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Reinterpreting Patent Valuation and Evaluation: The Tricky World of Nanotechnology

Luca Escoffier

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Abstract

In this paper, the author, an IP scholar and entrepreneur, analyses how nanotechnology will pervade all industries and therefore how important it is to find a proper method to valuate and especially evaluate nanotechnology-related inventions. Attaching a value or evaluating a technology is a fundamental task nowadays, especially when innovations are supposed to be licensed or assigned. The paper focuses on the different valuation and evaluation techniques that professionals usually employ, and then delves into the world of nanotechnology. It tries to develop a novel method that takes environmental and health-related issues into due consideration when attaching a value or evaluating a technology in the nano world. The novel tool envisioned in the paper is particularly suitable for nanotech innovations, but it can be used for the evaluation of other technologies and patents as well. The innovative idea consists of introducing the concept of Present Value After Evaluation, which takes qualitative variables into consideration and provides a figure for the analyzed technology or patent. This method and the accompanying tool are perfectly suited for evaluation purposes when environmental and human safety concerns are at stake, because they take these variables into consideration and throughout technology's life cycle.

Keywords

Nanotechnology, patent valuation, patent evaluation, technology, Present Value After Evaluation.

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I. Introduction

Nanotechnology is a very fascinating branch of technology. First of all, it is worth mentioning that there is a difference between science and technology. This might be a trivial explanation, but I am fairly certain that most of us think that these terms can actually be used interchangeably. Well, by "science" we mean a defined set of knowledge that allows us to understand and eventually change the world around us. By "technology" we mean the way humans and machines can turn science into something physically existing, and usable by humans or machines. So, to make things clearer and closer to our main topic, nanoscience is the study of the behavior of atoms and molecules within the 1 and 100 nanometers range. As for nanotechnology, the following is the most commonly accepted definition:[1]

> *nanotechnology is the understanding and control of matter at dimensions between approximately 1 and 100 nanometers, where unique phenomena enable novel applications. Encompassing nanoscale science, engineering, and technology, nanotechnology involves imaging, measuring, modeling, and manipulating matter at this length scale. [] Unusual physical, chemical, and biological properties can emerge in materials at the nanoscale [].*

[1] Definition provided by the website of the National Nanotechnology Initiative, available at http://www.nano.gov/html/facts/whatIsNano.html (last accessed on 23 January 2011).

Nanotechnology will change the way we live in this world.[2] Scientists are constantly discovering novel ways to obtain known or new results by reinventing the way metals react, change color, conduct electricity, etc and nanotechnology gives them a sort of mystical power. Indeed, the recently developed capacity to manipulate the matter transcends humanity. Products employing nanotechnology are growing steadily, and they offer consumers outstanding qualities and increased performances. The nanoscopic size of materials is the reason why nanotechnology is booming. However, it is also the main threat to this technology's otherwise brilliant future. Scientists are questioning whether more research on the side effects of these potentially hazardous materials should be carried out before continuing the use of nanotechnology research and nanomaterials. It is kind of paradoxical, but the truth is that the branch of science and technology that is most promising in terms of benefits may also be the most dangerous ever conceived in our history.

In this regard, it is worth talking about the potential risks that nanotechnology can entail in terms of human health and environment.[3] The phenomenal characteristics of nanomaterials are strictly correlated to the very size of the matter. In fact, it has been

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[2] There are 4,952 inventoried and on sale books on Amazon.com concerning Nanotechnology as of January 11, 2011. At any rate, two must-have books to understand what the future of nanotechnology is likely to be are:

- Ray Kurzweil, The Singularity is Near: When Humans Transcend Biology, Penguin Books, 2006;
- Eric K. Drexler, Engines of Creation The Coming Era of Nanotechnology, Anchor Books, New York, 1986.

[3] At present, there are already several reports and articles concerning the potential and assessed risks for the environment and humans related to the employment of nanotechnology. For a comparative review, please see Trudy E. Bell, Understanding *Risk Assessment of Nanotechnology*, available at http://www.nano.gov/Understanding_Risk_Assessment.pdf (last accessed on 9 January 2011), and the Cordis webpage about safety aspects, available at http://cordis.europa.eu/nanotechnology/src/safety.htm (last accessed on 18 January 2011).

understood that materials, when manipulated within the 1 and 100 nanometers range display novel and unexpected properties. Unfortunately though, these ranges are so small that they are not visible to the human eye, not even with an ordinary microscope. These materials are also able to enter human cells and pass through the blood brain barrier, and concerns about their potentially toxic effects are increasing. These concerns range from the impact that these materials can have on humans to the potential impact on the environment at large. In fact, subjects that might be impacted, and by extension the research of these subjects, is endless. Let us take an example in the food industry. Let us assume that a novel nanomaterial can improve the preservation of food and it is used in its packaging. The primary concerns would regard the incorporation of these materials into the usual packaging. In this first stage, the employment of nano-sized elements might endanger the workers involved in the production process. In the second stage it is the user who could potentially be harmed by the nano particles that could enter the human body, generating side effects that are still unknown. Finally, toxic elements could endanger the environment through contaminated feces and urine that would be ultimately absorbed by the external surroundings of the facility. This last step would cover the entire production circle of nature, which means the primary products originating from our environment could be contaminated from the very outset. The potential hazardous effects of nanomaterials is the topic of several ongoing studies, some of which are asking to suspend the use of nanomaterials until such time that scientists have assessed all the potential effects related to the employment of these materials in everyday's life.

Companies are pushing towards a wider use of nanotechnology and nanomaterials in their products, despite the potential harm to humans and the environment. The fields of application are very diverse, with products ranging from improved films for different purposes to solvents, drug delivery systems, tissue engineering, antibacterial packaging, beauty creams, etc.[4]

Before delving into the valuation and evaluation of nanotechnology, I think some figures about nanotechnology patenting will be useful to the reader. As I have already expressed in my previous work,[5] there are many articles[6] that measure nanotechnology patenting in terms of number of patents or applications. Unfortunately the numbers tend to be very different from one article to another, as everyone uses a different approach and different datasets, resulting in a general lack of coherence. The only clear and undisputable trend is that nanotechnology patenting has been on the rise in the last three decades. Lately however, a new trend can be discerned. The first plot I drafted represents the number of published international patent applications filed through the PCT route and published from 1983 to December 2010. As can clearly be inferred from the chart, from 2009 there has been an inflection in the number of filed applications. I do not think this is due to the limited space in the field. In fact, there is no reduction of the technology pace

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4 *See* the Project on Emerging Nanotechnologies, Consumer Products Inventory, available on the Internet at http://www.nanotechproject.org/inventories/consumer (last accessed on 18 January 2011).

5 *See* Luca Escoffier, *Patentability of Nanotechnology Innovations: a Closer Look at their Figures and Inventiveness*, Comparative IP Academic Workshop Working Paper No. 1, pp. 1-27, 2009, http://www.law.washington.edu/Casrip/WWIP/Papers/2009/Patentability%20of%20Nanotechnology%20Innovations%20-%20a%20Closer%20Look%20at%20their%20Figures%20and%20Inventiveness.pdf (last accessed on 18 January 2011).

6 *See*, for example, Raj Bawa, *Nanotechnology Patenting in* the US, 1 Nanotech. L. & Bus. 31 (2004), and Robert M. Hansen, *Survey of Nanotechnology Patent Trends*, presentation available at http://www.foley.com/files/tbl_s31Publications/FileUpload137/1576/nano_patent_trends.pdf (last accessed on 18 January 2011).

but rather a change of mind in patent drafting. As I argued in 2009, more and more companies are benefiting from the nanoscale intrinsic qualities of materials by introducing novel products into the market. However, in all likelihood these companies started adopting a more conservative approach as to the appropriateness of using the word "nano" in their marketing and patenting strategies. This new trend can now be confirmed. In fact, 1420 PCT applications were published in 2008, the number decreased to 1282 in 2009, and to 1126 in 2010 (1206 as of 30 December 2010). So, the decrease (taking into consideration the same approach used for the metrics) of published PCT applications in the last two years is considerable and close to 15 %.

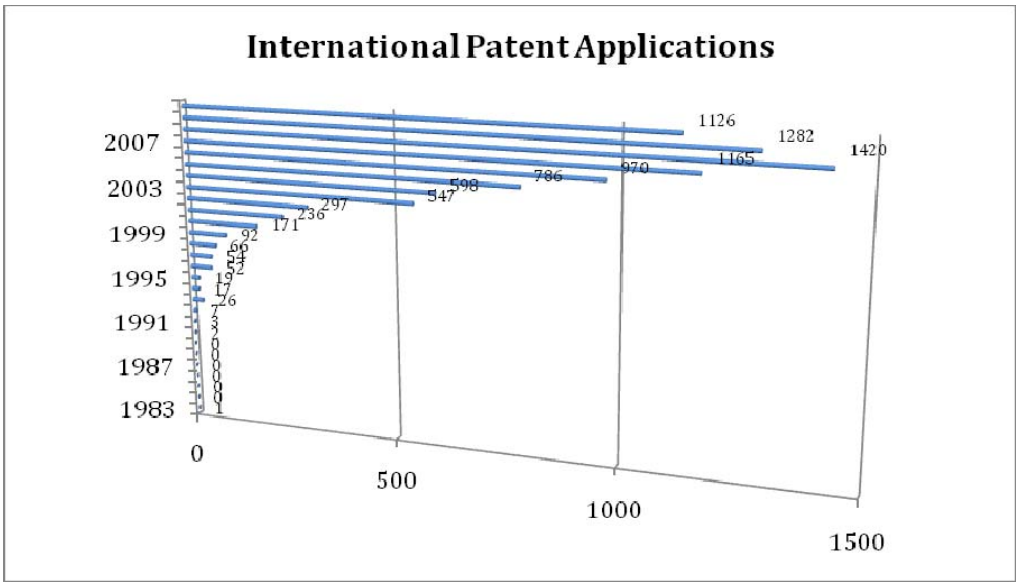

Figure 1: Number of International Patent Applications[7] (December 2010) – Source: Patentscope ®

The table below clearly depicts the dominance of U.S. filers, especially academic ones. The University of California consists of several campuses across the state; their number of applications is therefore understandably higher than the number of

[7] The search has been performed by using the keyword 'nano' in the title of the PCT applications.

applications filed by the MIT. I have performed a similar search on 15 June 2009, and the results were almost the same. The only notable new entrant is BASF SE, which was not in the "Top Ten" list in my previous survey.[8] This probably shows an increased interest in the sector or a company's reorganization.

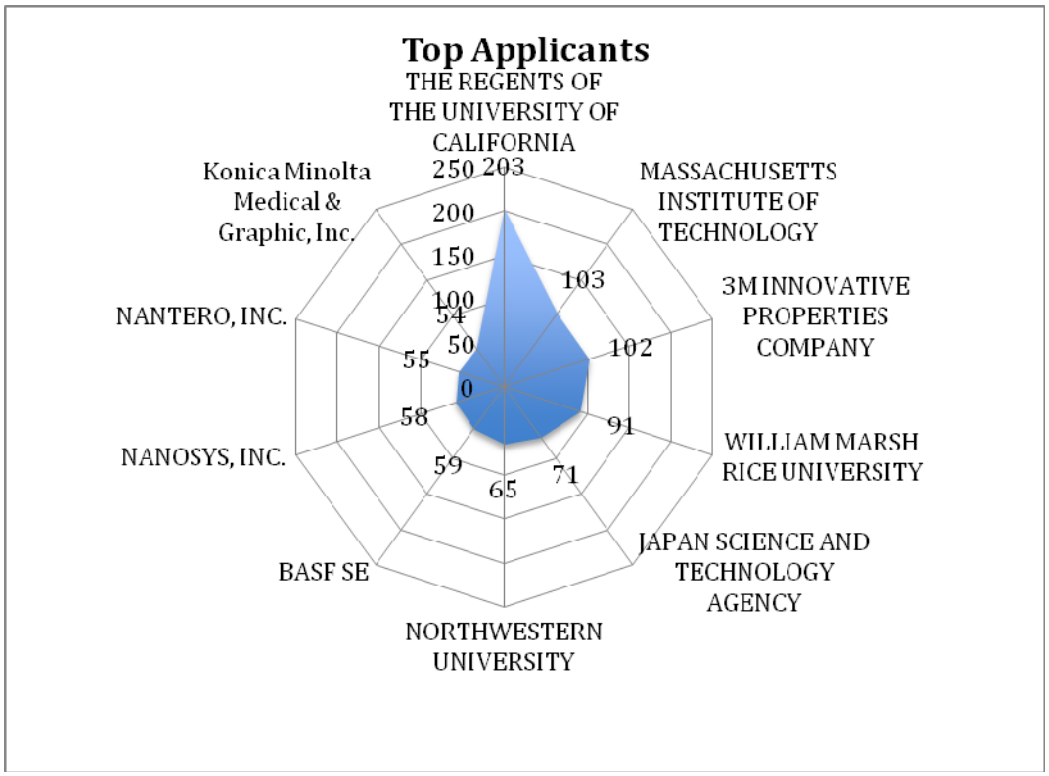

Figure 2: Top PCT applicants[9] (December 2010) – Source: Patentscope ®

II. Cost, Price and Value: Patent Valuation v. Patent Evaluation

There is a strong correlation between nanotechnology, patents and their value. Due to the fact that nanotechnology research is always trying to push the existing

[8] See *supra*, note 5 at 11.

[9] The search has been performed by using the keyword 'nano' in the title of the PCT applications.

boundaries of science and requires diverse skills, public research institutions – where these skills are present - undisputedly dominate the sector of nanotechnologies innovations. The findings of the previous section support this statement. However, this implies that universities and public research organizations are in strong need of monetizing these innovations to replenish their budgets. Therefore, universities and other research institutions have originally seen the patenting of nanotechnology innovations as a new way to monetize their intangible assets after the hype of the biotechnology era. The result is that now there are hundreds of technologies that are waiting to be licensed out or assigned.

The most important thing that must be emphasized at this stage is the crucial difference between three different and distinct concepts: cost, price, and value. The cost is the amount of money necessary to produce a product or perform a process. The price is the amount of money necessary to purchase a product or see a process performed and/or delivered. The price of a product can vary. Take the example of a can of coke, in a supermarket the price of one can of coke may be 1 Euro, in a bar it may be 2 Euro and 3 or more Euro in a fancy restaurant. Finally, the value of a product is the price that a person or a company is willing to pay in certain circumstances. So, a can of coke in the supermarket might be valued 1 Euro because of its abundance, but the same can of coke could be worth 1,000 Euro to a thirsty traveler lost in the desert. Technologies are no different from a can of coke. A novel invention may be worth millions of dollars if it is indispensable to a certain market, but it might be valued at 1 Euro if there is no market for it or if the technology is already obsolete.

So, moving forward, by patent valuation we mean the process of attaching a value, thus a figure, to a technology. It is therefore a quantitative method. When looking at the kind of technology covered by a patent and at the financing and regulatory hurdles that the technology may encounter before market entry, we are making a qualitative assessment. Such an approach is not related to a figure but to careful considerations drawn after an analysis of the different sectors concerned. Both valuation and evaluation are arbitrary since we make projections of the potential generated income of the technology, or we envision what kind of problems can or cannot be solved in its future employment. It is also worth mentioning that when attaching a value to a patent, we necessarily have to consider the potential cost, price, and value of a technology. However, this is not a valid assumption when we perform an evaluation. As mentioned before, in this latter case the assessment is purely qualitative and therefore there is no figure involved. It is true that an evaluation might change the cost, price and value of the technology but up until now this has not been assessed in great detail because of the generally accepted dichotomy between valuation and evaluation.

III. Patent Valuation

In today's professional practice several methods are employed to value a patent.[10] The most common are: cost approach, market approach and income approach.

[10] For an overview of patent valuation practices, see Martin A. Bauder, Frauke Rüether, *Still A Long Way To Value-Based Patent Valuation - The Patent Valuation Practices Of Europe's Top 500*, Les Nouvelles, June 2009, available at http://www.wipo.int/edocs/mdocs/sme/en/wipo_insme_smes_ge_10/wipo_insme_smes_ge_10_ref_theme06 _01.pdf (last accessed on 18 January 2011).

1. Cost approach

The cost approach is quite straightforward. In this case the value of the patent is strictly related to the amount of money that has been spent to conceive the technology. According to this method there are two subsets of rules. Some say that the amount of money spent is what should be taken into consideration, which means the historical costs occurred. Others adopt a different view, arguing that the costs to be considered should be accrued with the relevant interest up until the day the negotiation takes place. A third option might be to assess how expensive it would be to conceive the technology today. It may seem irrelevant, but as the following scenarios will illustrate the numbers may vary greatly. Let us assume that company A developed a technology in 1999 by investing a million dollars, and company B, to reproduce the same technology in 2010, would need to spend $ 500,000 dollars. If we want to consider inflation and update the price of goods and services, the amount would rise to $1,312,791.12.[11] So, it becomes clear that the sub-approach the parties choose to adopt when valuing their patent is not that trivial. In our case company B could pay for the same technology between $ 500,000 and $1,312,791.12!

2. Market approach

In theory, the market approach is the easiest approach. It assumes that the value that should be attached to a piece of IP should be equal to the value it would yield in the marketplace. So, what is fundamental is to take a look at similar transactions occurred in the market. This task is difficult in practice, since this type of information is not easily

[11] Amount obtained using the inflation calculator from http://data.bls.gov/cgi-bin/cpicalc.pl **(**last accessed on 18 January 2011). The CPI inflation calculator uses the average Consumer Price Index for a given calendar year.

accessible. Negotiations about IP are oftentimes kept highly confidential and only rarely are there leaks concerning the details of the transactions. In fact, in most cases even the disputes concerning these assets are settled through arbitration, and therefore the details of the case are kept secret.

3. Income approach

The income approach is divided into different sub-approaches: royalty relief, and discounted cash flow to find the present value of a technology. Both theories are related to the potential income that the user of the technology might accumulate over a certain period of time. Relief from royalty provides that if a company loses ownership of a particular intangible asset, it has to pay a royalty to license it from someone else. Under this method, the value of the patent is therefore the capitalized value of the royalties the company does not have to pay when it owns the patent. However, the amount of money to transfer should be calculated at present, therefore the amount of royalties given in a certain period must be discounted using a predetermined rate to find the present value of the technology. So, first the sum of the projected cash flows must be identified to then be discounted using an interest rate. This is usually the rate linked to treasury bonds, or others more or less stable indicators. The discounted cash flow method is based on the same principle and can be used for both discrete cash flows and multiple cash flows. It is worth emphasizing that this method is probably more useful for the type of technology that is an inherent and necessary part of the production process, in addition to contributing to the quality of a product and by extension boosting its sales.

Some considerations about nanotechnology must be mentioned with regard to the delineated approaches. Nanotechnology does not just bring novel features in our homes

and our daily life; it is strongly intertwined with different regulatory aspects that still need to be resolved. For example, it is still not clear whether products incorporating nanomaterials should comply with certain specific rules in the U.S. and Europe. Sure, numerous regulatory agencies have circulars and internal directives, stating that they have round tables and working groups about nanotechnology. However, the truth is that there currently is a lot of uncertainty surrounding the use of nanomaterials in everyday products, both for consumers and for producers. There are not enough studies addressing the potential toxicity of the products and the few that do exist often come to conflicting conclusions. So, when attaching a value to a product incorporating nanomaterials more attention should be paid to the underlying technology. In fact, when using the income approach, which is probably the most common, the projections of future cash flows are directly dependant on the projected sales. These might be heavily hindered by, for example, more or less stringent regulatory provisions in the future. Also, when thinking about future projections, we must rely on assumptions that may or may not be true. This is a common principle for all products or services, but nanotechnology is different. In this world made of invisible components, unexpected events can occur that may adversely affect the life of a product or service. Let us take a quick example. It might well be that a novel nanotechnology-based paint for cars that guarantees anti-scratch properties would actually result in a product that is highly inclined to corrosion after a couple of years. Nanotechnology is in its infancy, so, there might be not enough time or knowledge to assess the side effects of the novel products that are being marketed right now. Having that said, let us think for a minute about the potential consequences in this case. The paint producer or the car manufacturer could be obliged to repaint the cars after the corrosion if

it occurred during the warranty period. This is a real world scenario that might happen with nanotechnology-based innovations, since the unexpected properties displayed by these products may well have unexpected consequences too. An unexpected event like the one just mentioned would not only temporarily stop the sale of the cars employing the novel paint; it would also tarnish the company's image, which can be even worse than a potential drop in its sales. This illustrates that the common income approach might not be the right way to go for nanotechnology-based innovations due to their "volatile" nature at this point.

IV. Patent Evaluation

The term evaluation implies something more than a figure attached to a certain object. In fact, when we evaluate something we consider different variables and the kind of output is qualitative and not purely quantitative as in the case of the valuation.[12] We might think that when evaluating a technology, the most important variables to look at are: the market; regulatory and legal issues; technology's future; and financing opportunities.

1. Market

The market is the most important factor in a business plan and it is the most important variable when assessing the potential of a technology. Therefore, a promising technology will be even more so if the barriers to entry in the market are low due to little or no competition. On the other hand, the competitive advantage of being the first one in

[12] For an overview of patent evaluation, see the EPO webpage, *Patent Portfolio Management and Patent Evaluation,* available at http://www.epo.org/patents/patent-information/business/valuation/faq.html (last accessed on 18 January 2011).

a market could turn into a disadvantage. After all, the forerunner is clearing the way for his future competitors who had the opportunity to learn from his mistakes. Another important factor to consider is whether the market is ready for a new product, since its success cannot be taken for granted.

2. Regulatory and legal issues

When evaluating a technology it is crucial to take all the regulatory and legal issues into consideration. In fact, a technology might well be groundbreaking and have the potential to improve the consumer's quality of life, but if there are regulatory and legal barriers that do not or only partly allow its commercialization, the technology's value will be much lower than expected. For example, there are a lot of technologies nowadays based on stem cells, but at the same time many jurisdictions do not allow their experimentation. So, in these places the technology is theoretically worth nothing. As a consequence, environmental and safety-related aspects of a certain technology will probably be the major hurdles to overcome in terms of legal and regulatory barriers.

3. Technology

When evaluating a technology it is equally important to analyze its long term potential; since there is always a risk it will become obsolete or not used at all in the close or distant future. Keeping this in mind, it is key is to create different future scenarios to assess the life expectancy of the technology and its utilization. Just to give you an example, it is foreseen that by 2020 every household in the U.S. will have a 3D printing machine. The feedstock for these printers today consists primarily of plastics. At the same time plastics is destined to give the way to bioplastics in the near future. From this

assumption we can therefore infer that a technology related to bioplastic materials for 3D printers will probably have a bright future.

4. Financing

Financing issues are crucial when the technology and its owner are looking for potential investments. Say that the business plan of a future company relies on a strong patent/technology that is easily funded due to its potential future success, it will be easier for the would-be entrepreneur to find business angels or VC firms that believe in the investment, and they will probably more prone to invest in the business idea.

In light of the above, we can easily understand how evaluation is a way broader concept that takes into consideration more variables than the “mere” valuation of a product or process. In general terms, the evaluation is a complex analysis that is meant to be like a SWOT (i.e. strengths, weaknesses, opportunities and threats) analysis, which ponders the endogenous and exogenous components of the object to be examined. Among all technology fields, nanotechnology is probably the most suitable for evaluation techniques. In fact, nanotechnology opens the door to endless issues relating to the evaluation of technologies. Indeed, there is so much uncertainty on the regulatory issues or unexpected behaviors surrounding it, that all the different variables might be affected. For instance, if a new nanomaterial would be able to create a whole new market from scratch, the regulatory aspects around its use will be crucial. A novel drug delivery method to cure cancer, which employs nanomaterials, for example, might be a breakthrough. However, if the FDA or the EMEA would find it not suitable for human safety due to its confirmed or potential toxicity, it might lead the business in question to

bankruptcy if the commercialization would be stopped or heavily delayed for safety concerns. To sum up, the evaluation of nanotechnology-related inventions is probably the most difficult as the future of these innovations is still uncertain in terms of its latitude, regulation, drawbacks, and employment.

Therefore, due to the very nature of nanotechnology innovations, I believe that the only way to provide a reliable judgment about the economic potential of these products is to avoid the use of valuation techniques and rely on the evaluation as an adherent method to gauge potential real world scenarios. Unfortunately evaluation is a qualitative analysis and therefore there is no figure attached to it, which is why I conceived a method that can turn a qualitative analysis into different figures on the basis of different assumptions. This novel method is illustrated in detail in the next section.

V. Introducing a Novel Approach: the Present Value After Evaluation Method

In the quest to understand what might be a reasonable value to attach to a technology or patent, I am presenting a novel evaluation method called Present Value After Evaluation[13] ("PVAE"). This novel approach takes the present value of a patent or technology into consideration by using the discounted cash flow method and then adds the following additional variables using a scale from 1 to 5:

- Patent relevance (it considers the relevance of the patent in the final product or process);

[13] The author is the copyright holder of the PVAE tool, which is also used by Usque Ad Sidera LLC for its evaluation services. Starting January 2011, the University of Trieste will be the exclusive user of the tool for its technologies for an evaluation period.

- Patent coverage (it considers the strength of the patent according to the claims and existing or potential litigation);
- Technology (it considers technology's future scenarios);
- Financing (it considers the attractiveness for investors);
- Regulation (it considers regulatory and legal barriers);
- Market (it assesses the potential success of the product or process).

The model contains seven other assumptions that should be made when using the PVAE tool, namely:

- Growth rate (three variables);
- Discount rate;
- Royalty rate;
- Tax rate;
- Cost of goods sold (COG), overhead costs, etc.

In this model we start with an initial projection of the first cash flow. When populating the sheet, we have to make several assumptions concerning the discount rate, growth rate of the projected sales, royalty rate, tax rate, and percent of cost of goods sold and other expenses. All the other variables are modifiable using a 1 to 5 scale in which 1 is "poor" and 5 is "excellent", as it can be easily inferred from the table below. Patent Coverage and Patent Relevance are directly linked to the total present value of cash flows as opposed to the other variables that occupy a second layer of importance and provide an average output. In the example (Figure 3), we assumed that the initial cash flow is equal

to $100,000 and that all the variables are set on “excellent” (meaning that the technology is necessary to make the product or implement the process), that the claims of the patent have a wide and protectable breadth, that the technology is promising, and there are no regulatory and market barriers. So, we are dealing with an excellent technology in this case. Considering a life expectancy of 15 years, the total of cash flows is $2.867.778, and the total present value is $2.192.010. In this case, the PVAE after tax, cost of goods sold and other expenses is equal to $1.150.805. The sheet also provides the amount of royalties collected over time and their present value, which in this case is $107.226. So, in the projected scenario, the Present Value of the royalties is almost one tenth of the PVAE after tax, cost of goods sold and other expenses. This is an amazing outcome since it proves that for a very promising technology, the assignee would earn ten times as much than what was paid to the original patentee if the price of the transaction is equal to the present value of the prospected royalties.

In the second scenario (Figure 4) we populated our table using a different evaluation, and we graded the technology by attaching a “3” to all the variables. This means that the technology in question is not that crucial to the production of the product or the implementation of the process. It also implies that the claims of the patent have a medium breadth, that the technology is moderately promising, and that there might be some regulatory and market barriers. Starting with the same initial cash flow for the first year of sales, and considering a life expectancy of 15 years, the total of cash flows is again $2.867.778, and the total present value remains at $2.192.010. However, here the total present value considering the relevance of the patent and patent coverage is

$789.123, and the PVAE after tax, cost of goods sold and other expenses is equal to $248.574. The sheet also provides the amount of collected royalties, and their present value, which is again $107.226. So, in this second scenario, the present value of the prospected royalties is more than one third of the PVAE after tax, cost of goods sold and other expenses.

In the third scenario (Figure 5), the table is populated with different future scenarios, and we graded the technology by attaching a “2” to all the variables. The technology in question is therefore definitely not crucial to the production of the product or the implementation of the process. It also means that the claims of the patent have a medium-low breadth, that the technology is not that promising, and that there might be some serious regulatory and market barriers. Starting with the same initial cash flow for the first year of sales, and considering a life expectancy of 15 years, the total of cash flows is once again $2.867.778, and the total present value is still $2.192.010. However, here the total present value considering the relevance of the patent and patent coverage is $350.722, and the PVAE after tax, cost of goods sold and other expenses is equal to $73.652. The sheet also provides the amount of collected royalties, and their present value, which is again $107.226 because they are based on the same amount of sales. So, in this last scenario, the present value of the foreseen royalties is considerably higher than the PVAE after tax, cost of goods sold and other expenses. These three examples clearly show that using the present value of expected royalties to determine the price of the technology for a potential transaction is not a proper evaluation method. In fact, the

variables we have used to populate our sheet are definitely key aspects when evaluating the potential of a novel product or process.

The PVAE method and tool show that it is possible to have a valuation of a technology or patent that also takes crucial, non quantitative variables into account, such as the environmental and/or human safety concerns that might adversely affect a technology's potentially brilliant future. These risks can be quite problematic when dealing with nanotechnology-related products or processes. Due to the current rather unstable situation of this market, normative and regulatory barriers could pose serious commercialization barriers, and we have witnessed that by changing the qualitative variables the valuation may vary greatly. As previously mentioned, the unstable nature of nanotechnology can be further compromised by unexpected outcomes related to the very nature of the innovation in question, and these events may change the value of the product or process incorporating the technology dramatically. In the realm of human safety and environmental preservation, these technologies could imply serious hazards. Moreover, if a toxic substance is not totally metabolized in the human body, it can be excreted into the environment and endanger other humans too. Unfortunately, if a product is marketed before all the required or suggested tests, the only way to see whether there are undesired effects is to wait. Therefore, I am advocating for the use of evaluation techniques and especially of the PVAE method to ponder all the variables involved in the commercialization of nanotechnology-based innovations. In fact, the different assumptions (variables) that can be changed in the PVAE tool allow for a value adjustment depending on potential changes to the situation. The licensing agreements

could for example be linked to milestones or events that should allow the parties to change the variables and the values, accordingly.

VI. Conclusions

As previously stated, nanotechnology will play a key role in our lives, as the potential applications of this new convergent branch of technology are endless. We will see novel products and processes employing nanotechnology display unexpected properties, which are meant to make our life easier, more secure, faster, and more efficient than before. These are all promises that we hope will be kept and become reality one day, but we also know that further studies must be carried out before the safe release of novel products into the market.

The patent analysis performed in this article shows once again that research performed in universities is fundamental. These studies usually top all the rankings concerning nanotechnology patenting. This information is subject to further considerations though. In fact, research stemming from universities and research centers is usually in an early stage and therefore requires further development. Nanotechnology is no exception to this rule. So, in general, universities constitute a very fertile environment because of the convergence of skills that naturally occurs in there.

The opportunities offered by the PVAE method and tool are quite unique. In fact, by using the total present value of the foreseen royalties and the PVAE, the user will come to two figures that can serve as a range to be used during negotiations. Also, there is no predetermined scenario when using the PVAE tool. If the technology has all top

qualitative variables, then the PVAE will be greater than the present value of foreseen royalties (taking into account an average royalty rate). In the opposite case, when the qualitative variables are poor, it is very likely that the PVAE will be well below the present value of the expected royalties.

The University of Trieste (Italy) will officially start testing the PVAE tool in the following months to provide all potential assignees/licensees with a reliable method for the assessment of the value (post evaluation) of its posted available technologies. The tool will be applied indistinctly to all the technologies of the University, including those related to nanotech research. We hope that the PVAE tool will one day become the standard in the negotiation of patents and technologies. It is especially effective in the university-industry setting, where companies usually take advantage of their stronger position and there is not yet a simple way of finding an "objective" range to use as a starting point for negotiations. We can conclude that the PVAE method and tool are the best fit to evaluate technologies or patents that pertain to particularly "dangerous" fields, where environmental and human safety issues might hinder a prosperous future for the technology or patent in question.

In fact, a proper use of the PVAE tool allows the parties to a license agreement or assignment to change the variables and adjust the value to the current situations. For instance, a novel molecule engineered through nanotechnology could face hard times in governmental approval because of potentially adverse side effects to humans and/or the environment. In this case, the parties could simply adjust the "Technology" and

“Regulation” variables to make the value of the innovation more adherent to its current market potential.

Appendix

PRESENT VALUE AFTER EVALUATION							
Patent relevance 1-5:	5						
Initial Cash Flow:	$100,000			Technology 1-5	Financing 1-5	Regulation 1-5	Market 1-5
Patent coverage 1-5:	5			5	5	5	5
Years:	1-5	6-10	11-15				
Growth Rate:	7%	10%	5%				
	Before Tax and CO	After Tax and COG					
Total of Cash Flows	$2,867,778	$1,505,583	Discount Rate	3%		Tax rate:	25%
Total PV of Cash Flows:	$2,192,010	$1,150,805	Royalty Rate:	8%		COG,etc.	30%
Total PV of Cash Flows Considering the Relevance of the Patent and Patent coverage:	$2.192.010	$1.150.805	Partial PVAE	$2.192.010	$2.192.010	$2.192.010	$2.192.010
Present Value of Royalties (after tax)	$107,226		PVAE Before Tax and COG:	$2,192,010	PVAE After Tax and COG:	$1,150,805	

Year	Flows	Growth	Present Value	Year	Rate	Royalty-tax	Total
1	$107,000	7%	$103,883	1	8%	$6,420	$6,420
2	$114,490	7%	$107,918	2	8%	$6,869	$13,289
3	$122,504	7%	$112,109	3	8%	$7,350	$20,640
4	$131,080	7%	$116,463	4	8%	$7,865	$28,504
5	$140,255	7%	$120,985	5	8%	$8,415	$36,920
6	$154,281	10%	$129,208	6	8%	$9,257	$46,177
7	$169,709	10%	$137,989	7	8%	$10,183	$56,359
8	$186,680	10%	$147,367	8	8%	$11,201	$67,560
9	$205,348	10%	$157,382	9	8%	$12,321	$79,881
10	$225,882	10%	$168,078	10	8%	$13,553	$93,434
11	$237,176	5%	$171,341	11	8%	$14,231	$107,664
12	$249,035	5%	$174,668	12	8%	$14,942	$122,606
13	$261,487	5%	$178,060	13	8%	$15,689	$138,296
14	$274,561	5%	$181,517	14	8%	$16,474	$154,769
15	$288,289	5%	$185,042	15	8%	$17,297	$172,067

PRESENT VALUE AFTER EVALUATION							
Patent relevance 1-5:	3						
Initial Cash Flow:	$100,000			Technology 1-5	Financing 1-5	Regulation 1-5	Market 1-5
Patent coverage 1-5:	3			3	3	3	3
Years:	1-5	6-10	11-15				
Growth Rate:	7%	10%	5%				
	Before Tax and CO	After Tax and COG					
Total of Cash Flows	$2,867,778	$1,505,583	Discount Rate	3%		Tax rate:	25%
Total PV of Cash Flows:	$2,192,010	$1,150,805	Royalty Rate:	8%		COG,etc.	30%
Total PV of Cash Flows Considering the Relevance of the Patent and Patent coverage:	$789,123	$414,290	Partial PVAE	$473,474	$473,474	$473,474	$473,474
Present Value of Royalties (after tax)	$107,226		PVAE Before Tax and COG:	$473,474	PVAE After Tax and COG:	$248,574	

Year	Flows	Growth	Present Value	Year	Rate	Royalty-tax	Total
1	$107,000	7%	$103,883	1	8%	$6,420	$6,420
2	$114,490	7%	$107,918	2	8%	$6,869	$13,289
3	$122,504	7%	$112,109	3	8%	$7,350	$20,640
4	$131,080	7%	$116,463	4	8%	$7,865	$28,504
5	$140,255	7%	$120,985	5	8%	$8,415	$36,920
6	$154,281	10%	$129,208	6	8%	$9,257	$46,177
7	$169,709	10%	$137,989	7	8%	$10,183	$56,359
8	$186,680	10%	$147,367	8	8%	$11,201	$67,560
9	$205,348	10%	$157,382	9	8%	$12,321	$79,881
10	$225,882	10%	$168,078	10	8%	$13,553	$93,434
11	$237,176	5%	$171,341	11	8%	$14,231	$107,664
12	$249,035	5%	$174,668	12	8%	$14,942	$122,606
13	$261,487	5%	$178,060	13	8%	$15,689	$138,296
14	$274,561	5%	$181,517	14	8%	$16,474	$154,769
15	$288,289	5%	$185,042	15	8%	$17,297	$172,067

PRESENT VALUE AFTER EVALUATION							
Patent relevance 1-5:	2						
Initial Cash Flow:	$100,000			Technology 1-5	Financing 1-5	Regulation 1-5	Market 1-5
Patent coverage 1-5:	2			2	2	2	2
Years:	1-5	6-10	11-15				
Growth Rate:	7%	10%	5%				
	Before Tax and CO	After Tax and COG					
Total of Cash Flows	$2,867,778	$1,505,583	Discount Rate	3%		Tax rate:	25%
Total PV of Cash Flows:	$2,192,010	$1,150,805	Royalty Rate:	8%		COG,etc.	30%
Total PV of Cash Flows Considering the Relevance of the Patent and Patent coverage:	$350.722	$184.129	Partial PVAE	$140.289	$140.289	$140.289	$140.289
Present Value of Royalties (after tax)	$107,226		PVAE Before Tax and COG:	$140,289	PVAE After Tax and COG:	$73,652	

Year	Flows	Growth	Present Value	Year	Rate	Royalty-tax	Total
1	$107,000	7%	$103,883	1	8%	$6,420	$6,420
2	$114,490	7%	$107,918	2	8%	$6,869	$13,289
3	$122,504	7%	$112,109	3	8%	$7,350	$20,640
4	$131,080	7%	$116,463	4	8%	$7,865	$28,504
5	$140,255	7%	$120,985	5	8%	$8,415	$36,920
6	$154,281	10%	$129,208	6	8%	$9,257	$46,177
7	$169,709	10%	$137,989	7	8%	$10,183	$56,359
8	$186,680	10%	$147,367	8	8%	$11,201	$67,560
9	$205,348	10%	$157,382	9	8%	$12,321	$79,881
10	$225,882	10%	$168,078	10	8%	$13,553	$93,434
11	$237,176	5%	$171,341	11	8%	$14,231	$107,664
12	$249,035	5%	$174,668	12	8%	$14,942	$122,606
13	$261,487	5%	$178,060	13	8%	$15,689	$138,296
14	$274,561	5%	$181,517	14	8%	$16,474	$154,769
15	$288,289	5%	$185,042	15	8%	$17,297	$172,067