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Evaluating non-core technologies: Contrasting external and internal views on corporate research results

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ABSTRACT

Nowadays, many research organizations extract information from research findings that are, as such, not feasible or valuable for their own use. It is crucial for any organization conducting extensive research activities to have effective and efficient methods so that they receive maximum economic benefit from research outcomes. Two separate mail surveys were implemented to find appropriate measures for evaluating research outcomes from both internal and external perspectives. The results of this exploratory study show a wide gap between the internal and external respondents, when considering meaningful and appropriate measures for judging the commercial potential of non-core technologies. Based on the identified gaps between internal and external views, the study suggests several propositions to guide further theoretical work. Further research is needed to validate the observed differences between the internal and external perspectives on utilising non-core technologies. Moreover, the underlying reasons for these differences would provide a fruitful opportunity for future research.

1. Introduction

One of the most vital tasks for a research organization is carrying out on-going exploration of new ideas and technologies. This exploration inevitably produces – by its nature – many findings, which are, as such, not feasible for further development within that organization. Tao, Daniele, Hummel, Goldheim, and Slowinski (2005) argue that even sophisticated companies utilise less than 30% of their patents and the rest sit on the shelf. In addition, important and vital innovations are neglected and remain un-commercialized as a research surplus in many companies, threatening their long-term survival and existence (Christensen, 1997; Lehrer, Nell & Gärber, 2009).

Extracting value from research surplus is challenging, since non-core activities compete with core activities for scarce resources, and often, technology licensing meets intra-company resistance (Goldheim, Slowinski, Daniele, Hummel & Tao, 2005; Galbraith, DeNoble, Ehrlich & Kline, 2007). However, continuous competitive pressure has compelled many research organizations to find new ways to gain more revenue and to create new businesses from research surpluses (Blau & Harris, 1992; Chesbrough, 2004; Chesbrough, Vanhaverbeke & West, 2006). Instead of acting as 'shelf-warmers' that collect dust on the shelves of the R&D unit, they could be exploited and commercialized by other organizations if the proper instruments existed (Grimpe, 2006). Technologies that do not fit in the parent company's core businesses could be licensed out, sold, brought to the market via spin-off or start up or even donated (Chesbrough, 2003b; Narayanan, Yang & Zahra, 2009). The utilisation of research surplus is important in managing the commercialization of research findings and results, especially from the open innovation point of view.

Three drivers may exist behind this development. Firstly, a firm may attempt to cover sunk costs incurred by the development phase that did not lead, for any reason, to further actions. Sometimes, sunk costs may rise to a remarkable level (Keil, 1995). Selling a technology that does not fit into the firm's current strategy, business model or product/research portfolio may produce income

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that, at least partly, covers developmental costs. Secondly, although sunk costs presumably also exist, the main driver is the creation of a new revenue source (Kuczmarski, 2000). Alongside the firm's core business, many firms are striving for other revenue sources that could generate a significant source of income. Unlike the previous driver, in this case, the firm typically does not totally detach itself, but sells the licence to another company to perhaps generate a small, but constant flow of income. Instead of licensing, another possible strategy could be some kind of revenue sharing (van der Heijden, Potters & Sefton, 2009). Moreover, it may be possible to create another revenue stream alongside the initial royalty payments, for instance, by offering consultancy to companies that have already licensed innovations (Chesbrough, 2003a). Thirdly, a firm may use external interest to gain internally legitimised status for new ideas or innovations. In some cases, innovations may encounter internal inertia and to displace this inertia, external power is used to also induce internal interest. Hence, the third driver is tightly involved with strategic issues.

Identification of commercially appealing ideas is seldom straightforward. Although the parts of a business idea construct the basis for the evaluation of commercial potential of an incomplete non-core technology, i.e., the research surplus (see e.g., Normann, 1977), a more comprehensive approach is needed. Furthermore, the evaluation process needs to be carefully designed in order to find the appropriate personnel to implement it at each stage (Galbraith et al., 2007). This leads us to the question: how is the commercialization potential of non-core technologies evaluated? Two different parties are involved with the evaluation and commercialization of non-core technologies: the one that discovers the technology (internal perspective) and the one that can make use of the technology (external perspective). Therefore, in corporate research, we are also interested in this question: what differences exist between internal and external perspectives when evaluating commercial potential? These research questions are tackled with an exploratory survey of two groups: the internal and external agents of a company.

2. Evaluation as a part of commercialization

The evaluation of new technology and research surplus must support the commercialization process. There are many options open for the realisation of revenue from non-core technologies, such as licensing fees, direct sell-offs or founding a new business around an idea (Parhankangas, Holmlund & Kuusisto, 2003). They all have unique features that affect their risk and return expectation rates. The evaluation and its outcome will affect which of the options are worth considering. For example, if after the evaluation, the management decides that the technology in question will not be developed further internally, the decision will then exclude options of ‘internal development in existing businesses’ and ‘internal development in corporate venturing unit’. On the other hand, different commercialization options may have some specific features, questions or demands that the evaluation must be able to answer. An example is the option to form a spin-off. The spin-off provides strategic freedom, but concurrently requires attention and commitment of resources much more than some other options do. Thus, to tap the fullest potential, the evaluation process must be flexible and usable to all the requirements of the commercialization process.

After the research phase, the outcome of a project needs to be defined as a core or a non-core technology by the parent company or its strategic business units (SBU), according to their technology strategies (see Fig. 1). The outcome must be assessed from the viewpoints of the corporate and business units' technology strategies and then it must be decided whether or not the outcome fits the strategy (Loch & Staffan Tapper, 2002). There are two kinds of outcomes that fall into the ‘not commercialized by the parent company’ category: intentional and not intentional (Grimpe, 2006). Intentional outcomes can be called ‘shelf-warmers’, for they were intended for discovery, but were not commercialized. Unintentional outcomes can be called ‘gadgets’; they refer to unintended findings that have no chance for commercialization. However, this kind of separation into shelf-warmers and gadgets may not be reasonable, since this separation depends upon the current understanding of the potential users — and that current understanding might be short-sighted or even totally incorrect.

The evaluation process itself is an iterative process. It would be of great help to the post-evaluation if the non-core technologies were already properly evaluated during the research process. The outcome must be stored to the portfolio of non-core technologies, which is here called the Research Surplus Portfolio (RSP). The RSP is a tool for managing non-core technologies. It is an electronic inventory of the research surplus and a tool for assessment of future technical and commercial options of non-core technologies. The ultimate purpose of the RSP is to identify appropriate ways to bring a non-core technology to market, and furthermore, to facilitate new business creation and opportunity-seeking.

Storing the outcome to the RSP is the first stage in evaluating the outcome from the perspective that it could be further developed and commercialized by an outsider or in co-operation with outsiders. This outcome storage forms a basis to which

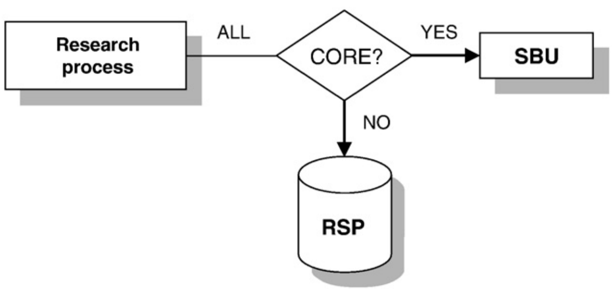

Fig. 1. Non-core technologies are stored to research surplus portfolio.

future evaluations can further contribute. This storing phase is the first evaluation of the outcome's commercial potential from the point of view that it could be exploited, even though it is not directly useful to the parent company. After the storing phase, the parent company and/or outsiders would occasionally evaluate the technology. In this way, the commercial potential of the technology will become more accurate as it gets increasing valuations.

The storing phase is rather straightforward. When a project's outcome (i.e., a technology) is defined as a non-core technology, it must be stored to the RSP. This is the responsibility of the project leader, who has the best general knowledge about the project, and thus s/he enters the basic information from the project and evaluates the measures that s/he can. If there is some technological detail that the project leader cannot provide, then s/he names the experts and researchers that have better knowledge concerning the issue. The experts and researchers are requested to fill in the missing information in a given period.

When all basic information about the technology is stored, a commercial valuation must be done. This can be done by the project personnel, the research centre's managers or outside appraisers. The more valuations, the better general view and evaluation are achieved. Finally, when all information is stored and the necessary measures evaluated, the technology is then available for the general users of the RSP.

In a case where the project is already evaluated during its implementation, this storing process easily becomes rather resource-demanding. However, it is important that all possible exploitation and commercialization opportunities are taken into account during the commercialization process so that all comments, guesses and valuations are stored to the RSP for all the viewers to see. This way, many perspectives given by many estimators from different organizations and positions can be compared. After the storing phase, the technology should be evaluated from time to time because the commercial potential of 'shelf-warmers' may change as the business environment changes.

Fig. 2 presents a possible evaluation process for shelf-warmers. The process not only analyzes technologies, but also seeks to find the best commercialization process. It begins when the research project has come to its end and its results are stored to the RSP. Technologies within the RSP must be evaluated and sorted by proper criteria. The agent who evaluates and sorts the technologies can either be from inside or outside the parent company. Naturally, if one is an outsider, one has to have access to the RSP. Metrics will help in evaluation, but other procedures can also be helpful to aid in technology evaluation (e.g., by using metadata or user-created tags).

Although, in Fig. 2, the evaluation process is represented as a linear process that moves systematically, the creation of new businesses is a highly dynamic process in research organizations (Kirschbaum, 2005). There is no specific order to determine what will be the most appropriate way to the market, but different alternatives rather 'compete' with each other. The evaluation process and metrics aid in deciding on the best exploitation options.

For commercialization decisions, the value to the customer needs to be defined. Benefits and sacrifices are the two basic components of that value (Woodall, 2003). Benefits can be separated into two categories: attributes and outcomes. The attributes include goods and service quality, features of the core product and added service and customization. In addition, technology

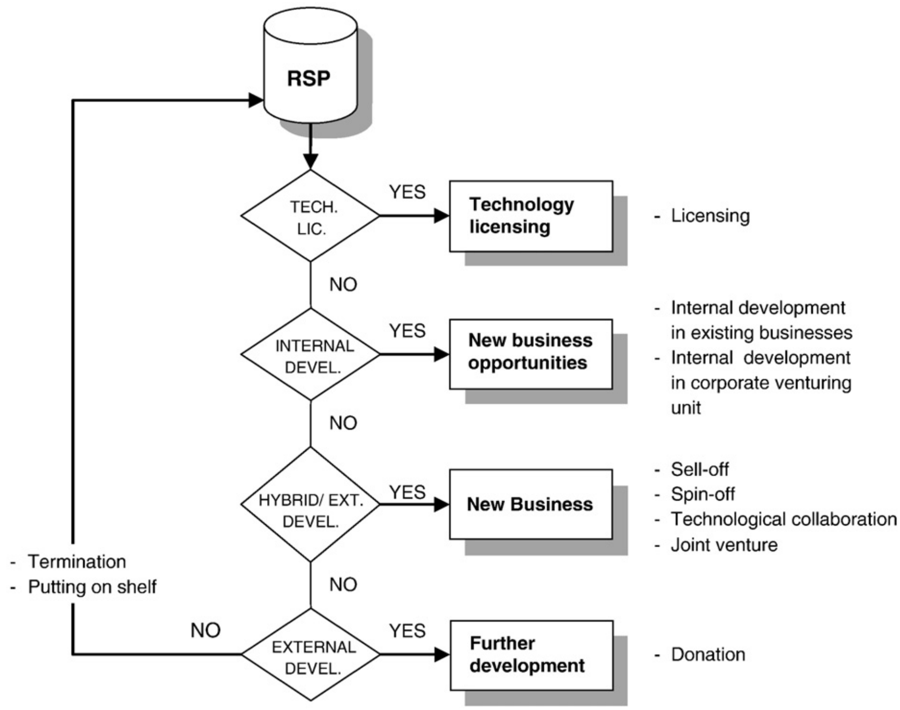

Fig. 2. Evaluation process of shelf-warmers in the RSP context (Parhankangas, Holmlund & Kuusisto, 2003:19–20).

should either create a new product/service offering or should support existing ones. Similarly, the outcomes can be decomposed to five types of benefits: strategic, personal, social, practical and financial.

Sacrifices can be categorized either as monetary or non-monetary costs. Monetary costs (e.g., price and costs of search, acquisition, opportunity, distribution, learning, use, maintenance and disposal) are self-explanatory, whilst non-monetary costs reflect time, effort and potential worries (relationship and psychological costs) associated with a customer's commitment to a particular offering (Woodall, 2003). Some examples of factors influencing the above costs are the maturity of the technology and the need for new investments. Moreover, risk and uncertainty are relentlessly imminent. These unfold themselves in commitment to a particular deal, decisions for commercialization (e.g., licensing, spin-off, joint venture, etc.) and possibilities for further development.

The size of the market and its growth rate pave the way for the assessment of overall commercial potential of a technology. In addition, the competitive position within the market defines how alluring the market might be. Benefits and sacrifices indicate how a potential customer may see value, whereas the market size indicates how many potential customers a firm may attract with its offering, thus creating the overall commercialization potential.

3. Method and data

Based on the aforementioned evaluation process, we posed the question: do internal and external views on the issues regarding the research surplus (RSP) differ? To answer this question, we implemented two separate mail surveys in order to find appropriate measures for evaluation from both internal and external perspectives. This separation was inevitable, since two different parties are involved with the commercialization of non-core technologies: the one that discovers the technology and the one that can exploit the technology. Differing views and opinions exist between these parties about what should be measured and evaluated from a technology in order to discover its commercial potential.

The questionnaire used in both surveys included 98 separate measures, which were based on literature review. The idea in developing the questionnaire was that by forming a comprehensive list of potential measures based on literature review, to rank the usefulness of each measure in evaluating a research project. Each measure was based on existing literature and the list was pre-tested and revised by academic researchers and firm participants. Length of measure varied between one word (e.g.

Table 1
Descriptive statistics of respondents from the internal perspective.

Age of respondent	Years
Min	27,0
Lower quartile	29,3
Median	35,5
Upper quartile	43,3
Max	65,0
Average	37,3
Working experience	**Years**
Min	2,5
Lower quartile	5,4
Median	9,8
Upper quartile	15,4
Max	30,0
Average	11,0
Current position	**Percentage**
Manager	29%
Team or project leader	26%
Researcher or expert	45%
Total	100%
Educational level	
Master's	50%
Doctoral	50%
Total	100%
Educational background	
Technical	87%
Arts and culture	3%
Applied maths	3%
Maths and soc. sciences	3%
Behavioral sciences	6%
Total	100%
$n=38$	

Table 2
Descriptive statistics for the 'top 20' measures from the internal perspective.

Descriptive statistics: top 20						
Rank	Measure	*N*	Min	Max	Mean	Std. dev.
1	Getting things done	36	3	5	4,64	0,543
2	Innovativeness	38	2	5	4,42	0,683
3	Customer needs	35	1	5	4,34	0,765
4	Potential for further technical development	38	3	5	4,29	0,565
5	Communication within the research project	35	1	5	4,29	0,957
6	Personnel's commitment to achieve set goals	37	2	5	4,27	0,804
7	Customer expectations	35	1	5	4,26	0,886
8	Technical feasibility	35	2	5	4,20	0,797
9	Teamwork building	36	2	5	4,17	0,737
10	The project personnel's technical expertise	36	1	5	4,08	0,906
11	Usability	37	1	5	4,08	0,829
12	Reliability	35	2	5	4,06	0,765
13	Innovation culture in a project	37	2	5	4,05	0,941
14	Value to the customer	37	1	5	4,05	0,970
15	Working atmosphere in the project	38	2	5	4,05	0,957
16	Project personnel's leadership abilities	38	2	5	4,03	0,753
17	Quality of documentation to development	37	3	5	4,00	0,624
18	Schedule planning and control	35	3	5	3,97	0,618
19	Actual product quality perform. vs. predicted	34	1	5	3,97	0,969
20	Management support to the project	37	2	5	3,92	0,924

"usability" or "innovativeness") to one sentence (e.g. "the pace of moving down the learning curve within this project's solution"). About half of the measures had a clarifying text in order to ensure that respondents could reach a similar understanding of the measure (e.g. technological yield = actual realized performance divided by technological potential). Moreover, 40 additional questions were utilised to clarify what types of questions should be used in the evaluation process and who are the persons most suitable to act as evaluators. The respondents were asked to assess the importance of each measure using a five-point Likert-scale. In addition, there were three more possibilities (do not know; do not understand the question; irrelevant question for research project) to enable crosschecking and validation of responses and their formulation.

The first survey was targeted at three separate research centres, whose responses were utilised to represent the internal perspective of the commercialization process. This survey was sent to 138 persons selected individually by researchers and contact persons in the research centres. Participation to research projects and long enough working experience were key selection criteria. Table 1 shows descriptive statistics of respondents ($n = 38$, response rate 28%). Respondents had fairly high educational level, half of them having PhD, as well as average working experience were 11 years. Further, majority of respondents had technical educational background.

The second survey was targeted at consultants to assess the commercial potential of new technologies and business ideas in order to gain an external perspective. We sent the survey to five potential respondents and received three answers. All three were males, having a Master's level education in technology or business and they were working business managers. Two of them were in their early 40's with 15 year working experience and third one was 29 years old with 4 years working experience. Using the opinions of these respondents, we were able to compare two perspectives, internal and external.

4. Results and discussion

In this chapter, the results of both surveys are presented and the findings are contrasted to clarify the possible differences in the emphasis of the respondents. The results of the first survey carried out in research centres are considered to cover the internal

Table 3
Descriptive statistics for the 'bottom 10' measures from the internal perspective.

Descriptive statistics: bottom 10						
Rank	Measure	*N*	Min	Max	Mean	Std. dev.
89	Easiness of copying the product	35	1	5	3,09	1,011
90	Number of patents publ. by project personnel	37	1	5	3,05	1,177
91	Unit cost of the product	30	1	5	3,00	1,174
92	Sales forecast	35	1	5	2,94	0,998
93	Internal rate of return (IRR)	13	1	5	2,92	1,115
94	Predictability of the project	35	1	5	2,89	0,900
95	Complexity of distribution	32	1	4	2,88	0,976
96	Net present value	22	1	5	2,82	1,259
97	Number of redesigns in the research project	30	1	4	2,73	1,048
98	Product size	29	1	5	2,45	1,242

view of evaluating non-core technologies. The findings of the internal survey are presented in Table 2, which depicts the top 20 measures based on the averages. Table 3 presents the bottom 10 measures. To ensure the statistical validity of summarizing the three different centres together, we conducted the Kruskal–Wallis' test. The results confirmed that there were no statistically significant differences between the centres (p-level less than 0.01).

The internal view is completed by the analysis of the external view that was inspected with another survey. The results of the second survey ($n=5$, three responses) were considered indicative due to the low number of respondents. However, we can draw some interesting observations based on the top 20 measures presented in Table 4. In addition, the comparison of the ranking of the measures of the internal and the external respondents has been included in Table 3.

Overall, the internal perspective is mainly focused on technologies, projects and their management, whereas the external perspective emphasises commercialization and usefulness of technologies. This leads us to the differences in parameters that were used to evaluate the potential of each technology. In addition, the customer value or customer need was not emphasised in the internal perspective. Our premise was that the external and internal views should converge in recognising the importance of the readiness of the technology in order to gain commercially successful technologies. However, we find that the internal and the external views are not converging at all but rather the views complement each other.

Financial issues are mostly absent in the internal top 20 list. Comparing the internal bottom 10 and the external top 20, it may be noted that issues concerning costs and revenue creation are present on both lists. For instance, the unit cost of the product is eighth lowest (rank 91) in the internal perspective, whereas it is externally ranked sixteenth on the top 20. In addition, several other financial measures (e.g., EVA and ROI) were explicated in the external perspective, but none of those exist in the internal top 20.

In addition to financial issues, external perspective emphasises customer perspective. Several measures (e.g., value to customer (rank 1), usability (2), technical feasibility (7), customer needs (10) and customer expectations 11)) are focused on evaluating this perspective. Moreover, market share (18) and market dynamics (20) complement the aforementioned measures. From the internal perspective, the customer needs to have a wide range in the evaluation (from 1 to 5) although its average was third highest (4, 34). Similarly, customer expectations, as a measure, received a high average and rank (4, 26 and 8, respectively), but also a wide range. Internal perspective places a fairly strong emphasis on having a comfortable working atmosphere (rank 15) and a good communication within the research project (rank 3). We interpret that respondents believe that an attractive working environment results in better outcomes.

When comparing the differences of the ranking results of internal and external respondents in Table 4, the internal respondents ranked higher innovativeness, customer needs and customer expectations. All these, however, were part of the external respondents top 20 list. Most notably, only 9 out of 20 were shared in the top 20 of both internal and external respondents' rankings. Therefore, the overlap between the two parties was rather disappointing, though natural, concentrating on different aspects of technology development and commercialisation. The internal and external parties agreed on the importance of the commitment to set goals and technical feasibility, which both ranked among the top 10 in the respective listings.

Further, if we look at the five highest differences between the internal and external rankings in Table 4, we see economic value added, unit cost of the product and sales to break-even, number of dedicated personnel and level of prototype maturity. These were ranked high in the views of the external respondents, while remaining very low in the internal respondents' views.

Table 4
'Top 20' measures from the external perspective.

External rank	Measure	Internal rank	Diff.
1	Value to the customer	14	13
2	Usability	11	9
3	Number of dedicated personnel	58	55
4	Time to market	36	32
5	Economic value added	84	79
6	Innovation culture in a project	13	7
7	Technical feasibility	8	1
8	Commitment to achieve set goals	6	−2
9	Innovativeness	2	−7
10	Customer needs	3	−7
11	Customer expectations	7	−4
12	Project personnel's leadership abilities	16	4
13	Level of prototype maturity	65	52
14	Competitive analysis	53	39
15	Return on investment	50	35
16	Unit cost of the product	91	75
17	Sales to break-even	85	68
18	Market share	57	39
19	Financial capital sufficiency	23	4
20	Market dynamics	71	51

5. Conclusions

The study examines the question of perceptions of internal and external research organizations' evaluators assessing the commercialisation potential of non-core technologies. Specifically, the study concentrates on what differences exist between the internal and external perspectives when evaluating commercial potential. The results were depicted as thematic contrasts between the internal and the external perspectives on research surplus. This created a valid thematic research setting and produced illuminating results but, indeed, lacks statistical significance as a whole. Hence, we presented the results of both surveys as exploratory. A similar study could be carried out by any organization aspiring to increase the level of utilisation of its research findings. Therefore, even though the research was exploratory in nature, it provides a guide for practical and further research efforts in studying possible barriers to the exploitation of research surplus in an open innovation fashion.

The core of the results is the wide gap between the internal and external respondents when considering meaningful and appropriate measures for judging the commercial potential of non-core technologies. This may be one of the reasons why large corporations and universities' shelves are used for storing new technological innovations, rather than exploiting the created potential. The created technologies are judged against varying internally oriented criteria and therefore, development work is mainly directed towards targets that are not valued on the actual commercialization side of the utilization process. Based on the exploratory results presented previously we may propose in a general level that

a) including external views on measuring the potential of research outcome increases the likelihood of its successful commercialisation
b) when the evaluation systems for non-core technologies have a step-wise process (Fig. 3), it increases the likelihood of success in commercialization
c) identifying internal and external views on the commercial potential of research surplus early on in the development work is crucial in solving possible differences in internal and external views.

In addition to these general propositions, to guide future theoretical work, we may derive from our results propositions that are more detailed. We establish these propositions on the largest differences between internal and external evaluations of metrics.

1. Considering economic value added as a part of the project work increases the likelihood of commercialisation of the research outcome.
2. Considering the unit cost of the product as a part of the project work leads to a mutual understanding between internal and external parties on the commercial potential of the research outcome.
3. Considering sales to break-even as a part of the project work directs project team's focus on considering also customer side and leads to increasing likelihood of commercialisation of the research outcomes.
4. Higher number of dedicated personnel increases likelihood of commercialisation and its successfulness.
5. The higher the maturity of the research outcome, the higher the likelihood of commercialisation.

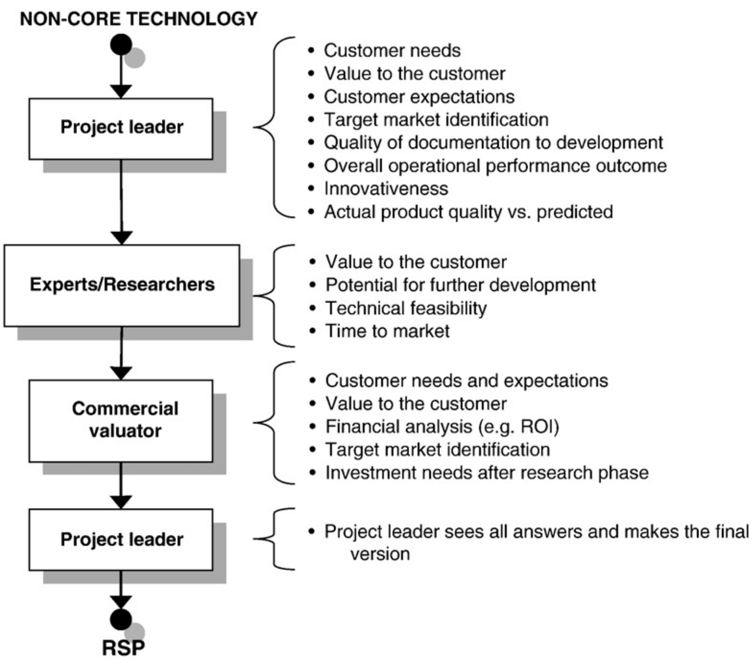

Fig. 3. Proposition for the first phase of the evaluation process.

Derived from discrepancies between external and internal views, we may suggest the following propositions directly from the results of this study.

6. When research project's workers have satisfying working conditions, the higher innovativeness measured by research outcomes will emerge.
7. Measurement systems capable to measure both hardware and software solutions (products) will lead to higher performance of research team.
8. Using the measures focusing on communication, mutual understanding and shared vision within the research team will decrease the likelihood of conflicts affecting negatively to the performance of research team.

Based on the findings concerning measures for the RSP, we propose the following phasing for evaluating non-core technologies, considering both the measures and the evaluators (Fig. 3). In order to gain a comprehensive evaluation of non-core technologies, we propose that both internal and external perspectives be combined in a research organization's evaluations. The proposed phasing of evaluation was created to constitute a comprehensive set of measures needed to evaluate the overall commercial potential of non-core technologies before they are included in the research surplus portfolio.

As a practical implication, our proposed framework is an addition to any research organization's toolbox for analysing, evaluating and managing their project portfolios. In detail, the above-proposed framework includes measures combining the necessary measures from both external and internal views. In addition, external evaluators are added to the process of considering the RSP. Since internal evaluators have limited view on the end customers or the final use environment, the process should also include external experts, such as representatives from facilitator companies or consultants acting as mediators between producers and end customers. As was shown above, internal evaluators are inclined to consider potential in different terms than the external parties utilising non-core technologies.

This study should be considered as exploratory in nature. Therefore, further research is needed to statistically validate the possible differences between internal and external perspectives on utilising non-core technologies. In addition, the underlying reasons for these differences would provide a fruitful opportunity for future research. Moreover, practical assessment and utilisation of non-core technologies and their assessment methods needs to be further developed to facilitate the linking of external and internal views. Finally, considering the uncertainty affecting the success of a technology project, portfolio management of non-core technologies could help in increasing the average success rate of development projects.

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