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Exploring Patent Awareness of Engineers. Evidence from Chinese R&D Units of a Multi-National Corporation

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Abstract

A sufficient patent awareness can be considered as a precondition of an efficient use of the benefits patents provide to companies. Hence, if a company would like to fully exploit the advantages of patent protection for its inventions, it should make sure that patent awareness of relevant employees, particularly engineers, is adequate. Though patent awareness related topics have been discussed in the previous studies on a country and organizational level, the patent awareness of individuals remains understudied. Furthermore, no study explores what individual and/or external factors affect patent awareness of R&D engineers in the corporate context. The present study attempts to close this knowledge gap by investigating patent awareness of local engineers at R&D centers in China of a European-based MNC, as well as two individual (invention disclosure experience and use of patent literature) and three managerial (supervisory encouragement, patent trainings and patent attorney consultancy) factors. The findings suggest that invention disclosure experience, use of patent literature, supervisory encouragement and patent trainings have a significant impact on the engineers' patent awareness, whereas the effect of patent attorney consultancy is probably mitigated by invention disclosure experience. Besides, the discussion shows a potential effect the managerial factors may have on the individual ones.

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Abstract

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Key words: patent awareness, management approaches

1. Introduction

Patents play an important role in corporate intellectual property (IP) strategies being regarded in general as the most valuable and hard to obtain IPRs (Gollin, 2008: p.172). Though the existing research on companies' patenting behavior can be considered relatively rich and diversified, little is known about what companies' internal conditions, procedures or efforts lead to a desirable patent output.

According to Pitkethly (2010, 2012), a precondition of an efficient use of the IP system and the benefits it provides is sufficient IP awareness and "there is a continuous need to promote IP awareness not just to firms but also within firms" (Pitkethly, 2010: p. 8). In other words, if a company would like to fully exploit the advantages of patent protection for its inventions, it should make sure that *patent awareness* of relevant employees, particularly engineers, is adequate.

Though patent awareness related topics have been discussed in the previous studies (Baldini, 2011; Chang & Chang, 2010; Figueiredo Moutinho, Fontes, & Godinho, 2007; Hynynen, 2013; Pitkethly, 2010; Pitkethly, 2012), the patent awareness of individuals remains understudied. Furthermore, no study explores what individual and/or external factors affect patent awareness of R&D engineers in the corporate context. The present study attempts to close this knowledge gap by investigating patent awareness of local engineers at R&D centers in China of a European-based MNC.

Despite that larger companies are considered more IP aware compared to small and medium size enterprises (Doern, 1997; Pitkethly, 2010), their local staff in the emerging economies may not always possess a strong knowledge of patents, for example due to relatively low IP awareness in the society (Kshetri, 2009). A low patent awareness among the local R&D staff may become a serious preclusion for a high patent productivity, since having little understanding of patents and their characteristics, the engineers may be simply unable to recognize a patentable invention in their work or may consider the idea of patenting their invention as unimportant. Hence, exploring the patent awareness of the engineers in the context of MNC's R&D laboratories in an emerging economy is a reasonable choice.

I outline my study as follows: first I review the existing research on patent awareness. Next, I provide a definition of the patent awareness of an engineer based on the previous studies and develop the hypotheses. Then I explain the methodology used for the research and then present the results of the analysis of the obtained data. Finally, I discuss my findings, their limitations and further research directions.

2. Theoretical background and hypotheses

2.1. Patent awareness in different research contexts

The patent awareness related issues have already been discussed in the previous research which mostly does not address the patent awareness separately, but discusses it under a general term of IP awareness.

Most of the studies focus on the IP awareness related issues in context of companies and general public. Viana and Maicher (2015) analyze different existing tools for improving IP literacy offered by IP offices and public organizations in Europe and South-east Asia and derive recommendations on improving of these tools. Van Pottelsberghe de la Potterie, Vandecandelaere, and de Bethune (2008) provide some broad policy recommendations aiming at improving the IP awareness and more effective use of the IP system in Belgium. Hynynen (2013) discusses the lack of IP awareness among SMEs in Finland and the relevance of the IP awareness for the business success. He strengthens in this regard the role of IP education and IP promotion services. The role of IP education is also emphasized by Kelli & Pisuke (2008) who explored the experience of Estonian universities in teaching specialized IP courses to students and by Kakonge (2014) in context of Africa's emerging economies where wrong assumptions of IPR among the general public is a common issue.

So far, Pitkethly's (2012) research based on the UK IP Awareness survey (Pitkethly, 2010) is the most comprehensive study regarding the topic providing definitions, components and measures of the IP awareness. His findings suggest that there is a need to promote IP awareness not only to the companies, but also within the companies, i.e. to the companies' employees.

The existing literature on patent awareness of individuals is scarce being limited to some discussion of patent awareness in context of patenting behavior, such as studies of Figueiredo Moutinho et al. (2007) and Baldini (2011). Stajano (1999) strengthens the role of professional support in improving IP awareness in academia. Chang and Chang (2010) investigate the influence of patent knowledge on some aspects of patenting behavior of software engineers in Taiwan. To date, their study is the only one addressing the patent awareness of an engineer in the corporate context. However, neither this nor other studies provide a comprehensive definition and measures of the patent awareness of an individual. Furthermore, the research on what factors or actions may affect the patent awareness is also limited to a few examples such as providing IP trainings to the employees (Keupp, Beckenbauer, & Gassmann, 2010; Potekhina, 2015). As the study of Pitkethly (2012) suggests the importance of promotion of IP awareness within the companies, the phenomenon of patent awareness of the engineers should be better investigated and understood.

2.2. Definition of patent awareness of an R&D engineer in a company's context

Scientific literature provides some definitions of the patent awareness in different contexts.

Chang and Chang (2010) define software engineers' knowledge on patents as "understanding of the difference between copyright and patent and understanding the information and value of patents". The studies on the patenting activities of academic researchers link the patent awareness with the ability to recognize the patenting opportunity (Baldini, 2011) and to the researchers' familiarity with the internal IP policies (Figueiredo Moutinho et al., 2007).

Beyond the context of an individual, Pitkethly (2012) provides a comprehensive definition of intellectual property rights awareness on the organizational level which consists of two types: the value awareness and the effective awareness. The value awareness relates to the awareness of benefits the IP system offers to its users whereas effective awareness implies adequate knowledge on how the IP system functions in order to use it effectively. Both types of awareness by Pitkethly have similarities to the definitions of Chang and Chang (2010), Baldini (2011) and Figueiredo Moutinho et al. (2007). Though value awareness in case of an individual may overlap with the phenomenon of patenting motivation in some studies (see e.g. Figueiredo Moutinho et al., 2007; Owen-Smith & Powell, 2001), it could also be interpreted as engineer's awareness of the benefits the patents provide to his employer.

Considering all the above mentioned definitions as relevant for the present study and given that the R&D staff of a company is not exposed to the IP system directly, but rather deals with the internal corporate rules related to patenting, the definition of patent awareness of an R&D engineer working in a corporate environment could be given as follows:

- Sufficient knowledge on functions and use of patents;
- Ability to recognize the patenting opportunity and knowing the criteria an invention should meet to be patented;
- Familiarity with the internal patenting processes;
- Awareness of benefits patents provide to the company.

2.3. Hypotheses

This chapter formulates several hypotheses on what individual and external factors affect the patent awareness of the engineers.

Individual factors: Patent-related working experience

Talking about individual factors affecting engineers' patent awareness it would be logical to assume that those engineers who deal more with patents in their daily working routine should have more knowledge and understanding on them. In this regard, the study of Figueiredo Moutinho et al. (2007) stresses the importance of researchers' filing experience in eliminating barriers to patenting: non-patenting researchers overestimated patenting difficulties compared to their colleagues with the patenting experience. Thus, the patenting experience can be considered as improving the patent awareness.

Furthermore, Chang and Chang (2010) demonstrate that the use of patent literature at work by software engineers eased searching, reading and applying for patents. Blackman (1995) promotes a more active use of patent information by companies and suggests that patent information can be used to find out if the idea is new and to give guidance for drafting a strong patent application. In other words, regular use of patent literature can result in better understanding of patents and their use.

Hence, I define patent-related working experience as (1) patent filing experience and (2) using patent literature in the daily R&D work and predict:

H1: *Patent-related working experience relates to patent awareness positively*

External factors: Role of management capabilities

Hall and Ziedonis (2001) emphasize the role of management capabilities in R&D processes. Company's R&D managers and patent experts should be able to influence engineers' patent awareness by providing them with needed support and consultancy in the patent-related tasks.

According to the expectancy theory, actions of the rational individuals are determined by the likelihood of a certain desired outcome (Petrock & Gamboa, 1976). In case of an R&D engineer this outcome is to a great extent defined by the responsible R&D manager, i.e. his/her supervisor. R&D managers influence the performance of the engineers by giving orientation, providing support and defining the priorities for the engineers' working tasks. The role of supervisor's appreciation can be found in the study of Bercovitz and Feldman (2008) on the organizational change in academia.

Besides, available time resources, as shown in empirical evidence, have an important influence on employees' perception of priority. If time resources provided for a certain task are not sufficient, the task will have lower priority in employee's daily activities (Nijhof, Krabbendam, & Looise, 2002).

Thus, if the supervisor appreciates, supports and provides sufficient time to the engineer to improve his knowledge on patents, an engineer should be more eager to do it. Therefore, I predict:

H2: *Supervisors' encouragement relates to the patent awareness of engineers positively.*

Hall and Ziedonis (2001) as well as Somaya, Williamson and Zhang (2007) suggest that internal patent attorneys play an important role in managing R&D processes. Pitkethly (2012) stresses the role of an "IP advice" in improving patent awareness which in the corporate context is most logically provided by company's IP expert or patent attorney.

Besides, several studies discuss the relevance of providing such "IP advices" in form of education and trainings in order to strengthen the IP awareness of the employees (ETAN Expert Working Group, 1999; Keupp et al., 2010; Ozkul, 2008; Yang, 2003). The study of Potekhina (2015) provides the evidence of patent trainings provided by internal IP experts to the local engineers in China to enhance their patent awareness. Hence I predict:

H3: *Availability and use of in-house patent consultancy services relate to patent awareness of engineers positively.*

3. Methodology

3.1. Empirical sample, survey instrument and data collection

The data for this study were collected at multi-national engineering company's three R&D centers in China. The company originates from Western Europe and specializes in drive, actuator and motion control technologies. Its global employee headcount is about 37,000. Company's annual investments in R&D account for about 6% of the revenue and are considered as substantially higher than the average in the related industrial sector. China is considered at the company as important strategic market. The R&D headcount in China almost doubled in the last five years and several measures were undertaken so far to increase the local patent output.

The survey instrument is a structured questionnaire in Chinese; hence it covered only local employees of the company. The development of the instrument started in April, 2014 with a preliminary qualitative study initiated by the company for which a small sample of company's in-house patent professionals, engineers and R&D managers was interviewed. Based on the data obtained from the interviews combined with findings in scientific literature (see Section 2 of the study), the initial version of the questionnaire was drafted in December, 2014. It was then further tested with 23 volunteers among engineers in three subsequent steps as suggested by Fowler (1995): focus group discussion, cognitive interviews and field test. Following the results of each step, the survey design was adjusted. The whole test procedure was carried out in close cooperation with company's R&D managers and patent professionals.

The survey took place in April-May 2014. The total number of targeted R&D staff was 165 engineers excluding managers, administrative personnel and expats. For this reason two measures were undertaken to avoid a low response rate. First, the engineers were informed in advance on survey's content, procedure and anonymity measures. Second, the management permitted to schedule appointments during working time to let the engineers fulfill the questionnaire. A survey supervisor was assigned at each R&D location to collect and send off the fulfilled questionnaires. 143 responses were received accounting for 77% response rate.

3.2. Variables and measures

Table 1 provides a summary of all variables and measures including reliability statistics for the composite variables.

I controlled for age, education and working experience at the company. For the ethical considerations, the specific age and length of working experience at the company were not asked in the questionnaire, but rather put into categories.

The dependent variable for this study is perceived patent awareness of an R&D engineer. The measures relevant for the variable were developed based on the definition of the patent awareness presented in the section 2.2 of this study.

Based on the hypotheses, two groups of predictor variables were applied. The first group of individual factors supports the hypotheses H1 in the section 2.3 and is represented by two variables. The variable *InvDisc* depicts the patent filing experience. For an employed engineer this is associated with an internal procedure of submitting an invention disclosure, based on which a patent application is later filed by the company. The variable *PatLit* is a composite of measures associated with the use of patent literature by an engineer in the daily working routine.

The second group of management factors supports the hypotheses H2 and H3. Supervisory encouragement consists of four items measuring the support and engagement of the engineer's direct supervisor in improving one's knowledge and understanding of patents. Availability and use of in-house patent consultancy services are represented by two dummy variables. *PatTrain* reflects whether an engineer has attained patent trainings provided by the internal patent attorney, whereas *PatAtt*

shows whether an engineer had an individual consultancy from patent attorney regarding patent matters.

Table 1. Variables and measures

Variable/ Construct	Description/Items	Coding
Control variables		
Age	---	1 = ≤30; 0 = >30.
Education	---	0 = no higher education; 1 = bachelor; 2 = master; 3 = Ph.D.
WorExp	Working experience at the company, years	1 = >1; 2 = 1-2; 3 = 3-4; 4 = ≤5.
Dependent variable		
PatAwar	Patent awareness (Chronbachs α = 0,831): I know what kind of technical solutions may become a patent. I know the difference between an invention patent, a utility model and a design patent. In general, I am able to understand the claim section of a patent without external help. I know the necessary criteria of an invention to apply for a patent. I know how to submit an invention disclosure in our company. I know which patents are in the products I am working with. I know what benefits the patents provide to my company.	Mean of the items scores on 5-point Likert scale
Predictor variables: individual factors		
InvDisc	Experience of submitting an invention disclosure	1= at least one patent disclosure submitted; 0 = no pantent disclosures submitted
PatLit	Use of patent literature in R&D work (Chronbachs α = 0,922): In general, I am able to conduct a patent search in my relevant technology area independently. I regularly read existing patents of my company. I regularly read existing patents of our competitors. I regularly analyze existing patents of my company. I regularly analyze existing patents of our competitors. I regularly use our company's patents for R&D projects. I regularly use our competitors' patents for R&D projects.	Mean of the items scores on 5-point Likert scale
Predictor variables: external (management) factors		
SupEnc	Supervisor encouragement (Chronbachs α = 0,920): My direct supervisor supports me to extend my knowledge on patents. My direct supervisor actively helps me to extend my knowledge on patents. My direct supervisor gladly shares with me his/her knowledge on patents. My direct supervisor provides me with sufficient time resources to improve my knowledge on patents.	Mean of the items scores on 5-point Likert scale
PatTrain	Attendance of patent trainings provided by the internal patent attorney	1 = at least one training attended; 0 = no trainings attended
PatAtt	Experience of internal patent attorney consultancy	1 = experience; 0 = no experience;

Three of the variables mentioned above, *PatAwar*, *PatLit* and *SupEnc* are composites of several items. Principal component factor analysis was used to assess the validity of these constructs, i.e. to test whether the items in the construct load onto a single factor. After running factor analysis the constructs were tested for reliability and showed Chronbach's alpha of >0.8 (see Table 1).

3.3. Method

Hierarchical multiple regression method was used to test the hypotheses. The first model reveals the impact of control variables on patent awareness. The predictors associated with individual factors are entered in the second model and the ones referred to management factors in the third model. The significance level of $p < 0.05$ is adopted to test the hypotheses.

4. Empirical analysis

4.1. Descriptive statistics and correlation

The descriptive statistics and correlation are shown in the Table 2. The means of invention disclosure experience, patent training attendance and use of patent attorney consultancy can also be interpreted as percentage of employees with the related experience. Only 28% of employees have ever submitted an invention disclosure. This conforms to the objective company data on the invention disclosures in China. This relatively low percentage is explained by the fact, that until recent years, the main task of the local engineers was not inventing new products, but rather to adapt the existing ones to Chinese market. Patent training experience accounted for 63%. Though the trainings are not compulsory for the engineers, many of them have been willing to attend to be better prepared to handle advanced R&D projects that require deeper patent knowledge[1]. The percentage of engineers having patent attorney consultancy is only 20%. Such consultancy often takes place when an engineer requires some help for submitting of invention disclosure. This fact is reflected by high significant correlation between Inv Disc and PatAtt variables.

Table 2. Descriptive statistics and correlations

	Mean	S. D.	N	Age	Educ.	WorExp	InvDisc	PatLit	SupEnc	PatTrain	PatAtt	PatAwar
Age	0,67	0,47	143	1								
Education	1,50	0,69	143	0,144	1							
WorExp	3,21	0,77	141	0,183*	-0,236**	1						
InvDisc	0,28	0,45	143	0,138	0,155	-0,087	1					
PatLit	2,60	0,69	141	0,123	0,195*	-0,150	0,199*	1				
SupEnc	3,31	0,83	143	0,240**	0,081	0,001	0,268**	0,479***	1			
PatTrain	0,63	0,48	140	0,104	0,136	0,139	0,247**	0,128	0,293***	1		
PatAtt	0,20	0,40	139	0,163	0,054	0,044	0,434***	0,317***	0,289**	0,278**	1	
PatAwar	3,39	0,57	142	0,196*	0,166*	0,040	0,374***	0,557***	0,593***	0,358***	0,352***	1

***. Correlation is significant at the 0.001 level.
**. Correlation is significant at the 0.01 level.
*. Correlation is significant at the 0.05 level.

PatLit variable has a mean of 2.6 showing a modest use of patent by the engineers in their work. The average supervisors' encouragement is also moderate (3.31). PatAwar variable shows slightly above average level at 3.39 indicating that less than a half of the engineers possess a good to strong patent awareness.

The outcome variable has high correlation with all five predictors at the 0.001 significance. This preliminary test demonstrates that the patent awareness and selected individual and management factors are highly associated.

[1] Few years ago the company started to advance its R&D strategy in China by giving more responsibility to the local R&D labs.

Most of correlations between dependent variables are significant at 0.01 or 0.001 (except for PatLit with InvDisc and PatTrain), which draws the attention to the multicollinearity. Though the correlations between variables do not exceed 0.8, it still might be an issue if variable inflation factor (VIF) is greater than 10 (Bowerman & O'Connel, 1990; Myers, 1990) and tolerance is below 0.1 (Field, 2014). The collinearity diagnostics showed that VIFs are smaller than 1.489 and tolerances greater than 0.672. As all the predictors are within the thresholds I retain them for further analysis.

4.2. Regression

Table 3 presents the results of multiple hierarchical regressions about the influence of individual and management factors on the patent awareness of engineers. Standardized regression coefficients (β), standard error and significance value are presented for each predictor. The summary for each model is shown at the bottom of the table. Little variations in the perceived patent awareness can be seen in the Model 1 where only control variables are entered (R^2 of 6%, no variables significant at <0.05 level). Model 2, with the entry of individual factors, shows increase of almost 37% in R^2, whereas overall significance of the model rises and standard error drops from 0.559 to 0.447. Both predictors, invention disclosure experience and use of patent literature, have positive beta coefficient significant at <0.001 which provides support for H1.

Entering supervisor's encouragement, patent training and patent attorney consultancy in the Model 3 results in the increase of R^2 to 52.4% showing a change of above 10%. In addition, standard error of the model becomes more deflated compared to the previous one. This model shows how the management factors contribute to the patent awareness of the engineers. Supervisory encouragement proves to have a positive effect on patent awareness ($p<0.001$) which confirms H2. Patent trainings are also effective at the 0.05 significance. This partly confirms H3. As for patent attorney consultancy, if individual factors are excluded from the model it shows a positive beta of 0.159 at the level of $p = 0.029$. In the Model 3 the variable loses its power. It can be explained by high significant correlations of PatAtt with InvDisc and PatLit variables. Besides, the small sample size precludes the possibility to detect small effects in the regression model.

Table 3. Hierarchical regression modeling for patent awareness.

Variable	Model 1			Model 2			Model 3		
	β	Std. Error	Sig.	β	Std. Error	Sig.	β	Std. Error	Sig.
(Constant)		0,259	0,000		0,258	0,000		0,253	0,000
Age	0,165	0,106	0,061	0,064	0,086	0,370	0,009	0,080	0,895
Education	0,153	0,073	0,086	0,050	0,059	0,490	0,046	0,055	0,490
WE_firm	0,046	0,066	0,605	0,140	0,053	0,054	0,094	0,050	0,164
InvDisc				0,268	0,088	0,000	0,169	0,089	0,018
PatLit				0,507	0,058	0,000	0,343	0,061	0,000
SupEnc							0,326	0,051	0,000
PatTrain							0,150	0,080	0,029
PatAtt							0,026	0,102	0,718
R^2		0,060			0,409			0,524	
ΔR^2		0,060			0,367			0,101	
Adjusted R^2		0,038			0,386			0,494	
Std. Error		0,559			0,447			0,406	
Sig. F Change		0,043			0,000			0,000	

5. Discussion

The present study has focused on analysis of the effects of individual and management factors on patent awareness of R&D engineers in China in a context of a multi-national engineering company. This research supports H1, H2 and partly H3. This study contributes to the literature on the phenomenon of patent awareness and is so far the first one defining its measures for individuals based on both, existing literature and empirical evidence.

Among five different factors the effect of which on the patent awareness was examined, four proved to have a significant positive effect: invention disclosure experience, use of patent literature, supervisory encouragement and patent trainings provided by in-house patent professional. As for patent attorney consultancy (PatAtt), it shows a significant effect on the patent awareness, if the regression is calculated without including the individual factors. When all the factors come into play, the effect becomes insignificant (as shown in the Model 3, Table 3). The feedback from R&D management of the company on this phenomenon was that the patent attorney consultancy often takes place when an engineer submits an invention disclosure (which is confirmed by the correlation of 0.434 between the variables significant at 0.001 level). Probably for this reason the effect of the patent attorney consultancy is diminished in the Model 3.

The findings of the study should also be viewed in the societal and cultural context the data was obtained in. For example, a modest mean value of PatAwar variable (3.39; see Table 3) reflects the situation of relatively low IP awareness in the Chinese society (Kshetri, 2009). Besides, the strong effect of supervisory encouragement can be explained by the traditional respect to hierarchy in Chinese culture (Fang, 1999).

Furthermore, some managerial implications could be drawn out of the present research. As shown in the Table 2 the managerial and individual factors show high significant positive correlations (except for the pair PatTrain and PatLit). This means, that managers could potentially influence the engineers' attitude toward using patent literature or make them put some extra efforts to transform their ideas into patentable inventions. It is anyway the managerial responsibility to provide time and other necessary resources to enable the engineers to perform certain tasks.

6. Limitations and further research

Discussing the limitations of the present study, it should be pointed out that the findings are based on a limited sample taken from three Chinese R&D units of a single multi-national corporation. Therefore the study depicts the experiences in a limited socio-cultural context. Furthermore, since the phenomenon of the patent awareness of an individual has been poorly addressed in the previous research, it was possible to depict only a limited number of possible individual and managerial factors influencing this object. Thus, the present study can set a threshold for several possible further research directions.

First, qualitative studies can be undertaken to explore further factors affecting the engineers' patent awareness. A pragmatic research approach could also be appropriate to subsequently confirm the hypotheses emerged from the qualitative research.

Second, it would be interesting to study patent awareness of the individuals exposed to different socio-cultural and working contexts. The present research focuses on experiences of Chinese R&D engineers working for a European-based MNC. Studies in other countries and organizations, and comparative studies between them (e.g. corporate context vs. academia) may further extend the knowledge on this topic and provide a more profound understanding of its dimensions.

Finally, the patent awareness represents only one of the domains of the individuals' patenting behavior. The existing literature suggests that the patenting behavior is also shaped by the individual motives (Baldini, 2011; Figueiredo Moutinho et al., 2007; Mathew & Chakraborty, 2012; Veer & Jell,

2012). Therefore, it would make sense to investigate the interaction of patent awareness and patenting motivation of the individuals to have a deeper insight into the nature of this phenomenon.

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