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Managing strategic intellectual property assets in the fuzzy front end of new product development process

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R&D MANAGEMENT

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The strategic use of intellectual property (IP) is crucial for technology-based companies to gain competitive advantage. The recent transformation of the US patent system brings new challenges and opportunities in this arena. In this regard, this study attempts to identify techniques which can help with IP evaluation and selection in the fuzzy front end (FFE) of new product development (NPD) process. This study combines data collection methods such as mining the literature, conducting in-depth interviews, surveying questionnaires, and analyzing cases. This research serves as an analysis of modern literature and identifies a multicriteria weighted scoring model that can be employed to help with the patent decision process. The criterion to discern patent eligibility is a contended discussion. For this survey administration, 300 companies, as the targeted sample, were randomly selected to be reached from LexisNexis database. Consequently, this paper identifies the key decision criteria to incorporate into this model and obtains weights gathered from surveying IP professionals and R&D managers in US-based electronics manufacturing firms (SIC code: 36). This study proposes a structured approach to identify ideas that should be patented in the FFE of NPD process by way of an analysis of pertaining literature and case studies. The technique we present in this paper could be essential for many firms to achieve IP success as their strategic means. Moreover, this tool can help R&D managers not only speed up the FFE of NPD process but also make more informed and target-worthy decisions for IP filing.

1. Introduction

The significance of innovation has been increasing with fast-changing markets and globalization. Innovation, which stems from the manifestation of a continuous stream of ideas, has influenced firms to transform creativity into economic value in order to ensure sustainable competitiveness. The sustainable competitive advantage is typically based on a capacity of unique knowledge, patents, trademarks, copyright, property, or process that the firm is able to protect as proprietary (Duening et al., 2009). Coyne classified the sources of sustainable competitive advantage through four types of capability gaps: business system gaps, position gaps, organization quality gaps, and regulatory/legal gaps (Coyne, 1986). Moreover, five key resources – human, organizational, relational, physical, and monetary – are suggested to deepen the understanding of the importance of intangible assets in value creation in technology-based companies (Pike et al., 2005). In order to maintain a sustainable competitive advantage, a firm must continually peruse the generation of systems with attributes such as price, quality, and functionality which correspond to the key decision criteria for the majority of the customers in a particular market (Coyne, 1986; Hall, 1992). Several studies (Hall, 1992; Greco et al., 2013; Klingebiel and Rammer, 2014) also emphasized the role of intangible resources in the strategic management process. Di Minin and Faems pointed out that intellectual property (IP)-based strategy can create interfirm differences (Minin and Faems, 2013). As such, the effective management of IP plays a pivotal role in creating a sustainable competitive advantage (Cesaroni and Piccaluga, 2013).

However, although many strategic management researchers indicate that IP strategy needs to be integrated with the strategic R&D plan (Cesaroni and Piccaluga, 2013; Ernst and Fischer, 2014; Ernst et al., 2016) and technology strategy should be coupled with business strategy (Lyne, 2003; Cooper and Edgett, 2010; Betz, 2011; Klingebiel and Rammer, 2014), the strategy, R&D, and IP functions are poorly integrated in practice (Fisher and Oberholzer-Gee, 2013). Conversely, it is more difficult for start-ups to sustain a competitive advantage mainly based on IP such as patents and trade secrets since competitive companies can find ways to avoid violating another firm's protected IP. Furthermore, the lifecycle of IP is significantly shorter than previous generations. Some patent experts state IP's current lifecycle is approximately 3–5 years on average, while it is protected for 20 years in the US-PTO. These trends are likely to reflect the growing importance of patent-related issues for the new product development (NPD) process in technology-based firms. Hence, this study attempts to propose decision-making processes for a firm to effectively deal with IP-related management in the fuzzy front end (FFE) of NPD process.

Meanwhile, IP policy and law enforcement vary across nations. Historically, the U.S. has held different patent laws from the rest of the world by following a 'first-to-invent' system. In this system, the US laws stated that as long as a patent applicant could prove that they were the first to create an invention, then they could be granted the rights to a patent. These laws allowed companies to pick and choose their patents more freely. If they were unsure if an idea was worth patenting, they could hold on to it and see what happened with the market. It also protected individual inventors and small companies without the financial ability to patent every invention (Malakoff, 2011). However, there exist several drawbacks of the 'first-to-invent' system in that it creates a very slow and cumbersome patent process. Lengthy court battles result from different firms attempting to prove that they were the first to invent an idea. In consequence, in March 2011, the US Senate voted on a measure that overhauled US patent laws. America Invests Act (AIA) draws US patent system closer to the patent laws of the rest of the world (Goldsmith and Koriat, 2012). In the 'first-to-file' patent system readily used by the rest of the world, the first party to file for a patent gets the rights to that patent. There are three main advantages to this approach: (1) simplification of the administration involved, (2) the decrease of disputes in law, (3) inventors are induced to submit their patent applications sooner. The reforms intention was aimed toward reducing the backlog of patent applications and streamlines the patent process since the US has been facing a struggle to keep up with patent applications. Figure 1 presents the large backlog of patent applications that the US system faced. After AIA went into effect in March 2013, the backlog of patent applications has been decreasing.

The transformation from 'first-to-invent' to 'first-to-file' has altered US IP strategies in dealing with wealth creation and protection for technological innovations at the firm level. In the 'first-to-file' patent system, firms should pay attention to select their ideas that are worth patenting since they could not unsurely maintain them. To date, relevant research on IP is plentiful; however, little attention has been given to methods for IP selection and evaluation in the FFE of NPD process to help managers in companies based on the recent enactment of AIA in the literature. What methods exist IP attorneys or R&D managers choose which idea to patent? To answer this question, an in-depth literature review of the various FFE methods

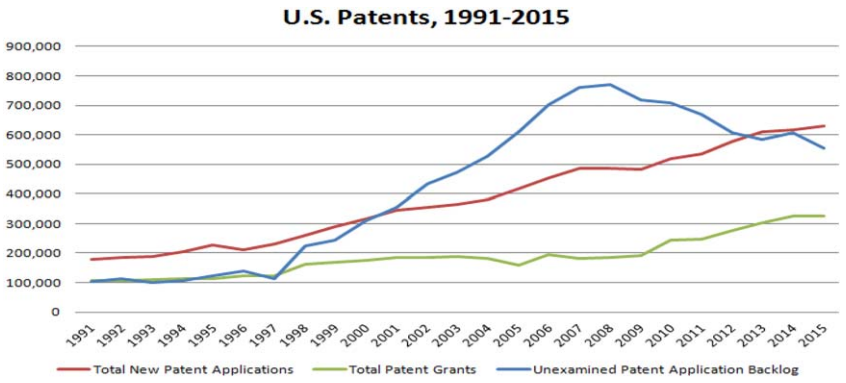

Figure 1. US patents, 1991–2015. Source: USPTO. [Colour figure can be viewed at wileyonlinelibrary.com]

was conducted on studies which used decision models to ascertain the valuation of patents. Moreover, prior research highlighting the relative importance of critical and influential creativity dimensions and their related criteria in FFE are scarce. Consequently, the objective of this study aims at constructing critical decision criteria of idea evaluation in FFE of NPD process in order to provide a reference for understanding and enhancing IP-related decision-making system. In this regard, this study identifies a multicriteria weighted scoring model and the key criteria that can be employed in the patent selection process by way of an analysis of pertaining literature and case studies.

2. Theoretical background

2.1. *Fuzzy front end in new product development*

The features of the front-end phase in NPD process are qualitative, informal, approximate, equivocal, unstructured, and uncertain in nature rather than quantitative, formal, and precise (Montoya-Weiss and O'Driscoll, 2000; Kim and Wilemon, 2002; Frishammar et al., 2011; Wowak et al., 2016). Many studies have made efforts to provide clarity and techniques for mitigating ambiguity in the FFE phase (Khurana and Rosenthal, 1997; Reinertsen, 1999; Montoya-Weiss and O'Driscoll, 2000; Koen et al., 2001, 2002; Martinsuo and Poskela, 2011; Achiche et al., 2013; Wowak et al., 2016). Reinertsen analyzed FFE process quantitatively to give some guidelines and deep understanding regarding the structural process design of FFE (Reinertsen, 1999). It helps us better understand and design the FFE processes in a methodical and quantitative manner. He identified which factors cause fuzziness in front-end processes by calculating the quantitative outcome at each step to optimize subprocesses (betting processes) as well as different process design choices in the FFE. Griffiths-Hemans and Grove also examined three sub-processes of the FFE – idea creation, idea concretization, and idea commitment stage (Griffiths-Hemans and Grover, 2006).

However, these frameworks may only work well in incremental innovations and relatively stable industries since it assumed prerequisite knowledge based on the probability of success as well as the cost of screening processes. Hence, it may not be able to calculate FFE process of the discontinuous or emerging technology related to R&D projects. In addition, they did not give some quantitative directions with respect to fuzzy front innovation processes including idea generation, idea selection, concept and technology development, opportunity identification, and opportunity analysis. Conversely, decision makers can hardly discern good from bad ideas preemptively. They can easily notice it afterward; therefore, they need considerable information and historical data to calculate benefits or costs in the FFE.

In this regard, Koen et al. indicated that any idea selection process in the FFE may be fundamentally flawed since disruptive ideas will be unable to garner resources against the firm's existing businesses (Koen et al., 2002). In order to prevent the rejection of disruptive ideas, prior studies emphasized the firm's friendly organizational environment to be open to disruptive ideas and be prepared to accept failures (Kim and Wilemon, 2002) as well as creating a small organization separate from the mainstream (Bower and Christensen, 1995). Several studies indicated differences in problem structure incremental versus discontinuous/radical innovations (Leifer et al., 2001; Reid and de Brentani, 2004; Brentani and Reid, 2012). They also proposed the decision-making process at the FFE of discontinuous innovation. However, this model does not have any linkage with later phase of innovation.

Prior research aimed toward better understanding the FFE in NPD has paid much attention to the idea source of innovation (Cooper and Kleinschmidt, 1986; Björk and Magnusson, 2009), opportunity

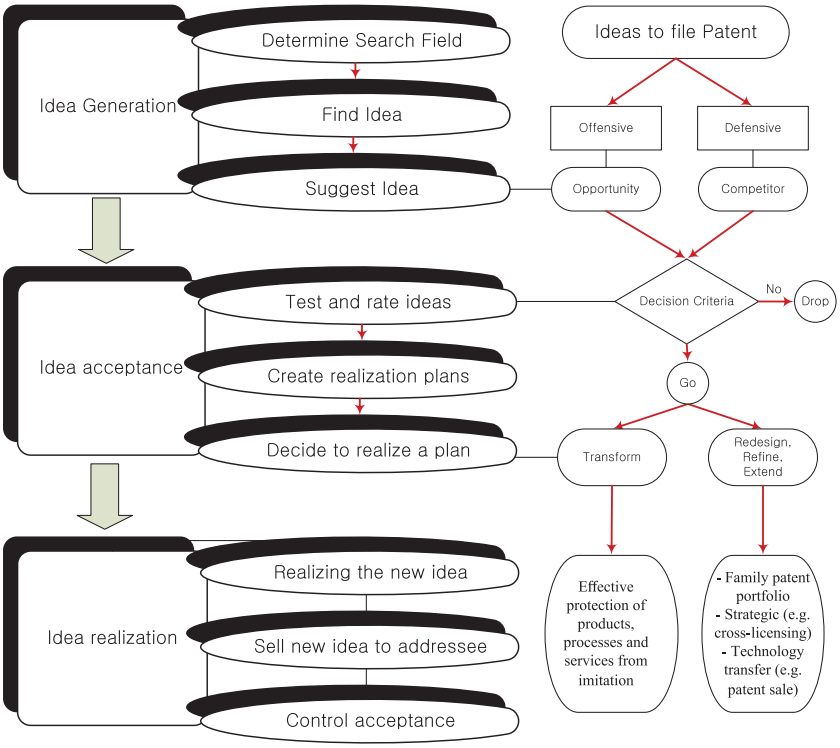

Figure 2. Idea selection process in the FFE. Modified from sources: (Ernst, 2003; Dean et al., 2006; Brem and Voigt, 2009). [Colour figure can be viewed at wileyonlinelibrary.com]

identification/recognition (Urban and Hauser, 1993; Leifer et al., 2000; Crawford and Benedetto, 2011), idea generation and concept development (Rangaswamy and Lilien, 1997; Crawford and Benedetto, 2011), up-front activities in NPD process (Cooper and Kleinschmidt, 1995; Griffiths-Hemans and Grover, 2006), the role of marketing activities in the FFE (Schoonmaker et al., 2013), decision support tools in the FFE (Leon, 2009; Achiche et al., 2013; Wowak et al., 2016), the role of intuition in the FFE (Eling et al., 2014), information collection/exploration (Crawford and Benedetto, 2011), supplier integration in the FFE (Wagner, 2012; Schoenherr and Wagner, 2016), customer's involvement in the FFE (Wong et al., 2011; Menguc et al., 2014), organizational processes (Khurana and Rosenthal, 1997; Markham and Lee, 2013), and the impact of FFE on product performance (Verworn, 2009; Markham, 2013). However, the screening process targeting product ideas intended to be filed for a patent at FFE phase has been underdeveloped and poorly supported through concrete decision-making methods and criteria.

2.2. *Decision-making process for IP management*

In accordance with this new direction for the US patent system, firms must adapt their strategic decision-making process. The main objectives to file a patent are offensive as well as defensive (Kingston, 2001; Chesbrough, 2003; Gilardoni, 2007; Hsueh and Chen, 2015). One reflects patent quality and the other represents patent quantity. Patents also support strategic technology management (Ernst, 2003; Reitzig, 2007; Germeraad, 2010; Conley et al., 2013). For the offensive purpose, effective patent protection of product, process, and service from imitation have been identified as an important source in taking a competitive advantage (Chen et al., 2016). Conversely, for the defensive purpose, firms not only make a profit from patent licensing and patent sale but also take advantage of bargaining chips in competitive business domains (Mihm et al., 2015).

In the past, patent decisions could be made later in the development process, but now the decision must be made in first-to-file patent law system at the FFE. As a consequence, the firm needs tools to make an adequate decision at the early stage. The illustration shown in Figure 2 demonstrates how the idea selection process links with the decision-making process of patent filing in the FFE.

Once an idea has been spawned from the ideation stage within the concept generation phase, pools of new product concepts are formed. Regardless of their creation, whether through analytical problem solving, applying existing technology in new ways, surprise

Table 1. Taxonomy of intellectual property (IP) management in new product development (NPD)

Approach	Agenda	Reference
IP management	• Protecting IP in collaborative development and relationship • Managing and benefiting intellectual assets using patents, copyrights, trademarks, designs, and secrecy	Goy and Wang (2016), Luoma et al. (2010), MacCormack and Iansiti (2009), Manzini et al. (2012), Minagawa et al. (2007)
IP strategy	• Aligning IP strategy with innovation/business strategy • Using IP as a source of strategic means	Cohen et al. (2000), Conley et al. (2013), Mihm et al. (2015), Reitzig (2007), Somaya (2012)
IP portfolio management	• Identifying R&D and business opportunities using IP portfolio analysis	Ernst (1998), Fabry et al. (2006)
IP performance	• Valuing IP with financial methods and decision-making methods • Analyzing impact of IP on NPD performance	Chiu and Chen (2007), Pitkethly (1997), Roessner et al. (2013)
IP organization	• Analyzing IP issues associated with functions of the firm and business performance	Borg (2001), Ernst and Fischer (2014), Minin and Faems (2013), Paik and Zhu (2016)
IP standardization	• Using IP as a means for strategic technology agreement and technological standardization • The relationship between standardization and patents	Blind and Thumm (2004), Caviggioli et al. (2016), Gallini (2014), Pohlmann and Blind (2014), Tamura (2013, 2016)
IP information	• Using patent information for competitor monitoring, technology assessment, R&D portfolio management, the identification and assessment of potential sources for M&A, NPD and human resource management	Boyd (1996), Ernst (2003)

problem solving or others, all nonobvious solutions are possible patent opportunities (Crawford and Benedetto, 2011). Meanwhile, there is lack of exploration of IP management at the early stage of innovation. As presented in Table 1, prior research has focused on managing IP for strategic means, information of innovation, standardization, and assets. However, little study has been done in idea evaluation to file a patent in FFE (Crawford, 1980; Dean et al., 2006). This study provides a brief overview of current stream of research in this field.

3. Research methodology

This study combines data collection methods such as mining the literature, conducting in-depth interviews, surveying questionnaires, and analyzing cases. First, an explorative research was conducted to identify techniques and decision criteria for managing IP in the FFE of NPD through the systematic literature review. The methods are identified, compared, and critically reviewed for effective application. Second, to supplement the literature review, we conducted in-depth interviews with attorneys who are involved in patent filing for companies. The interviews provide illustrations of how firms actually engage in patent filing selection processes. From this, four financial methods and five multicriteria decision-making tools emerged. Subsequently, based on the taxonomy, this study assessed methods using expert decisions and recommended a method for use as a patent selection tool.

Third, this study collected survey responses using a web-based survey instrument from IP professionals, and IP-related decision makers such as IP managers, R&D directors or Vice President of Engineering involved in the patent filing selection process regarding what methods have been used and can be considered in the FFE in a firm in the United States. The primary goal of this survey is to determine a technique and criteria available to a firm for managing IP and for making effective decisions about IP filing from products or technologies in the FFE of NPD. The rational scope described in this section presents electronics manufacturing firms (SIC code: 36) in the United States that are engaged in R&D and patent activities as the population of interest. Survey items were formulated on the basis of the systematic literature review and feedbacks from IP professionals. Prior to survey administration, survey content was validated by IP professionals. The survey

questionnaire consists of three parts which include background information, the familiarity, and usability of techniques, as well as the usability of decision criteria for evaluating patents in the early stage of product or process development.

This study used LexisNexis database as a university accessible one to obtain the list of potential respondents. Consequently, 300 experts, as a targeted sample, were randomly chosen to be reached from this database. Finally, 35 experts responded to this survey. The response rate of 11.7% is usual for this type of survey in which potential respondents have no incentives to take. We did no follow-up. Moreover, we conducted in-depth interviews with attorneys and IP managers with two of the companies surveyed. Once the criteria have been identified through an in-depth literature review and interviews with IP professionals, this study employs scoring method to rank the criteria based on how important each one is for patent selection. The survey result provides relative weights with respect to decision criteria for evaluating ideas that patents will be filed for. Survey results were used to prioritize the relative importance of selected criteria. Finally, the criteria and weights are assembled into the method chosen to propose a patent selection method.

Moreover, this study employs case study method for our empirical investigation (Eisenhardt, 1989; Yin, 2014). The in-depth case study is particularly well suited for investigating questions that have not been asked previously (Gartner and Birley, 2002). The primary research question of this study is how weighted scoring method and metrics can be used in evaluating ideas at the FFE stage. We selected cases from survey sample space. Small and large firms were determined to identify how they differ in their idea evaluation in the FFE of NPD process. In addition, this study decided different category such as core/niche technology as well as success/failure of patenting to verify the discernment of this tool and decision criteria proposed here. Thus, despite the several limitations in terms of validity, three case studies were undertaken to test the decision criteria and this method for the patent decision process in the FFE. This approach follows a multicriteria weighted scoring model by the subjective judgments of the experts in relevant technology areas. Detailed case results were collected from interviews held with executives, R&D managers, and IP management staff with the support of external IP attorneys. Semistructured interviews were conducted to collect and probe further on comparative and in-depth information regarding patent filing decision making on the corporate level. Due to the vagueness of the nature of front-end and difficulties in evaluating accurately, this fuzzy approach might be suitable to determine ideas to be filed for a patent in NPD process.

4. Taxonomy on decision methods for a 'first-to-invent' system in FFE of NPD

This study investigates several financial and nonfinancial decision methods from the FFE for a comparative research in this section. In the early stage of innovation, the level of uncertainty is high and the systematic organization of methods is low. We used a taxonomic scheme for characterizing techniques that can be used for managing IP in FFE. This research explored the literature thoroughly identified as relevant, along with a search for alternate key words and phrases with respect to IP, NPD, or fuzzy front that may have been used in adjacent relevant fields. As a result, little study has been done for deciding patent eligibility in the early stage of innovation.

However, we identified many techniques available to a firm for managing the FFE and for making effective decisions about products in the early stages of a new product or process development. Several studies suggested a checklist and scoring model for initial screen in idea stage (Cooper et al., 2002; Cooper, 2006; Dymond et al., 2012). Previous studies provided the evidence that small percentage of firms used a checklist for initial idea screening (Crawford, 1980; Cooper and Kleinschmidt, 1986). Chiu and Chen also demonstrated the utilization of analytical hierarchy process (AHP) as a means to valuate patents (Chiu and Chen, 2007). AHP and analytical network process (ANP) are models within the multiple criteria decision-making models (MCDMs). By contrast, ANP is not as widely used but has been found within literature in the areas of accounting or in areas where 'risk and uncertainty' are involved. These tools are typically applied to product/technology selection or idea evaluation (Huang et al., 2011). MCDMs are useful in solving higher level managerial planning and decision making problems by removing the 'mess' caused during the decision-making process (Kasanen et al., 2000; Wallenius et al., 2008). A subset of MCDM that focuses on how to evaluate alternatives helping decision makers select the optimum choices is named multiple attribute decision making (MADM). Underlying examples of MCDM models also include fuzzy AHP, fuzzy ANP, neural networks weighting, fuzzy neural network, interpretive structural modeling, fuzzy cognitive map, technique for preference by similarity to the ideal solution (TOPSIS), simple additive weighting method (SAWM), and preference ranking organization method for

enrichment evaluation (PROMETHEE). Since 2000s, all MADM models written and published AHP/ANP, multi-attribute utility theory (MAUT)/multi-attribute value theory (MAVT), PROMETHEE, elimination and choice expressing reality (ELECTRE), and TOPSIS were the highest focus of research and thus were also considered in this work for possible models to be used for patent selection in the literature (Huang et al., 2011).

In addition, decision tree method is a decision analysis tool that employs a tree-shaped diagram to determine a course of action or show a statistical probability (Churchman et al., 1957). Decision trees are useful in simplifying complex decision issues into small issues and representing them with easily understandable form. One of the disadvantages of both relevance trees and decision trees is that as the number of decision variables in the analysis increases the complexity of the model increases incrementally, making it visually hard to present the problem. Moreover, these decision methods are not suited for decision analysis problems where there exist multiple decision criteria.

On the other hand, many studies indicated that financial analysis has been conducted for preliminary market assessment, project evaluation, and predevelopment stages in NPD processes (Cooper and Kleinschmidt, 1986; Cooper, 1990; Crawford and Benedetto, 2011). In this regard, Crawford and Benedetto suggested the cumulative expenditures curve and awareness-trial-availability-repeat (ATAR) model for the concept/project evaluation in new product management process (Crawford and Benedetto, 2011). The ATAR formula is used as a way to calculate the path to profit within an organization (Crawford and Benedetto, 2011). Further, bass diffusion model (BASS), Required Rate of Return, and Real Options were the financial methods that we studied derived directly from the FFE of project development for aid in deciding if an idea is patentable. The BASS model allows a decision maker to conduct quantitative predictive future sales of a product based on historical sales of the same product (Bass, 1969). The required rate of return is a calculation that allows a decision maker to understand that the higher the risk of a given product the larger the rate of return should be (Crawford and Benedetto, 2011). The required rate of return depends on the stage of development (Pintado et al., 2007). The real options paradigm provides a technique for organizations to expand in response to 'future technological and market developments' (Kogut, 1991). Accordingly, the real option is defined as the situation where a decision maker can make a decision between multiple tangible assets. In many cases, financial methods have some limitations mainly because of data availability. The potential issue with financial model utilization is that some of the above variables may not be known at an early stage. For example, the BASS model is based on historical sales; however, if an idea may be beyond that of the firm's original historical sales data. A different example is with regards to the ATAR model's T variable. In accordance with the same aforementioned principle the trial percentage of customers may not be known. Our initial interview with IP professionals and general managers revealed that many firms already use financial methods to analyze their IP decisions.

Lastly, Teoriya Resheniya Izobretatelskikh Zadach (TRIZ) (the Russian-based acronym for the Theory of Inventive Problem Solving) developed by Altschuller and his colleagues has been used to solve design and technological problems (Herstatt and Verworn, 2004; Leon, 2009) or predict the technological maturity level on the evolutionary path (Zhang et al., 2004) in the concept generation stage of FFE. However, TRIZ is very demanding to apply and inappropriate to incorporate and evaluate various aspects such as customer-oriented or cost-oriented idea generation, risk-based idea assessment, alignment with existing projects, and strategic decision in technology portfolio. Prior research on FFE proposed multiple criteria decision-making methods for idea evaluation since it can incorporate various dimensions into a model. However, there is a marked shortage of investigating how these models can be applied to patent selection in FFE. As a consequence, based on the systematic literature review, we identified techniques in this research realm for our comparative study. Our guiding principle of evaluation for the validity was driven off of three main objectives:

(1) **Model adaptability** – providing a model that is easily applicable in practice within a firm, but not at the expense of its accuracy.
(2) **Multi criteria comparisons** – discovering that a decision maker must consider several criteria when considering if an idea is patentable.
(3) **Clear outcome** – suggesting a model that clearly identify and rank criteria to provide a clear, patent, do not patent decision.

5. Decision model selection for FFE

To review, it became evident during the course of our research that we were thinking about the problem using several criteria, not as to which belong in the model but as to which would determine the model itself. It is evident that the very nature of the FFE reduces the overall data available, and so the model

should be able to work off of relatively few factors, which in turn excludes the financial models. However, not all factors are created equally (as this study discusses in the next section) and so the model should also take into account the relative importance of each factor. Every method exists for specific reasons, but not every method is appropriate or even possible during the FFE phase of a project. In general, uncertainty can be quite high during this early development phase. Hence, decisions must be made with limited data. However, certain fundamental aspects of the project are often known even at this early stage. The best methods must capitalize on what is known and mitigate uncertainty about what is still unknown. Thus, this study investigates the usage of methods in the FFE within a firm by conducting the survey.

As a result of the survey, respondents reported the techniques that are involved in patent filing or strategic IP issues in FFE of NPD at their company. The results of the survey are presented in Table 2. Regarding the application of various methods to idea evaluation for patenting in the FFE of NPD, the survey results revealed that companies tend to frequently use a scoring model and/or a checklist in FFE of NPD. Some of them responded that the multicriteria methods appeared reasonable but much too complex. The application of MCDM models in an engineering field is based on simple scoring models (Wallenius et al., 2008). Based on these results, we propose a multicriteria weighted scoring model that can be employed to help with the patent decision in FFE of NPD. The model this study proposes is only useful if the usability is quite high. The simple question being asked is 'whether to proceed with the IP process or not' so a discrete positive or negative result is all that is required. The model selected represents a variant of MAVT utilizing Simple Additive Weighting to formulate a relatively simple score that can be easily understood and used. This hybrid model met our three guiding requirements in this study and was selected based on the literature review and survey results.

Table 2. Summary of survey responses with respect to the use of methods

Methods	Frequency on survey response	Percentage
AHP	2	5.7
ANP	1	3
Fuzzy AHP	1	3
Fuzzy ANP	–	–
Decision tree/Relevance tree	8	23
MAUT	–	–
MAVT	–	–
PROMETHEE	–	–
ELECTRE	4	11.4
TOPSIS	1	3
ATAR	1	3
BASS	–	–
TRIZ	–	–
Required rate of return	4	11.4
Real options	2	5.7
Scoring model	9	25.7
Checklist	12	34.3
Gut feeling	9	25.7

Note: $N = 35$.
Abbreviations: AHP, analytical hierarchy process; ANP, analytical network process; MAUT, multi-attribute utility theory; MAVT, multi-attribute value theory; PROMETHEE, preference ranking organization method for enrichment evaluation; ELECTRE, elimination and choice expressing reality; TOPSIS, technique for preference by similarity to the ideal solution; ATAR, awareness-trial-availability-repeat.

6. Decision criteria for multicriteria weighted scoring model

In the previous section, this study identified a method that could be used for the patent decision process in the FFE. This weighted scoring method required us to identify the key criteria. To that end, this study analyzed the literature to discover what key criteria are involved in IP evaluation and consider how these fit into the FFE. In order to properly analyze patents and patent methods, one should first consider the core of the patent, a new idea. At the FFE stage, idea evaluation with regard to applicable standards and implementation requirements results in a decision to discard, revise, or invest in the idea. There are some articles which regard idea evaluation in a philosophical context. Crawford (Crawford, 1980) determined how small firms differ in their idea evaluation. He indicated that in the case of small firms, evaluation is mainly concerned with marketing and technical feasibility. Surveys showed what kinds of evaluation process – first-stage screening, in-process evaluation, market place evaluation, and financial evaluation – differ across companies depending on their size. Licuanan et al. (2007) pointed out pitfalls or errors in idea evaluation, in that people may underestimate the originality of highly novel new ideas, and optimistic points of view may lead people to underestimate the time and resources needed to implement new ideas. However, the degree of originality is an important criterion which the ideal method should take into account. In this regard, Dean et al. (2006) identified four main dimensions – novelty, workability, relevance, and specificity – having two measurable

subdimensions for each of them to assess the new idea quality or creativity. In particular, we refer their study to incorporate idea originality, completeness, and feasibility as indicators for evaluating the new idea quality or creativity in the FFE.

The innovating firm ultimately needs to decide simply whether to pursue patent protection or drop it. Investment in the idea is efficient only if the return is sufficiently higher than the cost. Many types of uncertainty are also involved in the early life of the patent application. However, there is little significant literature on the return on investment of patents. This is obviously important to all firms, but it is inextricably tied to internal metrics and so each firm must ultimately handle this aspect themselves. Heher (2006) mainly focuses on national level and industry level effect of patents filed in order to compare between countries.

When examining what entails a good IP evaluation method, it is mainly important to understand the reason companies choose to pursue patent protection. Germeraad (2010) discussed the 'Games of Innovation' model developed by the Industrial Research Institute and revealed 11 common innovation strategies – technology races, RD&E tools & services, unique gadgets, safety journeys, battles for architecture, system design and consulting, asset-based problem solving, innovating in packs, high technology craft, consumer research and marketing, and news/clothing/food – used by firms within given industries. He also suggested seven metrics – portfolio size, patent fences, patent velocity, portfolio momentum, claim quality, claim scope, and geographic coverage – for integrating IP strategy with innovation strategy. The two chief variables to determine these strategies were the 'time-to-prototype' and the 'time-to-market', driving innovation. Where both timelines are long, patents may actually expire before the full extent of the product is understood in the marketplace, but also this breaking of new ground can present a ripe field for defensive patents to cut off competition. Patent quality is still expected to be high, however, as 'when the field becomes more crowded, the original art is likely to be subjected to scrutiny'. Conversely, where timelines are short and barriers to market entry are low, 'patent filing rates...tend to be low...as derivative work is protected by trade secret'. This well establishes that a significant variable is patent quality (broadness/defensibility of claims) as well as 'fit' to a given corporate strategy or business model. Both of these items should be relatively well understood by a development team, even during the FFE.

Reitzig (2007) discussed the role of the executive in patent strategy fitted to corporate strategy. This study addressed five 'IP strategy scopes' which also addresses the difference between corporate and functional level strategies. This can be another key during the FFE as the functional level can often spend significant effort prior to high-level management's involvement or even knowledge of the idea. This paper also found a correlation between 'IP rules and IP performance' stating that 'clear-cut rules about IP at the functional level' allow managers to save time – which makes sense in the context of a quick-moving team. If every decision was forced upstairs to a high-level manager, then overall productivity could drastically slow down.

Another avenue of evaluation methods concerns monetary value, or potential value as estimated during the FFE. The monetary value of a patent is a question unto itself, but there are insights to be gleaned for the FFE process. Patent value can be judged either by potential market value (estimated based on market data and/or predictions) or by relative merit within the IP community (judged by the number of citations a patent receives from other patents). Obviously, these citations can take a long time to gather and thus are not much help within the FFE, but a company's existing portfolio can provide clues to future worth. Hall et al. (2005) estimated that an additional patent citation (per patent) could boost stock market value as much as 3%, and specifically that 'past citations clearly help in forecasting future returns'. It went on to discuss 'self-citations', defined as patents which build upon each other within the same firm. These internal citations can be regarded as a sign of a 'strong competitive position' in which the company is in position to capitalize not only upon the original idea but also subsequent applications thereof. Thus, the potential for citations acts as a different method of ranking patent quality and must also be regarded as significant to deciding whether or not to patent, and luckily a firm is always in a unique position to capitalize upon their own IP history.

Another way to look at patent valuation is through the iterative steps of the patent process itself, discussed in a significant (if somewhat dated) report out of Oxford (Pitkethly, 1997). This study not only discusses several methods of patent valuation but also discusses the workflow of the patent process itself along with the costs at each level.

Given that this process extends several years, much of the valuation must be performed by the time of the first filing to fit within the FFE, securing the so-called 'call option' on the remainder of the process. Therefore, an important part of the FFE IP strategy should be the ability to evaluate future options in light of the continuing costs of IP protection. The question should be asked 'Does this method help to consider the lifecycle of the patent?' While this paper was primarily focused on the decision between spinning off a project

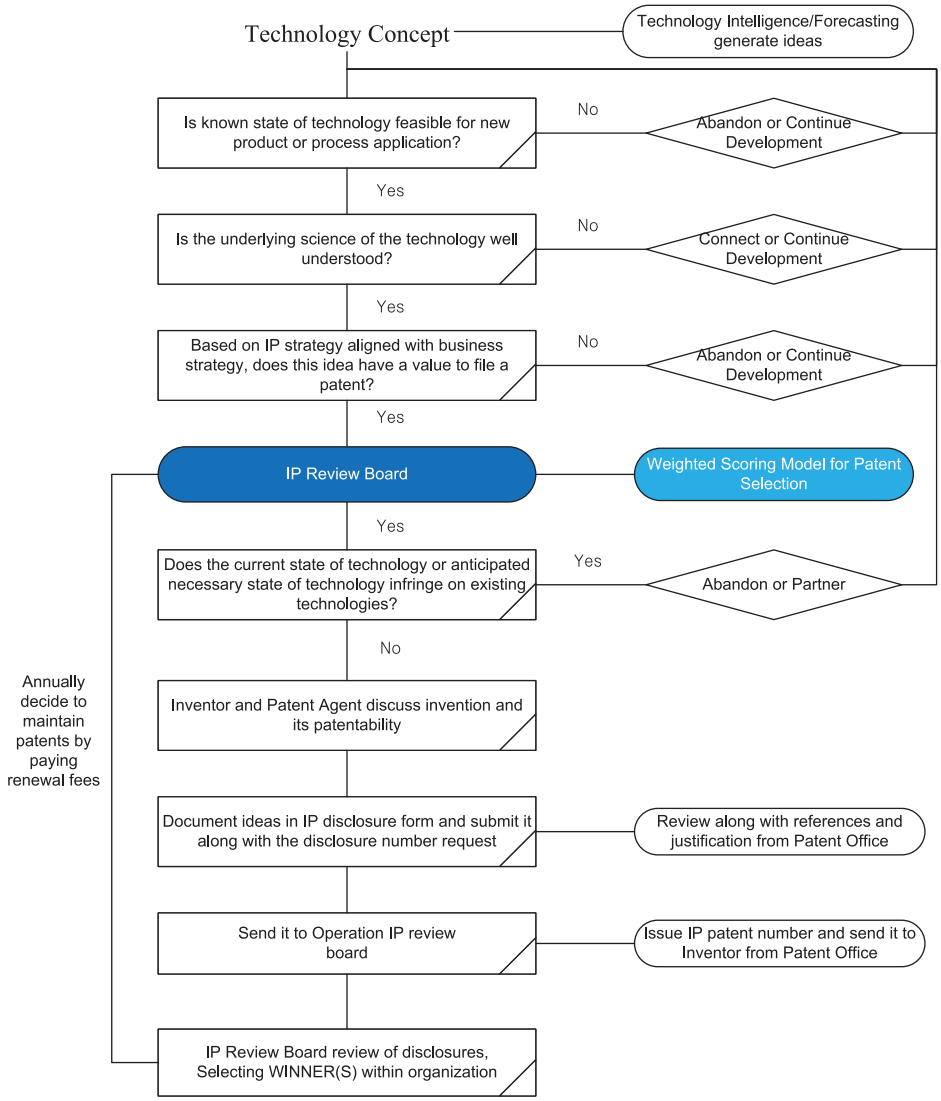

Figure 3. IP decision-making processes in FFE. [Colour figure can be viewed at wileyonlinelibrary.com]

versus developing it internally, many similar factors are considered during IP evaluation. Based on the interviews with IP professionals, this study created IP decision making processes in FFE which incorporate IP review board for evaluating ideas, as illustrated in Figure 3.

These stages include (among others) a technology assessment, organizational capability assessment, and a competitive assessment. The technology and organizational assessments are important as sometimes IP is generated that would not be feasible to develop internally, even if it has a large potential value outside your area of expertise. The competitive assessment is important for reasons which relate back to the corporate strategy of a firm. The term 'patent fences' (Germeraad, 2010) is used to indicate defensive patents which create a clear space around a current line of innovation, even if these patents themselves are not specifically targeted for further development. This consideration should be made not just for the current timeframe, but also for the future life of a company (Pitkethly, 1997).

7. Identifying weights of decision criteria for multicriteria weighted scoring model

Based on the literature and IP professionals' feedback, the criteria discussed in the previous section was pared down to eliminate redundancies, judged, and consolidated with feedbacks from IP professionals. The final key decision criteria in the patent selection are identified as presented in Table 3. In this section, this study attempts to apply weights to the criteria. In order to define these weights, we administer a survey

Table 3. The decision criteria for a patent selection

Decision criteria	Description	Reference
Impact on competitors	• The degree of impact on the nature of competitive intellectual property landscape as it plays with competitors	Fisher and Oberholzer-Gee (2013), Minin and Faems (2013), Reitzig (2004, 2007)
Quality of patent/ Broadness of claims	• The degree of potential for internal citations, strength of claims, broadness in scope, and geographic coverage	Albert et al. (1991), Arora et al. (2008), Cesaroni and Piccaluga (2013), Fabry et al. (2006), Germeraad (2010), Reiner (2008), Somaya (2012)
Idea novelty/ Originality	• The degree to which the idea is totally unique, ingenious, imaginative, or surprising	Dean et al. (2006), Maccrimmon and Wagner (1994), Woodman et al. (1993)
Idea quality/ Completeness	• The level of an idea that will solve the problem, lead to more innovative ideas, and has the impact on the business's new product/service performance, regardless of whether or not the idea itself is novel or unusual	Astebro and Koehler (2007), Björk and Magnusson (2009), Cooper (2006), Dean et al. (2006), Kim and Wilemon (2002), Maccrimmon and Wagner (1994), Nilsson and Ritzén (2014)
Alignment with company intellectual property strategy–offensive/defensive	• The links between intellectual property strategy and intellectual property rights as a complementary strategic tool	Cesaroni and Piccaluga (2013), Fisher and Oberholzer-Gee (2013), Germeraad (2010), Reitzig (2007)
Technological viability	• The degree of technological readiness which can be implemented with no technological constraints	Dean et al. (2006), Hall et al. (2005), Montoya-Weiss and O'Driscoll (2000)
Product feasibility (overall)	• The degree of probability with implementation and no violation of known constraints	Cooper (2006), Costello (1983), Dean et al. (2006), Markham (2013)
Time-to-market/ Development cycle	• The time elapsed between making the decision to begin product/service development and introduction of the product/service into the market place	Lilien and Yoon (1990); Mahajan and Muller (1996), Pitkethly (1997), Putsis (1993), Spivey et al. (2014)
Resources required/Technical capabilities	• The degree of an organization's ability to successfully implement technology	Bitondo and Frohman (1981), Jolly (2008), Khalifa and Davison (2006)
Alignment to strategic business units vision	• The links between strategic business units vision and intellectual property rights	Blomqvist et al. (2004), Germeraad (2010), Reitzig (2007)
Product fit to current business model	• A necessity to develop a product/technology/service for fueling a firm's business model; priorities that are consistent with the business model of the firm	Christensen and Overdorf (2000), van de Vrande et al. (2009)
Market acceptability	• The degree of acceptability of a new product/service in a particular market/customer based on a new idea	Balachandra and Friar (1997), Bruce et al. (2007), Mohan and Rao (2003), Wind and Mahajan (1987)
Target market understood	• The judgments about the identified target market/customer (the concept, benefits, and positioning) associated with a new idea	Cooper (1996), Khurana and Rosenthal (1997), Manzini et al. (2012), Michalek et al. (2005), Zhang and Doll (2001)
Lifespan of patent	• The value/benefit of patent protection derived from a new idea	Griliches (1990), Pitkethly (1997), Spivey et al. (2014)

questionnaire to professionals currently involved with the patent selection process.

We took the average of the weights provided in each survey and completed the following weighted scoring model. As illustrated in Figure 4, this study used a scale range of 0–5 to represent relative importance. The prioritized weights analyzed by experts cannot only serve as a useful assessment tool for a firm to better

Factor	Weights	Score (0-5)	Weighted Score
Impact on competitors	4.49		0
Quality of patent / Broadness of claims	4.83		0
Idea Novelty / Originality	4.42		0
Idea Quality / Completeness	4.22		0
Alignment with company IP strategy	4.79		0
Technological viability	3.92		0
Product feasibility (overall)	3.91		0
Time-to-market / Development cycle	3.38		0
Resources required / Technical capabilities	3.41		0
Alignment to strategic business unit's vision	3.70		0
Product fit to current business model	4.01		0
Market acceptability	3.69		0
Target market understood	3.97		0
Lifespan of patent	2.93		0
		Max Possible	Total Score	Percentage
		278.30	0	0

Note: Scoring guidelines (0—No impact on decision, 1—Least important factor for decision, 2—Less important factor for decision, 3—Somewhat important factor for decision, 4—Very important factor for decision, 5—Most important factor for decision)

Figure 4. Patent selection scoring model with weights restriction.

understand key influential factors on its creative ideas for developing new products, but also can provide an important reference for R&D units and/or stakeholders in decision making for NPD and strategies to help a firm have sustainable competitive advantages.

The weighted scoring model this study develops is constructed as follows:

$$\text{Tot} = \sum_{j=1}^{n} (W_j * S_j),$$

n: number of criteria,

S_j, Score for potential patent in criterion j; W_j, weight of j criterion, Tot, total score.

The potential patents to be filed are scored for based on each factor. The scores are multiplied by the weights to have the weighted scores. The weighted scores are totaled and a percentage is calculated based on the maximum possible. This percentage can then be used to help with the go/no-go decision for a potential new patent.

8. Case analysis

To help validate the model, we tested it using three case studies. In these cases, we had the advantage of hindsight, but this is still a valid test because we can see if the final score aligns with the success or failure of the patent.

Case 1: The first case study was focused on an idea that was not patented. In this case, the developer of the idea felt that this was a valuable opportunity lost. We tested the idea according to the model to see how it would score. The basic concept was for a product that is very well known today: the USB flash drive. The idea was conceived before this was a product that existed in the market. The idea covered the form factor, the hardware, and the software drivers to make it work. It did not cover the USB standard which was intentionally not patented by Intel to help encourage its adoption. The developer and external IP experts scored the idea, and average scores as follows:

Factors	Weights	Score (0-5)		Weighted Score			
		Developer	External experts	Developer	External experts		
Impact on competitors	4.49	4	4	20	17.95		
Quality of patent / Broadness of claims	4.83	4	4.3	19.33	20.91		
Idea Novelty / Originality	4.42	4	4	17.33	17.67		
Idea Quality / Completeness	4.22	4	4	16.66	16.89		
Alignment with company IP strategy	4.79	4	4	19.33	19.17		
Technological viability	3.92	4	3.7	15.33	14.38		
Product feasibility (overall)	3.91	5	4	19.16	15.63		
Time-to-market / Development cycle	3.38	5	3	16.66	10.15		
Resources required / Technical capabilities	3.41	4	3.3	13.33	11.36		
Alignment to strategic business unit's vision	3.70	5	4	18.33	14.79		
Product fit to current business model	4.01	5	4	20	16.02		
Market acceptability	3.69	5	3.7	18.33	13.54		
Target market understood	3.97	5	3	20	11.92		
Lifespan of patent	2.93	5	3.7	14.16	10.73		
		Max Possible		248.23	211.11	89.19	75.86
		278.30		Total Score		Percentage	

Figure 5. The results of case 1 using scoring model.

Table 4. The summary of case 1 by decision criteria

Factors	Implications
Impact on competitors	Strong due to preventing all others from creating a product like this
Quality of patent/Broadness of claims	Broad patent due to general product concept
Idea novelty/Originality	This was a new idea. Nothing like this existed on the market
Idea quality/Completeness	The idea was complete. It was a complete hardware and software solution
Alignment with company intellectual property strategy	This was exactly the kind of concept that the company typically patented
Technological viability	Technology existed and was ready to be adapted
Product feasibility (overall)	Completely feasible, simply a new application for existing technology
Time-to-market/Development cycle	Could be developed quickly and ready to go to market
Resources required/Technical capabilities	Well within the technical capabilities of the company
Alignment to strategic business unit's vision	This aligned with the business unit (BU) vision of creating unique peripherals
Product fit to current business model	Easily fit within existing business model
Market acceptability	The market for a product like this was clearing there
Target market understood	These would be the customers that the company was very familiar with
Lifespan of patent	Patent was applicable for several years. No obvious replacement on the horizon

We can see that this idea scored fairly well at 89.1%, when compared to the average score (75.86%) of external experts in Figure 5. Based on these scores, the model might suggest that this could have been an idea worth patenting. However, the idea is evaluated relatively and determined to file a patent since there is no guidance or norm whether to file a patent or not. Consequently, it should be discussed and decided based on a firm's prior experiences. The following table describes some of the thoughts from the evaluator behind the scores in the model. Table 4 provides the guidance and implications how the firm can use the criteria to determine whether to file a patent or not for new ideas.

Cases 2 and 3: For cases 2 and 3, we interviewed the senior manager of IP strategy at 'L' company. He proposed two cases. The first was considered a strong patent that is considered fundamental IP in a key technology area. The second patent was related to a single niche product. These cases present a differentiation of decision making on the patent filing of core ideas from peripheral ideas based on our decision criteria. Internal IP experts scored the idea, and average scores as follows.

As presented in Figure 6 and 7, the broader patent in the key technological area scores higher than the patent for the niche product. This begins to validate our decision criteria. If the scores had not reflected the

Factor	Weights	Score (0-5)	Weighted Score	
Impact on competitors	4.49	5	25	
Quality of patent / Broadness of claims	4.83	3	14.5	
Idea Novelty / Originality	4.42	4	17.33	
Idea Quality / Completeness	4.22	5	20.83	
Alignment with company IP strategy	4.79	5	24.16	
Technological viability	3.92	5	19.16	
Product feasibility (overall)	3.91	4	15.33	
Time-to-market / Development cycle	3.38	4	13.33	
Resources required / Technical capabilities	3.41	5	16.66	
Alignment to strategic business unit's vision	3.70	5	18.33	
Product fit to current business model	4.01	4	16	
Market acceptability	3.69	3	11	
Target market understood	3.97	3	12	
Lifespan of patent	2.93	5	14.16666667	
		Max Possible	Total Score	Percentage
		278.30	237.61	85.38

Figure 6. The results of fundamental IP in a key technology area.

Factor	Weights	Score (0-5)	Weighted Score	
Impact on competitors	4.49	3	15	
Quality of patent / Broadness of claims	4.83	5	24.16	
Idea Novelty / Originality	4.42	3	13	
Idea Quality / Completeness	4.22	3	12.5	
Alignment with company IP strategy	4.79	2	9.66	
Technological viability	3.92	5	19.16	
Product feasibility (overall)	3.91	5	19.16	
Time-to-market / Development cycle	3.38	5	16.66	
Resources required / Technical capabilities	3.41	2	6.66	
Alignment to strategic business unit's vision	3.70	2	7.33	
Product fit to current business model	4.01	2	8	
Market acceptability	3.69	5	18.33	
Target market understood	3.97	5	20	
Lifespan of patent	2.93	1	2.83	
		Max Possible	Total Score	Percentage
		278.30	192.63	69.22

Figure 7. The results of single niche product.

importance of the patents, we would know that the appropriate factors were not being considered.

9. Discussion

After investigating the current available FFE decision tools, MCDM's, we identified that a weighted scoring method could be effectively applied to the patent decision process. The MCVT's model selection was driven by the need for a paradigm that was simplistic but accurate, evaluated all criteria, and provided clear direction to the patent attorney utilizing the model. It was not our intention to indicate that any of the other models could not have been utilized, but rather due to the evaluation of each limitation and advantage in the literature as well as the current use of companies in this survey we choose to move forward with the MCVT-based model. Our effort in finding the appropriate model was based on the decisions by IP experts and R&D managers. To that end, there is a large opportunity to expand upon our base research to evaluate additional methods that may fit for this purpose.

Once we had identified this method, we researched which criteria should be included in the model. These criteria were sent to professionals involved in the patent selection process for weighting. The weights and criteria were entered into the model and the model was tested with three case studies. The sample set was based upon 35 respondents from electronics manufacturing firms in the United States. In order to create a more universal and reliable model, future research could complete a more comprehensive survey that includes more participants from a wider variety of sectors. To apply this model further in a different setting, our survey could be distributed to a more geographically dispersed sample set in the world for comparison.

The results of the case studies show that this model could be an effective tool for identifying ideas that should be patented in the early stage of innovation. A company may want to tailor the model that this study provides to best fit its own application. In this case, they could adjust the weights and add or subtract criteria. In this regard, more case studies should be completed to help create a scale for rating the outputs from the model. The theory-building process requires recursive cycling among the case data (Eisenhardt, 1989; Eisenhardt and Graebner, 2007). For example, a company could take a look at a list of successful patents, rank each one retrospectively using the model and then use the scores of the successful patents as a benchmark for future decision making. We would recommend benchmarking a whole portfolio of patents with the model.

In accordance with the necessity of appropriate tools for making the initial go/no-go decision associated with patent filing of proposed new ideas at the early stage of innovation, this study explores evaluation methods and decision criteria. The literature is still scarce on this issue. Thus, a clearly stated procedure with well-defined criteria and weights in this study can improve the visibility of evaluation of idea's patent filing. Raising the value of individual ideas would be of much greater value than simply ranking ideas or projects. One of the benefits of this method is not only to identify the ideas for patenting in the FFE but also to stimulate R&D engineers to develop better ideas for patenting. In this regard, this tool enables managers to effectively manage and deploy goals-driven R&D projects. When considering the motives to patent (Blind et al., 2006) as well as effectual and causal dimensions in the corporate R&D contexts (Brettel et al., 2012), a firm must create incentives as well as performance measures of its R&D personnel associated with patenting new ideas based on the evaluation made using this tool in IP review board.

When management group takes into account technology strategy aligned with business strategy, there is no clear-cut IP strategy fit with the organization in terms of quality versus quantity of patents in the literature. On the one hand, firms with significant patenting activities have an additional challenge to maintain IP rights of low quality and high quantity annually spending excessive patent-related costs (Basnet et al., 2006). On the other hand, small firms are facing significant litigation with large firms who have strong patents as a consequence of unwarily using a component already protected by them. As patent strategies (domestic vs. abroad, offensive vs. defensive, patent family, standardization, abandonment, etc.) became more complex and comprehensive (Ernst, 2003; Blind and Thumm, 2004), it has been a major concern for a firm to select the right inventions deserving patent protection (Cesaroni and Piccaluga, 2013). In this regard, this paper provides an easily implementable tool not only to improve the decision-making process for the management of patent activity and the high quality of patent portfolios but also to sustain and make profits from firms' R&D efforts. If senior managers take advantage of this technique and decision criteria presented in this study, they will allocate resource wisely and end up reducing the cost of connecting IP and market success.

There are still controversial debates in the literature on whether propensity rate to patent increases with firm size. Blind et al. (2006) indicated that firm size has a positive relationship with the motive to patent. Some studies report that small firms have more propensities to file a patent than larger ones (Brouwer and Kleinknecht, 1999). Halperin and Chakrabarti found that R&D productivity has a negative association with firm size (Halperin and Chakrabarti, 1987). However, if larger firms possess more qualified staff, resources, and assets, they should benefit more from deploying strategic IP decision making processes to speed filing of provisional applications. Based on this survey responses, large firms have a tendency to employ a formal IP review board while as small firms are more likely to rely on informal gut feeling in their IP decision-making process. Conversely, reduced fees seem to offer benefit to small firms. Regardless of the firm size, companies need to establish a formal process like Figure 3 for effectively communicating between attorneys and R&D team in the FFE of NPD.

10. Conclusion

AIA not only reduced fee structure along with process changes, but also reduced the backlog of patent applications through a new postgrant review phase (Spivey et al., 2014). The patent reform legislation requires for a firm to involve R&D managers in its strategic decision-making process about IP strategy and technology portfolios since R&D managers should evaluate the commercial potential of technology in the FFE phase. AIA may help R&D managers not only diversify the product portfolio by patenting several versions of a technology, but also effectively integrate R&D with business strategy (Spivey et al., 2014). Yet, in practice, no criteria have been established for making Filing/Drop decisions. Moreover, many senior managers do not understand their pivotal role in the FFE of product development process, and they are unprepared or unable to make vital Filing/Drop and prioritization decisions. Given the added pressure of the new patent laws, and ever-shrinking budgets, the technique we present in this paper could be essential for many firms to achieve IP success as their strategic means. Hence, firms need to establish a platform or protocols to carry out the communication between executives, managers, R&D engineers, and marketing personnel based on the AIA.

The strategic IP related decision-making process requires the communication and collaboration that are critical in the FFE of NPD. With the growing competition in the global economy, it is important to note that it is crucial that a technology-based firm must create and maintain a managerial support platform for its own IP decision-making process. This method can resolve disparity of the different expectation from various interest groups. In addition, systematic IP related decision-making process with IP review board in the FFE of NPD will not only provide an effective communication vessel but also promote the collaboration to have diverse contributions by the management group. However, small firms are most likely not to have IP review board to make a decision to file a patent, while as large firms have a tendency to use their own tools and decision criteria to determine how they strategically manage IP. Thus, although there might be a shortage of human resource, we would recommend a firm establish cross-functional IP review board to evaluate a patent filing.

The patenting efforts focus on the future value to the firm. Involving the corporate management group early in the IP-planning process appears to be a key factor in acquiring high returns from innovation (Reitzig, 2007). Therefore, it is important to note that decisions on patent portfolio must align with the business strategy. Such alignment would help the firm to have competitive advantages with scarce resources available. In high-tech markets, proactive management of IP portfolio is crucial for maintaining the virtuous

cycle of continuous new product and service introductions.

Finally, the weighted scoring model proposed in this study could be effectively employed in conjunction with other tools and methods to help select which ideas should be patented in the FFE such as real options. This tool also can help managers not only speed up the FFE of NPD process but also make more informed and target-worthy decisions for IP filing. Furthermore, it would be possible to make this technique more accessible to the R&D managers by creating the accumulative database based on experience as well as knowledge from both internal and external IP professionals.

11. Limitations and further research

There might be the effort heuristic and the sunk cost effect in patent evaluation (Kahneman and Tversky, 1979; Thaler, 1980; Arkes and Blumer, 1985; Kruger et al., 2004). With respect to IP review board, if the R&D managers themselves are the ones evaluating new ideas, they will be more likely to give their concepts higher ratings compared to the others because they have invested time in them. This is caused by the cognitive bias which is an inherent bias in human information processing. Thus, patents would be evaluated using the model when filed with the raters as completely un-invested stakeholders and external parties who have no prior exposure to the ideas or stake in their success. Based on the results of case 1, however, there might be a limitation in that due to confidentiality as well as external experts' limited knowledge in detail regarding a firm's strategy it may be difficult to make external experts involved in IP evaluation. Furthermore, it should be evaluated again after the patent issues to demonstrate the accuracy and credibility of this model. To this, it requires an iterative process in decision making for patent filing to validate and incorporate the model, as presented in Figure 3.

The additive weighted scoring model is employed in prioritizing project portfolio, evaluating new business ventures and the risk of military operations, and even for public policy issues (Hubbard, 2009). Through the literature review as well as the current use of companies in this survey, this study proposed the weighted scoring model. The weighted in this scoring model were provided by experts with current experience in patent filing in NPD. This value is quite subjective; other decisions might provide different weights, depending on their particular experience (Hubbard, 2009). However, the objective of cases is to test the decision criteria and to show how they can be utilized in a firm. The survey produces the weighted score for each criterion. More survey pool should be required to validate these values by averaging judgments of several experts.

Tony Cox indicated the drawbacks of the scoring method such as range compression, the presumption of regular intervals, and the presumption of independence (Hubbard, 2009). In this regard, the weighted scoring model proposed in this study is intended to overcome the drawback of range compression in the scoring model by using probability theory. This study determined the decision criteria that are mutually exclusive and collectively exhaustive based on the feedback of experts. This model also presumed regular intervals of the scores. There still exist some limitations inherent in this model. Many of the deficiencies in this study can be improved by the more applications of this method as well as by exploring peculiarities of theory-based approach since it is a common practice to ask researchers to reinforce the tools after review. We are actively seeking a new idea's patent filing decision making to apply this model to a firm. Further improvements including managerial implications based on firm size are recommended.

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