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Faculteit Bedrijfseconomische Wetenschappen

master in de toegepaste economische wetenschappen

Masterthesis

Mobiliteit van uitvinders en de innovatieve slagkracht van bedrijven

Arne Gabriels

Scriptie ingediend tot het behalen van de graad van master in de toegepaste economische wetenschappen, afstudeerrichting innovatie en ondernemerschap

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Foreword

This master thesis is written as an individual project in order to get a Masters degree in Applied Economics with a specialisation in innovation and entrepreneurship. This research examines the impact of the mobility of inventors on the innovative capacities of firms. By allowing me to conduct my own research, the University of Hasselt allowed me to translate theoretical concepts, which I learned through my education, into a practical research. This year I tried to finish my own research with success. But as I am still an unexperienced researcher, this research could not be finished successfully without any help. That is why I would like to thank some people who helped me throughout this process with their contributions.

First of all, I would like to thank my promoter prof. dr. Bart Leten and co-promoter Ms. Ngoc Han Nguyen. They gave me a lot of insights in the topic of inventor mobility and gave me constructive feedback when needed. The contributions of Ms. Nguyen in the analytical part of this thesis were a real help for me since I am not very experienced with working with statistical programs and big data. I also want to thank both of them for allowing me to use their data set, which contained patent information of more than 250 pharmaceutical firms. By using this data set, I was able to test my theoretical findings which helped me to find an answer to my research question.

I would also like to thank my friends and family for their support and motivation this year. Especially Maarten Coemans, who is a good friend and experienced PhD researcher, helped me a lot during the analytical part of this Master thesis. Maarten assisted me a lot in cleaning the data set, which was a very intensive process.

Arne Gabriels
August, 2019

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1. Problem statement

In today’s world, hiring away inventors has long been recognized as a way of learning by innovative firms because high skilled inventors are often seen as key input of innovation. Literature on innovation and inventor mobility indicates that a move of an inventor to another firm can lead to knowledge transfers. These knowledge transfers can be used to catch up on other firms or to create a competitive advantage (Arrow, 1962). From a managerial perspective, hiring away inventors is used as an effective learning mechanism. According to data from the 1993 Belgian Community Innovation Survey, 42% of innovating firms are using this learning mechanism to gain access to external knowledge and technologies (Cassiman, 2006). This is why firms and countries engage in a global race for the best and brightest inventors. This race is also called a ‘war for talent’. In the first section of this report, we will take a look at the concept of ‘*inventor mobility’*. We will try to give an answer to questions such as: What is inventor mobility? Who is leaving the firm to join another firm? Why do inventors leave their employers? What is the impact of inventor mobility on the firm?

Inventor mobility seems to be an important channel of knowledge transfers between firms and can help firms with innovating themselves. In the second section of this report, we will be focusing on the relationship between inventor mobility and the innovative performance of a firm. Innovation is the development of new products and/or production techniques and has become very important for managers. There are several reasons to explain this. First, innovation can help firms to create a competitive position relative to their competitors. It is important for firms to create added value for their customers and to serve their needs. Second, innovation can help to increase the productivity of a firm. New production techniques can increase the efficiency of a firm for example. Finally, firms need to understand that businesses never stand still. Firms are thus forced to innovate constantly because their competitors are innovating as well. In this section we will try to give answer to questions such as: What is the impact of inventor mobility on the departure firm? What is the impact of inventor mobility on the destination firm? When do new recruitments have an impact on the innovative performance? Does inventor mobility help to create a competitive advantage?

As mentioned earlier, firms can use the knowledge of new inventors to catch up on others. This can be useful in a situation where they are characterized by a lower technology level for example. This means that the causality between productivity and inventor mobility may run in the opposite direction (Hoisl, Tracing mobile inventors: The causality between inventor mobility and inventor productivity., 2007). The assumption that the causality runs in the opposite way may be a reason to think that the more productive an inventor is, the higher the probability will be that he might observe a move. In the literature study, we will take a closer look at the direction of the relationship between inventor mobility and productivity, but the main focus will be on the effects of inventor mobility on the productivity level of firms.

2. Research questions

This report will examine the relationship between the mobility of high skilled people and the innovative performance of firms. In this report, we will be focusing more specifically on the inter-firm mobility decisions of inventors. The central research question will be: "How does the inter-firm mobility of high skilled people relate with the innovative performance of firms?" This central research question will be divided in two sub-questions to get more information on the different aspects of this relationship.

Sub-question 1: "What are the determinants of inventor mobility?"

This report will start with concretizing the concept of inventor mobility. We will determine what inventor mobility is and which factors have an impact on the mobility decision. This examination will be based on the existing literature that is available where other researchers already developed several definitions and found factors that have an impact on the mobility decision. This sub-question will help us to find the variables that are needed for the empirical part of this report.

Sub-question 2: "What is the impact of joiners from other firms on the inventive performance of the destination firm?"

When studying the effect of inventor mobility, there must be made a distinction between the effect of incoming employees who are joining a new organization and the effect of outgoing employees who are leaving an organization. Sub-question 2 focuses on the effect of incoming employees and will examine how the mobility decision of an inventor can have an impact on the innovative performance of the destination firm. The destination firm can be defined as the new employer of the inventor. Here, we will be more interested in the productivity side of firms. Leaving a firm to join another one can lead to an increase of the match quality between the inventor and his new employer for example. A better match quality could mean that the inventor's own productivity level will increase which is beneficial for the destination firm. Furthermore, the destination firm could benefit from the knowledge and skills from the new inventor which could also increase the productivity level (Hoisl, Tracing mobile inventors: The causality between inventor mobility and inventor productivity., 2007). Because of a limited timeframe, this report will focus only on the effect of incoming employees on the performance level of firms. Further research could examine the effect of outgoing employees and try to determine the total effect of inventor mobility.

There will be done a literature study and an empirical research to examine these sub-questions. The literature study will be based on scientific articles from the database of the Hasselt University. The empirical part will be based on a panel database with information on patents between 2000 and 2015 of approximately 200 companies. The companies of this panel database are active within the pharmaceutical sector. The pharmaceutical sector is known as a knowledge-intensive sector where innovation is crucial for companies to create a competitive position. Therefore, it will be interesting to study how firms acquire new knowledge for the exploitation of current activities and the exploration of new activities. Hiring employees from other companies might be a strategy that is more important in this industry than in other industries (Lenzi, 2009).

3. Literature study

3.1 Approach of the literature study

There will be done an extended literature study in order to collect the right information to investigate our research questions. In this report, we will make use of scientific articles available on the online database from the university library at the University of Hasselt. These articles will give us more insights on our topic and more information on research that has been done in the past by other researchers. Based on the scientific articles that are relevant to our research questions, we will be able to detect the different types of variables that are needed for our empirical research.

From the literature available, we will discover different variables and research methods that can help us to give an answer to our research questions. Variables such as inventor mobility, innovative performance and inventor productivity will be defined, concretized and used for this research. Ultimately, the aim of this report is to detect the different relations that exist between the variables that we will use in this research. We want to investigate which variables have a (significant) effect on our dependend variables in order to find a conclusion for our research.

3.2 Definitions and standards

3.2.1 Inventor mobility

3.2.1.1 Concept of inventor mobility

There is a broad consensus in the world that innovation is a key process for many firms in order to create a competitive advantage over other firms. Inventors who possess unique knowledge and skills are often seen as valuable human assets that can help a firm in this process of innovation. Recruiting an individual inventor from outside an organization gives an opportunity to increase a firm's access to external ideas and thus better enable it to complement exploitation of native ideas with exploration of foreign ideas (Agarwal A. , 2011). External sources of knowledge are essential for the innovative capabilities of firms. Many innovations result from a **knowledge transfer**. In particular, the transfer of crucial tacit knowledge that is otherwise immobile is facilitated by inventor mobility (Hoisl, Tracing mobile inventors: The causality between inventor mobility and inventor productivity., 2007). This is knowledge that is held tacitly by the inventor and is very costly or impossible to codify (Agarwal, Cockburn, & McHale, 2006). The acquisition of knowledge from other firms through the hiring of their inventors is also known as **"Learning by hiring"** (Palomeras & Melero, Markets for Inventors: Learning-by-Hiring as a Driver of Mobility, 2009).

Inventor mobility implies that strategic management of human assets is important, particularly in knowledge-intensive industries. But yet, the management of human assets is complicated because employees are able to walk out the door each day, leaving some questions about whether they will ever return to the firm. Inventor mobility puts firms in a position where they can lose their competitive advantage when inventors leave the firm to join another firm or create spin-outs for example (Campbell, Ganco, Franco, & Agarwal, 2011). Another consequence of inventor mobility is that the firm possibly loses an inventor where it may have invested in for years. This gives firms incentives to retain its inventors. Firms could address this problem of inventor mobility by designing contracts that deter employees from leaving or resorting to noncompete covenants and patent protection. Patent protection seems to be an effective way to address inventor mobility. In a study from Kim and Marschke (2005), there was found evidence that mobility positively affects the propensity to patent by firms in high-tech industries. Patents ensure that firms are protected from imitation and the negative effect of a departing inventor is limited to the loss of valuable knowledge (Palomeras & Melero, Markets for Inventors: Learning-by-Hiring as a Driver of Mobility, 2009).

When studying mobility, we have to make a distinction between the different types of mobility. Mobility can be seen as a change in some dimensional space. If this space is geographic, we are studying interregional or international mobility. If the space is the industrial structure of an economy, we are studying the intra-firm or inter-firm mobility decisions of employees. If the space is technological, we are studying the movement from one technological class to another (Latham, Le Bas, Bouklia hassane, & Voldin, 2011). In this report, we will be studying the effects of **inter-firm mobility** of employees. This means that we will focusing on the movements from employees from one firm to another. We are interested in the people who are moving, the incentives these people have to make a move and the effects and implications of their decision on the inventive performance of the destination and the departure firm.

3.2.1.2 Who is leaving the firm?

B. A. Campbell et al. (2011) conducted a study that examined questions related to employee propensity to exit. The underlying assumption in this study is the ability of an employee to generate value for an employer. The value of an employee depends on many factors such as his education, experience, motivation to work and his responsibilities within the firm for example. Each employee is unique and variation in these factors result in heterogeneity among employees in the generation of value for the firm. The core knowledge of the employee is important because it determines what is complementary for the value creation of the firm. Employees with less human capital than others are likely to contribute less to the total created value.
People with high human capital (strong skills, high education, experience, …) will also have a bigger chance to have promotions, which increases the control and authority of the employee within the firm.

Employees with high human capital are in a strong position and can threaten firms by exiting and transferring complementary assets. Examples of these assets are technologies that are used while working in the firm, team members and social networks. The exit of employees with high human capital has a bigger negative effect on the firm value than the exit of employees with low human capital. B. A. Campbell et al. (2011) posit that despite employees with high human capital generate more value and thus have more bargaining power than others, they are less likely to actually exit. There are two reasons to explain this. First, these employees will be offered higher wages which creates an incentive to stay in the firm. Second, employees with high human capital value more the intrinsic satisfaction of their efforts and input in the firm. Firms can thus motivate their employees with high human capital to stay and perform well by implementing the right management strategies. These management strategies can eventually reduce the desire of employees to leave the company and reduce the costs and risks of employee mobility.

In their study (2011), B. A. Campbell et al. indicate that demographic characteristics and observable human assets have an important role in the mobility decision. Examples are age, tenure, gender, race and education. In their empirical research, they found that older employees, those with longer tenure, and men are all less likely to exit. They also found that employee earnings are negatively related to employee mobility.

Topel and Ward (1992) argued in their study that mobility can lead to an improvement of the match quality between the employer and the employee. A better match quality is of great importance because it will lead to an increase of the productivity of the employee. Employees with poor matches will thus leave their employer more often and inventors who are satisfied will not change their employer. In a study from Schankerman et al. (2006) which used a database of software companies, there was no evidence found that the match quality between the employee and the employer is an important incentive for the employee to change their employer. Schankerman et al. found on the other hand that the asymmetric information between the employer and the employee about the value of an invention could be an incentive for a move.

3.2.1.3 Where do inventors move to?

Inventors have in general some options where they can choose from when they are leaving an organization. From the literature (Campbell, Ganco, Franco, & Agarwal, 2011), we can make a distinction between two big options. On the one hand, the employee can move to an established firm that is possibly active in the same domain as the current employer. On the other hand, the employee might become an entrepreneur himself and create a spin-out. Spin-outs can be defined as entrepreneurial ventures by ex-employees of an incumbent firm (Agarwal, Ganco, & Ziedonis, 2004). Both options are very different from each other and will have different 'costs' for the employee. Moving to another established firm does entail adjustment costs for the inventor because he will have to get used to his new colleagues, the processes and routines of his new employer for example. Creating a spin-out on the other hand implies that the inventor will take all the risks of operating a new business. The failure rate of new entrepreneurial enterprises is high. The major reason for this is not the quality of the ideas of the founder, but the lack of business and management skills. Spin-outs are however very important in high-technology industries and can be seen as major innovators. These companies that are founded by ex-employees pose a real threat to incumbents because they can capitalize on gained knowledge during their period at the organization (Agarwal, Ganco, & Ziedonis, 2004).

In their study, B. A. et Campbell et al. (2011) examined who is more likely to create a new business. They found evidence that high performing employees, who are usually high earners as well, are more likely to create their own organization. The reason behind this is that many of the characteristics that are related to the job performance are also related with entrepreneurship. High skilled employees will have a better absorptive capacity than other employees and will be able to recognize and exploit new opportunities. High skilled people will also be better at replicating and transferring complementary assets and resources from their previous employer.

3.2.1.4 Implications of inventor mobility

What is the impact of the individual mobility decision? Inventor mobility will have implications for the inventor himself, organizations, the management of knowledge and innovations developed within organizations and the competitiveness of an organization for example. In fact, three parties should be analysed: the inventor, the departure firm and the destination firm (Lenzi, 2009).

For the inventor, the literature indicates that the decision to change employers can possibly affect the productivity level of the inventor. However, the literature that focuses on the relationship between inventor mobility and the inventor productivity is limited. One of the first researches that focused on the inventor productivity was conducted by Topel and Ward in 1992. They suggested that inventor mobility can increase the match quality between the employer and the employee and that a better match quality will be beneficial for the inventor's productivity. Employees who experience poor matches will change their employer and inventors with good matches are more likely to stay at the company. Another study, conducted by Tratjenberg (2006), examined the relationship between employee mobility and employee productivity, focusing on R&D personnel who were active in the United States. Tratjenberg found that employee mobility has a positive impact on the performance level of people. Particularly, the patents of the inventors received more citations. The amount of citations can be seen as an indication for the value of a patent meaning that the more citations a patent gets, the more valuable it is. Interesting to remark is that Tratjenberg did not make a differentiation between the pre-move and the post-move period. Next, we shift to a study that was conducted by Schankerman et al. in 2006. Schankerman et al. used a database of software inventors and did not find evidence that the match quality between the employer and the employee is an incentive for mobility. Schankerman et al. found that the asymmetric information between the employer and the employee about the invention turned out to be an incentive for a move. In 2007, Hoisl found evidence that there is a simultaneous relationship between inventor mobility and inventor productivity. Movers are generally more productive than non-moving inventors because they can interact with their new colleagues to increase their performance level for example. Moreover, she found that more productive inventors have less incentives to move. These findings confirm the results that were founded by Topel and Ward in 1992. Hoisl also indicates that multiple movers turn out to be more productive than single movers or non-movers but future research should further examine this.

Next, we focus on the implications for the departure firm. Obviously, the departure firm will lose an employee. This means that the company will lose a human asset that is no longer available. As we have seen in the previous part, the employee can choose between different options when he leaves. He can choose to join another established firm or to create his own business. Joining another organization means that the departing employee might work for a competitor of his previous employer because mobility is more frequent within than across sectors (Lenzi, 2009). Ultimately, the departure firm risks not only to lose the knowledge and the skills of the employee, but it also risks that a third party can benefit from this loss. When the employee chooses to create a spin-out, the departure firm risks that the employee will replicate and transfer complementary assets. As a result, the blueprint of the departure firm will carry over to the new organization of the inventor. Employees who found their own business will have incentives to transfer the necessary resources and capabilities because of the entrepreneurial risk and the high failure rate of start-ups. B. A. Campbell et al. (2011) found evidence that moving to a spin-out will have a bigger impact and will work more adversely than a move to an established firm.

Another research that was conducted by F. Aime et al. (2009) focused on the role of higher-order routines in the sustainability of a competitive advantage for firms. Higher-order routines are difficult to imitate for competitors because they are socially complex and reside in the collective. Because of this, higher-order routines can help firms to have a sustainable competitive advantage. According to F. Aime et al. (2009), there are three mechanisms by which the departure of a key employee can hurt a firm that has an advantageous set of higher-order routines. First, the firm that hires the key employee will gain knowledge about the set of higher-order routines via the employee. Competing firms will try to hire key employees of their competitors because they are unable to respond adequately to the set of higher-order routines of these competitors. By gaining this knowledge, the hiring firm will be able to defend itself against it by creating a competitive response and to imitate some of the routines. Second, the diffusion of the set of higher-order routines via the mobility of key employees gives other organizations additional opportunities for exposure to those routines through competition. This means that other firms can learn about the advantageous set of higher-order routines via the competitors of the originating organization. Because of the diffusion of the routines, the focal organization will be exposed to more frequent encounters which will have an impact on the performance level of the focal organization. Third, the diffusion of the set of higher-order routines will have some consequences for the future. Because of the diffusion, competitors will expect more competition against the advantageous set of routines. Firms will search for and try to exploit any weaknesses in the set of higher-order routines that are diffused in order develop some counterstrategies to give themselves a better competitive position (Aime, Johnson, & Ridge, 2009).

Finally, there will also be some implications for the new employer of the inventor. The destination firm will be excited to welcome a new employee. Kaiser et al. (2014) argue that there are several reasons why labour mobility can have a real impact on the inventive performance of firms. First, mobility causes a reallocation of skills and abilities and there will be a shift in the available skills and abilities when an employee moves from the departure firm to the destination firm. The capabilities of the new employer will increase while the capabilities of the old employer will decrease. Second, there will be a knowledge transfer due to labour mobility. Especially the tacit knowledge is here of great importance because this is the private knowledge that the old employer will lose. This new knowledge can be used by the destination firm to exploit current ideas and to explore on new ideas for the future. Hiring a new employee can be interesting in order to explore technologically distant areas where the organization has less experience and insights on. This means that hiring strategies are of great importance in order to get access to new knowledge and to create knowledge transfers (Lenzi, 2009). Third, mobility can create social ties between the old employer and the new employer where both companies are citing each other's patents more frequently. According to Corredoira and Rosenkopf (2010), this can be explained by the remaining contact of employees with former co-workers and the increased awareness of the old employer on the activities of the new employer. These three reasons indicate that there will be opportunities for the new employer to increase the inventive performance of the firm and that there will be a loss for the old employer because he loses the skills and knowledge of the former employee. From their empirical findings, Kaiser et al. conclude that labour mobility will increase a firm's patenting behaviour. A new employee from a patenting firm who joins the firm has a six times higher patenting productivity than a worker who does not move. Also, there was found evidence that the patenting activity of the old employer does not decrease when an employee leaves the organization.

> **Hypothesis 1:** Incoming inventors are expected to have a positive effect on the patenting behaviour of the destination firm.

However, it cannot be taken for granted that new employees will be integrated fluently in the organization and will contribute to the productivity of their new employer immediately without any frictions. It is even possible that a high rate of employee mobility will have a negative effect on the performance of firms. For firms, it is important to possess the required absorptive capacity to understand the knowledge of new employees and transform it into growth. Also, attention must be given to the type of knowledge and skills of the new employee who joins the organization. In their study, Boschma et al. (2009) found strong evidence that incoming employees with knowledge and skills that were related to the existing knowledge stock of the new organization had a positive impact on the performance level, while employees with knowledge and skills that were already present in the organization had a negative effect on the performance level. Boschma et al. (2009) argue that some degree of cognitive proximity between the incoming employees and their new employer is needed to ensure that the new employee will contribute to the performance level of their new employer. In a following study which focused on employees who are active in the Danish labour market, Timmermans and Boschma (2013) also found the positive effect of related knowledge and skills on the performance of firms. In addition, they found evidence that significance of the effect of employee mobility on the performance level of firms depends on whether the employees are recruited from the same region or from other regions.

3.2.1.5 Inventor co-mobility

Research that has been done in the past has often considered inventor mobility as an individual process. Literature that focuses on the co-mobility of employees is limited today. Given that much work in organizations is accomplished by work groups and that the performance level of a work group increases with joint experience, it seems surprising that job mobility would not occur collectively so as to preserve shared skills that already exist between colleagues (Marx & Timmermans, 2017). However, both employees and firms are becoming more aware of the potential advantages of co-mobility that will be discussed next.

When firms are looking for a new employee, they often post a job description for which the employee can apply. The firm will select a group of potential candidates and will have job interviews to get more information about the quality of the job candidates. Eventually, the most capable candidate will get the job and becomes the new employee of the firm. Interesting to remark is that the job-matching process is thought to operate almost exclusively on an individual level, given that people often work in groups within an organization. As mentioned above, employees will get experience through their collaborations at work and this has a direct impact on their performance levels. This makes co-mobility, where a group of employees that have been working together in the past will be transferred, interesting because the organization is not just transferring information, but also the experience and the shared skills of the work group. From the perspective of the employee, co-mobility is also interesting because it allows him to work together with existing colleagues. This means that they don't have to integrate with a new group of colleagues. Keeping a work group together also has the advantage that a firm does not have to assemble a new work group that might fail to congeal into an effective team or that they have to wait until the new team acquires enough joint experience to perform well (Marx & Timmermans, 2017).

Because of the advantages that are mentioned above, firms are more willing to pay higher wages in order to attract a group of workers instead of just one employee. Marx and Timmermans (2017) found evidence that co-mobility is still relatively rare, but remunerative for co-movers. Important to remark is that firms find it important that the employees of a specific group are not identical. Work groups with related but not identical skills will be more valuable for a firm.

3.2.1.6 Measurement of inventor mobility

Patent data can be helpful to study the movements of employees to other established firms or spin-outs. The reason why patent data is used by other researchers is that they contain a lot of information that can be used to track the mobility of inventors. Patent data usually give more detailed information about the inventor names, inventor's employer, application and grant dates, technological classifications, etc. (Agarwal A. , 2011). This information allows us to study the mobility of inventors because over time, we might see changes in the firms they work for at different times. Counting the number of firms for which an inventor has worked minus the one where the inventor started provides us a simple way to study inter-firm mobility. However, this calculation does not allow for the movement away from an organization and a subsequent return to it.

But we have to admit that using patent data to track inventor mobility has some serious limitations. First, it is only possible to identify a move of an inventor when he patents before as well after he changed employers. Second, there might be some complications in identifying patents with the right inventor because of spelling differences, incomplete data and because of the possibility that there exist more people with the same name. Third, the importance of patents often depends on the specific industry. It might be possible that other means such as trade secrets or trademarks are preferred over patents (Palomeras & Melero, Markets for Inventors: Learning-by-Hiring as a Driver of Mobility, 2009).

3.3 Determinants of inventor mobility

In this report, we will be interested in the determinants of inventor mobility. We will be starting with creating an overview of some variables that possibly influence the mobility decision based on research from the past. These variables can be useful for the empirical part of this report where we are able to test the significance of these determinants.

The first determinant of inventor mobility is the education level of the inventor. When firms are recruiting a new employee, they often struggle to find the right job candidate because they lack information of the possible job applicant. This creates uncertainty for the firm because they are not sure if the job candidate has the right skills and capabilities to do the job. But, there are some characteristics that can help firms in this process such as the education level of the job candidate because it gives a signal of his qualification. Hoisl (2007) found evidence that inventor mobility is more common among inventors with a higher level of education because these people will generally receive more job offers from interested companies. A second determinant is the complementarity of the inventor’s knowledge to that of his colleagues because many innovations result from the combination of different types of knowledge. As mentioned earlier, Topel and Ward (1992) argued that the match quality between the employee and the firm is of great importance. If an inventor has a poor match with the firm, he will have incentives to leave their employer. However, Hoisl (2007) did not found support for this argument. According to her research, working conditions have no significant impact on the mobility decision. A third determinant might be the technological dominance of a firm in a specific core area. Inventors might be attracted to join firms with technological dominance in a field in which the inventor is active because the inventors of these firms have access to a widespread of the know-how that is available in this field. Working together with these new colleagues gives many opportunities to learn through interaction, which is favourable for the new employee. A fourth determinant are the monetary incentives and rewards that an inventor will get for changing their employer. Inventors could be attracted by other companies when they receive better offers. Advancement is seen as important according to Hoisl (2007) and has an impact on the mobility decision of an inventor.

Next to these main determinants, researchers often use some other determinants that are often used as control variables in their empirical approach. A first example can be found in the demographic characteristics of inventors. B. A. Campbell et al. (2011) showed that characteristics such as the age, tenure, gender and race have an impact on the mobility decision of the inventor. A possible reason why these variables are added, is because some of them correlate with the monetary incentives and rewards. Another determinant that is often used as a control variable is the firm size. Topel and Ward (1992) found that jobs in large firms are more stable in general. This means that inventors who are employed in large firms will move less than inventors who work in small firms. Topel and Ward (1992) also found that workers who changed their employer already once in the past are more likely to change their employer again. This makes it interesting to study the previous mobility behaviour of the inventor. Other determinants that can be used as control variables are regional characteristics, patent propensity, number of patents, time, …

3.4 Determinants of inventor productivity

In this section, we will create an overview of possible determinants that have an impact on the inventive performance of the inventor. From available research that studied the inventor productivity in the past, we will be able to detect variables that might be useful for the empirical part of our research.

The first determinant of the inventor productivity is the mobility of the inventor. One of the main things we want to examine during this research is the impact of inventor mobility on the productivity of the inventor. We want to study if a new environment and the interactions with new colleagues that have complementary knowledge will increase the inventive performance of the inventor. A second determinant is the education level of the inventor. Inventors with a high educational level tend to detect problems faster and are able to use their skills and knowledge better than others. We could expect that the high educated inventors will be more productive in general. A third determinant is the usage of scientific literature or literature from research by the inventor. These types of literature can give inventors inspiration and ideas and help them to get more information on specific relations. Hoisl (2007) found evidence that inventors who conduct scientific literature or university research can increase their performance level. A fourth determinant might be the firm size. Hoisl (2007) found that firm size is positively related to the performance level of an inventor. Large firms are often using new technologies earlier than other companies and have more knowledge and facilities available on specific areas.

Next to the main determinants, there will be other determinants that are often used as control variables in research. This is similarly to the study of the inventor mobility. Demographic characteristics of the inventor such as age, tenure and gender are often used as control variables when studying the inventor productivity. Another determinant of inventor productivity might be the industry in which the inventor is active. Also, there might be some regional differences in the inventive performance of an inventor.

3.5 Determinants of the firm's productivity

From existing research, we see that there are multiple factors that have an impact on the productivity of firms, which we measure through their patenting activity. Next, we will describe some of those factors that might be useful for this report.
A first determinant is the influence of R&D spending of firms. Investments in R&D can be useful for firms to create new knowledge or to use and understand existing knowledge. The expenditures on R&D are often seen as investments by the firm to construct a stock of knowledge within the firm. Research from the past found generally a positive impact of R&D spending on the outcomes of firms. Research that was conducted by Mansfield (1980) found that R&D spending is positively related to the productivity growth. Later on, Pakes and Griliches (1984) found that there is a strong relationship between the R&D spending and the number of patents. This finding was confirmed by another research of Hall et al. (1986). Finally, a research (Cardinal and Hatfield, 2000), which focused on pharmaceutical companies, found that investments in R&D are key to new drug discoveries and that

firms who invest more in R&D are more productive than firms with lower investments in R&D (Artz et al., 2010). Second, and most importantly, we will be interested in the impact of the mobility of inventors on the productivity level of firms. In this report, the effect of incoming mobility will be central when studying the patenting activity of firms. As mentioned before, previous research found that the movement of inventors causes a reallocation of the skills and abilities for firms for example. For the destination firm, the available skills and knowledge will increase, and this can be used to create new knowledge, which will increase a firm's productivity level. A third determinant of a firm's productivity can be the technological diversification of firms. Firms are often creating so called technology portfolios by acquiring knowledge in different technology fields. When firms have technology portfolios in which knowledge is spread over multiple fields, we say that their portfolios have a higher level of technological diversification. In general, the portfolios of large firms will have a higher level of technological diversification. Diversification is needed for several reasons. First, the increasing complexity of products and production processes makes it more necessary to have a more diversified technology portfolio. Second, firms are often experimenting with new technologies on different domains to find new opportunities to exploit and learn about their economic potential. Benefits of technological diversification arise when for example combinations of knowledge from different technology fields result in new products or services, which is called technology fusion. However, technological diversification is not costless. First, diversified technology portfolios can increase integration, coordination and communication costs for companies. Second, firms with diversified technology portfolios might not focus enough on some technology fields to develop strong capabilities in these fields. Because of these costs and benefits, an inverted U-shaped relationship is expected between the technological diversification and the technological performance of firms. This means that firms will have to search carefully for their optimal level of technological diversification in order to maximize their performance level (Leten, Belderbos, & Van Looy, 2007).

Next to these determinants, there might be other determinants that can be used as control variables when we study the impact on the firm's productivity. Examples of these determinants are the firm size, the industry in which the firm is active, or regional effects. Later on, we will determine which variables will be used for our own research based on the information that is available and complete.

4. Empirical research

4.1 Data

The insights from the literature study will be examined during the empirical part of this report. For this report, a panel database is provided which contains information of more than 200 international companies who are all active in the pharmaceutical sector. The panel database has information of these companies for 20 different time periods, starting in 1995 and ending in 2015. The panel database is an unbalanced panel, which means that the panel has some missing data for at least one time period for at least one entity.

The pharmaceutical sector is a setting that is often used by researchers for studying the effects of employee mobility and its impact on innovation. This sector is considered as a knowledge-intensive sector where innovation is important in order to create a competitive advantage over other firms. Innovation will also have an impact on the competition level among firms. Because the pharmaceutical sector is a knowledge-intensive sector, it is interesting to study how firms acquire new and valuable knowledge for the innovation activities within the firm. Hiring new inventors from other firms and keeping the inventors with valuable knowledge are even more important in this industry.

The panel database consists of four files and gives more information on different aspects of the pharmaceutical companies. The first file, *'parent_docdb'*, creates an overview of all the firms, the consolidation year and the patent identification numbers. The second file, *'docdb_ipc'*, contains information about the patent identification numbers and their IPC class(es). IPC stands for the *international patent classification* and is a classification that provides a hierarchical system of symbols for the classification of patents according to the different areas of technology to which they pertain. The third file, *'docdb_inventor'*, contains information of the inventors for each patent identification number. The name of the inventors, their address and the country code is given for each patent identification number. The last file, *'docdb_5y_fwcit'*, creates an overview of the amount of forward citations with a time frame of five years.

As mentioned earlier, working with patent data to trace inventor mobility has some serious limitations. First, a lack of standardization of the spelling of the names of inventors in the panel database leads to a name matching problem. In our panel database, the names of inventors are written in different ways which complicates the search for all patent applications per inventor. An example of this problem is given below.

Table 1: example of lack of standardization of the spelling of names

Parent Firm	Application year	Patent ID number	Name of the inventor	Country code
PFIZER	1995	1341416	NISHIDA, H.	JP
PFIZER	1995	1341416	Nishida, Hiroyuki	
PFIZER	1995	1341416	NISHIDA, H.- PfizerPharm. Inc., Nagoya Plant Res.	JP
PFIZER	1995	1341416	NISHIDA H	JP
PFIZER	1995	1341416	NISHIDA HIROYUKI	JP

Because of the lack of standardization of the spelling of names, the panel database contains many duplicate cases which complicate the analysis of the impact of inventor mobility. Multiple corrections are needed because without any corrections, the names of inventors could be double counted when we try to count the total number of inventors for each firm or the same person could be considered as a new inventor because of a different spelling. Three corrections were made in total. The first correction we did was to put every inventor name in *UPPER CASE* and removed all the punctuation marks such as commas and dots. By doing this, we managed to delete **2114722** duplicate cases of the 3788243 cases from the original panel database. The second correction we did was to delete all the prefixes such as 'Dr.' that were attached to inventor names. By doing this, another **24078** duplicate cases were removed from the original panel database. The last correction we did was to create a clear order for every name. For every inventor, we put the last name first and the first name second. By implementing this correction, another **393113** duplicate cases were removed. In total, **2531913** cases were identified as duplicate cases and were removed from the panel database.

After these corrections, we found that there remain different types of duplicate cases in the dataset which we did not manage to delete. A first example is the way of how the first name of the inventor is written: some first names are written fully and others are written with the first letter only. A second example of the remaining duplicate cases can be found in the spelling of first names. 'Bjorn' or 'Bjoern' refer to the same person but are considered as different cases. Finally, there are data lines of inventors with adresses an data lines without adresses in the dataset. Because of this inconsistency, there remain some duplicate cases which we did not manage to remove. In the analysis of this report, the remaining duplicate cases will be considered as different inventors. This means that we will have deviating results in the end.

A second limitation of patent data is that we can only measure the incoming mobility if an inventor appears on patent(s) before and after he changed employers. Because we measure the incoming mobility by using patent data, we might have a selection bias which means that the probability to observe a move increases with the number of patents per inventor. As a result, the more productive inventors will have a bigger chance of being observed. A third limitation is mentioned in the research of Hoisl (2007). She argues that the fact that different inventors are listed on a patent does not automatically mean that the inventor changed employers. Possible explanations herefore are a strategic alliance between two companies or a merger. A fourth limitation of patent data is that probably not all firms will patent their innovations. Some firms might decide to protect their innovations by keeping them secret.

4.2 Description of the variables

Table 2: Description of the variables

Description of the variables	
Number of patents	The total amount of patents of the firm in year t. The number of patents can be calculated by counting the different patent identification numbers for every firm in every year. Every patent in the panel database is distinguished from another by a unique 7 digit code.
Inventor stock	Number of patent inventors on patents of the firms in year t-1. The inventor stock can be calculated by taking the sum of the number of different inventors on every patent for each firm in a specific year. It is possible that the name of an inventor appears on multiple patents because of his contributions, but each name can only be counted once.
Share of new inventors	Indicator to measure the effect of incoming mobility in year t-1. The ratio is calculated by dividing the number of new inventors by the number of inventors who are working in the parent firm (= inventor stock). The first step in this calculation is to identify which inventor is 'new' and which inventor is a 'stayer'. An inventor will be identified as 'new' for firm X if he did not appear on a patent of firm X in the previous four years. If the inventor did appear on a patent, he will be labeled as a 'stayer'. The second step will be to divide the number of new inventors by the inventor stock.
Technology diversification measure	Linear and quadratic term to check for the inverted u-effect between the technological diversification and the technological performance of the firm in year t-1. Each patent belongs to a specific IPC (*international patent classification*) class which is defined by an 8 digit code. In this research, we will reduce the difficulty of the calculation of the diversity variable by using only the first 4 digits of the IPC class for every patent. The technological diversification for each firm can be calculated by using the formula DIV = $1/(\Sigma_i(N_i/N)^2)$. This formula is a transformation of the Herfindahl index ($\Sigma_i(N_i/N)^2$), which is used to measure the degree of concentration of patents among patent classes. N_i is the number of patents of a firm that belongs to technology class i, and $N = \Sigma_i N_i$. The Herfindahl index equals 1 if a firm has patents in a single class only and approaches

	0 if patents are evenly dispersed over a large number of technology fields (Leten, Belderbos, & Van Looy, 2007).
Yr2011, Yr2012, Yr2013, Yr2014, Yr2015	Dummy variables that are added to capture the year effects more meaningfully. (Yr2011= 1 if t= 2011, otherwise Yr2011=0; Yr2012= 1 if t= 2012, otherwise Yr2012=0;…; Yr2015= 1 if t=2015, otherwise Yr2015= 0)

4.3 Descriptive statistics

Some descriptive statistics for the variables being used in the estimation model are given in table 3. Also, some descriptive statistics of the number of patents and the number of new inventors are given to create some more insight information. For each firm in the panel data set, there are maximum 6 years with data of the variables being used starting from 2010 and ending in 2015. The data set contains information of 257 different companies in the world. It is possible that there is no data for some firms in the data set in one or multiple years in the period of 2010-2015 because there was no information found.

When we take a look at the inventors, we see that there is a big geographical distribution over the world. The inventors of the 257 companies come from 166 different countries. In the pie chart, we tried to create an overview of the distribution, but it is tough to make the geographical distribution clear because there are so many different countries. However, we see that there is one big piece in the pie chart. An explanation could be that in this piece, the United States are represented.

In the data set, we see that the minimum number of patents for which a firm applied is 1 and the maximum is 1467 in a single year. On average, the firms in the data set apply for 60,68578 patents in one year. The standard deviation is 145,6314.

When we take a look at the inventor stock of the firms, we see that there is minimum 1 inventor present who appeared on a patent for a firm and that the maximum is 7040. On average, the inventor stock of the firms in our data set consist of 296,9319 inventors on a yearly basis.

The average number of new inventors in a firm in one year is 218,2366. The minimum number of new inventors is 0,00 and the maximum is 6914. This means that for at least one firm, there was one year were all the inventors who appeared on a patent were already working at the firm for the past four years.

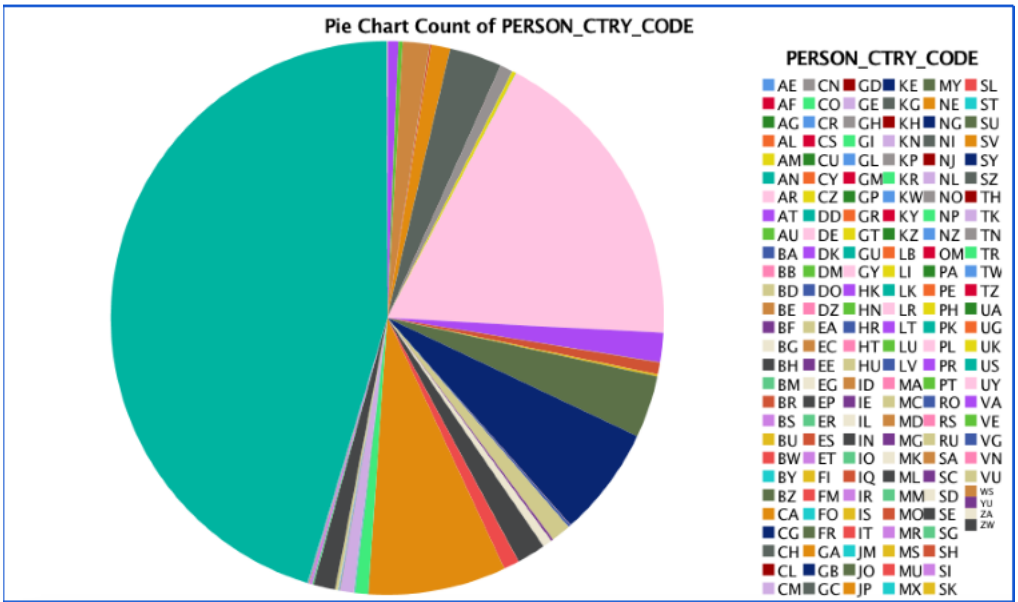
The minimum for the share of new inventors is 0,00 and the maximum is 1,00. For the minimum, we can refer to the explanation above. For the maximum, this means that for at least one firm, all the inventors who appeared on the patents in at least one year were new inventors. The average share of new inventors is 0,6817317 and the standard deviation is 0,1847869.

The minimum for the diversity variable is 1, meaning that there is at least one firm who has patents in a single technology class only in at least one year. The maximum is 44,64, meaning that there is at least one firm who has patents in many technology classes. This maximum might be an outlier because the average value for the diversity variable is 6,83045.

Table 3: Descriptive statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Number of patents	837	1	1467	60,68578	145,6314
Log (Number of patents+1)	837	0,30	3,17	1,254553	0,6273096
Inventor stock	837	1	7040	296,9319	725,1923
New inventors	837	0,00	6914,00	218,2366	562,7128
Share of new inventors	837	0,00	1,00	0,6817317	0,1847869
Diversity	837	1,00	44,64286	6,83045	4,750782
Diversity square	837	1,00	1992,985	69,19801	141,1729
Yr2011	837	0	1	0,1959379	0,3971583
Yr2012	837	0	1	0,2019116	0,4016666
Yr2013	837	0	1	0,2031063	0,4025516
Yr2014	837	0	1	0,2007168	0,4007761
Yr2015	837	0	1	0,1983274	0,3989784
Valid N	837				

Pie chart 1 : Distribution of the inventors



4.4 Estimation methods

During this report, we will use one estimation model in order to find an answer to our research question and sub-questions. This model will be used for five years of analysis, starting from 2011 and ending in 2015. By having five years of analysis, we will be able to compare the coefficients of the independent variables in the estimation model over multiple years. This means that we can create a more reliable conclusion and see if the measured effects are sustainable or not. The estimation model that is created will be an OLS regression. The *ordinary least squares* method chooses the regression coefficients so that the estimated regression line is as close as possible to the data of the panel data set (Stock & Watson, 2012).

4.4.1 The model of analysis

$Log(PAT+1)_{t,i} = \beta_0 + \beta_1 STOCK_{t-1,i} + \beta_2 SHARE_{t-1,\,i} + \beta_3 DIV_{t-1,i} + \beta_4 DIV^2_{t-1,i} + \beta_5 Yr2011 + \beta_6 Yr2012 + \beta_7 Yr2013 + \beta_8 Yr2014$

- PAT = number of patents
- STOCK = inventor stock
- SHARE = share of new inventors
- DIV, DIV^2 = technology diversification measure
- t = year of measurement
- i = identification of the firm
- Yr2011,…,Yr2015 = year dummies

As we can see in the model of analysis, we will take the logarithm of the number of patents. This type of model is called a log-linear model. Logarithms are often used in models because they convert changes in variables into percentage changes. In this log-linear model, a one-unit change of variable X is associated with a $(100 * \beta_x)$% change in the number of patents. We take the logarithm of (PAT+1) because it is possible that firms don't apply for patents in year t, and we cannot take the logarithm of 0. In this model, the impact of four main variables on the patenting activity of firms will be examined. First, we will examine if the size of the inventor stock of a firm has a significant (positive) effect. Second, we will examine if new inventors who recently joined the firm have an impact on the patenting behaviour of firms. Finally, we will examine if the technological diversification of a firm has a significant effect on the patenting behaviour of firms. In order to check if there exists a non-linear relationship between the technological diversification and the technological performance, both DIV and DIV^2 are included in the estimation model. A negative coefficient of DIV^2 will confirm the expected inverted U-shape between the technological diversification and the technological performance (Leten, Belderbos, & Van Looy, 2007). Another remark on the estimation model is that the independent variables will be analysed in year t-1. The reason behind this is that it takes time for the independent variables to have an effect on the patenting behaviour of firms. For example, an increasing inventor stock means not that there will be immediately an increase in the number of patents for a firm. Another example is the impact of the new inventors. New inventors will need time to adapt to the ways of working of the new employer and to create relationships with their new colleagues before they can optimize their performances. Next to the main variables, some year dummies are added to the estimation model to capture the year effect. As we can see, the year dummy variable for 2015 is excluded. The reason why is because if all the binary variables are included in the regression, the regression will fail because of the problem of perfect multicollinearity.

4.5 Results

The results of the regression are summarized in the table below. For every coefficient, the standard error will be written between brackets under the estimated value of the coefficient. Also, the R^2 will be added to the table. Coefficients which are significant at 10%, 5% or 1% significance level will be labeled with '*', '**' or '***'.

Table 4: Results of the regression

	MODEL (OLS)
DEPENDENT VARIABLE	LOG (PAT+1)
(constant)	1,217824*** (0,0566903)
$STOCK_{t-1,i}$	0,0001329* (0,0000689)
$SHARE_{t-1,i}$	-0,0455977 (0,0565001)
$DIV_{t-1,i}$	0,0111431 (0,0076377)
$DIV^2_{t-1,i}$	-0,0005169** (0,0002241)
Yr2011	0,0040231 (0,0266411)
Yr2012	-0,0276771 (0,0257422)
Yr2013	0,0092653 (0,0252558)
Yr2014	-0,0455023* (0,0253572)
R^2	0,4419

(*) significant at 10%, (**) significant at 5%; (***) significant at 1%

4.6 Discussion

From the OLS regression, we can see that the coefficient for the inventor stock, β_1, has a positive value and that it is significant at the 10% significance level (coefficient of 0,0001329 with a standard error of 0,0001329). This means that an increasing inventor stock has a positive influence

on the number of patents that are applied by firms. More specific: a one-unit change in the inventor stock (ΔSTOCK = 1) is associated with a (100*0,0001329) % change in the number of patents.
Looking at the coefficient of the share of new inventors, β_2, we see that this coefficient is negative (coefficient of -0,0455977 with a standard error of 0,0565001), but not significant at any significance level. However, it is remarkable that the coefficient of SHARE is negative because this would suggest that an increasing number of new inventors would have a negative effect on the patents that are applied by firms. A possible explanation could be that the absorptive capacity of the firms is not high enough to deal with the incoming knowledge of the inventors as mentioned in 3.2.1.4. But based on the results of the OLS-regression, there is insufficient statistical evidence to conclude that SHARE would have a negative effect on the number of patents that are applied by firms.

The coefficient β_3 (0,0111431 with a standard error of 0,0076377) suggests that the technological diversification has a positive effect on the dependent variable of this OLS-regression but is not significant. Again, based on the results of this regression, we cannot confirm this relationship because there is insufficient statistical evidence.

β_4, which is the coefficient of DIV^2, is negative and significant at the significance level of 5% (coefficient of -0,0005169 with a standard error of 0,0002241). This result confirms the idea that there exists an inverted U-shape between technological diversification and technological performance for firms. The technological diversification will initially have a positive effect for a firm but will decrease and become negative if the level of technological diversification gets too high for the firm.

Finally, for the coefficient of Yr2014, β_8, we can see that this coefficient is negative and significant at the 10% significance level (coefficient of -0,0455023 and a standard error of 0,0253572). This means that firms applied less for patents in 2014 compared with 2015. The coefficients of Yr2011 and Yr2013 are positive and the coefficient of Yr2012 is negative but based on the results, we cannot confirm these relationships because there is insufficient statistical evidence.

4.7 Limitations of the research

This research has some limitations because of my limited experience in working with statistical programs and its short time frame. Also, we have to admit that using patent data to trace inventor mobility has some serious limitations. The limitations that are mentioned below could provide avenues for future research. The first limitation comes from the lack of standardization of the spelling of the inventor names in the panel database. As mentioned in 4.1, three corrections were made in total in order to delete multiple duplicate cases out of the panel database. We found that a big part of the duplicate cases were removed from the database, but there still remained duplicate cases. The biggest remaining problems are the spelling of first names of the inventors, the lack of information on the addresses of inventors and if the names are written fully or just with the first letter. Due to a limited experience with statistical programs, we were not able to create further corrections that could improve the reliability of our results. The remaining duplicate cases of inventor names were observed as different persons during the analysis. A second limitation can be found in the calculation of the inventor stock for each firm in each year. Because inventors are only counted when they appear on a patent, we might have forgotten to take into account inventors who did not appear on a patent for a firm in a specific year. So in reality, it is possible that the inventor stock of some firms is bigger than we calculated, but due to a lack of information, we cannot perfectly know this. A third limitation comes from the calculation of the share of new inventors. In this calculation we had to define which inventors were 'new' and which inventors were 'stayers'. An inventor was seen as 'new' when he did not appear on a patent of the same firm in the previous four years. Because of this definition, it is possible that some inventors who were already working at the firm in the past four years, but didn't appear on patents in these four years, are labeled as new inventors while they should be labeled as stayers. Another possible problem in the definition of new inventors comes from people who just started working for their first employer and did not work for another employer. They will also be labeled as new inventors despite the fact that they did not work anywhere else. A fourth limitation comes from the lack of information which can give biased results to our research. For example, for some firms there is lacking information of their patenting activities in one or multiple years and this can give some problems for the calculation of the share of new inventors. Because of the lack of information on the patents of the firms in previous years, it is possible that all the inventors are considered as 'new'. However, it might be possible that the firm did apply for patents in these years, so this will give a deviation to our calculations and results. Finally, we might not forget that this research focuses only on the effects of incoming mobility and does not take into account the effects of outgoing mobility due to a limited time frame. In order to calculate the total effect of inventor mobility on the innovative capacities of firms, we should calculate both the incoming and outgoing effects of inventor mobility.

5. Conclusion

This research tried to examine the impact of inventor mobility on the innovative capacities of firms who are active in the pharmaceutical sector. Our research contains two parts of analysis. In the first part of this report, we defined the concept of inventor mobility based on existing literature from other researchers and highlighted the implications of the mobility decision for the inventor himself, the destination firm and the departure firm. In the second part of this report, we conducted a practical research towards the effects of incoming mobility on the patenting activities of firms by using a panel database with patent information of more than 200 companies over 20 years.

Since knowledge can be seen as one of the most important inputs for the innovative activities of firms, high skilled employees often represent an organization's key competency and source of competitive advantage, especially in knowledge-intensive sectors. Over the past years, researchers found that a move of an inventor to a new employer can lead to knowledge transfers (Arrow, 1962). Especially the transfer of tacit knowledge is of great importance for firms. This process where firms hire new employees in order to get access to their valuable knowledge is also called learning-by-hiring.

When we study the types of employees who leave their employer, we found that employees with high human capital are actually less likely to leave a firm despite having more bargaining power than other employees because these employees are offered higher wages and value more the intrinsic satisfaction of their efforts and input in the firm. Wages seem to have negative effect on the mobility decision. In their empirical research, B. A. Campbell et al. (2011) also found that older employees, those with longer tenure, and men are all less likely to exit. Also the match quality between employers and employees is important. A good match between the employer and employee will benefit the productivity level of the inventor, but employees will tend to leave their employer more if they experience a bad match with their employer.

When we focus on the inter-firm mobility of inventors, we see that employees generally have two big options when they switch employers: they can join another firm or they can create a spin-out. Spin-outs pose a real threat to incumbents because the inventor(s) who leave(s) can capitalize on the gained knowledge during his/their period at the organization (Agarwal, Ganco, & Ziedonis, 2004). However, the survival rate of spin-outs is not very high because the founder(s) of the new business often lack some experience and management skills to create a successful story. B. A. Campbell et al. (2011) indicated that high skilled employees will have a bigger chance to survive when they create a spin-out because they possess a great absorptive capacity and will be able to transfer complementary assets and resources from their previous employer.

Looking at the implications of inventor mobility, we have three units of analysis: the inventor, the departure firm and the destination firm. Existing research suggests that the mobility of inventors could benefit the performance level of the moving employees. Hoisl (2007) found evidence that there is a simultaneous relationship between inventor mobility and inventor productivity. Movers tend to be more productive because they will interact with more different people who can help them to increase their performance level. Hoisl also indicated that multiple movers turned out to be more productive than single mover or non-movers.

The departure firm will experience some difficulties when it loses an employee depending on whether the inventor chooses to join another firm or decides to create a spin-out. When the inventor decides to move to another firm, the departure firm risks not only to lose the knowledge and the skills of the employee, but it also risks that a third party can benefit from this loss. When the inventor chooses to create a spin-out, he might transfer some complementary assets from his previous employer into his own firm. Inventors could also hurt their previous employer by transferring knowledge about the higher-order routines that are being used within the firm. This could benefit competitors because they will be able to defend themselves against these routines or they can imitate some of these advantageous routines.
On the other side, the destination firm will be excited to welcome a new employee because there will be a shift in the available skills and abilities when an employee moves from the departure firm to the destination firm. The new knowledge of the incoming inventor can be used by the destination firm to exploit current ideas and to explore on new ideas for the future. Hiring new employees can be seen as a valuable strategy when the firm is trying to explore in technologically distant areas where the firm has less experience and insights on.

In the practical part of this research, we tried to test if the incoming mobility of inventors would have significant positive effect on the patenting behaviour of firms. Based on the results of our empirical model, we cannot confirm our hypothesis that incoming inventors have positive and significant effect. The coefficient of SHARE is negative and not significant at any significance level.
We did found evidence that the inventor stock of a firm has a significant positive effect on the patenting behaviour of firms. This means that the bigger the size of the inventor stock of a firm, the more it will apply for patents.
We did also find that there exists an inverted U-shape for the technological diversification because the coefficient of DIV^2 turned out to be negative and significant at the 5% significance level. As mentioned before, the quadratic term of DIV was added to the regression to test if there exists a non-linear relationship between the technological diversification of a firm and its technological performance.
Based on the year dummies for 2011, 2012, 2013 and 2014 in the regression, we can only conclude that firms applied less for patents in 2014 compared with 2015.
Finally, it is also interesting to mention that R^2, which measure the fraction of the variance of log (PAT+1) that is explained by the independent variables, is 0,4419. The value of R^2 ranges between 0 and 1 and indicates if the OLS regression line fits the data of the panel database. Based on the value of our R^2, it is possible that our OLS regression doesn't fit very well with the data.

Finally, we want to end with some advice for the R&D management of firms. We found that the match quality between inventors and their employers is of great importance, so firms should take their time to analyse the motives to move of their inventors in order to create a healthy relationship. Factors as new colleagues, monetary incentives, advancement in the job responsibility,… might be possible reasons why the inventor wants to move. Based on these factors, firms can develop management strategies in order to keep the inventors in the firm and reduce the risk and costs of inventor mobility.

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