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Participatory development of a strategic product portfolio in a telecommunication company

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Abstract: The development of a product portfolio is a strategic decision which is often complicated by the large number of competing products, product interactions and high uncertainties about how successful the products will be in the marketplace. These decisions are commonly supported either by financially oriented approaches (*e.g.*, net present value) or more qualitative approaches (*e.g.*, scoring models) which, however, tend to suffer from shortcomings in capturing uncertainties and portfolio effects. Motivated by these, we report a real-life case study where a recently developed preference programming method – called *Robust Portfolio Modelling* (RPM) – was used to support the management group of a telecommunication company in the development of a strategic product portfolio in view of a 2–3 years time horizon. The positive experiences from this case study suggest that RPM may be useful even in other related settings where the presence of multiple objectives, uncertainties about product outcomes and possible variations in budgetary constraints must be accounted for.

Keywords: decision analysis; multi-criteria decision making; portfolio management; portfolio optimisation; preference programming.

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1 Introduction

In high-technology companies, product portfolio management involves strategic decisions about which markets will be entered and how competition will be fought by balancing the capabilities and opportunities that are available to the company. These decisions are dynamic, not least because different products are at different life-cycle stages and must therefore be supported through separate yet interlinked marketing strategies. They are also allocative decisions, since available resources do not usually allow the company to enter more than a subset of possible markets which pose their own specific challenges and objectives. In effect, the development of a product portfolio can be regarded as a multi-criteria problem where the company chooses a portfolio option that best fits its strategic goals (McGrath, 2000).

While strictly financially oriented methods (*e.g.*, Net Present Value, NPV) are widely employed in portfolio selection (Luenberger, 1998), empirical evidence suggests that these methods tend to yield poorer performance results than the application of multi-criteria methods (Cooper *et al.*, 1999). On the other hand, the many methods of multi-attribute value theory (Keeney and Raiffa, 1976; Belton and Stewart, 2001) are capable of accommodating incommensurate criteria; but these methods are typically concerned with the selection of a single alternative out of many, whereby project interactions and budget constraints need not be accounted for (Stummer and Heidenberger, 2003; Gustafsson and Salo, 2005). Furthermore, real-world cases are challenging in that the future prospects of products are often highly uncertain while Decision Makers (DM) may find it difficult to provide complete information about their preferences. These reasons, among others, have motivated the development of so-called preference programming methods that accommodate incomplete information about alternatives and preferences (see, *e.g.*, Salo and Hämäläinen, 1995; 2001).

Seen from the broader perspective, the straightforward application of Multi-Criteria Decision-Making (MCDM) methods may not lead to a decision *process* that is aligned with the demands of real-world organisations (Kasanen *et al.*, 2000). That is, although the decision maker and decision point can often be identified, the rest of the decision context may be dynamic in the sense that alternatives tend to 'evolve' during the analysis. The corresponding decision outcomes may therefore remain ambiguous, which may partly explain why the definition of relevant criteria and evaluation of alternatives is seldom done 'by the book'. To complicate matters, managers may have hidden agendas, vested interests, or conflicting long-term visions that may influence their decisions; they may also have a strong 'feeling' about some specific judgements, yet they may be unable to rationalise it. Methods for organisational decision support should recognise and accommodate such concerns, for instance, by offering opportunities where their implications are addressed through a constructive dialogue among the stakeholders.

In this paper, we report how a recently developed preference programming approach – called *Robust Portfolio Modelling* (RPM) (Liesiö *et al*., 2005) – was used to support the development of a product portfolio strategy in a telecommunications company. The case study was essentially a mid-level strategic decision (Campbell *et al*., 2003; Porter, 1987; 1996; Mintzberg, 1990) with a large number of options and varying degrees of uncertainty: specifically, the company had to decide which products it would develop and launch over a 2–3 years time horizon, with the aim of achieving its strategic objectives. Towards this end, it was necessary to structure the decision process in a transparent manner, and to carry out the analysis effectively within the time and resource constraints that were placed on the decision support process itself. Particular emphasis was laid on the communication of results, to ensure the necessary commitment to the decision among the stakeholders (Rios *et al*., 2005).

Drawing upon experiences from this case study, we argue that the RPM approach offers potential benefits to product portfolio management because it lends structure to a complex decision problem, contributes to enhanced communication among the stakeholders and provides a clear justification for the decision recommendation. Although based on the appraisal of individual products, this approach explicitly accounts for the arrival of new information and transforms it into portfolio-oriented visual presentations that can be readily understood by persons who are not quantitatively oriented. Apart from the consideration of incomplete information about products or the DMs' preferences, the approach makes it possible to carry out extensive sensitivity analyses with regard to varying resource levels, among others.

The paper is structured as follows. Section 2 discusses previous research on strategic product portfolio decisions and decision support. Section 3 describes how the RPM approach was used in a telecommunications company. Section 4 concludes the paper with a discussion on the merits and limitations of this approach.

2 Concerns in product portfolio selection

As an activity, *product portfolio selection* determines which products must be included in the company's product portfolio. Typically, a more general term *project* portfolio selection is employed in settings where 'go/no-go' decisions must be made about discrete investment opportunities, resulting in the project portfolio. The term *portfolio management*, in turn, emphasises that the maintenance and revision of the portfolio is essentially a continuous activity. The portfolio is dynamically adjusted in response to the arrival of new information, emergence of new project opportunities, completion of earlier projects, or even changes in available resources.

Traditional financial methods for project portfolio selection include Net Present Value (NPV) and Internal Rate of Return (IRR) (see, *e.g.*, Luenberger, 1998). These methods assign performance measures to individual projects based on their expected cash flows. Although relatively simple to use and understand, they have been criticised for inadequate treatment of risk and project interdependencies; in effect, projects are treated individually, wherefore the overarching objective of selecting the best portfolio may be missed (Gustafsson and Salo, 2005).

Apart from traditional financial methods, firms also employ scoring models that – perhaps surprisingly – seem to outperform financial methods in terms of the resulting portfolio value (Cooper *et al*., 1999). In scoring models, project proposals are typically evaluated against several criteria (and not only with regard to a single criterion, as is done in NPV and IRR), whereafter the resulting scores are used to obtain an overall priority ranking for the projects (see, *e.g.*, Henriksen and Traynor, 1999; Kleinmuntz and Kleinmuntz, 1999). Yet, the application of scoring models involves both practical and conceptual difficulties. For instance, when criterion-specific project scores are aggregated in order to compare the overall 'goodness' of projects, do the trade-offs between criteria reflect the DM's preferences? And is the DM really able or willing to provide precise estimates about future cash flows? Furthermore, scoring models are not necessarily employed for selecting *the* best portfolio but, rather, for motivating the selection of *some* projects that seem attractive; these two cases are not generally the same.

The limitations of traditional financial models have motivated the development of a wide range of portfolio optimisation models. There is, in effect, an extensive literature on optimisation models that capture relevant concerns in portfolio management (*e.g.*, correlated project outcomes, multiple time-periods, risk aversion, opportunities due to follow-up projects) and rely on computational approaches such as dynamic programming or linear integer programming in the determination of the recommended portfolio (for a brief survey, see Gustafsson and Salo, 2005). But although these models do capture multiple concerns, they have not won popularity in practice (Cooper *et al*., 1999). One reason for this is that they make high demands on data that is often incomplete or of poor quality, if not downright inaccessible. Also, the very complexity of these methods is a weakness as managers may find them difficult to use and understand.

In view of the above, a major challenge in *supporting* the development of a project portfolio is to find an adequate balance between complexity, transparency, and data requirements. Indeed, because complex optimisation models tend to require large amounts of data (not to mention that DMs cannot readily understand them without a strong mathematical training), the trade-off is obvious. Arguably, a transparent model that is easy to understand may increase the DM's confidence in the analysis so that s/he is more willing to use the results. In particular, because the acquisition of high-quality data is both costly and time-consuming, models that offer tentative results based on the available incomplete data are more attractive than models that require complete data before they offer any results.

A further trade-off has to be made between the analysis of (i) individual projects and (ii) entire project portfolios. That is, the comparison of portfolios emphasises project interdependencies and recognises that projects with a low value *and* low cost may be optimal if they fit the portfolio well. Yet, when analysing the composition of such portfolios the DM is ultimately requested to compare sets of binary vectors that correspond to different portfolios, which may be a difficult cognitive task. Therefore, the

DM is probably more comfortable conducting the analysis at the level of individual projects, since each project opportunity calls for a concrete 'go/no-go' decision. As a result, performance measures for individual projects that account for portfolio level aspects of the decision, such as scarce resources, may be useful in decision support.

3 Case study

3.1 Background and context

The case study was carried out at a local Finnish telecommunications company that had enjoyed a relatively stable business environment for about 80 years. Due to recent changes in markets and technology, however, it was forced to reconsider its business focus: for example, the deregulation of the Finnish telecommunications market had led to sharpened competition among traditional telecommunications companies (Björkroth and Willner, 2002), while technological advances (especially Internet Protocol (IP) and Voice over IP (VoIP) technologies) had brought new competitors.

Before the case study, the company had reconsidered its vision, mission and long-term strategies. The achievement of these revised strategic objectives called for changes in its product portfolio, whereby the company was effectively faced with the problem of choosing which products would contribute to the achievement of its long-term strategic objectives. Towards this end, preliminary studies were carried out to identify possible products and customer segments for further analysis.

Even though the 'products' could be clearly stated (*i.e.*, sell or do not sell technology *X* in customer segment *Y*), the technologies and customer segments entailed varying degrees of uncertainties which were driven by the maturity of the product, pace of technological change, developments in market prices, changes in competitive situation, among others. A thorough Return-on-Investment (ROI) analysis would therefore have been impossible. Furthermore, the large number of products (52) implied additional challenges, because the presence of product interactions made it practically impossible to produce a thorough analysis on each and every product in view of relevant criteria.

Thus, the company needed a method that could help cast the problem into an easy-to-understand format while addressing the relevant uncertainties and the stakeholders' preferences for competing objectives.

3.2 Participants

In the company, seven people were included in the team, which participated in the development of the new product portfolio. The CEO was represented in this team, as well as the sales people and technical experts who were responsible for the product lines. These participants acted as representatives for their particular areas of responsibility, whereby it was recognised that they might be inclined to provide biased statements in support of hidden agendas (*e.g.*, pet products). After the decision workshop, the results and their rationale were communicated to other stakeholders in the company.

The authors – including the CEO of the company – formed the team of analysts that structured the decision problem, designed the decision support process and adapted the RPM methodology to this context. Before the workshop, this team met four times over a period of some one and a half months. In each meeting, it spent about two hours on the above topics.

3.3 Process design

The process design started with an initial outline of the decision problem, as presented by the CEO. At this stage, several methodological requirements were noted. Specifically, the method was expected to help in decision structuring and to provide readily understandable results without necessitating more than a few hours of intensive group work. In addition, the method had to accommodate incomplete information because reliable point estimates about the products' future performance with regard to different criteria could not be obtained. A variety of sensitivity analyses were also needed in order to explore the impacts of perturbations in the underlying parameters.

The following were considered in the formulation of the product portfolio selection problem:

- Technology-customer matrix

  The products were structured as a matrix with four customer segments (columns) and 13 technologies (rows). Each product corresponded to the intersection defined as a combination of technology and customer segment, meaning that the matrix contained 4*13 = 52 products.

- Multi-criteria value of products

  The value of each product (*i.e.*, cell in the technology-customer-matrix) was to be assessed with regard to three criteria, *i.e.*, net profits, market risk and technical risk. The technical risk was judged to be identical for all products based on the same technology.

- Limited resources

  A key consideration in the project selection problem was that the provision of each product called for a certain number of staff, but the total staff limit was not a strict constraint because the company had the option of hiring additional experts. It was therefore of interest to examine which products should be started, subject to varying assumptions about the total level of staffing.

- Product synergies

  The products were not independent, because launching two products based on the same technology would have called for less staff than launching them separately in the absence of such technological synergies, for instance. However, because such synergies would have been difficult if not impossible to quantify in formal terms, it was decided that they should be acknowledged through *ex post* judgmental adjustments to the results obtained without the explicit consideration of such synergies. The model was also expected to provide guidance on the choice of products and to associate an indicative performance measure for each product.

- Incomplete information about product outcomes

  The model had to accommodate the participants' subjective evaluations, as well as incomplete information caused by the difficulties of predicting the future profitability of different products.

In response to the above requirements, the RPM methodology (Liesiö *et al*., 2005) was adopted as the analytical framework. The choice of RPM was motivated by its ability to support multi-criteria portfolio selection problems in the presence of incomplete information about both the relative importance of criteria and criterion-specific performance levels of products. In effect, RPM provided a systematic framework where each product could be assessed with regard to several criteria, subject to the constraints imposed by the limited availability of resources.

In the RPM model, the m products were evaluated against n criteria, which resulted in a total of $m \times n$ *scores*. The overall value of a product was defined as the weighted sum of its criterion-specific scores whereby *weights* reflected the relative importance of criteria. A 'go/no-go' decision for all products thus corresponded to a possible product *portfolio* whose overall value could be computed as the value sum of its constituent products. A portfolio was *feasible* if the resource consumption of products did not exceed the budget (staff limit); clearly, only feasible portfolios were of interest. If complete information on scores, weights and resource consumptions had been available, the task of selecting the 'best' portfolio would have lead to a conventional capital budget problem, in which the feasible portfolio with the greatest overall value would have been presented as the recommended product strategy.

However, because precise weight and score estimates were not available, it was necessary to admit incompletely defined scores and weight information. This could be achieved in the RPM approach by characterising scores as intervals while weights could be stated through incomplete ordinal preference statements (*e.g.*, 'the profit criterion is more important than the market risk criterion'). These incompletely specified weight and score parameters resulted in several *non-dominated* portfolios whose overall value was not exceeded by any other portfolio for all combinations of feasible weight and score parameters. The attention was restricted to such non-dominated portfolios: for otherwise, it would have been possible to identify another non-dominated portfolio for which the overall value would have been equal to or higher than that of the portfolio under consideration.

Following the RPM concepts, the set of these non-dominated portfolios was analysed by associating a *core index* for each product. Specifically, this index was defined as the share of those non-dominated portfolios in which a given product was contained. That is, products with a core index of 100% were included in all non-dominated portfolios and were therefore included in the set of recommended products. On the other hand, products with a core index of 0% were not included in the set of recommended products because they were not contained in any non-dominated portfolios. Finally, an intermediate core index, say 50%, meant that the product was contained in half of the non-dominated portfolios. From another perspective, if a product with a core index of 100% *had not been chosen* or if a product with a core index of 0% *had been chosen* for the product strategy, the result would have been either a dominated or infeasible portfolio.

3.4 Methodological outline of Robust Portfolio Modelling (RPM)

In formal terms, the product portfolio selection problem can be formalised as follows in the RPM framework. Let $X = \{x^1,...,x^m\}$ denote *m* products that are evaluated against *n* criteria. The score of the *j*-th product with regard to the *i*-th criterion is v_i^j. These scores form a matrix $v \in R_+^{m\times n}$, where the *j*-th row contains the scores of the *j*-th product. The relative importance of the *i*-th criterion is captured by its weight w_i. Following the usual convention in multi-criteria decision analysis, these weights are positive and add up to one; thus, the weight vector $w = [w_1,...,w_n]$ belongs to the set

$$S_w^0 = \left\{ w \mid w_i \geq 0, \sum_{i=1}^{n} w_i = 1 \right\}.$$

The overall value of a product x^j is

$$V(x^j, w, v) = \sum_{i=1}^{n} w_i v_i^j .$$

The decision objective is to select a product portfolio – *i.e.*, a subset of all products $p \subseteq X$ – such that the portfolio value is maximised. The overall value of a product portfolio is obtained by summing the values of those products that are contained in the portfolio, *i.e.*,

$$V(p, w, v) = \sum_{x^j \in p} V(x^j, w, v).$$

A portfolio is feasible if its staff requirement does not exceed the given staff limit *B*. Formally, this means that feasible portfolios belong to the set

$$P_F = \{p \subseteq X \mid \sum_{x^j \in p} c^j \leq B\},$$

where c^j is the resource requirement of the *j*-th product.

The 'true' weight vector is included in the feasible weight region $S_w \subseteq S_w^0$. Scores are given as intervals that include the 'true' score resulting in the set of feasible scores

$$S_v = \left\{ v \mid \underline{v}_i^j \leq v_i^j \leq \overline{v}_i^j \right\} \subset \mathbf{R}_+^{m\times n}.$$

Portfolio *p* dominates portfolio p' (denoted $p \succ p'$) if and only if

$V(p, w, v) \geq V(p', w, v)$ for all $w \in S_w, v \in S_v$ and
$V(p, w, v) > V(p', w, v)$ for some $w \in S_w, v \in S_v$.

The set of non-dominated portfolios

$$P_N = \{p \in P_F \mid \nexists p' \in P_F \ s.t.\ p' \succ p\}$$

can be computed by a multi-criteria optimisation algorithm based on dynamic programming (Liesiö *et al.*, 2005). The core indexes of products are calculated from P_N by using the equation

$$CI(x^j) = |\{p \in P_N \mid x^j \in p\}| \,/\, |P_N|,$$

where $|.|$ denotes the number of portfolios in the respective set.

3.5 Process implementation

3.5.1 Preparation phase

The decision support process consisted of three phases, *i.e.*, preparatory analysis, decision workshop and final evaluation. Before the RPM analysis, the company had already identified a set of products that were aligned with its long-term vision and mission. During the process design, the team of analysts structured these products into a customer-technology matrix, developed the evaluation criteria and identified the staff requirement as the overriding scarce resource.

In the preparatory analysis, the criterion-specific scores for every product were obtained from each of the seven workshop participants through a questionnaire survey which was sent to them two weeks before the workshop. This questionnaire was similar to the customer-technology matrix (see Table 1) where each product (or cell) was evaluated with regard to three criteria. For reasons of confidentiality, the technologies are here labelled as *1–13* while the customer segments are denoted by *A–D*. The staff requirements were estimated before the decision workshop by the CEO. In the first customer segment, however, there were only two viable products: thus, the total number of relevant products was 3 × 13 + 2 = 41, rather than 4 × 13 = 52.

The following evaluation scales were employed in the questionnaire:

- *Net profit* was defined as the combined net profit which the product would offer in the given market segment (average profit per customer × number of customers). The 8-step scale was given verbally and ranged from large losses to large profits.
- *Market risk* was defined as the risk of failing to sell the product according to plans or, briefly put, the risk of losing market share to competitors. A scale of 0 (unlikely to be able to beat competitors) to 10 (no competition at all) was used.
- *Technology risk* was defined as the risk that this particular product (regardless of market segment) would fail due to technological problems (*e.g.*, malfunctions, delivery problems or production cost problems of new technologies). This was judged on a scale from 0 (severe risk of miscalculations) to 10 (no risk).
- *Staff requirement* referred to the number of person-years that would be needed to support the product in the given market segment.

Table 1 The product evaluation questionnaire of one respondent. Each product was evaluated against three criteria and the staff requirements were calculated beforehand.

		Customer Segment A			*Customer Segment B*			*Customer Segment C*			*Customer Segment D*		
	Technology risk	*Net profit*	*Market risk*	*Staff requirements*	*Net profit*	*Market risk*	*Staff requirements*	*Net profit*	*Market risk*	*Staff requirements*	*Net profit*	*Market risk*	*Staff requirements*
1	10	6	10	0.1	6	9	0.2	7	8	0.3	6	3	0.2
2	9	N/A	N/A	N/A	5	8	0.1	5	6	0.5	4	1	0.3
3	8	4	3	0.05	4	5	0.1	4	4	0.1	4	0	0.1
4	9	N/A	N/A	N/A	5	5	0.1	5	4	0.3	5	0	0.5
5	6	N/A	N/A	N/A	4	5	0.1	5	2	0.2	5	0	0.1
6	8	N/A	N/A	N/A	2	6	0.1	4	4	0.5	4	0	0.2
7	6	N/A	N/A	N/A	6	5	0.3	6	3	0.5	5	0	0.2
8	2	N/A	N/A	N/A	3	7	0.1	5	5	0.4	4	2	0.2
9	3	N/A	N/A	N/A	3	7	0.1	5	5	0.5	4	1	0.5
10	6	N/A	N/A	N/A	6	7	0.3	6	4	0.5	5	1	0.1
11	6	N/A	N/A	N/A	3	6	0.1	4	5	0.4	6	0	0.2
12	8	N/A	N/A	N/A	4	6	0.2	6	5	0.5	6	0	0.5
13	8	N/A	N/A	N/A	6	4	1.0	5	3	0.5	3	1	0.1

For each cell of the technology-market segment matrix, the seven respondents gave their independent judgmental estimates about net profit, market risk and technology risk. In order to keep the elicitation effort minimal, no interval judgements were acquired from individual respondents.

Information on the relative importance of criteria were elicited in the preparatory meetings from the CEO. Relative importance was captured through criterion weights, *i.e.*, Criterion 1 is more important than Criterion 2, if a change in Criterion 1 from its worst level to the best is preferred to a change in the second criterion from its worst level to the best (see, *e.g.*, Keeney and Raiffa, 1976). Specifically, the CEO stated that "Profits is the most important criterion" and "Market risk is more important than Technology risk". Furthermore, he noted that each criterion should have a strictly positive weight, which was implemented by imposing a lower bound of one-third of the average weight ($1/3 \times 1/3 = 1/9 \approx 0.11$) on each criterion. Since there was no information on how much more important a criterion was compared to another, this preference information did not imply a single weight vector, but a set of feasible weights

$$S_w = \left\{ w \in S_w^0 \mid w_1 \geq w_2 \geq w_3 \geq 1/9 \right\}$$

that were consistent with the given preference statements.

The workshop participants provided their judgements one week before the workshop. In what follows, $e_i^j(k)$ denotes the evaluation of the *j*-th product with regard to the *i*-th criterion, as given by the *k*-th participant. Using these evaluations and the above characterisation of weights, the following computations were carried out before the workshop:

- Non-dominated portfolios were computed using the individual evaluations of the seven participants with staff limits 5, 7 and 10, which resulted in a total of 7*3 = 21 sets of computations. Formally, for the *k*-th participant, the scores were obtained by:

  $$\underline{v}_i^j = \overline{v}_i^j = \alpha_i \cdot e_i^j(k),$$

  where the scaling factor of the *i*-th criterion α_i was used to map the corresponding evaluation scale to scores between 0 and 1. Such a mapping was needed to ensure the correct interpretation of criterion weights (Keeney and Raiffa, 1976).

- Non-dominated portfolios were also computed by using the average evaluations of all participants with staff limits 5, 7 and 10. In principle, one could have used wide enough score intervals to cover all the individual evaluations. However, it turned out such intervals would have covered almost the whole scale for many products. Thus, we instead formed a confidence interval for the average of evaluations, formally:

  $$\underline{v}_i^j = \alpha_i \left[\frac{1}{7} \sum_{k=1}^{7} e_i^j(k) - dSTD\left[e_i^j(\cdot) \right] \right]$$

  and

  $$\overline{v}_i^j = \alpha_i \left[\frac{1}{7} \sum_{k=1}^{7} e_i^j(k) + dSTD\left[e_i^j(\cdot) \right] \right],$$

where *STD* is the standard deviation over all respondents. The parameter *d* was set to 0.3, which approximates the 50% confidence interval for the expected value assuming the individual evaluations are from the same normal distribution.

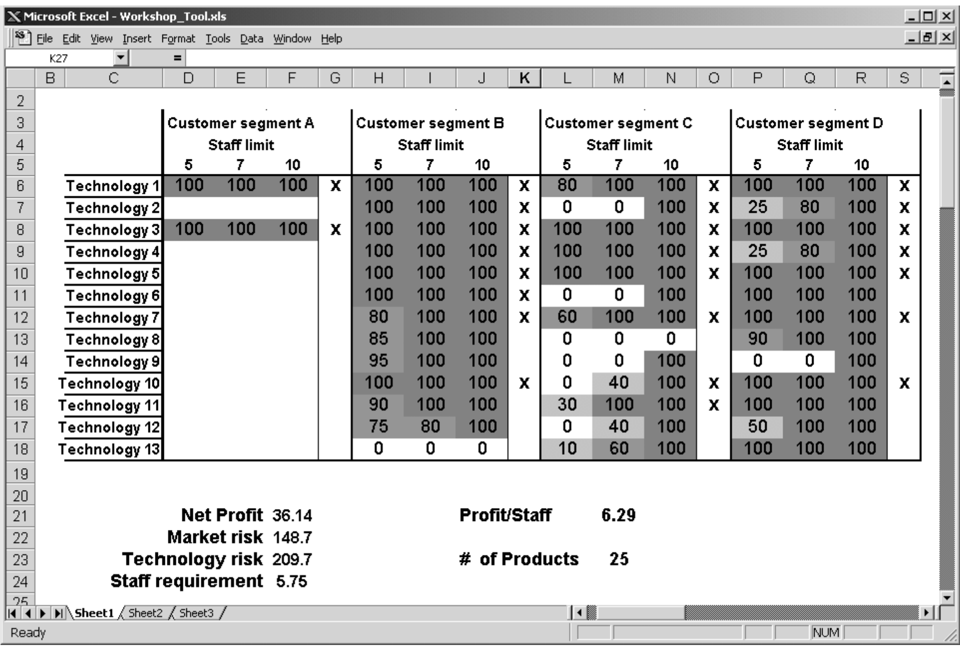
Thus, a total of 24 computations were carried out. Each took some 3–60 seconds on a personal computer (Intel Pentium 3, 933 Mhz) and resulted in 1–30 non-dominated portfolios. Core indexes for the different products were stored for later presentation at the decision workshop.

3.5.2 Decision workshop

The decision workshop started with a general discussion about the overall strategy and goals of the company, to ensure that the participants would share a similar mindset. Each participant was then given the result sheet based on his individual evaluations (see Table 2), whereafter results based on the average evaluations were shown with a video projector to the entire group (see Figure 1). Apart from focusing on these results, the participants discussed considerations that were not explicitly captured by the decision model, such as synergies between different products.

To help participants address such characteristics, a dedicated spreadsheet tool was developed to highlight the 'go/no-go' decision for each cell in the technology-market segment matrix (*i.e.*, should the product be included in the portfolio or not; see Figure 1). The tool then calculated the total staff need for the selected portfolio as well as the criterion-specific performance levels.

Figure 1 Spreadsheet-tool used in the workshop. The chosen products are marked with 'X'. Criterion specific performances and staff requirements of the resulting portfolio are shown at the bottom.



	Customer segment A Staff limit 5	7	10		Customer segment B Staff limit 5	7	10		Customer segment C Staff limit 5	7	10		Customer segment D Staff limit 5	7	10	
Technology 1	100	100	100	X	100	100	100	X	80	100	100	X	100	100	100	X
Technology 2					100	100	100	X	0	0	100	X	25	80	100	X
Technology 3	100	100	100	X	100	100	100	X	100	100	100	X	100	100	100	X
Technology 4					100	100	100	X	100	100	100	X	25	80	100	X
Technology 5					100	100	100	X	100	100	100	X	100	100	100	X
Technology 6					100	100	100	X	0	0	100		100	100	100	
Technology 7					80	100	100	X	60	100	100	X	100	100	100	X
Technology 8					85	100	100		0	0	0		90	100	100	
Technology 9					95	100	100		0	0	100		0	0	100	
Technology 10					100	100	100	X	0	40	100	X	100	100	100	X
Technology 11					90	100	100		30	100	100	X	100	100	100	
Technology 12					75	80	100		0	40	100		50	100	100	
Technology 13					0	0	0		10	60	100		100	100	100	

Net Profit	36.14	Profit/Staff	6.29
Market risk	148.7		
Technology risk	209.7	# of Products	25
Staff requirement	5.75		

Table 2 Result sheet in which the core indexes resulting from the individual evaluations of one of the participants are presented with regard to different staff limits.

	Customer Segment A			*Customer Segment B*			*Customer Segment C*			*Customer Segment D*		
	Staff limit			*Staff limit*			*Staff limit*			*Staff limit*		
	5	*7*	*10*	*5*	*7*	*10*	*5*	*7*	*10*	*5*	*7*	*10*
Technology 1	100	100	100	100	100	100	100	100	100	100	100	100
Technology 2				100	100	100	0	100	100	0	33	50
Technology 3	100	100	100	100	100	100	100	100	100	100	100	100
Technology 4				100	100	100	100	100	100	0	0	100
Technology 5				100	100	100	100	100	100	100	100	100
Technology 6				33	58	75	0	0	25	41	75	100
Technology 7				100	100	100	16	100	100	100	100	100
Technology 8				66	100	100	33	83	100	41	75	100
Technology 9				91	100	100	0	25	100	0	0	0
Technology 10				100	100	100	83	100	100	100	100	100
Technology 11				75	100	100	0	16	75	100	100	100
Technology 12				100	100	100	100	100	100	0	41	100
Technology 13				0	0	75	0	8	100	33	66	75

3.6 Results

Results based on the average data are presented in Figure 1 whose visual format gives an overview and assigns the products into three groups. In this figure, dark grey indicates products whose core index is 100% and which should therefore be selected in the product portfolio. White colour indicates products whose core index is 0%, meaning that they should be excluded from further consideration. Further analyses should thus focus on products with an intermediate colour, as indicated by varying shades of light grey. These products need to be examined further, either by obtaining more information or by evaluating them on the basis of judgements that are not necessarily included in the structure of the decision model. In this way, the visual presentation shows where further efforts on information elicitation are needed.

As described above, sensitivity analysis with regard to the staff limit was carried out by producing results based on three different levels of staffing. Specifically, the default assumption was that seven persons would be available to support the product portfolio. Additional analyses were produced for the scenario where only five persons would be available (whereby some products would have to be dropped in comparison with the base scenario), or where the number of staff would grow to ten persons (which would make it possible to add some products to the base scenario).

From the viewpoint of portfolio management, some interesting conclusions could be drawn from Figure 1. A comparison of the customer segments showed that segments A and B were on the whole attractive, while Segment C was more problematic. Indeed, due to interdependencies pointed out by the participants, the attractiveness of Segment C was found questionable. Furthermore, Technologies 1, 3 and 5 seemed 'winners' across all customer segments while Technologies 8 and 9 did not score all that well. This gave highly valuable insights to the company because these two latter technologies were so-called 'hype' technologies that had been previously regarded as self-evident candidates for the product strategy.

Two weeks after the workshop a final evaluation of the results was held with the aim of validating the results. In between, the results were also presented to and assimilated by other key people at the company. They were also adopted as key inputs in other strategic planning processes in the company.

3.7 Discussion

Based on experiences from this case study, one may ask to what extent the RPM analysis responded to the requirements at this company. To begin with, the RPM model made it possible to evaluate products with regard to several criteria, which was a basic requirement that would not have been fulfilled by other purely financial models. Future uncertainties and other sources of incomplete information were also acknowledged in the decision support process; and the RPM model allowed the company to complete the decision process in the allotted amount of time, helped in focusing the data-collecting effort and fostered the development of a decision that the stakeholders could commit to. Overall, a satisfactory balance was apparently achieved between the size of the decision model, on one hand, and its usability and usefulness, on the other hand. It is of interest to note that the RPM results differed from a priori assumptions in some areas, most notably in relation to the acceptance of 'hype' technologies. This notwithstanding, the participants nevertheless felt comfortable with the analysis.

More generally, it appears that the RPM may be useful in drawing attention to the salient features of the problem while recognising that not all the relevant information can be acquired and quantified. For example, although the life cycle considerations were not covered through explicit modelling in this case study, the participants could accommodate them through judgmental adjustments when interpreting the results of the spreadsheet tool in Figure 1. Such interpretative tasks are crucial in that they allow the participants to address issues that are not captured by the model. These tasks may also increase the participants' acceptance of and commitment to the results because the decision model still remains sufficiently transparent.

In product portfolio management, it is vital to retain the focus on portfolios and not on single products only. In this regard, the RPM seems suitable for the analysis of portfolios that contain up to a hundred products or so; but if the number of products runs into several hundreds, the collection of judgmental inputs is likely to call for a considerable amount of time and effort. Nor is the simple matrix structure of this case study any longer an effective visualisation tool. Conversely, if there are only a few products, one may also consider performing more detailed analyses on these products, for instance, by relying on value tree analysis or other MCDM methods.

The size of the organisation and the number of participants are also key design factors in the development of the RPM process. In our case, the collection of input data was carried out by sending an identical questionnaire to the participants before the workshop; but if this is carried out in a large organisation, it may be necessary to solicit judgements on different fields of expertise from separate respondents to ensure that respondents with a lesser degree of expertise do not decrease the quality of responses obtained from the more experienced ones. Caution may also be called for in the mapping of judgmental responses onto score intervals because the derivation of scores from averages may tilt results in favour of product lines with most respondents, since products from other competing product lines may be evaluated from a more pessimistic point of view. Another concern is that wide score intervals make it difficult to identify products that should be clearly included or excluded from the portfolio. Similar difficulties in offering decision recommendations also occur when the number of criteria is large and only incomplete information on their importance is available.

4 Conclusion

In this paper, we have described a case study on participatory decision modelling where the management group of a telecommunications company made use of the RPM model in the development of its strategic product portfolio in view of a 2–3 year time horizon. In this case study, special emphasis was placed on aligning the decision support process with organisational demands: specifically, the process had to be transparent and implementable within a tight time limit and even interactive because it was required to provide easy-to-understand results that would enhance the participants' commitment to the decision. Here, much of the value of RPM modelling was derived from the problem-structuring phase where the development of product strategy was formulated as an optimisation problem. Several additional considerations – most notably multiple evaluation criteria, incomplete preferences and uncertainties about the future performance of products – were also addressed.

In the RPM analysis, some considerations were deliberately left beyond the scope of formal modelling efforts (*e.g.*, product interdependencies, life cycle analyses), in the understanding that these considerations would be addressed at length at the decision workshop through informal discussions. More generally, the positive experiences from this approach suggest that in portfolio modelling, it may be pertinent to focus the modelling efforts on those salient aspects of the problem that can be modelled in a transparent manner: that is, it may be better to introduce judgmental adjustments to a transparent model than to build a more complex and ambiguous model based on suspect assumptions and estimation procedures.

Encouraged by experiences from this case study, we contend that RPM can be useful in other related decision settings where the presence of multiple objectives, incomplete information about possible outcomes and budgetary limits need to be accounted for. This is the case, for instance, in companies and public organisations which must develop their technology strategies in view of future opportunities, based on the solicitation and synthesis of judgmental evaluations about how alternative technologies are likely to respond to these opportunities.

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