# Configurations of Effective Knowledge Networks

A qualitative comparative study towards network effectiveness among green educational institutions in the Netherlands

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## Abstract

This study explores the way in which network integration (cohesion and centralization), network size, and resource munificence relate to the effectiveness of consciously created knowledge networks. Therefore, a theoretical model which is established through empirical research on public service implementation networks, is tested against 34 whole knowledge networks that are formed among green educational institutions in the Netherlands, to ascertain how different configurations of factors affect the effectiveness of the network as a whole at the network level. 34 Network managers were subjected to a survey, which was established on the basis of three semistructured interviews with network managers. In the end, the data for 34 networks were analyzed with fuzzy-set Qualitative Comparative Analysis. The results revealed that there are two ways in which knowledge networks can be effective. Both ways include cohesion and size as necessary but not sufficient conditions. One way is in conjunction with centralization, and the other one with resource munificence. This suggests that network managers always should try to create a large and cohesive network. If a network manager is unable to get a sufficient amount of funding available to the network, he has to make sure that the network will be characterized by a high level of centralization in order to achieve network effectiveness. As this study is first in its kind in the context of knowledge networks, more extensive research with a configurational approach is recommended in this context.

***Keywords:*** *Cohesion, Centralization, Network integration, Network size, Resource munificence, Network effectiveness, Whole networks, Knowledge networks, QCA.*

# Table of Contents

# 1. Introduction

Over the past few decades, scholars have shown a great interest into the study of interorganizational networks. An interorganizational network can nowadays be seen as a separate organizational form. The reasons for working in networks, rather than in hierarchies of organizations are clear. The most frequently mentioned advantage of working in networks is that they can produce outcomes that can not be produced by single organizations. Podolny and Page (1998) argue that working in networks allows organizations to learn new skills, acquire knowledge, and improve economic performance. Raab and Kenis (2009) argue that a network represents a new organizational form, "which is about to become the new dominant form in the future, replacing the formal hierarchical organization that has dominated the 20th century" (p. 199).

Most research on interorganizational networks, both in the profit and not for profit sector, has primarily focused on issues such as network formation, network governance, and power and influence in networks (Turrini, Cristofoli, Frosini & Nasi, 2010). However, the determinants of the overall effectiveness of interorganizational networks remain underexposed in current literature. Provan and Milward (1995) proposed that the network effectiveness of publicly funded goal directed service implementation networks is dependent on the network integration and resource munificence. The type of networks that they study can be called 'whole networks' according to Raab and Kenis (2009).

Contrary to whole networks, we can also identify serendipitous networks. Literature about knowledge networks, like the study of Phelps, Heidl, and Wadhwa (2012), is mainly concerned with interorganizational networks that arise through dyadic interactions without pre-existing goals for the network. These types of networks can be regarded as serendipitous networks (Raab & Kenis, 2009). Phelps et al. (2012) reveal that most literature on knowledge networks is mainly concerned with serendipitous networks.

Thus, different streams exist within the body of literature regarding network effectiveness. On the one hand, there are information diffusion networks that are usually serendipitous and relatively cohesive. On the other hand there are service implementation networks, such as the networks as described by Provan and Milward (1995), which are consciously created and have a more centralized structure. It is not known to what extent these two streams in current literature are applicable to consciously created information diffusion networks, in this research referred to as whole knowledge networks.

An aspect that has been superseded in the literature is the potential for structured forms of networks to promote knowledge diffusion and innovation (Turrini et al. 2010). To date, most research on knowledge networks has focused on serendipitous networks, which is argued to be the optimal form for knowledge networks because of its emergent nature. Recent literature in the public management field, however, endorses that some form of structured networks can help to increase knowledge sharing (Turrini et al. 2010). This leaves a scientific gap for possible research on the effectiveness of whole knowledge networks, which this study is to fill up.

This research contributes to the literature regarding interorganizational networks in (at least) two ways. Firstly, a theoretical model which is established through empirical research on public service implementation networks, is tested against 34 whole knowledge networks in the Netherlands to ascertain how different configurations of variables affect the effectiveness of the network as a whole at the network level. Thus, this research either expands the scope of earlier published theoretical models or it modifies these earlier published theoretical models so that they are applicable to whole knowledge networks. Secondly, by using a configurational approach and a relatively new analytical technique, Qualitative Comparative Analysis (QCA), the effects of different variables on network effectiveness are not examined in pure isolation but in combination with each other. The potential value of using a configurational approach is reflected in the growing attention it is receiving in recent publications (Raab et al., 2013; Fiss, 2011). Raab et al. (2013) state that this theoretical and analytical approach is appropriate for the further development of theory on network effectiveness.

By assessing different features of whole knowledge networks, namely the network integration (cohesion and centralization), size, resource munificence, and effectiveness, the aim of this study is to provide managers of whole knowledge networks insights in how to organize their network in such a way that will most likely lead to an enhanced network effectiveness. The practical relevance of this study can be derived from the research aim. The practical relevance of this study is that it has the potential to help managers of whole knowledge networks to become aware of the fact that different configurations of features of a network lead to different levels of effectiveness. By not only creating the awareness, but by presenting different configurations of features that lead to high levels of network effectiveness, this study is practically relevant for whole knowledge network managers. This leads to the following research question:

*Which configurations of the features cohesion, centralization, size, and resource munificence will lead to effective whole knowledge networks?*

In order to carry out this research, network managers of whole knowledge networks were approached and interviewed on their vision of the different features of whole knowledge networks. Based on their answers, it was possible to create a questionnaire on the basis of which the different features and the effectiveness of whole knowledge networks could be measured accurately.

## 2. Theoretical background

This section will provide a short but comprehensive overview of the current literature regarding the most important concepts of this study. The following paragraphs will elaborate on the relevant theoretical concepts and mechanisms. Firstly, the configurational approach which is applied in this research will be described in detail. Secondly, theory on interorganizational networks will be presented. A distinction will be made between whole networks and serendipitous networks, and knowledge networks will be introduced as this type of networks form the research setting in this study. Thirdly, the most prominent insights in the dependent variable of this research, network effectiveness, will be presented. Fourthly, three network structural characteristics will be presented: cohesion, centralization, and size. At last, one network contextual characteristic will be introduced as independent variable: resource munificence. Figure 1 presents the conceptual model of this research.

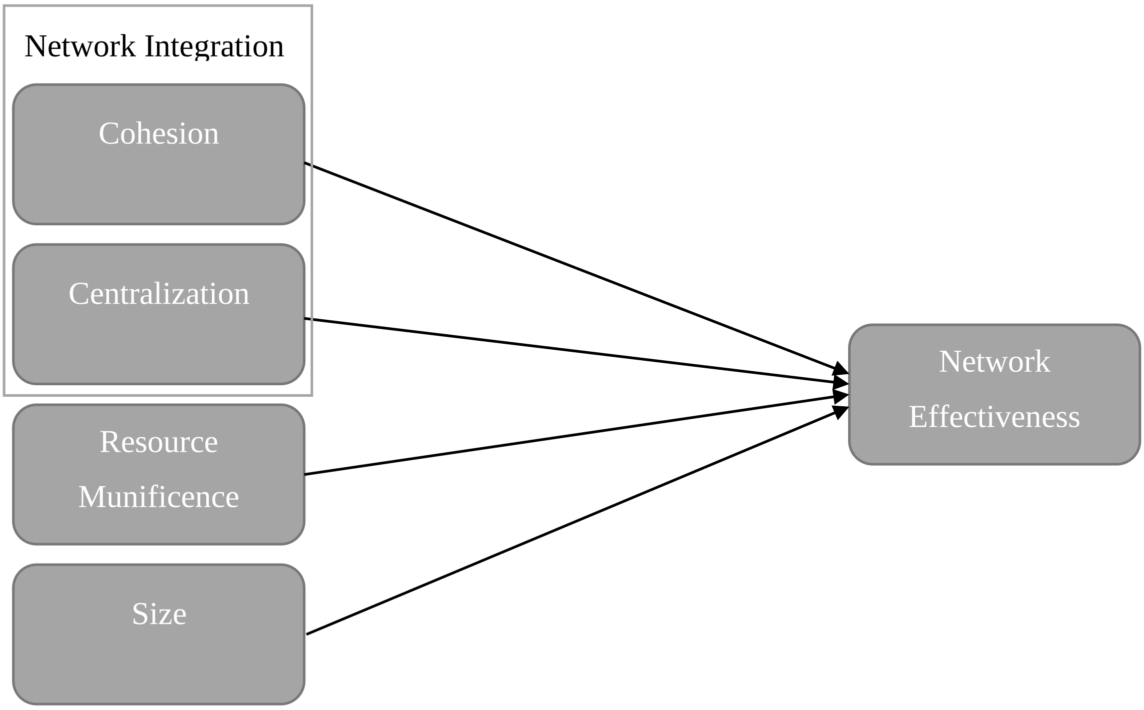


Figure 1. Conceptual model

## 2.1. The configurational approach

As mentioned before, this research will apply a configurational approach to the empirical analysis of network effectiveness. The idea behind this approach in management and organization studies is that “organizations are best understood as clusters of interconnected structures and practices, rather than as modular or loosely coupled entities whose components can be understood in isolation” (Fiss 2007, p.1180). Whereas more conventional approaches to organizational research try to understand the behavior of a social entity by separately analyzing its constituent parts, the configurational approach takes a more holistic stance (Meyer, Tsui & Hinings, 1993). When adopting a configurational approach, researchers look more at the effects of the interaction of certain parts on a certain outcome instead of the effects of the separate parts on a certain outcome.

This research is based on the research and theoretical ideas of Provan and Milward (1995). They have performed a research in which their propositions on network effectiveness were actually formulated in a configurational or set theoretic way, instead of the conventional linear way (Raab et al., 2013). In doing so they reffered to necessary and sufficient conditions that, in combination with each other, lead to network effectiveness. That is actually the core idea behind the configurational approach, which is argued to be the core of a network theory on effectiveness (Raab et al., 2013). Thus, by applying a configurational approach, this research will test hypotheses based on necessary and sufficient conditions for network effectiveness. Ultimately, by combining the hypotheses based on necessary and sufficient conditions to network effectiveness, a pathway to network effectiveness will occur. This pathway will be composed of al necessary or sufficient conditions leading to network effectiveness. The next section will discuss theories regarding interorganizational networks, after which the concepts included in this study will be addressed and linked to each other.

## 2.2. Interorganizational networks

Interorganizational networks are becoming increasingly important nowadays and societies are moving towards a society of networks (Raab & Kenis, 2009). This means that the formal, vertically integrated organization that has dominated the 20$^{th}$ century will be replaced or complemented by interorganizational networks. Organizations have to interact and exchange goods, information, and knowledge with each other as modern society is becoming more and more interdependent. A few decades ago, Mintzberg (1979) was one of the first researchers to wonder how organizations should be structured and organized. Today, this question has shifted from the organizational level to the network level. Thus, now the question is how to structure and organize interorganizational networks in such a way that will most likely lead to effective networks.

The most basic definition of a network is “a set of nodes and the set of ties” (Brass, Galaskiewicz, Greve & Tsai, 2004, p. 795). Turrini et al. (2010) use a definition that relies above all on the organizational features that networks typically assume. According to Turrini et al. (2010), a network is “a set of organizations that coordinate their joint activities through different types of peer-to-peer relations” (p. 529). Powell (1990) contrasts networks with market and hierarchical structures of organizations, and highlights the distinctive features of networks. According to Powell (1990), networks depend more heavily upon relationships and mutual interest as compared to markets and hierarchies. Powell (1990) highlights three factors that are critical components of networks, namely: know-how, the demand for speed, and trust.

Over the past years, researchers have distinguished different forms of networks. Kilduff and Tsai (2003) were the first to introduce the difference between goal-directedness and serendipity. These two processes differ in structural dynamics. In goal-directed networks, member firms see themselves as a part of the network and are committed to network-level goals (Human & Provan, 2000). According to Raab and Kenis (2009), this type of networks can be called whole networks. Whole networks can then be defined as consciously created and goal directed networks of three and more organizations (Raab & Kenis, 2009). Kilduff and Tsai (2003) found that one of the key identifying features of whole networks is the existence of an entity that coordinates the activities of the network as a whole. This entity can either be a member of the network, or a separate actor. Whole networks develop around specific goals that members share, and relationships among these members are structured to achieve the goals of the network (Kilduff & Tsai, 2003). In knowledge networks this goal can, for example, be to enhance knowledge sharing and knowledge creation among different educational institutions.

Serendipitous networks, as opposed to whole networks, develop somewhat randomly as a result of interactions between individual actors. Network-level goals do not drive the formation of these networks. In these networks, individual actors make choices about who to connect with based on their own interests without any guidance of an entity that coordinates the network’s activities (Kilduff & Tsai, 2003). Later, Raab and Kenis (2009) stated that goal-directed, consciously created, bounded and governed networks as a new organizational form has received little attention in the scientific literature. Table 1 is adapted from Kilduff and Tsai (2003), and describes both whole networks and serendipitous networks.

| | Whole networks | Serendipitous networks |
|---|---|---|
| **Underlying assumptions** | - Actors share a goal.<br>- Network is formed to achieve this goal (engineered)<br>- Success is measured against this goal | - No pre-existent goal<br>- Network evolves through random selection (emergent) |
| **Structural dynamics** | - Centralized structure with a leader<br>- Tight coupling and clear boundary | - Decentralized structure with no single leader<br>- Loose coupling and diffuse boundary |
| **Implications for individual actors** | - More homogeneous actors<br>- Actors participate based on shared goals | - More diverse actors<br>- Actors participate based on individual interests |

Table 1. Whole versus serendipitous networks. Adapted from Social Networks and Organizations (p. 91), by M. Kilduff, and W. Tsai, 2003, London: Sage Publications.

Where research in the service implementation industry has mainly focused on whole networks, research on knowledge networks has mainly been concerned with serendipitous networks. Phelps et al. (2012) have studied and reviewed literature about knowledge networks. They define a knowledge network as “a set of nodes—individuals or higher level collectives that serve as heterogeneously distributed repositories of knowledge and agents that search for, transmit, and create knowledge—interconnected by social relationships that enable and constrain nodes’ efforts to acquire, transfer, and create knowledge” (Phelps et al., 2012, p. 1117).

According to Galunic and Rhodan (1998), the ability of an actor to create knowledge is influenced by the ease with which the actor effectively searches for, access, transfers, absorbs, and applies knowledge. “A fast-growing body of research shows that characteristics of social relationships and the networks they constitute influence the efficacy and efficiency by which individuals and collectives create knowledge by affecting their ability to access, transfer, absorb, and apply knowledge” (Phelps et al., 2012, p. 1117). Those studies are referred to as ‘knowledge network’ research.

Research on knowledge networks is conducted in multiple fields and with different levels of analysis. At the interpersonal level, for example, scientists have studied the influence of social networks on individual creativity (Burt, 2004). At the group level, for example, Reagan and

McEvily (2003) have researched social network structures within and beyond teams, and how it affects the combination, exchange, and creation of knowledge. At the interorganizational level, strategy researchers have examined how characteristics of strategic alliances affect inter-firm knowledge transfer (Phelps et al., 2012). However, research at the network level has not been able to examine how the different features of networks affect the effectiveness of whole knowledge networks.

### 2.3. Network effectiveness

The fact that describing, defining, and evaluating network effectiveness is a hard thing to do, is stressed out by multiple researchers (Mandell & Keast, 2008; Provan & Kenis, 2008; Provan & Milward, 2001: Turrini et al., 2010). During the past decade, a considerable amount of work has been devoted to the understanding of network effectiveness. The difficulties of assessing network effectiveness are closely related to those of evaluating organizations, but they are even more complex (Provan & Milward, 2001). Approaching the satisfaction of the key stakeholders of an organization is the most widely used manner of assessing organizational effectiveness. However, it is not always clear who the key stakeholder is. Even when this is clear, the needs of the key stakeholder may be fragmented and thus resulting in different views about how effectiveness should be measured (Provan & Milward, 2001). Unlike organizations, networks have to deal with a joint-production problem. Multiple organizations produce pieces and work together to ultimately come up with a single product or service. Also, networks are multidimensional and can be analyzed at multiple levels (Raab et al., 2013). Because of the complexity of the concept network effectiveness, researchers usually choose their own criteria and indicators to determine effectiveness (Vollenberg, Raab, & Kenis, 2007).

To date, there are numerous of different approximations and definitions of network effectiveness that can actually be divided into three different types of effectiveness. The most important question that raises when researching network effectiveness is: 'effectiveness for whom?' (Provan & Kenis, 2008). Dependent on the answer to that question, one type of effectiveness will suit best with a specific network. Turrini et al. (2010) have distinguished three different types of network effectiveness. Provan and Milward (1995) define network effectiveness as the improvement of the client well-being and the overall quality of service delivery. This type of effectiveness can be called 'client level effectiveness' according to Turrini et al. (2010). Provan and Milward (2001) have broadened the criteria for measuring effectiveness to relate them to an overall benefit for the entire community. Their claim is that clients of a network represent one group of stakeholders, but that there are other groups of stakeholders that may be even more important. This type of effectiveness can be called ‘overall community level effectiveness’. Then, there is a third type of effectiveness: ‘network level performance’, from now on referred to as network level effectiveness. According to Turrini et al. (2010) network level effectiveness is mainly concerned with sustainability/maintenance and the capability of the network to reach stated goals. Regarding the sustainability issue, Provan and Milward (2001) state that “while a network may benefit the community in which it is embedded, it must become a viable interorganizational entity if it is to survive” (p. 417). These two indicators of network effectiveness are suitable when it comes to researching whole knowledge networks, since those indicators are important for future knowledge creation and knowledge transfer within networks.

Furthermore, it is important to understand that public-sector networks, like the whole knowledge networks in this study, differ from those in the for-profit world. In the for-profit world, the financial performance of a network is commonly seen as a legitimate way of assessing network effectiveness (Provan & Milward, 2001). In the public sector however, other aspects of the network are more important. As whole knowledge networks, where the goal is to improve knowledge sharing and create new knowledge, form the context of this research, it is chosen to assess network level effectiveness rather than either client level effectiveness or overall community level effectiveness. Therefore the definition drawn up by Provan and Kenis (2008) of network effectiveness is applicable to this research. They defined network effectiveness as “the attainment of positive network level outcomes that could not normally be achieved by individual organizational participants acting independently” (Provan & Kenis, 2008, p. 230).

In the literature, numerous different factors that influence network effectiveness are mentioned. Turrini et al. (2010) have reviewed former theoretical and evidence-based research on network effectiveness. Figure 2 presents a framework as drawn up by Turrini et al. (2010), which is mainly based on the model proposed by Provan and Milward (1995). Turrini et al. (2010) make a distinction between two groups of independent variables: network structural characteristics and network functioning characteristics. Next to the independent variables, they found a group of both moderating and independent variables: network contextual characteristics. The group ‘network structural characteristics’ contains variables such as type and intensity of external control, level of formalization, and integration mechanisms and tools. The group ‘network functioning characteristics’ contains variables such as traditional managerial work and generic networking. The group 'network contextual characteristics' is composed of the variables system stability, resource munificence, and support from the community.

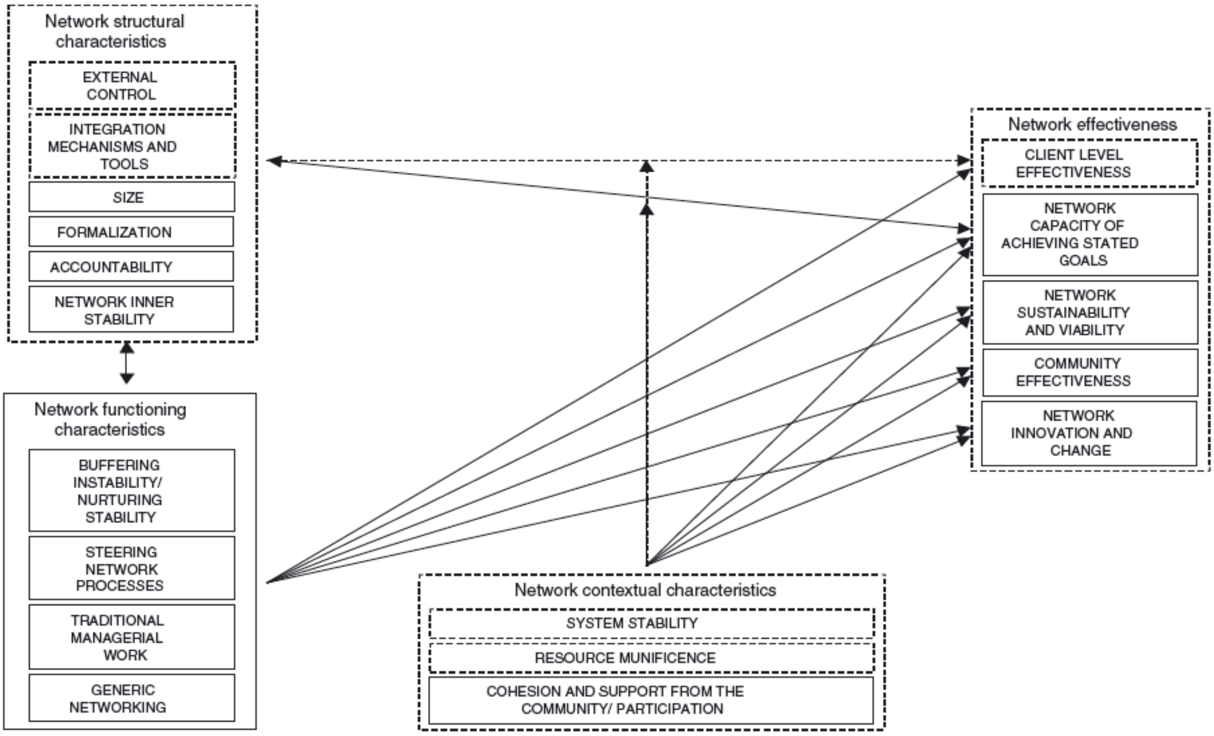


Figure 2. Integrated framework of network effectiveness. Reprinted from "Networking literature about determinants of network effectiveness", by A. Turrini, D. Cristofoli, F. Frosini, and G. Nasi, 2010, *Public Administration, 88*, p.546.

This study is based on the model of Provan and Milward (1995) but focusses on another type of networks, namely whole knowledge networks. Provan and Milward (1995) focused on health care networks, or public service implementation networks, and examined the effect of network integration, external control, system stability and environmental resource munificence on network effectiveness. As is clear from the framework of Turrini et al. (2010), the model of Provan and Milward (1995) has remained intact. For the purpose of this study, the model of Provan and Milward (1995) is adjusted in three places. No variation, both on external control and system stability, was expected and therefore these two variables were excluded from the research. Variation on these two variables was not expected as all networks were located in the same environment and were dealing with the same environmental circumstances (e.g. same funding agency). The third adjudment that is made, is adding size as an independent variable to the conceptual model. Provan and Milward (1995) controlled for the size of the mental health delivery systems in their study, by only including comparably sized mental health delivery systems. This indicates that the size of a network may have an effect on network effectiveness. Following this line of reasoning, three network structural characteristics (cohesion, centralization, and size) and one network contextual characteristic (resource munificence) remain left to consider.

## 2.4. Network structural characteristics

Network structural characteristics refer to the overall pattern of relationships between the network participants (Tichy, Tushman, and Fombrun, 1979). As is apparent from this definition and from figure 2, network integration and network size are network structural characteristics.

Network integration is still very loosely described in current literature. Provan and Milward (1995) tried to describe this concept based on two dimensions; cohesion and centralization. In this approximation, network integration can be defined as "the cohesion and interconnectedness among actors, and the extent to which the actors are integrated and coordinated through a central authority" (Provan & Milward, 1995, p.10). Furthermore, Provan and Milward (1995) found that the integration among different actors within the network is presumed to have a strong impact on the outcomes of the network. According to Reagans and McEvily (2003), network integration can affect knowledge transfer independent of the effects of common knowledge. The following three paragraphs will elaborate on the concepts of cohesion, centralization, and size as they are all independent variables in this research.

### 2.4.1. Cohesion

Cohesion can be seen as an environment's interconnectedness. Next, an environments' interconnectedness is comparable to network density (Rowley, 1997). According to Rowley (1997), density is a characteristic of the whole network which describes the relative number of ties in the network that link actors together. A network in which all participants have ties to each other is highly interconnected, so the density is high. A network in which few participants have ties to each other is less interconnected, and therefore it has a lower density. The cohesion perspective views connections among organizations in networks as pipes through which information and knowledge flows. A cohesive network enables a greater communication frequency and the sharing of more relevant and high fidelity information (Phelps et al., 2012).

In more general terms, density is simply a measure of the extent to which all network organizations are interconnected, or linked to one another, and reflects network cohesiveness (Provan & Milward, 1995). According to Reagans and McEvily (2003), who researched informal interpersonal networks, cohesion around a relationship can ease knowledge transfer as it increases the willingness and motivation of individuals to invest time, energy, and effort in sharing knowledge with others. Provan and Milward (1995) found no significant effect of network density, or cohesion, on network effectiveness in health-care networks. An important notion is that this study takes place in another setting. Phelps et al. (2012) found that the few whole network studies that exist about knowledge networks show that network cohesion influences the rate, extent, and fidelity of information diffusion in a network. They state that a cohesive network structure increases the rate and extent of information diffusion, leading to an effective network. Hence, it is expected that network effectiveness increases as cohesion increases. Therefore, it is hypothesized that cohesive integration is a necessary but not sufficient condition for network effectiveness (H1).

### 2.4.2. Centralization

"Centralization refers to the power and control structure of the network, or whether network links and activities are organized around any particular one or small group of organizations" (Provan & Milward, 1995, p. 10). Coordination in networks can be highly centralized around one focal point in a network, diffused among all actors in the network, or somewhere in between. Wasserman and Galaskiewicz (1994) state that an actor's centrality in the network evaluates the prominence of the actor. As just mentioned, network density reflects the network's cohesiveness. According to Provan and Milward (1995), cohesion and centralization can be seen as complementary to each other, since centralization describes the extent to which this cohesion is organized around particular focal points in the network.

In the light of this study, centralization refers to the extent to which actors in a network are integrated and coordinated through a central authority. Provan and Milward (1995) examined network centralization in goal-directed service networks. They found that a relatively high score on centralization leads to an effective network whereas a relatively low score on centralization leads to a less effective network. The rationale behind this is that centralized integration facilitates both integration and coordination. Furthermore, in a highly centralized network, the central (and most likely leading) organization can monitor and control the activities of the network members and prevent free-riding (Raab et al., 2013). Where Raab et al. (2013) found this for service implementation networks, this is also expected to be the case for whole knowledge networks. The first reason for this is that goal-directedness, and thus goal directed coordination, is crucial for both types of networks. The second reason is that the transfer and creation of knowledge is crucial in whole knowledge networks, both of which are processes that require some kind of coordination. Hence, it is expected that a high centralization is beneficial for network effectiveness. Following, it is argued that centralized integration is a necessary but not sufficient condition for network effectiveness (H2).

### 2.4.3. Size

For the purpose of this study, the size of a network is defined as the number of members that participate in a network. Turrini et al. (2010) found that network size has an effect on network effectiveness, especially on the capacity of achieving stated goals and the sustainability and viability of a network. According to Hasnain-Wynia, Sofaer, Bazzoli, Alexander, Shortell, Conrad, and Sweney (2003) the relationship between network size and network effectiveness is negative. They found that "in any case, the larger the network, the lower the degree of its perceived effectiveness" (Turrini et al, 2010, p.542). An important notion is that the research of Hasnain-Wynia et al. (2003) had been performed among community care networks. The rationale behind the observed effect implies that more actors complicate the coordination and achievement of agreement. The effect of network size on network effectiveness in whole knowledge networks is expected to be different. However research on knowledge networks has not yet been able to examine the effect of size on network effectiveness, it is expected that a minimum amount of network members is required for establishing an effective network. Small networks are generally more limited in their information diversity as compared to large networks. Information diversity is an important factor in sharing and creating new knowledge, which is one of the main goals of whole knowledge networks. According to Weiss, Miller, and Lasker (2002), the combination of perspectives, knowledge, and skills of different network participants is considered as fundamental for improving the ability of the network to reach stated goals. Therefore, it is argued that size (a minimum amount of network participants) is a necessary but not sufficient condition for network effectiveness (H3).

## 2.5. Network contextual characteristics

Network contextual characteristics refer to matters that are external to the network (e.g. system stability). Next to the three network structural characteristics, one network contextual characteristic is included as an independent variable in this research: resource munificence. The following paragraph will elaborate on this concept.

### 2.5.1. Resource munificence

"Resource munificence is the scarcity or abundance of resources a firm has access to" (Castrogiovanni, 1991). In the light of this study, resource munificence can simply be seen as the amount of money available to the network. Provan and Milward (1995) proposed that a high resource munificence per se is not sufficient to ensure favorable outcomes. However, their findings propose that networks embedded in poorly funded environments are very unlikely to have effective network outcomes. On the contrary, being a network embedded in a well-funded environment is no guarantee for effective network outcomes. From a more practical point of view, there are costs when members of a (knowledge) network arrange a meeting. If such meetings, where knowledge can actually be shared, are not feasible, network effectiveness is likely to suffer from it. Concluding, it is expected that sufficient resource munificence is important in achieving effective network outcomes but network level factors such as integration are critical for taking advantage of resource munificence. Therefore, it is hypothesized that resource munificence is a necessary but not sufficient condition for network effectiveness (H4).

### 2.6. A configurational model of network effectiveness

As mentioned earlier, by combining the above discussed necessary and sufficient conditions of hypothesis 1-4 that are expected to lead to high levels of network effectiveness, the following sufficient pathway to network effectiveness emerges (H5): networks that are cohesive, centrally coordinated, have a minimum amount of members, and have sufficient resources will be effective. This fifth hypothesis results from the former four. The first four hypotheses state that a single condition is a necessary but not sufficient condition to reach network effectiveness. Following from the configurational approach, all necessary conditions have to be combined into one pathway which in itself is sufficient to reach network effectiveness. An overview of all five hypotheses is presented below:

H1: Cohesive integration is a necessary but not sufficient condition for network effectiveness.

H2: Centralized integration is a necessary but not sufficient condition for network effectiveness.

H3: Size (a minimum amount of participants) is a necessary but not sufficient condition for network effectiveness.

H4: Resource munificence is a necessary but not sufficient condition for network effectiveness.

H5: Networks that are cohesive, centrally coordinated, have at least a minimum amount of participants, and have sufficient resources will be effective.

## 3. Data and methods

This section will comprehensively describe the methodology of the research by paying attention to the following sub fields: research design, research setting and sample strategy, data collection, data analysis, and concept measurement. As the configurational approach of this research is rather unconventional, it is chosen to elaborate on the data analysis prior to the concept measurement in order to increase understanding.

### 3.1. Research design

The goal of this study is to provide managers of whole knowledge networks insights in how to organize their network in such a way that will most likely lead to an enhanced network effectiveness. The research can be labelled both inductive as deductive. It is inductive since the results and conclusions of this study will be derived from questionnaires. The theories and empirical research on which this study is based cause this study to be deductive as well. This study uses a cross-sectional research design, as an explanatory survey is performed.

As mentioned earlier, and as follows from the hypotheses, this study makes use of a configurational approach to the empirical analysis on network effectiveness. QCA is the analytical technique that will be performed. QCA represents Qualitative Comparative Analysis and combines Boolean algebra with set theory. The dominant perspective on current scientific research is: "the more we observe variable X, the more we should observe outcome Y" (Raab et al., 2013, p. 5). This view always assumes that "each independent variable is assumed to be capable of influencing the level or probability of the outcome regardless of the values or levels of other variables" (Ragin, 2008, p.177-178). The configurational approach, however, takes into account the effect that different combinations of variables have on a certain outcome. The effect of a variable mostly depends upon its environment, that is, the presence or absence of other characteristics of variables (conditions). According to Fiss (2011), "the basic intuition underlying QCA is that cases are best understood as configurations of attributes resembling overall types and that a comparison of cases can allow a researcher to strip away attributes that are unrelated to the outcome in question" (p. 402).

### 3.2. Setting and sample

The research setting is composed of networks that are formed among green educational institutions in the Netherlands, which are supported by the Ministry of Economic Affairs, Agriculture and Innovation because of their agricultural roots. During the past decades, the connections and links between the green educational institutions in the Netherlands were strongly diluted. In order to maintain the global leading position of the Dutch agribusiness, a revitalization of the ‘green knowledge’ was urgently needed. In 2006, all green educational institutions in the Netherlands made a long term agreement with each other and the minister of Agriculture, Nature, and Food Quality in order to improve the ‘green knowledge system’ in the Netherlands. Hereafter, networks among green educational institutions started to arise. The objectives of the networks are to increase knowledge sharing, create new knowledge in the agricultural sector, and to facilitate new teaching methods. The practical results of these networks range from files and websites to teachers days and journal articles.

All networks included in this research can be regarded as single whole knowledge networks as they meet the definition of knowledge networks as defined by Phelps et al. (2012). Furthermore, all networks also meet the definition of whole networks as defined by Raab and Kenis (2009) as they possess the necessary characteristics of being whole networks instead of serendipitous networks (e.g. consciously created to reach certain goals). An important aspect to be addressed is the fact that these networks do not have a fixed end date and can clearly be distinguished from temporary organizations. A partnership of all green educational institutions in the Netherlands publicly shows details about whole knowledge networks with respect to the goals, the outcomes, the resource munificence, the composition etcetera. By using these details, it was possible to generate a database including all networks and their specifications as published by this partnership.

A distinction can be made between ‘between sample strategy’ and ‘within sample strategy’. Regarding the ‘between sample strategy’, a convencience sampling strategy was applied. The CEO of the partnership of all green educational institutions in the Netherlands could identify all network managers in this context since 2007. Depending on the accessibility and approachability of these managers, they were included in the research sample. The ‘within sample strategy’ concerns the selection of individuals within the networks. Regarding the ‘within sample strategy’, a purposive sampling strategy was applied. Network integration is one of the core concepts in this study, and is composed of two network level dimensions (cohesion and centralization). Network managers are ought to have a better view on the network integration as compared to network members, and are therefore selected to fill in the survey. This line of reasoning also applies to the other two variables included in this research.

### 3.3. Data collection

Data collection took place among network managers of different networks in this context, thus network managers are the unit of observation in this study. The objective of the data collection was to check if the hypotheses could either be confirmed or not, so that the research question could be answered. To perform this research, two rounds of data collection were held.

First, three semi-structured interviews were held with network managers in order to gain insights into the concepts of cohesion, centralization, and network effectiveness. The interviews have been recorded on a voice-recorder to increase the research controllability afterwards. During the interviews, network managers were asked questions regarding their visions on the meaning of the core network concepts of this research. After these interviews took place, the interviews were transcribed and coded. The topic-list of the interviews is included in appendix I, whereas the transcripts of the coded interviews are included in appendix II. The analysis table of the coded interviews is included in appendix III. Each column in the analysis table stands for a different interview/respondent whereas each row stands for a different network concept. Relevant statements about the core network concepts were numbered in the interview transcripts, and placed in the appropriate box in the analysis table. By using this numbering system, statements could easily be traced back in the transcripts. The last column of the analysis table provides indicators for measuring the network concepts by summarizing and aggregating the statements of the respondents. In the end, on the basis of the analysis table it was possible to create a questionnaire, which was used in the second round of data collection.

The second round of data collection consisted of administering the questionnaire. After the application of the sampling strategies, the research sample existed of 86 whole knowledge network managers. As 35 network managers took the effort to fill in the questionnaire, the response rate was 41 percent, which was satisfactory.

### 3.4. Data analysis

As mentioned earlier, this research will perform QCA. Since there are different variants of QCA, a grounded decision had to be made regarding which kind of QCA to perform. The two main variants of QCA are crisp-set QCA (csQCA) and fuzzy-set QCA (fsQCA). These two variants differ in the type of sets on which they operate. csQCA operates exclusively on sets where cases can be either fully in (1) or fully out (0). For example, consider a set of males. A male receives a score of 1 on this set where a female receives a score of 0. It is impossible to get a score somewhere in between. fsQCA on the other hand, operates on sets where cases can be fully in (1), fully out (0), or somewhere in between the set (e.g. 0.5). For example, if a country receives a score of 0.7 in the set of democratic countries, this means that this country is more in than out of the set of democratic countries. Such a differentiation is useful for many, if not most social science concepts (Schneider & Wagemann, 2012). Differentiating by using fsQCA mitigates some of the problems that are concerned with csQCA. Clearly, most concepts can not be measured as dichotomies, therefore it is chosen to perform fsQCA rather than csQCA.

The software fsQCA (v2.5) was used to analyze the data. In order to analyze the observed data, all scores that are withdrawn in the research had to be converted to fuzzy-set scores. This was possible by using the arithmetic function 'calibrate' in fsQCA (2.5). In order to calibrate the raw scores to fuzzy-set scores, three threshold values had to be determined for each variable: full membership (1), full nonmembership (0), and a crossover point of maximum ambiguity regarding membership in the set. During the calibration, variables are rescaled using the crossover point as an anchor from which deviation scores are calculated, taking the values of full membership and full nonmembership as the upper and lower bounds (Fiss, 2011, p. 406-407). After calibrating, the scores on the variables ranged from 0 to 1.

Usually, the threshold points are determined by substantive knowledge on the matter rather than on the basis of the data. However, substantive knowledge was not available for determining the values of the threshold points for all variables included in this study. Therefore, threshold points for calibrating the raw scores to fuzzy-set scores for the variables cohesion, centralization, and network effectiveness are determined by the interpretation of the measurement scales. Threshold points for the variables size and resource munificence are determined by using substantive knowledge on all whole knowledge networks that are formed among green educational institutions in the Netherlands.

Next to the main fsQCA, it was also important to conduct several sensitivity analyses to examine whether the findings are robust to the use of alternative specifications of the variables (Fiss, 2011). The next section will explain how the score for each variable is measured and calibrated into fuzzy-sets.

### 3.5. Concept measurement

On the basis of the interview transcripts, an interview analysis table was created. This table is included in appendix III. This table shows the most relevant answers of the interviewees regarding the measurement of the core concepts. After this analysis table was completed, it was possible to operationalize all concepts that are withdrawn in this study. The operationalization table of the independent variables is included in appendix IV, whereas the operationalization of the dependent variable is included in appendix V. Resulting from the operationalization tables, a questionnaire was built in which all concepts are measured accurately due to the qualitative research that had been performed in the first round of data collection. The questionnaire is included in appendix VI. Scores for network integration (cohesion and centralization), size, resource munificence, and network effectiveness can be calculated on the basis of the results of the questionnaire. As this questionnaire is specifically developed for this study and not based upon earlier developed measurement scales, factor and reliability analyses have been performed. Prior to the factor analysis and reliability analysis, the scores on some variables were converted in order to make them more comprehensible and ready to analyze. Due to the QCA that is performed, threshold points had to be determined for each variable in order to calibrate the raw scores into useful scores for the analysis. Now, the measurement and calibration of each variable will be explained sequentially.

### 3.5.1. Dependent variable

As discussed earlier, network effectiveness was determined at the network level. As derived from the literature, network effectiveness determined at the network level is constructed of two dimensions: (1) availability to reach stated goals and (2) sustainability and viability. A principal component factor analysis with varimax rotation was performed to check if the theoretically based expectations on the existence of two dimensions were confirmed. All survey questions measuring network effectiveness were included in the factor analysis, showing a solution that (almost completely) confirms the initial assumption (see figure 3). The scree plot in figure 3 decreases steeply until the second factor, after which the graph takes a considerable less steep decline. This indicates that the concept network effectiveness may indeed be composed of two dimensions.

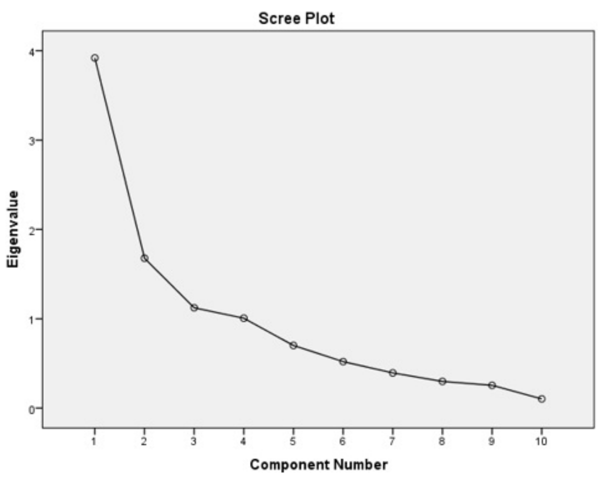

Figure 3. Scree plot of network effectiveness

After the first explorative factor analysis, a second factor analysis with a fixed number of factors (2 factors) was performed in order to verify to what extent the questions measuring network effectiveness cover both dimensions. Table 2 presents the rotated component matrix including the loads of the items on each factor.

| **Item / Component** | **1. Ability to reach stated goals** | **2. Sustainability and viability** |
|---|---|---|
| **SustSharing** | .246 | **.880** |
| **SustProjects** | -.004 | **.780** |
| **SustNetwork** | .068 | **.778** |
| **SustContact** | .312 | **.769** |
| **GoalsWorkfield** | **.160** | .647 |
| **GoalsUtOthers** | **.743** | .092 |
| **GoalsCollegues** | **.715** | .206 |
| **GoalsTeam** | **.713** | .088 |
| **GoalsUtMe** | **.656** | .256 |
| **GoalsAchieved** | **.533** | .032 |

Table 2. Rotated component matrix

The expectation beforehand was that the first four items (SustSharing until SustContact) constituded the dimension ‘ability to reach stated goals’ and that the last six items (GoalsWorkfield until GoalsAchieved) constituted the dimension ‘sustainability and viability’. The rotated component matrix (almost completely) confirms the initial idea. Item 5, GoalsWorkfield, is the only item that loads more on the other dimension than expected. This could be an indication that this item should be placed in the second dimension. However, this item is measured by the following statement: ‘during the project, knowledge was shared with the field of activity’. Therefore, it makes more sense to place this item in the first dimension, ability to reach stated goals, despite the outcome of the factor analysis.

The first dimension, availability to reach stated goals, was measured using six survey questions/statements on the extent to which the stated goals are reached. The statements concerned the topics knowledge sharing and utilization of the outcome. The answer to each statement was rated on a scale anchored by (1) strongly disagree, (2) disagree, (3) nor agree/nor disagree, (4) agree, and (5) strongly agree. The six statements were combined into one scale, showing a sufficient reliability (cronbach’s alpha = 0.703). The second dimension, sustainability and viability, was measured using four survey questions/statements on the extent to which there was still contact after completion of a project. The answer to each statement was rated on the same scale as the former dimension. The four statements were combined into one scale, showing a good reliability (cronbach's alpha = 0.850). At last, both dimensions measuring network effectiveness were combined into one scale measuring overall network effectiveness. A reliability analysis revealed a good reliability for the constructed scale (cronbach's alpha = 0.812).

Next, for the purpose of the fuzzy-set QCA, the raw scores on network effectiveness had to be converted to fuzzy-set membership scores. As discussed above, determining the threshold points for full membership, full nonmembership, and the crossover point of maximum ambiguity is the starting point. Substantive knowledge on network effectiveness measured by the above described scale was not available, and therefore threshold points had to be determined on the basis of the measurement scale. Anchor point '4' (agree) is determined to be the cross-over threshold point, as scores under this point do not (fully) agree on statements about the network being effective. Accordingly, anchor point '4.5' is chosen to be the threshold point for full membership and '3.5' represents the threshold point for full nonmembership. The next paragraph will elaborate on the measurement and calibration of the independent variables.

### 3.5.2. Independent variables

Cohesion was measured using four survey questions on the frequency of contact that took place in the network. The answer on each question was rated on a scale anchored by: (1) daily, (2) weekly, (3) monthly, and (4) less than once a month. The four questions were combined into one scale, showing a good reliability (cronbach's alpha = 0.802). Then, the final score for network cohesion had to be negated for the purpose of analyzing the results. Using the original scores, a (relatively) low score on cohesion (e.g. 1.5) implies a cohesive network. By negating the scores, a (relatively) high score on cohesion (e.g. 2.5) implies a cohesive network, which is convenient for further analysis. Negation is performed by the formula: new score = 4 – old score. Next, the threshold points for calibrating the raw scores to fuzzy-set scores were determined. A network is found to be cohesive if there is, on average, at least montly contact between the network participants. After negating the scores, anchor point '2' indicated a frequency of contact of once a month and is therefore set to be the crossover threshold point. Accordingly, anchor point '2.5' is chosen to be the threshold point for full membership and '1.5' represents the threshold point for full nonmembership.

Centralization was measured using nine survey questions/statements on who coordinated several key activities in the network. The nine key activities were determined on the basis of the interviews and were measured on a scale anchored by: (1) one party, (2) a (sub) group of parties, and (3) all parties together. The nine questions/statements were combined into one scale, also showing a good reliability (cronbach's alpha = 0.807). This scale was also negated for the purpose of further analysis. The negation was performed by the formula: new score = 3 – old score. Hence, a (relatively) high score on network centralization indicated a centralized network. A network was considered to have a centralized structure if, on average, coordination of activities was performed by a single party or by a (sub) group of parties. Anchor point '2' indicated that coordination was performed by a (sub) group of parties and was therefore set as the crossover threshold point. Accordingly, anchor point '2.5' was set as the threshold point for full membership and anchor point '1.5' was set as the threshold for full nonmembership.

Size is the number of organizations that participate in the network, and was measured by the question: 'What is the number of organizations that participated in the network?' The threshold points for size were determined on the basis of substantive knowledge on the features of all whole knowledge networks that are formed among green educational institutions in the Netherlands. As the mean size of such networks in the total population is 6.92, this number is set as the crossover threshold point. The standard deviation of the size of such networks is 3.27. The threshold points for full membership and full nonmembership were determined by adding and subtracting the standard deviation to the population mean, leading to a threshold point for full membership of 10.18 and a threshold point for full nonmembership of 3.65.

Resource munificence is the amount of money available to a network, and was measured by the question: 'What is the amount of money available to the network, funded by the KIGO-regulation?' The threshold points for resource munificence were also determined by substantive knowledge on the features of all whole knowledge networks that are formed among green educational institutions in the Netherlands. As the mean amount of funding in the total population is € 209.209,91, this amount is set as the crossover threshold point. The standard deviation of the amount of money available to the networks in the total population is € 116,140.95, leading to a threshold point of € 325,350.86 for full membership and a threshold point of € 93,068.96 for full nonmembership. Table 3 presents the above determined threshold points for all variables.

| | Full membership | Crossover point | Full nonmembership |
|---|---|---|---|
| **Cohesion** | 2.50 | 2.00 | 1.50 |
| **Centralization** | 2.50 | 2.00 | 1.50 |
| **Size** | 10.18 | 6.92 | 3.65 |
| **Resource Munificence** | 325 350.86 | 209209.91 | 93 068.96 |
| **Network Effectiveness** | 4.50 | 4.00 | 3.50 |

Table 3. Threshold points

# 4. Results

This section will present the results of the research in a structured manner. First, the descriptive statistics will be presented to interpret the data. Second, the actual fsQCA analysis is presented, including both complex and parsimonious solutions for both network effectiveness and network ineffectiveness. At last, the results of the sensitivity analyses are presented.

## 4.1. Descriptives

Some notable features will be discussed in this section. Table 4 presents the descriptive statistics for all measures included in this research. As can be derived from table 4, the measures regarding cohesion and centralization are distributed across almost the entire scales. Whereas the mean score on centralization approaches the scale mean, the mean score on cohesion clearly deviates from the scale mean. As mentioned in the section above, the mean size of the entire population of whole knowledge networks that are formed among green educational institutions in the Netherlands is 6.92. As the mean score of the sample is 10.12, this score also deviates from the predetermined threshold point. An important notion is that the minimum score for size should be at least 3 as, by definition, a network requires at least 3 participants. If the minimum score on size would have been lower than 3, the data would have been deleted for that case. Regarding resource munificence, the mean score in the sample is almost equal to the mean score in the population. Hence, regarding resource munificence, the research sample provides an accurate reflection of the population. An important notion is that one network included in the research sample had a very deviating value on the variable ‘Resource Munificence’. During the calculation of the descriptives, this network is not included in the calculation of the descriptives for ‘Resource Munificence’. It would have given a distorted image of the distribution of scores, which in turn would have major effects on the determination of the threshold points for the sensitivity analyses, which will be dealt with in a later stadium. Next, the minimum score for network effectiveness is 2.88 whereas the measurement scale ranges from 1 to 5, and the mean score for this variable is 3.88. This indicates that, on average, all network managers have rated their networks with relatively high scores for network effectiveness.

| | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| **Cohesion** | 34 | 1.00 | 3.50 | 1.93 | 0.62 |
| **Centralization** | 34 | 1.33 | 2.89 | 2.04 | 0.41 |
| **Size** | 34 | 3 | 25 | 10.12 | 6.71 |
| **Resource Munificence** | 31 | 19 111.40 | 700 000.00 | 206 333.99 | 150 267.53 |
| **Network Effectiveness** | 34 | 2.88 | 4.92 | 3.88 | 0.49 |
| ***** Correlation is significant at ≤ 0.05 | | | | | |

Table 4. Descriptives

Table 5 provides the correlations for all five measures included in this research. It is chosen to assess the correlation scores on the basis of the Spearman's Rho as outliers have less influence on this score as compared to the Pearson's R correlation scores. As presented in table 5, there are two variables that correlate significantly with the outcome network effectiveness: cohesion and size. According to Cohen (1988), correlation coefficients between 0.30 and 0.49 are considered as medium correlations. Hence, the relationships between cohesion and network effectiveness, and size and network effectiveness, show a medium positive correlation (rho = 0.40 and rho = 0.42, $p \leq 0.05$). This indicates that high levels of cohesion and high levels of size are associated with high levels of network effectiveness.

| Variable | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| **1. Cohesion** | X | X | X | X |
| **2. Centralization** | -0.02 | X | X | X |
| **3. Size** | 0.14 | 0.24 | X | X |
| **4. Resource Munificence** | -0.08 | -0.15 | 0.20 | X |
| **5. Network Effectiveness** | **0.40*** | -0.08 | **0.42*** | 0.01 |

Table 5. Correlations

### 4.2. Configurations for network effectiveness

After the threshold points for each variable were determined, fuzzy-set membership scores were calibrated using the arithmetic function 'calibrate' in fsQCA (2.5). Table 8 provides the membership scores that are generated by fsQCA for each case on each variable. For example: a membership score of 0.82 on cohesion (see case 5) means that this specific network is more in than out of the set 'cohesive networks'. The crossover threshold point for cohesion was determined at 2.00, and the threshold point for full membership was determined at 2.50. As case 5 has a membership score of 0.82 on cohesion, the raw score of case 5 on cohesion is somewhere in between 2.00 and 2.50.

| Network | Cohesion | Centralization | Size | Resource Munificence | Network Effectiveness |
|---|---|---|---|---|---|
| **1** | 0.19 | 0.51 | 0.87 | 0.06 | 0.39 |
| **2** | 0.99 | 0.8 | 0.99 | 0.98 | 0.98 |
| **3** | 1 | 0.51 | 1 | 0.18 | 1 |
| **4** | 0.19 | 0.12 | 0.94 | 0.07 | 0.28 |
| **5** | 0.82 | 0.99 | 1 | 0.03 | 0.33 |
| **6** | 0.01 | 0.8 | 0.3 | ? | 0 |
| **7** | 0.05 | 0.02 | 0.15 | 0.1 | 0.33 |
| **8** | 0.95 | 0.94 | 0.15 | 0.22 | 0.03 |
| **9** | 0.51 | 0.8 | 0.99 | 1 | 0.51 |
| **10** | 0.82 | 0.12 | 0.03 | 0.44 | 0.01 |
| **11** | 0.01 | 0.51 | 0.73 | 0.96 | 0.01 |
| **12** | 0.01 | 0.02 | 0.3 | 0.74 | 0.01 |
| **13** | 0.95 | 0.03 | 0.52 | 0.95 | 0.58 |
| **14** | 0.51 | 0.8 | 1 | 0.14 | 0.78 |
| **15** | 0 | 0.67 | 0.03 | 0.01 | 0.33 |
| **16** | 0.05 | 0.99 | 0.3 | 0.32 | 0.33 |
| **17** | 0.99 | 0.51 | 0.03 | 0.03 | 0.51 |
| **18** | 0.82 | 0.67 | 1 | 0.99 | 0.78 |
| **19** | 0.01 | 0.07 | 0.94 | 0.44 | 0.06 |
| **20** | 0.19 | 0.94 | 0.52 | 0.18 | 0.33 |
| **21** | 0.19 | 0.51 | 0.94 | ? | 0.63 |
| **22** | 0 | 0.12 | 0.06 | 0.89 | 1 |
| **23** | 0.19 | 0.21 | 0.99 | 0.99 | 0.69 |
| **24** | 0.01 | 0.88 | 0.99 | 0.22 | 0.01 |
| **25** | 0.19 | 0.67 | 1 | 0.06 | 0.96 |
| **26** | 0.05 | 0.97 | 0.73 | 0.06 | 0.23 |
| **27** | 0.19 | 0.88 | 1 | 1 | 0.19 |
| **28** | 0.99 | 0.51 | 0.06 | 0.74 | 0.39 |
| **29** | 0.05 | 0.99 | 0.15 | 0.22 | 0.01 |
| **30** | 0.51 | 0.51 | 0.3 | 0.01 | 0.95 |
| **31** | 0.19 | 0.07 | 1 | 1 | 0.45 |
| **32** | 0.51 | 0.51 | 0.15 | 0.44 | 0.05 |
| **33** | 1 | 0.51 | 1 | 0.07 | 0.88 |
| **34** | 0.95 | 0.03 | 0.03 | 0.01 | 0.01 |

Table 8. Membership scores

After all membership scores were determined, the next step was to perform a necessity and a sufficiency test for each factor separately. A variable is a necessary condition for the outcome if all networks in which the outcome is present (membership > 0.5), the condition is also present (membership > 0.5). In other words; each case's fuzzy-set membership score in variable X must be equal to or greater than its fuzzy-set membership in oucome Y (Schneider & Wagemann, 2012, p.75) Thus, when displaying this graphically in a XY-plot, all networks fall below or onto the main diagonal. Then, in set-theoretic terms, one could say that X is a superset of Y.

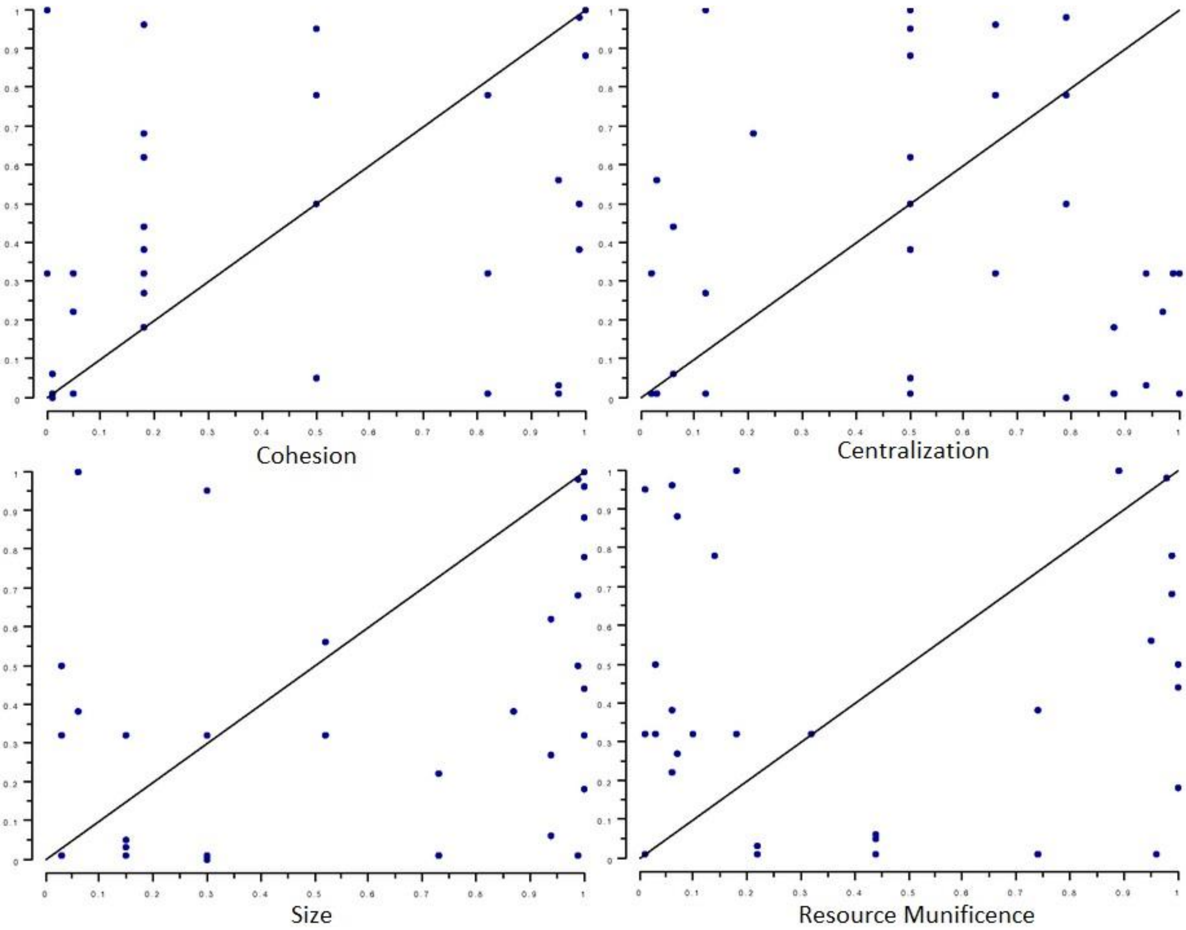


Figure 4. XY-plots

A variable is a sufficient condition for the outcome if all networks in which the condition is present, the outcome is also present. In other words: each case's fuzzy-set membership score in X must be equal to or smaller than its fuzzy-set membership in Y (Schneider & Wagemann, 2012, p.67). Thus, when displaying this graphically in a XY-plot, all networks fall above or onto the main diagonal. Then, in set-theoretic terms, one could say that X is a subset of Y. Figure 4 shows that none of the four independent variables individually were either necessary or sufficient conditions for the outcome 'Network effectiveness'. Therefore, following the configurational approach, the next step was to look at configurations of conditions.

Using the fuzzy truth table algorithm available in fsQCA (v.2.5), a truth table was drawn up. The number of rows in a truth table is based on the formula $2^k$ where 'k' stands for the number of independent variables. In this case, the truth table consists of $2^4$ = 16 rows. Each row represents a possible combination or configuration of variables. It is highly unlikely that all possible combinations of variables are empirically observed, especially when the number of cases is relatively low. Naturally occurring social phenomena are profoundly limited in their diversity as the empirical world almost never presents all the logically possible combinations of causal conditions (Ragin, 2006). This is also the case in this research, as can be concluded from the truth table presented in table 9.

| Cohesion | Centralization | Size | Resource Munificence | Network Effectiveness | Nr. of cases |
|---|---|---|---|---|---|
| 1 | 0 | 0 | 1 | ? | 0 |
| 1 | 0 | 1 | 0 | ? | 0 |
| 1 | 0 | 1 | 1 | 1 | 1 |
| 1 | 1 | 0 | 1 | 0 | 1 |
| 1 | 0 | 0 | 0 | 0 | 2 |
| 1 | 1 | 1 | 1 | 1 | 3 |
| 1 | 1 | 0 | 0 | 0 | 4 |
| 1 | 1 | 1 | 0 | 1 | 4 |
| 0 | 1 | 0 | 1 | ? | 0 |
| 0 | 0 | 0 | 0 | 0 | 1 |
| 0 | 0 | 0 | 1 | 0 | 2 |
| 0 | 0 | 1 | 0 | 0 | 2 |
| 0 | 0 | 1 | 1 | 0 | 2 |
| 0 | 1 | 1 | 1 | 0 | 2 |
| 0 | 1 | 0 | 0 | 0 | 3 |
| 0 | 1 | 1 | 0 | 0 | 5 |

Table 9. Truth table

Three possible combinations of causes were not observed on the basis of the collected data. The three rows of the truth table with a '?' in the column 'Network Effectiveness', lack empirical cases and therefore the outcome can not be determined. Also, there are three rows in the truth table that are only observed by one case. It is important to set a frequency threshold in order to determine when to withdraw a row, or combination of causes, in the further analysis. According to Schneider and Wagemann (2012), the frequency threshold per row is usually set to at least one case for small- to medium-sized N studies (10-100 cases). As this study includes 34 cases, the frequency threshold is set to one case. After determining the frequency threshold, three possible configurations (rows) do not meet the frequency threshold. These truth table rows that do not meet the frequency threshold are called logical remainders, and make causal inference more difficult. By setting the frequency threshold to 1, only those cases that lack empirical instances are logical remainders.

To overcome the limitations of a lack of empirical instances, counterfactual analysis is a helpful tool (Ragin, 2008). The truth table algorithm provided by fsQCA ultimately presents three different solutions: the parsimonious, the complex, and the intermediate solution. The difference between these solutions is based on different counterfactuals. Counterfactuals refer to situations in which a redundant causal condition is *added to* (easy counterfactual) or *removed from* (difficult counterfactual) a set of causal conditions that by themselves already lead to the outcome in question. Mostly, theoretical or substantive knowledge links the presence of a condition to the outcome instead of the absence of the condition. Therefore difficult counterfactuals are less certain. The difference between the three possible solutions presented by fsQCA is based on the use of these counterfactuals: the complex solution does not include counterfactual analysis, the parsimonious solution includes simplifying assumptions based on any counterfactual (easy and difficult), and the intermediate solution only includes simplyfing assumptions based on easy counterfactuals (Fiss, 2011). Counterfactual analysis is performed on the basis of logical remainders. The last step in the fsQCA analysis is to perform the truth table analysis. The complex solution of the analysis is composed of two configurations that lead to network effectiveness. The solution can be presented in the following formula:

$$Co \cdot Si \cdot (Ce + RM) \rightarrow E$$

The above formule should be interpreted as follows. Each abbreviation denotes a variable included in this research (Co = cohesion; Si = size; Ce = centralization; RM = resource munificence; E = network effectiveness). The symbol '·' denotes the logical operator 'and', the symbol '+' denotes the logical operator 'or', and the symbol '~' denotes the logical operator 'not'. Table 10 provides information regarding the consistency, coverage, and cutoff scores of the complex solution.

| Configuration | Raw Coverage | Unique Coverage | Consistency |
|---|---|---|---|
| **Co · Si · RM** | 0.339552 | 0.069403 | 0.934292 |
| **Co · Si · Ce** | 0.423134 | 0.152985 | 0.877709 |
| | | | |
| **Frequency cutoff** | | 1.000000 | |
| **Consistency cutoff** | | 0.803440 | |
| **Solution coverage** | | 0.492537 | |
| **Solution consistency** | | 0.888291 | |

Table 10. Complex solution of network effectiveness

Applying this knowledge, two pathways that lead to network effectiveness can be deduced from the solution formula. The first pathway shows that networks that combine high levels of cohesion with size (at least 6.92 network participants) and high levels of resource munificence will show high levels of network effectiveness. The second pathway shows that networks that combine high levels of cohesion with size (at least 6.92 network participants) and high levels of centralization will show high levels of network effectiveness.

Two important outcomes are the solution consistency and the solution coverage. Solution consistency "assessess the degree to which the cases sharing a given condition or combination of conditions agree in displaying the outcome in question" (Ragin, 2006, p.292). A solution is completely consistent if all cases with the same combinations of causes (configurations) lead to the same outcome. Configurations that lead to both the presence as the absence of the outcome (contradictory configurations) lower the solution consistency. In the case of this study, no contradictory configurations were found. As displayed in table 10, the solution consistency of the configuration leading to network effectiveness is 0.89, indicating a high solution consistency.

Solution coverage measures how much of the outcome is covered (or explained) by the solution (Ragin, 2006). "It is a measure of the fit of the model and the reliability of the results" (Raab et al., 2013, p. 22). As displayed in table 10, the coverage of the solution is 49 percent. The raw coverage scores indicate the percentage of cases that take a given path to the outcome, which makes it possible to evaluate the importance of different paths (Fiss, 2011). The solution coverage of 49 percent means that the combined solutions account for 49 percent of membership in the outcome network effectiveness. An important notion is that the lowest acceptable consistency cutoff for solutions is set at 0.80, which is above the minimum recommended threshold of 0.75 (Ragin, 2006, 2008).

The above presented configurations leading to network effectiveness are based upon the fsQCA analysis without counterfactual analysis, thus the complex solution is provided. This complex solution is reached without logical remainders, so configurations that are not empirically observed but can help to create a more parsimonious solution are excluded. As the truth table (table 9) shows, there are three logical remainders that can help to provide a more parsimonious solution. The parsimonious solution including all logical remainders can be presented in the following formula:

$$Co \cdot Si \rightarrow E$$

Only one pathway that leads to network effectiveness can be deduced from this formula. This pathway shows that networks that combine high levels of cohesion with size (at least 6.92

network participants) will show high levels of network effectiveness. As displayed in table 11, the solution consistency of the parsimonious solution is nearly the same as compared to the solution consistency of the complex solution. The solution coverage, however, is higher as compared to the solution coverage of the complex solution (57 percent). This is easily explained in set theoretic terms: the complex solution (Co · Si · Ce) is a subset of the parsimonious solution (Co · Si). There are more configurations possible with networks that show high levels of cohesion combined with size as compared to networks that show high levels of cohesion combined with size and high levels of centralization. As this research is testing a theoretical model that is established through empirical research in another context, there are no strong assumptions concerning the relationships between the variables in this context, based on either theory or substantive knowledge. Therefore, it is chosen to build on the solution without logical remainders, thus the complex solution.

| Configuration | Raw Coverage | Unique Coverage | Consistency |
|---|---|---|---|
| **Co · Si** | 0.561941 | 0.561941 | 0.886926 |
| | | | |
| **Frequency cutoff** | | 1.000000 | |
| **Consistency cutoff** | | 0.805897 | |
| **Solution coverage** | | 0.561941 | |
| **Solution consistency** | | 0.886926 | |

Table 11. Parsimonious solution of network effectiveness

### 4.3. Configurations for network ineffectiveness

Next to the fuzzy set analysis modeling the presence of network effectiveness, a second fuzzy set analysis was performed to model the presence of network ineffectiveness, from now on abbreviated as 'I'. When conducting regular standard regression analyses, this kind of analysis is always part of the process because of the symmetry that exists in regression models (Fiss, 2011). Different from standard regression analyses, the causality in configurations is mostly assymetric. This means that network ineffectiveness, may not simply be predicted by the opposite model of network effectiveness. Following the principles of a standard regression analysis, one would expect the following formula for network ineffectiveness:

$$\sim Co \cdot \sim Si \cdot (\sim Ce + \sim RM) \rightarrow I$$

However, as just mentioned, the causality in configurations is mostly assymetric. There are two ways in which this second analysis could have been performed. One way was to model for the absence of network effectiveness, thus for ~E. However, every network that was not regarded as being effective would have been withdrawn in this analysis. The second way was to model for the presence of network ineffectiveness, by determining new threshold points for network ineffectiveness. This way, only the least effective, and thus most ineffective networks of the sample were included in the analysis. From a practical point of view it is more interesting to look for pathways that lead to ineffective networks rather than to look for pathways that lead to 'not effective' networks, as the former reveals pathways to the most ineffective networks. If it is too hard to reach the pathways that lead to high levels of network effectiveness, it is possible for network managers to at least avoid pathways that lead to network ineffectiveness.

When analyzing the truth table displayed in table 9, it can be concluded that 25 percent of the networks withdrawn in this research can be regarded as effective networks, as 8 of the 32 analyzed networks score a '1' on network effectiveness. The threshold points for the analysis modeling the presence of network ineffectiveness were determined so that only the 25 percent least effective networks were regarded as being ineffective. The threshold points were determined on the basis of the first quartile (Q1) in the data, which splits of the lowest 25 percent of data from the highest 75 percent. This lead to a crossover threshold point for network ineffectiveness of 3.48, and threshold points for full- and nonmembership of respectively 2.99 and 3.97 (+/- standard deviation score of network effectiveness).

As expected, following from the assymetric understanding of causality in configurations, the analysis modeling network ineffectiveness did not result in the exact opposite as the analysis modeling network effectiveness. In contrast, the analysis modeling network ineffectiveness indicated no consistently identifiable solution. All configurations showed a consistency score for the solution below the lowest acceptable level of 0.75. Thus, there are many pathways that lead to network ineffectiveness, but they show no consistent pattern. These findings confirm the idea that the pathway(s) to network ineffectiveness are not the exact opposite of the pathway(s) to network effectiveness. This result complements the former results in that it suggests a picture of asymmetry. The table containing membership scores and the truth table are included in appendix VII.

### 4.4. Sensitivity analyses

Several sensitivity analyses were conducted to test the robustness of the findings to the use of alternative threshold points. Modifying the threshold points, especially the crossover threshold point, may lead to different results. In order to check if the results of this research also hold when other threshold points are determined, three other fsQCA analyses have been performed wherein other threshold points were determined.

The threshold points for the three sensitivity analyses were based on the sample data instead of substantive knowledge on the variables and were determined as follows: the crossover threshold points of the first sensitivity analysis were based on the mean sample score for each variable, and the threshold points for full- and nonmembership were determined by either adding or subtracting the standard deviation from the mean score. The crossover points of the second sensitivity analysis were also based on the mean sample score of each variable, but they were slightly modified. Regarding the mean scores for cohesion, centralization, and network effectiveness, 0.25 point was added to the score. Regarding the mean scores for size and resource munificence, the score was increased with 25 percent. The threshold points for full- and nonmembership were determined by adding and subtracting the standard deviation from the crossover point score. The crossover points for the third sensitivity analysis were determined in the same way as in the second sensitivity analysis, but this time 0.25 point was subtracted from the variables cohesion, centralization, and network effectiveness. The scores on resource munificence and size were decreased with 25 percent. The threshold points for full- and nonmembership were determined by adding and subtracting the standard deviation from the crossover point score. A table including all threshold points for the sensitivity analyses can be found in appendix VIII.

The results, consisting of the membership scores, truth tables, and solutions for all three sensitivity analyses have been included in appendix IX. As expected, differences in the solutions for network effectiveness occurred. However, all three results of the sensitivity analyses include the combination of high levels of cohesion combined with a minimum amount of network participants leading to high levels of network effectiveness (Co · Si). The number of solutions presented by each analysis differs, and only one analysis presents solutions in which low levels of cohesion combined with a maximum amount of members lead to high levels of network effectiveness. The thresholds determined in this analysis were the lowest of all analyses performed, and thus it is more likely that these threshold points do not accurately differentiate between belonging in to or out of a group. In this third analysis, 12 out of the 16 possible configurations were leading to effective networks, which in itself is a good reason to doubt the quality of this analysis.

By combining all the findings presented above, the results indicate that few configurations consistently lead to high levels of network effectiveness, and no configuration of cohesion, centralization, size, and resource munificence consistently leads to network ineffectiveness. Based on the above described finding, support for the hypotheses is as follows:

| | | |
|---|---|---|
| H1: | Cohesive integration is a necessary but not sufficient condition for network effectiveness. | Not Confirmed |
| H2: | Centralized integration is a necessary but not sufficient condition for network effectiveness. | Not confirmed |
| H3: | Size (a minimum amount of participants) is a necessary but not sufficient condition for network effectiveness. | Not Confirmed |
| H4: | Resource munificence is a necessary but not sufficient condition for network effectiveness. | Not confirmed |
| H5: | Networks that are cohesive, centrally integrated, have at least a minimum amount of participants, and have sufficient resources will be effective. | Partially confirmed. Two paths with three of the four factors. |

## 5. Conclusion

Research on interorganizational networks is conducted in multiple fields and with different levels of analysis. The public sector has been the most popular sector for conducting scientific research on the outcomes of networks. Such research was launched by Provan and Milward (1995), who conducted a research among service implementation networks to explore the factors that might play a role in achieving network effectiveness. Later, Turrini et al. (2010) expanded the model that was drawn up by Provan and Milward (1995) and presented a more comprehensive theoretical framework. Until now, research at the network level has not been able to examine how the different features of networks, and whole knowledge networks in particular, affect the effectiveness of whole knowledge networks. As knowledge networks are receiving more and more attention in current literature it is important to shift the current theories, and see to what extent they apply to knowledge networks. Therefore, this research was guided by the following research question:

*Which configurations of the features cohesion, centralization, size, and resource munificence will lead to effective whole knowledge networks?*

In order to answer the research question, this study examined 34 whole knowledge networks to determine the effects of cohesion, centralization, size, and resource munificence on network effectiveness. Five hypotheses were drawn up in a configurational format to serve as a guideline for this research. In these hypotheses, necessary conditions for network effectiveness were predicted. By combining the first four hypotheses, a fifth hypothesis emerged. This fifth hypothesis is specified as a sufficient pathway for network effectiveness.

Hypotheses 1-4, predicting the effect of either cohesion, centralization, size, or resource munificence on network effectiveness, are all not confirmed. Figure 4, presenting the XY-plots for all four independent variables, shows that none of the four independent variables are either necessary or sufficient conditions for network effectiveness as the dots on the graphs are equally distributed. Following from the configurational approach that is applied in this research, the next step was to look at combinations of factors that may influence network effectiveness. Hypothesis 5, combining the factors predicting network effectiveness, is partially confirmed. Two pathways to network effectiveness exist that contain three out of the four conditions included in this research. Both pathways leading to high levels of network effectiveness incorporate the conditions cohesion and size (at least a minimum amount of participants). Remarkably, these were also the only two factors that showed a positive significant correlation with network effectiveness. One pathway leading to high levels of network effectiveness incorporated high levels of resource munificence whereas the other pathway incorporated high levels of centralization.

Even though hypotheses 1-4 are not supported, single conditions may still play a role in achieving high levels of network effectiveness. This role, however, must always be seen in the light of the interplay with other conditions. Next to the evident roles of cohesion and size, centralization and resource munificence also play a role in achieving high levels of network effectiveness. As it seems, centralization and resource munificence are substitutable to each other to a certain extent. If a network is characterized by a low level of centralization, this network can still achieve a high level of network effectiveness if there is a sufficient amount of resources available. This can be interpreted in the following way: coordinating the activities of a network can be an expensive job if it is not performed efficiently. By performing this job in a centralized way, thus with a high level of network centralization, by assigning this job to a single network participant or a single group of network participants, the job of coordinating the activities within the network requires little resource munificence. On the other hand, when this job is not performed centrally, it requires more effort and thus more resources to perform this job properly. From a practical point of view this indicates that managers of whole knowledge networks with a low amount of funding have to make sure that the network is characterized by a high level of centralization in order to achieve a high level of network effectiveness.

By combining all findings, it is concluded that cohesion, centralization, size, and resource munificence are neither necessary nor sufficient conditions for effective whole knowledge networks. However, when looking at the interplay of these conditions by combining them, two sufficient pathways leading to network effectiveness exist. One pathway incorporates high levels of cohesion, at least a minimum amount of participants, and high levels of resource munificence. The second pathway incorporates high levels of cohesion, at least a minimum amount of participants, and high levels of centralization.

Fuzzy set QCA was used as a method to understand how different configurations of factors are relevant for the outcome network effectiveness. Executing a fuzzy set QCA allows for the analysis of causal asymmetry. The analysis of causal asymmetry showed that, indeed, the factors leading to network effectiveness are different as compared to the factors leading to network ineffectiveness. Regarding the analysis of network ineffectiveness, the findings show that there are many pathways that lead to network ineffectiveness, but there is no consistent pattern. In the end, the findings suggest that the conceptual model that is tested in this research, is only partially confirmed. None of the four conditions have been identified as necessary conditions for network effectiveness. However, when combining these conditions into configurations, two sufficient pathways to effective whole knowledge networks exist. Both pathways incorporate the conditions of (high levels of) cohesion and size (at least a minimum amount of participants), where centralization and resource munificence play an interchangeable role in the sufficient pathways to effective networks.

## 6. Discussion

It is clear that organizing in the form of a network is increasingly important for organizations nowadays (Raab & Kenis, 2009). As mentioned earlier, knowledge networks are especially important for knowledge sharing and knowledge creation. This research presents findings that show different pathways leading to effective whole knowledge networks. As mentioned before, different streams exist within the body of literature regarding network effectiveness. This section will therefore, firstly, relate the findings of this study to findings on service implementation network studies. Secondly, the findings of this study will be related to findings on serendipitous information diffusion network studies. Thirdly, the effect of size will be discussed. Fourthly, the findings of this research will be related to the actual data on the networks. Fifthly, attention will be payed to the asymmetry that is inherent to this type of research. Sixthly, the contribution of this study to the existing literature will be discussed. Seventhly, the limitations of this study will be discussed and recommendations for future research will be provided. At last, the practical implications of this research will be discussed.

### 6.1. Whole knowledge networks vs. Service implementation networks

As could be expected, there are differences between service implementation networks and whole knowledge networks in the pathways leading to effectiveness. This study found that a high level of cohesion is a necessary but not sufficient condition for high levels of network effectiveness. Raab et al. (2013) also included network integration in their study, and they found that the networks included in their study were dependent on centralized integration rather than 'density-based integration' or cohesion. They even found that a high level of cohesion was a sufficient predictor for network ineffectiveness. So, regarding cohesion, the results of Raab et al. (2013) contradict the results of this study. This difference can be explained by Phelps et al. (2012), who found that network density (cohesion) increases the rate, extent, and fidelity of information diffusion in knowledge networks. As whole knowledge networks are consciously created information diffusion networks, it makes sense to assume that increasing the rate, extent, and fidelity of information diffusion are more important activities in whole knowledge networks than in the service implementation networks studied by Raab et al. (2013). This can be explained by the different tasks that the different types of networks have. The service implementation network is funded by the government to deliver services to clients. The main task of a service implementation is to "manage programs that are lodged in public, private, and nonprofit organizations that actually deliver services to clients" (Provan and Milward, 2006, p. 12). Collaboration is critical in these networks as the networks are based on the joint production of services. The main task of an information diffusion network, however, is to share and create knowledge, by sharing information across governmental boundaries, in order to deal with a variety of ongoing and future problems. The finding that cohesion is a necessary but not sufficient condition for high levels of network effectiveness in information diffusion networks is thus comprehensible.

Another difference in the pathways leading to network effectiveness in those two different contexts is the role of network centralization. Whereas network centralization is a necessary condition for network effectiveness in service implementation networks, this is not the case for whole knowledge networks. Thus, the findings seem to correspond with current literature in that they show a positive effect of high levels of cohesion instead of centralization on network effectiveness in whole knowledge networks. This difference can also be explained by the nature of the different types of networks. In information diffusion networks, such as whole knowledge networks, a key network goal is to provide an answer to ongoing and future problems through knowledge sharing and knowledge creation. According to Provan and Milward (2006), the key management tasks of service implementation networks include encouraging cooperation, negotiating contracts, and planning network expansion. It is likely that these tasks are performed more efficiently when the network is characterized by a high level of centralization.

Next to the differences leading to effective networks, one similarity was found. Resource munificence, in both network contexts, can reduce or distort the negative effect of the absence of a factor that is required to reach network effectiveness. Whereas this research found that the negative effect of the absence of centralization can be reduced by the presence of resource munificence, Raab et al. (2013) found that the presence of resource munificence reduces the negative effect of the absence of NAO governance. Thus, it is confirmed by different studies that resource munificence is an important factor in the pathways leading to high levels of network effectiveness.

### 6.2. Whole knowledge networks vs. Serendipitous information diffusion networks

The main difference between whole knowledge networks and serendipitous information diffusion networks is the distinction between goal directedness and serendipity. Whereas whole knowledge networks are formed to achieve certain goals, serendipitous information diffusion networks evolve through random variation, selection and retention processes (Kilduff & Tsai, 2003). Research on the network effectiveness of serendipitous information diffusion networks is less common than research on the effectiveness of service implementation networks. It is therefore more difficult to compare existing literature and theories of serendipitous information diffusion networks with whole knowledge networks. Phelps et al. (2012) performed a meta-analysis on knowledge networks, which includes most relevant studies on this topic. One finding of the study by Phelps et al. (2012) is especially relevant for this study.

The finding of the study by Phelps et al. (2012) which is particularly relevant for this study is that cohesive network structures increase the rate and extent of information diffusion, which is especially important for knowledge networks. However, according to Lazer and Friedman (2007), dense or cohesive structures also reduce information diversity. Building on these arguments, Phelps et al. state that “while rapid information diffusion enhances network performance, declining information diversity reduces it” (p. 1133). These arguments indicate that in order to balance these opposing forces, networks in which cohesive groups of organizations maintain some ties with other cohesive groups of organizations are most likely to show high levels of network effectiveness. This finding can be translated in terms of cohesion and centralization: Phelps et al. (2012) found that the most effective way to structure serendipitous information diffusion networks is by integrating them through both cohesion and centralization. The current study on whole knowledge networks partially confirms this idea as one of the two pathways to network effectiveness was found in which high levels of cohesion were combined with high levels of centralization.

### 6.3. Size

The study on the effectiveness of public networks by Turrini et al. (2009) found that the number of members that join a network may have an influence on the effectiveness of the network. Literature, however, was not able to predict whether the effect of network size on network effectiveness would be either positive or negative for whole knowledge networks in particular. Most studies that researched the effect of network size on network effectiveness found a negative effect. For example, Hasnain-Wynia et al. (2003) found that the perceived network effectiveness declines as the number of network participants increases. The findings of this study, however, show that a minimum amount of network participants is required to achieve a high level of network effectiveness. Thus, it appears that a certain tension in the literature exist regarding the relationship between network size and network effectiveness. This relationship at least seems to vary according to the type of network under study.

However this research found that at least a minimum amount of network members is required in order to reach high levels of network effectivenss, it is not able to tell if the positive effect of an increasing number of network participants is infinite. Larger networks are usually characterized by a greater information diversity, which is an important factor in sharing and creating new knowledge. It may be the case that the positive effect of an increasing number of participants may diminish and eventually alter to a negative effect, indicating a curvilineair effect. Researchers found that this is the case for knowledge creation at the firm level

(Rothaermel & Alexandre, 2009; Wadhwa & Kotha, 2006). The rationale behind such an effect is that more actors complicate the coordination and achievement of agreement within networks. The costs of coordinating activities and achieving agreement within the networks can exceed their knowledge-creating benefits (Phelps, 2012). This argument may also apply to knowledge creation on the network level, implying that an increase in the number of network participants leads to an increase in the network's knowledge creation or effectiveness up to a certain point. At a certain point the costs of coordinating activities and achieving agreement within the network exceed the network's knowledge-creation benefits. From this point, an increase in the number of network participants will rather imply an increase in the costs of maintaining the network than an increase in the knowledge-creating benefits of the network.

The form of governance of the network may also play a role in the effect of network size on network effectiveness. Provan and Kenis (2008) identified three basic forms of network governance: shared governance, lead organization, and network administrative organization (NAO). In a network in which the governance is shared, every participating organization would interact with each other to govern the network. In a network characterized by a lead organization or a NAO, network governance regarding issues that are critical for overall network maintenance and survival occurs by one powerful organization (Provan & Kenis, 2008). It is likely that networks characterized by shared governance will show the highest level of network effectiveness when the number of participants is low. As the amount of participants in such networks increases, "shared governance becomes highly inefficient, with participants either ignoring critical network issues or spending large amounts of time trying to coordinate across 10, 20, or more organizations" (Provan & Kenis, 2008, p. 238). Networks characterized by a lead organization or a NAO are better able to accomodate more network participants as not all participants have to be directly involved in all network decisions (Provan & Kenis, 2008). Thus, in a network characterized by shared governance, an increase in the size of the network will ultimately lead to a decrease of network effectiveness. In networks characterized by a lead organization or a NAO, this is not necessarily the case as participants must no longer interact directly with each other. Instead, they can directly interact with the lead organization or the NAO for the purpose of coordinating the network (Provan & Kenis, 2008).

### 6.4. Association with network data

This section will link the results of this study to the actual data concerning the included whole knowledge networks by elaborating on the data regarding each independent variable. Firstly, networks were labeled as cohesive if the value for cohesiveness was at least '2.00'. When interpreting the data, it is concluded that only three effective networks do not meet the threshold point for cohesion. This means that 77 percent of the effective networks are labeled as cohesive. Regarding the networks that do not meet the thresholdpoint for network effectiveness, 29 percent does reach the threshold point for cohesion. These observations also confirm the findings of this research in that cohesion is not a sufficient nor necessary condition for network effectiveness.

Regarding network centralization, networks were determined to show high levels of centralization if the value was at least ‘2.00’. Following from the network data, 77 percent of all effective networks meet the threshold point for centralization. However, 5 of the 13 effective networks had a score of exactly ‘2.00’. This indicates that these networks belonged into the group of networks with high levels of centralization, but only just. If the threshold point for centralization was determined only slightly different, the results for network centralization could have changed significantly.

The threshold point for size was determined at ‘6.92’, which is practically equivalent to seven organizations. When looking at the networks under study, only three networks that show a high level of network effectiveness are composed of less than seven participating organizations. One of these three networks is composed of six organizations, which thus approaches the threshold point. Thus, most of the networks that show high levels of network effectiveness consist of at least seven participants (77%). Furthermore, almost half of the networks characterized by low levels of network effectiveness are composed of seven or more organisations (48%). This also confirms the finding of this study that size (at least a minimum amount of participants) is not a sufficient condition for network effectiveness but that it may be a condition in the sufficient pathways to network effectiveness.

At last, regarding resource munificence, the threshold point was set at € 209,209.91. About half of the networks that met the threshold point for resource munificence was effective, where the other half was not. Thus, there was no clear direct relation between resource munificence and network effectiveness. However, it was remarkable that all effective networks with a low budget combined this with high levels of centralization. This confirms the findings of the fsQCA.

### 6.5. Assymetry

The methodological approach of this research requires some attention. As mentioned by Fiss (2011), causal asymmetry is mostly neglected in typological theory and organizational research more broadly. Not taking this causal structure into consideration would have lead to an incomplete or incorrect answer to the research question. Next, most research on strategy and organization research more broadly mostly seems to imply either a linear or curvilinear relationship between the concepts withdrawn in the studies. As the findings of this research provide two different configurations leading to network effectiveness and no consistent configuration to network ineffectiveness, it is indicated that bearing the notion of asymmetry in mind may be essential in this kind of research. The fact that most other organization and network researchers have not taken this into account may even be responsible for the inconsistent empirical findings in current literature on the relationships between network features and network performance (Fiss, 2011).

One study that included the notion of asymmetry is performed by Raab et al. (2013). Whereas Raab et al. (2013) performed a qualitative comparative study in the context of public service implementation networks, this study demonstrates that the existence of different configurations of necessary conditions that lead to network effectiveness is also the case in the context of consciously created information diffusion networks, in this study referred to as whole knowledge networks. However, where Raab et al. (2013) found consistent pathways leading to network ineffectiveness, this research failed to address consistent pathways leading to ineffectiveness. The fact that this study was not able to address pathways leading to network ineffectiveness may be explained by the way in which networks were labeled as effective or ineffective. Raab et al. (2013) took the exact opposite of network effectiveness (~E), and labeled it as ineffective. By simply taking the exact opposite of network effectiveness, the study of Raab et al. (2013) was not able to look at the most ineffective networks. This study only included the 25 percent least effective networks, and labeled them as ineffective (~I). By doing so, it was possible to only investigate the effects of different conditions on network effectiveness for the most ineffective networks.

### 6.6. Contribution to the literature

As mentioned in the introduction of this research, this study contributes to the literature regarding interorganizational networks on (at least) two ways. Firstly, a theoretical model which is established trhough empirical research on public service implementation networks is tested against 34 whole knowledge networks in the Netherlands to ascertain how different configurations of variables affect the effectiveness of the network as a whole at the network level. The empirical model on the effectiveness of service implementation networks drawn up by Provan and Milward (1995) is slightly adapted for the purpose of this study. The findings by Provan and Milward (1995) on the service implementation networks are mainly not applicable to whole knowledge networks. Provan and Milward (1995) propose that “other things being equal, network effectiveness will be enhanced when the network is integrated, but only when integration is achieved through centralization of the network. Networks that are both centrally integrated, through a core agency, and decentrally integrated, through cohesive links among network members, will be less effective than networks that are predominately centralized” (p. 25). This study demonstrates that this finding is not applicable to whole knowledge networks as this study provides two pathways in which whole knowledge networks are most likely to be effective. No pathway to effectiveness exists in which high levels of centralization are combined with low levels of cohesion. In the end, this study mainly adjusted an empirical model that was established through research on service implementation networks, so that it is applicable to whole knowledge networks.

Secondly, by using a configurational approach and a relatively new analytical technique, Qualitative Comparative Analysis (QCA), the effect of different variables on network effectiveness are not examined in pure isolation but in combination with each other. Whereas more conventional analytical techniques tend to look at the effects of single factors on an outcome, QCA provides a possibility to deliver knowledge on the combined effects of key network and contextual characteristics (Raab et al., 2013). Thus, this research contributes to the literature regarding network effectiveness by identifying causal combinations that lead to effective whole knowledge networks. Furthermore, this research shows that it is possible to systematically conduct small and medium N comparative studies.

### 6.7. Limitations and recommendations

As this study provides clear results on the effects of network integration, network size, and resource munificence on network effectiveness, the results of this study have to be seen in the light of its limitations. One limitation concerns the theoretical foundation. Whereas Turrini et al. (2010) provided a more complete model towards network effectiveness, this research only included four independent variables to predict network effectiveness. It is to be expected that other factors than the four included in this study do also have influence on the effectiveness of whole knowledge networks. However, adding a new factor that may influence network effectiveness into the model of this research would increase the number of configurations exponentially. This would have led to a greater number of unobserved cases, and would not have contributed to the strength of this research. Expanding the current theoretical model can only be executed by including more cases into the study, which is recommended for future research.

A second limitation concerns the data collection. For example, cohesion was measured only by asking network managers for the frequency of contact that occurred in the network. It is expected that network managers have a better view on such matters than network participants, but it is still questionable whether or not network managers can correctly answer these questions as they may not be aware of all contact that has been taking place in their network. Although this may be regarded as a limitation, it can also be regarded as an approach that provides an answer to the need for generating larger N-studies in this field of study, as mentioned above. The concept of cohesion is operationalized in different ways across different studies. The way cohesion is operationalized in this study is determined by the possibilities of data gathering. As this study tries to make statements of whole knowledge networks on the network level, it would be best to collect the relevant data by questioning all participants of the whole knowledge network. However, due to time restraints, it was not possible to create a complete image of 34 networks by questioning all participants of the 34 whole knowledge networks. As considerations had to be made, and in order to collect data of 34 networks, it was chosen to assess the data on the networks through network managers. The problem that is inherent to this way of data collection is that network managers may be biased and are therefore not accurate in rating the different features of their network. In order to deal with this problem, it is tried to only include measures in the questionnaire that can accurately be answered by network managers.

Thirdly, three out of the five variables in this research were not precisely ratio variables. Regarding network effectiveness this means that a network with a score of 4 is not twice as effective as a network with a score of 2. Furthermore, as the network manager is mostly responsible for the network outcomes, it may be expected that this person would evaluate the effectiveness of his/her network rather high. By collecting qualitative data on how network managers interpret network effectiveness, is was possible to include multiple indicators based on substantive knowledge to measure network effectiveness. In the end, the data confirmed the expectation that network managers evaluate their network rather effective. In order to cope with this problem, the threshold points for network effectiveness were set relatively high. The measurement of network effectiveness may therefore also be seen as an implication of this research. Network effectiveness was measured at the network level as Provan and Milward (2001) addressed that measuring at the network level improves the evaluation of network effectiveness. Other possibilities were to measure network effectiveness at the client level or overall community level. Measuring network effectiveness at the community level may improve the evaluation of network effectiveness as the networks under study ultimately serve the society as a whole by creating new knowledge and teaching methods. Therefore, in order to improve the measurement of network effectiveness, future researchers may shift the focus of network effectiveness from the network level to the community level.

A fourth limitation has to do with the methodological approach of this research. As mentioned earlier, the configurational approach has its advantages over the conventional approaches to scientific research. The use of the fsQCA was necessary to conduct this type of research, although there are some things that have to be taken into account. Determining the threshold points in QCA is of crucial importance, as it implies making a decision between belonging in or out of a group for every variable in every case. Even though fsQCA allows a variable to have any continuous value from 0 to 1, the crossover threshold point for each variable codes the variable somewhat like a binary variable. Rihoux and Ragin (2009) argue that there is always room for discussion about the determination of the values of the threshold points. This can thus be seen as an unavoidable limitation inherent to (any form of) QCA. The sensitivity analyses performed in this study showed different results for different threshold points. Therefore, determining inaccurate threshold points will lead to the wrong conclusion. However, as this approach also offers new perspectives on scientific research, future researchers may be able to explain the inconsistent empirical findings on network research in current literature by providing new or adapt existing network theories.

Fifthly, the findings of this research can hardly be generalized as only 34 cases were included in this research. The external validity can therefore be regarded as low (Yin, 2009). As this study is one of the first in its kind in this context, a high external validity is not the main goal of this study. Indicating that there are different pathways towards network effectiveness in the context of whole knowledge networks was more important, and the findings support this general idea. The generalizability of network studies in general can be increased with the help of future researchers. As it is hardly impossible to perform studies with a sufficient amount of networks to draw up generalizable conclusions, future researchers should compose uniform measurement models to enrich the study on networks and whole knowledge networks in particular. By creating and using such uniform measurement models, studies of different authors can ultimately be compared on the basis of meta-analyses. This may even be the most important and challenging recommendation in order to create a more solid base for future network researchers.

### 6.8. Practical implications

In addition to the theoretical findings that have been exposed on the basis of this research, this study also has practical implications for network managers. Generally, it is important for network managers to be aware of the fact that there are multiple ways of organizing a network in such a way that will most likely lead to a high level of network effectiveness. Hence, derived from the presented results, network managers have to keep the following things in mind when trying to organize effective networks.

As is apparent from the interviews with network managers, it is clear that the size of a network and its resource munificence are largely determined in the early stage of the network. Potential network participants are informed about the objectives of the network during this stadium. As this research demonstrates, the two pathways leading to effective networks contain a minimum amount of network participants. Therefore, when forming a network it is important for the network manager to get at least seven organisations excited about the network and its goals, so that the network will ultimately consist of at least seven participating organizations. Program days, as they are mentioned by an interviewee, may serve as the most important place to enthuse and excite potential network participants about the network goals.

Another important activity in the beginning stadium of a network is that the network manager has to make sure that sufficient funding will be available to the network. This research proposes that a minimum amount of funding will help to reach high levels of network effectiveness. If a network manager is not able to collect sufficient funding for the network, the manager has to pay special attention to the centralization of the network during and after its formation. It is showed that an insufficient amount of funding can be substituted by high levels of centralization. In other words: when a network receives an insufficient amount of funding, it is important for network managers to make sure that the network key activities are either coordinated by a single actor or by a group of actors in the network, but not by all network participants together. An explanation for this may be that collectively coordinating the activities in the network causes inefficiency.

At last, to reach high levels of network effectiveness, network managers must create high levels of cohesion in their network by ensuring a high frequency of contact among network participants, so that the information available in the network can flow through the different actors.

In the end, this research is proposes two pathways for whole knowledge networks that lead to high levels of effectiveness. However, as is the case with most network studies, the results and conclusions heavily depend upon the tasks and environment that a network is dealing with. Therefore, the results and conclusions of this study are only applicable to, and can only be of value to network managers of whole knowledge networks and not to managers of any other type of network.

## 7. References


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