Forward-Looking Valuation of Strategic Patent Portfolios Under Structural Uncertainty

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Strategic patent portfolios are intangible assets that technology oriented companies hold to secure their competitive advantage in the future. Traditionally, valuation of forward-looking strategic patent portfolios is more an art than a science, nevertheless, they play an important role in the future competitive advantage positioning of high-tech oriented companies.

This paper discusses forward-looking strategic patent portfolios and presents some new ideas on how numerical valuation methods could be used in framing the valuation of these portfolios. The basis on which the forward-looking far away from exploitation strategic patent portfolios are valued is crucially different from the valuation of ‘in production’ patents or already existing licensable IPRs, since future strategic patents must be based on vague information with structural uncertainty about the future. The authors show how flexible tools and analysis using the pay-off method can be used to solve these complex problems faced by companies; and illustrate the same using a numerical example.

Keywords: Patent portfolios, strategic management, real options, structural uncertainty, pay-off method

The importance of intangible assets (ranging from the patents and copyrights to trade secrets and trademarks) as sources of competitive advantage is rapidly increasing.1 The Swiss Reinsure Company study in the year 2000 estimates that about two-thirds of the value of large industrial companies can be traced back to their intangible assets.2 Hence, it is of great importance for a company to be able to somehow value the future value of its intangible assets. In this article, the authors focus on the valuation of forward-looking strategic patents. According to the European Patent Office glossary definition, a patent ‘…gives inventors the right, for a limited period (usually 20 years), to prevent others from making, using or selling their invention without their permission in the countries for which the patent has been granted.’ Patent holders can profit from these exclusive rights either by protecting themselves against rivals and/or by exploiting new ideas through licensing (i.e. by receiving royalties) or cross-licensing them (i.e. overcoming protection). In some industries, for instance, in biotechnology and pharmaceuticals, patents are valuable mainly, because of their value creating features, whereas in other cases patents as such are perhaps not that valuable, but together they can be used in a way that makes them valuable (different patent strategies3,4 can be considered). Hence, it is important to be able to assess their value.

In this article, the authors examine possible approaches to the valuation of strategic patent portfolios. Often in general management parlance, the term patent is used collectively to describe any and all kinds of patents (present or possible in future). That is to say, the existing patents relevant to the day-to-day operations of a firm are also spoken in the same terms as forward-looking strategic patents that the firm might use to secure its technological footholds, perhaps ten years into the future. This conceptual inaccuracy however creates problems, when one tries to identify suitable methods for valuating different patents, from the operational to the strategic, from the existing ones to the ones that may be utilized later, in future.

According to our definition, strategic patent portfolios consist both of existing and forward-looking strategic patents a firm might use far into the future. The forward-looking patents are especially relevant within nascent technologies that do not yet have any ‘dominant designs’, or where the ecosystems are rapidly changing.1 By owning future-oriented strategic patent portfolios, companies proactively make sure that they will not be left out of future markets, since building a base

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of intangible rights after a winning technology unfolds may prove to be prohibitively expensive to obtain, or even impossible to build up, because rivals already have the exclusion rights through their IPRs.

The strategic use of patents can be very diverse, depending on the differences between industrial ecosystems, namely, on the interplay between patent strategies and organizational models. For instance, in mature process industries, operational patents are often used as means to create cost reductions, to slow down the development of rivals and/or to create standards, whereas in the rapidly developing ecosystems like in the ICT they are often used as ‘exchangeables’ through cross licensing. Within the ecosystems also, there are different patent strategies, i.e. ways to utilize patents while sustaining competitive advantage. For example, in the ICT there are companies like Qualcomm that mainly profit from the royalties on their strategic patents (or even companies like Nortel Networks that sold more than 6000 patents from their portfolio to rivals at an estimated price of US$ 4.5 billion) and companies like Apple that often carefully calculate the marginal litigation cost and the marginal benefits of patent infringements. Of course, there are also ecosystems like biotechnology and pharmaceuticals, where iron-clad patents are the main source of competitive advantage and where strategic patents are used for obtaining a temporary monopoly position. However, even the most strategic, already existing patents are not ‘forever’ (20 years at maximum) and that is why the firms have to search for new strategic patents all the time and here, even very vague calculations and estimates about their forthcoming value are of great importance. Hence, a ‘rolling’ valuation scheme that is effectively able to take into account and include the information about future patent options is badly needed. The present paper aims at contributing to this issue.

Because of the forward-looking nature of strategic patent portfolios, a large part of the strategic patents are in financial terms ‘not in the money’ – that is, the innovations they protect cannot yet be used in production and thus the patents do not have any intrinsic cash-flow value at the present time. Instead, the forward-looking parts of strategic patent portfolios are playing chips of technology-dependent companies for the right to exist in their technology-driven future markets. Indeed, they can be viewed as ‘currency that you can use to trade to another company’ for its patents.

Companies can and often wish to trade, or cross license only value creating patents, thus making individual patents’ quality and relevance an important issue for the tradability of patent rights. However, the patent quantity in portfolios is also an issue of importance. A portfolio of a single relevant patent is likely to be weaker in litigation than a portfolio of multiple complementary patents. Having a powerful enough portfolio in future markets is of key importance, because the quality and quantity of patents held by a technology dependent firm may determine whether the firm will be a real player in the future markets. For the purposes of this paper, the authors look at only two alternatives: a portfolio either is, or is not good enough to allow the firm a competitive advantage in future markets.

What this means is that a technology-dependent company must have an access to the relevant future technologies in its core business area, otherwise it will lose market share and even cease to be a profitable player in the market, thus signaling a need to perhaps exit the market. It is sometimes said that companies use their forward-looking strategic patent portfolios to mine the future playing field, meaning that the likely directions of future technologies, relevant to the firm have to be covered by patent portfolios (or cross licensed IPRs) owned by the firm.

This paper is organized as follows. First, patent valuation under different types of uncertainty is discussed. Second, the idea of ‘rolling’ valuation, when dynamically valuing forward-looking strategic patent portfolios is introduced. Third, a new simple approach to the valuation of strategic patent portfolios, more suitable for the conditions under structural uncertainty and a numerical example of how the approach can be used together with the pay-off method in the analysis of strategic patent portfolios are presented. The discussions and conclusions follow.

**Patent Valuation under Different Types of Uncertainties**

There could be different patent portfolios, some that are existing operational portfolios with the patents in ‘production’ use, some that will become operational portfolios in the intermediate (and thus mostly recognizable and sometimes even calculable) future and some, perhaps the most important ones from the ‘rolling’ valuation perspective, are the forward-looking portfolios that have their operational use much farther in the future. From the valuation


perspective, this means that the uncertainties involved in the different kinds of patents are quite dissimilar — an issue that should be taken into account in the choice of valuation methods used as indicated in Table 1.

Table 1 connects different patent types to the different categories of uncertainty faced by the decision makers and brings to the forefront the core of this paper. In the footsteps of Knight, the authors speak about ‘risk’, when the probability functions and the probabilities of different options are known, and about ‘parametric uncertainty’, when a decision maker has an exhaustive list of all the possible future states of the world and he/she knows the consequences of the actions, that is, he/she has certain knowledge about the structure, the future technology trajectories can take. In such a situation, where the probability functions are known (i.e. parametric uncertainty) the use of traditional (real options) valuation methods is possible and sometimes also advisable. However, then the much simpler method introduced in this article, the pay-off method, can also be used.

Unfortunately, the ideal conditions characterized by parametric uncertainty are seldom met when one looks at the domain of strategic patent portfolios consisting at least partly of ‘far away from exploitation’ (likely to be exploited only in the distant future) ‘not in the money’ patents. In this case a decision maker typically faces a situation characterized by structural uncertainty that is based on imperfect knowledge about the structure the future can take. There are many reasons for that, e.g., the agents do not know the set of all the possible future states and/or consequences of the actions of the players, there may be unintended and/or emergent (not yet existing) consequences, and there may be game-theoretic, or endogenous uncertainties depending on the acts of existing or forthcoming rivals. With structural uncertainty, traditional valuation methods fail, even if there are some strategic options-based devices for such a situation as well. In this paper, the authors utilize a recent approach for the valuation of strategic options based on the ‘pay-off method’ that can at least partly overcome some of the obstacles raised by structural uncertainty.

The usability of different commonly used patent valuation methods depends critically on the type of uncertainty that a decision maker faces. Under the condition of risk and/or parametric uncertainty, the patent valuation methods are usually divided into three general categories: the cost approach, the market method, and the DCF method. There are also other ways to classify patent valuation methods into finer categories, but the above division to three categories is well known.

The cost approach is based on assessment of benefits and the presupposition that an investor will not pay more for an asset if another investment of equal utility is available at a lower price. That is to say that a patent cannot be sold for a higher price if the benefit to the buyer is the same as the benefit from another patent with a lower price. Therefore, the price must reflect the costs of acquiring the same patent related utility from somewhere else – from reproducing the benefit of the patent with another asset, or from replacing the benefit in other means. The cost approach can involve the estimation of a number of separate costs that ultimately add up to the total cost, that is to say, a present value estimate of the patent analysed. The main problem with this method, of course, is that the markets for patents that are far away from exploitation are very imperfect or even non-existent, which in turn means that the cost methods cannot be used in such cases. Hence, this method is of no value when trying to valuate strategic patent portfolios.

<table>
<thead>
<tr>
<th>Patent types that compose the strategic patent portfolio</th>
<th>Uncertainty type pertaining to expected returns of the patent portfolio</th>
<th>Available valuation methods</th>
</tr>
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<tbody>
<tr>
<td>Present Existing operational patent portfolios</td>
<td>Risk or parametric uncertainty</td>
<td>Discounted cash flow (DCF), classical real options or the pay-off method</td>
</tr>
<tr>
<td>Near future Not yet existing operational or strategic patents that are recognizable and calculable</td>
<td>Parametric uncertainty... Structural uncertainty</td>
<td>DCF with e.g. simulations real options, if the structure can be identified, or the pay-off method</td>
</tr>
<tr>
<td>‘Far away from exploitation’ in the future ‘Not in the money’ strategic patents. Only weak signals recognizable by technology experts</td>
<td>Structural uncertainty</td>
<td>Pay-off method based on expert’s opinions or hunches and guesses</td>
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The market approach uses two categories of procedures to indicate value: (i) transactional data (of similar patents) and (ii) assessment of market conditions. By locating transactional data about the price of (as similar as possible) patents sold, and by analysing the market conditions at the time of the deal (in comparison to the moment of analysis), the market approach can be used to reach guideline pricing/valuation information about the patent. The approach is not exact and is based on the analyst’s judgment; nevertheless, the approach offers an often used way to price already existing patents in today’s value. However, if there are no comparable markets available this method does not function and therefore it is clear that it is most suitable for the short-run decision making, under risk or parametric uncertainty, when using the terminology of Table 1. The more structural the uncertainty, the more unsuitable is this method.

The third and most common DCF method is based on estimating future cash flows, revenues and costs, from the patent in question. The cash flows can include the (i) revenues based on better competitive advantage due to the exclusion right, (ii) licensing fee revenues and royalty rates now and in the future, (iii) the maintenance costs of patents (renewal fees, potential litigation costs, etc.) and (iv) any other cash flows, identified as being generated by ownership of the patent under analysis.\(^5\) The cash flows are estimated for the coming, future years and their value is discounted to the present value by using appropriate, risk adjusted discount rates, yielding as a result a present value estimate of the patent. This method is usable\(^5\) (but hard to work out) when valuating already existing patents whose revenues can be evaluated relatively accurately. The higher the uncertainty, the harder it is to estimate the expected cash flows and especially the value of faraway strategic options related to the use of patents as a complementary part of the whole patent portfolio. The value of single patents may depend on the size of the portfolio to which they belong and also on the function of the single patent in the portfolio.\(^15\) In other words, there may be (strong) synergetic effects in holding a patent portfolio. In addition, the valuation also needs to be done in terms of markets evolution and potential manoeuvres by rivals.\(^16\) Thus, the DCF method cannot help when one deals with strategic patents that are far away from exploitation.

In addition to the three methods mentioned above, there is also increasing literature on using the real options approach as a valuation method.\(^17\) This is not surprising, since it has been said that: ‘A real option is the investment in physical and human assets that provides the opportunity to respond to future contingent events.’\(^18\) Since all managerial and operating flexibilities that are embedded in non-financial (real) assets and liabilities can be interpreted as real options, it seems to be very usable in the current context, when looking for methods to valuate strategic patent portfolios. The value of a real asset (e.g. the patent) is the net present value of expected cash flows + (positive or negative) value of all the (strategic) real options related to it.\(^19\) From this perspective, the real options approach can be interpreted as an extension of the DCF method.\(^5\) It always needs more information than traditional DCF, but also gives a better estimate, if all the very strict preconditions needed for this approach exist. In brief, the domain of the real options approach is parametric uncertainty. The problem, however, is that in the strategic patent portfolio context, uncertainty is often structural in nature and cannot be tackled with random walk based options valuation models. Even harder is the use of valuation methods when the markets of underlying real assets are inefficient (thin) or even non-existent.\(^8,20\) In addition, especially the Black-Scholes\(^21\) model is based on several critical assumptions, such as the asset price distribution is lognormal, the asset price follows a Markov process, there are no riskless arbitrage opportunities, and that there are no transaction costs.\(^22\) These assumptions are all fundamentally violated in the context of far away from exploitation strategic options (patents) analysed here. No doubt, the method is suitable for some purposes, when the decision structure of the underlying asset (i.e. the patent concerned) is well structured and there are already quite similar products in the quite similar markets, as sometimes is the case in the pharmaceuticals business. However, in the ‘far away from exploitation’ context this method is seldom usable.

In brief, all the four methods above are hard to use for the valuation of strategic patent portfolios, as the information available is not in a well-structured form. In addition, the goal of the valuation here is to get a metric for the strategic value of the portfolio for the firm holding it, not for a market valuation. In the author’s view, the need to assess the value for the
holder, under ill-structured information and structural uncertainty presents a real challenge in the four above presented methods. Hence, this paper presents a blueprint for a simple fuzzy logic-based valuation method that is able to handle structural uncertainty and that is based on the portfolio-value-for-the-firm focus that is to say, is based on the judgements of the decision makers and technology experts.

It is perhaps worth mentioning that econometric patent literature also records numerous attempts to classify and even valuate patents based on information contained in patent databases. Such classifications and analyses based on these classifications rely on, for example, the amounts of patents granted, patents renewals, patent performance, and patent citations. They are often based on econometric methods for document classification and reveal the quantity and quality of patents in different industries and countries. Leydesdorff provides a good review of different types of document based patent classifications. Based on these classifications and matching classes to perceived or observed patent value, conclusions can and have been drawn on the value of a patent, based on the classification; there is a resemblance to methods used for example in bankruptcy prediction. However, all types of classifications discussed above are based on historical data only. Hence, they cannot reveal the future reasons for which the organization is holding the patents, that is, whether the patent is used to protect the present day business, near-future of the firm, or to strengthen the strategic long-term competitive advantage of the firm. Therefore, they are not relevant in this context.

**Increasing Information and Strategic Patents – The Idea of Rolling Valuation**

Having information about future technology trends and the types of technologies (i.e. technology trajectories) that may become relevant from the strategic patent portfolio perspective is necessary, when trying to value strategic patent portfolios. Nowadays, gathering of this information is becoming an explicit corporate function that can be called business and technology intelligence (B&TI) which is facilitated with special systems designed for the job. The B&TI function can be found in many corporations and different types of technology intelligence processes have been identified. The main idea of technology/market forecasting and matching it with strategic patent portfolios is that having the strategic portfolios of relevant technologies ensures the continuity of a high-tech firm. Hence, the ability to sense weak signals, create trajectory scenarios and proactively react upon them is becoming necessary in the rapidly changing turbulent environments.

Figure 1 depicts a situation, where a firm has identified a general technology trajectory, as a span or cone (indicating the path of future technologies) and has been able to identify three major technology strands within the general trajectory, for each of which the company has generated a portfolio of strategic patents. 'Generated' here means that the portfolio has been created either through (i) own R&D, (ii) imitation or purchased from rivals that engage in R&D, (iii) cross licensed from other players in the same markets, or (iv) from other players that do not have a foothold in the markets (e.g. universities, research centres, other firms). One could also, correctly, say that the three portfolios within a general trajectory together form one large portfolio of strategic patents.

Going back into the uncertainty categories introduced above, it can be observed that the near future domain of patents, that is the area A in Fig. 1, is under risk or parametric uncertainty. Such conditions often allow one to identify cash-flows for the operational or near future patents and means that classical numerical valuation methods or the pay-off method, based on estimated cash-flow scenario as previously reported can be used.

As can be seen from domains B and C in Fig. 1, the conditions characterized by parametric uncertainty are seldom met. B and C are the most important domains of the strategic patent portfolios and a decision maker
typically faces a situation characterized by structural uncertainty that is based on imperfect knowledge about the structure the future can take. In the extreme case, with regards to strategic patents, one may even come close to the so-called Knightian radical uncertainty, which is not far from ignorance. Under these circumstances the classical methods for numerical assessment of value cannot be relied upon.

As time ‘rolls’ from the starting period \( t_0 \) to the next evaluation period \( t_1 \), the direction that the emerging markets/relevant technologies take becomes clearer due to the reduction in the uncertainty (i.e. from radical to structural to parametric to risk to certainty). Some patents in the (originally three) strategic patent portfolios are found to become obsolete from the point of view of the firm (Fig. 2, encircled with a dotted line). They are often abandoned: the firm can either sell the unnecessary patents or stop paying the renewal and/or licence fees. It is a normal practice in high-tech companies that the patent portfolios are visited yearly to check if they still match the firm’s strategy; obsolete/non-suitable patents are retired and other patents exchanged for better (new) patents. This kind of ‘rolling’ dynamic patent portfolio management is often based on the more general corporate strategy. The important issue to note here is that as time passes, the span of the relevant technologies becomes ‘narrower’ (transition from area A to area B in Figs 1 & 2), and that the value of the remaining, ‘still relevant’ patents increases. This increase in value is most likely to be significant, since closer to operational or already existing strategic patents are, better are the chances to generate real cash-flow and greater are the chances that the firm becomes an important player in the future markets (based on the patented technologies) as well. This is also where the ‘portfolio theoretic nature’ of populating the whole span of future technologies, or mining the future playing field, becomes visible and understandable. If one has the whole board full of chips it is a good bet that one will win.

Fig. 2 shows the same patents that are visible in Fig. 1 at a later time \( t_1 \), illustrating the dynamic, rolling nature of patent portfolio management.

As time passes from period \( t_0 \) to period \( t_1 \), more information about the winning technology is revealed. Some patents become obsolete and can be abandoned (visible on the sides, encircled with a dotted line). The dynamic firm will re-populate the future playing field with new strategic patents to ensure continued existence in the future markets. Dynamic valuation that can capture the essence of this kind of thinking, where the future is revealed, period by period, as more information is received; causing the amount of uncertainty to decrease is here called ‘rolling’ valuation.

**Strategic Patent Portfolios under Structural Uncertainty: Simple Valuation Procedure**

The interest herein lies in the value of a given strategic portfolio for the holder firm of the portfolio, based on the future market position that the portfolio will enable the firm to obtain. That is, the strategic patent portfolio is seen as a membership card that allows entry to the future markets as a (lead) player. The valuation reason should be differentiated based on for whom the valuation is made and why. The aim here is not to obtain a likely sales price of a strategic patent portfolio, but to assess the value of holding the portfolio for future position in the markets for the firm holding the portfolio.

Based on the observation that firms populate the future technology landscape with their strategic patent portfolios to be players in the future markets, it is, from a long term strategy perspective, irrelevant to consider the value of a single patent or a single patent family. The value of the overall strategic patent portfolio, however, is of interest, because that is the ticket to the future markets, and the value comes from being a profitable player in the future markets. Therefore the valuation of a firm’s strategic portfolio is based on the value of the future market position it opens. The authors suggest a very simple and straightforward approach for the valuation of strategic patent portfolio(s) that is based on the managerial estimation of four values (issues):
(i) Estimated total size of the future markets (TSFM) that are opened by holding a relevant strategic patent portfolio (dollars in present value). Future market size estimation is not necessarily a very simple task, and it is made more difficult by structural uncertainty. Literature on forecasting in general\textsuperscript{31} and specifically on forecasting market size for new products\textsuperscript{32,33} can be used for guidance to the right direction. If the new innovation replaces some old technologies then the starting point may be to look at the size of the markets for the old technology.

(ii) Estimated market share (EMS) of the firm in the future markets (percentage). There are many approaches for estimating market share, and a good starting point may be to use the firms’ present day market share, as an anchor for the best estimate. There is a lot of literature on what determines market share and on different econometric approaches that can be used for supporting the estimation.\textsuperscript{34,35}

(iii) Estimated likelihood of the patent portfolio being the ‘enabling’ patent portfolio (LBEP) in the future markets, that is, the portfolio that allows the firm to be a player in the future markets and to capture the envisioned market share. All the firm’s strategic patent portfolios aiming at the specific future market should add to 100 per cent (percentage).

(iv) If one is a risk averse, a term that estimates the (overall) chances of having covered ‘all bases’ of the future technology landscape can be included (RT). This can be used to lower the odds of the firm to be a player in the future markets (percentage). RT is usable especially when strategic patent portfolios are being built, because it reflects the confidence of managers about the firm having necessary strategic patent portfolios.

The value of the patent portfolio can be calculated using formula 1:

\[ V_{\text{portfolio}} = \text{TSFM} \times \text{EMS} \times \text{LBEP} \times \text{RT} \quad \ldots \text{(1)} \]

For the cost side of the portfolios, it is suggested that DCF valuation of the estimated cost cash-flows be used. This recommendation is based on the fact that information about patent related costs is rather well known, and is under parametric uncertainty in the worst case. When this is done, one must account for the maintenance costs of the portfolio and include any renewal fees that have to be paid to keep the portfolio valid and estimate any legal costs in the case of litigation.\textsuperscript{5} Calculation of the net value of the patent portfolio can be calculated by deducting the present value (PV) of the total costs from the \( V_{\text{portfolio}}. \)

It is easy to observe that the estimation of the three or four values used in the above proposed evaluation method are all forward-looking and their value is difficult to estimate with precision. Indeed, the measurement instrument in the assessment of these values is most likely the judgments and expert estimates of the responsible managerial team. According to the authors, no laws of nature are violated if the managers are trusted in the estimation parameters for the above described method. It is, and has been well acknowledged for a long time that in practice, one usually employs educated guesses in the estimation of cash-flows or other variable values.\textsuperscript{35} Indeed in an investment context giving absolutely correct estimates about future variable values is impossible in practice.

One way to quantify the inaccuracy with regards to variable values, and especially forward-looking variable values that are contingent on the future state-of-nature of the environment is using scenarios. Using scenarios is a widespread practice of modeling the uncertain future of projects and assets. Here, different future scenarios are thought out according to different possible future ‘states of the world’ and cash-flows or value connected to these states, are estimated. Creating scenarios for strategic patent portfolios can be done based on the available information about the future; the information need not be precise, because the scenarios allow for a very wide variation of the states of the world/value. The information used in creating the scenarios can come from qualitative information gathered and even from existing patent/IPR analysis/management systems.\textsuperscript{37,38} Scenarios can be used to complement all three of the above mentioned patent valuation method categories. The scenario approach can also be used for strategic patent portfolio analyses, as it allows a large variation of the market size and market share estimations, as well as the variability of the likelihood of success and ‘coverage’ estimates. It is also commonly understood that any outcome ‘between’ these scenarios is possible. The scenario approach is also compatible with and used in the valuation of assets other than IPRs.\textsuperscript{39,40}

To utilize the proposed method in numerical analysis, the pay-off method is used which is a good fit with scenario based information and is able to work with imprecise information. The method has been presented in detail earlier\textsuperscript{41,42} and has also been introduced by the author previously\textsuperscript{11} in connection with valuation of operational patents. As the construct of the pay-off method is already previously documented, it is not discussed here.
The pay-off distribution, created from scenarios drafted for the value of the strategic patent portfolios, is a powerful graphical presentation that not only gives the decision-maker an intuitive understanding about the most likely value, but also about the relationship between the most likely future and the up and the downside; that is the potential and the negative risk that the value faces. In fact the shape of the pay-off distribution gives much information. When the shape is symmetric around the best guess value (the high point of the distribution), then the upside and the downside are expected to be equally possible and similar; an assumption that seldom holds for real world assets that most often offer a very asymmetric downside and upside. The width of the pay-off distribution reveals the extent of uncertainty of the value; the wider the distribution the more there is uncertainty. This ability to show the amount of uncertainty is what ties the pay-off method firmly to the rolling valuation discussed above.

In fact, when new, more accurate information arrives as the future is revealed, the width of the distribution decreases; this is perfectly in line with the ‘rolling’ planning discussed above. In the presence of certainty, the distribution reduces to a single number, this is the case always ‘after the fact’, i.e., when the outcome is known for certain. When scenarios are used in the valuation of strategic patents, the changes caused by new, more accurate information cause a change in the scenario values that are reflected directly and transparently in the resulting new pay-off distribution for the strategic patent portfolio value; the shape and the width of the distribution changes exactly in line with the changes in the scenarios. This is illustrated in Fig. 3, with the pay-off distribution for a strategic patent portfolio at four different times: starting from a situation with a more uncertainty (t₀) and ending up after two updates of new, more accurate, information (at times t₁ and t₂) to a situation with certainty (t₃). When new, more accurate, information is revealed the pay-off distribution narrows down and at t₃ (certainty) reduces to a single number. It can be seen from Fig. 3 that the change in the scenario values is not symmetric, that is, the change is not of the same size in the minimum and the maximum possible values and even the best guess ‘moves’ – this is realistic; as things change, very seldom change uniformly.

**Numerical Example of the Simple Valuation Procedure for Strategic Patent Portfolios**

In this example there are two strategic patent portfolios; both portfolios for the same future market. Portfolio 1 is a ‘ready’ portfolio of patents that the firm already has full ownership of and the Portfolio 2 is a portfolio of some patents that the firm has and others that need to be acquired through R&D, acquisition, or cross licensing. This is also reflected in the expected costs of the two portfolios.

Firstly, one estimates the total size of the future markets opened by holding the relevant strategic patent portfolio in present value terms (the estimate is the same for both the portfolios, as they are for the same markets), the market share of the firm in the future markets, the likelihood of the portfolio to be an enabling portfolio and the overall chance of the firm’s overall portfolio being effective. For each one of the four to-be-estimated values, the managers are required to give estimates for three scenarios (states of the future).
world): the minimum possible outcome, the maximum possible outcome, and the best estimate that represents the outcome that they think is the most likely one. These estimates for the two portfolios and for three scenarios for each can be seen in Table 2.

One continues by estimating the costs of keeping the portfolio alive and the estimated costs of litigation connected to the portfolio and in the case of Portfolio 2 the cost of acquiring the necessary IPR for the portfolio to become a ‘good enough’ portfolio. The cost side may be sometimes easier to estimate, as there is often information available on the size and timing of the recurring payments to keep the patents alive. Estimation of costs of acquiring more assets or the cost of litigation is more difficult; the use of scenarios helps on the cost side also.

The cost figures are not ‘connected’ to any revenue scenario that is, the highest estimated cost may take place in the lowest revenue estimate scenario; this is why, in order to get the overall minimum and maximum values, the lowest revenue estimate is matched with the highest cost estimate and vice-versa. The most likely best estimates for revenues and costs are matched. The result is the three net present value scenarios for the strategic patent portfolios, visible in the row marked NPV portfolio in Table 2. From the portfolio NPV scenario values a pay-off distribution for the strategic patent portfolios is created, the possibilistic mean value (MEAN in Fig. 4), and the real option value (ROV in Fig. 4) for the portfolios are calculated by using methods presented in an earlier work of the author. The MEAN and the ROV for Portfolio 1 turn out to be US$ 264M and US$ 263M and for Portfolio 2 they are US$ 13M and US$ 183M, respectively.

Figure 4 depicts the pay-off distributions showing how the value of the strategic patent portfolios is distributed according to the scenarios given by the managers. The real option value and the possibilistic mean value are visible and in relation with the pay-off distributions. Also zero NPV is visible (solid line in Fig. 4).

<table>
<thead>
<tr>
<th>Table 2—Estimates for two strategic patent portfolios given by managers</th>
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<tbody>
<tr>
<td><strong>Strategic patent portfolio 1</strong></td>
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<tr>
<td>Total size of future markets (US$)</td>
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<tr>
<td>Market share (%)</td>
</tr>
<tr>
<td>Likelihood of enabling portfolio (%)</td>
</tr>
<tr>
<td>Overall chances (%)</td>
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<tr>
<td>( V_{\text{Portfolio}} = TSFM \times EMS \times LBEP \times RT ) (US$)</td>
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<tr>
<td>PV total costs of portfolio (US$)</td>
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<tr>
<td>NPV portfolio (US$)</td>
</tr>
<tr>
<td><strong>Strategic patent portfolio 2</strong></td>
</tr>
<tr>
<td>Total size of future markets (US$)</td>
</tr>
<tr>
<td>Market share (%)</td>
</tr>
<tr>
<td>Likelihood of enabling portfolio (%)</td>
</tr>
<tr>
<td>Overall chances (%)</td>
</tr>
<tr>
<td>( V_{\text{Portfolio}} = TSFM \times EMS \times LBEP \times RT ) (US$)</td>
</tr>
<tr>
<td>PV total costs of portfolio (US$)</td>
</tr>
<tr>
<td>NPV portfolio (US$)</td>
</tr>
</tbody>
</table>

Notes: NPV-net present value, PV-present value
For Portfolio 1, the best estimate value is clearly positive at US$ 292M and the shape of the distribution is rather non-symmetric with a long left tail that is only for a small part in the negative area. This causes the probabilistic mean value and the real option value to be very similar (MEAN=264M and ROV=263M). From a decision-maker perspective, Portfolio 1 is ‘looking good’.

Portfolio 2 offers a different story, because the best estimate (net present) value of the portfolio is negative (-340M). If a classical net present value decision rule were being used, the portfolio should be abandoned. However, in this case, the interest lies in scenarios other than the best estimate, and the pay-off distribution allows viewing beyond the best estimate scenario; thus, Portfolio 2 has an asymmetric pay-off distribution with a large upside that caps at 145M and a downside of -5014M at the maximum. Possible questions are: can one get a good single number that takes into consideration the downside and the upside that gives something to compare the best estimate with and what is the upside worth? Answers to both questions can be got from the probabilistic mean value (MEAN = 13M) and from the real option value (ROV = 183M). The probabilistic mean reveals that the ‘smart expectation’ taking into consideration the shape of the pay-off distribution is actually positive, and that the option value of the upside is even above the mean of the pay-off distribution, indicating that it would make sense to wait and see what the future reveals. The actual cost of acquiring the complementary assets may prove to be a positive surprise, in which case the waiting will pay-off. Ultimately holding on to Portfolio 2 and going ahead with the acquisitions of the completing assets or abandoning the portfolio is a management decision; the point made here is that using the presented simple strategic patent portfolio valuation method with the visualizations offered by the pay-off distributions and calculating smart descriptive numbers, changes the nature of decision-support for these hard to valuate assets in a fundamental way.

**Conclusion**

Strategic patents are defined by the authors as patents that are of strategic importance when a firm tries to sustain its competitive advantage now and, most importantly, in the future. It is hence clear that strategic patent portfolios are a key class of intangible assets for firms and thus it is of importance to be able to quantify and valuate these assets. It is notable that the ideal conditions for valuation are seldom met and typically the case with strategic patent portfolios is that a decision maker faces a situation characterized by structural uncertainty that is based on imperfect knowledge about the structure the future can take. This causes the most often used patent valuation and analysis methods to be incompatible or even irrelevant with the valuation of strategic patent portfolios. It is, and has been well acknowledged for a long time that in practice, one usually employs educated guesses in the estimation of cash-flows or other variable values. Indeed in an investment context, in which the investments into strategic patent portfolios also take place, giving absolutely correct estimates about future variable values is impossible in practice.

The authors have proposed a solution to this dilemma by presenting a simple numerical method for the analysis of the value of strategic patent portfolios that is based on: (i) using expert opinion and judgement to quantify three to four factors that contribute to the value of the patent portfolio; (ii) giving estimates for each factor, under three scenarios (states of the world); and (iii) using the pay-off method to analyse the value of the patent portfolios further. Using the pay-off method has been also previously reported, however, the context has been very different—valuation and pricing of operational patents. Here, one is looking at a different class of patents in the sense that information about strategic patents and operational patents is in a fully different form. While speaking of the pay-off method, the authors do not claim to have invented a new method, but that the pay-off method is a good fit with strategic patent valuation with the simple method that is introduced.

The method shown has been designed to reveal the inaccuracy of the given estimates and the available information (rather than to disguise it) thus giving decision-makers better grounds on which to base their decisions on strategic patent portfolios. Graphically presenting the pay-off distributions of the strategic portfolio value with descriptive numbers gives a clear advantage, even when valuation is made under risk or parametric uncertainty, over the commonly used valuation methods that often use and present results with single expected numbers alone.

The paper has presented how information, with regards to strategic patents, changes with time and some patents become more valuable as others lose value. This information is highly relevant and being able to understand and use it constitutes the
foundation of dynamic valuation of strategic patents that we call rolling valuation. It has been seen that the pay-off method is compatible with rolling valuation, because it is able to visualize the changes in information. This is a clear advantage over previous methods. The advantage is accentuated by the fact that when new, more precise information arrives, the numbers change and the changes are transparently reflected by changes in the pay-off distribution. Transparency is important when dealing with inherently complex and inaccurate issues in the first place. The ability to adjust strategic patent portfolio valuation dynamically allows decision makers to compare the pay-off distributions in two different times for information about the direction the value of the portfolio is taking and about the changes in the amount of risk that is connected to the portfolio value. Put in other words the above described methods enable the badly needed ‘rolling’ valuation scheme for the valuation of strategic patent portfolios.

The methods above are flexible tools, as they can easily be accommodated to be used in the commonly used spreadsheet environment found in many firms. What the method also enables is a good basis for further analysis and decision-making with regards to strategic patent portfolios, including possibilities to connect the method to systems that support group decision-making and consensus that might be important when multiple experts/decision-makers are doing the valuation as a collaborative effort.43,44

There are however limitations: with the presented method it is not possible to get answers/valuations that are any more accurate than the accuracy of the expert opinions and judgement that is used as an input into the method – this is a principle that must be fully understood, when using the method. This observation goes hand-in-hand with the acknowledgement that in a real world setting getting good information about the strategic patent portfolios may be hard, or very hard, and it is likely that one must accept simplification of reality in order to be able to perform analysis. The presented use of the method is in situations where the decision-maker faces structural uncertainty. When information about market structure and parameters that drive the markets become available one may want to start using methods such as the Monte Carlo simulation that allow for specific treatment of single parameters.

Even while acknowledging the limitations, the authors feel that the above presented method offers a very useful addition to the toolkit of managers working with the valuation of strategic portfolios under structural uncertainty.

References
9 Knight F, Risk, Uncertainty and Profit (Hart, Schaffner & Marx, Boston, 1921).