The effects of CEO's personality traits (Big 5) and a CEO's external network on innovation performance in SMEs.

Inger ter Weele
Universiteit Twente

Supervisor:

Dr.ir. S.J.A. Löwik

Second reader:

Ir. A.A.R. Veenendaal

FOREWORD

At the end of my bachelor Business Administration at the University of Twente, I was challenged to bring the subject material from the study in practice by writing a bachelor thesis about a curtain topic. I choose to research the effects of CEO's personality traits (Big 5) and the CEO's external network on innovation performance in SMEs.

I would like to thank Mr. S.J.A. Löwik, for his help and support in the process of writing the thesis. Also I would like to thank the second reader Mr. A.A.R. Veenendaal for his valuable comments.

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Abstract

This study researches the effects of CEO's personality traits (Big 5) and the CEO's external network contacts in SMEs on the performance of innovation. As a lot of studies describe the individual relationship between the personality traits or external network contacts and innovation performance, this study is going deeper in on the suggestion of Hambrick that not only personalities or strategic decision making has an influence on innovation performance but that there could also be combinations that are related to innovation performance. Another point of discussion in this research is the quality and quantity of an external network. Since there are studies who conclude that for a positive effect on innovation performance a CEO should have a large network, while other studies suggest that also with a small network a CEO could have a positive influence on innovation performance in a SME.

By this study it can be concluded that there is indeed a combinations that lead to innovation performance while one of them individually not leads to innovation performance. Personality traits have individually an influence on innovation performance but external network contacts needs the combination with personality traits to have an influence on innovation performance.

1. INTRODUCTION

At the time of an economic crisis, innovation is very important (Roberts, 2003). This is the time to innovate because there are major changes in the competitive market (Prahalad & Ramswamy, 2003). It is not only important for large companies to invest in a recession but also for small-and medium-sized enterprises (SME). Also in The Netherlands, innovation is important. In a 2012 research by Technisch Natuurwetenschappelijk Onderzoek (TNO) and The Hague Centre for Strategic Studies (HCSS) is concluded that every euro invested in innovation becomes multiplied. Companies that do not invest in innovations have a greater chance of a failure, because they probably cannot compete if they do not find innovative solutions to problems (Australian Government, 2008 & Statistics Canada, 2006).

1.1. Innovation, personality & network

So, at this moment, innovation is important for the survival of many SMEs, but what impact does a Chief Executive Officer (CEO) have on innovation within a company? Wincent and Westenberg (2005) showed that a CEO is the key factor of innovation, especially the role that a CEO plays within the innovation process (Becheikh et al. 2006). The CEO can affect the vision and leadership of the innovation process, but also the willingness to innovate (Tidd and Bessant, 2009). Research showed the role of a CEO is important for innovation and the success of an innovation. How more belief a CEO has in an innovation, the more likely it will be that the innovation is successful (Tidd and Bessant, 2009). Confirming this is the Upper Echelons' theory, which argues that decisions and choices by top management have an influence on the performance (positive/negative), through their assessment of the environment, the strategic decisions making and support for innovation (Tidd and Bessant, 2009). In 2007, the founder of the Upper Echolon theory, Hambrick (2007), suggested that there could be some combinations of executive characteristics and compensation systems that could affect innovation, mainly because most of the studies who are researching the Upper Echelons' theory, only researched one aspect, the personalities or the strategic decision making part in combination with some other key factor, that also can influence the strategic decision making. This research will follow that suggestion by introducing a third element, next to innovation performance and personalities, the personal external network contacts of the CEO. The locus of an innovation is often found in an inter-organizational collaboration, a network, because innovation is a complex and interactive process, and this process involves many different actors (Basile, 2011). The personal network of a CEO can place the resources and sources of an innovation outside a company, so it can be a source for innovation but also it can give resources, such as external knowledge. In particular SME's rely on external knowledge network for innovation (Rogers, 2004). In this way, help from a network by innovation can lead to competitive advantages, which will lead to a successful company (Basile, 2011). Also, personal network contacts can be important for innovation, especially in the time of a recession. Through personal network contacts, the money needed for the start of an innovation process can be found. (TSN, 2009).

In summary, literature has shown that networking and the CEO are important for innovation, also is shown that the personalities of a CEO are important for the innovation performance of a company (Hambrick, 2007). This study will combine innovation performance, personalities and the personal network contacts of a CEO. They both are a key factor in the success of an innovation. Therefore this study focuses on the link between CEO's and innovation performance, in relation with CEO's personality traits and a CEO's external network. This is

especially, important for the CEOs of (new) SMEs, but it is also academic relevant because it fills the gap in the literature as described by Hambrick (2007).

1.2. Research Question

In this paper the relationship between the personality traits and external network contacts of a CEO and the innovation performance at SMEs in the Netherlands will be researched. Countless studies have shown the importance of innovation for companies. Each of these use a different approach and definitions of innovation. This study will look at innovation performance of a company in combination with the five big personal traits and external network contacts, since the Upper Echelons' theory stated that CEO's experiences, values and personalities makes how they act on a given situation. In addition, in general is stated that a CEO should have a broad network to innovate successfully. There are numerous studies (Capaldo, 2007, p. 587) that imply this. In one of these studies, Capaldo (2007) claims that a company, in order to increase the innovation performance, must maximizes the number of bridges (connections that are not obvious (Burt, 2002)). The company should focus on the diversity of the network. Whereby the size of the network provides a greater chance of diversity. As a result of his research among managers and CEO of numerous companies in Italia, Capaldo (2007, pp 605-606) concludes that, successful companies are set on a heterogeneous network.

However, there are also studies that conclude that also with a small network you can be successful in the field of innovation. One of those study is Löwik et al. (2012), they suggest that SMEs instead of investing in a large network of weak ties, should invest in strong ties. So is the number of external network contacts of a CEO (quantity of external network) more important or is the quality of an external network contact important for the innovation performance of the SME? The big five personality traits have an influence on both, the quality and quantity of external network contacts. Some personality traits have a positive influence on a large network, while other personality traits have a positive influence on a small network (Kalish & Robins, 2006). If only is looked at the quantity of external network contacts, suggest this that only CEOs with personality traits which have a positive effect on external network contacts have successful innovations. However also CEO's with personality traits which have a negative effect on network size, could have a positive effect on innovation performance (Löwik et al. 2012). In this case the quality of a network is important, not the size but the resources the CEO could get from his network (Corsaro, Ramos et al., 2012). This leads to the following research question:

How do CEO's personality traits (Big 5) and a Chief Executive Officer's (CEO's) external network effect the innovation performance in Small- and Medium-sized Enterprises (SMEs)?

1.1.Outline

In the introduction of this study the research problem was introduced, the content of the problem and the situation was sketched and following that, the research question was introduced. In the next chapter the hypothesis based on a literature review will be introduced. The database and the methodology of the statistical data analyse will be discussed in the chapter methodology. After the methodology is introduced, the statistical data will be analysed and the results of that research will be presented the chapter results. In the conclusion the research question will be answered based on the results. At the final chapter, the relevance of this study and further research will be discussed.

2. THEORY

In this chapter the three variables of this research will be defined, first the dependent variable innovation performance and after that the independent variables personality traits and external network contacts. After the three variables are defined, the hypothesis will be introduced.

2.1. Innovation Performance

Before going deeper in on innovation performance, innovation should be defined. Innovation is defined by Linder et al. (2003) as "implementing new ideas that create value" and is driven by the ability to see connections, to spot opportunities and to take advantage of them. Innovation is not only focused on opening up new markets but it can also offer new ways of serving established and mature markets. There is a divide in the firm's behaviours towards exploration and exploitation. Exploration is the firms' behaviours categorised by search, discovery, experimentation, risk taking and innovation. And exploitation is the firms' behaviours categorised by refinement, implementation, efficiency, production and selection. He and Wong concluded in their research in 2004 that exploration and exploitation must be seen separately, because together they cause difficulties and complications for SME's. Innovation can give competitive advantages and is not only important for the individual company but also for the national economy (de Visser et al. 2011).

2.2. Big five personalities traits

A Chief Executive Officer (CEO) is the leader of the company, and is responsible for all decisions and all activities within the company, he/she set the strategy and vision of a company. In SMEs, the CEO can also be an operation manager and is mostly also the owner of the company. However, the most important role of a CEO is to promote the company's products/services. Looking specifically at the role of a Chief Executive Officer (CEO) and innovations, a significant relationship is found by many studies between the characteristics of the CEO and a firm's innovative activity (Becheikh et al. 2006). These studies (e.g. Jung et al., 2003 and Morris et al., 1993) concluded that: a CEO with a transformational leadership style and a high need for achievement often sets challenging goals, always seeks to do things better and does not hesitate to embark upon innovation projects. These studies found also a positive correlation between innovation and the interest by the CEO to business goals of reputation and power, so innovation is a powerful tool for the company to achieve these goals. So, a CEO influences the decision making and the goals of the company. In the management literature there are very different ideas what could influence this, but recent approaches emphasizes the importance of understanding, the background, experience and values of top managers in explaining the choices they make (Finkelstein & Hambrick 1990)

Big five traits

Looking at the personal characteristics of a CEO, the Big Five traits theory can be used. Tupes & Christal (1961) and Digman (1989) defined five personality traits, also called the Big Five. These traits are combined wide-ranging personality constructs. The Big Five traits are: (see for an overview Appendix B)

1 **Extraversion**, these are people who are: outgoing, assertive, active, and seeking for excitement. It also can be described as people with energy, positive emotions, who are social, and who talk often and have the tendency to seek simulation in their environment, for example of colleagues.
2 **Agreeableness**, these are people who can be described as kind, gentle, trusting, trustworthy and warm. These are people who show compassion and are helpful instead of suspicious and unfriendly toward others.
3 **Conscientiousness**, is indicated by two major facets: achievement and dependability. These people have the tendency to show self-discipline, act dutifully, they like to plan and to be organized.
4 **Emotional Adjustment (or Neuroticism),** these are anxious, fearful, depressed, and moody persons. The people experience often unpleasant emotions, they are not always emotional stable.
5 And finally, **Openness to Experience** (sometimes called Intellectance), people who are creative, imaginative, perceptive, and thoughtful. This trait reflects the degree of intellectual curiosity, and preference for originality and variety.

2.3.External Networking

Personal networking is important for sharing ideas and the development of vital business contacts, it is a key to success. There are two forms of networks; internal and external. Internal networks are contacts within the company and can lead to a better working atmosphere and workforce. In addition to internal, there is external networking, on which this study is focussed. An external network created meetings with (new) people outside the company, these people can deliver the company 'must-needed-support'. An example of this is a partnership for an innovation, which can lead to more resources and skills, greater cost efficiency, access to new markets and defining industry standards and the company can also learn from the other partner. Nevertheless, it is important that the communication and trust between both is good and that in advance good arrangements are made, so that for example, the loss of trade secrets is regulated and that legal issues are settled (Tidd and Bessant, 2009). A study from the 90 's has shown that SME's, which are characterized as innovative, communicate more with the external environment (technical, business and marketing) and that they involve more infrastructural institutions, such as research agencies and universities, in their innovation process. (Stockman & Dotter, 1987, Rothwell, 1991). Also, more SMEs are becoming involved in innovations of large companies, because the small companies sometimes have more specific knowledge (Mohr, Sengupta & Slater (2010).

2.4. Hypothesis building

Since the three elements are defined, now the relation between these concepts can be considered. There will be looked at the combination of the big 5 personality traits and network contacts in relation with innovation performance.

2.4.1. Hypothesis effects of personality traits on innovation performance

As stated above, a significant relationship is found by many studies between the characteristics of the CEO and a firm's innovative activity (Becheikh et al. 2006). A CEO influences the decision making and the goals of the company. In the management literature there are very different ideas what could influence this, but recent approaches emphasizes the importance of understanding, the background, experience and values of top managers in explaining the choices they make (Finkelstein & Hambrick 1990). Also, Jung et al. (2003) found in their study a positive and direct relation between the transformational leadership style and organizational innovation. And also indicate that transformational leadership has significant and positive relations with both empowerment and an innovation-supporting organizational climate. Transformational leaders, who obtain support by inspiring followers to identify with a vision that reaches beyond their own immediate self-interests, are linked by a study of Judge et al. (2000) with 5-factor model of personality (the Big 5). Many studies have proven that creativity is needed for innovation, to get new ideas which can lead to innovation of existing and new products and process. Not only organizational creativity is important but also individual creativity is needed for a successful innovation (Bharadwaj, & Menon, 2000). Creativity is one of the characteristics which defines an extravert person, but also openness to experience implies creativity. Both, extraversion and openness to experiences, are also described as risk-takers. To be innovative, the CEO should take a risk, (Miron, Erez & Nayeh, 2004), because the CEO can only forecast the results of the innovation, in advance the success of the investment in an innovation is not known. On the other hand, there is also proof that the support of a team is very important for the impact of a CEO on innovation performance (Yadav et al., 2007). This suggest that to be innovative a CEO has to be trusting, trustworthy, show compassion and helpful instead of suspicious and unfriendly toward others. This describes an agreeable person. Also Hsieh et al. (2011) found that agreeableness, conscientiousness and extraversion have a positive impact on innovation. If a CEO is emotional stable it is more likely that he stays calm if a problem arises. In the innovation process there will be probably arise some problems and a CEO has to take some risky decisions. In these situations it is important to be calm as a leader or CEO (Weisbord, 2004). All reasons mentioned above lead to the following hypothesis:

H1a: All personality traits of a CEO have a direct influence on innovation performance of the SME.

2.4.2. Hypothesis effects of a CEO's external network on innovation performance

So personality is important for innovation, but on the other hand are networks also important for innovation. There are many studies that suggest that a CEO needs a large and heterogeneous network to be successful in an innovation, but there are also studies who question this (Löwik et al., 2012). Companies network to exchange and assemble resources with and from other companies, most of the time these relationships are long-term arrangements. This is supported by the resource-dependency theory, which states that the main reason to network for companies is to get access to resources (Corsaro, Ramos et al, 2012). Innovation is diffused and adopted within networks, what makes it difficult to identify the innovation path. Ceci and Iubatti (2012) concluded that personal relationships play a pivotal role in facilitating contacts among networked members. Innovation is enabled by

personal relationships and strategic and innovative activities go on in different networks; but the locus of innovation is not the locus of strategy: there are a lot of factors that are involved, like actors, relationships and foundations. This confirms the existence of a multidimensional network that involves different functions: the diffusing of innovation in networks, and on the other hand strategic activities (Ceci & Iubatti, 2012) which are influenced by the background, experience and values of the CEO of the SME (Finkelstein & Hambrick 1990). This is confirmed by the Upper Echelons' theory, which suggests that several factors affect performance levels of an innovation, such as age, functional tracks, other career experiences, education, socioeconomic roots and financial position (Hambrick, 2007). A network is influenced by these, and also the contacts that a CEO has is influenced by these factors. A research of Roberts, Wilson, Fedurek and Dunbar (2007) suggested that the relationship between personality and network size is complex. There is maybe at a young age a direct relation between personality and network size, but at a later ages this relation is no longer so direct anymore. There are a lot of things that influence this relationship, like contacts with others, experiences, background, work experience etc. This suggest that not only a personality has influence on the network, but that also network contacts can influence the personality. With this in mind, the following hypothesis could be defined:

H1b: The number of external networks contacts of a CEO have a positive influence on innovation performance in the SME.

2.4.3. Hypothesis Exploration

Looking more closely to the kind of innovation, a distinction between exploration and exploitation can be made. In which exploration is innovation of new products and exploitation is innovation of existing products. First will be looked at exploration and after that exploitation will be explored.

Exploration is defined by Greve (2007) as: *the activity of searching for new knowledge, the use of technology that is not known by the SME and producing products and services for which the demand is unknown*. A CEO must be willing to take risk and to be experimental, but he must also be flexible, creative and imaginative. (Greve, 2007).

As stated before, persons who are emotional stabile, are more likely to remain calm within risk taking actions, and therefore a high score on emotional stability can lead to exploration. However to be willing to take a risk and willing to search and discover new products, you also must be adventurous and ambitious, what means that a high level of extraversion also leads to exploration (Judge et al., 1999). Extravert, agreeable persons and persons who are open to new experience are flexible, creative, and imaginative, and therefore this must score high if it will lead to exploration. Conscientiousness is another story. On one hand, a high score of conscientiousness is not good for exploration because conscientious persons don't like uncertainty. They like to plan everything, but by exploration there is a lot of uncertainty. On forehand never is known if it will be a success (Miron, Erez & Nayeh, 2004). However on the other hand, a low score is also not good for exploration because if a person has no self-discipline and is nor focused on achievement, it will not lead to exploration. For these reasons, conscientiousness will left out of this hypothesis.
New knowledge is necessary for exploration (Greve, 2007), and to get new knowledge, SME's rely often on their network. To be successful Capaldo (2007) stated that companies had to have a heterogeneous network with weak ties and strong network ties. This means that for exploration a CEO has to have a high number of external network contacts. Looking at

the relationship between a large network and the big five personality traits, Kalish and Robins (2006) suggested that extraversion leads to a large network. Also openness to new experiences leads to a large network, while agreeableness and emotional adjustment lead to a small network (Doeven-Eggens et al. 2008). However, these last two personality traits, agreeableness and emotional adjustment are necessary for exploration. Having mentioned this, lead all these statements leads to the following hypothesis:

H2a: The combination of a CEO's high score on emotional adjustment, extraversion, agreeableness and openness to experience and a high number of external network contacts of a CEO will lead to exploration in the SME.

Secondly will be looked at the combination of a low number of external contacts and exploration. This relation also concerns the big five personality factors; extraversion, agreeableness, conscientiousness, emotional adjustment and openness to experience. Can the big five traits compensate for a low number of external network contacts? Löwik et al. (2012) suggested that SMEs instead of investing in a large network of weak ties, should invest in strong ties. Kalish and Robins (2006) suggested that neuroticism has a negative effect on network size, but have a positive effect on weak ties triads. In other words, they suggested that extravert people try to keep their contacts close and actively seek to introduce them to other people, while neurotic people, aren't so close with their contacts and have smaller networks. So people in the category neuroticism, see often things in a negative daylight, so they are not advantageous for relationships (Doeven-Eggens, et al., 2008). Other personality traits combined with a small network are agreeableness and conscientiousness. Doeven-Eggens et al. (2008) concluded that people, who can be described as agreeable, are strongly motivated to maintain the relationship. Conscientiousness benefits social relations because conscientious individuals have a high level of self-control, are responsible, predictable, and inclined to make a success of their relationships. And that makes that the last factor is also good for social relationships. They are committed, understanding and persistent in relationships and less defensive in the presence of conflict. However as mentioned above it is not very well for exploration because conscientious people do not like uncertainty very well. That is why conscientiousness does not play a role in the following hypothesis. On point, before introducing the hypothesis is that for exploration is creativity very important. A person who is open for new experiences is creative. So, if looked at the relationship of personality traits and exploration, could be concluded that a high score on openness to new experiences, agreeableness and neuroticism or emotional adjustment can lead to exploration. So the following hypothesis could be formed:

H2b: The combination of a CEO's high score on emotional adjustment, agreeableness and openness to experiences and a low number of external network contacts of a CEO will lead to exploration in the SME.

2.4.4. Hypothesis Exploitation

At last will be looked at exploitation. Exploitation is defined by Greve (2007) as*: the activity of improving existing knowledge, technologies, products or services of the SME for which the demand to certain extent is known*. Exploitation is the firms' behaviours categorised by refinement, implementation, efficiency, production and selection (de Visser et al. 2011).

As also mentions above, while innovating, a lot can go wrong, not only with exploration but also with exploitation. It is therefore important to have a CEO that remains calm in stressful situations. A high level of emotional stability will therefore also lead to exploitation. The

support of a team is very important for the impact of a CEO on innovation performance (Yadav et al., 2007). This suggest that to be innovative a CEO has to be trusting, trustworthy, show compassion and helpful instead of suspicious and unfriendly toward others. This describes an agreeable person, but also to be in a team you must be social. This suggest that a high score on extraversion also lead to exploitation. A low score on openness to experience leads to exploitation, because this indicates that a CEO is more comfortable with the current situation, the CEO doesn't like new experiences. And exploitation is the innovation of the current situation in which the demand is known (Greve, 2007). Exploitation often start with the influence of customers and suppliers. These also called strong-tie partners' makes it often possible for SME's to innovate (Hagedoorn & Frankort, 2008). However there will be a point in which the stronger ties partners suffer from "overembeddedness" (Hagedoorn & Frankort, 2008) or in other words they cannot see improvements anymore because they get too similar. Löwik (2012) found that SME still can benefit from these strong tie partners who are willing to the application of bridging capabilities. And in this way SMEs could invest more in smaller, strong tie network, which leads to more effectiveness. So for exploitation the network should be small.
Following these statements the following hypotheses is formulated.

H2c: The combinations of a CEO's high score on emotional stability, extraversion, agreeableness, a low score on openness to experience and a low number of external network contact of a CEO will lead to exploitation in the SME.

Overview hypotheses	
Hypothesis 1	*Personality traits have a direct influence on innovation performance.*
	External networks contacts have a direct influence on innovation performance
Hypothesis 2	*The combination of a high score on emotional stability, extraversion, agreeableness and openness to experience and a high number of external network contacts will lead to exploration.*
	The combination of a high score on emotional stability and agreeableness and a low number of external network contacts will lead to exploration.
	The combinations of a high score on emotional stability, extraversion, agreeableness, a low score on openness to experience and a low number of external network contacts will lead to exploitation.

THEORETICAL FRAMEWORK			
	Network Size	Exploration	Exploitation
Extraversion	+	+	+
Agreeable	-	+	+
Conscientiouness	-	0	0
Emotional adjustment	-	+	+
Openness to experience	+	+	-

Table 1 Relation between the individual personality traits and network size en innovation performance; + stands for a positive relation, - stands for a negative relation and 0 stands for an average relationship

3. METHODLOGY

3.1. DATA

This study will include a qualitative comparative data analysis, in which a database, collected by earlier research will be used. The data in the database consists a survey which was sent to 8000 CEO's of industrial SMEs in The Netherlands, of which 230 CEO's replied. The data includes the Big 5 personality traits, the exploration or exploitation orientation regarding innovation, the CEO's cognitive style (associative or bisociative), the CEO's prior knowledge and his external network contacts. For this research only the results of the questions about Big 5 personality traits, exploration or exploitation and the CEO's external network contacts is important. Only looking at these results of the survey a selection of 140 CEO's can be made. These 140 cases filled in all of the questions, and had a total percentage of 100% by the divide of R&D investment on exploitation and exploration. If the CEO missed or forgot one question to fill in than these missing values were filled with the missing value analyse, EM method of SPSS. This EM method of SPSS calculates the means, the covariance matrix, and the correlation of quantitative variables with missing values, using an iterative process. EM makes implications on the missing values based on the likelihood under the specified distribution (IBM Corporation, 2011).

3.2.DATA ANALYSIS

Following the theory as described above, concluded could be that the following figure describes the relationship between the three variables.

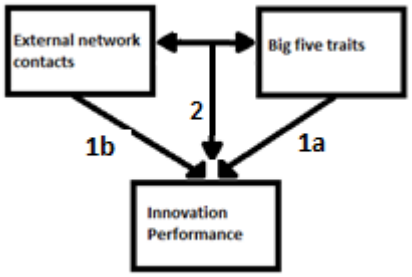

Figure 1 Relationship variables

The external network contacts and the big five traits can compensate for each other, because if only looked at the relationship between network size and the big five personality traits, Doeven-Eggens et al. (2008) and Kalish & Robins (2006) concluded that only extraversion and openness to experience has a positive effect on the network size, while emotional adjustment, agreeable and conscientiousness has a negative effect on the network size. In hypothesis 2 could be seen that extraversion with a low network could lead to exploitation, while in fact extraversion should lead to a big network. Through this compensation in relation with innovation performance, will the above introduced database be examined by the fuzzy set qualitative comparative analysis. This research method technique allows the explicit conceptualization of cases as combinations of attributes which in turn give cases their unique nature (Fiss, 2007). QCA makes it possible to answer complex research questions, because qualitative comparative analysis can manage the complex nature of organizations and their multidimensional characteristics (Fiss, 2011). So, the fuzzy set qualitative comparative analysis could explore the effects on innovation peformance of the relation of specific personality traits combinations together with network contacts. Furthermore, fs/QCA identifies different paths that lead to the same outcome. (Fiss, 2007).

In the fuzzy set qualitative comparative analysis is Boolean algebra used to analyse the combinations of attributes (Fiss, 2007, 2011, Ragin, 2008). This method consists of several steps: First, aims this method to provide empirical patterns found in the data, with the help of fuzzy set that scales degree of membership. Fuzzy set makes it possible to not only divide the variables in two extremes (full non-and full membership), but also make a partition between these two extremes (Wagemann, 2010). In the fuzzy set, the variables (conditions) must be transformed into values between 0-1, in which 0 means that there is 'full nonmembership' and 1 that there is ' full membership ' (Ragin, 2008). Secondly, the necessary causal and sufficient causal conditions must be analysed (Fiss, 2011). This distinguish between necessary and sufficient causal conditions is important to unknot of the causal complexity (Wagemann, 2010) At last a truth table must be formed. Al these four steps will be explained more in 3.3. Fuzzy set qualitative comparative analysis.

3.2.1. Big five personalities traits

Before the data can be analysed with the fuzzy set qualitative comparative analysis, first the big five personalities traits must be defined in the data, because Tupes, Christal (1961) and Digman (1989) made only a distinction in all the personalities, the big five traits. To define all personalities of the data in the big five traits: Extraversion, Agreeableness, Conscientiousness, Emotional Adjustment and Openness to Experience, a measure of Saucier is be used. Saucier (2002) defined 40 Big Five mini-markers, so that also the big five personalities could be measured, and all personalities of CEO could be connected to one of the big five. See for an overview of the 40 big five mini-markers appendix C. The scores of all these mini markers are summed up, to give total score for each big five trait (Srivastava, 2013).

3.2.2. External network Contacts

In this research the goal is to get to know if the quantity of an external network is more important than the quality of an external network contact for the innovation performance of the SME. The quantity of an external network will in this research be determined by the network size. However, it is difficult to measure the network size of a CEO (Carrington, Scott, Wasserman, 2005). This research used the summation method of McCarty et al. (2001), in which all network contacts of a CEO are summed up.

3.2.3. Innovation Performance

Innovation can be divided in two activities, exploration and exploitation. Since He and Wong (2004) stated that exploration and exploitation must be seen as two separate activities, and that if a company has difficulties and complications as it wants to adopt exploration and exploitation simultaneously. So, a SME cannot focuses or invests equally on both, exploration and exploitation at the same time. This is the reason that this research to measure innovation performance, will look at the percentage investments in R&D in 2012 divided over exploitation and exploration. To measure exploration and exploitation this research uses a scale of 0-100%. Both cannot be high (100%) or low (0%), because a SME invests in exploration or exploitation. Concluded can be that Exploration = 1- Exploitation, and therefore this research only looks at exploration and ~exploration

3.3.FUZZY SET QUALITATIVE COMPARATIVE ANALYSIS

The fuzzy set qualitative comparative analysis exist out four steps. As first the data must be converted into the fuzzy sets (0-1). Secondly the necessary causal conditions must be

analysed. The third step is the analysis of the sufficient causal conditions. The first three steps will be explained below. The results of the last step will be given in chapter 4.

3.3.1. Calibration

Calibration is the first step in fuzzy set qualitative comparative analysis, this step transforms the 'real' values in values between 0 and 1. There are many ways for this transformation into fuzzy sets, (see appendix D) however in this research the continuous fuzzy sets (any value between the (≥) 0 and (≤) 1) will be used, because this one is the most precise. In order to transform the values this research uses the percentile function or SPPS (see table 1 below). This feature defines 25%, 50% and 75% of the variables values. In this research stands 25% for non-membership (0), 50% for fuzzy score 0.5 (cross-over point) and 75% for fully in (1). In Appendix E is an overview of the real variables and the fuzzy set values.

Statistics

		Extraversion	Agreeable	Consciencious	Emotional ajdust	Openness to new experiences	Network size	Exploration	Exploitation
N	Valid	140	140	140	140	140	140	140	140
	Missing	0	0	0	0	0	0	0	0
Mean		30,75	33,19	30,81	21,03	28,71	181,97	48,54	51,46
Std. Deviation		3,881	3,653	4,128	3,530	3,506	226,821	28,704	28,704
Minimum		23	25	23	14	20	0	0	0
Maximum		40	40	40	29	37	1374	100	100
Percentiles	25	28,00	31,00	28,00	19,00	27,00	66,25	20,00	30,00
	50	31,00	33,00	30,50	21,00	28,00	105,00	50,00	50,00
	75	33,00	36,00	33,00	23,64	31,03	219,75	70,00	80,00

Table 2 Descriptive statistics + percentiles

3.3.2. Necessary causal conditions

The table below shows the necessary conditions. These necessary conditions indicate that the outcome (Y) is there only if the causal connection (X) is also present (Wagemann, 2010). These values are calculated with the fuzzy set scores of variables, by means of the following formula:

$$Consistency\ (Y_i \leq X_i) = \sum (min(X_1, Y_1) / \sum (Y_1)$$

In which the X_1 stands for membership scores in a combination of conditions, Y_1 stands for membership scores in the outcome. The Consistency of the necessary conditions indicates whether an empirical connection is significant (Ragin, 2008).

In this research, the fs/QCA software is used to analyse the necessary conditions. Looked is at the outcome of 'high' exploration and 'low' (~) exploration, in relation to the big five personality traits (both low and high) and network size (also low and high). In order to assess the consistency value, a threshold needs to be determined. In this research the threshold is set at 0.80 (Fiss, 2011).

Causal conditions	Consistency value for necessity	
	Exploration	*~Exploration*
extraversion	0.533883	0.554908
~extraversion	0.579847	0.552135
agreeable	0.573659	0.567942
~agreeable	0.527991	0.527731
conscientiouness	0.511638	0.561425
~conscientiouness	0.576459	0.521492
emotionaladjustment	0.586034	0.489046
~emotionaladjustment	0.511638	0.602884
opennesstoexperience	0.495581	0.578758
~opennesstoexperience	0.596347	0.507765
networksize	0.553035	0.485857
~networksize	0.551414	0.612451

Table 3 Necessary conditions

The analysis of necessary causal conditions in table 3 show that none of the variables is causal, the consistency value of all variables is between the 0,48 and 0,60 and none is above the threshold value of 0.8. This means that exploration or exploitation is present even when none of the variables are present.

3.3.3. Sufficient causal conditions

A sufficient causal condition indicates that the conditions are present together with the outcome, but the outcome can also be present without the condition (Wagemann, 2010). This can be measured with the following formula:

$$Consistency\ (X_i \leq Y_i) = \sum (min(X_1,Y_1)/\sum(X_1)$$

In which the X_1 stands for membership scores in a combination of conditions, Y_1 stands for membership scores in the outcome. The consistency of the sufficient conditions indicates whether the membership of the variables (big five traits and external network) are less or equal to the membership of the outcome innovation performance (Ragin, 2008).

The first step of the sufficient causal conditions analysis is the construction of the truth table. This truth table consists of all possible combinations of causal conditions with an increase of 2^k combinations, where k means the number of causal conditions. In this research, there are 6 conditions (5 big five personality traits and network size). This leads to $2^6 = 64$ combinations, all this combinations are expected to have cases and are called "logical remainders". The threshold is set at 0,75 (Ragin, 2008), this means that there should be a consistency value of 0,75 in order to be used. As cut of point, 1 is used, which is recommend by Ragin (2008). Next to consistency is by the testing of the hypotheses also the coverage value important. Coverage indicates the "empirical relevance or importance of a set-theoretic connection" (Ragin, 2008). So in other words the more involved cases are (cases who have all the specific conditions), the higher the coverage score.

For the accepting of denying of the hypotheses, the truth table is used in order to derive to the intermediate solution. The intermediation solution is used, because it makes it possible to test

the hypotheses correctly. With this solution a selection could be made in the fuzzy set qualitative comparative analysis, whether the conditions need to be “high” or “low”.

4. RESULTS

In this section the results will be introduced. These are the results obtained from the fuzzy set qualitative comparative analysis in regard to the hypotheses. Started will be with the hypotheses regarded to the effect of the personal big five traits and external network contacts on innovation performance. After this, the results of the hypotheses regarding the effect of the combination of personal big five traits and external network contacts on exploration and exploitation will be explored. See for results of fuzzy set qualitative comparative analysis Appendix F.

4.1.1. The effect of CEO’s personality trait on innovation performance.

Fist the hypothesis: Personality traits have a positive influence on innovation performance, will be explored.

Extraversion * Agreeable * Conscientiousness * Emotional adjustment * Openness to experiences ≤ exploitation

This gives the following result of the intermediate solution

	raw coverage	unique coverage	consistency
~opennesstoexper*emotionaladjust*conscientiounes	0.154243	0.042575	0.732680
~opennesstoexper*emotionaladjust*extraversion	0.195639	0.080731	0.764536
opennesstoexper*emotionaladjust*agreeable*~extraversion	0.106070	0.076900	0.767591
solution coverage: 0.317767 solution consistency: 0.753669			

So,

~opennesstoexper*emotionaladjust*(conscientiounes + extraversion) + opennesstoexper* emotionaladjust*agreeable*~extraversion ≤ exploitation (coverage: 0.317767; consistency: 0.753669)

Now the results for exploitation. If,
Extraversion * Agreeable * Conscientiousness * Emotional adjustment * Openness to experiences ≤ exploitation,
is put in in fsQCA, leads this to the following immediate solution:

opennesstoexper*~agreeable*~extraversion + ~emotionaladjust*~agreeable*extraversion ~opennesstoexper*emotionaladjust*agreeable*~extraversion ≤ exploitation (coverage: 0.339296; consistency: 0.803085)

Both scores have a consistency above the 0.75, but in both you need a low score on one of the personality big five traits, and therefore the hypothesis is not supported.

4.1.2. The effect of a CEO's external network on innovation performance.

The second hypothesis 1b: External network contacts have a positive influence on innovation performance, leads to the following results:

~ External networks contact ≤ exploration

~ External networks contact ≤ exploitation

The results give that there is an error because the 1 Matrix is Empty. This means that the coverage is 0. There is no case that fits in this profile. So in this case the hypothesis 1b is then not supported.

4.1.3. The effect of the combination of personal traits and external network contact on exploration.

This section of the results coffers hypothesis 2a en 2b. Started will be with hypothesis 2a: The combination of a high score on emotional stability, extraversion, agreeableness and openness to experience and a high number of external network contacts will lead to exploration.

If,
Emotional adjust * extraversion* agreeable* openness to experiences * external network contacts ≤ exploration,
is put in in fsQCA leads this to the following immediate solution:

networksize* extraversion (emotionaladjust +~openness toexper*~agreeable) + emotionaladjust (~openness toexper*~agreeable*extraversion + openness toexper*agreeable* ~extraversion) ≤ exploration (coverage: 0.356512; consistency: 0.710928)

Looking more closely, concluded can be that networksize* extraversion (emotionaladjust +~openness toexper*~agreeable, leads to exploration. And therefore the hypothesis cannot be supported.

Secondly will be looked at hypothesis 2b: The combination of a CEO's high score on emotional adjustment, agreeableness and openness to experiences and a low number of external network contacts of a CEO will lead to exploration in the SME.

If
Emotional stability*agreeable*openness to experience*~ external network contacts ≤exploration,
is put in in fsQCA leads this to the following immediate solution:

networksize *emotionaladjust (~opennesstoexper + agreeable) ≤exploration (coverage: 0.283294; consistency: 0.748832)

This result implies that there must be a large network to get exploration, therefore the hypothesis is not supported.

4.1.4. The effect of the combination of a CEOs personal trait and external network on exploitation.

As last of the results hypothesis H2c: The combinations of a high score on emotional stability, extraversion, agreeableness, a low score on openness to experience and a low number of external network contacts will lead to exploitation.

Results
If,
Emotional stability * extraversion, * agreeableness, * openness to experience * - external network contacts ≤ exploitation
is put in in fsQCA, leads this to the following immediate solution:

~networksize*~opennesstoexper*agreeable (~extraversion + ~emotionaladjust) +

~networksize* extraversion (opennesstoexper*agreeable + ~emotionaladjust) ≤ exploitation

(coverage: 0.579312; consistency: 0.762270)

So a small network in combination with different combinations of the personality big five traits lead to exploitation.

4.2.CONCLUSION

As answer of the research question: "*How do CEO's personality traits (Big 5) and a Chief Executive Officer's (CEO's) external network effect the innovation performance in Small- and Medium-sized Enterprises (SMEs)? ",* concluded can be that personality traits in combination with external network contacts have an positive influence on the innovation performance. Individually has only personality traits an effect on innovation performance, external network contacts have no direct influence on innovation performance. In curtain combination they have a positive effect on both exploration and exploitation.

5. DISCUSSION

This study has as goal to research the effects of CEO's personality traits (Big 5) and the CEO's external network contacts in SMEs on the performance of innovation. As a lot of studies describe the individual relationship between the personality traits or external network contacts and innovation performance, this study is going deeper in on the suggestion of Hambrick (2007) that not only personalities or strategic decision making has an influence on innovation performance but that there could also be combinations that are related to innovation performance. By this study it can be concluded that there is indeed a combinations that lead to innovation performance while one of them individually not leads to innovation performance. Personality traits have individually an influence on innovation performance but external network contacts needs the combination with personality traits to have an influence on innovation performance.

However this research answers on the research question, there are some points of discussion. At first, in table 2 Descriptive statistics + percentiles, could be seen that the mean of emotional adjustment is lower than the means of the other personality traits. This can be declared by the definition of emotional adjustment. Emotional adjustment is described with characteristics that are seen as negative. A person does not often describes him/herself with negative characteristics. So, the CEO will give the questions in the questionnaire about emotional adjustment a low score, and therefore the mean of emotional adjustment is lower.

When looking at the results (Appendix F), concluded could be that openness to experience together with extraversion play a vital role in the distinction between exploration and exploitation. In the results (Appendix F) can be found that a high level of openness to experience or extraversion in combination with a low level of the other lead to exploration. If the scores on openness to experience and extraversion are both low, than will this lead to exploitation. So concluded could be that by exploration extraversion and openness to experience compensate for each other. Looking at the definition for both personality traits concluded could be that creativity is important for exploration. Looking at the low scores on openness to experience and extraversion in the case of exploitation, could be said that these results confirm the theory that if a CEO is open to new experiences is more likely to innovate new products, while CEO who don't stand open for new experiences are more likely to innovate existing products. For openness to new experiences are creativity and risk taking important characteristics, these characteristics are also important for exploration (Bharadwaj, & Menon, 2000 and Miron, Erez & Nayeh, 2004). Looking at the role that extraversion does (not) plays in relation with innovation performance. It is striking that extraversion not always plays a role because following the theory a CEO should be extravert to be innovative. Not only is it needed for the creativity and risk taking (Bharadwaj, & Menon, 2000 and Miron, Erez & Nayeh, 2004), but a CEO should also be adventurous and ambitious and social for exploration and exploitation (Judge et al., 1999). The results show that in some combinations a CEO doesn't needs to be extravert to be innovative. Especially, the role of agreeableness by exploration is interesting, if agreeableness is high, extraversion is high. However if agreeableness is low, extraversion is low. So concluded can be that agreeableness, and extraversion compensate for each other. Looking at the characteristics of the two personality traits individually is this not strange, while agreeable persons are flexible, and trustworthy, is an extravert person sociable. All these three characteristics are important characteristics for a

team member. This support the theory that support of a team is very important for the impact of a CEO on innovation performance (Yadav et al., 2007).

Looking at the role of external network contacts, concluded could be that only a large network leads to exploration, while a small network leads to exploitation. This confirms the theory of Löwik et al. (2012) that suggested that SMEs instead of investing a large network of weak ties, should invest in strong ties. It also is confirmed by the theory of Kalish & Robins (2006), they suggested that emotional adjustment has a negative effect on network size, but a positive effect weak ties triads. In other words, they suggested that neurotic people, aren't so close with their contacts and have smaller networks. So people in the category emotional adjustment, see often things in a negative daylight, so they are not advantageous for relationships (Doeven-Eggens, et al., 2008). Doeven-Eggens et al (2008) concluded that people, who can be described as agreeable, are strongly motivated to maintain the relationship, and have therefore a positive effect on strong ties

Striking is the role of emotional adjustment, in the case of exploration, the results (appendix F) show a high score on emotional adjustment, while in the case of exploitation the results show a low score on emotional adjustment. This could be declared if looked at the risk factor of exploration and exploitation. Exploration innovations have higher risks than exploitation, because by exploration a whole new products needs to be introduced to the market, while in case of exploitation, the product or services is only improvements should be introduced, the markets knows already the product and service.

5.1.LIMITATIONS AND FUTHER RESEARCH

There are a several limitations that have to be considered. Fist, the role of external network contacts. In this research is chosen to look at the size of a network, however the measurement of network size is also a point of discussion. There are many ways to measure the network size, but it stays difficult to measure it of an open and large population, because everyone defines a contact in another way (Carrington, Scott, Wasserman, 2005). This also leads to different suggestions about network in relationship with innovation performance. There are many studies who suggest that a CEO needs a big and heterogeneous network to be successful in an innovation, but there are also studies who deny this. In this research is chosen for this hypothesis because Finkelstein & Hamrick (1990), Ceci & Iubatti (2012), Hambrick (2007) and Roberts, Wilson, Fedurek and Dunbar (2007) stated that background, ages and life experience influences the innovation performance, next to personality traits. In further research maybe distinction should be made between several different contacts, like supplier, family, (study) friends etc. and must be looked at the hours spend on the specific network contacts. But also could be looked at another factor of external network contacts, like the ties between the network contacts.

Another limitation is the number of samples used in the research. In total 8000 CEO's received the questionnaire, only 230 send them back, and in this research only 140 samples are used. For FSQA there is no problem with small sample, however big samples are preferable (Ragin, 2008). On the other hand could be a problem with the generalization of the findings. These findings only represent the 1140 samples and not 8000 CEOs. So to get the findings more represented of CEOs of SMEs in the Netherlands a bigger research should be done.

Finally, this research is based on the 5 big personality traits, which are divided in 40 mini markers of Saucier (1994). The question is: are these five traits broad enough, since the Upper Echelons' theory stated that not only CEO's personalities but also experiences and values, make how they act on a given situation. And therefore CEO's experiences and values also have influences on innovation performance. Another point of focus is an examination of John & Srivastava (1999) to the big five traits in Netherlands, they concluded is that the English big five traits (as stated above) are the same as the Dutch big five traits, only the fifth is different. Instead of focussing on intellectual and imagination, the Dutch are more focused on Unconventionality and Rebelliousness. So, another suggestion for future research could be a study who also researched if there also other traits who could influence the relationship between external network contacts and innovation performance.

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APPENDIX

Appendix A

Definitions of Small- and Medium Enterprises

Kind of Enterprise	Number of Employees	Annual turnover	Annual balance
Macro	> 250	≥ 50 Million	≥ 2 Million
Middle big	< 250	≤ 50 Million	≤ 43 Million
Small	< 50	≤ 10 Million	≤ 10 Million
Micro	< 10	≤ 2 Million	≤ 43 Million

Table 1 Overview of different kind of enterprises (MKB servicedesks, 2013)

Appendix B

Big-five traits

Big-Five trait	characteristics	general description
Conscientiousness	being dependable, carefully, torough, responsible, organized, planful, hardworking, achievement-oriented and persevering	inclination to achievement orientation (hardworking and persistent), dependability (responsible and careful), and orderliness (planful and organized)
Extraversion	being sociable, gregarious, assertive, active, powerful and talkative	propensity for social orientation (outgoing and gregarious), to be surgent (dominant and ambitious) and active (advanturesome and assertive)
Agreeableness	being courteous, flexible, trusting, good-natured, cooperative, forgiving, soft-hearted and tolerant	propensity to be cooperative (trusting of others and caring) as well as likeable (goodnatured, cheerful and gentle).
Openess	being imaginative, cultured, curious, original, broad-minded, intelligent and artistically sensitive	disposition to intellectance (philosophical and intellectual) and unconventionality (imaginative, autonomous and nonconforming).
Neuroticism	being anxious, depressed, angry, embarrassed, emotional, worried and insecured	tendency to render a lack of positive psychological adjustment and emotional stability

Table 2 Overview Big five traits (Canter et al., 2011)

Appendix C

Mini-Markers Big Five Scoring Sheet

Extraversion	Agreeable	Conscientious	Neurotic/emotional adjustment	Openness/Intellect
Bashful *	Cold *	Careless *	Envious	Complex
Bold	Cooperative	Disorganized *	Fretful	Deep
Energetic	Harsh *	Efficient	Jealous	Creative
Extraverted	Kind	Inefficient *	Moody	Imaginative
Quiet *	Rude *	Organized	Relaxed *	Intellectual
Shy *	Sympathetic	Practical	Temperamental	Philosophical
Talkative	Unsympathetic *	Sloppy *	Touchy	Uncreative *
Withdrawn *	Warm	Systematic	Unenvious *	Unintellectual *

*Table 2 * These are negative scores.*

Source http://psychology.okstate.edu/faculty/jgrice/psyc4333/MiniMarkersScoresheet.pdf

Appendix D

Three-value fuzzy set	Four-value fuzzy set	Six-value fuzzy set	"Continuous" fuzzy set
1 = fully in	1 = fully in	1 = fully in	1 = fully in
0,5 = neighter fully in nor fully out	0,67 = more in than out	0,9 = mostly but not fully in	Degree of membership is more "in"than "out": 0,5 < Xi < 1
0= fully out	0,33 = more out than in	0,6 = more or less in	0,5 = cross-over: neither in nor out
	0 = fully out	0,4 = more or less out	Degree of membership is more "out" than "in": 0 < Xi < 0,5
		0,1 = mostly but not fully out	0 = fully out
		0 = fully out	

Table 3 overview fuzzy sets (Ragin, 2008)

Appendix E

Real Values + Fuzzy set values

Black = real values, Red = Fuzzy set values

ID	Big 1	Big 2	Big 3	Big 4	Big 5	Netw Size	plor	ploit	Tot	BIG 1	BIG 2	BIG 3	BIG 4	BIG 5	NETW SIZE	PLOR	PLOIT
1	30	31	32	25	26	38	60	40	100	0,27	0,05	0,86	0,99	0	0	0,18	0,82
2	30	33	32	19	28	379	30	70	100	0,23	0,5	0,86	0,05	0,5	1	0,88	0,12
3	30	36	33	19	30	261	50	50	100	0,2	0,95	0,95	0,05	0,88	0,97	0,5	0,5
4	31	32	26	20	28	201	80	20	100	0,5	0,18	0	0,18	0,5	0,89	0,01	0,99
5	29	39	27	19	24	355	10	90	100	0,12	1	0,01	0,05	0	1	0,98	0,02
6	28	34	28	19	24	587	20	80	100	0,05	0,73	0,05	0,05	0	1	0,95	0,05
7	31	35	36	14	29	149	40	60	100	0,5	0,88	1	0	0,73	0,71	0,73	0,27
8	28	30	31	19	27	131	0	100	100	0,05	0,01	0,65	0,05	0,05	0,62	0,99	0,01
9	34	35	29	18	30	123	50	50	100	0,99	0,88	0,14	0,01	0,88	0,58	0,5	0,5
10	29	34	27	21	31	156	0	100	100	0,12	0,73	0,01	0,5	0,95	0,74	0,99	0,01
11	32	34	31	20	27	334	20	80	100	0,82	0,73	0,65	0,18	0,05	0,99	0,95	0,05
12	39	36	25	22	34	220	30	70	100	1	0,95	0	0,76	1	0,92	0,88	0,12
13	35	32	32	23	35	143	40	60	100	1	0,18	0,86	0,91	1	0,68	0,73	0,27
14	30	33	26	22	35	275	90	10	100	0,27	0,5	0	0,76	1	0,98	0	1
15	31	36	34	18	28	440	70	30	100	0,5	0,95	0,99	0,01	0,5	1	0,05	0,95
16	34	37	32	19	24	0	20	80	100	0,99	0,98	0,86	0,05	0	0	0,95	0,05
17	30	35	36	18	25	130	10	90	100	0,27	0,88	1	0,01	0	0,62	0,98	0,02
18	24	34	28	18	26	422	80	20	100	0	0,73	0,05	0,01	0	1	0,01	0,99
19	24	35	27	19	27	272	50	50	100	0	0,88	0,01	0,05	0,05	0,97	0,5	0,5
20	36	37	29	27	20	109	0	100	100	1	0,98	0,14	1	0	0,5	0,99	0,01
21	29	36	28	23	34	128	25	75	100	0,12	0,95	0,05	0,91	1	0,6	0,92	0,08
22	33	35	40	21	28	91	20	80	100	0,95	0,88	1	0,5	0,5	0,21	0,95	0,05
23	38	36	27	16	31	82	5	95	100	1	0,95	0,01	0	0,95	0,12	0,99	0,01
24	27	36	29	17	30	67	0	100	100	0,02	0,95	0,14	0	0,88	0,04	0,99	0,01
25	26	29	28	23	25	35	10	90	100	0,01	0	0,05	0,91	0	0	0,98	0,02
26	30	28	31	24	32	215	100	0	100	0,27	0	0,65	0,96	0,98	0,91	0	1
27	30	33	31	28	32	307	80	20	100	0,27	0,5	0,65	1	0,98	0,99	0,01	0,99
28	37	30	30	24	28	108	15	85	100	1	0,01	0,35	0,97	0,5	0,48	0,97	0,03
29	32	34	29	19	27	773	50	50	100	0,82	0,73	0,14	0,05	0,05	1	0,5	0,5
30	36	32	40	23	29	48	20	80	100	1	0,18	1	0,91	0,73	0,01	0,95	0,05
31	35	33	27	24	27	97	20	80	100	1	0,5	0,01	0,97	0,05	0,29	0,95	0,05
32	32	36	34	19	27	74	40	60	100	0,82	0,95	0,99	0,05	0,05	0,07	0,73	0,27
33	35	36	28	22	27	171	70	30	100	1	0,95	0,05	0,76	0,05	0,8	0,05	0,95
34	28	36	35	17	29	75	80	20	100	0,05	0,95	1	0	0,73	0,07	0,01	0,99
35	35	33	27	28	28	83	20	80	100	1	0,5	0,02	1	0,44	0,12	0,95	0,05
36	32	32	24	17	29	136	100	0	100	0,82	0,18	0	0	0,73	0,65	0	1
37	30	30	27	24	25	52	5	95	100	0,27	0,01	0,01	0,97	0	0,01	0,99	0,01
38	37	34	40	21	33	242	80	20	100	1	0,73	1	0,5	0,99	0,95	0,01	0,99

39	34	29	25	26	35	69	50	50	100	0,99	0	0	1	1	0,05	0,5	0,5
40	31	35	29	20	32	40	40	60	100	0,5	0,88	0,14	0,18	0,98	0,01	0,73	0,27
41	33	33	30	17	25	30	70	30	100	0,95	0,5	0,35	0	0	0	0,05	0,95
42	31	35	26	22	32	434	20	80	100	0,5	0,88	0	0,76	0,98	1	0,95	0,05
43	34	36	28	27	33	118	50	50	100	0,99	0,95	0,05	1	0,99	0,55	0,5	0,5
44	27	30	28	25	28	108	60	40	100	0,02	0,01	0,05	0,99	0,5	0,48	0,18	0,82
45	36	31	38	20	28	55	60	40	100	1	0,05	1	0,18	0,5	0,02	0,18	0,82
46	32	30	31	23	33	45	20	80	100	0,82	0,01	0,65	0,91	0,99	0,01	0,95	0,05
47	33	32	33	23	32	105	60	40	100	0,95	0,18	0,95	0,91	0,98	0,43	0,18	0,82
48	28	34	26	26	26	88	80	20	100	0,05	0,8	0	1	0	0,17	0,01	0,99
49	38	38	34	17	32	92	70	30	100	1	0,99	0,99	0	0,98	0,22	0,05	0,95
50	34	37	37	18	29	88	90	10	100	0,99	0,98	1	0,01	0,73	0,17	0	1
51	31	32	32	21	28	82	50	50	100	0,5	0,18	0,86	0,5	0,5	0,12	0,5	0,5
52	31	32	28	22	36	166	70	30	100	0,5	0,18	0,05	0,76	1	0,78	0,05	0,95
53	27	27	25	20	29	216	80	20	100	0,02	0	0	0,18	0,73	0,92	0,01	0,99
54	32	33	34	27	37	174	50	50	100	0,82	0,5	0,98	1	1	0,81	0,5	0,5
55	33	33	26	27	30	163	50	50	100	0,95	0,5	0	1	0,88	0,77	0,5	0,5
56	35	33	37	23	29	215	50	50	100	1	0,5	1	0,91	0,73	0,91	0,5	0,5
57	32	35	27	21	28	52	60	40	100	0,82	0,88	0,01	0,5	0,5	0,01	0,18	0,82
58	33	37	29	21	35	91	80	20	100	0,95	0,98	0,14	0,5	1	0,21	0,01	0,99
59	27	32	32	22	31	84	70	30	100	0,02	0,18	0,86	0,76	0,95	0,13	0,05	0,95
60	27	34	24	29	28	84	0	100	100	0,02	0,73	0	1	0,5	0,13	0,99	0,01
61	26	36	37	23	33	88	20	80	100	0,01	0,95	1	0,91	0,99	0,17	0,95	0,05
62	26	32	23	22	27	23	75	25	100	0,01	0,18	0	0,76	0,05	0	0,02	0,98
63	34	30	33	25	32	28	100	0	100	0,99	0,01	0,95	0,99	0,98	0	0	1
64	27	39	38	19	27	91	80	20	100	0,02	1	1	0,05	0,05	0,21	0,01	0,99
65	36	35	37	17	34	244	100	0	100	1	0,88	1	0	1	0,95	0	1
66	31	32	31	22	27	71	25	75	100	0,53	0,18	0,65	0,76	0,05	0,05	0,92	0,08
67	29	32	29	21	23	113	60	40	100	0,12	0,18	0,14	0,5	0	0,52	0,18	0,82
68	27	32	32	16	33	55	0	100	100	0,02	0,18	0,86	0	0,99	0,02	0,99	0,01
69	30	33	32	22	29	64	70	30	100	0,28	0,35	0,86	0,78	0,75	0,03	0,05	0,95
70	33	37	31	15	30	215	50	50	100	0,95	0,98	0,65	0	0,88	0,91	0,5	0,5
71	33	35	34	23	32	225	20	80	100	0,95	0,88	0,99	0,91	0,98	0,93	0,95	0,05
72	31	38	31	15	28	84	60	40	100	0,5	0,99	0,65	0	0,5	0,13	0,18	0,82
73	33	40	27	25	28	294	50	50	100	0,95	1	0,01	0,99	0,5	0,98	0,5	0,5
74	30	37	30	22	28	1374	35	65	100	0,27	0,98	0,35	0,76	0,5	1	0,82	0,18
75	31	34	33	20	25	127	60	40	100	0,5	0,73	0,95	0,18	0	0,6	0,18	0,82
76	33	27	34	25	36	74	20	80	100	0,95	0	0,99	0,99	1	0,07	0,95	0,05
77	32	37	39	16	27	104	65	35	100	0,82	0,98	1	0	0,05	0,41	0,1	0,9
78	24	37	30	14	26	1135	45	55	100	0	0,98	0,35	0	0,01	1	0,62	0,38
79	33	36	27	24	31	37	100	0	100	0,95	0,95	0,01	0,97	0,95	0	0	1
80	28	37	31	17	27	42	80	20	100	0,05	0,98	0,65	0	0,05	0,01	0,01	0,99
81	32	32	31	23	30	219	5	95	100	0,82	0,18	0,65	0,91	0,88	0,92	0,99	0,01
82	27	30	31	18	26	106	70	30	100	0,02	0,01	0,65	0,01	0	0,44	0,05	0,95
83	33	32	30	19	27	111	40	60	100	0,95	0,18	0,35	0,05	0,05	0,51	0,73	0,27
84	32	35	37	21	28	29	100	0	100	0,82	0,88	1	0,5	0,5	0	0	1

85	27	31	30	20	26	22	25	75	100	0,02	0,05	0,35	0,18	0	0	0,92	0,08
86	31	26	25	25	26	39	0	100	100	0,5	0	0	0,99	0	0,01	0,99	0,01
87	23	28	35	21	29	92	100	0	100	0	0	1	0,5	0,73	0,22	0	1
88	23	29	24	22	27	100	0	100	100	0	0	0	0,76	0,05	0,34	0,99	0,01
89	33	28	33	29	23	10	80	20	100	0,94	0	0,95	1	0	0	0,01	0,99
90	27	34	33	15	25	492	5	95	100	0,02	0,73	0,95	0	0	1	0,99	0,01
91	27	26	32	28	28	138	15	85	100	0,02	0	0,86	1	0,5	0,66	0,97	0,03
92	30	26	25	28	27	66	50	50	100	0,27	0	0	1	0,05	0,04	0,5	0,5
93	28	26	37	26	32	69	65	35	100	0,05	0	1	1	0,98	0,05	0,1	0,9
94	29	38	37	16	32	144	40	60	100	0,12	0,99	1	0	0,98	0,69	0,73	0,27
95	29	37	40	17	28	175	50	50	100	0,12	0,98	1	0	0,5	0,81	0,5	0,5
96	37	36	30	16	33	274	50	50	100	1	0,95	0,35	0	0,99	0,98	0,5	0,5
97	35	34	25	16	23	16	80	20	100	1	0,73	0	0	0	0	0,01	0,99
98	30	35	27	20	31	246	50	50	100	0,27	0,88	0,01	0,18	0,95	0,96	0,5	0,5
99	39	38	27	19	35	92	70	30	100	1	0,99	0,01	0,05	1	0,22	0,05	0,95
100	29	25	30	19	24	100	75	25	100	0,12	0	0,35	0,05	0	0,34	0,02	0,98
101	31	33	37	21	33	153	40	60	100	0,5	0,5	1	0,5	0,99	0,73	0,73	0,27
102	28	28	28	24	28	96	20	80	100	0,03	0	0,04	0,97	0,27	0,27	0,95	0,05
103	24	26	24	24	24	14	80	20	100	0	0	0	0,97	0	0	0,01	0,99
104	31	34	38	14	26	105	70	30	100	0,5	0,73	1	0	0	0,43	0,05	0,95
105	30	39	31	19	23	14	100	0	100	0,27	1	0,65	0,05	0	0	0	1
106	26	30	28	23	31	97	70	30	100	0,01	0,01	0,05	0,91	0,95	0,29	0,05	0,95
107	32	36	29	14	29	54	70	30	100	0,82	0,95	0,14	0	0,73	0,02	0,05	0,95
108	25	27	35	23	23	99	30	70	100	0	0	1	0,91	0	0,32	0,88	0,12
109	29	39	31	19	31	72	20	80	100	0,12	1	0,65	0,05	0,95	0,06	0,95	0,05
110	24	26	29	20	27	26	0	100	100	0	0	0,14	0,18	0,05	0	0,99	0,01
111	31	30	32	24	22	91	50	50	100	0,5	0,01	0,86	0,96	0	0,21	0,5	0,5
112	40	28	29	24	24	83	50	50	100	1	0	0,14	0,97	0	0,12	0,5	0,5
113	32	39	38	24	23	81	50	50	100	0,82	1	1	0,97	0	0,11	0,5	0,5
114	31	30	30	21	29	1137	50	50	100	0,5	0,01	0,35	0,5	0,73	1	0,5	0,5
115	29	29	27	26	27	0	15	85	100	0,12	0	0,01	1	0,05	0	0,97	0,03
116	31	31	34	20	25	623	50	50	100	0,5	0,05	0,99	0,18	0	1	0,5	0,5
117	29	33	32	20	27	253	100	0	100	0,12	0,5	0,86	0,18	0,05	0,96	0	1
118	26	25	28	23	27	1342	50	50	100	0,01	0	0,05	0,91	0,05	1	0,5	0,5
119	35	35	30	17	22	189	30	70	100	1	0,88	0,35	0	0	0,86	0,88	0,12
120	27	35	31	21	25	41	20	80	100	0,02	0,88	0,65	0,5	0	0,01	0,95	0,05
121	28	26	28	25	30	20	65	35	100	0,05	0	0,05	0,99	0,88	0	0,1	0,9
122	28	31	29	26	27	176	50	50	100	0,05	0,05	0,14	1	0,05	0,82	0,5	0,5
123	36	32	29	18	28	49	60	40	100	1	0,18	0,14	0,01	0,5	0,01	0,18	0,82
124	29	38	37	21	36	493	40	60	100	0,12	0,99	1	0,5	1	1	0,73	0,27
125	28	33	30	19	34	285	80	20	100	0,05	0,5	0,35	0,05	1	0,98	0,01	0,99
126	27	38	33	15	30	301	50	50	100	0,02	1	0,95	0	0,88	0,99	0,5	0,5
127	27	36	28	24	27	16	70	30	100	0,02	0,95	0,05	0,97	0,05	0	0,05	0,95
128	23	29	28	25	24	44	50	50	100	0	0	0,05	0,99	0	0,01	0,5	0,5
129	36	32	33	22	32	43	60	40	100	1	0,18	0,95	0,76	0,98	0,01	0,18	0,82
130	32	30	40	19	36	16	90	10	100	0,82	0,01	1	0,05	1	0	0	1

131	37	40	32	23	31	409	70	30	100	1	1	0,86	0,91	0,95	1	0,05	0,95
132	23	29	24	24	27	285	30	70	100	0	0	0	0,97	0,05	0,98	0,88	0,12
133	35	31	33	21	26	226	50	50	100	1	0,05	0,95	0,5	0	0,93	0,5	0,5
134	24	34	36	20	34	189	50	50	100	0	0,73	1	0,18	1	0,86	0,5	0,5
135	26	36	34	16	32	76	100	0	100	0,01	0,95	0,99	0	0,98	0,08	0	1
136	39	40	35	21	29	210	0	100	100	1	1	1	0,5	0,73	0,91	0,99	0,01
137	27	31	30	21	27	333	30	70	100	0,02	0,05	0,35	0,5	0,05	0,99	0,88	0,12
138	38	40	26	18	30	254	60	40	100	1	1	0	0,01	0,88	0,96	0,18	0,82
139	35	37	24	23	27	305	20	80	100	1	0,98	0	0,91	0,05	0,99	0,95	0,05
140	33	33	31	16	29	40	0	100	100	0,95	0,5	0,65	0	0,73	0,01	0,99	0,01

Big 1 stands for extraversion, Big 2 for agreeableness, Big 3 for conscientiousness, Big 4 for Emotional adjustment, Big 5 for openness to experiences. Netw. size stands for network size. Plor stands for exploration and Ploit stands for exploitation, and Tot stands for total which is tot total of exploration and exploitation.

Appendix F

Hypothesis 1a

Exploration

Algorithm: Quine-McCluskey

True: 1

0 Matrix: 0L

Don't Care: -

--- INTERMEDIATE SOLUTION ---

frequency cutoff: 1.000000

consistency cutoff: 0.755943

Assumptions:

opennesstoexper (present)

emotionaladjust (present)

conscientiounes (present)

agreeable (present)

extraversion (present)

	raw coverage	unique coverage	consistency
~opennesstoexper*emotionaladjust*conscientiounes	0.154243	0.042575	0.732680
~opennesstoexper*emotionaladjust*extraversion	0.195639	0.080731	0.764536
opennesstoexper*emotionaladjust*agreeable*~extraversion	0.106070	0.076900	0.767591

solution coverage: 0.317767

solution consistency: 0.753669

Exploitation

Algorithm: Quine-McCluskey

True: 1

0 Matrix: 0L

Don't Care: -

--- INTERMEDIATE SOLUTION ---

frequency cutoff: 1.000000

consistency cutoff: 0.762447

Assumptions:

opennesstoexper (present)

emotionaladjust (present)

agreeable (present)

extraversion (present)

	raw coverage	unique coverage	consistency
opennesstoexper*~agreeable*~extraversion	0.194814	0.121742	0.811201
~emotionaladjust*~agreeable*extraversion	0.174432	0.098170	0.837550
~opennesstoexper*emotionaladjust*agreeable*~extraversion	0.074321	0.037992	0.762447

solution coverage: 0.339296

solution consistency: 0.803085

Hypothesis 1b

Exploration

Algorithm: Quine-McCluskey

True: 1

0 Matrix: 0L

Don't Care: -

--- INTERMEDIATE SOLUTION ---

frequency cutoff: 65.000000

consistency cutoff: 1.000000

Assumptions:

networksize (present)

*** ERROR(Quine-McCluskey): The 1 Matrix is Empty. ***

Exploitation

Algorithm: Quine-McCluskey

True: 1

0 Matrix: 0L

Don't Care: -

--- INTERMEDIATE SOLUTION ---

frequency cutoff: 65.000000

consistency cutoff: 1.000000

Assumptions:

networksize (present)

*** ERROR(Quine-McCluskey): The 1 Matrix is Empty. ***

Hypothesis 2a

Algorithm: Quine-McCluskey

True: 1

0 Matrix: 0L

Don't Care: -

--- INTERMEDIATE SOLUTION ---

frequency cutoff: 1.000000

consistency cutoff: 0.770136

Assumptions:

networksize (present)

opennesstoexper (present)

emotionaladjust (present)

agreeable (present)

extraversion (present)

	raw coverage	unique coverage	consistency
networksize*emotionaladjust*extraversion	0.210666	0.111226	0.715716
networksize*~opennesstoexper*~agreeable*extraversion	0.098556	0.030642	0.781542
~opennesstoexper*emotionaladjust*~agreeable*extraversion	0.128904	0.057602	0.792572
opennesstoexper*emotionaladjust*agreeable*~extraversion	0.106070	0.054213	0.767591

solution coverage: 0.356512

solution consistency: 0.710928

Hypothesis 2b

Algorithm: Quine-McCluskey

True: 1

0 Matrix: 0L

Don't Care: -

--- INTERMEDIATE SOLUTION ---

frequency cutoff: 2.000000

consistency cutoff: 0.776420

Assumptions:

~networksize (absent)

opennesstoexper (present)

emotionaladjust (present)

agreeable (present)

	raw coverage	unique coverage	consistency
networksize*~opennesstoexper*emotionaladjust	0.173100	0.083972	0.789120
networksize*emotionaladjust*agreeable	0.199322	0.110195	0.746689

solution coverage: 0.283294

solution consistency: 0.748832

Hypothesis 2c

Algorithm: Quine-McCluskey

True: 1

0 Matrix: 0L

Don't Care: -

--- INTERMEDIATE SOLUTION ---

frequency cutoff: 1.000000

consistency cutoff: 0.756288

Assumptions:

~networksize (absent)

~opennesstoexper (absent)

emotionaladjust (present)

agreeable (present)

extraversion (present)

	raw coverage	unique coverage	consistency
opennesstoexper*~agreeable*~extraversion	0.194814	0.119523	0.811201
~emotionaladjust*~agreeable*extraversion	0.174432	0.018996	0.837550
opennesstoexper*~emotionaladjust*extraversion	0.256933	0.060455	0.769199
~networksize*~opennesstoexper*agreeable*~extraversion	0.134637	0.026206	0.826383

~networksize*opennesstoexper*agreeable*extraversion 0.165835 0.028702 0.799465

~networksize*~emotionaladjust*extraversion 0.244454 0.012479 0.768526

~networksize*~opennesstoexper*~emotionaladjust*agreeable 0.163616 0.004021 0.767230

solution coverage: 0.579312

solution consistency: 0.762270