sufficiently actionable recommendations for R&D decision making. Nor had the smaller companies been represented in the earlier studies, and there had been relatively few inputs by research groups which might have offered interesting perspectives into new technologies or societal and behavioural developments.

After the discussions with the research group from Systems Analysis Laboratory in Helsinki University of Technology (the two first authors of the paper, later SAL group), the PTR agreed that the exercise would be conducted using the RPM-Screening methodology (Könnölä et al., 2007; Liesiö et al., 2007; see also Könnölä et al., 2009; Brummer et al., 2008). Also, in contrast to the earlier priority-setting exercises in PTR, it was felt that the PTR Board should be closely involved in the process so as to obtain a greater variety of inputs for its decision making, building on suggestions from both new and traditional partner organizations. The process was not to be too time-consuming, because the Board and the other engaged stakeholders could devote only a limited amount of time to the exercise.

The basic process ascribed well-defined roles and responsibilities to the participants. It was based on Internet-consultation and multi-criteria analysis, in keeping with some earlier consultation processes based on the RPM-Screening methodology (Brummer et al., 2008; Könnölä et al., 2007, 2009; see also Salo et al., 2009). However, unlike in earlier processes, the results from the consultation activities were communicated to the Board through an interactive decision support tool, RPM-Explorer©, which allowed the Board members to explore the proposed research themes.

### 3.1 Internet consultation

In the process design, it was regarded important to engage also those stakeholders who may not have enough opportunities to participate in the workshops. Thus, the first part of the process consisted of Internet activities where the PTR management team identified and invited researchers, industrialists and other stakeholders to submit, comment, elaborate and evaluate research themes through the website. Two groups of participants were involved:

- *Idea creators* consisted of about 70 researchers and other experts from the packaging-related industries, research institutes, universities and other relevant stakeholders. They submitted and elaborated research themes and commented on them.
- *Evaluators* consisted of about 25 leading experts of packaging industry. They evaluated the research themes.

The Internet activities took place in three phases that lasted approximately one month each (see Table 1).

**Table 1.** Internet consultation

| Phase | Participants | Weeks |
|---|---|---|
| 1. Solicitation of research themes | Idea creators | 1-4 |
| 2.Commenting and elaboration of research themes | Idea creators | 4-8 |
| 3. Evaluation of research themes | Evaluators | 8-12 |

*Phase 1: Solicitation of Research Themes*

In the first phase, the management team of the PTR identified and invited idea creators to participate in the foresight exercise through the Internet. Specifically, the idea creators were requested to submit one to five research themes that they considered relevant for the future of the Finnish packing industry in five different theme areas: 1) Delivery, transportation and logistics; 2) Structure and appearance of a package; 3) Consumer needs and functionality of a package; 4) Packaging materials and technologies; and 5) Active or intelligent packaging.

For each theme, the idea creators were first asked to give a short title and a concrete description (approximately 200 words). Some relevant results were taken from the earlier PTR activities, including (i) an external consultant-driven strategy process for prioritizing R&D activities of Finnish packaging industry, (ii) description of requirements of packages compiled by PTR management team, and (iii) results from two interactive consumer workshops. The idea creators were asked to identify which of these earlier activities the particular theme was related to. Moreover, they were asked to describe how the theme should be approached (approx. 200 words) and to explain what impacts could be possibly achieved through the exploitation of research results (approx. 200 words).

About 40 idea creators (~60% response rate) participated in the first phase. They submitted 102 research themes that were transferred to Phase 2.

*Phase 2: Commenting and elaboration of research themes*

In Phase 2, the idea creators were asked to comment on the themes proposed by others and to elaborate their own themes based on the other participants' comments. They were also asked to submit new research themes if they felt that some relevant themes were missing.

Based on the comments, the PTR management team elaborated the research themes by combining similar research themes and adding relevant comments on them. As a result, total 78 issues were transferred to Phase 3.

*Phase 3: Evaluation of research themes*

In Phase 3, PTR management team identified and invited 25 evaluators to assess the themes through the Internet with regard to three criteria using a one-to-seven Likert scale:

- *Innovativeness*: How innovative is the research theme?
- *Feasibility:* How probable is it that challenges associated with the research theme can be successfully addressed in ten years' time by pursuing proposed R&D activities on it?
- *Significance:* How important is the research theme for the Finnish packaging industry?

The criteria were aligned with the process goals and they were also general enough so that all the themes could be assessed with regard to them. The number of criteria was limited to three in order to curtail the workload of evaluators. Seen from this perspective, the above three criteria were deemed most relevant: innovativeness, which is a crucial factor in enhancing competitiveness of the Finnish packaging industry; significance, which reflects the usefulness of research in industry and society; and feasibility, which reflects the chances of achieving the described results.

All in all 15 experts (~60 % response rate) participated in the evaluation phase. Each theme was evaluated by about four evaluators.

### 3.2 Analysis of themes with RPM-Explorer©

After the Internet consultation rounds, the numerical evaluations of research themes were analyzed with multi-criteria portfolio methodologies. For each theme, the criterion statistics were calculated from the evaluations, including average ratings, standard deviations and ranges. Each theme area was analysed with RPM-Screening (see more; Könnölä et al., 2007; Liesiö et al., 2007, 2008), that highlighted themes that the Evaluators had seen most interesting in view of different criteria.

The RPM-Screening method is based on RPM-methodology (Liesiö et al., 2007, 2008) that has been initially developed for project portfolio selection problems. In the PTR foresight project, the method was applied by treating a research theme as a tentative proposal of a research activity. The value of each theme was approximated as a weighted sum of criterion specific average ratings. A portfolio was defined as a set of themes, and the overall value of a portfolio was approximated by the sum of values of the themes that were contained in it.

The suggested research themes were only short descriptions of themes on which the packaging cluster could focus. There was no reliable information on how much resources each theme would consume. Thus, instead of treating the priority-setting activity as resource allocation problem, the analysis was used for the tentative identification of those themes that the discussions should be focus on. For the purposes of priority-setting, it was assumed that the themes would be similar in terms of the required amount of 'resources'. Also, the analysis was designed so that it would highlight one third of proposed themes, based on the evaluators' ratings. This was regarded seen an appropriate number of themes that could be brought to discussions in the later workshops.

For the comparison of single themes, Core Index (CI) was calculated for each theme as a ratio of (i) the number of non-dominated portfolios (i.e. portfolios such that there does not exist any other portfolio which would have a higher overall value for all feasible criterion weights; see Liesiö et., al 2007, 2008 for details) that includes the particular theme and (ii) all the non-dominated portfolios. In the analysis, themes with a high CI value near 100 % were interpreted as more interesting than themes with a low CI value near 0%.

The analysis supported discussions at the PTR Board meeting where each theme area was separately examined. In contrast to earlier RPM-Screening processes (see. e.g. Könnölä et al., 2007, 2009; Brummer et al., 2008) where analyses were presented through written documents only, results were communicated through an interactive decision support tool called RPM-Explorer© (Jalonen, 2007) which allowed the Board members to explore research themes from different perspectives. Specifically, at the Board meeting, a facilitator used the tool based on the Board member suggestions, and the results were viewed on a whiteboard. This tool was also placed on the project website where all project participants could interactively explore the results. Below, the term "user" refers to both these groups, i.e., it includes both the Board members and the other participants.

A distinctive feature of the RPM-Explorer© is that the user can interactively change the relative importance of criterion weights and explore the resulting implications for Core Indices. If, for instance, the user seeks to identify themes that are evaluated as particularly innovative, she can define a rank-ordering (see Salo and Punkka, 2005) according to which innovativeness is the most important criterion. Conversely, if the user finds that feasibility is not as important criterion as the others, she can introduce this preference statement as well.

RPM-Explorer© is illustrated in Figures 1 through 6 which show the results from the theme area "Packaging materials and -technologies". In each figure, at the right, there is a pane for specification of weight information for three criteria; *innovativeness*, *feasibility* and *significance*. In the pane, the user can change the relative importance of the criteria by moving the corresponding boxes by mouse (i.e. "drag and drop" command), where the vertical locations of the boxes indicate the importance of the particular criteria. On the left, there is a histogram that shows the Core Indices of the themes that correspond to the stated weight information (length of the bar illustrates the value of the CI value). By clicking the name of the theme, the user can see the detailed description of the research theme.

When the user changes the relative importance of criteria (e.g., by giving some other rank ordering of criteria; see Salo and Punkka; 2005), the RPM-Explorer© updates the results. Thus, the user can highlight themes that best correspond to her preferences concerning the relative importance of criteria. As an example,

consider the research Themes #4.14 and #4.17 (see Figures 1-3). With no information about the relative importance of criteria (see Figure 1, later initial state), both Themes #4.14 and #4.17 are exterior themes (i.e. 0 < CI < 100%). With the rank ordering *significance* >> *feasibility* >> *innovativeness* (Figure 2), Theme #4.14 becomes a core theme (i.e. theme with CI = 100%) while the Core Index value of Theme #4.17 decreases. On the other hand, with the rank ordering *innovativeness* >> *feasibility* >> *significance* (Figure 3), Theme #4.17 becomes a core theme and the Core Index of Theme #4.14 decreases. Thus, depending on the given rank-orderings, RPM-Explorer© highlights themes that perform best with different rank-orderings. Note that in our illustrations, the themes are always listed in the order of their Core Index values, meaning that the location of the themes along the vertical axes can be different in different panes.

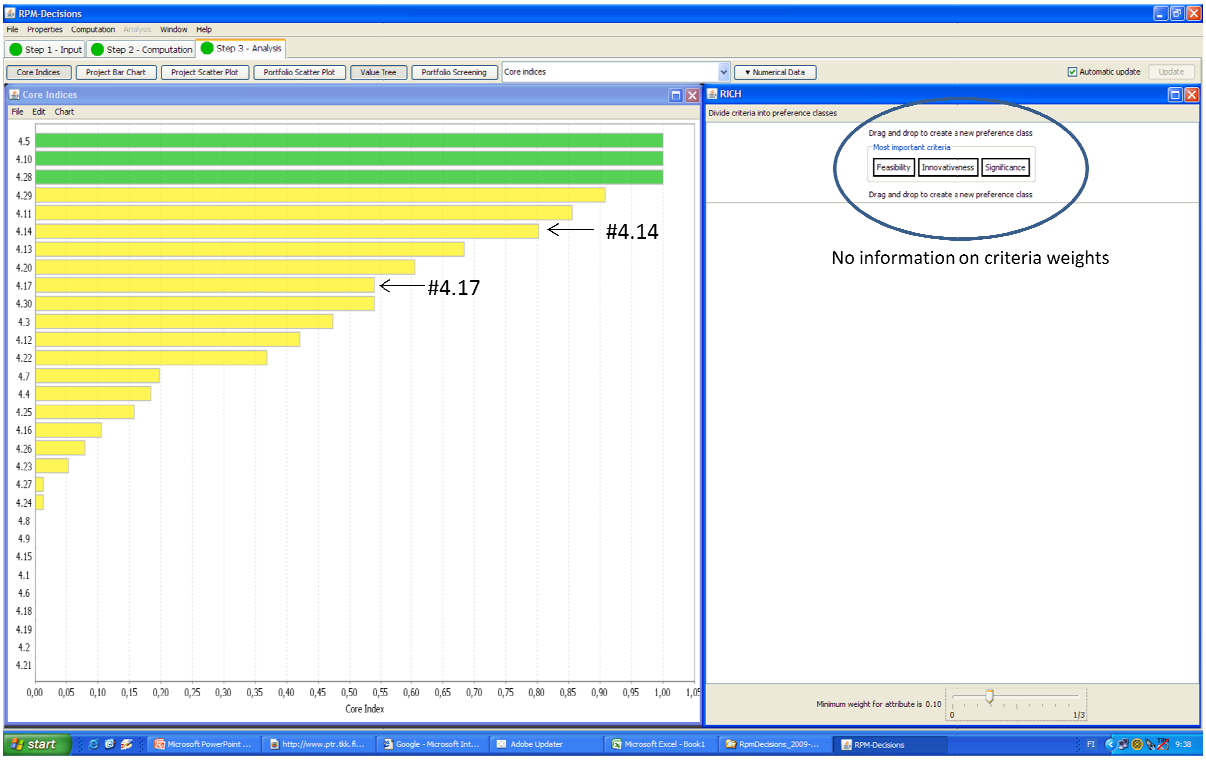


**Figure 1** Core Indices of the themes with no information about the criterion weights.

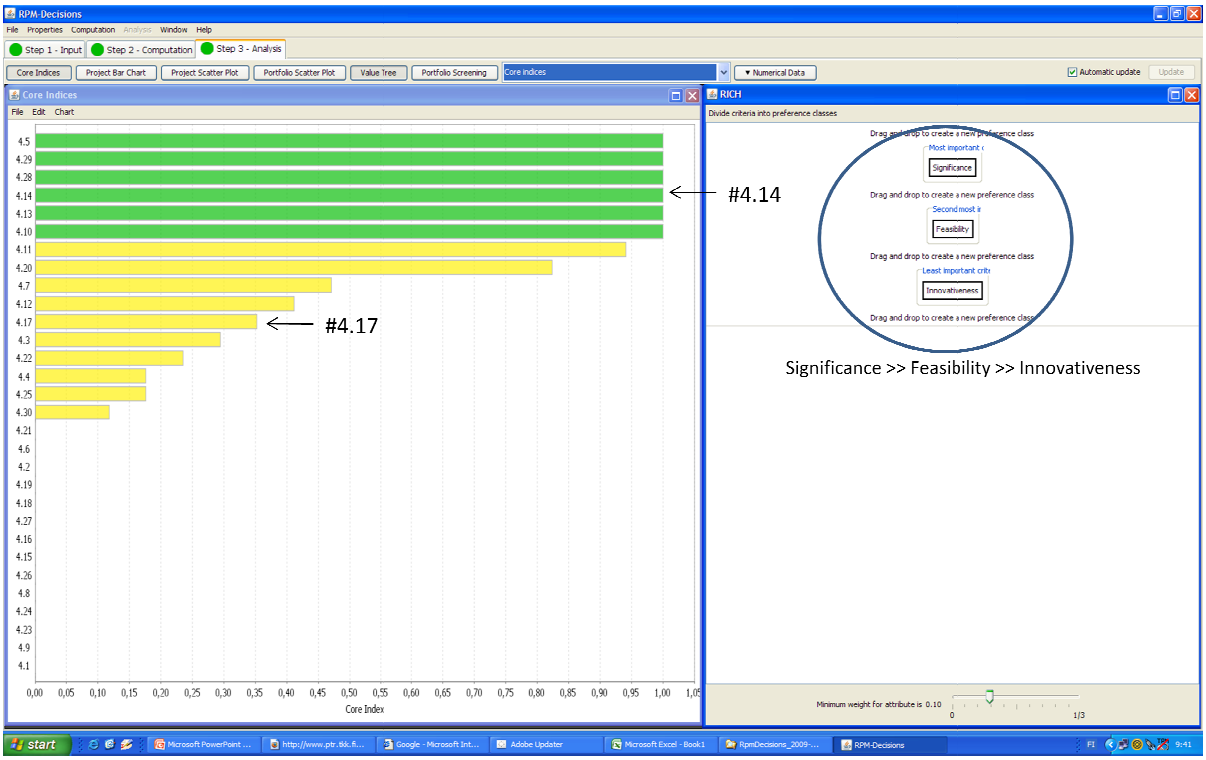


**Figure 2** Core Indices with the rank ordering *significance* >> *feasibility* >> *innovativeness*.

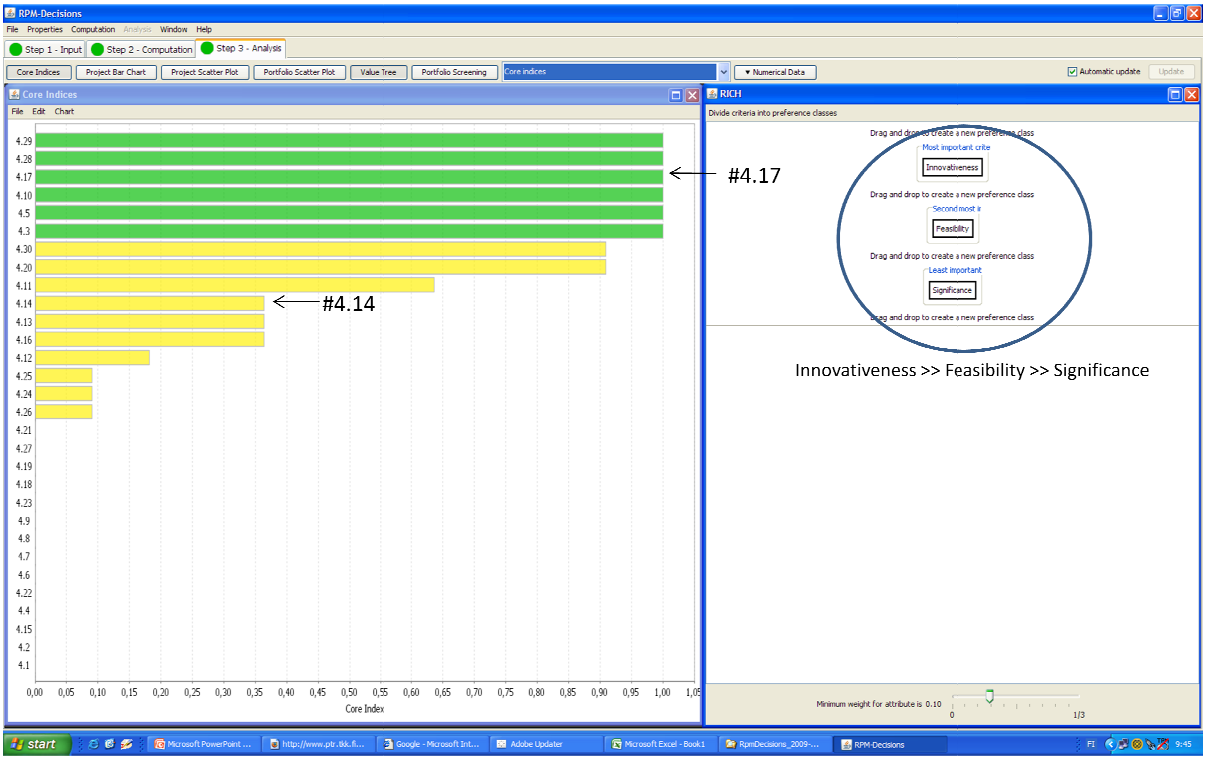


**Figure 3** Core Indices with the rank ordering *innovativeness* >> *feasibility* >> *significance*.

Figures 4-6 illustrate how the priorities based Core Index values are driven by the stated preferences and the content of the themes, For example, Themes #4.20 and #4.3 involve issues with radical technological

development while Themes #4.12 and #4.22 pertain to the usability of the packages and recycling. In Figure 4, no information about the relative importance on the weights is given. Subject to the preference statement that feasibility is the most important criterion (rank ordering; *feasibility* >> *significance, innovativeness*; see Figure 5) Themes #4.12 and #4.22 receive high priorities. This is logical, because these themes are not very innovative and they may be less relevant to the Finnish packaging industry than new technological innovations; yet they may be relatively easy to implement. On the other hand, if feasibility is regarded less important than the other criteria (rank ordering; *significance, innovativeness* >> *feasibility*; see figure 7), Themes #4.20 and #4.3 receive high priorities while Themes #4.12 and #4.22 low priorities with Core Index value of 0%. This is because the development of new technologies and their applications based on Themes #4.20 and #4.3 involves very high risks; but if these activities were to be successful, they would have major impact on the whole packaging industry. Note that in these illustrations the vertical location of the themes does not change due to changes in criteria weights, because the CI results are here shown by the lengths of the bars.

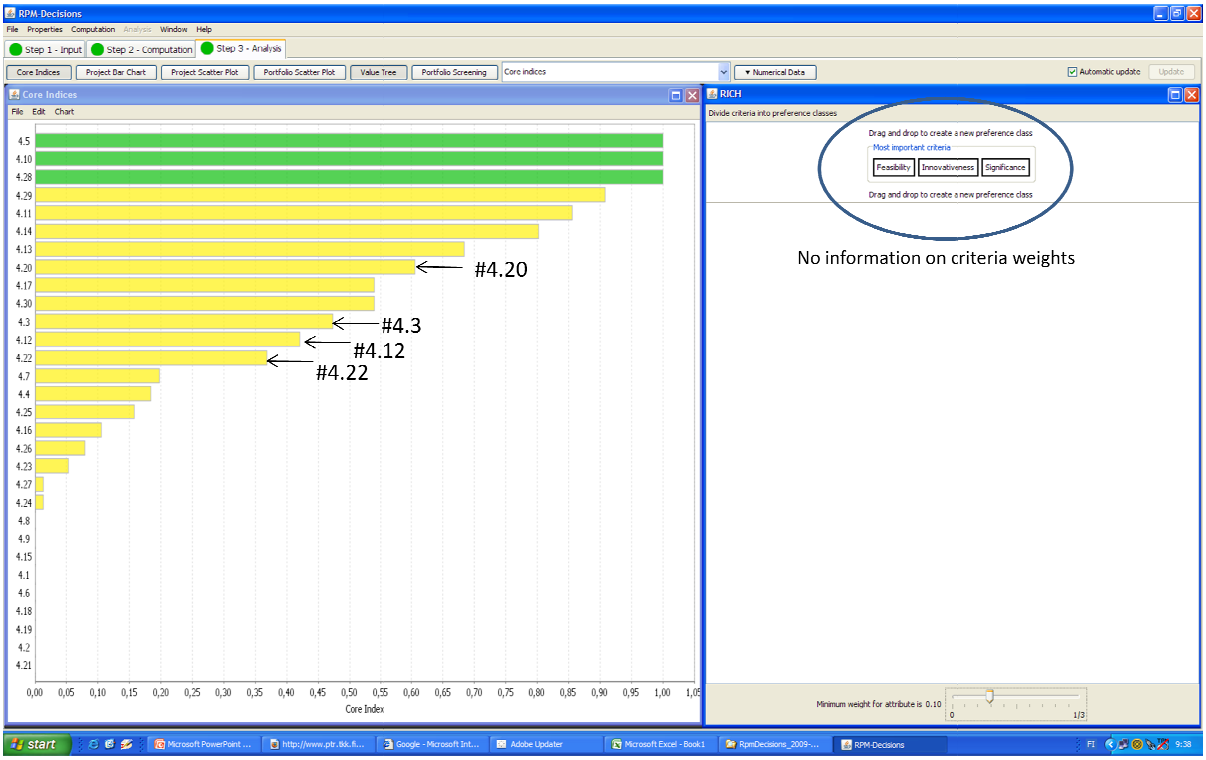


**Figure 4** Core indices of the themes in the absence of information about criterion weights.

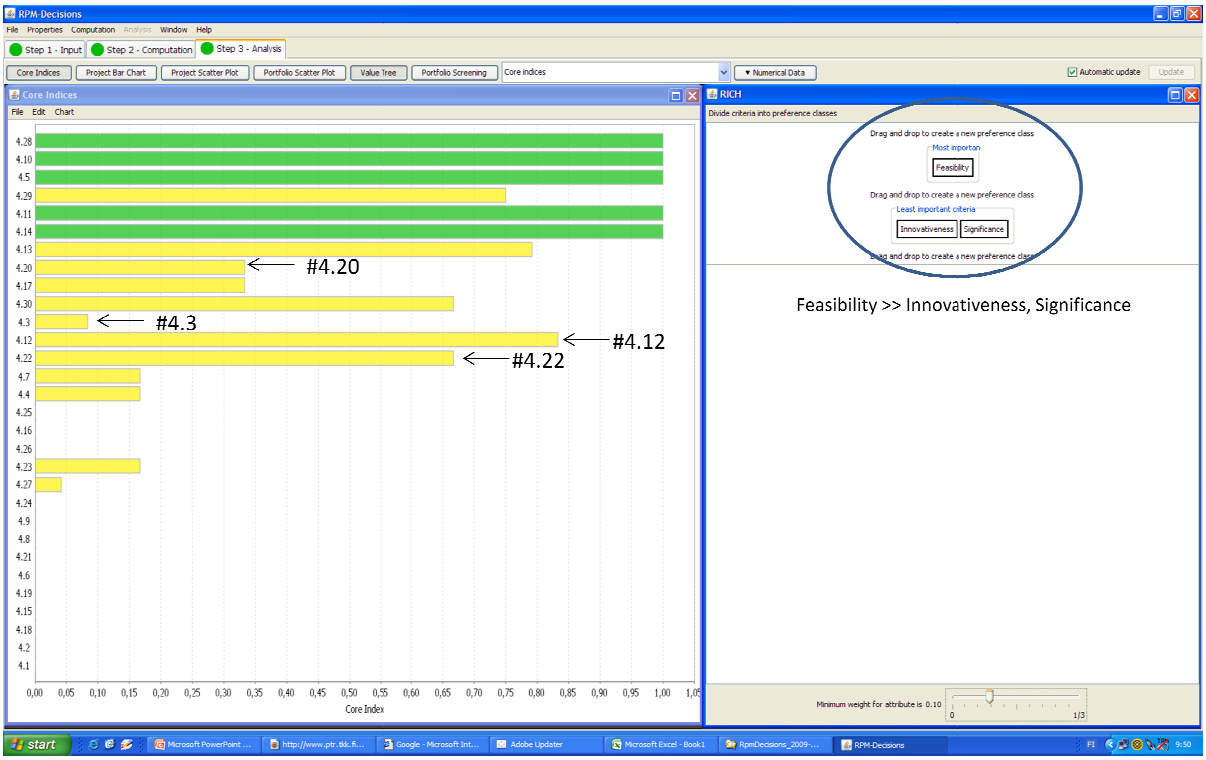


**Figure 5** Core indices with the rank ordering *feasibility >> innovativeness, significance*.

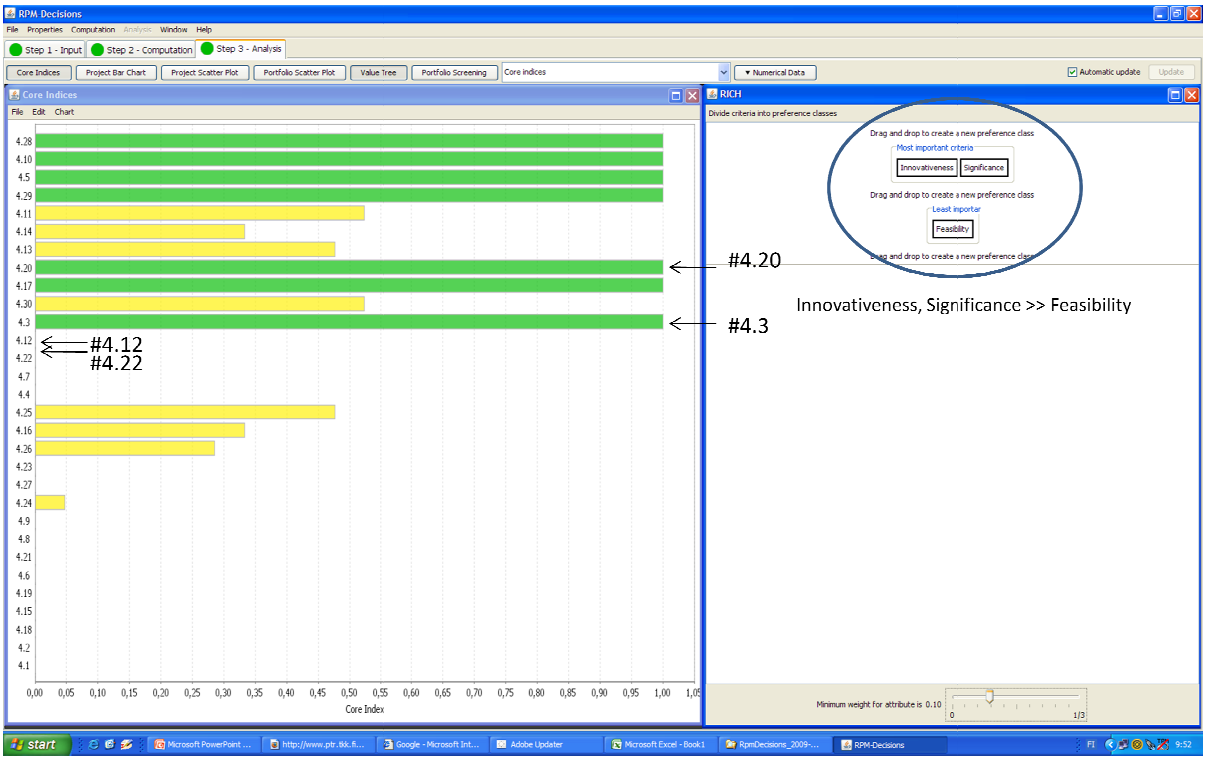


**Figure 6** Core indices with the rank ordering *innovativeness, significance >> feasibility*.

### 3.3 Workshops

Two workshops were organized after the Internet surveys and the analysis. In the first workshop, the PTR Board discussed the collected themes, their evaluations and analyses, and identified key themes that could be promoted through joint actions. In the second workshop, the PTR management team invited 15 leading researchers, R&D directors and other senior experts of packaging industry to discuss how the selected research themes could be best implemented. At this stage, the RPM-Explorer© tool helped identify which themes tended to receive most support in general and which themes had been deemed important with regard to a single criterion only. More specifically, after the initial consultation rounds, a smaller group of selected experts and managers developed recommendations to support the final decision making activities by the Board of the PTR which consisted of 12 directors from packaging industry and which was engaged in the exercise already after the Internet consultation.

*Workshop 1: PTR Board meeting*

The aim of the Board meeting was to identify research themes that would offer most potential for the enhancement of industrial competiveness and the development of prospective innovations. Before the meeting, results from the previous phases were given to the Board, including collected research themes, tables and histograms on criterion-specific key statistics of evaluations. On the project web-site, a link for starting the RPM-Explorer© was placed. Before the meeting and also afterwards, the Board members could interactively explore how the evaluators had seen the importance of the research themes with regard to the three criteria. The Board meeting took three hours and it consisted of three parts. First, the process was briefly explained. Then, the theme areas were discussed and the most interesting themes were noted. Finally, based on the multi-criteria analysis and the discussions, the Board formed aggregate priorities that should be promoted.

Technically, when the research themes were examined, the results for each theme area were projected onto a whiteboard with RPM-Explorer©. First, the research themes with highest Core Index values without any information on criterion weight were discussed. Second, the workshop facilitator (the first author of this paper) changed the relative rankings for criteria weights and the Board members could see what themes would be highly prioritized with different weight information. This allowed the Board to focus on issues that had been deemed interesting by some evaluators and to identify themes that were not necessarily the "best" in view of all three criteria but only in view of a single criterion. Apart from considering themes with a CI value, the Board members were encouraged to discuss and suggest any theme they personally saw important or interesting.

After a thorough discussion, the Board formulated the following six priority by merging some of the proposed research themes:

1. *Development of a comprehensive logistics*, which seeks new opportunities in the future delivery and transportation of goods, incorporating new retail loading systems, product security and the whole value chain.
2. *Environmental requirements* in relation to packaging materials, spanning natural packaging materials, diverse raw materials (e.g. cellulose, other fibres, starch) as well as recycling and reuse.
3. *Communicative packaging*, which covers topics in relation to design, brand forming, packaging construction, information adoption, consumer behaviour and culture.
4. *Solutions for small series,* which responds to the diversity of consumer cultures and groups by exploiting new flexible printing methods and small flexible production machines.
5. *Research in printable electronics,* which has already shown promise, although commercial break-throughs will need additional international networking to complement the value chain.
6. *Authenticity,* which is a growing demand in global business. It builds on advances in fast developing ICT- and biotechnologies that contribute to product security, safety and traceability.

*Workshop 2: Workshop for invited experts*

Fifteen experts from universities, research institutes, packaging industry and funding agencies were invited to the second workshop where they discussed the results from the preceding phases and made tentative plans for taking forward the six research themes that the Board had identified.

In this workshop, the process was explained where after the theme areas were shortly discussed. The RPM-Explorer© applet was shown on the whiteboard but, instead than identifying new aggregate priorities (which had been done by the Board), the discussion focused on an in-depth analysis of the selected themes. In particular, the participants discussed implementation challenges of all the six priorities. The consideration of each theme was facilitated through questions about how, when and where the research should it be carried out.

Key conclusions were noted from the discussions and along with the theme descriptions. These proactive conclusions towards further actions were one of the main results of the consultation process.

## 4 Discussions

In the above exercise, the characteristics of the changing innovation network and the requirements of the stakeholders placed requirements on the methodological design. For example, advances in ICT technologies, stricture environmental requirements and shifting consumer preferences implied that the PTR had to broaden its earlier research priorities to encompass new research areas. The exercise also had to support the Board's decision making activities, which meant that the foresight results were expected to contain actionable recommendations that would allow the Board to revisit and revise earlier priorities. Also, due to the fragmentation of the innovation network and the need to engage several new organizations in the process, most participants could devote only a limited amount of time and effort to the process. Thus, an excessively laborious foresight exercise would not have been appropriate.

During the process, several methodological choices were made to address these requirements:

- **Proximity to raw material:** In contrast to the earlier exercises conducted in PTR, the Board did not receive summary reports from workshops or surveys. Rather, it based its discussions on the research themes that were compiled directly from the Internet surveys. In comparison with processes where discussions are based on reports and ready-made recommendations–which may emphasize consensual and traditional themes over new and more risky ones (see Salmenkaita and Salo, 2004)–these themes proposed by the experts helped the facilitator to feed the discussion with themes that had connections to several S&T fields. The raw material supported the consideration of themes that were novel to the packaging industry, although it contained proposals for more traditional themes as well.
- **Systematic Internet-surveys; definition of units of analysis, taxonomy and tentative prioritization of research themes** (see also Brummer et al., 2008, 2009; Könnölä et al., 2007, 2009; Salo et al., 2008): Even though the Board meeting considered rather different viewpoints on S&T activities, it was not unfocused or chaotic, partly because all research themes had been formulated using the same procedure so that the themes were comparable. As the research themes included concrete suggestions for action, they could be used to derive actionable results. The pre-defined taxonomy for research themes comprising five sub-areas offered a useful framework for discussions. Also, because the themes were tentatively prioritized with regard to the several criteria, the focus could be laid on those themes that were important in view of different perspectives. These methodological choices, among others, seemed to contribute to efficiency. For example, stakeholders that could not participate in the workshop could submit their ideas through the Internet. In the Board meeting, their 'raw' inputs could still be used as to support discussions, even though only three hours were reserved for the meeting.
- **Use of decision support tools:** A novel feature in this exercise was that the results were communicated to the Board with the RPM-Explorer© decision support tool. Assisted by this tool, the Board could explore which themes performed well with regard to all criteria and which ones had high ratings on some criteria only. Also, by successively emphasizing innovativeness and feasibility over the other criteria, both new and more traditional suggestions could be brought onto the research agenda. The use of RPM-Explorer© thus allowed the facilitator feed the Board discussions with complementary themes. Because RPM-Explorer© was available on the Internet, all stakeholders could carry out their own analyses.
- **Combination of rigorous methodological support and free discussion:** Even though the process was supported by rigorous methodologies, the participants had ample time for free discussions. In the surveys, for instance, the participants could suggest any themes that they regarded important, and subsequently they could provide verbal comments as well. In the workshops, the RPM analyses served only as a starting point for discussions. Apart from the themes that were highlighted by RPM-Explorer©, the Board members were encouraged to discuss any themes they felt were interesting or important. Some discussions explicitly focused on why some themes had received low rankings. The workshop participants were also encouraged to propose new themes that had not been submitted earlier on.

Even though the methodology in the PTR process supported thematic R&D priority-setting, it did not provide explicit support for all considerations. For instance, while the notion of a "research theme" was useful for purpose deriving and communicating potential priorities to the Board, the multi-criteria evaluation did not provide formal support for the clustering of themes (i.e., combining themes with similarities either technologies or end-users), or for combining themes with different granularities arising from different levels of detail, albeit some discussions served to aggregate different themes (see also Durand, 2003; Wagner and Popper, 2003). Nor

did the participants analyze scenarios or mega-trends, and no formal support was provided for considering how feasible the themes would be in alternative futures (see Liesiö and Salo, 2008; see also Eriksson and Weber, 2008; Salmenkaita and Salo, 2004).

While this foresight process was designed for the thematic R&D priority setting for the Finnish packaging industry, it suggests lessons for other foresight exercises as well. First, the time and effort that the participants can devote to foresight is a central concern which, in our case, lead us to streamline the methodological choices so that no formal support was given for the bundling of themes or consideration of scenarios or megatrends, because these aspects could be meaningfully covered in workshop discussions. Second, the methodological choices seemed appropriate for this industry that faces pressures due to technological advances and societal values. Such changes are not specific to the packaging industry but, rather, they characterize more overarching trends in innovation management, which suggest that our methodological choices may be relevant in other innovation networks as well.

## 5 Conclusions

The variety of incentives, requirements and objectives of stakeholders and organizations places complementary requirements on methodological choices for supporting thematic R&D priority setting in innovation networks. In this setting, there is a need to adopt methodologies which facilitate creative discussions, foster the development of innovations, and expand the scope of prevailing agendas. In addition, these methodologies may need to support for the development of foresight results that serve the needs of decision making, account for the influence of existing priorities, and are compatible with the constraints of time and effort that the participants can dedicate to foresight.

In this paper, we have described methodologies which helped address these complementary requirements in the priority-setting process for packaging industries. For instance, we employed an interactive decision aiding tool RPM-Explorer© to communicate tentative results to the decision makers and other stakeholders. This tool contributed to several objectives: for instance, it promoted open-ended discussions on S&T opportunities and helped in the shaping of thematic R&D priorities. Moreover, the PTR Board was engaged in the foresight process from the very earliest phases, and the Board meeting was organized shortly after Internet surveys. Thus, the Board could build its discussions on a broad range of suggestions, which provided a informed basis for the development of multi-faceted yet well-focused priorities.

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