



RESEARCH PAPER

Intellectual property for generating value for start-up companies in key enabling technologies



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Abstract We have studied how start-up companies operating within key enabling technologies, KETs, manage formal and informal intellectual property (IP) protection for generating value. Six key aspects helping executives to create effective IP strategies for start-ups in these highly complex technologies have been identified. 15 start-ups defined as nanotechnology companies have been interviewed with open questions regarding value generated through protecting innovations. The start-ups operate in southern Sweden which currently is a KET heavy hub.

Our findings indicate six key aspects to help executives within KETs, specially within the nanotechnology start-up sector, to create effective IP strategies. First, it is important to **map the technological environment and the commercial market**. Most of the interviewed nanotechnology start-ups expressed that they want to increase in market share however, only four out of fifteen start-ups actually had set strategies for mapping the commercial market. Neglecting to focus on commercial market demands and merely on the innovation itself can present a future hindrance for nanotechnology start-ups. Second, it is beneficial for nanotechnology start-ups to consider and **determine which actual values are important** in order for them to thrive, and thereafter strategically plan formal and informal IP accordingly. Third, **protecting different aspects of an innovation with different types of IP** is beneficial for nanotechnology start-ups to effectively generate value. Important factors to consider when choosing how to protect different aspects of innovations are, what the market needs, the possibility to work around the solution, as well as risk of reverse engineering the innovation. Fourth, due to the complexity within nanotechnology, start-ups may benefit from treating **aspects of an innovation that are difficult to reverse engineer as trade secrets**. Such aspects include e.g. know-how related to the production process and other underlying know-how which add to the product's uniqueness but which not directly derivable from the product itself. Notably, only five out of fifteen nanotechnology start-ups have set strategies for how to manage their trade secrets. Fifth, to

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generate value, it is beneficial to **formally protect aspects of an innovation that fulfill market demands** as well as aspects that competitors likely would need to develop their products. Thus, aspects which are associated with sales arguments or which could form the basis for licensing agreements are beneficial to protect by patents for nanotechnology start-ups. All the studied nanotechnology start-ups have patents, but surprisingly only seven out of fifteen start-ups stated have patented aspects that generate commercial value on their market. Sixth, it is important for nanotechnology start-ups to have a **plan for how the rights attained actually should generate value**. This plan may encompass anything from how the rights support increased sales, form the basis for a licensing schedule, increase the value of the company, etc. The plan for how the rights should generate value is also the basis for a review procedure concerning whether to maintain a specific IP right or not.

Introduction

Nanotechnology is widely incorporated throughout various markets, including medicine, life science, electronics, and nutritional sciences. Furthermore, previous research has shown that nanotechnology is becoming a central part of the world's technological advancements (Fulekar, 2010; Mangematin & Walsh, 2012). The topic of nanotechnology was chosen among the Key Enabling Technology, KET, group (micro and nanoelectronics, nanotechnology, industrial biotechnology, advanced materials, photonics, and advanced manufacturing technologies) as it by its nature is multidisciplinary, requires complex processing and advanced research and development and is applicable in multiple industries.

Protecting innovations can give nanotechnology start-ups the ability to capitalize on know-how behind innovations (Bastani & Fernandez, 2005; Bawa, Bawa, & Maebius, 2005). When protecting innovations not only creation of IP but also procurement of IP may be beneficial in order to give the owner a collection of rights giving the owner monopolistic rights to use the protected innovation (La Ferla, 2004). Throughout this report, value generation is defined as *the process where value is first created, and then captured*.

IP can be divided into two categories; formal IP and informal IP, where formal IP typically requires legal documentation, and informal IP does not (Bonakdar, Frankenberger, Bader, & Gassmann, 2017). The formal IP are said to include *patents, design rights, trademarks and copyrights* which are tools for protecting original innovations in a court of law. The informal IP are said to include: *trade secrets, complexity of products and manufacturing processes, and lead time advantage*. Studies have also shown that it is important to differentiate and divide values into categories, such as strategic and financial value (Andersen, Rosli, Rossi, & Yangsap, 2012; Bastani & Fernandez, 2005). IP can generate strategic values for nanotechnology start-ups through *possibility to increase in market share, qualified recognition or brand recognition, having a competitive presence on the market, ability to engage in collaborative agreements and innovativeness* (Andersen et al., 2012). The financial values that can be generated through IP are *direct income from market transactions, cost cutting and increased ability to attract investors* (Andersen et al., 2012). Moreover, licensing is becoming a preferred method for

technology transfer, and most licenses include both patents and surrounding know-how (Pham & Garsson, 2014). Thus, greater value could be generated by combining formal and informal IP (Bastani & Fernandez, 2005; Pham & Garsson, 2014). A more extended literature survey is presented as Supplemental Material 1.

The purpose of this study was to increase the understanding not only of how formal and informal intellectual property may affect value generation of strategic and financial values within the nanotechnology start-up sector, but also to increase the understanding of how and to what extent the potential value generation is actually considered and used as a decision making tool within the nanotechnology start-up sector.

The study further describes how different IP may be utilized to generate value and explore how the choice of IP may be important for generating strategic and financial value within nanotechnology start-ups. To fulfill the purpose of this study, three separate research questions have been identified and answered:

RQ1: Which strategic values are nanotechnology start-ups seeking by protecting innovations?

RQ2: Which financial values are nanotechnology start-ups seeking by protecting innovations?

RQ3: How can nanotechnology start-ups effectively combine formal and informal intellectual property to generate strategic and financial value?

This study was performed with an inductive approach through a qualitative multi-case study. The data collection was carried out through 23 interviews, including four exploratory interviews and 19 semi-structured interviews. The collected data was continuously analyzed in order to identify concepts, themes and aggregated dimensions. The collected data was analyzed through two categories, namely type of intellectual property and prioritized type of value desired. In this study a start-up is defined as *an organization without clear departments and directions for strategic management* (Bamford, Dean, & Douglas, 2004). The study was based at Ideon Science Park in Lund, Sweden, which is an innovation hub which has been active for more than 35 years and which comprises a diverse set of companies within a wide range of technology areas including nanotechnology, information and communications technology, life science, cleantech, medtech, smart materials and food innovations.

The methodology used in this study includes four steps, namely research design, data collection, data analysis and grounded theory articulation; 8 interviews were held with IP experts; 4 exploratory interviews and 4 semi-structured interviews. 15 nanotechnology start-ups were interviewed in a multiple case study in order to be able to consider several perspectives to the problem and to avoid bias and preconceived limitations toward interviewees and when analyzing data (Gioia, Corley, & Hamilton, 2012). Semi-structured interviews were used as the data collection method for the interviews with the 15 nanotechnology start-ups. Please see Supplemental Material 2 for details on the research approach, design and how the data analysis was conducted.

Results

The collected data was analyzed by using an inductive analysis approach described in Gioia et al. (2012) to avoid bias in the findings. Collected data was coded and themed and resulted in 6 aggregated dimensions. The data collected through the semi-structured interviews with the nanotechnology start-ups is presented in four sections:

- **Strategic values and corresponding dimensions** presents findings regarding the first research question, *which strategic values are nanotechnology start-ups seeking by protecting innovations?*
- **Financial values and corresponding dimensions** presents findings regarding the second research question, *which financial values are nanotechnology start-ups seeking by protecting innovations?*
- **Conceptual framework for effective IP strategies** summarizes the results of the first and second research question and presents a conceptual framework including the identified relations between type of IP and the different values in correspondence to how each value can be generated.
- **Combination of formal and informal IP and corresponding enablers** presents findings regarding the third research questions, *how can nanotechnology start-ups combine formal and informal intellectual property to generate strategic and financial value?*

Strategic values and corresponding dimensions

Dimension 1: Trustworthiness through qualified recognition

The findings show most nanotechnology start-ups see great value in building trustworthiness through

qualified recognition on the market. One interviewee stated, *“Trustworthiness is the most important value we achieve from having patents and trademarks. Without these we have nothing to bring to the table, and no negotiations”*. Trustworthiness is often seen by nanotechnology start-ups to be enabled through *negotiation baseline* as well as *quality and brand recognition*, see Fig. 1.

In more detail, a **Negotiation baseline** can be attained through communicating a nanotechnology start-up’s formal IP to the market and can be vital in order to be an option for customers or investors. One interviewee argued *“owning formal rights can be the difference between having a business case or not”*. Furthermore, formal IP such as patents and trademarks can provide the trustworthiness necessary to start negotiations and be considered by customers and investors. Another interviewee elaborated similarly stating, *“customers will first take a look at your patent portfolio behind your technology before buying from you. It needs to be there even if it is not usually the main focus. The same goes for trademarks, they are also commercialized, differentiating products and when marketing”*.

Quality and brand recognition can also be attained through formal IP displaying the potential and quality of the product offerings in association to the brand of a nanotechnology start-up. One interviewee stated *“we also use our patents in display to the market. Patents explain to the market that the company, processes and products have potential, and that it is worth investing”*. Another interviewee argued similarly, *“the competitive advantage we get from having patents and trademarks is trust and quality recognition from our customers”*. Moreover, formal IP such as patents can enable trustworthiness through helping customers and investors comprehend the know-how and work behind the products. One interviewee argued *“Patents give you certain considerations. It is important that customer know the processes behind the products, they need to know the serious work behind our offerings and innovations. Proof that what you have done is of interest and that it is good, thus formal IP gives quality recognition”*. Another interviewee stated *“in our case trademarks help our customers organize and understand our different products”*.

Dimension 2: Ability to increase in market share

The findings show nanotechnology start-ups view the ability to increase in market share as essential. Increasing in market share is argued by multiple interviewees to be possible to achieve through both formal and informal IP. One interviewee stated, *“we map areas on our market where our competitors are not yet active and can therefore increase*

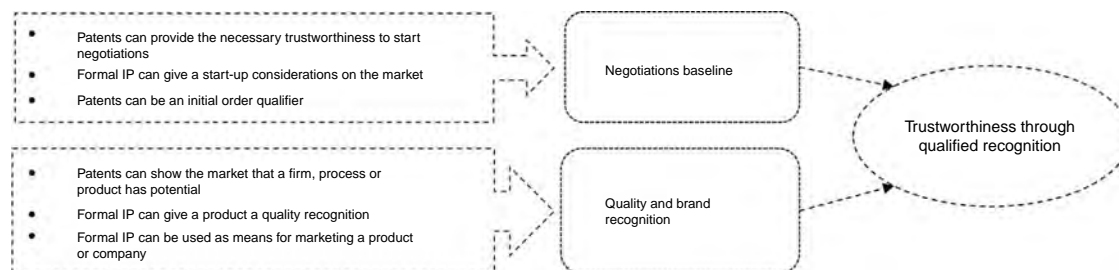


Figure 1 Trustworthiness through qualified recognition.

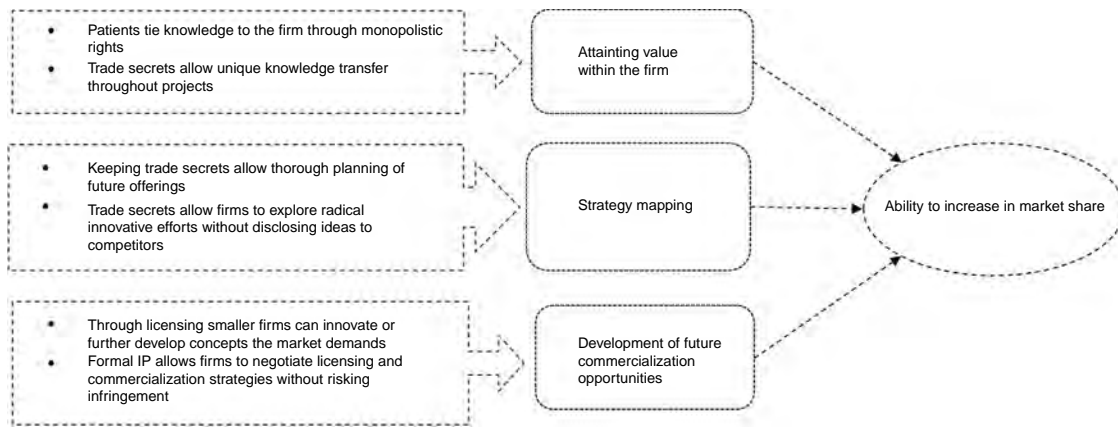


Figure 2 Ability to increase in market share.

in market share through both patenting and secrecy”. The analysis suggests the ability to increase in market share can be viewed through three enablers, namely *attaining value within the firm*, *strategy mapping* and *development of future commercialization opportunities*, as presented in Fig. 2.

Attaining value within the firm can be done through filing for, and maintaining formal rights on innovations. As one interviewee stated, “we foremost achieve increase in market share through building value within the firm through developing our products and filing for relatively specific patents”. Nanotechnology start-ups can also attain value within the firm through informal IP, thus prioritizing learning and knowledge transfer throughout projects. One interviewee stated, “we gather knowledge throughout projects which we then can apply on future projects. We treat such knowledge as a trade secret and do not publish such information”.

Strategy mapping can be achieved through nanotechnology start-ups keeping the informal IP trade secrets. Informal IP can allow thorough testing and planning of future offerings as well as strategic information disclosure to the market. One interviewee stated, “we prioritize our trade secrets in accordance to the increase in market share it would enable if protected formally. Strategic disclosure to the public of innovative efforts is very important to us”. Another interviewee agreed stating, “our trade secrets are only utilized internally when planning our strategies and when investigating new possible applications of our products”. It can thus be beneficial to maintain solid routines regarding informal IP such as trade secrets to enable increase in market share.

Development of future commercialization opportunities can be achieved mainly through formal IP. When an innovation is formally protected, a start-up can proceed with continuous development and research on the innovation without fear of theft or infringement. One interviewee argued “we look at details and components which larger firms can make use of. We view ourselves as road-finders for the industry, we continue development on already existing concepts thereafter larger firms can make choices based on our research and know-how”. Development of concepts and future opportunities is an important part of business for nanotechnology start-ups since they are at early stages

of business development. As confirmed by another interviewee stating, “we have been trying to put more resources into commercialization since we are now a company with shareholders and need to perform in numbers. We have to identify and investigate some things further, we are in the exploratory stages.”

Dimension 3: Having a competitive presence on the market

The findings show that most nanotechnology start-ups seek competitive presence on the market. However, there are different thoughts regarding how the competitive presence is achieved. One reason for this might be that competitive presence is a broad term. One interviewee stated “what gives us competitive advantage stems from our know-how and what we can deliver to our customers”. The analysis suggests that there is a need to further clarify the term competitive presence and break it down in different value enablers that nanotechnology start-ups can observe more closely. The analysis show competitive presence on the market can be generated through four enablers, namely *ability to hinder or block competitors*, *control over time and information disclosure* and *ability to sustain uniqueness, first mover advantage*, as presented in Fig. 3.

Ability to hinder or block competitors can be attained foremost from formal IP such as patents and informal IP such as trade secrets. Patents give the owner monopolistic rights over an innovation, blocking competitors from commercializing on the protected aspects on that innovation. One interviewee stated “the value we gain from having patents is the competitive advantage attained from having monopoly on the market”. Both formal and informal IP can limit competitors’ advancements on the market. Trade secrets can indirectly hinder competitors by limiting the ability to imitate products or processes as knowledge is kept away from the public. One interviewee expressed this by stating, “we use both our patents and trade secrets exclusively to hinder competitors”.

Control over time and information disclosure can be attained by keeping knowledge and know-how within a start-up through the informal IP trade secrets. Nanotechnology start-ups can generate value by having the choice of when to disclose ideas as well as the extent of information shared to the public domain. One interviewee said great value could

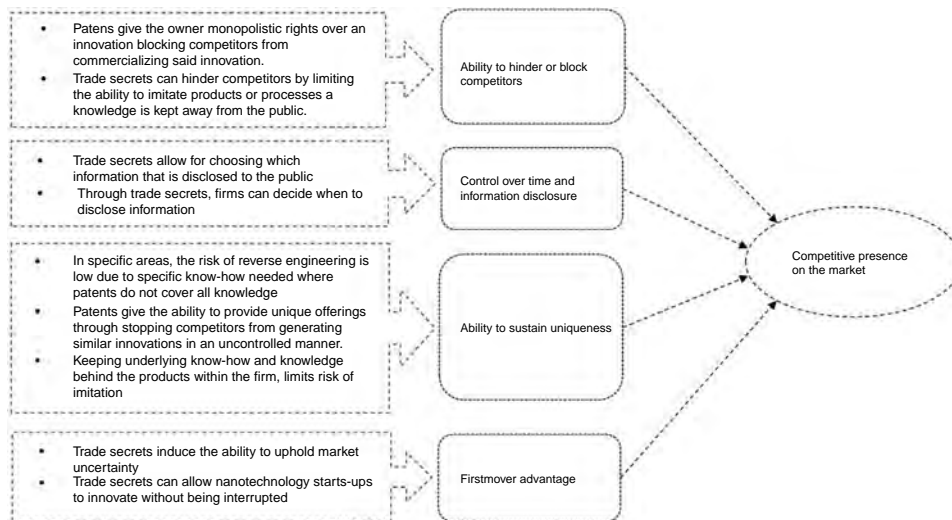


Figure 3 Competitive presence on the market.

be attained through informal IP, stating *“it is crucial for our business that the public does not have access to all our know-how”*. Another interviewee had similar arguments stating *“for us it is important to decide what information we disclose to the public”*. Moreover, timing is a vital factor for start-ups in disclosing information and filing for formal IP. One interviewee elaborated on the importance of timing, stating *“for us it is of great value to have control over when we disclose our ideas to the public as novelty is imperative to sustain until filing for a patent”*.

Ability to sustain uniqueness can be attained through formal IP, filing patents and trademarks, as well as maintaining informal IP such as trade secrets. Uniqueness can be a vital part for nanotechnology start-ups in achieving competitive advantages on the market, as stated by one interviewee *“we stay competitive by prioritizing uniqueness in our products”*. Moreover, patents can induce uniqueness through stopping competitors from making use of similar innovations. One interviewee continued in the same direction stating *“having a patent is not going to grant business but it is giving strength to your position on the market. I think patents are important and I think it puts us in a different situation when negotiating with customers and investors since we can show we are the only ones with our unique product.”* Furthermore, trade secrets can also have the ability to induce uniqueness through keeping underlying know-how and knowledge behind the products within a start-up. One interviewee argued uniqueness as a value from informal IP stating *“due to our trade secrets, we can offer our customers unique solutions, they cannot get from anyone else”*.

First mover advantage can be attained through keeping knowledge and know-how within a start-up through informal IP. By not disclosing ideas to the public domain and maintaining market uncertainty regarding new innovations for a prolonged timespan, nanotechnology start-ups can innovate without interruption from competitors. One interviewee stated, *“I think many start-ups are moving toward more and more trade secrets, and that it can be more important to focus on gaining first mover advantage and being first to*

the market than having many patents”. This statement was confirmed by another interviewee stating, *“having patents is important, however we find value in being first to offer new products to the market”*.

Financial values and corresponding dimensions

Dimension 4: Effective resource allocation

Nanotechnology start-ups are typically lacking financial resources, making it difficult to apply for or procure formal IP connected to all innovative efforts. It can be important for start-ups to prioritize informal IP in order to achieve effective resource allocation. One interviewee stated, *“it is motivating to realize there is no right or wrong when it comes to trade secrets and that focusing on them can have a positive effect on our business without us having to make large investments”*. The analysis shows effective resource allocation can be achieved through three main enablers, namely *prioritizing projects, cost cutting and knowledge transfer*, as presented in Fig. 4.

Prioritizing projects, in terms of which projects are subject to formal or informal IP protection, can be beneficial for nanotechnology start-ups with limited resources in terms of both time and financial resources. Prioritizing projects is in this context when a start-up is strategically determining which innovations to move forward with in terms of continuing development or filing for formal IP. For nanotechnology start-ups, a project can be defined as developing an innovation as well as taking it to the market. Prioritizing which projects may have the most long-term potential can be beneficial when trying to make effective use of available resources. One interviewee stated, *“we try our best to make sure we can generate financial returns on the investments we make toward formal IP, and also try to prioritize which innovative efforts would be the most beneficial to commercialize first”*. It can also be beneficial for nanotechnology start-ups to ensure necessary resources can be allocated before initiating a project in order not to waste resources on unrealistic projects. Within the same direction, another interviewee stated, *“it is important for us*

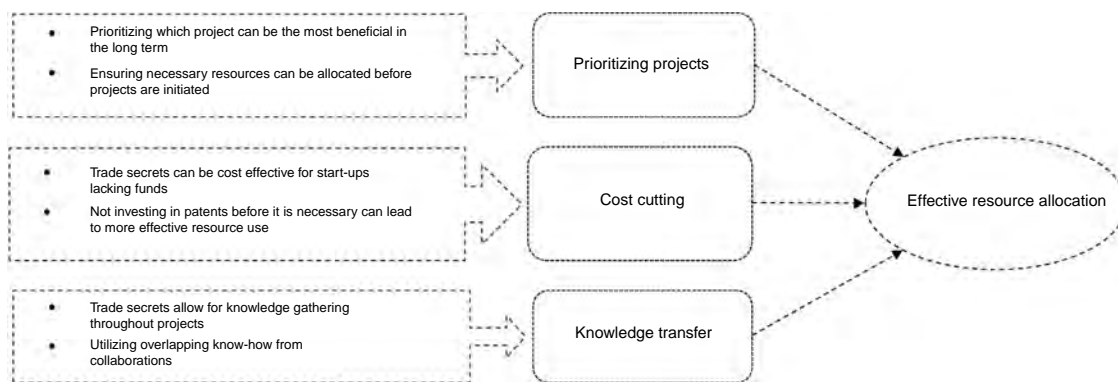


Figure 4 Effective resource allocation.

to operate under the radar, since we do not have the funds to invest in formal IP on all our innovations and for us it is necessary to have a feasible budget connected to all our initiated projects”.

Cost cutting is an important factor for nanotechnology start-ups to stay competitive on the market. By cutting costs from formal IP, nanotechnology start-ups can allocate resources toward other cost-straining activities. One interviewee stated, “the benefits we see with trade secrets is the ability to put resources toward other parts of the company”. Another interviewee agreed stating, “it is important to remember the cost aspect of IP, patents are expensive and keeping quiet is not”. Informal IP trade secrets can further help a nanotechnology start-up when prioritizing which innovations to formally protect avoiding costs on non-value generating formal IP. One interviewee confirmed this stating, “we build our patent portfolio on a long-term basis, where our strategies change depending on market demand, we are after all a start-up with limited resources”.

Knowledge transfer is a value for nanotechnology start-ups that can be generated mainly through informal IP. By transferring know-how and trade secrets between projects nanotechnology start-ups can reuse knowledge and does not have to start from scratch with every new project or collaboration. One interviewee stated, “we save time and resources by building know-how throughout our projects that we can use in future projects”. Another interviewee had a similar point of view stating “we sell knowledge, and we build our knowledgebase through our collaborations. When we enter a new project, we use the know-how we gathered through our previous projects”.

Dimension 5: Direct income from market transactions

For nanotechnology start-ups to thrive it is important to effectively generate revenue streams through direct income from market transactions, which can be achieved through both formal and informal IP. One interviewee stated, “We have a patent on our basic concept, but our know-how is woven into our selling process, in order to increase our profits”. Another interviewee elaborated further, stating “our customers should feel the need to buy or license specifically from us because of our formally protected know-how”. Formal IP may thus contribute or even be necessary for a nanotechnology start-up to be considered by the market when their trying to license know-how. To achieve this state

of being considered, it can be important to map marked demands and invest in formal IP accordingly. One interviewee stated, “for start-ups it is important to map the existing patents on the market and to listen to market demands in order for patents to generate maximum value”. The analysis suggests direct income from market transactions includes two enablers, namely *ability to license* and *ability to sell*, as presented in Fig. 5.

The **ability to license** can mainly be achieved through formal IP, specifically patents, for nanotechnology start-ups. Licensing can be an effective way to generate direct income from formal IP for nanotechnology start-ups. One interviewee stated, “our entire business model relies on licensing and without patents we would not be able to generate value returns at all”. Strategically mapped application-based patents can be beneficial for nanotechnology start-ups to have since these can be of value to license to both partners and competitors. This is confirmed by another interviewee stating, “we have a patent on our base technology, however we only license know-how from our application-based patents since these have higher demand on the market”. Thus, for nanotechnology start-ups to be able to effectively generate financial value from IP through licensing it can be beneficial to strategically map the market to identify demands and thereafter file for patents accordingly.

Ability to sell is a main factor for nanotechnology start-ups and can be a central part of the revenues. Nanotechnology start-ups perceive formal IP, mainly patents, to be important when customers choose where to buy a product. One interviewee stated “customers will first take a look at your patent portfolio behind your technology before buying from you”. In a similar manner, another interviewee stated “our patents bring customers a sense of security, and customers want to know whether we have a patent or not”. However, one interviewee stated that patents can be valuable, but that they are only a small part of the selling process and argued “a patent is not valuable until you have a product that can be sold on the market and IP is only a small part of our selling arguments”. Informal IP, such as know-how, can also be used by nanotechnology start-ups in selling discussions to help convince customers. One interviewee stated “we do not tell our secrets to our customers, but we use the consequence of the know-how in discussions for selling”.

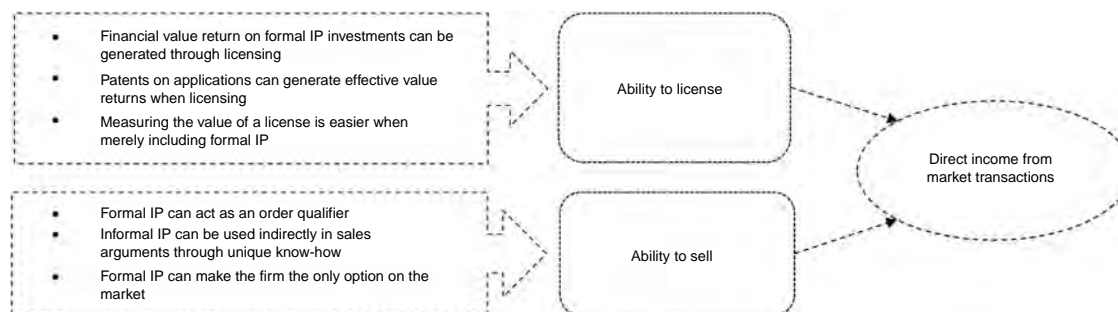


Figure 5 Direct income from market transactions.

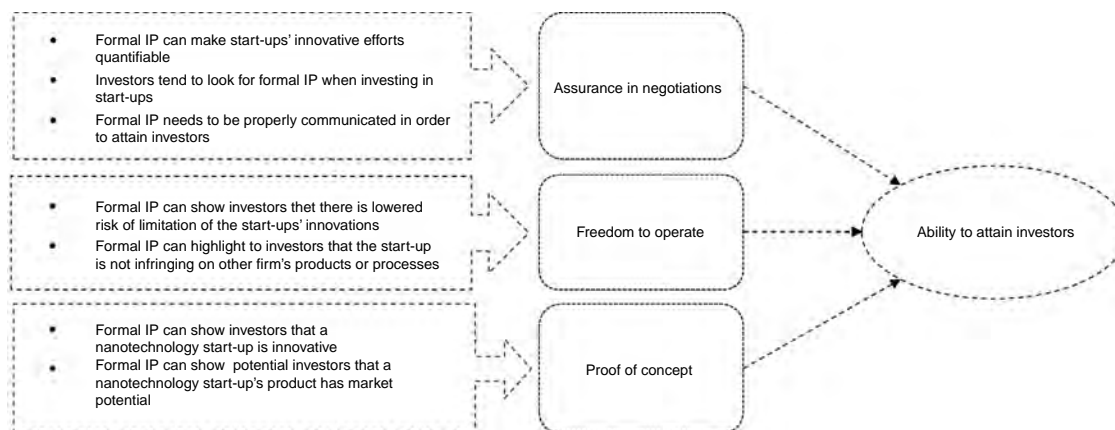


Figure 6 Ability to attain investors.

Dimension 6: Ability to attain investors

Since nanotechnology start-ups often lack financial resources, attaining investors can be beneficial in order to be able to commercialize products and carry out innovative efforts. In some cases, nanotechnology start-ups seek investors that will contribute financially toward the development costs of a new product or process. One interviewee stated *"since we are a start-up that cannot afford to take large risks, we try to convince investors, customers or universities to pay for our research and prototypes"*. Moreover, formal IP can be a major part of negotiations with investors. One interviewee argued *"When seeking larger investments, collaborations cannot be based on hope and secrets, which is why we need to have patents on our innovations to get investors"*. The analysis shows that nanotechnology start-ups can attain investors through three main enablers, assurance in negotiations, freedom to operate and proof of concept as presented in Fig. 6.

Assurance in negotiations can be important for nanotechnology start-ups to maintain when negotiating with investors. Investors tend to ask for formal IP, specifically patents, when discussing investments with a start-up. One interviewee stated, *"the competitive advantages we see in IP is the ability to maintain negotiations with investors since investors value patents highly"*. Another interviewee agreed stating *"patents puts us in a strengthened position when negotiating with potential investors"*. Formal IP can bring assurance toward a start-up's innovations

and make innovative efforts quantifiable. One interviewee argued, *"investors care about us having patents since patents bring measurability and make our innovations easier to understand"*. In order to make it easier for investors to comprehend innovations however, it can be important to properly communicate innovations through formally protected aspects that might be of interest to investors. One interviewee argued similarly stating *"when we negotiate with investors we make sure to clearly communicate our formal IP since we know they are going to ask if and how our innovations are formally protected"*.

Freedom to operate can be attained through formal IP and patents play an important part for nanotechnology start-ups to show security toward investors. Formal IP can show investors that a product or process has a lower risk of imitation by competitors. One interviewee stated *"we need to show that we have freedom to operate on our market, and that no other firm can do exactly what we do. Freedom to operate is critical for us to continue what we do without imitation"*. Formal IP further has the ability to show investors that a nanotechnology start-up is not infringing on other firm's protected rights. By having formal IP, the risk of being subject to infringement proceedings is lowered which is something that can be of importance to investors. Another interviewee similarly stated *"we communicate to investors that we are free to operate and are using our patented knowledge in our processes. If investors are investing a lot of money, it is important to discuss IP and our ownerships"*.

Proof of concept is sought after by nanotechnology start-ups in terms of showing potential investors proof of innovative efforts and products with market potential through having formal IP. One interviewee argued “*patents show investors that the company, processes and products have potential and have been validated as being innovative*”. Another interviewee had similar arguments stating “*We use our patents when communicating to potential investors, the patent is proof that we are innovative and have innovative products*”. Furthermore, when a nanotechnology start-up is looking for investment toward development communicating formal IP can be beneficial. Another interviewee elaborated similarly stating “*when we search for investors for development projects, in the end investors always ask if we are protected, and it is always good to be able to say you own rights to a product because it proves that what you have is inventive*”.

Conceptual framework for effective IP strategies

Table 1 shows how the aggregated dimensions and corresponding enablers are connected to strategic and financial values. Table 1 further presents which type of IP can be utilized to generate value through each enabler in accordance to the analyzed findings.

As suggested by the analyzed findings, the actual **strategic values** nanotechnology start-ups seek from protecting innovations can be conceptualized as *trustworthiness*

through qualified recognition, ability to increase in market share and having a competitive presence on the market. Nanotechnology start-ups seek strategic values to create and maintain competitive advantages on the market. The strategic values do not only stem from innovating products successfully but creating **effective** IP strategies for innovations that show potential on the market.

As suggested by the analyzed findings, the actual **financial values** nanotechnology start-ups seek from protecting innovations can be conceptualized as *effective resource allocation, direct income from market transactions and ability to attain investors.* Nanotechnology start-ups seek financial values in order to survive and thrive. The financial values do not only stem from selling innovative products but also from protecting innovations and capitalizing on the rights obtained from IP.

To generate **strategic and financial values**, nanotechnology start-ups can benefit from focusing on both formal and informal IP. The findings suggest, that for nanotechnology start-ups the most value generating types of formal IP are patents and trademarks, and the most value generating type of informal IP is trade secrets. The analysis further suggests patents and trade secrets to be an effective combination for nanotechnology start-ups as the two different forms of IP can effectively cover different aspects of an innovation. The findings indicate patents can effectively protect a finished product within the nanotechnology start-up sector and trade secrets can effectively protect the knowhow behind a product. The findings further indicate that trademarks

Table 1 Aggregated dimensions and corresponding enablers.

Types of value	Value	Enabler	Type of IP
Strategic value	Trustworthiness through qualified recognition Ability to increase in market share	Negotiation baseline	Formal
		Quality and brand recognition	Formal
		Attaining value within the firm	Formal
			Informal
	Competitive presence	Strategy mapping	Informal
		Development of future commercialization opportunities	Formal
		Ability to hinder or block competitors	Formal
		Control over time and information disclosure	Informal
		Ability to upkeep uniqueness	Formal
			Informal
Financial Value	Effective resource allocation	First mover advantage	Informal
		Prioritizing projects	Formal
			Informal
		Cost cutting	Formal
	Direct income from market transactions	Knowledge transfer	Informal
		Ability to license	Formal
		Ability to sell	Formal
			Informal
	Ability to attain investors	Assurance in negotiations	Formal
		Freedom to operate	Formal
Proof of concept		Formal	

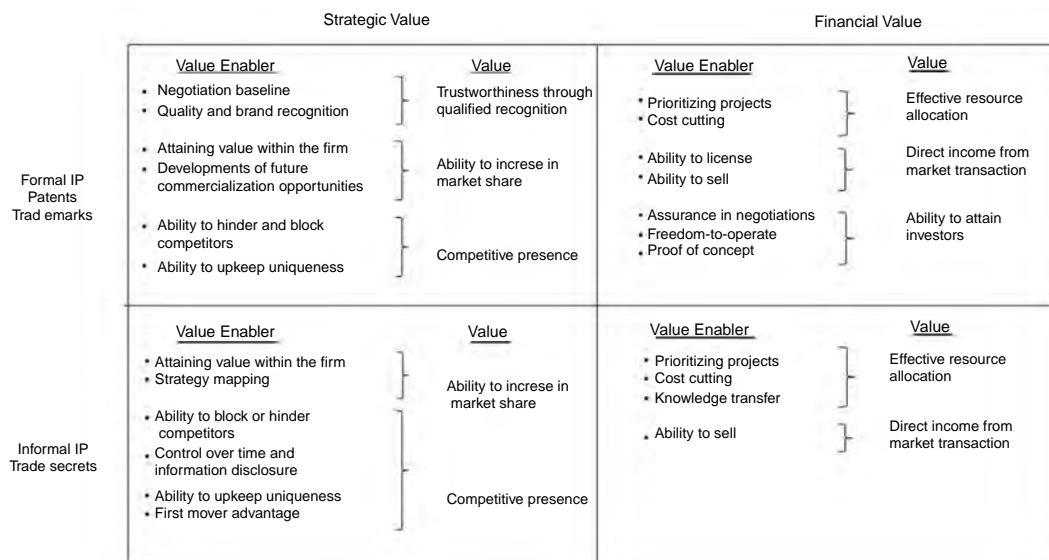


Figure 7 Conceptual framework for generating strategic and financial value through formal and informal IP.

can effectively protect a name of a company or product to increase quality and recognition. Formal and informal IP can be utilized in order to attain different value enablers that in turn form the strategic and financial value concepts. However, to effectively generate the value concepts through corresponding enablers, a combination of formal and informal IP can be necessary as visualized in Fig. 7.

As the framework in Fig. 7 shows, to effectively generate strategic and financial value within a nanotechnology start-up, both formal and informal IP can be beneficial. The analysis suggests most of the value concepts can be generated through formal and informal IP. However, the findings indicate that the strategic value *trustworthiness through qualified recognition* and the financial value *ability to attain investors* can be attained through formal IP and is not influenced by having informal IP. Thus, suggesting a higher ability to generate strategic and financial value from combining formal and informal IP.

Combination of formal and informal IP and corresponding enablers

Due to the high complexity of nanotechnology, start-ups within the sector can benefit from combining formal and informal IP. As presented in Fig. 7 all the strategic and financial values can be generated through formal IP. However, not all value enablers can be attained only through formal IP, hence a higher level of value can be generated through effectively combining formal and informal IP since different enablers are attained through different types of IP. Nanotechnology start-ups can effectively attain all enablers when combining trade secrets, patents and trademarks.

Formal IP can give nanotechnology start-ups competitive advantage on the market and informal IP assures no unnecessary information is disclosed to the public. One interviewee stated *"If you succeed in combining formal rights with secrecy, you disclose nothing to your competitors while still getting competitive advantages, this however is only true*

when underlying know-how is impossible to reverse engineer". The analysis suggests that combining formal and informal IP has three main advantages, namely *cost effectiveness*, *difficulty to reverse engineer* and *added value* as visualized in Fig. 8.

Since many nanotechnology start-ups are lacking financial resources it can be important to maintain **cost effectiveness** regarding IP strategies. Informal IP strategies often require less financial resources to maintain than formal IP strategies and are therefore often seen as cost effective for nanotechnology start-ups. One interviewee stated *"for us as a start-up it is important to consider the fact that it is expensive to file for patents and inexpensive to keep quiet"*. Another interviewee agreed arguing *"patents are expensive if merely used as a marketing strategy, in order not to waste resources I think it is important to consider which aspects of market offerings need formal protection and which can be maintained through secrecy"*. Effectively combining trade secrets and patents can therefore be advantageous for nanotechnology start-ups when seeking to achieve IP cost effectiveness. Furthermore, if utilized effectively patents can be seen as investments due to the possibility to generate value within a start-up. One interviewee stated *"patenting is relevant for us since it ties value to our firm"*. Another interviewee stated *"formal IP is good to discuss with potential customers or investors since patents are proof of our novelty. However, we also use the consequence of our know-how in such discussions which makes our offerings more unique"*.

Many nanotechnology innovations can be **difficult to reverse engineer** making it beneficial to have both formal and informal IP. Nanotechnology products are of a complex nature and can therefore be hard to reverse engineer just by studying the final product. Moreover, the processes nanotechnology start-ups use to produce products can be beneficial to keep as trade secrets while at the same time having formal IP for the actual product. One interviewee stated *"We protect our products by patents but keep underlying processes and know-how as trade secrets. Our*

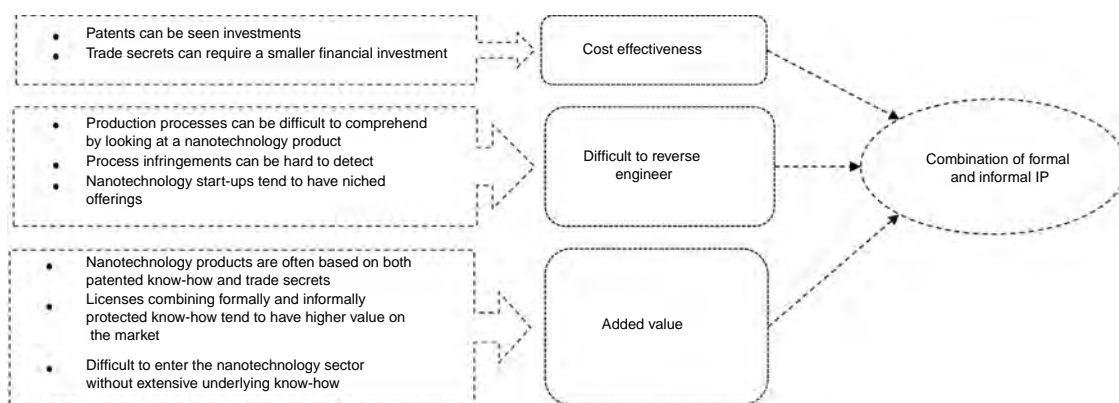


Figure 8 Combination of formal and informal IP.

competitors cannot see our process from looking at our products and if we patent the process, it is difficult for us to see if someone is using our process". Many nanotechnology start-ups have niched offerings which can add to the difficulty of reverse engineering. On the same subject one interviewee stated "right now we have a very niche product and are not afraid of any competitors doing exactly what we do through reverse engineering." Another interviewee said that trade secrets can be vital in avoiding reverse engineering and stated, *we are often asked about specific parts of our products, but if we disclose the secrets we have, there is a high risk of competitors' reverse engineering our products and we can lose our selling point of being unique*".

Combining formal and informal IP can bring **added value**, in terms of both strategic and financial values for nanotechnology start-ups. Licenses that include both informal IP in addition to formal IP is often more desired on the market and can thus generate a higher value. One interviewee noted "we can justify more exclusive pricing on our licenses when we combine our patents with secreted know-how". This view is agreed upon and another interviewee argued "direct competitive advantages lie more in know-how than formal rights when we are in selling discussions". Nanotechnology products are often based on both formal IP and informal IP, and it can be difficult to enter the market with only one form of IP. One interviewee stated, "trade secrets go hand in hand with our formal rights since our products are based on know-how". Another interviewee agreed stating "you cannot enter our market merely with financial resources acquiring formal IP unless you also have the underlying know-how. That is why there is a great value of keeping some things secret".

Discussion and conclusions

The overall conclusion is that many companies within the nanotechnology start-up sector is often favoring secrecy on certain aspects of innovations. Keeping secrets can be beneficial for nanotechnology start-ups since they in most cases have limited financial resources to invest in protecting all innovative ideas by patents. The findings indicate that it can be beneficial for nanotechnology start-ups to initially keep trade secrets while strategically mapping the market. Thereby, they can strategically decide which aspects

of innovations have potential to enhance the value possible to generate if protected by patents and which can generate value if kept as trade secrets.

For a nanotechnology start-up, having patents that fulfill market demands can be value generating. However, the findings show that nanotechnology start-ups often mistake the negative rights obtained from having patents as the right to operate the market freely. *Freedom to operate* the market, is not necessarily connected to innovative technologies protected by patents. Patents only block others from using the patented technology and does not give the owner rights to operate the market. To reach *freedom to operate* the market, a nanotechnology start-up can benefit from patenting aspects of innovations that fulfill market demands which not only can be used in sales arguments but also can be used in cross-licensing negotiations. Moreover, the findings indicate that investors see patents as an important factor when investing in a start-up which is in accordance to statements made by Bawa et al. (2005). Therefore, when seeking investors nanotechnology start-ups can benefit from having filed for patents or granted patents to create *assurance in negotiations* with investors, *proof of concept* as well as *quality and brand recognition*. The theoretical contribution of this study to existing literature is discussed in Supplemental Material 1.

Practical implications

In order for nanotechnology start-ups to create effective IP strategies the finding indicate six important aspects to consider in real business situations. The following six aspects were constructed through analyzing the identified value enablers to find similarities. By sorting out all value enablers, this recommendation can help executives within the nanotechnology start-up sector to create effective IP strategies and to effectively combine formal and informal IP to generate both strategic and financial values.

First, it is recommended to **map the technological environment and the commercial market**. Neglecting to focus on commercial market demands can be a future hindrance for nanotechnology start-ups when trying to create effective IP strategies. Important factors to consider when choosing how to protect different aspects of innovations are, what the market needs, the possibility to work around the solution,

as well as risk of reverse engineering the innovation. When IP strategies are created in accordance to the technological and commercial mapping, nanotechnology start-ups can attain *freedom to operate* the market and have the *ability to hinder and block competitors*.

Second, it is recommended for nanotechnology start-ups to consider and **determine which actual strategic and financial values are important** in order for them to thrive, and thereafter strategically plan formal and informal IP accordingly. How an innovation is protected can have impact on *values attained within the firm*. *Strategy mapping* can be used to *prioritize projects* and create effective IP strategies in accordance to the desired values.

Third, **protecting different aspects of an innovation with different types of IP** is recommended for nanotechnology start-ups to effectively generate value. Protecting an innovation by a combination of patents and trade secrets can be advantageous. However, a nanotechnology start-up cannot merely file for patents with the sole purpose of having a patent. Neither can they focus on trade secrets merely due to the lower costs. By strategically choosing which aspects to protect by patents and which to protect by trade secrets, nanotechnology start-ups can *cut costs* by not filing patents on all aspects of their innovations.

Fourth, due to the complexity within nanotechnology, start-ups are recommended to have **trade secrets on aspects of an innovation that are difficult to reverse engineer** for competitors. Such aspects can include tweaks in the production process and underlying know-how that add to the product's *uniqueness*. When treating these aspects as trade secrets *knowledge transfer* can be enabled within the start-up if effectively managed.

Fifth, to generate value from patents it is recommended to **formally protect aspects of an innovation that fulfill market demands** as well as aspects that competitors probably need in order to develop their products. Thus, aspects connected to sales arguments or licensing agreements may be beneficial to protect by patents for nanotechnology start-ups, increasing the *ability to sell* and the *ability to license*. Furthermore, patents can act as a *negotiation baseline* through *proof of concept* on innovations when discussing with potential customers, partners and investors.

Sixth, it is recommended for nanotechnology start-ups to have a **plan for how the rights attained actually should generate value**. By having a structured plan for how to maintain trade secrets, nanotechnology start-ups can have *control over time and information disclosure* and thus be able to *develop future commercialization opportunities* without the background noise of competitors. Moreover, to further remove background noise and create clarity for customers patents can enable considerations and increase the *ability to initiate sales*. Through strategically managed formal and informal IP nanotechnology start-ups may be able to

maintain uncertainty on the market, thus enable *first mover advantage* and increase possibility to enter the market without disclosing any unnecessary information.

Conflicts of interest

The authors declare no conflicts of interest.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at [doi:10.1016/j.biori.2019.01.001](https://doi.org/10.1016/j.biori.2019.01.001).

References

- Andersen, B., Rosli, A., Rossi, F., & Yangsap, W. (2012). Intellectual property (IP) governance in ICT firms: strategic value seeking through proprietary and non-proprietary IP transactions. *International Journal Of Intellectual Property Management*, 5(1), 19.
- Bamford, C. E., Dean, T. J., & Douglas, T. J. (2004). The temporal nature of growth determinants in new bank foundations: Implications for new venture research design. *Journal of Business Venturing*, 19, 899–919.
- Bastani, B., & Fernandez, D. (2005). Intellectual property rights in nanotechnology. *Information Technology Journal*, 4, 69–74.
- Bawa, R., Bawa, S. R., & Maebius, S. B. (2005). *The nanotechnology patent 'gold rush'*.
- Bonakdar, A., Frankenberger, K., Bader, M. A., & Gassmann, O. (2017). Capturing value from business models: The role of formal and informal protection strategies. *International Journal of Technology Management*, 73(4), 151–175.
- Fulekar, M. H. (2010). *Nanotechnology: Importance and applications*. IK International Pvt Ltd.
- Gioia, D., Corley, K., & Hamilton, A. (2012). Seeking qualitative rigor in inductive research. *Organizational Research Methods*, 16(1), 15–31.
- La Ferla, B. (2004). Back to basics. What's IP all about? *Engineering Management*, 14(1), 22–23.
- Mangematin, V., & Walsh, S. (2012). The future of nanotechnologies. *Technovation*, 32(3–4), 157–160.
- Pham, C. H., & Garsson, R. S. (2014). What nanotech inventors need to know about trade secrets and the prior user rights defense. *Nanotechnology Reviews*, 3(6), 597–600.