KU LEUVEN

FACULTY OF ECONOMICS AND BUSINESS

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Fostering Creativity in the Organization

The impact of management instruments and office structures on the creativity of inventors

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R0257213

Thesis submitted to obtain
the degree of

MASTER OF BUSINESS ECONOMICS

Major International Business, Strategy and Innovation

Promoter: Prof. Dr. Dirk Czarnitzki
Assistant: Julie Delanote

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Creativity in the Organization

Which management instruments and organizational structures foster the creativity of inventors?

Companies crave insights about creativity. How can they seize and stimulate the creativity of their members? The literature helps us to understand how organizational creativity can boost both the creativity of its members separately and strengthens the creativity that originates from interaction and information sharing. Some of the most commonly used management tactics are studied in more detail. By surveying inventors and mapping their organizational environments, we examine the impact on the value of their inventions. Arguments made in the literature are supported or countered, based on the analysis of the descriptive statistics and various regression models of two value measures. The results provide insights for a link between creativity and the organizational environment, thus highlighting the necessity of promoting an organizational context that supports creativity.

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“The solutions that are most creative, arise from your own problems.”

- *A chief inventor of Barry Callebaut AG during the telephone survey*

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General Introduction

Innovate or die. A common belief that is repeated over and over again. Achieving radical innovation is seen by many to be the same as winning the jackpot. However, believing that innovation will only lead to breakthrough innovation is naïve (Getz & Robinson, 2003). The odds of achieving groundbreaking innovation, that completely transforms and overloads your organization with high margins and profits, are extremely low. Why do corporations and other organizations still pursue this unrealistic dream? Is it because there actually are a few who did manage to achieve this? Apple for instance, with their slogan 'think different', has recently become the most valuable brand in the world. The second place has been claimed by Google. What are they doing differently? While there are multiple factors that set them apart, they certainly have one thing in common. They both focus on creativity.

Creativity. A term that has been studied for decades from a psychological perspective, has also received considerable research attention from academics who study it with a managerial point-of-view. It is widely accepted that creativity is the first step in the innovation process. How managers can enhance the creativity that comes forth from the social interaction of the organizational members within an organization has been studied by many academics. This is reflected in the vast literature. Interaction and interconnectedness emerge as two important factors here. However, a growing body of literature suggests that the organization can also influence the individual creativity of its employees. Now neuroscience is weighing in on this concept with research explaining what happens in the mind during idea generation and creative thinking.

Consultants, spokespersons and management gurus promote many tactics that are supposed to foster creativity within an organization. Create an open work environment. Motivate your team. Give free time to your employees. Provide resources. Reward great thinking. Encourage conversation. Although many of these tactics seem logical for fostering creativity, most are not based on empirical evidence. Despite widespread interest of managers, academics and organizations, empirical evidence on creativity in the workplace has proved hard to retrieve. One of the chief challenges for research on creativity is finding empirical evidence for these tactics.

This thesis attempts to shed light on the effectiveness of some of the frequent-used management instruments that are commonly believed to make organizations able to harvest the benefits from the resulting increase in creativity. The strategy behind this thesis is to study the numbers of citations an invention receives and whether or not it is granted a patent. A number of 69 inventors were questioned about their work environment during a telephone interview. Based on their information, we explore which management tactics have had a significant impact on the creative performance of their inventions.

The thesis is organized as follows: the first section explains creativity from within one individual. We provide a conceptual framework to understand which components determine individual creativity. Touching on the relevant literature of psychology, neuroscience, the science of ideas and the managerial sciences, we look how an individual generates an idea and how he/she is impacted in this process. The second section moves the focus from the individual to the organizational context. First we clarify the connection between creativity and innovation. Afterwards we reveal how interaction between individuals can lead to creativity in a social context. This is then extended to an organizational setting. In the third section we take a deeper look at some management instruments and organizational environments that are generally believed to foster creativity. First we consider those that affect creativity by influencing the interaction and interconnectedness of the members in an organization. These are organized as follows:

1. The structure of the workplace
2. Telework
3. Interaction through meetings (both formal as informal)
4. Team-building and non-work events
5. Free time program

After mentioning the reasons why these management instruments and office environments might foster creativity (or destroy it), we postulate a hypothesis. At the end of the third section, we look into one exception, the free time program that solely focuses on the enhancement of individual creativity. In the fourth section, we describe the empirical part of the thesis. This section is structured as follows:

1. Data description
2. Method of data collection
3. Definition of the variables
4. Descriptive statistics
5. Model description and results
6. Interpretation of the results
7. Limitations

In the final section, we postulate the conclusions.

1 Creativity at the individual level

In a company, creativity originates from two main sources. These sources are the individuals themselves and the organizational context. To understand how an organization can foster creativity and innovation, we observe these two main sources separately. In this chapter we focus on the individuals. First we describe a componential model which gives three components that explain individual creativity: expertise, intrinsic motivation and creative thinking skills. Afterwards we look into the idea generation process. We highlight some of the relevant insights that various disciplines have given us. We do not only look at the managerial point-of-view but also at psychology, psychodynamics, neuroscience and the science of ideas. Although every discipline has differences in approaching creativity, they all agree that creativity is not a characteristic that you are born with. All of them point out that creativity is something that you can create, improve and foster yourself.

1.1 The Componential Model

Quoting Harvard Professor Amabile (1996; 1):

"Creativity is the production of novel and useful ideas in any domain."

The most extensive discipline, which has focused in the beginning on a psychological view of individual creativity and later expanded to a more managerial point of view, is led by Professor Amabile (1996). She has developed a componential model for explaining individual creativity. This model has been adopted and cited by most of the researchers and academics who examine creativity. She argues, in her paper, that expertise, intrinsic task motivation and creative thinking skills are the determinants of creativity (see figure 1).

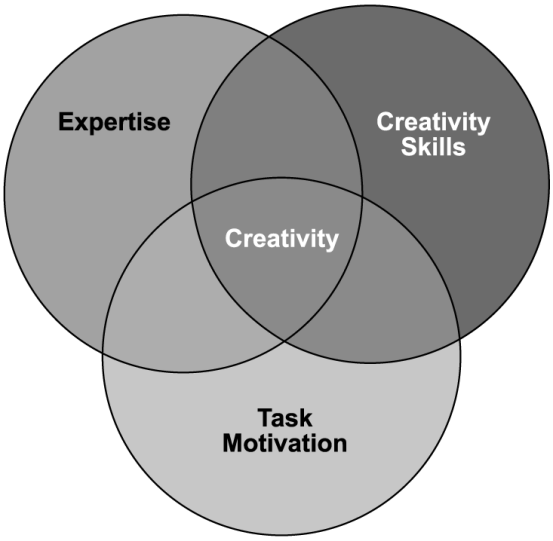
Amabile describes expertise as the set of cognitive pathways that can be used in the process of solving a problem. An example is given by Ko & Butler (2007). They demonstrate that a wide span of general start-up know-how improves the creativity of entrepreneurs. The second component, intrinsic task motivation, consist of two sub-elements: the personal attitude toward the task itself and the reasons for undertaking the task. These two sub-elements should both be present for intrinsic motivation to happen. Motivation is one of the components that is easiest to manipulate. Important to remember here is that motivation should be intrinsic, not extrinsic. Most academics and researchers consent with this distinction. The third component of the model is the creative thinking skill of the individual. This term was described very briefly in the studies of Amabile (1996) but later studies elaborate further upon this, leading to many fascinating interpretations.

The creative process can range from activities like simple problem-solving to the creating of highly original or unique things (Andriopoulos & Dawson, 2008). According to a recent study by Kramer & Amabile (2011), emotion and perception are important factors to enhance the creativity as well. This is because they both positively influence the intrinsic motivation and the creative thinking skill of a person. In their article they state that a positive emotion, also called affect, not only intensifies the creativity of the employees on the given day, but in addition makes the employees think more creative the following day. In addition they argue that this effect is strengthened if the employees perceive the organization in a positive light.

Although the componential model of Amabile (1996) has been cited by many authors, the prediction has never been verified until the research of Eder & Sawyer (2008). They have examined the determinants

of the componential model and have found that there is no relationship between the components separately with creativity but however they have found strong evidence that the interaction of the three components did give a very strong prediction for explaining individual creativity. Thus, when looking at the componential model we should keep in mind that the three components must interact with each other for creativity to happen.

The Componential Model (Amabile, 1996)



1.2 The Idea Generation Process

Many general beliefs about creativity are present. One major belief is that creativity is a characteristic of personality. In reality, it is not a divine gift that you do possess or do not possess (Arnold, 2010). A similar conclusion is made by Gino & Ariely (2011). In their research they demonstrate that giving creativity primes (in the form of word combinations that are related to creativity) leads toward an increase in the motivation of an individual to think creatively. An important insight is made here. The creativity of the individuals were influenced by external stimuli. This means that creativity can be shaped by the outside world. Similarly, Ogle (2007) denounces in the upcoming science of ideas that creativity is a personal characteristic. He consents with the idea that anyone can become creative. Gino & Ariely (2011) bring forth yet another insight, which they confirmed in their research. The presence of creativity does not guarantee that the solution will be creative, nor guarantee that it will be used for the right reasons. Take for example an individual who is primed with creativity when he is looking for a solution to a given problem. When he/she does not have the appropriate resources to be able to solve this problem, then he/she might focus on getting these resources in a creative way instead of focusing his/her creativity on the given problem. This is why taking away resources from the workforce will not yield creative solutions, ideas or projects (Amabile, 2011).

Creativity and the innovation process start with the idea generation of the individual (Reid & Oliver, 2009). Psychodynamics give us more insight in the idea generation and creative thinking process. This discipline has introduced two concepts that point out that creativity comes forth from the tension between the conscious reality and the unconsciousness. Kris (1925) defines creativity as two subsequent processes. The primary process, adaptive regression, refers to the intrusion of unmodulated thoughts in

the consciousness which may stimulate creative thinking. The secondary process, elaboration, is the reworking and transformation of primary process material through reality-oriented-ego-controlled thinking.

In line with these concepts, another discipline is emerging in importance. Neuroscience gives us insights that the previous literature had failed to clarify. Waytz & Mason (2013) point out that we have different networks inside our brain. The default network, as explained by Waytz & Mason, is responsible for the processing of internalized, existing knowledge and also for transcendence, which stands for detachment from external stimuli. The deeper the level of transcendence, the more engaged the default network is. Detachment lets us visualize alternative places, time and worlds. When we are not concentrating on external stimuli or sleeping or wandering off only the default network keeps on working while all the other networks are offline. This is why we often find better solutions for a problem when we are not concentrating on it (Waytz & Mason, 2013). Creative thinking often happens in these moments because the default network lets us process existing information and envision alternative places, time, point-of-views and so on. In this way we can make free-associations without interruption or limitations from external stimuli (Thagard & Stewart, 2010).

Elsbach & Hargadon (2006) show us that the implementation of these insights in the work environment are possible and beneficial. They present us a framework of workday design that lets employees switch between cognitively challenging work and mindless work. They suggest walking around, performing maintenance tasks, making copies, doing simple repetitive manufacturing line operations, etc…as mindless tasks. These breaks of high cognitive task do not only enhances the possibility of creative thinking by tapping into the default network, it also decreases stress-levels and increases intrinsic motivation, which may in turn enhance creativity.

2 Creativity in the Organization

According to a spokesperson for 3M and Microsoft, organizational creativity does not come from the 'big idea' genius but instead from team effort (Arnold, 2010). However, many authors and academics still recognize the importance of the single inventor within the collective environment. In fact, it emerged from the literature, that both the creativity of the individuals and the supporting organizational context, where the individuals are active, are important for the creative output and performance of an organization.

2.1. The Link between Creativity and Innovation

What is the role of creativity in the innovation process and why is it relevant? Nowadays, innovation is of uttermost importance to companies and organizations because it gives them a competitive advantage. Romer (1990) shows in his growth model that human capital creates endogenous growth. According to his growth model, investing in the production of knowledge does pay off in the long term because it yields new knowledge and results in increased production. Similarly, as stated by Nonaka & Takeuchi (1995), the companies that stay successful are those that consistently create knowledge, spread it throughout their organization and implement it in their products and services. Striving for continuous innovation is the most important business in the knowledge creating companies.

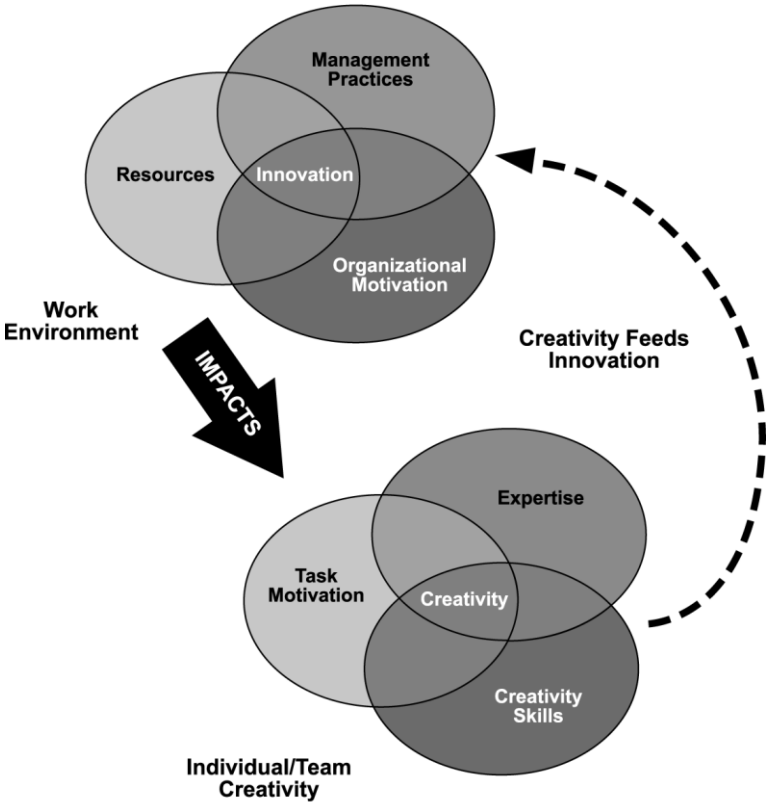
While we already gave a definition for creativity, the importance of this concept for organizations has not yet been identified. The vast literature agrees that organizations benefit only if creativity is turned into innovation. Amabile (1996; 1) defines the relation between these two concepts very clearly.

"Innovation is the successful implementation of creative ideas within an organization."

Thus creativity results in innovation when the generated ideas are applicable, useful and implementable. Creativity does not always result in innovation, but the presence of creativity is a necessary component for radical innovation to happen. Creativity is the first step of the innovation process, as stated by Reid & Oliver (2009). They argue that creativity is of critical importance for this process to be successful.

The current componential model of Amabile (1996) can be extended to the organizational level of creativity. Innovation is defined here to have three components: organizational motivation, resources and management practices (see figure 2). The first component, organizational motivation, is influenced by open, active communication, feelings of recognition and a feeling of pride for working in the company. The second component on the organizational level are resources. Not only money, but also time is considered as an important resource for creativity. Putting time pressure destroys creativity because it takes away the opportunity to think creatively (Amabile, 1998, 2011). As suggested by Amabile (1996), the third influence on innovation are management practices. Managers have attempted to use different practices and tactics to enhance the creativity and innovativeness of their employees, for instance various brainstorming techniques.

Figure 2: The Componential Model expanded (Amabile, 1996)



2.2. Collective and Organizational Creativity

Collective creativity is described by Parjanen (2012) as a result from interaction between individuals which lead to new understandings and interpretations of a given problem or concept. She argues that collective creativity can occur because each contributor brings a different mindset to the table. Creativity within an individual is brought forward by combining old and new mindsets (Flemming, 2006). The research of Taggar (2002) has shown that together with the presence of creative individuals, collective creativity is of great importance for innovation. Further studies have shown that collaboration and the resulting information sharing is especially critical for process innovation but less so for product innovation (Cuijpers, et al., 2011).

We can ask ourselves if a high level of individual creativity is still of a necessity for the creative performance of a team. Pirola & Mann found that collective creativity is highest if the separate team members also have high ratings of individual creativity. This has been supported by multiple other authors. Bissola and Imperatiori (2011) state that creative performance is a result of the interaction of individual creativity, collective creativity and organizational creativity. Similarly, Woodman (1993) has argued that creative performance is enhanced by the interaction of the individual, collective and organizational level of creativity. Thus, creativity will be higher if the individuals are creative and the team interaction supports and stimulates creativity. To quote Hargadon (1999; 137):

"Group interactions elicit relevant though often non-obvious knowledge from how individuals regard the current situation or past experiences and trigger creative ways of combining those ideas to solve new

problems. In practice, groups often create novel and unexpected combinations of an organization's past knowledge in ways that individual or more formal organizational structures do not."

Here, a connection is made between the collective and the organizational level. In a business context organizational and collective creativity are often used as synonyms because they are intertwined (Davis, et al., 2008). The collective team is shaped by the organizational context. There are many examples: the workplace environment impacts how close co-workers are located from one another, the unwritten behavioral rules of the organization dictate if it is appropriate to disturb co-workers with questions and so on. However, collective creativity is not the only thing that is affected by the organization. The organizational context clearly also affects the creative individuals within the organization (Morris, 2006). An organizational context that fosters and supports creativity creates trait activation of its individuals. This leads to increased creative thinking of its members and increased motivation to think creative. For instance, management support of creative projects results in an increase of these projects (Meuleman, 2011). The definition of organizational is clarified by Woodman (1995, p61) as follows:

"The creation of a valuable, useful new product, service, idea, procedure or process by individuals working within a complex social organization."

The collective creativity of a team and the individual creativity of its team-members are strengthened if the organization supports and stimulates the creative process. According to Andriopolous (2001) an organization has five organizational components that it can use to influence the organizational creativity of the employees. Firstly, organizational climate strengthens creativity when it is seen as a company value and priority. Secondly, when creativity is perceived as part of the organizational culture, the creative performance of the employees is enhanced. In a research made by Fitzsimons et al. (2008), 219 students were primed with the image of the brand Apple, which is associated with creativity. They were able to create more unusual, creative uses for a brick than the students primed with IBM, which is less associated with creativity. Working in a company that emphasizes the importance of creativity as a corporate goal and where creativity is part of the corporate culture causes employees to generate an increased creative output and performance. Consider for example how Google uses dream-pods and the 20% free time program to stress the importance of creativity for their company. Thirdly, the structure of the firm also has its influence on creativity in the workplace. Support, for instance from the senior management, has a large positive effect on creativity. Receiving input and feedback of co-workers and team-leaders stimulates the creative performance and motivation of employees. The fourth component, the amount of resources provided and the fifth component, the skills of the employees, also have an impact on the creative performance.

Thus to conclude, both individual and collective creativity are influenced by the organization. The organization can positively impact the individual level of creativity of its employees by increasing their intrinsic motivation, by giving them sufficient resources and by improving their knowledge base and so on (Eder & Sawyer, 2008). The organization might also hamper individual creativity by imposing hard deadlines on their employees, by taking away resources, etc. (Amabile, 1998). In an organization employees interact, which leads to the presence of collective creativity. The organization can impact the collective creativity by shaping the work environment, offering communication devices, creating informal networks and so on. Patterson (2002) advocates that organizations should not wait for eureka moments to happen but that they should create their own 'chance events'. She proposes that this can be done by creating moments of interaction where information is shared between co-workers. In the next chapter we look at a couple management instruments and office environments that are often utilized to increase interaction and interconnectedness, who in turn increase the creative performance of the employees and their networks. We also take a deeper look at how the lone inventor is supported by the organization to think more creatively, how he/she is stimulated to have a higher level of intrinsic motivation and how the organization encourages organizational creativity in a favorable way.

3 Fostering Creativity

Understanding creativity from an individual, collective and organizational perspective we can now ask ourselves how managers can influence and optimize these into a competitive advantage. Multiple management instruments and office environments are used to boost the creativity within an organization. In this thesis we limit ourselves to the study of only a couple of the most frequently used management instruments and office structures that are widely believed to foster creativity. In the first part, we take a closer look at how the interaction and interconnectedness of the organizational members affect the creative performance of innovation. Office structure, telework, informal and formal meetings and team-building events emerge as important concepts. Even though these concepts mostly have an effect on the collective level of creativity, they sometimes also impact the individual level of creativity. De Croon et al. (2005) have developed a conceptual model to explain the influence of the office location (telework versus conventional), lay-out (open versus closed) and use of the office (fixed versus shared workplaces) on communication, workload, privacy and interpersonal relations at work among some other concepts. Afterwards they tested if these concepts have a significant positive impact on job performance. Unfortunately, they did not find sufficient evidence to back up their conceptual model. So our questions remain unanswered. Secondly, we look in more detail how an organization can stimulate the creativity process of the lone inventor by giving free time during work hours.

3.1 Building Interaction and Interconnectedness in the Organization

As stated by Luoma-aho and Halonen (2007), collective and organizational creativity find their origin in a dynamic multi-channel network where the interaction between people are the dependent factor of creativity and innovation. High performers in R&D labs, according to Allen (1971), report a significantly greater frequency and time spent in interacting and communicating with their colleagues. Luoma-aho and Halonen (2007) state the importance of interaction because it facilitates cooperation between different players (for example entrepreneurs, researchers and attention workers) in the innovation process. Hence it is clear that communication and interaction are useful instruments that might foster creativity. Some authors even go so far as to state that individual players alone do not succeed but that innovation depends solely on the interaction and interconnectedness of the players (Jansen, 2006). Interconnectedness is defined by Everett (1995) as the degree to which the units in a social system are linked by interpersonal networks. Ideas are easier and more rapid transferred throughout the members of a network when there is a higher degree of interconnectedness. This interconnectedness has a positive relationship with organizational innovativeness (Everett, 1995). In the following sub-chapters we look in more detail to some of the frequent-used management instruments and structures that are applied to stimulate interaction and interconnectedness. At the end of each subchapter a hypothesis is formulated.

3.1.1 The Structure of the Workplace

Allen & Genn (1987) show the impact of the office structure in the workplace on interaction and communication between co-workers. They indicate that employees rarely communicate with other co-workers when their desks are more than 30 meters away. As proposed by Stack (2013), spokesperson for 3M and Microsoft, creativity can be increased by creating an open work environment because it encourages communication, a positive attitude and a low-stress environment. In line with her arguments, Stryker (2009) has studied two different R&D pharmaceutical sites. He found that an open environment structure increases face-to-face communication with 60%. In addition he documents that being close to

other team-members increases face-to-face communication with 84%. De Croon et al. (2005) have found the existence of a positive relationship between desk sharing and interaction in the workplace. Switching places in the office is argued to further strengthen this positive relationship.

But does more interaction of employees necessarily lead to increased creativity? Davenport (2005) presents the pros and cons for choosing a physical open environment structure. He notes that knowledge workers spend up to half of their time in meetings, informal communication or in the offices of other employees. In these interactions they collaborate and exchange tacit knowledge, whether they realize it or not. Therefore Davenport strongly advocates the presence of collaborative spaces. However he informs that most knowledge workers prefer to work in closed and quiet offices so they are able to concentrate. He warns managers for blindly believing that open office structures will improve the creativity and innovativeness of the organization. De Croon et al. (2005) argue that managers should first consider the negative side-effects before adopting an open office environment. The employees might get interrupted more often than is needed and they might see it as a loss of privacy and concentration. Managers should instead make a trade-off between the benefits of more interaction and the costs on the concentrating side before implementing an open physical office structure. Likewise Luoma-aho & Halonen (2007) argue that increased communication and interaction can either strengthen or weaken innovation. This depends on the presence of intangibles like knowledge, social networks and trust. These arguments are acknowledged by Oldham et al. (2004). They note that too much unexpected interruptions decrease the individual attention on the work itself which might decrease the intrinsic motivation. Looking at the componential model of Amabile (1996), this can lead to a decreased individual creativity of the employee. Similarly Martens (2008) questions if simply placing everyone in one room will foster creativity. He states that creativity can happen in all types of offices, whether it are separate offices, shared offices or complete open offices. He highlights a second finding that favors an open environment: employees who work in an open environment acknowledge that the physical openness gives them space for thoughts, it stimulates individual creativity by providing comfort, visualization and spaces for presentations of inventions. The employees perceive the openness of space as a stimulator of creativity which in turn makes them think more creative (Ariely & Gino, 2011). They perceive their office as supporting creativity, so if we look back at the conclusions of Amabile & Hennessy (2010), the employees will also engage more in creative thinking.

Looking at the pros and cons of the structure of the workplace, it is difficult to pick a structure that fosters creativity the most. Separate offices give the workers more opportunity to concentrate but they benefit less of the possibility to share information and ideas with others. Vice-versa, the wide-open office structure (+/- 100 workers) creates more interaction but the downside is the loss of concentration for the inventor. Too many interaction might distract the inventor from the invention. On the other hand, an open environment is acknowledged to give space for thoughts, leading to more creative thinking.

Based on the argument that a wide open office provides space for thoughts and elicits more interaction, assuming that interaction between inventors is most of the time the basis for information sharing and not for interrupting each other, my first hypothesis is formulated as follows:

Hypothesis 1: The wide open office is a better structure of the workplace for the creative performance of inventions than the separate office and the shared office.

3.1.2 Telework

Teleworking has grown in popularity over the past few decades, as shown by Korte & Wynne (1996). Even though more and more companies are implementing telework, Davenport (2005) argues that few telecommuters do serious full-time telecommuting. In addition he argues that knowledge workers prefer

to work in organizations who are not committed to teleworking. The knowledge workers do not want to lose the opportunity of networking and they do not like to be separated from their knowledge base (Allen, 2001). As proven by Davis & Cates (2013), employee engagement also has a significant negative relationship with workplace isolation. The underlying argument is that a decrease in social relationships causes the level of intrinsic motivation of the teleworker to decline. De Croon et al. (2005) ascertain in their research that teleworking often means more overwork and time pressure. Companies often put strict deadlines on work that is done at home so that the teleworker is forced to do serious full-time telecommuting. If we take a look back at the first chapters, these are two major obstacles that hinder individual creativity (Arnold, 2010; Amabile, 1998, 2002). However, De Croon et al. (2005) argue that teleworking can increase the concentration on the invention, because inventors are interrupted less.

Golden et al. (2008) question if time spent teleworking or having access to communication-enhancing technology matters for job performance and professional isolation. Professional isolation is defined as the state of mind or belief that one is out of touch with others in the workplace. Their findings suggest that there might be a negative relationship between professional isolation and job performance. They argue that job performance of teleworkers suffers because they have limited face-to-face interaction. However, they also discover contradictive insights. Golden et al. (2008) suggest teleworkers can counter-attack this negative effect by engaging into more face-to-face interaction than usual whenever they are physically present in the company. In their research they effectively found that teleworkers are actually more inclined to make conscious efforts to interact with others in the organization. This is reflected in a positive correlation between time spent teleworking and face-to-face interactions. Duxbury & Neufeld (1999) argue that the new arrangements of telework have the potential to improve communication. Next to this first contradictive insight, Golden et al. discover that teleworkers are also less likely to turn over to another company. So to take for granted that telework decreases employee engagement might not be so accurate or correct as is widely assumed.

Due to the contradictive findings of Golden et al. (2008) that telecommuters engage in more interaction whenever they are in the office, the lower level of turnover intention and the assumption that there is an increase of concentration, I hypothesize:

Hypothesis 2: Inventors, who are active in organizations that offer telework, score higher on creative performance in comparison with inventors who work in organizations that do not offer telework.

3.1.3 Interaction through Meetings

3.1.3.1 Collaborative spaces for Informal Meetings

Luoma-aho and Halonen (2007) note that the existing literature on communication considers the sharing of ideas through social interaction and informal conversation as the most important function of communication. In line with this findings, Stryker (2009) found a 102% increase of face-to-face communication of employees who have the opportunity to meet co-workers in informal meeting places in comparison with employees who do not have this luxury. As demonstrated by Davenport (2005), employees spend up to half their time outside their offices engaging in informal meetings and exchanging information. It is important, as Martens (2008) argues, that employees have common spaces where they have the opportunity to encounter other colleagues for an informal meeting, small talk, gossip and so on. Davenport (2005) consents with these arguments. A divergent research approach of Parjanen (2012), where employees where interviewed thoroughly, confirms the importance of informal meetings, café breaks and corridor discussions.

But does informal interaction benefit the innovativeness of the organization? As observed by O'Connor & McDermott (2004) informal networks are the communication platforms on which radical innovation thrives. This can be explained because radical innovation often does not follow the formal rules and logical processes of organizations. As argued by Everett (1995), innovation happens all the time. So informal patterns are a necessity to capture the innovation that comes out the organization and its members. Informal networks are more flexible and thus a better base for radical innovation. A higher degree of interconnectedness between the employees causes them to engage more rapidly in informal meetings and they are less likely to see it as interruption. In addition, in order to get the relevant information needed for these radical innovation the employees have to reach much further than their immediate contacts. As a consequence, weak ties will also play an important role in this case (O'Connor & McDermott, 2004).

Building on these conclusions informal meetings have shown to be of critical importance for innovation and radical innovation in particular. Hence it follows that:

Hypothesis 3: The presence of spaces where inventor can have informal meetings is positively related to their creative performance.

3.1.3.2 Formal meetings

However, according to Kornberger & Clegg (2009), 64 percent of all interactions still happens in the individual offices. Evidently, informal meetings are not the only way of interacting with colleagues. Regular meetings are a formal way of communicating as well through exchanging information and giving evaluation and feedback. Developmental feedback and evaluation, according to Zhou & Oldham (2011), increases creativity of the employees. Similarly Patterson (2002) indicates the importance of feedback loops for the innovation progress. She argues that the use of regular feedback generates organizational learning. The information from feedback can be used by the creative individual as input for the innovation process. Consider that these feedback moments must be developmental focused and not judgmental or criticizing. Having meetings to control strict deadlines and putting time pressure on the employees decreases the individual creativity (Oldham G. & Shalley, 2004).

Given that formal meetings within the department mostly focus on the development of the invention and provide feedback loops for the inventor(s), it can be expected that the more frequent regular meetings are held, the more it creates organizational learning and provides relevant information for the innovation process. Hence, it follows that:

Hypothesis 4: Regular meetings concerning the invention, held within the department or team, has a positive impact on the creative performance of the invention.

3.1.4 Team-building and non-work events

Team-building and non-work events create trust and interconnectedness not only between team-members but also between other people throughout the company. Trusted colleagues serve as valuable sounding-boards for feedback and input. Team-building and non-work events also lead to the development of weak ties. According to Granovetter (1983), weak ties are an important factor for interaction and especially for the transference of relevant information. Similarly Ko & Butler (2007) note that a large amount of relevant information is being transferred through interaction with other people. These arguments are supported by the social learning theory. Bandura (1986) states in this theory that workers who do not have sufficient interaction and communication are bound to work with limited insights, information and feedback. In addition, interaction often results in a higher degree of interconnectedness

between team members and also with other members of the organization like team-leaders, members of other department and so on. This increase in the level of interconnectedness is also argued by Oldham et al. (2004) to increase the intrinsic motivation of the employee. Recall that intrinsic motivation is one of the determinants of individual creativity in the componential model (Amabile, 1996).

Assuming team-building and non-work events strengthen the interconnectedness of the employees by creating trust and social networks and by letting employees tap into the ideas of other organizational members, the sixth hypothesis is as follows:

Hypothesis 5: Team-building and non-work events have a positive effect on the creative performance of an invention.

3.2 Stimulating the Creative Thinking Process of the Innovator: The Free Time Program

"Men of genius sometimes accomplish most when they work the least, for they are thinking out inventions and forming in their minds the perfect idea that they subsequently express with their hands." –Giorgi Vasari (1511-1574)

Regular meetings with evaluation and feedback, informal meetings, open structures, telework clearly affect the amount of interaction and the interconnectedness between employees. However, there are also other ways to influence the creativity in the workplace than through increased interaction and interconnectedness. Decades ago 3M introduced a free time program, which has led to the invention of the Post-It (Goetz, 2011). 20% free time of Google is another famous example of giving time off to employees for exploration. This management instruments differs from the former instruments because it is solely based on fostering the individual creativity of the organizational members. Why is this program rising in popularity? As explained by Doug Williams (Baldwin, 2012):

"The CEO may say innovation is one of the company's top priorities but there is always something happening in the short-term that pushes the long-term innovation."

Giving employees the opportunity and freedom to explore is as a motivational instrument that boosts individual creativity (Pink, 2009). Burkus & Oster (2012) describe two types of non-commissioned work, a synonym often used for free time work. Free time given to the employees through the use of structured events is defined as transient non-commissioned-work. Many companies use the transient method via exploration days (ex.: University of Pennsylvania and Atlassian) or project weeks (ex.: Twitter). Persistent non-commissioned work is free time given for a specific percentage of work-time. An important insight in the relevance of free time programs is found by Amabile in 1990. A number of 460 pieces of art and sculptures were presented to a panel of experts (Baldwin, 2012). The non-commissioned works were rated considerably higher in terms of creativity than the commissioned works (Pink, 2010). According to the study of Hennessy & Amabile (2010) non-commissioned time gives employees a sense of ownership over their projects, which increase the possibility that they produce more creative work. Burkus & Oster (2012) suggest non-commissioned work is positively related with autonomy and the willingness to take risk. They also challenge the use of rewards: bonuses linked with short-term performance decreases the engagement in creative behavior while the absence of recognition and rewards based on long-term performance makes the employees feel like the creative outcomes are not appreciated. Burkus & Oster (2012) propose a balancing act of rewards.

From a neuroscientific point-of-view, free time programs are heavily promoted by Waytz & Mason (2013). As described above, the default network of our brain is responsible for creativity. Waytz & Mason promote unfocused free time as an important factor for breakthrough innovation. In addition they acknowledge the importance of these programs for the inventors themselves because it offers a higher sense of self-sufficiency and intrinsic motivation. But they argue that the current programs do not go far enough. They challenge the focus of these programs should not be on the quantity of time given. Instead the focus should be on the quality of the time given, so that employees can truly detach from the external environment. Examples are: taking away phones, calendars and e-mails or send them away from the office and so on. They however do acknowledge that these programs for detachment are hard to integrate into the office organization because the results cannot be measured. Still they promote the use of meditation and detachment for finding breakthrough ideas. Another neuroscientist, Flaherty (2005), has discovered that the more dopamine we release in our brain, the higher our chances of having breakthrough ideas become. Dopamine, a specific neurotransmitter, is released when we are in situations where we feel relaxed, for example when take a hot shower, driving home and so on. This is why we often get great ideas when we are not concentrating on a certain problem while relaxing. From a business perspective, giving employees time to explore, without many restrictions and without performance based evaluations causes the employees to think more creative.

Does giving inventors an extreme amount of resources always foster their individual creativity? Resources should at least be provided when there is a necessity for them (Amabile, 2011). People still need input, they require stimuli, before they can come up with creative solutions for a given situation or problem. This explains why the Creative Problem Solving Process, which pictures randomly selected images to spur creative thinking, remains so effective and popular. This is also why giving a creativity goal (for example: the invention must be creative of nature) leads to more creative output, even when there is a deadline present. A creativity goal causes the employee to focus on the task itself. Otherwise the employee might instead utilize his/her creativity to circumvent the deadline (Oldham G. & Shalley, 2004). Introducing a free time program into the structure of an organization is a clear message that the company prioritizes and invests in creativity. As a result, employees will focus more on the task itself, feel that creative effort is acknowledged and supported by the organization and will have a sense of ownership over their projects. This leads to an increased intrinsic motivation, employee engagement and it causes the inventor to think more creatively. Thus, building on the predictions of Waytz& Mason (2013) that the more qualitative the free time is, the more it fosters the creativity of the inventor, I predict:

Hypothesis 6: The more qualitative the free time given to the innovators, the greater the creative performance of these inventors becomes.

4 Empirical part

4.1 Description of the dataset

The first part of the data is collected by contacting the inventors themselves. 300 listed inventors in the year 2008 from Belgium were selected randomly from the EPO Worldwide Patent Statistical Database (PATSTAT). These inventors were contacted directly at their home or in their office. Phone numbers of the inventors were first looked up in the official national phonebook of Belgium or they were contacted on their phone in the office or by mail. At the end of the data collection, 69 inventors were reached and interviewed. The second part of the data, consisting of the value measures and control variables, is collected from PATSTAT. PATSTAT can be seen as a snapshot of the EPO master documentation database (DOCDB). DOCDB receives its data from 90 national and international patent offices from around the world. It contains the bibliographical data, family links and citations of patents. At the end of the data collection, the data retrieved from PATSTAT is merged with the information that is acquired from the telephone survey.

After dropping one outlier, we end up with 68 inventors. The invention is an outlier because it obtained 96 citations, while all the others ranged between 0 and 20 forward citations. There are no missing values for the other observations.

4.2 Method of data collection

There are many approaches for measuring the creativity of innovation. One of the main methods of judging creativity is consensual assessment. It is based on the assumption that inventions, products, and projects are creative if and only if appropriate observers agree that they are creative. These observers are most often experts in the topic of the invention. In our research, consensual assessment is not practical. This is due to the fact that the topics of the inventions differ in great extent. For example some applications in our sample are science-based, like the application for the patent on the preparation and morphology of metalloaluminophosphate molecular sieves with lamellar crystal. Other applications are business specific, like the invention made by the national bank of Belgium for an invention related with the printing of security items or the invention made by an agricultural business concerning a mounting of crossbeams in a weaving machine. These were 3 examples of inventions made by inventors that were surveyed.

Another method of researching creativity is the Torrance test of creative thinking. This test has also been widely used in the past but requires all participants to look for a solution to the same given problem or find unusual uses for the same product. This is not applicable in our case. Some research of creativity is based on self-assessment. However, self-reported creativity has been shown to have a certain level of bias so it was not taken in consideration. Qualitative research for measuring creativity is conducted frequently in the form of interviews. Qualitative and quantitative research have both their pros and cons. A qualitative approach can provide deeper information about a certain topic that otherwise could be overlooked. On the other hand, it is harder to find empirical evidence for the hypotheses than in the case of quantitative research. This is why we chose to use a quantitative research method.

We look at two dependent variables to measure the value of an invention. We examine the number of forward citations and the granting of patents. These are explained in the following subsection. Considering that these measures are not based on the answers of the interviewed inventors, they can

be seen as objective value measures (Davis, et al., 2008). These value measure are retrieved from the PATSTAT. The explanatory variables were obtained by conducting telephone surveys. Data collection by using telephone surveys are stated by Augustine & Friedman (1978) to have an equal response rate as data collection by using personal surveys. A mail survey has a low response rate so it was not chosen for data collection in this thesis. A second reason for this type of data collection is the uncertainty whether enough cases could be found on certain topics in the survey (for example: the free time program). In this case, the effort of obtaining data was not lost because a mini-case could be provided using the additional information. A third reason for this approach is to make sure that we reached the inventor himself and that the inventor himself/herself completed the questionnaire, not the management, nor his/her supervisor, nor his/her family. These other parties might not agree to give information on certain topics in the survey or they might block the survey because they do not want the inventor to be distracted during his/her work hours or for other reasons. The approach for obtaining the specific information from the inventor has also been chosen with another reason. If an inventor was willing and enthusiastic to provide more information on a certain topic of the survey or on the topic of creativity in general, this was documented. The variable 'freeproposals' was added for instance during the data collection because most companies used this option to reach the ideas of their employees instead of utilizing a free time program. An online survey would be less likely to have noticed that many inventors did have the chance to propose their own ideas.

4.3 Definition of the variables

In this section, we describe the variables that were used in the process of the research. They are divided in three subsections: dependent variables, explanatory variables and control variables. The description of the variables are concluded in table 1 at the end of this section.

4.3.1 Dependent variables

Patent granted – This binary variable ascertains whether a patent is granted to an application. Patent applications are examined extensively by an examining division of the European Patent Office. This division consists of three examiners. They decide whether an invention is worth protecting by a patent or whether it should be refused based on EPC criteria. An invention only receives a grant if the invention (product, process or apparatus) is new (art 54), industrially applicable (art 57) and if it contains an inventive step (art 56) (Van Overbeek, 2011). In addition, the examiners also look at the clarity and non-unity of the patent application (EU Patent Office, 2013).

Forward citations – We measure the value of a patent also by looking at a second value measure. We look at the total number of citations that an invention receives from subsequent inventions within a period of 6 years. This is based on the theory that if an idea is creative, new and applicable, and thus the invention has more value, than others will pick up on it. According to Czarnitzki, Hussinger and Schneider (2011) forward citations are to be interpreted as the 'quality', 'importance' and 'significance' of an invention. This indirect measure reflects the technological importance as it is perceived by other inventors. They can be seen as experts and appropriate observers to rate the value, and hence the creativity of the inventions.

4.3.2 Explanatory variables

Structure – This category variable is partitioned in 3 possible office structures. First, we have the separate office. These are offices where the inventors have their own separate office. The second office structure is the shared office. The number of employees who work in a shared office ranges from 2 to 10. The last office structure is the wide-open office. These offices usually contain 50 – 300 persons who work in the same office space. The name for the dummy variables used in the regressions for the separate, shared and wide open office are defined respectively as structurex1, structurex2, structurex3.

Telework offered by the organization – The questionnaire asked the inventors if at the time of the project, the company offered the possibility of telework. This is also a binary variable.

Informal spaces– This binary variable illustrates if employees have the opportunity to encounter others in a separate place in the office not used for a business activity. Examples are a coffee room, a break room, a bar or restaurant and so on.

Regular meeting – The questionnaire contained a question to clarify if the project of an application for a patent has regular follow-up meetings. Important to notice is that the regular meetings are focused on the project for the application in particular, this within the R&D-department and with the team leader of the project present. As an example, meetings about the financial state of the company do not fall in this category of regular meetings.

Free Time Program – A question was generated in the survey to describe the different sorts of free time programs, if they were present at all. If no free time program is offered by the company than the value is zero. However, if the company offered persistent free time than the variable is set to one. If the free time is transient than the variable is set to two. (Recall that the persistent method stands for free time given in the form of a certain percent per week and that the transient method specifies that free time is given in the form of a project week). Three is the value set if the company did not have an active free time program but however did allow the employees to propose their own ideas for projects/products/processes. These proposals are then evaluated by the company and if relevant to the business implemented in the project portfolio. The dummy variables used for the different forms of free time programs are ‘procentfree’, ‘projectweek’ and ‘freeproposals’. Notice that the persistent method is the more extensive and qualitative form of free time in comparison with the others.

Teambuilding and non-work events – This question was added in the survey to look at the company attempt to foster the interconnectedness and interaction of its employees.

All the explanatory variables described above derive from the year 2008. So it is possible that company X now offers the opportunity of telecommuting but did not have this possibility in the year of the invention that is examined. (In that case, the variable ‘telework offered by the organization’ is set to zero for that inventor.)

4.3.3 Control variables

In the model used to research our hypotheses, we control for the characteristics of the inventor, the application of the patent and the organization where the employee was working during the year 2008.

Age - This variables illustrates the age of the inventor at this current time. The age of an inventor and his experience should be positively related to the value of the patent.

PhD – We also generated a question to indicate if the inventor has a PhD degree. It can be expected that a PhD receives more citations for his/her application of a patent because he/she has more experience with research.

Number of IPC codes – The number of International Patent Classification is hierarchical patent classification system used internationally to classify patents to the different areas of technology which they pertain in a uniform matter.

Number of back word citations of a patent – The amount that an application is cited by another patented application made in the past.

Number of applicants on the patent – The number of applicants that are listed on a patent application.

Table 1: Variable Description

Type of Variable	***Description of the variable***	***Source***
Dependent Variables		
Forward citations of an application	Number the application is cited by other applications	Patstat
Patent granted	Dummy variable to indicate if a patented is granted	Patstat
Explanatory Variables		
Structure	Category variable that partitions between the separate office, the shared office and the wide-open office	Telephone survey
Fixed Places	Dummy variable illustrating if there are fixed places	Telephone survey
Informal meeting	Dummy variable indicating if there are common spaces present for informal meetings	Telephone survey
Regular meeting	Dummy variable indicating if there are regular follow-up meetings for the project of an application for a patent	Telephone survey
Telework offered by the organization	Dummy variable showing if the company offers telework	Telephone survey
Active telework by employee	Dummy variable indicating if the teleworker actively telecommutes	Telephone survey
Free Time Program	Category variable partitioning between the transient method, the persistent method or the possibility of proposing the ideas to the company	Telephone survey
Teambuilding and non-work events	Dummy variable illustrating if there are team-building or non-work events present in the company	Telephone survey
Control Variables		

Age	The age of the inventor in 2013-2014	Telephone survey
PhD	Dummy control variable indicating if the inventor has the degree of PhD	Telephone survey
Number of applicants	Number of applicants listed on the application	Patstat
Number of IPC codes	Codes for classifying the application of the patent between the different areas of technology	Patstat
Number of back word citations of a patent	The number that the application has cited a patent	Patstat

4.4 Descriptive statistics

In our sample 26 out of 69 inventions are granted a patent. There are 28 inventions who did not receive any forward citations. After dropping one outlier, the forward citations ranged between 1 and 20. Table 1 summarizes the descriptive statistics. On the left side, the descriptive statistics of the forward citations are listed and on the right side you can observe the descriptive statistics of the grants of patents. These numbers on the right are supposed to be observed as percentages.

Regarding the office structures in our sample, each form is often used. The separate office (structurex1) is used most often (41%) while the wide open office is used less (22%) in the sample. Contradicting the hypothesis, the shared office has a higher mean of forward citations than the wide open office. However, looking at the granting of patents, the wide open office reports a higher probability of receiving a patent. When conducting a t-test, we observe that the wide open office is strongly significant for explaining the granting of patents (t = -2.66). This supports the first hypothesis.

Telework is offered in 67% of the organizations. In the 46 cases where telework was present, 9 inventors did not actively telecommute. Running a t-test has shown us that the mean of forward citations of the companies who offer telework are significantly different from those that do not offer telework (t= -2.22). As illustrated on the left side of the table, the second hypothesis is thus supported. The variable of telework reports the second highest mean of forward citations in the table 1. The probability that a patent is granted (34,7%) however, lies just beneath the general mean, contradicting our hypothesis.

A majority of the respondents indicated that they held regular meetings with their department or project team and that there were spaces present to have informal meetings. Approximately 96% of the respondents are active in an organization that contains informal meeting spaces like coffee rooms, break rooms, cafeterias, restaurants and so on. Around 91% of the inventors in the sample have had regular meetings about their project with their department or team.

Remarkable to notice is that inventions who were made in organizations that offer a persistent free time program (procentfree) obtain the highest mean of forward citations. This mean stands out in comparison with the other variables. A t-test shows us that these sort of programs are significant for explaining the higher mean of forward citations (t= -2.21). 9 out of the 68 inventors worked in an organization that offers this form of free time program. In our sample a project week is not used once. However, organizations that offer the possibility to their employees to let them propose their own ideas seems more popular since approximately 60% of the inventors indicated that they had this option. Teambuilding, as illustrated, does

not have a significant impact on the means of forward citations, nor on the mean of the grants of patents. The t-tests did not show any significant impact.

Table 2: Descriptive Statistics

Variables	Forward Citations			Isgrant		
	Mean (StDev)	Minimum	Maximum	Mean (StDev)	Minimum	Maximum
N°of observations		68			68	
Structurex1	4.857143 (6.120)	0	20	.3214286 (.475)	0	1
Structurex2	3.16 (4.633)	0	19	.28 (.458)	0	1
Structurex3	3.8 (3.931)	0	15	.6666667 (.487)	0	1
Infspaces	3.953846 (5.215)	0	20	.3692308 (.486)	0	1
Regmeeting	4.225806 (5.292)	0	20	.4032258 (.494)	0	1
Orgtelework	4.934783 (5.478)	0	20	.3478261 (.481)	0	1
Procentfree	7.444444 (6.444)	0	20	.2222222 (.441)	0	1
Projectweek	0 (0)	0	0	0.0 (0)	0	1
Freeproposals	3.853659 (5.101)	0	19	.3902439 (.494)	0	1
Teambuilding	3.617021 (4.901)	0	20	.3617021 (.486)	0	1

Inventor, sector dummies are omitted.

4.5 Model Description and Results

The empirical strategy is as follows: we look into two dependent values to measure the value of an invention. When examining these separate value measures we use two different models. The OLS regression is chosen for both the granting of a patent and the forward citations. We also add another model for each value measure, which applies to the distribution of the data.

4.5.1 Regression for the granting of patents

The empirical strategy for looking into the dependent variable of isgrant is to run both OLS regressions and probit regressions. We chose to utilize a probit regression because the dependent outcome variable here is binary.

However, caution is suggested with interpreting the probit regression because of the limited sample size. Probit models require a large sample size and outcomes that are not rare. This is why we have chosen in this case to also utilize OLS regressions. Even though the predicted probabilities of an OLS regression can be larger than 1 or smaller than 0, in this case the OLS regression is a better way to interpret the results. As illustrated in table 3 we always first run a regression without the control variables and afterwards run a second regression including the control variables, both for the OLS regression as for the probit regression.

As can be seen in table 3, the wide open office (structurex3) increases the probability that an invention is granted a patent. However, the significance of this variable disappears when we include control variables. Informal meeting spaces and regular meetings report a high significance level in the OLS regression, however their standard deviations in the probit regressions are off the chart. This is due to the fact that we have a small sample size and that almost all organizations in the sample held regular meetings and had informal meeting spaces present in their company. Hence, the probit regression does certainly not give a correct prediction for the variables infspaces and regmeeting. Having the opportunity to propose own ideas for projects is at least weakly significant if we add the control variables.

Regrettably, these regressions do not provide us enough evidence to back up any of the proposed hypotheses. This is why we also need to take a look at the regressions of the forward citations. If evidence is found in those regressions than they might be backed up by these results but these regressions themselves do not provide enough evidence to reject or support a hypothesis.

Table 3: Regression of the dependent variable isgrant

	Lineair Regression		Probit Regression	
	Mean*(StDev)	Mean*(StDev)	Mean*(StDev)	
Structurex2	-0.123 (0.161)	-0.255 (0176)	-0.348 (0.438)	-0.845 (0.592)
Structurex3	0.362** (0.170)	0.175 (0.178)	1.082** (0.592)	0.706 (0.727)
Infspaces	-0.640*** (0.183)	-0.467** (0.179)	-6.125 (445.300)	-5.912 (339.77)
Regmeeting	0.516*** (0.130)	0.702*** (0.135)	5.628 (445.298)	6.310 (339.77)
Orgtelework	-0.062 (0.176)	-0.045 (0.168)	-0.275 (0.499)	-0.218 (0.594)
Procentfree	-0.083 (0.242)	-0.108 (0.199)	-0.080 (0.666)	-0.149 (0.781)
Freeproposals	0.195 (0.141)	0.276** (0.136)	0.692 (0.551)	1.317* (0.737)
Teambuilding	-0.083 (0.168)	-0.059 (0.166)	-0.168 (0.486)	-0.161 (0.566)
PhD		-0.422*** (0.13)		-1.61***(0.51)
agebetween25and35		-0.119 (0.265)		-0.514 (1.372)
agebetween35and45		0.233 (0.170)		0.921* (0.532)
agebetween45and55		0.070 (0.161)		0.206 (0.639)
nr_class_all		-0.040 (0.031)		-0.124 (0.130)
nr_bw_cites		-0.002 (0.010)		-0.017 (0.032)
nr_applt		0.118 (0.156)		0.642 (0.508)
_cons	0.483* (0.254)	0.207 (0.288)	0.013 (1.050)	-1.141 (1.561)
N	68	68	68	68
R^2	0.21	0.38	0.34	0.35
F	15.747	6.477		
P-value	0.000	0.000	0.034	0.007
* p<0.10, ** p<0.05, *** p<0.01				

4.5.2 Regression for forward citations

The empirical strategy for the regressions of forward citations is similar to the strategy for the regressions of the granting of a patent, except for the fact that we included two extra regressions. These regressions are added for two reasons. The first reason is to check if the coefficients and the significance of a selection of the variables, based on t-tests, do not change dramatically if we add the control variables. The second reason is to find support for hypothesis 6. We again use the OLS regression model, but this time we do not utilize the probit regression model (due to the fact that forward citations is not a binary variable). Instead, we make use of a Poisson model. 28 inventions did not receive any citation, so this model provides a good fit.

Table 4 reports the OLS regression of forward citations. Striking are the results for the presence of telework in the organization. Consistent over the three regressions, telework offered by the organization has a large positive impact on the number of forward citations. In addition, this variable remains strongly significant. As can be seen, holding regular meetings has a significant positive impact on the number of forward citations. Noteworthy is the positive impact of the persistent free time program, however it is only weakly significant in just one of the regressions. Contradicting our hypothesis, the coefficient of teambuilding is negative. However this variable is only significant in just one of the regressions.

Table 4: OLS regressions of forward citations

	Mean*(StDev)	Mean*(StDev)	Mean*(StDev)
Structurex1	-0.702 (1.244)		0.332 (1.293)
Structurex2	-0.709 (1.295)	-1.535 (0.976)	-0.763 (1.418)
Infspaces	-3.95* (2.309)	-1.267 (1.566)	-1.885 (2.158)
Regmeeting	6.751*** (1.464)	3.661** (1.408)	5.151** (2.095)
Orgtelework	5.105***(1.148)	3.222*** (1.079)	4.024*** (1.302)
Procentfree	3.115 (1.917)	2.436* (1.319)	1.869 (1.283)
Freeproposals	-0.699 (1.426)		-0.054 (1.346)
Teambuilding	-3.530**(1.572)		-2.333 (1.575)
PhD		-0.002 (1.026)	-0.128 (1.076)
agebetween25and35		0.132 (2.936)	0.933 (2.797)
agebetween35and45		0.511 (1.374)	0.403 (1.372)
agebetween45and55		-0.109 (1.374)	0.034 (1.533)
nr_class_all		-0.215 (0.235)	-0.205 (0.250)
nr_bw_cites		0.530*** (0.174)	0.513*** (0.171)
nr_applt		-3.754** (1.701)	-3.328** (1.596)
_cons	1.166 (3.419)	1.603 (3.116)	1.204 (3.508)
N	68	68	68
P-value	0.000	0.000	0.000
R^2	0.27	0.60	0.62
F	7.635	6.447	7.021
* p<0.10, ** p<0.05, *** p<0.01			

Table 5 presents the Poisson regressions of forward citations. When we look at the coefficients of the structure types, we see that they remain negative. When we include the control variables these negative

coefficients become weakly significant at least. This supports hypothesis 1. The significance of informal meeting spaces disappears when we add the control variables, which might indicate that they are not relevant to look at for explaining the number of forward citations. Regular meetings remain relevant but less so than in the OLS regression. In line with the OLS regression, the offering of telework remains a positive coefficient for the forward citations. Notice however that the coefficients of the variables have decreased in comparison with the coefficients in the OLS regression. Still, telework remains the largest coefficient and the most significant of the regressions. Teambuilding again disappears when we add the control variables. As illustrated in the second regression of table 5, the persistent free time program is weakly significant. However in the two other regression this significance disappears. Hypothesis 6 is thus only supported by one OLS regression and one Poisson regression.

Tabel 5: Poisson regressions of forward citations

	Mean*(StDev)	Mean*(StDev)	Mean*(StDev)
Structurex1	-0.323 (0.334)		-0.220 (0.326)
Structurex2	-0.289 (0.403)	-0.401** (0.201)	-0.552* (0.327)
Infspaces	-0.957** (0.471)	-0.263 (0.357)	-0.353 (0.426)
Regmeeting	1.796*** (0.665)	1.026* (0.566)	1.091* (0.650)
Orgtelework	1.344*** (0.336)	1.133*** (0.317)	1.169*** (0.316)
Procentfree	0.547 (0.497)	0.424* (0.228)	0.602 (0.452)
Freeproposals	-0.013 (0.427)		0.258 (0.393)
Teambuilding	-0.756** (0.372)		-0.146 (0.251)
PhD		-0.203 (0.221)	-0.241 (0.241)
agebetween25and35		0.452 (0.588)	0.340 (0.622)
agebetween35and45		0.283 (0.262)	0.228 (0.257)
agebetween45and55		0.165 (0.303)	0.112 (0.334)
nr_class_all		-0.188*** (0.073)	-0.173** (0.081)
nr_bw_cites		0.114*** (0.015)	0.112*** (0.015)
nr_applt		-0.0852* (0.456)	-0.768* (0.465)
_cons	0.241 (-1.055)	0.308 (0.956)	0.302 (1.117)
N	68	68	68
P-value	0.000	0.000	0.000
R^2	0.20	0.44	0.62
* p<0.10, ** p<0.05, *** p<0.01			

4.6 Interpretation of results

The empirical strategy of this thesis is to look at the results of the two value measures to see if there exists similarities. By combining the insights we made from the descriptive statistics and the different regression models used, we can now interpret these results.

Results show that the probability of being granted a patent is 66% for the inventors who are active in the wide open office. The separate and shared office have only the half of this probability, supporting hypothesis 1. However, the separate office has a higher mean of forward citations, which is in the

opposite direction to what we hypothesized. The conducted t-test shows us that the value measure isgrant and the wide open structure are strongly significant, while a t-test with forward citations did not provide any significant results. This can be understood by looking at the difference between the two different value measures. The granting of a patent is a binary variable. Hence, it shows when an invention is new, applicable and involves an inventive step. This might suggest that the wide open office is a structure that provides a well structured environment for improving the creativity and innovativeness of inventions to a certain level. This can be an effect of the increased interaction on the work floor that leads to a better understanding of the needs for innovation of the organization and an increase in the sharing of knowledge (Stryker, 2009). However, on the concentration side, there might be a loss leading to a decrease in creativity, which might be reflected in the higher means of forward citations for the inventions who were made in separate offices. Thus, more interaction in the wide open office might not necessarily lead to increased creativity, as suggested by Davenport (2005), Oldham et. al (2004) and Luoma-aho & Halonen (2007). Hence, hypothesis 1 is only partially confirmed by the data.

Hypothesis 2, that telework offered by the organization increases the creative performance of the inventors, is confirmed. This is remarkable because telework is not often seen as the management tactic to foster creativity. The mean of forward citations is higher than for most of the other variables. In all the OLS regressions and Poisson regressions for the forward citations, telework is strongly significant and has one of largest coefficients of all variables. Even though telework has a negative sign in the regressions with the granting of patents, the coefficients are almost zero and there does not exist any significance.

Striking is that the general theoretic literature did not predict this positive effect of telework on the performance of inventions. Golden et al. (2008) however also made contradicting, yet intriguing results on the impact of telework. They found that teleworkers expressed lower intentions to turn over to another company. This may indicate that the teleworkers have a higher level of intrinsic motivation, engagement and organizational commitment. They also discovered that teleworkers made conscious efforts to interact more whenever they were present in the company, and by doing so, counter-attacking the negative side-effect of loss of interaction. In addition, by telecommuting, inventors can decrease the interruptions, which increases their concentration on the task itself. All these factors can in turn augment the creative performance of the inventors. Overall, hypothesis 2 is supported.

Looking at the results of the first two hypothesis, one remark needs to be highlighted. Telework and the separate office are argued in the literature to enhance creativity because the inventors benefit on the concentration side because they are interrupted less (De Croon, et al., 2005). In our output, both the variables orgtelework and structurex1 report a high number of forward citations, but a lower probability of being granted a patent. The wide open office and the organizations that did not provide telework report a lower number of forward citations but instead have a higher probability of receiving a patent. These office environments are characterized by more face-to-face interaction between inventors, which is also argued in the literature to benefit creativity. The difference in results might be interpreted as follows: the increase on the concentration side fosters creativity in a different way (more forward citations) than the interaction on daily basis does (higher probability of receiving a patent).

The presence of informal meeting spaces was assumed to increase the creative performance of the inventors by the vast literature. However, the results contradict this. The presence of informal meeting spaces has a negative coefficient in all the regressions. But are the predictions made in the vast literature wrong? Clearly, these results are not supportive enough to predict anything because only 3 inventors expressed that their organization did not have any informal meeting spaces. We can however note that in our sample collaborative spaces for informal meetings are present a lot in the organizations of the inventors of our sample. Hypothesis 3 is not supported due to the shortage of cases where informal meeting spaces are present.

Results in part confirm hypothesis 4 that holding regular meetings about the project within the R&D department or project group positively affects the creative performance of the invention. Given the positive impact on the invention we can assume that the meetings are mostly developmental-focused. The positive sign of the coefficient can be explained as follows: developmental meetings provide organizational learning and information sharing, which in turn is used as an input for the novelty, usefulness and inventive step of the invention, thus increasing its value. However, also in this case, there is no balance in answers of the respondents. 91% of the inventors expressed that regular meetings are held daily, weekly or two-weekly.

Teambuilding and non-work events are hypothesized to increase the creative performance of inventions because it enhances the interconnectedness of the inventors in the organization. As can be seen, the inventions, made in organizations were teambuilding and non-work events are present, have a mean of approximately 3.6 citations, which is a slightly lower mean in comparison with the other variables. Both in the first OLS and Poisson regression, the variable has a negative sign. When we add the control variables, the significance of teambuilding and non-work events disappears. This might mean that teambuilding and non-work events do not have a large impact on the creative performance, not in a positive way or in a negative way. The literature argued that teambuilding and non-work events improve the level of interconnectedness and in turn should improve the creativity in the organization by creating a social network where ideas and information are shared easier and more rapidly. But our results predict that these events do not have a relevant impact on the creativity in the organization. This makes us belief that in order to foster creativity, holding teambuilding and non-work events do not do the job. This leads us to reject hypothesis 5.

Hypothesis 6, which predicted that the higher the quality of free time given to the inventors, the higher the creative performance of these inventors will be, is supported slightly. Ranking the quality of the free time programs that are found from high to low, we first have the persistent free time program (percent per week structure) then the transient free time program (project week) and then the possibility of proposing own ideas by the inventors. The latter is not a free time program in the strict sense of the word, but it is a way how many companies attempt to grasp the ideas and insights of their employees. The persistent free time programs are in 9 of the cases a 10% free time program. One of the companies who offers this sort of program, even took a step further. Each researcher in the organization receives 50.000 euros or 3 months of laboratorial work for their own idea and their supervisor does not have the authority to reject their idea or project. Undoubtedly, these free time programs are the most qualitative of the free time programs that exist in the sample. The project week is not used by any of the organizations in the sample. Descriptive statistics show that the inventions made in organizations who have persistent free time programs have the highest mean, approximately 7.5 forward citations (t= -2.21). Thus, other inventors perceive the inventions of high quality. These findings support the arguments made by Waytz & Mason (2013). However, the dependent variable isgrant shows us that these inventions have also the lowest mean (22%) of receiving a patent. This can be due to the nature of the inventions made in free time programs. While those ideas are usually more novel and creative, hence receiving more citations, they are also often less feasible and there are often more failures. In the 41 cases that the option for proposing own ideas is given to the inventors, the mean of forward citations (4.85 citations) becomes also considerably higher than in the cases where no free time is given (2.6 citations). However, the probability of receiving a patent is highest for the inventors who worked in organizations that do not offer any free time nor the option of proposing their own ideas (44%). This might be due to the focus that is put by the top management on the inventions that are part of the core business of the organization and therefore are of strategic importance to be protected by patents. Looking at the results retrieved from the forward citations statistics and regression, the persistent free time program seems to foster the creativity of the inventions the most, as predicted by the hypothesis. However, there has only been found a weak significance in the regressions and the results retrieved from the regressions of the grants of patents are opposed to our hypothesis. Therefore, hypothesis 6 is not supported due to lack of evidence.

4.7 Limitations

This study contains various limitations. First, the sample size is limited to 68 inventors. Due to the fact that a telephone survey costs extensive time and effort, a large sample could not be obtained. This causes our predictions to be less grounded, especially if some of the answers are rare. A second limitation, is although the inventors were drawn from a random sample, only those inventors, who were either easy accessible at home or who worked in the organizations who were willing to co-operate, were reached. A third limitation, is the indirect characteristic of the value measures of the inventions. Forward citations are used often because they represent the economic and technological value of an invention, but it is not the general accepted measure for creativity. An additional limitation is that creativity is just only one of the various factors that impact the value of an invention.

5 Conclusion

The purpose of this study was to extend understanding on the factors that contribute to the creativity of inventions. A growing number of organizations focus on innovation, and in turn on the first step of innovation. Reaching high levels of creativity in the organization seems difficult but not impossible as some companies like IDEO, Google and Apple show us. Creativity, as the first step in the innovation process, is critical for this process. We first defined where individual creativity originates, touching on multiple disciplines. Afterwards we explained how the organizational context contributes to the creativity in the organization and how it stimulates the creative individuals in the organization. But we want to understand which management instruments and office structures impact the creativity in the organization. All the management tactics discussed, except for one, focus on the interaction and the resulting interconnectedness and information sharing between the inventors on the work floor. The exception is the free time program, which is specifically designed to foster the creative thinking of the inventors separately. Data is collected by using a telephone survey and merged with two value measures from PATSTAT afterwards. An analysis of the environments of multiples inventors revealed multiple insights.

In our sample, inventions reported a higher probability of being granted a patent when they were made in a wide open office work environment. The hypotheses concerning the presence of collaborative spaces for informal encounters and the presence of teambuilding or non-work events were rejected. Creative performance (measured by forward citations) was higher in the following situations:

- When the organization offered telework (supported)
- When the department, unit or team held regular meetings concerning the invention (partially supported)
- When the company gave free time structured as 10% per week (partially supported)

Results show that the variables researched might impact the two value measures, the grants of patents and the forward citations, in different ways. Due to the various limitations of this thesis, further research is needed to unravel the impacts of various management tactics on the creativity of organizations. The challenge for future research is not only to find empirical evidence for the factors that alter creativity, but also to prove how these factors influence creativity. Creativity still remains a phenomenon that is impacted by more factors than we can count. It might only be fully understood when we comprehend all the findings and insights of various disciplines. I hope that this thesis provides some insights in how organizations can foster the creativity of its members and that it stimulates future endeavors to decipher creativity and all its drivers.

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