

Enhancing Patent Valuation with the Pay-off Method

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Numerical valuation of patents is a difficult task due to great uncertainty regarding the future and inaccuracy in estimation. The pay-off method is an easy to use and understand analysis method that is based on using value scenarios and real options-thinking. The method is designed for the analysis of assets that suffer from difficulties in estimation precision and often face high uncertainty. This paper shows how patent valuation can be enhanced with the help of the pay-off method, based on any of the three 'conventional' patent valuation methods. A numerical case about how the pay-off method can be used together with the discounted cash flow method is presented. The method is already in use by a number of multinational companies for valuation of R&D and is on its way to be introduced into the IPR functions of a number of corporations.

Keywords: Pay-off method, patent valuation, discounted cash flow method

In practical IPR management, the evaluation of existing patents takes place on a regular basis, usually once every year. During the evaluation, managers adjust their evaluation of patents (patent families) according to the available new data. Patent valuation data can be collected in a structured way, but it is the authors' experience that in many organizations the data regarding valuation of patents and other IPR resources in monetary terms is seldom methodically gathered. Patent analysis and decision-making regarding patents are most often done based on qualitative assessments alone. This is also visible in the volume of qualitative methods for patent valuation (*vs* methods that use monetary terms); out of twenty-five observed valuation and measurement methods most are qualitative measures of patent 'goodness' and the ones that include valuation in terms of money rely on the conventional discounted cash flow.^{1,2}

There are, however, also examples of how qualitative and quantitative information about patents can be collected and even of systems dedicated to the task.^{3,4} Many of the general information gathering is notably more interested in the 'patent landscape' or about gathering information

on whether certain innovations are patentable or not, than the actual valuation of the individual patents or patent families held by a given company. In this paper, it is expected that there is at least a desire to use the result of patent valuation in monetary terms as an input in the patent(ing) decision-making process, and concentrates on how the recurring yearly patent analysis process can include patent valuation and patent value adjustment based on available new and changed data. It is felt that valuation in terms of money together with qualitative analysis can yield new insights for decision-makers and furthermore there is certainly a market for methods that can be used in giving, even a directional monetary value to patents.⁴⁻⁶

Since new data may imply changes in the patent value, it is important that these changes are made visible to the decision makers, who determine the future of individual patents and the company patent portfolio. For this purpose, it is essential that the gathered data is processed and stored systematically and presented to the decision-makers in a coherent way that facilitates decision-making. That is, the causal logic of how a change in data affects the estimated patent value should be made as clear as possible. When monetary valuation is attempted,

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many issues regarding the patent that can contribute to the value of the patent need to be addressed^{7,8}; these 'variables' are all uncertain and their effect to patent value needs to be understood correctly.

When decisions about patents are made and patent valuations are available, the managers can compare the updated value of patents to the values in previous years, and trace reasons for the change in the values; perhaps even back to individual 'variables'. This facilitates decision-making – it is easier to decide to continue/discontinue a patent, when information about the 'direction' the patent value is taking, is available. The managers can also possibly reflect on the consequences of their previous decisions and pave way for new, better informed decisions. The decision-makers will also usually want to know the value of new patenting opportunities, because they may affect the value of both, current patent families and new technology based business opportunities. Consequently, patent valuation has a close connection to R&D valuation⁹ and can often utilize data collected from R&D managers; or data already collected for the analysis of projects in the R&D stage, if such data is available.

The usual understanding is that there are three general categories of valuation methods for patents. These are the cost approach, the market method, and the income approach or the discounted cash flow (DCF) method.^{10,11} The cost approach is based on the supposition that an investor will not pay more for an asset than the price of another investment with the equal utility. That is to say that a patent cannot be sold for a price if the benefit to the buyer is the same as the benefit from another patent (asset) with a lower price. Therefore, the price must reflect the costs of acquiring the same utility from elsewhere – 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 cost, that is to say, the value of the patent under analysis.

The market approach uses two categories of procedures to indicate value (i) transactional data (of similar patents) and (ii) assessment of market conditions. By finding transactional data about the price of (as similar as possible) patents sold and by analysing the market conditions at the time of the deal and in comparison to the moment of analysis, the market approach can be used to reach comparative or

guideline pricing/valuation information about the patent. The approach is not exact and is based on the analyst judgment; nevertheless, the approach offers an often used way to price patents.

The income approach or the DCF method is based on estimating the future cash flows, revenues and costs, from the patent in question. These can include royalties, licensing income, costs of keep and any other cash flows, identified as being generated by ownership of the patent under analysis. The cash flows are projected (estimated) to the future and their value is discounted to present value by using appropriate discount rates, yielding a present value of the patent.

The numerical valuation of patents is a tricky business and there is no one established, only way of patent valuation. Patents that have only clearly identifiable and rather certain future cash flows can be valued quite reliably with the most commonly used asset valuation methods¹², but unfortunately, often when these methods are used for the valuation of patents they do not seem to offer a good fit to the problem.⁹ This is due to cash flows from patents being difficult to estimate and causes the results often to be rather 'direction giving' than a true basis for serious analysis.

Using scenarios is a widespread practice of modeling the uncertain future of projects. The idea with scenarios is that different future scenarios are thought out according to different future 'states of the world' and cash flows or value connected to these states, are estimated. Creating scenarios for patents and patent families can be done based on the available information about the future; the information need not be precise, because the scenarios allow for even a very wide variation of the states of the world/value. The information used in creating the scenarios can come from the qualitative information gathered and even from existing patent/IPR analysis/management systems.^{7,13} Scenarios can be used to complement all three of the valuation method categories. It is usual that three scenarios are drafted for an investment (patent); best guess, optimistic, and pessimistic. The scenarios reflect how the patent value will fare under the most likely future circumstances and under better-than-expected and worse-than-expected states. It is commonly understood that any outcomes 'between' these scenarios are possible. The scenario approach is also compatible with and used in the valuation of other assets.^{14,15}

The pay-off method is an easy to use and understand analysis method that is based on using value scenarios for building a pay-off distribution of the asset under analysis. The method is specifically designed for the valuation and analysis of assets that suffer from difficulties in the accurate estimation of timing and size of cash flows and allows for wide margins of uncertainty. The pay-off method is usable together with the three most often methods for patent valuation, when these are combined with using value scenarios. The relationship of the pay-off method with the three conventional valuation methods is presented in Table 1.

The Pay-off Method

The pay-off method (POM)¹⁶ is an analysis method that is suitable for cases, where value information is in the form of scenarios. The main idea behind the pay-off method is to create a distribution from values of, usually three, value scenarios: best guess scenario, minimum possible value scenario, and maximum possible value scenario. This is done by:

- (i) observing that the best guess scenario is the most likely one and assigning it full degree membership in the set of expected outcome;
- (ii) deciding that the maximum possible (optimistic) and the minimum possible (pessimistic) scenarios are the upper and lower bounds of the distribution – there is also a simplifying assumption: to not consider values higher than the optimistic scenario and lower than the pessimistic scenario; and
- (iii) assuming that the shape of the pay-off distribution is triangular.

After the construction of a pay-off distribution, treating it as a fuzzy number allows the performance of mathematical operations on it. It is possible, for example, to calculate a real option value for the patent under analysis, directly from the pay-off distribution

by using the fuzzy pay-off method for real option valuation.¹⁶ One can also calculate a single number expected value from the pay-off distribution that takes into consideration the shape of the distribution by calculating the possibilistic mean value¹⁷ of the distribution. These calculations are easy to perform when using triangular pay-off distributions.

When the discounted cash flow approach for patent valuation is used, the POM can be also used in valuation of compound real options¹⁸ and other compound assets for which cash flow scenarios can be built. These characteristics make the pay-off method a good fit with the patent analysis performed with the discounted cash flow method. The method seems to be useful also in valuing projects that are based on patent protection and that require real option valuation, such as research and development (R&D) projects. The use of the pay-off method in R&D project valuation has been reported earlier.¹⁹⁻²¹

For the purposes of patent analysis with the pay-off method, it is suggested that three or four value scenarios are used, because they lead to triangular or trapezoidal pay-off distributions. Derivation of the possibilistic mean for the positive side of different types of distributions in this context has been presented by Collan *et al.*¹⁶ and the definition of the possibilistic mean has been presented by Carlsson *et al.*¹⁷ Figure 1 shows an example of a triangular pay-off (NPV) distribution from where the real option value can be calculated with the pay-off method.

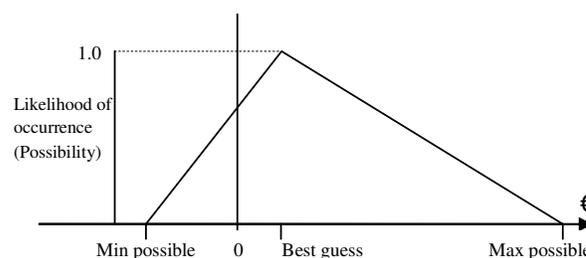


Fig. 1—An example triangular pay-off distribution as a fuzzy number

Table 1—The three conventional patent valuation methods and their relationship to the pay-off method

Valuation method	Description	Pay-off method
Cost approach	Valuation based on the costs of being able to reproduce or replace the benefits from the patent under analysis from other sources	'Maximum possible', 'best guess', and 'minimum possible' scenarios are created by using the valuation method of choice. These are then used as input into the creation of a pay-off distribution. The distribution can be used to show graphically the variability of the expectations under different states of the world.
Market method	Valuation based on comparable or guideline transactions that are used as a benchmark in valuation	The real option value and a single number expected net present value (NPV) can be calculated from the distribution
Income approach / DCF method	Valuation based on discounting the expected cash flows from the patent in question to present value	

Patent Valuation Using Three Scenarios with the DCF Method

In this section, the creation of three scenarios for a patent value with the DCF method is discussed. The resulting scenario values can later be used as a basis for the pay-off method.

Identifying the relevant cash flows; for the purposes of this research two main sources of patent cash flows: 'own use' and 'licensing' are considered, where 'own use' includes all in-house use of the patent (technology) that cause identifiable cash flows that are generated by the fact that the patent exists. 'Licensing' includes all the cash flows originating from other sources, e.g., royalties, sales income, cross-licensing related cash flows. In reality, the cash flows may originate from many sources, however, for the purposes of this research it is simplified to include these two aggregate sources.

When future patent cash flows are estimated, the IPR manager needs to gather all the relevant information that, according to current knowledge, affects the benefits of the patent in own business operations and generates licensing benefits, such as licensing fees and royalties. In addition to current own production and licensing contracts, the manager needs to estimate the effects of future own production, future contracts and own and customer IPR actions, such as replacements of existing patents with new ones. The main focus is on the net effects of the patent, either independently, or as part of a bigger entity, such as a patent family.

In the absence of market data, cash flows often need to be constructed by taking expert opinion on the patent cash flows; their size and timing. A typical question to an expert may read: 'How much do you expect our own production to benefit if we replaced patent A (that covers us from harmful low cost production) with patent B (that helps us not only to remain our position for the next three years, but also expand it to new businesses)?' The emphasis of this type of question is on net benefits, that is, on net cash inflows. When a company competes internationally and has patents in several countries, these questions can be made for each market separately, if such accuracy is desired.

The uncertainty concerning the future cash flows can be considerable that is why it must not be overlooked. In this approach, to tackle the estimation uncertainty, the authors' asked managers to give information on three different states: a best guess (most likely), an optimistic (maximum), and a

pessimistic (minimum) scenario of the future cash flows. By asking the managers to consider different scenarios, constraining them to create averages that may be misleading is avoided. As a result of collecting the expert opinions on cash flows, one gets cash flow scenarios as shown in Table 2. These scenarios can then be discounted to present value (scenarios) by using appropriate discount rates, which should be higher for the market steered revenues, than for the company steered costs.

Aggregating the present value (PV) scenario information by adding for each year the optimistic scenario cash flows for cost and revenues, and doing the same for the best guess and the pessimistic scenarios the PV scenarios for the patent were obtained. Fig. 2 is a graphic representation of the cumulative PV scenarios for the data in Table 2. The cumulative PV for the scenarios over the estimation horizon is the scenario NPV.

Using the net present values of the three cash flow scenarios a simple NPV distribution, that is, a pay-off distribution for the patent is constructed. Firstly, this is done by observing that the best guess scenario is the most likely one and assigning it full membership in the set of possible outcomes. Secondly, it is decided that the optimistic and pessimistic scenarios are the upper and lower bounds of the distribution – with a simplifying assumption that the values higher than the optimistic scenario and lower than the pessimistic scenario are so unlikely that they need not be taken into consideration. Although this assumption may not be very accurate, the simplification does not jeopardize the reliability of the results which will remain at a 'good enough' level. Thirdly, it is assumed that the shape of the pay-off distribution is triangular. These three steps allow us to easily construct the triangular pay-off distribution, based on the three scenarios constructed for the patent cash flows, and needed for the analysis with the pay-off method.

In the next section, the use of the pay-off method in the valuation of patents is illustrated with an example and it is shown how the information about patents in the form of cash flow scenarios can easily and intuitively be used in the valuation of patents. The numbers presented above in Table 2 and Fig. 2 are used.

Illustration of the Pay-off Method

Consider a company in the process of analysing the value of patenting a cost reducing innovation. The company has limited own production capacity that

Table 2—Cost- and revenue cash flow and present value for a patent with three scenarios

Time (t)	0	1	2	3	4	5	6	7	8	9	10
Cost cash flows (patent maintenance costs)											
Optimistic	3000	3000	1000	1500	1500	3000	1500	1500	1500	2000	2000
best guess	3500	4000	1200	1550	1550	3200	1600	1600	1700	2200	2200
pessimistic	6000	6500	3000	1800	1800	4000	2000	2000	2000	2500	2500
Present value of cost cash flows rd= 5.00%											
Optimistic	3000	2857.143	907.0295	1295.756	1234.054	2350.578	1119.323	1066.022	1015.259	1289.218	1227.827
Best guess	3500	3809.524	1088.435	1338.948	1275.189	2507.284	1193.945	1137.09	1150.6269	1418.14	1350.609
Pessimistic	6000	6190.476	2721.088	1554.908	1480.864	3134.105	1492.431	1421.363	1353.6787	1611.522	1534.783
Licensing fees and royalty income											
Optimistic	0	0	20000	30000	50000	50000	50000	50000	50000	50000	50000
Best guess	0	0	10000	18000	27000	35000	35000	35000	35000	35000	35000
Pessimistic	0	0	0	3000	5000	5000	5000	7500	7500	7500	7500
Competitive advantage resulting from the patent											
Optimistic	0	0	1000	1000	1000	1000	1000	1000	1000	1000	1000
Best guess	0	0	500	500	500	500	500	500	500	500	500
Pessimistic	0	0	0	0	0	0	0	0	0	0	0
Present value of the positive wealth resulting from the patent rd= 20.00%											
Optimistic	0	0	14583	17940	24595	20496	17080	14233	11861	9884	8237
Best guess	0	0	7292	10706	13262	14267	11889	9907	8256	6880	5733
Pessimistic	0	0	0	1736	2411	2009	1674	2093	1744	1454	1211
Net present value of the patent											
Optimistic	121546	Real option value (ROV)				62444					
Best guess	68423	Possibilistic mean value				63512					
Pessimistic	-14162										

can utilize the competitive advantage resulting from the patent in its home country. The most important source of cash flows from patenting is in the form of licensing fees and royalty income from selling the rights to use the innovation to other producers. The value generated by the patent is estimated in three scenarios (optimistic, best guess, and pessimistic) for both the licensing and royalty fees and for the competitive advantage resulting from the patent. The discount rate for the revenues is estimated at 20 per cent (see Table 2).

The costs of filing and patent maintenance are estimated for ten years following the current year. Three scenarios are estimated for the filing and maintenance costs. The estimations are based on company experience on similar patents filed previously. The filing and maintenance costs are discounted at a 5 per cent rate. Both the created value and costs are estimated for ten years, eleven counting the current year (Table 2).

To create the maximum value of the NPV distribution, the sum of present values of the optimistic cost scenario (lowest cost) is deducted from the optimistic created value scenario (highest created

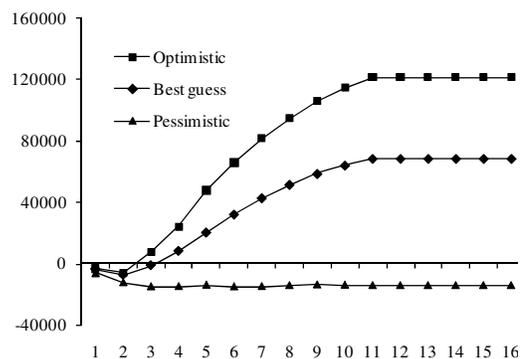


Fig. 2—Cumulative PV scenarios for the patent

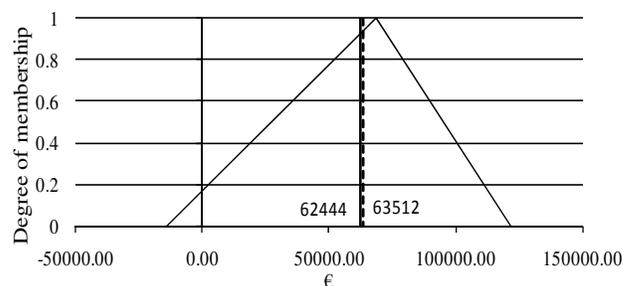


Fig. 3—Pay-off distribution for the patent with the real option value (62444) and the expected value (63512) indicated

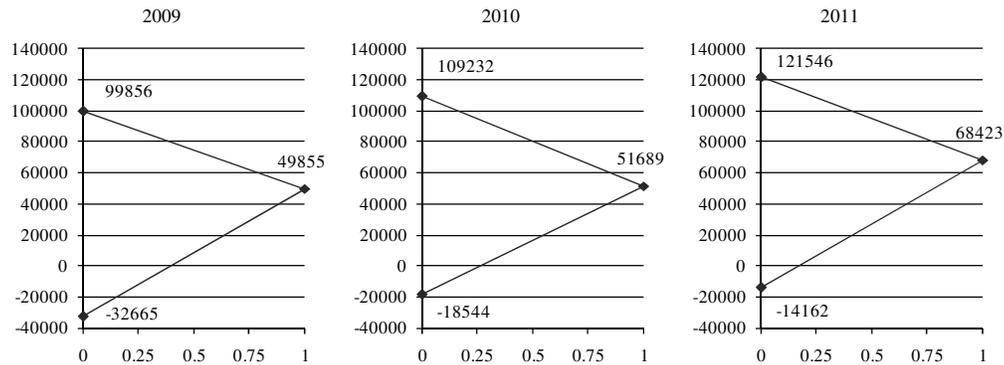


Fig. 4—Graphical comparison of the pay-off distributions of a patent for three consecutive years, the numbers from the example are for 2011

value); similarly the minimum value for the NPV distribution is calculated by deducting the sum of the present values of the highest cost scenario (pessimistic) from the sum of the present values of the lowest created wealth scenario (pessimistic). The best guess scenario present values for created value and costs are used to create the best guess scenario.

The resulting net present values for the patent range from (min) -14162€ to (max) 121546€ with the best guess scenario value at 68423€ (using the numbers from Table 2). A triangular distribution from the resulting patent net present values is created: first, the most likely scenario value (the middle value) is assigned a full membership in the set of possible patent NPVs, that is, the best guess scenario value will receive a membership grade of 1.0. The minimum and maximum (pessimistic and optimistic) NPV scenario values are assigned a minimum membership in the set of possible project net present values, that is, a membership grade that approaches zero. This means that values below the pessimistic scenario value and above the optimistic scenario value do not belong to the set of possible project net present values, and are not considered possible values. The values between the minimum and the best guess value and the maximum and the best guess value will have an intermediate grade of membership in the set of possible patent net present values. The resulting net present value distribution, that is, the pay-off distribution is visible in Fig. 3.

The created triangular distribution can now be used for the calculation of the real option value by calculating the possibilistic mean value for the distribution and the real option value. 62444€ is obtained as the real option value and 63512€ as the single number expected NPV.

The ‘real power’ of the pay-off method is revealed when it is used graphically in the comparison of patents competing for the same budget or with earlier pay-off distributions of the same patent, as in Fig. 4. The pay-off distributions show graphically the change in the value expectation of the patent. This is good for enhancing understanding about the direction in which the value of a patent is developing and is helpful in comparing patents, for example, in portfolio selection situations.

Conclusion

The evaluation process of new patenting opportunities and existing patents needs quantitative methods that give the IPR management insights to the value of their patents. Analysis of patent portfolios is often done on a regular basis, usually once every year. If good methods are available, this recurring analysis can also yield information on the direction that a patent value is taking; while comparing consecutive analysis results gives even more information. Many of the evaluation and analysis methods reported in the literature for patents are to a very high degree qualitative. This may be due to the often very wide margin of uncertainty and estimation inaccuracy connected to patent information. Three conventional methods, the cost based approach, the market method and the discounted cash flow method, are most often used in valuation of patents.

The pay-off method presented above offers an intuitive method for presenting the value of patents that includes and is able to intuitively present the uncertainty in the valuation. The method is based on the creation of value distributions, that is, pay-off distributions by utilizing the value scenarios. The method takes a leap of faith when constructing

a simple pay-off distribution that is directly based on the value scenarios, and that includes the perceived uncertainty and inaccuracy that is then treated as a fuzzy number.

The pay-off distribution can then be used for the calculation of a real option value and a 'smart' single number expected value for the patent. The method is based on sound use of fuzzy logic (fuzzy mathematics) and is straightforward. The results, including the graphical presentation of the pay-off distribution for the patent and the single number real option value and the NPV give valuable support to the manager when considering the value of a patent. Changes in the pay-off distribution reflect changed information in the value scenarios, updated by the experts during the recurring analysis sessions. Each change in the scenario values has a direct effect on the shape and size of the pay-off distribution and the end results. When the discounted cash flow method is used, a change in a single expected cash flow causes a change in the pay-off distribution; such transparency is something that managers are likely to commonly appreciate. Comparison of the pay-off distributions allows the management to put two patents (families) 'on the same line' and, if needed, to select the better one. Changes in the patent information change the distribution and allow the management to compare the distributions (value) of a given patent as a function of time.

Graphical presentation of the pay-off distributions can be used for the comparison of different patents in an intuitive way. It may sometimes be difficult to understand the potential and the risk of patents easily and therefore their comparison may be hard. When pay-off distributions are compared, the comparison becomes easy as the potential and the downside are visible clearly.

Using the pay-off method introduces an additional step to patent analysis, on top of the normal valuation procedures, perhaps performed with one of the three conventional patent valuation methods. The method is based on simple procedures, and for the calculation of single number descriptives like the real option value and the possibilistic mean value (a single number expected value) uses fuzzy logic based formulae. These may prove to be difficult as fuzzy logic is not well known by all. The method is admittedly a rather simplified picture of reality, and if a more complex representation is needed, then perhaps the pay-off method should not be used as the final tool in patent analysis. The method is suitable for situations of screening and fast analysis.²²

The method presented here opens new avenues for managers involved in the valuation of patents, patent families, and patent portfolios. The method is not in conflict with any of the earlier methods presented in the literature, but can complement them, and on many occasions is able to utilize directly the inputs already available in companies using the discounted cash flow based methods earlier presented.

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