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An investigation of the mediating effects of network externalities on the relationships between perceived innovation attributes and the intention to adopt an innovation

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Eindhoven, August 2008

**An investigation of the Mediating Effects of
Network Externalities on the relationships
between Perceived Innovation Attributes
and the Intention to Adopt an Innovation**

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in partial fulfilment of the requirements for the degree of

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in Innovation Management**

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Mark Wouters
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Summary

Background

Predicting or explaining the adoption of innovations has been an important research topic for many years. From the literature it becomes clear that it is important that a firm understands the factors that influence adoption and use decisions of potential customers in order to launch an innovation successfully (e.g. Van Slyke et al., 2007; Rogers, 2003; Frambach & Schillewaert, 2002; Majumdar & Venkataraman, 1998). Two well-known research streams that focus on factors that influence the adoption decisions of potential adopters are the “Diffusion of Innovations (DOI)” literature and the “Network Externalities” literature. According to the diffusion of innovations literature several innovation characteristics, as perceived by (potential) adopters, help in explaining the differences in adoption-rates of innovations (Rogers, 2003). On the other hand, the literature regarding network externalities is concerned with the fact that the utility of many innovations is dependent on the number of other agents consuming the same product or technology (Katz & Shapiro, 1985). According to the literature, network externalities also influence adoption decisions of potential adopters, as is clearly phrased by Padmanabhan et al. (1997, p. 456): “The presence of network externalities implies that consumers’ adoption decisions and their willingness to pay for the product increase with the demand associated with a product”.

Research Question

Practically no empirical studies have been undertaken to examine the possibly existing relationships between (aspects of) network externalities and innovation attributes in explaining the adoption of innovations. An exception to this is the recent empirical study of Song et al. (in press) who investigated the adoption of DVD players in the United States. Song et al. (in press) propose that both Relative Advantage and Trialability will mediate the relationships between variables of network externalities (installed base and the availability of complementary goods) and the adoption of a product. The results only supported the mediating effect of Trialability between the number of complementary products (i.e. the number of DVD titles) and the adoption of an innovation (in this case a DVD player). Although not hypothesized, additional tests were done to investigate possibly significant effects of network externality variables on Complexity, Observability and Compatibility. However, none of these relationships was found to be positive and significant. Therefore, the question that rises is whether the proposed relationships between perceptions of innovation attributes and (variables of) network externalities represent the right direction. To our knowledge no empirical study exists that examines possibly mediating effects of (variables of) network externalities between perceptions of innovation attributes and the adoption, or the intention to adopt, an innovation. In this paper we proposed that perceptions of innovation attributes may play an important role in determining the rate of network externality effects by influencing the installed base of the innovation and the number of complementary goods and services available. By means of this study we have tried to answer the following research question: *Do network externalities (direct and indirect) mediate the relationships between perceptions of innovation attributes and the intention to adopt an innovation?*

Conceptual Model and Methodology

Based on the “Diffusion of Innovations” literature, the “Network Externalities” literature, and the Theory of Reasoned Action, a conceptual model has been proposed in which the

relationships between different innovation characteristics (Relative Advantage, Image, Observability, Trialability, Complexity and Compatibility) and the Intention to Adopt an innovation are mediated by Network Externalities. Both Direct Network Externalities and Indirect Network Externalities were expected to play a mediating role.

A survey regarding the adoption of car navigation systems has been used to gather the data needed to test the conceptual model. In the autumn of 2007 the survey has been carried out by master students who were enrolled in the master course 'New Product Development' at the Eindhoven University of Technology. The final sample consisted of 452 Dutch citizens who had not (yet) adopted a car navigation system at the time of filling in the questionnaire. LISREL 8.54 has been used to estimate the full (structural equation) model.

Main Findings

Based on the estimation of the full model by means of LISREL 8.54 two main conclusions can be drawn. At the first place it seems to be that perceptions of innovation attributes indeed are important determinants of network externality effects. The results show that Relative Advantage, Compatibility, Image and Complexity determine both the rate of direct network externality effects as well as the rate of indirect network externality effects, while Observability only acts as a determinant of indirect network externalities. Surprisingly, the results show that Complexity and Relative Advantage have a positive influence on the rate of direct network externalities, while both factors influence the rate of indirect network externalities in a negative way. Secondly, the results indicate that direct network externalities fully mediate the effects of Relative Advantage, Image and Complexity on the intention to adopt a car navigation system and partially mediate the relationship between Compatibility and intention to adopt. No support was found for a mediating effect of indirect network externalities.

Theoretical and Managerial Implications

This study has some important theoretical implications. First, the results of this study show that perceptions of innovation attributes indeed play an important role in shaping an innovation's network externality effects. Secondly, our research shows that direct network externalities can play an important mediating role between perceptions of innovation attributes and the intention to adopt an innovation. These are two important theoretical contributions as (to our knowledge) prior research has never investigated the possibility that network externality effects may mediate the relationships between perceptions of innovation attributes and the intention to adopt an innovation. This provides further evidence for the suggestion that the "Network Externalities" literature and the "Diffusion of Innovations" literature complement each other in explaining adoption decisions regarding (network externality) innovations. Even more important is the contribution of this study to the Marketing (and New Product Development) literature, as this study adds to an increased understanding of the mechanisms that influence the adoption decisions regarding innovations with network externalities. This is an important contribution because a better understanding of the mechanisms that influence adoption decisions regarding (network externality) innovations also means that one will be better able to predict the adoption of such innovations. Being able to predict the adoption of an innovation in an early stadium of the development process, by having knowledge of the factors and mechanisms that influence the adoption(-rate) of that innovation, will importantly reduce the chance on an unexpected disappointing adoption-rate of the innovation. The sooner the adoption of an innovation can be predicted in an accurate way, the earlier in the development process one can

anticipate on the adoption process of that innovation. Finally, this study provides an important contribution to the “Network Externalities” literature by proposing (new) measurement scales to measure network externality effects. In contrast to previous research we did not focus on (perceptions) of installed base or (perceptions of) the availability of complementary goods and services as measures of network externalities. Instead, we have proposed measures that focus on the (perceived) value or utility derived from an innovation as a function of that innovation’s installed base and as a function of the availability of complementary products and services. These measures better represent network externalities as defined in literature.

Our study has also some managerial implications, although it has to be taken into account that the framework presented in this paper needs to be further validated by future (empirical) research. Managers can use the framework to determine how perceptions of innovation attributes influence network externality effects and the intention to adopt an innovation (via direct network externality effects). Furthermore, the finding of this study that perceptions of innovation attributes act as determinants of network externality effects has an economical implication for managers. As the utility (or value) of innovations with network externalities is dependent on the size of its user base managers will often use penetration pricing to maximize the installed base of an innovation (Mohr et al., 2005), which is needed to ‘start up’ network externality effects. Sometimes products are even given away for free in order to raise the user base of an innovation quickly. Taking into account the specific characteristics of an innovation and their influences on network externality effects during the design, production and promotion of an innovation may lower the need for extreme low prices or even giving away the products for free when the product is marketed. This means that money can be saved.

Limitations and Future Research

Despite the careful design and execution of this study there are several limitations that should be addressed in future research. At the first place the results of our study are based on a single innovation, namely the car navigation system. Future research should replicate this study for other innovations. Secondly, our full model includes several one-item and two-item constructs. Although this does not have to be a problem Hair et al. (2006, p. 783) mention that “good practice dictates a minimum of three items per factor”. Therefore, future research should replicate our research incorporating broader measurement scales in order to validate our findings. Another limitation of this study is the fact that actual adoption has not been measured. This means that a third future research direction might be to extend the current study by measuring actual adoption after a specified space of time, for example a year. An even more interesting future research direction would be to investigate how (i.e. where) our model fits into the whole “Theory of Reasoned Action model”. Fourthly, additional research is needed to the specific mechanisms through which perceptions of innovation attributes influence the rate of network externality effects. The question is which other mechanisms (than via installed base) may also explain the relationships between perceptions of innovation attributes and the rate of direct and indirect network externality effects. At last, our study did not take into account possible interrelationships between innovation attributes. It is important that future research takes into account possible relationships between innovation attributes.

Abbreviations

CA	Compatibility
CO	Complexity
DNE	Direct Network Externalities
DOI	Diffusion of Innovations
IM	Image
INE	Indirect Network Externalities
INT	Intention to Adopt / Intention to Purchase
OB	Observability
PIA	Perceptions of Innovation Attributes / Perceived Innovation Attributes
RA	Relative Advantage
TAM	Technology Acceptance Model
TRA	Theory of Reasoned Action
TR	Trialability

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Abstract

In this paper we examine how the research areas of “Network Externalities” and “Diffusion of Innovations” together explain the intention to adopt innovations. More specifically, we propose a conceptual framework in which both direct network externalities and indirect network externalities mediate the relationships between perceived innovation attributes and the intention to adopt an innovation. Based on a survey, regarding the adoption of car navigation systems, among 452 Dutch citizens the following conclusions can be drawn: (1) Perceptions of innovation attributes indeed seem to be important determinants of network externality effects. Relative Advantage, Compatibility, Image and Complexity determine both the rate of direct and indirect network externality effects, while Observability only acts as a determinant of indirect network externalities. Surprisingly, the results show that Complexity and Relative Advantage have a positive influence on the rate of direct network externalities, while both factors influence the rate of indirect network externalities in a negative way. (2) Direct network externalities mediate the effects of Relative Advantage, Image, Complexity and Compatibility on the intention to adopt a car navigation system. No support was found for a mediating effect of indirect network externalities between perceptions of innovation attributes and the intention to adopt a car navigation system. Both theoretical as well as managerial implications are discussed.

1. Introduction

Predicting or explaining the adoption of innovations has been an important research topic for many years. Knowing what factors explain the adoption(-rate) of innovations is crucial for innovating firms. A seemingly good idea for a new product or technology is no guarantee for success. Getting a new idea adopted is difficult and many innovations require a long time before they are widely adopted, even when the new idea exhibits obvious advantages (Rogers, 2003). According to Rogers (2003) this situation has resulted in the following common problem for many individuals and firms: How can the diffusion of an innovation be accelerated? Customized versus mass production, complex products¹ versus ‘simple’ products and a high introduction price versus a low introduction price (or even giving the product away for free) are all trade-offs that have to be made before an innovation is introduced to the market. These considerations and many others may influence the successful adoption of the innovation. However, the question that remains is: What are the crucial factors and what choices have to be made in order to speed up the adoption-rate? From the literature it becomes clear that it is important that a firm understands the factors that influence adoption and use decisions of potential customers in order to launch an

¹ “Innovation(s)” and “Product(s)” will be used interchangeably throughout this paper.

innovation successfully (e.g. Van Slyke et al., 2007; Rogers, 2003; Frambach & Schillewaert, 2002; Majumdar & Venkataraman, 1998).

Two well-known research streams that focus on factors that influence the adoption decisions of potential adopters are the research areas regarding “Diffusion of Innovations (DOI)” and “Network Externalities”. According to the diffusion of innovations literature several innovation characteristics, as perceived by (potential) adopters, help in explaining the differences in adoption-rates of innovations (Rogers, 2003). Several empirical studies have been carried out to investigate the relationships between different innovation attributes² and the adoption of innovations (e.g. Song et al., in press; Moore & Benbasat, 1991; Fliegel & Kivlin, 1966). On the other hand, the literature regarding network externalities is concerned with the fact that the utility of many innovations is dependent on the number of other agents consuming the same product or technology (Katz & Shapiro, 1985). According to the literature, network externalities also influence adoption decisions of potential adopters, as is clearly phrased by Padmanabhan et al. (1997, p. 456): “The presence of network externalities implies that consumers’ adoption decisions and their willingness to pay for the product increase with the demand associated with a product”. Empirical studies provide evidence for the existence of positive relationships between variables of network externalities (installed base and the availability of complementary products) and the adoption of innovations (e.g. Song et al., in press; Dranove & Gandal, 2003). A question that has not been addressed by empirical research, with the exception of the study of Song et al. (in press), is how these two research areas may be related to each other in explaining the adoption of (or the intention to adopt³) an innovation in the presence of network externalities. That is, in the presence of network externalities the adoption decisions of potential adopters will be influenced by both network externality effects and by their perceptions of different innovation attributes. This is supported by Song and Read (unpublished paper) who showed that their “DINAM” model, including variables from the network externalities literature AND the innovations literature, better predicts the adoption of DVD players as compared to a model that only includes network externality variables or variables from the innovations literature. However, in the “DINAM” model of Song and Read no possible relationships between the variables of both literature streams have been taken into account. Therefore, following the study of Song et al. (in press), we investigate the *relationships between perceptions of innovation attributes and network externality effects* and how they together explain the intention to adopt innovations. By means of this paper we try to increase the understanding of the mechanisms that influence adoption decisions regarding network externality innovations.

Two concrete gaps in literature will be addressed in this study. The first gap concerns the relationships between network externalities and perceptions of innovation attributes. As mentioned, practically no empirical studies have been undertaken to examine the possibly existing relationships between (aspects of) network externalities and innovation attributes in explaining the adoption of innovations. An exception to this is the recent empirical study of Song et al. (in press) who investigated the adoption of DVD players in the United States. Song et al. propose that both Relative Advantage and Trialability will mediate the relationships between variables of network externalities (installed base and the availability of complementary goods)

² “Innovation characteristics” and “Innovation attributes” will be used interchangeably throughout this paper.

³ The Theory of Reasoned Action “views *intention* to perform (or not to perform) a behavior as the immediate determinant of the action” (Ajzen & Fishbein, 1980, p. 5). This implies that actual adoption will be determined by a person’s intention to adopt.

and the adoption of a product. Contrary to the expectations the results only supported the mediating relationship of Trialability between the number of complementary products (i.e. the number of DVD titles) and the adoption of an innovation (in this case a DVD player). Although not hypothesized, additional tests were done to investigate possibly significant effects of network externality variables on Complexity, Observability and Compatibility. However, none of these relationships was found to be positive and significant. Therefore, the results of the study of Song et al. provide only minor support for the expectation that innovation attributes may act as mediators between variables of network externalities and innovation adoption.

Looking at the results of the study of Song et al. (in press) the question that rises is whether the proposed relationships between perceptions of innovation attributes and (variables of) network externalities represent the right direction. From a chronological point of view it can be questioned that an innovation's installed base and the availability of complementary products act as determinants of perceptions of innovation attributes. This means that first an installed base has to be build up, and/or a certain amount of complementary products have to be available, before perceptions of innovation attributes will become important in determining the adoption of innovations. Especially for innovations (with network externalities) that are at the beginning of the product life cycle this does not make sense. At the beginning of the product life cycle no large installed base will exist and the availability of complementary goods and services will be scarce most of the times. This means that (variables of) both types of network externality effects, (variables of) direct as well as indirect network externalities, can not play an important role in shaping a potential adopter's perceptions of innovation attributes. That is, dependent on the innovation, direct and/or indirect network externality effects still have to be 'activated'. In contrast, potential adopters may already have certain perceptions about the characteristics of an innovation right from the launch of the innovation or even before. This means that, compared to network externality effects, perceptions of innovation attributes will influence adoption decisions regarding an innovation from an earlier point in time. Therefore, it might be interesting to investigate whether perceptions of innovation attributes act as determinants of network externality effects instead of the other way around. To our knowledge no empirical study exists that examines possibly mediating effects of (variables of) network externalities between perceptions of innovation attributes and the adoption, or the intention to adopt, an innovation.

The second gap in literature addressed in this study concerns the measurement of network externalities. In general it is stated that network externalities are present when the value or utility of a product increases as a function of a product's user base (installed base) and/or as a function of the availability of complementary goods and services (e.g. Farrell & Saloner, 1985; Katz & Shapiro, 1985). However, measurements used in previous studies, in which network externalities are linked to the adoption (or sales) of innovations, only focus on one aspect of network externalities, namely (perceptions of) installed base when talking about direct network externalities and (perceptions of) the availability of complementary products in case of indirect network externalities: e.g. Song et al. (in press) use the change in perceptions of installed base and the change in the number of DVD-titles available in local rental stores as predictors of DVD player adoption; Berndt et al. (2003) use past sales of Antiulcer drugs as determinant of change in sales of this type of drugs; Dranove and Gandal (2003) use the percentage of US box-office top 100 films released on DVD format as a determinant of DVD player sales, and Inceoglu and Park (2003) use the cumulative number of DVD titles (all DVD's) and movie titles as determinants of DVD player sales. An important aspect of network externalities that is not measured in these and other previous studies is whether potential adopters actually perceive a

higher value or utility from an innovation because of a larger installed base and/or a greater availability of complementary goods. This means that the value or utility aspect of network externalities seems to be underexposed in the final measurements used. This is a bit puzzling as network externalities will only be 'effective' when they are also recognized as such by potential adopters. Because of a lack of this (perceived) value/utility-measurement none of the previous studies can provide 'hard' support for the statement that the increase in adoption or sales of network externality innovations indeed is attributable to a higher value or utility derived from the product by potential adopters. Therefore, no clear conclusions can be drawn about the effect that network externalities, as defined in literature, may have on the adoption of, or the intention to adopt, an innovation.

In this study we address both gaps in literature as described above. The first gap, the 'mediating-gap', will be dealt with by proposing a model in which network externality effects (direct and indirect) mediate the relationships between perceptions of innovation attributes and the intention to adopt an innovation. That is, we propose that perceptions of innovation attributes may play an important role in determining the rate of network externality effects by influencing the installed base of the innovation and the number of complementary goods and/or services available (via installed base). The second gap will be dealt with by proposing newly developed measurement scales for both direct network externalities as well as indirect network externalities. In our survey respondents (i.e. potential adopters) were asked whether they are prepared to pay more for the innovation under study when more people own the same innovation (larger installed base) and whether the innovation under study becomes more valuable to them when more complementary goods are available. As becomes clear, these measures do not only focus on (perceptions of) installed base and (perceptions of) the availability of complementary products, as previous research has done. Instead, these measures also take into account the utility or value aspect of network externalities and therefore better represent network externalities as defined in literature.

This study especially contributes to the Marketing (and New Product Development) literature by adding to an increased understanding of the mechanisms that influence the adoption decisions regarding innovations with network externalities. This is an important contribution because a better understanding of such mechanisms means that one will also be better able to predict the adoption of such innovations. On its turn, the more accurate and the sooner in the development process one is able to predict the adoption of an innovation, the better one will be able to adapt the product development process in such a way that the adoption-rate of the innovation is maximized. That is, being able to predict the adoption of an innovation in an early stadium of the development process, by having knowledge of the factors and mechanisms that influence the adoption(-rate) of that innovation, will importantly reduce the chance on an unexpected disappointing adoption-rate of the innovation.

The conceptual model that will be presented in this paper is tested with the help of data that has been gathered by means of a survey. The survey, carried out in the autumn of 2007 among Dutch citizens, focused on the intention of potential adopters to adopt a car navigation system. The car navigation system is a highly innovative product and its popularity has increased dramatically during the last couple of years. The basic-function of such a system is to direct car drivers to the desired place of destination by means of visual and oral instructions, although many systems also have the possibility to store (and to view/listen) photo's and music, for

example. Each car navigation system contains a certain amount of ‘fixed’ data or information. Examples of such information are road maps and predetermined points of interest, like addresses of hotels, amusement parks and gas stations. We typify this information as fixed or stable because it will not change (i.e. it will not be automatically updated) when the system is used in a car. Manual updates, like installing new software or road maps, are needed to adapt such data or information. Additionally, most car navigation systems can also receive real-time (or up-to-the minute) traffic information. However, this information can only be received via a special antenna, which most of the times is not a standard part of the basic car navigation system. With the help of such an antenna the car navigation system can receive information about for example traffic jams and free parking places. The system can use such information to recalculate a route in case of for example a traffic-jam or to direct the user to a free parking place. This means that ‘up-to-the minute traffic information’ extends the possibilities (functionalities) of a car navigation system. Therefore, also taking into account that in general the antenna needed to receive traffic information is not a standard part of a car navigation system, the availability of real-time traffic information is treated as a complementary good or service in this paper.

The remaining sections of this paper are organized as follows. Section two, the theoretical background section, reviews definitions and empirical research with regard to the research areas of “Network Externalities” and “Diffusion of Innovations” and shortly introduces the “Theory of Reasoned Action”. Next, in section three we will develop the conceptual model and the accompanying hypotheses. In section four the research methodology will be presented, followed by the results of the model estimation in section five. In the last section of this paper, section six, the main findings, theoretical and practical implications, and future research directions will be discussed.

2. Theoretical background

The present study focuses on two well-known research areas, namely the research areas of “Network Externalities” and “Diffusion of Innovations”. In the literature review below, including important definitions and main empirical findings, both research areas will be discussed in more detail. Besides, we will discuss shortly the Theory of Reasoned Action, which is important for our study in view of our outcome variable “Intention to Adopt”.

2.1 Network Externalities

Network externalities, also called positive consumption externalities, exist when “the utility that a user derives from consumption of the good increases with the number of other agents consuming the good” (Katz and Shapiro, 1985, p. 424). Katz and Shapiro (1985) mention several possible sources of positive consumption externalities: At the first place there may exist a direct physical effect in that the quality or utility of the product increases when more people or firms buy (and use) the product. Secondly, an indirect effect may exist because a larger installed base of the hardware will increase the amount and variety of the complementary software supplied. At last, the number of goods sold may influence the size and experience of the service network, which on its turn determines the quality and availability of service offered to the buyer after the product has been purchased. Higher availability of information for popular brands, the role of installed base as a signal of quality and bandwagon effects are mentioned by Katz and Shapiro (1985) as more ‘subtle’ sources of consumption externalities. In accordance with Katz and Shapiro, Farrell and Saloner (1985) talk about direct network externalities, which is comparable with the direct physical effect mentioned by Katz and Shapiro (1985), and a mediated effect, which is comparable to a combination of the second (indirect effect) and third (service network) source of positive consumption externalities mentioned by Katz and Shapiro (1985). Additionally Farrell and Saloner (1985) mention that compatibility may be beneficial because it may enhance price competition among sellers, and because it leads to a larger second-hand market

In line with Farrel and Saloner (1985) most researchers who have studied network externalities make a clear distinction between Direct Network Externalities and Indirect Network Externalities (e.g. Song et al., in press; Basu et al., 2003; Gupta et al., 1999; Shurmer, 1993). In general direct network externalities are defined in accordance with the direct physical effect as described by Katz and Shapiro (1985). That is, *the larger the installed base of a product, or the more users of a specific product, the larger the utility or value a user derives from that product* (e.g. Basu et al., 2003; Gupta et al., 1999; Gandal, 1995). The telephone for example is a product from which the utility is directly dependent on the number of other users who have joined the telephone network (Katz & Shapiro, 1985). In contrast, indirect network externalities mainly concern the availability of complementary products. Indirect network externalities exist when *the utility or value that a customer derives from a product is dependent on the availability of complementary goods and/or services* (e.g. Song et al., in press; Basu et al., 2003). A DVD player for example is useless without the availability of prerecorded movies, documentaries etc. Indirect network externalities are also called complementary network externalities (Gandal, 1995) or market-mediated network externalities (Gupta et al., 1999).

Many authors have empirically investigated network externalities. Although the concept of network externalities originates from the telecommunication industry (Kauffman et al., 2000), in which physical networks are of essential importance, previous empirical research activities have focused on many different product categories (or systems), like DVD players (Song et al., in press; Inceoglu & Park, 2003), CD-players (Basu et al., 2003), Digital television (Gupta et al., 1999), Electronic banking (Kauffman et al., 2000), Pharmaceuticals (Berndt et al., 2003) and Spreadsheet software (Brynjolfsson & Kemerer, 1996). Supportive evidence has been found for a positive relationship between a product's (expected) installed base and the adoption of, or demand for, a product or system (Song et al., in press; Berndt et al., 2003). The same holds for the availability of complementary products: The number of available complementary products (software) has been found to be positively related to the adoption of, or demand for, the hardware product (Song et al., in press; Dranove and Gandall, 2003; Inceolu & Park, 2003; Gupta et al., 1999). Song et al. (in press) conclude, based on a review of previous empirical investigations of network externalities, that in general previous studies have found a positive relationship between a product's installed base and product adoption in the presence of direct network externalities. In the presence of indirect network externalities in most studies also a positive relationship between the availability of complementary products and product adoption has been found (Song et al., in press). Furthermore, both a product's installed base and the availability of complementary product have been found to be positively related to the price of a product. For example, a product's installed base has been found to be positively related to the price of CD-players (Basu et al., 2003), while the price of spreadsheet software has been found to increase when more products are sold (Brynjolfsson & Kemerer, 1996). Besides, Chakravarty (2003) found that customers are willing to pay a higher price for a product when they expect that the product will also be bought by 'later' buyers or when there already exists an installed base.

2.2 Diffusion of Innovations

In his book "Diffusion of Innovations" Rogers (2003, p. 15) mentions that "the characteristics of innovations, as perceived by individuals, help to explain their different rates of adoption". The author discusses five innovation characteristics and their influence on the rate of adoption of an innovation. These five innovation characteristics are called Relative Advantage, Compatibility, Complexity, Trialability and Observability (Rogers, 2003). According to Rogers all these characteristics have a positive effect on the rate of adoption of an innovation, with the exception of Complexity, which has a detrimental effect on the rate of adoption.

In general, other authors agree with the model of Rogers (2003) consisting of the five different innovation characteristics as described above. However, some changes or adaptations have been proposed. The proposed changes are clearly incorporated in the paper of Moore and Benbasat (1991), who developed an instrument "intended to be a tool for the study of the initial adoption and eventual diffusion of IT innovations within organizations" (Moore & Benbasat, 1991, p. 192). In the final measurement instrument of Moore and Benbasat (1991) Image is included as a separate construct instead of being an aspect of Relative Advantage, while Observability has been split up in Result demonstrability and Visibility.

Several authors have empirically examined the influence of innovation characteristics or innovation attributes on the adoption of innovations. Although authors like Rogers (2003) and Moore and Benbasat (1991) mention multiple innovation characteristics as important determinants of (the rate of) innovation adoption, empirical results show differences in both the

number and types of innovation characteristics that have been found to be significantly related to the adoption of innovations or the intention to adopt innovations, as has also been recognized by Holak (1988, p. 53): “the significance and relative impact of the product dimensions [as predictors of adoption behavior] differ across studies”.

An early study that links innovation attributes to the adoption of innovations is the study done by Fliegel and Kivlin (1966) regarding the adoption of modern farm practices by dairy firms. Later on, several empirical studies followed. For example, Holak (1988), using a sample of 19 technology intensive durable products (categorized as photographic, entertainment, kitchen appliance and electronic innovations), has investigated the influence of innovation attributes on the intention to purchase an innovation. Furthermore, Moore and Benbasat (1991) tested their measurement scales on their ability to discriminate between adopters and non-adopters of personal work stations, while He et al. (2006) used the five innovation attributes as defined by Rogers to investigate the adoption of online e-payment by Chinese companies. In the recent mediator-study of Song et al. (in press) all five innovation attributes were included as determinants of the adoption of DVD players in the U.S. At last, Handfield and Pagell (1995) and Hargadon and Douglas (2001) incorporated the diffusion of innovations ‘theory’ in a more descriptive type of study. Handfield and Pagell (1995), who investigated the slow adoption rate of U.S. flexible manufacturing systems, show in their study that the manufacturers of these systems have ignored the five innovation attributes as defined by Rogers. In contrast, the study of Hargadon and Douglas (2001) shows how the innovation attributes regarding Edison’s electric light may have contributed to the successful adoption of the system.

In this study we will focus on the five characteristics as defined by Rogers (2003), extended with a sixth characteristic, namely Image. The five innovation characteristics proposed by Rogers (Relative Advantage, Compatibility, Trialability, Observability and Complexity) are used because they represent the main innovation attributes of innovations for most (potential) adopters (Rogers, 2003). These five innovation attributes have been validated by a broad range of empirical studies. Although Image is not included as a separate innovation characteristic in his framework, Rogers (2003) clearly emphasizes the importance of status aspects of an innovation, as part of Relative Advantage. Rogers (2003) mentions that gaining social status is one of the motivations for many individuals to adopt an innovation. For some innovations social prestige can even be almost the sole benefit that adopters receive from the innovation (Rogers, 2003). Therefore, following Moore and Benbasat (1991), we will use Image as a sixth innovation characteristic in our study.

2.3 Theory of Reasoned Action

In this study we are not directly interested in the actual adoption of innovations. Instead we will focus on the intention of potential adopters to adopt (or to purchase) an innovation⁴. Intention is one of the core variables in the Theory of Reasoned Action (TRA) as well as in the Technology Acceptance Model (TAM), which is an adaptation of TRA indented to model the user acceptance of information systems (Davis et al., 1989). According to the Theory of Reasoned Action the performance of a behavior is determined by the intention to perform that behavior (Van Slyke et al., 2007; Davis et al., 1989): i.e. TRA “views a person’s *intention* to perform (or to not perform) a behavior as the immediate determinant of the action” (Ajzen & Fishbein, 1980, p. 5). When we apply this to our study this would imply that the actual adoption

⁴ “Intention to adopt” and “Intention to purchase” will be used interchangeably throughout this paper.

of an innovation will be preceded by a heightened intention to adopt. Of course there will be some exceptions to this reasoning. For instance, an impulse purchase will not be preceded by a clearly increase in intention to purchase (or the heightened intention and the actual adoption will act upon each other in a very short period of time). However, such purchases will determine only a small part of the adoption of most (consumer) products. Therefore, we expect that (in general) actual adoption of an innovation will take place via a heightened intention to adopt.

According to TRA the intention to perform a specific behavior is determined by the Attitude toward the behavior and subjective norm (Ajzen & Fishbein, 1980). On its turn Attitude toward the behavior is determined by a person's beliefs about, and evaluation of, the outcomes of performing the behavior (Ajzen & Fishbein, 1980). Subjective norm is determined by a person's beliefs that specific individuals or groups think that he or she should perform that behavior (or not) and his or her motivation to comply with these referents (Ajzen & Fishbein, 1980). Unfortunately, it is not possible to incorporate all these aspects of the Theory of Reasoned Action in our conceptual model. Instead, in this study we will investigate the direct influence that perceptions of (i.e. beliefs about) innovation attributes may have on intention; in this case intention to adopt a car navigation system. This is comparable with the general Technology Acceptance Model in which intention (to use) is (directly) determined by two beliefs or perceptions, namely perceived Usefulness and perceived Ease of Use (Venkatesh et al., 2003; Venkatesh & Davis, 2000). Besides, we will investigate the effects that network externality effects may have on intention to adopt an innovation.

Nowadays many innovations exhibit direct and/or indirect network externality effects. This means that adoption decisions of potential adopters regarding such innovations will be influenced by perceptions of innovation attributes as well as by network externality effects. From the literature review above it can be derived that (perceptions of) innovation attributes will influence the size of the installed base (user base) of an innovation via their influence on the adoption(-rate) of that innovation. That is, each adopted product results in an increase of the installed base, assuming that current users keep using the product. This means that a positive effect on the adoption-rate of an innovation will also imply a positive effect on the growth-rate of that innovation's installed base, while a negative effect on the adoption-rate of an innovation will imply a negative effect on the growth-rate of that innovation's installed base. On its turn an innovation's installed base or user base forms the basis of network externality effects, as becomes clear from the general definition of the concept of "Network Externalities". Therefore, in the remaining of this paper we will argue that (perceptions of) innovation attributes will influence a product's network externalities via their influence on the adoption (and thus via their influence on the installed base) of that product. Besides, it will be argued that perceptions of innovation attributes and network externality effects will influence the intention of potential adopters to adopt an innovation.

3. Conceptual Model and Hypotheses

Based on the two main research areas discussed in the previous section of this paper, the “Diffusion of Innovations” literature and the literature regarding “Network Externalities”, the Theory of Reasoned Action, and the two gaps identified in the introduction, we propose the conceptual model below (figure 1). As becomes clear from the model we expect that the relationships between different innovation characteristics (Relative Advantage, Image, Compatibility, Trialability, Complexity and Observability) and the Intention to Adopt an innovation (in this case a car navigation system) are mediated by Network Externalities. Both Direct Network Externalities and Indirect Network Externalities are expected to play a mediating role. In the remaining of this section we will discuss all relationships presented in the conceptual model in more detail.

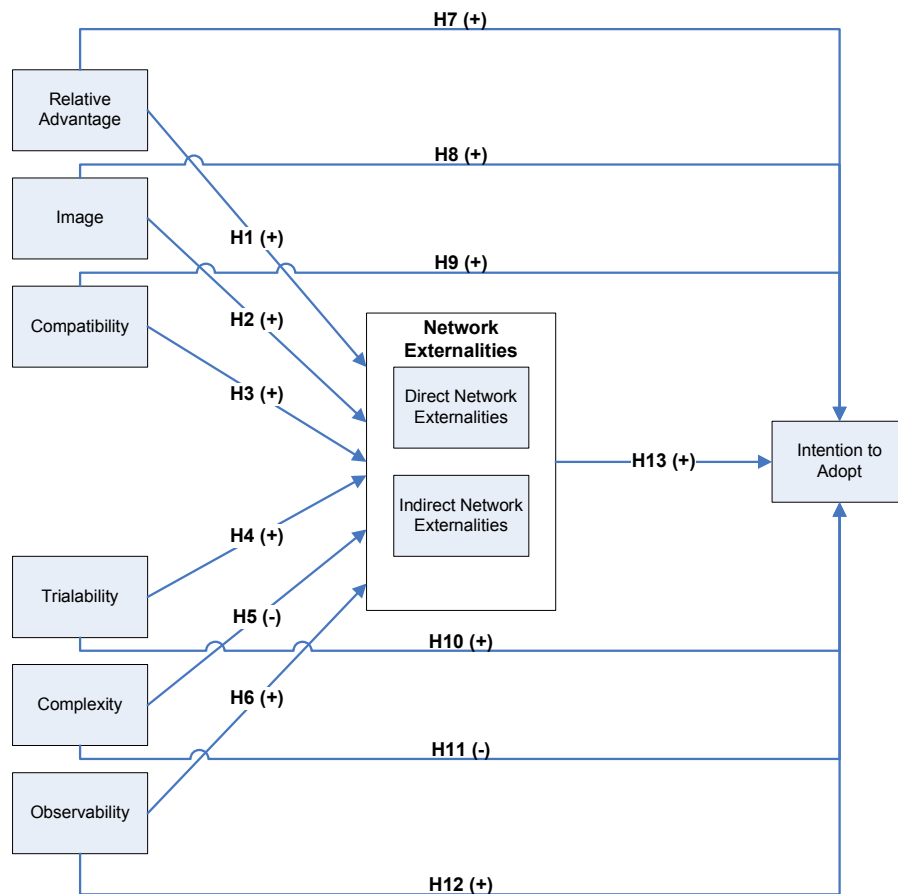


Figure 1 Conceptual model representing the mediating effects of Network Externalities

3.1 Innovation Attributes on Network Externalities

In this subsection we will discuss the mechanisms through which Direct Network Externalities and Indirect Network Externalities are expected to be influenced by perceived

innovation attributes. In short we will argue that each of the six innovation attributes influences the installed base of an innovation through its influence on the adoption(-rate) of that innovation. By determining the size of the installed base of an innovation each innovation attribute will (indirectly) influence the rate of Direct Network Externalities. Besides, the amount of complementary goods and/or services available will be determined by the size of an innovation's installed base, which means that each innovation attribute will also influence the rate of Indirect Network Externalities (via installed base). As shown in the conceptual model this means that perceptions of (a Car Navigation System's) Relative Advantage, Image, Compatibility, Trialability and Observability will have a positive influence on both types of network externality effects, while perceptions of Complexity will have a negative effect on both types of network externality effects. The relationships between each innovation attribute and both types of network externalities are discussed in more detail below.

3.1.1 Relative Advantage on Network Externalities

Perceptions of Relative Advantage, one of the innovation characteristics described by Rogers (2003), will have a positive effect on the rate of Direct Network Externality effects. Below we will reason that perceptions of Relative Advantage positively influence the adoption (-rate), and thus also the size of the installed base, of an innovation. Subsequently this positive effect on the installed base of an innovation will positively influence Direct Network Externalities through several mechanisms.

Relative Advantage represents “the degree to which an innovation is perceived as being better than the idea it supersedes” (Rogers, 2003, p. 229). In literature different types of Relative Advantage are mentioned, like economic advantages, savings in time and efforts and decreases in discomfort (Van Slyke et al., 2007; Rogers, 2003). According to Rogers (2003) the importance of the different types of Relative Advantage is dependent on the nature of the innovation as well as on the characteristics of the potential adopters. For example, improved picture quality would be an important aspect of Relative Advantage for DVD players (compared to VCR players), while economic savings might be one of the most important aspects of Relative Advantage looking at electricity-saving lamps (compared to the usual light bulb).

When potential adopters have to decide whether or not to adopt an innovation they will compare that innovation with the innovation (product) it supersedes: i.e. According to the definition of Rogers (2003) potential adopters will try to estimate the degree to which the innovation is better (provides more advantages) than the preceding idea. The higher the perceived benefits of an innovation as compared with the idea it supersedes, the more interesting or valuable the innovation will be for potential adopters. Besides, potential adopters that perceive a high level of Relative Advantage may expect that the innovation is a high quality product. This will be especially the case when improvements in quality-aspects, like for example sound-quality (CD-player) and picture quality (DVD player), are noticed by a potential adopter. According to Rogers (2003) perceptions of Relative Advantage have a positive effect on the adoption rate of an innovation: “The greater the perceived relative advantage of an innovation, the more rapid its rate of adoption will be” (Rogers, 2003, p. 15). Empirical findings (for different products) seem to support this statement. Song et al. (in press) mention that in many preceding studies Relative Advantage has been found to be an important determinant of the adoption of, or the intention to purchase, a product. Song et al. (in press) themselves found a positive effect of Relative

Advantage on the adoption of DVD players in the U.S. Consistent with these findings we expect that perceptions of a car navigation system's Relative Advantage will have a positive effect on the adoption(-rate) of such a system.

It is obvious that the adoption of an innovation has a positive influence on the installed base of that innovation: i.e. Each adopted product leads to an increase in the installed base of that product (assuming that the current users keep using the product). Therefore, the positive effect that Relative Advantage has on the adoption(-rate) of an innovation also means that Relative Advantage has a positive effect on the installed base of an innovation. On its turn, in the presence of Direct Network Externalities a larger installed base implies greater Direct Network Externality effects: i.e. The larger the installed base of an innovation, the larger the value or utility derived from that innovation. Song et al. (in press) summarize several perceptions and processes that are (positively) influenced by a product's installed base. Each of these 'mechanisms' may influence the value or utility derived from an innovation, which means that they all represent possible sources of Direct Network Externalities. The most well known (Direct Network Externality) mechanism⁵ is that a larger installed base may lead to an increased utility derived from an innovation because of a direct physical effect (Katz & Shapiro, 1985). For example, the utility (and thus also the value) derived from a phone is strongly dependent on its installed base (i.e. the number of users). Furthermore, a product's installed base may be used as a signal of quality or value (Hollofs & Jacobson, 1999; Schilling, 1999; Katz & Shapiro, 1985). This signaling function will especially be present when consumers are uncertain about a product's quality or value or when these attributes are difficult to measure for a consumer (Schilling, 1999). A larger number of users will also result in increased word-of-mouth communication (Redmond, 1991) and an increased ability to share standardized information with a larger group of users (Padmanabhan et al., 1997). In the presence of a large installed base (potential) adopters can ask (more) other users for information or help (i.e. more informal support; Song et al., in press) and become more knowledgeable about the product. Potential adopters also become more knowledgeable because information about products or brands that are more popular will be easier available (Katz & Shapiro, 1985). At last, as mentioned by Song et al. (in press), a larger installed base may result in a lower uncertainty regarding future complementary products and services, and product upgrades. This is quite understandable as producers of complementary products are more likely to produce these goods for the innovation with the largest installed base (Schilling, 1999). Besides, just the fact that an innovation has a large user base will lower the uncertainty of potential adopters about the availability of future product versions. Lower perceived risks with regard to the availability of complementary goods, services and product upgrades will have a positive effect on the value derived from the product as potential adopters will have more confidence in the future existence of the product, formal support etc. Through its positive influence on adoption, and thus through its positive influence on installed base, perceptions of Relative Advantage will strengthen one or more of these (direct network externality) mechanisms. This means that perceptions of Relative Advantage will positively influence Direct Network Externalities. In general this will also be the case for a car navigation system, although the direct physical effect will be less applicable to such a system as compared to for example a telephone network. Therefore, based on the preceding theoretical

⁵ The perceptions and processes (that are influenced by an innovation's installed base) discussed in this paragraph are mainly based on the ones mentioned by Song et al. (in press). However, some adaptations have been made with regard to the formulations and the explanations of the mechanisms and/or the literature used.

reasoning we hypothesize that perceptions of a car navigation system's Relative Advantage will have a positive effect on Direct Network Externalities (regarding such a system).

H. 1a: *Perceptions of a Car Navigation System's Relative Advantage will have a positive effect on Direct Network Externalities.*

Besides the positive effect of perceptions of Relative Advantage on Direct Network Externalities perceptions of Relative Advantage will also have a positive effect on Indirect Network Externalities. Below we will reason that Relative Advantage positively influences the availability of complementary products and services through its influence on installed base. Subsequently this increase in the availability of complementary goods and/or services will have a positive effect on the value or utility derived from a product, which implies that Relative Advantage has a positive effect on Indirect Network Externalities.

Indirect Network Externalities, the second aspect of network externalities, concerns the value derived from an innovation as a function of the availability of complementary products or services. Farrell and Saloner (1985, p. 70-71) talk about a market-mediated effect, that may exist "when a complementary good (spare parts, servicing, software . . .) becomes cheaper and more readily available the greater the extent of the (compatible) market". As becomes clear from this statement the availability of complementary goods, and thus also the rate of Indirect Network Externalities, is dependent on the installed base of a product. In line with the model of Hill (1997), Schilling (1998; 1999; 2002) even talks about a self-reinforcing virtuous cycle: Just like many consumers, developers of complementary products are likely to choose the product or technology with the largest installed base (Schilling, 1998; 1999; 2002). On its turn the availability of complementary products will influence the installed base of a product because the choice of consumers between competing products will be influenced by the availability of complementary products (Schilling, 1999). This reasoning is supported by a strong positive correlation between installed base and the availability of complementary products (Schilling, 2002). Similarly, Inceoglu and Park (2003) found that an increase in the number of DVD titles available raises the demand for DVD players and that an increase in the number of DVD players that have been sold has a positive effect on the availability of DVD titles. According to Gupta et al. (1999) the actions of complementors and manufacturers influence each other indirectly via the demand for the whole product. The results of their simulation study indicate that complementors in the digital television industry indeed wait with providing a broad range of content in digital format until a certain level of acceptance has taken place. On its turn the complementor actions were found to have an important influence on the adoption of digital television, especially the adoption of high definition television.

From the discussion above it becomes clear that both theoretical reasonings as well as empirical findings point out a positive relationship between an innovation's installed base and the availability of complementary goods and services. This also means that perceptions of Relative Advantage will positively influence the availability of complementary products and services via its influence on a product's installed base. On its turn, in the presence of Indirect Network Externalities, the availability of complementary goods will have a positive effect on the value or utility derived from an innovation: i.e. "An Indirect Network externality exists when the value of a product depends on the supply of complementary goods and services" (Song et al., in

press, p. 3). For example, the availability of software will influence the utility (and thus also the value) derived from a personal computer and a DVD player will have no value at all when no pre-recorded DVD's (e.g. films, documentaries etc.) are available. As already mentioned the availability of real-time traffic information (or up-to-the minute traffic information) is an important complementary service for a car navigation system. Consistent with the reasoning above the availability of such information will increase when the number of users of a car navigation system grows. That is, more users of a car navigation system means that there are more potential users of traffic-information, which makes it more interesting to 'supply' real-time traffic information. On its turn car navigation systems can use this information for example to recalculate routes in case of for example a traffic-jam or to direct a user of the system to the nearest free parking place. This means that the availability of such information increases the possibilities or functionalities of a car navigation system. This means that the utility and thus also the value derived from a car navigation system will increase when more real-time traffic information becomes available. Besides an increase in possibilities or functionalities of a hardware product the availability of complementary goods and/or services may also decrease the uncertainty with regard to the future availability of complementary goods and services and product upgrades (Song et al., in press). With regard to a car navigation system the availability of a broad range of traffic-information will strengthen the belief of potential adopters that (more of) such information will also be provided in the future. Besides, the fact that providers of complementary products provide such goods and/or services for an innovation means that they have trust in the future existence of the innovation. This probably will also lower the uncertainty of potential adopters about the future existence of a product. On its turn this lower uncertainty regarding the future availability of complementary products, services and product upgrades will have a positive effect on the value derived from an innovation. Thus, by influencing the amount of complementary products (via installed base), perceptions of Relative Advantage will positively influence the value or utility derived from an innovation that is dependent on such complementary goods and/or services. For a car navigation system this means that perceptions of a car navigation system's Relative Advantage will have a positive influence on the availability of traffic-information (via installed base), which on its turn will have a positive effect on the utility and value derived from such a system. This means that perceptions of a car navigation system's Relative Advantage will have a positive effect on the rate of Indirect Network Externalities for such a system, as is hypothesized below.

H. 1b: *Perceptions of a Car Navigation System's Relative Advantage will have a positive effect on Indirect Network Externalities.*

3.1.2 Image on Network Externalities

The five innovation characteristics as defined by Rogers (2003) do not include Image as a separate characteristic. Instead, social status or social prestige is seen as a specific type or dimension of the innovation characteristic Relative Advantage (Van Slyke et al., 2007; Rogers, 2003). However, Rogers (2003) clearly emphasizes the importance of this social aspect of Relative Advantage. According to the author "one motivation for many individuals to adopt an innovation is the desire to gain social status" (Rogers, 2003, p. 230). Nowadays this aspect of Relative Advantage is often classified as a separate innovation characteristic named Image. According to Moore and Benbasat (1991, p. 195), who developed a measurement instrument

intended to measure perceived innovation characteristics, Image is defined as “the degree to which use of an innovation is perceived to enhance one’s image or status in one’s social system”. Making use of the measurement scale developed by Moore and Benbasat (1991), Venkatesh and Davis (2000) have incorporated Image as a determinant of Perceived Usefulness in their extension of the Technology Acceptance Model.

For the adoption of many consumer products, from clothes to cars, status seeking will be of influence on the decision process to some extent. Therefore, an innovation that is perceived to enhance one’s social status or image will be much more interesting or valuable for a potential adopter as compared with an innovation that will ‘maintain the status quo’ or that even may harm his or her image. Besides, it would also not be unreasonable to suspect that innovations that are perceived to enhance one’s status are also seen as products of high quality, as normally spoken one’s image will not be enhanced by adopting low quality products. Taken this into account, a potential adopter will be more willing to pay for a product that is expected to enhance his or her social status because it will be perceived as more interesting or appealing (as compared with other products). Therefore, apart from Relative Advantage, Image will have a positive effect on the adoption of an innovation and thus also on an innovation’s installed base. Consistent with this reasoning we expect that perceptions of a car navigation system’s Image will have a positive effect on the adoption of such a system.

Like perceptions of Relative Advantage we propose that perceptions of Image will also have a positive effect on the amount of Direct Network Externalities. That is, by influencing an innovation’s installed base the value or utility derived from that innovation will be influenced in a positive way via one or more of the mechanisms discussed before. For example, we mentioned that the utility derived from a product may increase because of an increase in users (direct physical effect) (Katz & Shapiro, 1985); potential adopters may use the size of an innovation’s installed base as a signal of quality or value (Hellofs & Jacobson, 1999; Schilling, 1999; Katz & Shapiro, 1985); and potential adopters may perceive lower uncertainty regarding the availability of (future) complementary goods and product upgrades in the presence of a larg(er) installed base (Song et al., in press). As mentioned before, these general direct network externality mechanisms will also be applicable to a car navigation system, with the exception of the direct physical effect, which will be of less importance. Therefore, following the reasoning above, we expect that perceptions of a car navigation system’s Image will (also) influence Direct Network Externalities (regarding such a system) in a positive way (via installed base).

H. 2a: *Perceptions of a Car Navigation System’s Image will have a positive effect on Direct Network Externalities.*

As mentioned before both theory and empirical findings indicate that a product’s installed base has a positive effect on the amount of complementary goods and services available (e.g. Schilling, 2002; Farrell & Saloner, 1985). This means that perceptions of Image will positively influence the availability of complementary products via its influence on installed base. On its turn the availability of complementary goods may positively influence the value or utility derived from the hardware product because of increased possibilities or functionalities of the hardware product. Besides, the availability of complementary goods and/or services may lower uncertainties regarding future complementary goods and product upgrades (Song et al., in press). As already mentioned before for Relative Advantage this reasoning is also applicable to a car

navigation system with ‘real-time traffic information’ being the complementary service. Therefore, as is hypothesized below, we expect that perceptions of a car navigation system’s Image will positively influence the amount of Indirect Network Externalities regarding such a system.

H. 2b: *Perceptions of a Car Navigation System’s Image will have a positive effect on Indirect Network Externalities.*

3.1.3 Compatibility on Network Externalities

Compatibility is defined as “the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters” (Rogers, 2003, p. 240). According to Rogers (2003) a more compatible innovation is perceived as less uncertain by potential adopters. Besides, a more compatible innovation will fit more closely to the situation of the individual (Rogers, 2003). This means that innovations (or new ideas) have to fulfill two conditions at the same time, as has been clearly formulated by Hargadon and Douglas (2001, p. 476): “To be accepted, entrepreneurs must locate their ideas within the set of existing understandings and actions that constitute the institutional environment yet set their innovations apart from what already exists”.

An innovation that fits closely to the situation of a potential adopter and which is perceived as less uncertain will be perceived as more interesting or valuable than an innovation that completely diverges from existing values, past experiences and needs of potential adopters. This means that a more compatible innovation will be more interesting for a potential adopter. According to Rogers (2003) Compatibility has a positive effect on the adoption-rate of an innovation. The author mentions that incompatible innovations often require the adoption of a new value system which slows the rate of adoption. Edison already seemed to recognize the importance of Compatibility as he tried to develop the electric light in such a way that it required no big adaptations to the surrounding understandings and patterns of use (Hargadon & Douglas, 2001). Empirical results also underscore the positive influence of Compatibility on adoption: e.g. In recent studies Compatibility has been found to be positively related to the adoption of online e-payment by Chinese companies (He et al., 2006) and to the adoption of DVD players in the U.S. (Song et al, in press). In line with these findings we expect that perceptions of a car navigation system’s compatibility will have a positive influence on the adoption of such a system.

Being positively related to the adoption of an innovation means that perceptions of Compatibility also have a positive effect on the installed base of that innovation. On its turn a larger installed base will put into action one or more mechanisms that enhance an innovation’s Direct Network Externalities, as has also been described for perceptions of Relative Advantage and Image. Besides, via its positive effect on the availability of complementary goods and services (in our case ‘real-time traffic information), an innovation’s installed base will positively influence the amount of Indirect Network Externalities, as reasoned before. Therefore, in line with these reasonings, we hypothesize that perceptions of a car navigation system’s Compatibility will have a positive influence on both Direct Network Externalities and Indirect Network Externalities.

H. 3a: *Perceptions of a Car Navigation System's Compatibility will have a positive effect on Direct Network Externalities.*

H. 3b: *Perceptions of a Car Navigation System's Compatibility will have a positive effect on Indirect Network Externalities.*

3.1.4 Trialability on Network Externalities

Another innovation characteristic that helps to explain the adoption rate of innovations is Trialability (Rogers, 2003). Trialability represents “the degree to which an innovation may be experimented with on a limited basis” (Rogers, 2003, p. 258). According to Rogers (2003) an innovation that can be tried out represents lower uncertainty to a potential adopter. This is because a potential adopter has the possibility to learn to operate an innovation before adoption: i.e. “it is possible to learn by doing” (Rogers, 2003, p. 16). Often an innovation can be tried out in the shop where the product is sold. Edison, for example, offered potential users of the electric light system the opportunity to try out the system in one of his headquarters before subscribing (Hargadon & Douglas, 2001). In other instances a potential buyer may be allowed to try out the product at home during a specified period without any obligation. Besides, a potential adopter may for example ask friends or family, who already may have adopted the innovation, whether they are allowed to try out the innovation.

Many potential adopters will attach importance to the possibility to try out an innovation before adoption. As mentioned, innovations that can be tried out before adoption represent lower uncertainty to potential adopters (Rogers, 2003). According to Rogers (2003, p. 258) “the personal trying out of an innovation is one way for an individual to give meaning to an innovation and to find out how it works under one’s own conditions”. Therefore, by lowering the uncertainty, potential adopters will likely be more interested in innovations that can be tried out before adoption. This supports the suggestion of Rogers (2003) that perceptions of Trialability will have a positive effect on the adoption rate of an innovation. Empirical findings seem to support this suggestion. For example, Fliegel and Kivlin (1966) concluded that, within their study population, divisibility for trial is an important attribute in encouraging rapid adoption of modern farm practices by dairy farms. Recently, Song et al. (in press) found a highly significant positive effect of Trialability on the adoption of DVD players in the U.S. Applying this to our situation this means that perceptions of a car navigation system’s Trialability will have a positive effect on the adoption of the system.

Just like the innovation attributes described before, it is expected that perceptions of a car navigation system’s Trialability will have a positive effect on the installed base of such a system via their positive effect on adoption. Therefore, we expect that perceptions of a car navigation system’s Trialability also will positively influence the amount of Direct Network Externalities as well as Indirect Network Externalities (via the same mechanisms as described before). This results in the following two hypotheses:

H. 4a: *Perceptions of a Car Navigation System's Trialability will have a positive effect on Direct Network Externalities.*

H. 4b: *Perceptions of a Car Navigation System's Trialability will have a positive effect on Indirect Network Externalities.*

3.1.5 Complexity on Network Externalities

Potential adopters will have different opinions about how easy it is or will be to use an innovation. This means that the perceived complexity of an innovation will vary between individuals. Complexity is one of the 'original' five innovation characteristics defined by Rogers (2003). It stands for "the degree to which an innovation is perceived as relatively difficult to understand and use" (Rogers, 2003, p. 257). More complex innovations require that an adopter develops new skills and understandings (Rogers, 2003).

Before adopting a specific innovation potential adopters will have an opinion regarding the Complexity of that innovation. The higher this perceived Complexity is, the lower the interest in the product will be. Potential adopters with high perceptions of Complexity will expect that they are not able to use all options of the product because they will not understand how to use or operate them. This means that the (expected) value or utility derived from an innovation will be negatively influenced by perceptions of Complexity. Therefore, it is not surprising that Rogers (2003) suggests that perceptions of Complexity are negatively related to the rate of adoption. Recently, the results of the study of Song et al. (in press) underscored the negative effect of perceptions of Complexity on adoption. The electric light system of Edison was relatively low in Complexity and adopters needed little expertise to light their homes or offices (Hargadon & Douglas, 2001), which may have contributed to the success of his system. In contrast to the previous innovation attributes this implies that perceptions of Complexity regarding a car navigation system will have a negative effect on the adoption(-rate) of such a system.

Having an adverse effect on the adoption of an innovation also means that higher perceptions of Complexity will have a detrimental effect on the creation of an innovation's installed base. This implies that the mechanisms, through which an innovation's installed base may influence the value or utility derived from an innovation, will be negatively influenced by perceptions of Complexity. For example, a lower installed base means less word-of-mouth communication (Redmond, 1991), potential adopters may have lower perceptions of an innovation's quality or value because of a smaller installed base (Hellofs & Jacobson, 1999; Schilling, 1999; Katz & Shapiro, 1985) and the increase in utility or value derived from the innovation because of a direct physical effect (Katz & Shapiro, 1985) may be smaller or even absent (because of a smaller installed base). Thus the value or utility derived from an innovation's installed base will be negatively influenced by perceptions of Complexity (via the negative influence of Complexity on installed base). Therefore, we hypothesize that perceptions of a car navigation system's Complexity will have a negative effect on Direct Network Externalities. Similarly, a lower installed base will mean that less complementary goods and services will be provided (e.g. Schilling, 2002; Farrell & Saloner, 1985). For a car navigation system this implies that perceptions of Complexity will have a negative influence on the availability of real-time traffic information. This will imply a lower number of additional functionalities (because of a lack of information) and (potential) adopters may perceive more uncertainties regarding the future availability of complementary goods, services and product upgrades (Song et al., in press). This means that the value derived from a car navigation system because of the availability of such information will be lower. Therefore, we expect that perceptions of Complexity regarding a car navigation system will also have a negative effect on Indirect Network Externalities, as is hypothesized below.

H. 5a: *Perceptions of a Car Navigation System's Complexity will have a negative effect on Direct Network Externalities.*

H. 5b: *Perceptions of a Car Navigation System's Complexity will have a negative effect on Indirect Network Externalities.*

3.1.6 Observability on Network Externalities

The last innovation characteristic that we expect to be an antecedent of both Direct Network Externalities and Indirect Network Externalities is the innovation characteristic Observability. The perceived Observability of an innovation is defined as “the degree to which the results of an innovation are visible to others” (Rogers, 2003, p. 258). A highly visible innovation stimulates peer discussion in that neighbors, friends or family of the adopter will often ask for information or an evaluation of the innovation (Rogers, 2003).

An innovation that is highly visible for potential adopters probably will have a decreasing effect on the perceived uncertainty regarding the results of that innovation. That is, potential adopters can observe the results of an innovation before they actually adopt the innovation. The results of an innovation may be highly visible because for example friends or family already have adopted the innovation or because the results can be observed in a shop where the product is sold. Potential adopters will be more interested in, or will derive more value from, innovations that are perceived as highly observable because the results of such innovations are clear to them. Innovations from which the results are not that visible will be surrounded with more uncertainty. According to Rogers (2003) especially innovations with a dominant software component (the information base) are less observable. In general, it is suggested that higher perceptions of Observability have a positive effect on the adoption rate of an innovation (Rogers, 2003). The fact that the electric light developed by Edison became such a success may be (partially) due to the fact that the innovation was highly observable. Potential users could observe (the results of) the electric light for example in the houses of people who already adopted the system or in local businesses (Hargadon & Douglas, 2001). Therefore, consistent with the literature we expect that perceptions of Observability regarding a car navigation system will have a positive effect on the adoption of the system.

A positive effect on adoption means that perceptions of Observability also will positively influence the creation of an innovation's installed base. This means that perceptions of Observability regarding a car navigation system will have a positive effect on the installed base of such a system. Via one or more of the same mechanisms as discussed for the other innovation attributes (with the exception of the direct physical effect which will be of less importance for a car navigation system) installed base on its turn will have a positive influence on the amount of Direct Network Externalities. Thus we hypothesize that perceptions of a car navigation system's Observability have a positive effect on Direct Network Externalities. Besides, because the positive effect on installed base will positively influence the availability of complementary goods and services, in this case the availability of real-time traffic information, we also expect a positive effect of perceptions of a car navigation system's Observability on Indirect Network Externalities. Both hypotheses are formulated below.

H. 6a: *Perceptions of a Car Navigation System's Observability will have a positive effect on Direct Network Externalities.*

H. 6b: *Perceptions of a Car Navigation System's Observability will have a positive effect on Indirect Network Externalities.*

3.2 Innovation Attributes on Intention to Adopt

In this study we are not directly interested in the actual adoption of innovations. Instead we will focus on the intention of potential adopters to adopt (or to purchase) an innovation⁶. In this subsection we reason that all innovation attributes, with the exception of Complexity, will have a positive effect on the intention to adopt an innovation.

In the previous subsections we have shown that literature points out a positive effect of perceptions of Relative Advantage, Compatibility, Trialability, Observability and Image on the adoption of innovations. In contrast, perceptions of Complexity were found to have a negative effect on the adoption(-rate) an innovation. However, our outcome variable is not actual adoption but intention to adopt (a car navigation system). Therefore, the question that rises is how perceptions of innovation attributes may influence the intention to adopt an innovation.

In the theoretical background section of this paper we already introduced the Theory of Reasoned Action (TRA). According to the TRA the intention to perform a specific behavior is the immediate determinant of the actual behavior (Ajzen & Fishbein, 1980), which implies that actual adoption of an innovation will be preceded by a heightened intention to adopt. On its turn intention to perform a specific behavior is determined by a person's attitude toward the behavior, while a person's attitude is determined by a person's behavioral beliefs (Ajzen & Fishbein, 1980). In line with the TRA potential adopters of an innovation will have certain beliefs (perceptions) about the different characteristics of an innovation. For example, a potential adopter of a car navigation system may believe (perceive) that the adoption of such a system will provide him or her with certain advantages (e.g. safer driving, lower total costs) compared to for example using an Internet Route Planner (positive beliefs about Relative Advantage). In contrast a potential adopter may also believe that a car navigation system may be too difficult to operate (negative belief about Complexity). Consistent with the TRA positive beliefs with regard to innovation attributes will result in a more favorable attitude toward adopting an innovation and consequently to a higher intention to adopt. Negative beliefs will result in a more unfavorable attitude toward adoption and thus also in a lower intention to adopt an innovation. Therefore, following the Theory of Reasoned Action, we expect that perceptions of (or beliefs regarding) innovation attributes will determine the actual adoption of an innovation via intention to adopt. This reasoning is further supported by the Technology Acceptance Model (TAM), which is an adaptation of TRA indented to model the user acceptance of information systems (Davis et al., 1989). That is, in the final conceptualization of the general Technology Acceptance Model, which "excludes the attitude construct in order to better explain intention parsimoniously" (Venkatesh et al., 2003, p. 428), a clear (positive) succession is visible from two beliefs or perceptions, namely perceived Usefulness and perceived Ease of Use, to intention (to use), and from intention (to use) to actual (usage) behavior (Venkatesh et al., 2003; Venkatesh & Davis, 2000). The two beliefs incorporated in TAM show resemblance with two of the innovation attributes used in the diffusions of innovations literature: Ease of Use is the conceptual opposite of Complexity (Van Slyke et al., 2007), while Usefulness is shows resemblance with Relative Advantage, although is has to be kept in mind that Usefulness focuses on using the innovation while Relative Advantage focuses on perceptions of the innovation itself (Moore & Benbasat, 1991). Therefore, despite the fact that TAM focuses on usage behavior instead of adoption behavior, TAM provides further support for the reasoning that perceptions of, or beliefs about,

⁶ "Intention to adopt" and "Intention to purchase" will be used interchangeably throughout this paper.

innovation characteristics determine the intention to perform a certain behavior, which in turn determines the actual behavior.

Summarizing, based on the discussion above we expect that perceptions of innovation characteristics directly (or indirectly via attitude) influence the intention to adopt an innovation. This means that we agree with Holak and Lehmann (1990, p. 59) who mention that the “acceptance or adoption of [...] a[n] [innovative] product is necessarily influenced by consumers’ purchase intentions which, in turn, are determined by certain general attributes (characteristics) of the products”. Because the actual adoption of an innovation is determined by the intention to adopt an innovation we expect that the direction of the relationships between the six innovation attributes and intention to adopt are equal to the relationships between the six innovation attributes and actual adoption as discussed before. That is, we hypothesize that higher perceptions of a car navigation system’s Relative Advantage, Compatibility, Trialability, Observability and Image will have a positive effect on the intention to adopt such a system. For example: The stronger a potential adopter believes that a car navigation system will be compatible with his or her existing values, past experiences and needs (Compatibility; Rogers, 2003), the more interest a potential adopter will have in such a system which, on its turn will result in a higher the intention to purchase or to adopt a car navigation system (via a favorable attitude toward adopting). In contrast, higher perceptions of a car navigation system’s Complexity (i.e. the innovation is perceived to be complex, difficult to use, etc.) are expected to have a negative effect on the intention to adopt such a system, as is hypothesized below.

- H. 7: *Perceptions of a Car Navigation System’s Relative advantage will have a positive effect on the Intention to Adopt a Car Navigation System.*
- H. 8: *Perceptions of a Car Navigation System’s Image will have a positive effect on the Intention to Adopt a Car Navigation System.*
- H. 9: *Perceptions of a Car Navigation System’s Compatibility will have a positive effect on the Intention to Adopt a Car Navigation System.*
- H. 10: *Perceptions of a Car Navigation System’s Trialability will have a positive effect on the Intention to Adopt a Car Navigation System.*
- H. 11: *Perceptions of a Car Navigation System’s Complexity will have a negative effect on the Intention to Adopt a Car Navigation System.*
- H. 12: *Perceptions of a Car Navigation System’s Observability will have a positive effect on the Intention to Adopt a Car Navigation System.*

3.3 Network Externalities on Intention to Adopt

In order to be able to investigate potentially mediating effects of network Externalities we have to demonstrate that the mediators (Direct Network Externalities and Indirect Network Externalities) have a significant influence on the outcome variable, the intention to adopt an innovation (Baron & Kenny, 1986). Therefore, in this subsection we reason that both Direct Network Externalities and Indirect Network Externalities will have a positive influence on the intention to adopt an innovation.

In general previous research has shown that in the presence of network externalities an innovation’s installed base and/or the availability of complementary goods has/have a positive effect on the adoption of an innovation (Song et al., in press). As has already become clear from

the previous sections of this paper the current study diverges from these previous studies in two important ways. At the first place intention to adopt is used as outcome variable instead of actual adoption. Secondly, we do not focus on (perceptions of) installed base and (perceptions of) the availability of complementary goods and services. Instead we focus on the (expected) value or utility derived from an innovation as a function of that innovation's installed base or as a function of the availability of complementary goods and services. Therefore, previous research offers no direct support for a positive relationship between the value derived from an innovation as a function of an innovation's installed base (i.e. Direct Network Externalities) and intention to adopt, and for a positive relationship between the value derived from an innovation as a function of the availability of complementary goods (i.e. Indirect Network Externalities) and intention to adopt.

In the presence of Direct Network Externalities the value or utility derived from a product is positively associated with the product's installed base. As mentioned before a product's installed base may influence the perceived value or utility derived from that product in several ways: (1) The utility of an innovation may increase because of a direct physical effect (Katz & Shapiro, 1985); (2) The installed base of an innovation may be interpreted as a signal of the innovation's quality or value (Hellofs & Jacobson, 1999; Schilling, 1999; Katz & Shapiro, 1985); (3) A larger installed base will lead to an increase in word-of-mouth communication (Redmond, 1991); (4) Information will be easier available for popular brands (Katz & Shapiro, 1985); (5) A larger installed base increases the ability to share standardized information with a larger group of users (Padmanabhan et al., 1997); and (6) A larger group of users may lower the uncertainty regarding the future complementary products and services, and product updates (Song et al., in press). In the presence of Direct Network Externalities a larger installed base will, through one or more of these mechanisms, positively influence the value or the utility derived from the innovation by potential adopters. This also explains why measures of installed base have been found to be positively associated with the adoption of innovations. That is, the higher value or utility derived from an innovation because of a larger installed base makes that the innovation will be adopted faster. However, as the actual adoption is determined by the intention to adopt an innovation (as reasoned in the previous subsection), we expect that the value derived from a product as a function of its installed base (called Direct Network Externalities) will be positively related to the intention to adopt an innovation: i.e. The higher the (expected) value derived from a product, or the more positive the beliefs regarding the value or utility of an innovation are (because of its installed base), the higher the intention of a potential adopter will be to adopt the product. This will also be the case for a car navigation system, although the direct physical effect will be less applicable to such a system, as mentioned before. Therefore, we hypothesize that Direct Network Externalities (with regard to a car navigation system) will have a positive effect on the intention to adopt a car navigation system.

H.13a: *Direct Network Externalities will have a positive effect on the Intention to Adopt a Car Navigation System.*

In the presence of Indirect Network Externalities the value or utility derived from the product is positively associated with the availability of complementary goods or services. That is, for some products the value of the product is dependent on the availability of complementary goods and/or services (Song et al., in press). For a car navigation system the availability of real-

time traffic information is an important complementary service. As mentioned before the availability of such information increases the potential functionalities (e.g. recalculation the route in case of a traffic-jam) of such a system. This means that the utility and thus also the value derived from a car navigation system will increase when more real-time traffic information becomes available. Besides, (in general) the availability of complementary products and/or services may have a positive effect on the value derived from an innovation because it lowers the uncertainty regarding the future availability of complementary goods, services and product upgrades (Song et al., in press). The increased utility or value derived from an innovation due to the availability of complementary goods and/or services will explain why measures of the availability of complementary goods have been found to be positively associated with the adoption of innovations, as is for example recognized by Iceoglu and Park (2003, p. 18): “Greater variety of titles [(DVD titles)] has a positive effect on consumer utility and, hence on hardware demand”. However, as the actual adoption is determined by the intention to adopt an innovation (as reasoned in the previous subsection), we expect that the value derived from a product as a function of the availability of complementary goods and/or services (called Indirect Network Externalities) will be positively related to the intention to adopt an innovation: i.e. The higher the (expected) value derived from a product, or the more positive the beliefs regarding the value or utility of an innovation are (because of the availability of complementary goods and/or services), the higher the intention of a potential adopter will be to adopt the product. This will also be the case for a car navigation system as the availability of up-to-the minute traffic information will result in a higher utility and value derived from such a system. Therefore, the availability of such information makes a car navigation system more interesting for a potential adopter which, on its turn will result in a higher intention to adopt such a system. Hence, we expect that Indirect Network Externalities (regarding a car navigation system) will have a positive effect on the intention to adopt a car navigation system.

H.13b: *Indirect Network Externalities will have a positive effect on the Intention to Adopt a Car Navigation System.*

3.4 Direct and Indirect Network Externalities as mediators between Perceptions of Innovation Attributes (in general) and Intention to Adopt

Each of the hypotheses formulated in this section of the paper focuses on an individual innovation attribute. Because it is expected that each innovation characteristic may be mediated by Direct Network Externalities as well as by Indirect Network Externalities we can add two general hypotheses (not visible in the conceptual model). That is, we hypothesize that Direct Network Externalities as well as Indirect Network Externalities mediate the relationship between perceptions of innovation attributes (regarding a car navigation system) in general and the intention to adopt a car navigation system.

H.14a: *Direct Network Externalities mediate the relationship between Perceptions of Innovation Attributes regarding a Car Navigation System (in general) and the Intention to Adopt a Car Navigation System.*

H.14b: *Indirect Network Externalities mediate the relationship between Perceptions of Innovation Attributes regarding a Car Navigation System (in general) and the Intention to Adopt a Car Navigation System.*

The conclusions that will be drawn about both hypotheses formulated above can be derived from the conclusions that will be drawn about all other hypotheses (hypothesis 1a upto and including hypothesis 13b). This means that hypothesis 14a is only supported when the relationships between each individual innovation attribute and intention to adopt are all mediated by Direct Network Externalities. Similarly, hypothesis 14b is only confirmed when the relationships between each innovation attribute and intention to adopt are all mediated by Indirect Network Externalities.

4. Methodology

4.1 Sample and Data collection

The data needed for this study have been collected by means of a survey during the autumn of 2007. This survey has been carried out by master students enrolled in the master course 'New Product Development' at the Eindhoven University of Technology. Respondents were asked to fill in a questionnaire about the adoption of car navigation systems. This questionnaire has been developed by Song, Van der Bij, Keizer and Podoyntsyna. As we focus on the intention to adopt an innovation (or the intention to purchase an innovation) our sample only includes people who had not (yet) adopted a car navigation system at the moment of filling in the questionnaire. All respondents completed the questionnaire only once, which means that this is a cross-sectional study (Cooper & Schindler, 2003).

The final sample consists of 452 Dutch citizens who did not have adopted (yet) a car navigation system at the moment of filling in the questionnaire. The age of the respondents ranges from 16 to 79 years old, with an average age of 35.6 years. The number of males and females in the sample is almost equal: 219 females (48.5%) versus 233 males (51.5%).

4.2 Measurements

The questionnaire used in our study mainly consisted of items that have already been validated by prior research. For both Direct Network Externalities and Indirect Network Externalities new items have been formulated. This was needed because prior research only uses measures of installed base and the availability of complementary goods. To our knowledge no items have been formulated that are intended to measure the value derived from a product as a function of its installed base. Similarly (to our knowledge) no items exist that are intended to measure the value derived from a product as a function of the availability of complementary goods and/or services. The response format for each item in the questionnaire consisted of an 11 point Likert scale ranging from 0 ("Extremely unlikely") to 10 ("Extremely likely"). Appendix A contains an overview of the questionnaire items used in the survey and the construct reliabilities. Below the measurements are discussed in more detail.

Dependent variable

Intention to Adopt (INT): Intention to Adopt a car navigation system has been measured by a single item. The respondents were asked to indicate how likely it would be that they would purchase a car navigation system during the coming twelve months.

Mediating variables

Direct Network Externalities (DNE): Direct Network Externalities have been measured by means of one item. According to Padmanabhan et al. (1997, p. 456) "the presence of network externalities implies that consumers' adoption decisions and their willingness to pay for the product increase with the demand associated with a product". That is, in the presence of Direct Network Externalities customers will be willing to pay a higher price for a product with a larger installed base (i.e. user base) because they derive a higher value or utility from such a product (compared to a product with a smaller installed base). Therefore, in the current study respondents

were asked whether they would be prepared to pay more for a car navigation system if more people own such a system.

Indirect Network Externalities (INE): Indirect Network Externalities have been measured by two newly developed items. By means of these two items respondents were asked whether a car navigation system would become more valuable to them when more up-to-the minute traffic information is available. Up-to-the minute traffic information, like information about traffic-jams and free parking places, is expected to be an important complementary product of car navigation systems. For example, with the help of such information users can avoid traffic-jams and they do not have to drive a long time before they have found a free parking place. This means that the availability of such information extends the possibilities of the system. Therefore, up-to-the minute traffic information will increase the value or utility derived from a car navigation system. The Cronbach's α for both measures of Indirect Network Externalities is 0.77, which is acceptable as it exceeds the minimum level of 0.70 (Hair et al., 2006).

Independent variables

Relative Advantage (RA): Perceptions of Relative Advantage have been measured by a single reversed item that has been adopted from Song and Read (unpublished paper)⁷. The respondents were asked whether they thought that the total costs of car navigation systems would be higher compared with internet route planners.

Image (IM): Perceptions of Image have been measured by two items. Both items, in a slightly adapted form, were taken from the scale developed and validated by Moore and Benbasat (1991). People were asked whether they thought that having a car navigation system would result in more prestige. Besides, the respondents were asked whether they thought that people who own a car navigation system would have a high profile. The Cronbach's α for both measures of Image is 0.80, which exceeds the minimum level of 0.70 (Hair et al., 2006).

Observability (OB): Two items have been used to measure Perceptions of Observability. Both items have been validated by Moore and Benbasat (1991). The respondents were asked whether it is easy for them to observe others using the car navigation system and whether they have plenty of opportunity to see the car navigation system being used. The Cronbach's α is 0.72, which is acceptable as it exceeds the minimum level of 0.70 (Hair et al., 2006).

Trialability (TR): Perceptions of Trialability have been measured by one item. The respondents were asked whether it would be easy for them to find a place to satisfactorily try various uses of a car navigation system. This is a slightly adapted version of the item "I know where I can go to satisfactorily try out various uses of a PWS" (Moore & Benbasat, 1991, p. 216).

Complexity (CO): Perceptions of Complexity have been measured by a single item. The item used in our study is a slightly adapted version of one of the "Ease of Use items" proposed by Moore and Benbasat (1991). Respondents were asked whether they would find it frustrating to operate a car navigation system.

⁷ No 'original' scale has been found that includes the same item, or a similar item, as used in our questionnaire.

Compatibility (CA): Three items have been used to measure perceptions of Compatibility. The items are slightly adapted versions of the items proposed by Moore & Benbasat (1991). The respondents were asked whether the use of a car navigation system fits into their life style and whether the use of a car navigation system fits with the way they like to drive. Besides, the respondents were asked whether using a car navigation system is compatible with all aspects of their driving style. The Cronbach's α for these three items is 0.86, which easily answers the minimum level of 0.70 (Hair et al., 2006).

4.3 Data analysis

Table 1 contains an overview of descriptive statistics (correlations, means and standard deviations) and Cronbach's α 's. All Cronbach's α 's exceed the minimal level of 0.70 (Hair et al., 2006). This means that the reliability of all constructs with multiple items is acceptable.

Before testing our hypotheses we tested the convergent and discriminant validity of the constructs (with multiple items) by means of a confirmatory factor analysis (Maximum Likelihood Estimation) using LISREL 8.54⁸. The goodness of fit statistics provided by LISREL (Appendix C) indicate a good model fit (Hair et al., 2006): χ^2/df is 1.08, the RMSEA is 0.014, the standardized RMR is 0.018, NFI is 0.99, CFI is 1.00, and GFI is 0.99. As becomes clear from table 2 all factor loadings are highly significant ($p < 0.001$). Besides, all completely standardized factor loadings exceed the minimal level of 0.50 (Hair et al., 2006; Fornell & Larcker, 1981) and most of them (except the factor loading of OB1) even exceed the more preferable level of 0.70 (Hair et al., 2006). Therefore, we conclude that our scales have convergent validity (Hair et al., 2006; Fornell & Larcker, 1981). Additionally, the correlations between each pair of factors are all less than one. This means that it can be concluded that our measurement scales achieve discriminant validity (Bagozzi et al., 1991).

All hypotheses formulated in section 3 will be tested by the estimation of a full (structural equation) model using LISREL 8.54. LISREL will be used because one of its major advantages is its ability to estimate multiple and interrelated dependence relationships instead of only a single relationship between the dependent and independent variables (Cooper and Schindler, 2003). This is an important advantage for our study as we have included two mediators in our conceptual model. The full model consists of the constructs and their items as presented in the confirmatory factor analysis. Besides, the full model will contain single-item constructs for Relative Advantage, Complexity, Trialability, Direct Network Externalities and Intention to Adopt (dependent variable).

⁸ The results of the exploratory factor analysis can be found in Appendix B.

Table 1 Descriptive statistics

	Mean	St.Dev.	1	2	3	4	5	6	7	8	9
1. Intention to Adopt	2.14	2.56	n/a								
2. Direct Network Externalities	2.26	2.07	.23**	n/a							
3. Indirect Network Externalities	6.91	2.02	.12*	.06	0.77						
4. Relative Advantage	2.18	2.11	.06	.11*	-.12**	n/a					
5. Image	3.69	2.39	.16**	.29**	.20**	.09	0.80				
6. Compatibility	4.40	2.19	.26**	.34**	.34**	.08	.30**	0.86			
7. Trialability	5.86	2.82	.16**	.10*	.17**	.04	.14**	.24**	n/a		
8. Complexity	3.98	2.49	-.07	-.00	-.20**	-.07	-.07	-.28**	-.07	n/a	
9. Observability	5.96	2.27	.08	.06	.27**	-.02	.04	.28**	.48**	-.13**	0.72

Figures on the diagonal represent Cronbach's α 's

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

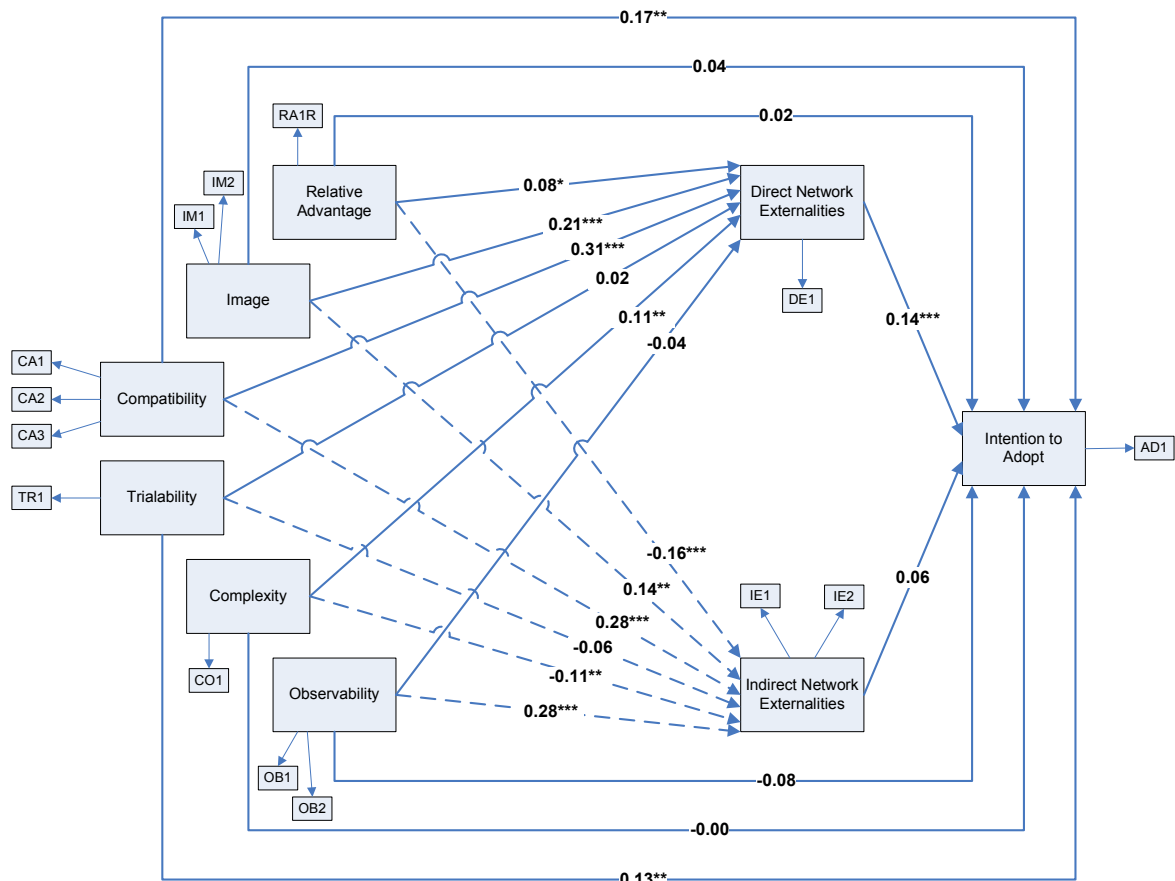
Table 2 Confirmatory Factor Analysis

Construct Item	Factor Loading*				T-value
	INE	CA	IM	OB	
<i>Observability</i>					
OB1				0.65	10.35
OB2				0.86	11.89
<i>Image</i>					
IM1			0.91		13.24
IM2			0.74		11.86
<i>Indirect Network Externalities</i>					
IE1	0.72				12.92
IE2	0.87				14.72
<i>Compatibility</i>					
CA1		0.73			17.14
CA2		0.84			20.77
CA3		0.89			22.30

* Completely Standardized Solution

5. Results

The results of the model estimation are presented in figure 2 and in table 3. The goodness of fit statistics provided by LISREL 8.54 (Appendix D) indicate a good model fit (Hair et al., 2006): χ^2/df is 1.89, the RMSEA is 0.044, the standardized RMR is 0.026, NFI is 0.96, CFI is 0.98, and GFI is 0.97. Our general hypothesis was that both Direct Network Externalities and Indirect Network Externalities mediate the relationships between perceived innovation characteristics and the intention to adopt an innovation, in this case a car navigation system. As becomes clear from figure 2 our results do not support the expectation that Indirect Network Externalities mediate the relationships between innovation characteristics and intention to adopt. With regard to Direct Network Externalities it becomes clear that this type of network externalities fully mediates the relationships between Image and intention to adopt, between Complexity and intention to adopt (although in the opposite direction), and between Relative Advantage and intention to adopt. Direct Network Externalities partially mediate the relationship between Compatibility and the intention to adopt a car navigation system.



- Completely standardized solution
- Dashed lines are used to increase the readability of the full model
- RA1R: This item has been reversed

* $p < 0.10$, two-tailed ** $p < 0.05$, two-tailed *** $p < 0.01$, two-tailed

Figure 2 LISREL results for the mediating effects of both types of Network Externalities

Table 3 Overview of results

	Hypothesis	Estimate*	t-value	Hypothesis confirmed?
H. 1a	RA → + → DNE	0.08	1.72	Yes
H. 1b	RA → + → INE	-0.16	-3.23	No
H. 2a	IM → + → DNE	0.21	3.82	Yes
H. 2b	IM → + → INE	0.14	2.33	Yes
H. 3a	CA → + → DNE	0.31	5.29	Yes
H. 3b	CA → + → INE	0.28	4.11	Yes
H. 4a	TR → + → DNE	0.02	0.30	No
H. 4b	TR → + → INE	-0.06	-0.97	No
H. 5a	CO → - → DNE	0.11	2.36	No
H. 5b	CO → - → INE	-0.11	-2.08	Yes
H. 6a	OB → + → DNE	-0.04	-0.55	No
H. 6b	OB → + → INE	0.28	3.37	Yes
H. 7	RA → + → INT	0.02	0.48	No
H. 8	IM → + → INT	0.04	0.67	No
H. 9	CA → + → INT	0.17	2.60	Yes
H. 10	TR → + → INT	0.13	2.14	Yes
H. 11	CO → - → INT	-0.00	-0.07	No
H. 12	OB → + → INT	-0.08	-1.00	No
H. 13a	DNE → + → INT	0.14	2.83	Yes
H. 13b	INE → + → INT	0.06	0.89	No
H. 14a	DNE acts as mediator between PIA and INT	n/a	n/a	No
H. 14b	INE acts as mediator between PIA and INT	n/a	n/a	No

* Completely Standardized Solution

In hypothesis 1a, 2a, 3a, 4a, and 6a we hypothesized a positive effect of perceptions of Relative Advantage, Image, Compatibility, Trialability and Observability on Direct Network Externalities. In hypothesis 5a we proposed a negative effect of perceptions of Complexity on Direct Network Externalities. As expected perceptions of Relative Advantage ($\beta=0.08$, $p<0.10$), Image ($\beta=0.21$, $p<0.01$), and Compatibility ($\beta=0.31$, $p<0.01$) have a positive influence on Direct Network Externalities. This means that hypotheses 1a, 2a and 3a are supported. Perceptions of Complexity ($\beta=0.11$, $p<0.05$) have an unexpected positive influence on Direct Network Externalities. Furthermore, perceptions of Trialability and Observability are not significantly related to Direct Network Externalities. This means that hypotheses 4a, 5a and 6a are not supported.

In hypothesis 1b, 2b, 3b, 4b, and 6b we hypothesized a positive effect of perceptions of Relative Advantage, Image, Compatibility, Trialability and Observability on Indirect Network Externalities. In hypothesis 5b we proposed a negative effect of perceptions of Complexity on Indirect Network Externalities. As expected perceptions of Image ($\beta=0.14$, $p<0.05$), Compatibility ($\beta=0.28$, $p<0.01$) and Observability ($\beta=0.28$, $p<0.01$) have a positive effect on Indirect Network Externalities. Besides, perceptions of Complexity ($\beta=-0.11$, $p<0.05$) have a

negative effect on Indirect Network Externalities. This means that hypotheses 2b, 3b, 5b and 6b are supported. Contrary to our hypothesis perceptions of Relative Advantage ($\beta=-0.16$, $p<0.01$) have a negative effect on Indirect Network Externalities. No significant relationship was found between perceptions of Trialability and Indirect Network Externalities. This means that both hypotheses 1b and 4b are not supported.

In hypotheses 7, 8, 9, 10 and 12 we hypothesized a positive effect of perceptions of Relative Advantage, Image, Compatibility, Trialability and Observability on intention to adopt a car navigation system. In hypothesis 11 we hypothesized a negative effect of perceptions of Complexity on intention to adopt. As becomes clear from figure 2 we only found supporting evidence for hypotheses 9 and 10: Perceptions of Compatibility ($\beta=0.17$, $p<0.05$) and perceptions of Trialability ($\beta=0.13$, $p<0.05$) have a positive effect on the intention to adopt a car navigation system. No significant relationships have been found between one of the other innovation attributes and intention to adopt. Thus hypotheses 7, 8, 11 and 12 are not supported.

In hypotheses 13a and 13b we hypothesized a positive effect of both Direct Network Externalities and Indirect Network Externalities on the intention to adopt a car navigation system. As expected Direct Network Externalities ($\beta=0.14$, $p<0.01$) have a positive effect on the intention to adopt a car navigation system, supporting hypothesis 13a. No significant relationship has been found between Indirect Network Externalities and the intention to adopt a car navigation system. This means that hypothesis 13b is not supported.

In the last two general hypotheses, hypotheses 14a and 14b, we hypothesized that both Direct Network Externalities and Indirect Network Externalities will mediate the relationship between perceptions of innovation attributes (PIA) in general and the intention to adopt a car navigation system. From the results of all sub-hypotheses discussed above we can conclude that hypothesis 14a is not supported, as not all innovation attributes are found to be significantly related to Direct Network Externalities. Furthermore, no mediating effects at all have been found for Indirect Network Externalities because Indirect Network Externalities are not significantly related to the intention to adopt a car navigation system. This means that hypothesis 14b is not supported too.

6. Discussion

6.1 Main findings

The purpose of this study was to investigate whether network externality effects mediate the relationships between perceptions of innovation attributes and the intention to adopt an innovation. More in general, the aim of this study was to increase the understanding of the mechanisms that influence adoption decisions regarding network externality innovations. Two research streams, namely the research areas regarding “Network Externalities” and “Diffusion of Innovations”, formed the basis for this study. According to “Diffusion of Innovations” literature several innovation characteristics, as perceived by (potential) adopters, help in explaining the differences in adoption-rates of innovations (Rogers, 2003). On the other hand, the literature regarding network externalities is concerned with the fact that the utility of many innovations is dependent on the number of other agents consuming the same product or technology (Katz & Shapiro, 1985). Based on these two research streams and the Theory of Reasoned Action a conceptual model has been proposed in which perceptions of innovation characteristics act as determinants of network externality effects (via their influence on the installed base of an innovation), which on their turn influence the intention to adopt an innovation. A questionnaire regarding the adoption of car navigation systems has been used to collect the data needed to evaluate the model.

Figure 3 below shows how our conceptual model looks like when we only take into account the significant effects that have been found in this study. The figure provides a quick overview of the hypotheses that are supported by the results (solid lines). Furthermore, the relationships between Relative Advantage and indirect network externalities, and between Complexity and direct network externalities, are represented by means of dashed lines. Both relationships are found to be significant but their direction is contrary to our hypotheses.

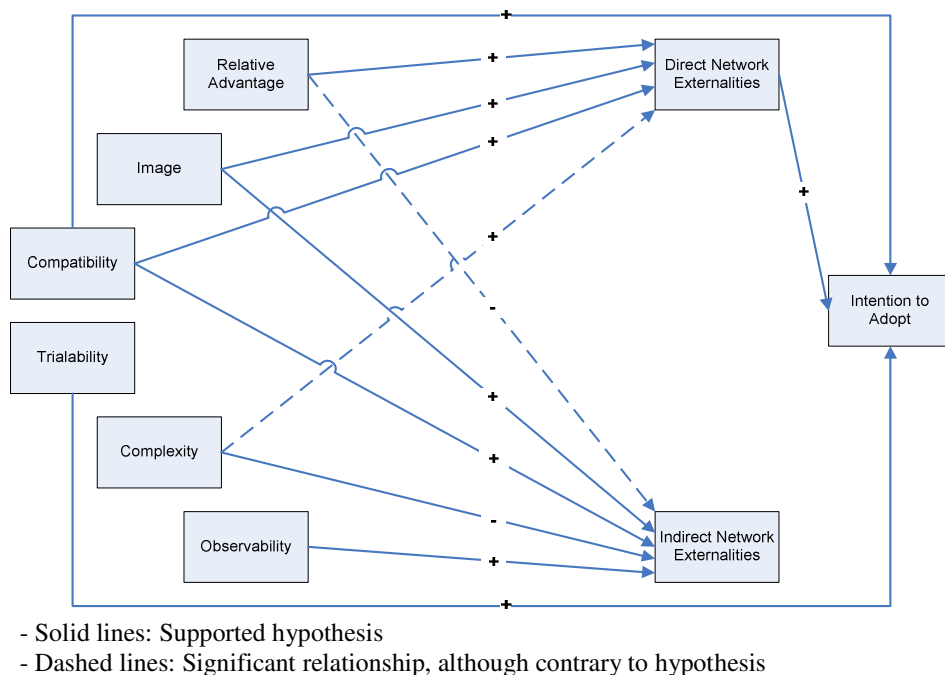


Figure 3 Framework providing a quick overview of all significant relationships

As becomes clear from figure 3 the results of this study provide quite strong support for the expectation that perceptions of innovation attributes influence the rate of direct network externality effects as well as the rate of indirect network externality effects. With the exception of Trialability each of the innovation attributes has been found to be significantly related to one or both types of network externality effects. The rate of direct network externalities regarding car navigation systems has been found to be significantly influenced by four innovation attributes, namely Compatibility (positive effect), Complexity (positive effect), Image (positive effect) and Relative Advantage (positive effect). The other type of network externality effects, indirect network externalities, is significantly influenced by five innovation attributes: That is, the results show that Compatibility, Image and Observability have a positive effect on the rate of indirect network externalities, while Complexity and Relative Advantage have a negative effect on the rate of indirect network externalities regarding car navigation systems.

The expectation that both types of network externality effects mediate the relationships between perceptions of innovation attributes and the intention to adopt an innovation receive mixed support. Based on the results of this study it can not be concluded that network externalities mediate the relationships between perceived innovation attributes and the intention to adopt an innovation in general. At the first place not all six innovation attributes were found to be significantly related to both types of network externality effects. Secondly, although the sign was as expected (positive), our measures of indirect network externalities were not found to be significantly related to the intention to adopt a car navigation system. This means that we found no support at all for a mediating effect of indirect network externalities. Apparently the availability of up-to-the minute traffic information is not of crucial importance in determining a potential adopter's intention to buy a car navigation system. A possible explanation for this may be that important traffic information, like information about traffic jams, can also be received for example via the car radio. Another explanation may be that potential adopters may not know exactly what the advantages are of up-to-the minute traffic information. For example, people may not know that a car navigation system can use this information to propose an alternative route in case of a traffic jam. Informing the respondents about these advantages might have resulted in higher reported indirect network externalities and perhaps a stronger effect on intention to adopt.

The findings for direct network externalities as mediator between perceived innovation attributes and the intention to adopt an innovation are much more supportive. Our measure of direct network externalities was found to be significantly related to the intention to adopt a car navigation system. Taking into account the results regarding the direct relationships between the six innovation attributes and intention to adopt a car navigation system the following can be concluded: (1) Direct network externalities fully mediate the effects of Complexity, Image and Relative Advantage on the intention to adopt a car navigation system. This becomes clear from the fact that none of these innovation attributes was found to be significantly related to the intention to adopt a car navigation system, while they were all found to be significantly related to our measure of direct network externalities. (2) Direct network externalities partially mediate the relationship between Compatibility and intention to adopt. Besides its strong positive effect on direct network externalities, perceptions of Compatibility also have a smaller direct positive effect on the intention to adopt a car navigation system. Summarizing this means that the results of this study indicate that direct network externalities have a mediating effect on four of the six relationships between perceptions of innovation attributes and the intention to adopt a car navigation system.

Besides the more general findings that can be derived from the results of this study (as described on the previous page), a closer look at the estimations of the relationships between perceptions of innovation attributes and both types of network externality effects also reveal some unexpected, but interesting results. At the first place the positive effect of Complexity on direct network externalities is contrary to our hypothesis that perceptions of Complexity will have a negative effect on the rate of direct network externalities. One explanation for this finding may be the “heightened interest in technology intensive products with seemingly complex control panels, electronic readouts, etc.” (Holak & Lehmann, 1990, p. 66). That is, potential adopters may be attracted by the complex capabilities of innovations (Holak & Lehmann, 1990). Taking this into account, perceptions of Complexity will have a positive effect on the adoption-rate of car navigation systems and consequently will positively influence the rate of direct network externalities. Another explanation may be that potential adopters who perceive a car navigation system as a highly complex product may have a greater need for informal support and additional information. According to literature both informal support (Song et al., in press) and the availability of (additional) information (Katz & Shapiro, 1985) are positively influenced by an innovation’s installed base. Therefore, in case of high perceptions of Complexity the (expected) value derived from an innovation’s installed base may be higher (i.e. higher rate of direct network externality effects). This last explanation implies that Complexity may influence the rate of direct network externalities also via other mechanisms than the one proposed in this study (via its effect on installed base).

With regard to indirect network externality effects it is striking that perceptions of Relative Advantage influence this type of network externality effects in a negative way. This is contrary to our hypothesis that perceptions of Relative Advantage will have a positive effect on indirect network externalities. In interpreting this finding we have to take into account that we only measured one aspect of Relative Advantage, namely the total costs of owning a car navigation system compared to Internet route planners. This means that the results of this study indicate that when the total costs of car navigation systems are perceived to be lower than the total costs of Internet route planners this will have a negative effect on the value derived from the availability of complementary goods and services. A possible explanation may be that producers or suppliers of complementary goods and/or services do not want to provide such goods and/or services for products that are perceived as being ‘cheaper’ than the preceding product or technology. That is, providers of complementary goods may be afraid of getting a ‘cheap’ image when they provide such goods for products that are associated with lower costs. This also implies that the decision whether or not to supply complementary goods and/or services may not be solely based on the size of an innovation’s installed base but may also be based directly on perceptions of Relative Advantage. Therefore, similar to the relationship between Complexity and direct network externalities, it might be that perceptions of Relative Advantage influence indirect network externality effects via other mechanisms than the mechanism proposed in this study (via installed base). Also the finding that Observability only (positively) influences indirect network externality effects seems to support the supposition that perceptions of innovation attributes may influence network externalities also via other mechanisms. Potential adopters do not seem to attach much value to the visibility (i.e. Observability) of a car navigation system in making their choice to adopt such a system, as becomes clear from the non-significant relationships with intention to adopt and direct network externalities. However, despite this seemingly absent influence on adoption decisions (and thus also on installed base) it may be that suppliers of complementary goods still prefer to supply these goods or services for an

innovation, just because the innovation is perceived as highly visible. That is, when a product is highly visible this means that complementary goods and their results will also be highly visible, something suppliers of such complementary goods will definitely prefer. Hence, this may explain the strong positive effect of perceptions of Observability on indirect network externalities.

6.2 Theoretical implications

The results of our study have some important theoretical implications. First, (to our knowledge) prior research has never investigated the possibility that perceptions of innovation attributes may influence the rate of network externalities. This study provides quite strong support for the suggestion that perceptions of innovation attributes may play an important role in shaping an innovation's network externality effects (instead of the other way around). Secondly, the fact that previous research has not investigated the influence that perceptions of innovation attributes may have on network externality effects automatically means that no research is done to possible mediating effects of network externality effects between perceptions of innovation attributes and the adoption of, or the intention to adopt, innovations. Our findings provide quite strong support for the proposition that direct network externality effects play an important mediating role between perceptions of innovation attributes and the intention to adopt innovations. This provides further evidence for the suggestion that the "Network Externalities" literature and the "Diffusions of Innovations" literature complement each other in explaining adoption decisions regarding innovations. Even more important is the contribution of this study to the Marketing (and New Product Development) literature, as this study adds to an increased understanding of the mechanisms that influence the adoption decisions regarding innovations with network externalities. More specifically, this study is the first study that demonstrates that the way in which different innovation attributes are perceived indeed may influence adoption decisions of potential adopters via network externality effects (in this case via direct network externalities). This is an important contribution because from literature it becomes clear that (in general) it is important to understand the factors that influence adoption and use decisions of potential customers in order to launch an innovation successfully (e.g. Van Slyke et al., 2007; Rogers, 2003; Frambach & Schillewaert, 2002; Majumdar & Venkataraman, 1998). A better understanding of the mechanisms that influence adoption decisions regarding (network externality) innovations implies that one also will be better able to predict the adoption of such innovations. On its turn, the more accurate and the sooner in the development process one is able to predict the adoption of an innovation, the better one will be able to adapt the product development process in such a way that the adoption-rate of the innovation is maximized. That is, being able to predict the adoption of an innovation in an early stadium of the development process, by having knowledge of the factors and mechanisms that influence the adoption(-rate) of that innovation, will importantly reduce the chance on an unexpected disappointing adoption-rate of the innovation. The sooner the adoption of an innovation can be predicted in an accurate way, the earlier in the development process one can anticipate on the adoption process of a specific innovation. Finally, this study provides an important contribution to the "Network Externalities" literature by proposing (new) measurement scales to measure network externality effects. Previous studies regarding network externalities and the adoption of innovations only focus on aspects or variables of network externalities, namely (perceptions of) installed base and/or (perceptions of) the availability of complementary goods (e.g. Song et al., in press; Berndt et al., 2003). This means that the value or utility derived from an innovation's installed base

and/or from the availability of complementary products is not measured at all. The proposed measures of (in)direct network externalities in this study better represent both types of network externality effects as defined in literature. This is because our measures focus on the (perceived) value or utility derived from an innovation as a function of that innovation's installed base, and as a function of the availability of complementary products and services.

6.3 Managerial implications

Besides the theoretical implications discussed in section 6.2 our results also have some implications for managers. However, it has to be taken into account that the framework presented in this paper has to be further validated by future (empirical) research.

Managers can use the framework proposed in this study to determine how perceptions of innovation attributes influence network externality effects and the intention to adopt an innovation (both directly as well as indirectly). That is, the framework shows managers how decision regarding specific characteristics of their innovation may impact network externalities and the intention of potential adopters to adopt their innovation. Our results show that managers should pay special attention to the Compatibility of an innovation as this innovation attribute seems to be a very important determinant of both types of network externalities. Besides, Compatibility positively influences the intention to adopt an innovation, both directly as well as indirectly (via direct network externalities). Therefore, our main advice to managers, who intent to bring an innovation that is characterized by network externalities to the market, is that they have to make sure that their "innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters" (definition Compatibility; Rogers, 2003, p. 15). This also means that managers have to emphasize the Compatibility aspect of their innovation in their promotion activities in order to convince potential adopters that the innovation fits their way of working, life style etc. Furthermore, this study shows that managers should emphasize the Image aspects of an innovation in their promotion activities. Our results indicate that when potential adopters associate an innovation with a high profile and/or prestige this will have an important positive effect on both types of network externalities and on the intention to adopt an innovation (via direct network externality effects). With regard to the other innovation attributes managers have to realize that these attributes do not have to influence both types of network externality effects in the same direction. Managers should keep in mind that high perceptions of Complexity and low perceptions of 'total costs of ownership' (i.e. total costs perceived to be lower than preceding innovation) may severely harm the rate of indirect network externality effects. This means that for innovations that are highly dependent on complementary goods and/or services managers should keep the complexity as low as possible, while economical advantages should not be emphasized too much when present. Besides, when the value or utility of an innovation is highly dependent on complementary products and/or services it is advisable to take into account the Observability of an innovation as this innovation attribute seems to be a very important determinant of indirect network externality effects.

The finding of this study that perceptions of innovation attributes act as determinants of network externality effects also has an economical implication for managers. As the utility (or value) of innovations with network externalities is dependent on the size of its user base managers will often use penetration pricing to maximize the installed base of an innovation (Mohr et al., 2005), which is needed to 'start up' network externality effects. Sometimes products are even given away for free in order to raise the user base of an innovation quickly. By

means of this study we have shown that network externality effects can also be enhanced or started up by focusing on specific characteristics of an innovation, like Compatibility and Image. That is, taking into account the specific characteristics of an innovation and their influences on network externality effects during the design, production and promotion of an innovation may lower the need for extreme low prices or even giving away the products for free when the product is marketed. This means that managers can save money by anticipating on how potential adopters will perceive the different characteristics or attributes of their innovation.

6.4 Limitations and Future research

Despite the careful design and execution of this study there are several limitations that should be addressed in future research. At the first place the results of our study are based on a single innovation, namely the car navigation system. Therefore, in order to evaluate the generalizability of our results this study should be replicated for other innovations than the car navigation system. Secondly, despite the use of mainly existing measurement scales for measuring the perceptions of innovation attributes our full model includes several one-item and two-item constructs. Although this does not have to be a problem Hair et al. (2006, p. 783) mention that “good practice dictates a minimum of three items per factor”. A low number of items may result in a situation in which not all aspects of a construct are measured. In this study this may have been especially the case for Relative Advantage as the one-item measure focuses only on the economical aspect, while it is theorized that there exist different types or dimensions of this innovation attribute (Van Slyke et al., 2007; Rogers, 2003). Therefore, future research should replicate our research incorporating broader measurement scales in order to validate our findings. This may require a critical review of existing measurement scales. The same is true for our measurement scales for direct (one item) and indirect (two items) network externalities. Another limitation of this study is the fact that actual adoption has not been measured. According to the Theory of Reasoned Action (TRA) intention to adopt is the immediate determinant of actual adoption (Ajzen & Fishbein, 1980) and Song et al. (in press) even mention that the results of their study provide support for the use of intention to purchase as a surrogate for actual adoption behavior. However, a high intention to adopt an innovation does not guarantee that the innovation will be actually adopted within a certain space of time, while a low intention to adopt an innovation does not guarantee that the innovation will not be adopted within a specific space of time. Therefore, a third future research direction might be to extend the current study by measuring actual adoption after a specified space of time, for example a year. An even more interesting future research direction would be to investigate how our framework fits into the whole “Theory of Reasoned Action model”. This means that besides actual behavior (i.e. actual adoption) also all other aspects of TRA, like attitude toward the behavior and subjective norm, should be taken into account. Fourthly, additional research is needed to the specific mechanisms through which perceptions of innovation attributes influence the rate of network externality effects. Some results of this study seem to indicate that innovation attributes may not always influence network externality effects (solely) via their effect on an innovation’s installed base. The question is which other mechanisms may explain the relationships between perceptions of innovation attributes and the rate of direct and indirect network externality effects. At last, our study did not take into account possible interrelationships between innovation attributes. According to Fliegel & Kivlin (1966) the possibility of interrelationships should be taken into account. The study of Holak and Lehmann (1990) already has provided supportive evidence for

the existence of several interrelationships between innovation attributes. Therefore, it is important that future research takes into account possible relationships between innovation attributes.

References

Ajzen, I., and Fishbein, M., *Understanding Attitudes and Predicting Social Behavior*, Englewood Cliffs (New Jersey): Prentice-Hall, 1980.

Bagozzi, R.P., Yi, Y., and Philips, L.W., "Assessing Construct Validity in Organizational Research", *Administrative Science Quarterly* 1991, 36 (6), p. 421-458.

Baron, R.M., and Kenny, D.A., "The Moderator-Mediator Variable Distinction in Social Psychological Research: Conceptual, Strategic, and Statistical Considerations", *Journal of Personality and Social Psychology* 1986, 51 (6), p. 1173-1182.

Basu, A., Mazumdar, T., and Raj, S.P., "Indirect Network Externality Effects on Product Attributes", *Marketing Science* 2003, 22 (2), p. 209-221.

Berndt, E.R., Pindyck, R.S., and Azoulay, P., "Consumption externalities and diffusion in pharmaceutical markets: Antiulcer drugs", *The Journal of Industrial Economics* 2003, 51 (2), p. 243-270.

Brynjolfsson, E., and Kemerer, C.F., "Network Externalities in Microcomputer Software: An Econometric Analysis of the Spreadsheet Market", *Management Science* 1996, 42 (12), p. 1627-1647.

Chakravarty, S., "Experimental Evidence on Product Adoption in the Presence of Network Externalities", *Review of Industrial Organization* 2003, 23 (3-4), p. 233-254.

Cooper, D.R., and Schindler, P.S., *business RESEARCH METHODS* (8th ed.), New York: McGraw-Hill/Irwin; 2003.

Davis, F.D., Bagozzi, R.P., and Warshaw, P.R., "User Acceptance of Computer Technology: A Comparison of Two Theoretical Models", *Management Science* 1989, 35 (8), p. 982-1003.

Dranove, D., and Gandal, N., "The DVD-vs.-DIVX Standard War: Empirical Evidence of Network Effects and Preannouncement Effects", *Journal of Economics & Management Strategy* 2003, 12 (3), p. 363-386.

Farrell, J., and Saloner, G., "Standardization, compatibility, and innovation", *Rand Journal of Economics* 1985, 16 (1), p. 70-83.

Fliegel, F.C., and Kivlin, J.E., "Attributes of Innovations as Factors in Diffusion", *The American Journal of Sociology* 1966, 72 (3), p. 235-248.

Fornell, C., and Larcker, D.F., "Evaluating Structural Equation Models with Unobservable Variables and Measurement Error", *Journal of Marketing Research* 1981, 18 (1), p. 39-50.

Frambach, R.T., and Schillewaert, N., “Organizational innovation adoption – A multi-level framework of determinants and opportunities for future research”, *Journal of Business Research* 2002, 55 (2), p. 163-176.

Gandal, N., “Competing Compatibility Standards and Network Externalities in the PC Software Market”, *The Review of Economics and Statistics* 1995, 77 (4), p. 599-608.

Gupta, S., Jain, D.C., and Sawhney, M.S., “Modeling the Evolution of Markets with Indirect Network Externalities: An Application to Digital Television”, *Marketing Science* 1999, 18 (3), p. 396-416.

Hair, J.F., Black, W.C., Babin, B.J., Anderson, R.E., and Tatham, R.L., *Multivariate Data Analysis* (6th ed.), Upper Saddle River (New Jersey): Pearson Prentice Hall, 2006.

Handfield, R.B., and Pagell, M.D., “An analysis of the diffusion of flexible manufacturing systems”, *International Journal of Production Economics* 1995, 39 (3), p. 243-253.

Hargadon, A.B., and Douglas, Y., “When Innovations Meet Institutions: Edison and the Design of the Electric Light”, *Administrative Science Quarterly* 2001, 46 (3), p. 476-592.

He, Q., Duan, Y., Fu, Z., and Li, D., “An Innovation Adoption Study of Online E-Payment in Chinese Companies”, *Journal of Electronic Commerce in Organizations* 2006, 4 (1), p. 48-69.

Hellofs, L.L., and Jacobson, R., “Market Share and Customers’ Perceptions of Quality: When Can Firms Grow Their Way to Higher Versus Lower Quality”, *Journal of Marketing* 1999, 63 (1), p. 16-25.

Hill, C.W.L., “Establishing a standard: Competitive strategy and technological standards in winner-take-all industries”, *The Academy of Management Executive* 1997, 11 (2), p. 7-25.

Holak, S.L., “Determinants of Innovative Durables Adoption – An Empirical Study with Implications for Early Product Screening”, *Journal of Product Innovation Management* 1988, 5 (1), p. 50-69.

Holak, S.L., and Lehmann, D.R., “Purchase Intentions and the Dimensions of Innovation: An Exploratory Model”, *Journal of Product Innovation Management* 1990, 7 (1), p. 59-73.

Inceoglu, F., and Park, M., “Diffusion of a New Product under Network Effects: The Case of U.S. DVD Player Market”, *Department of Economics Boston University* 2003, p. 1-32.

Katz, M.L., and Shapiro, C., “Network Externalities, Competition, and Compatibility”, *The American Economic Review* 1985, 75 (3), p. 424-440.

Kauffman, R.J., McAndrews, J., and Wang, Y., "Opening the "Black Box" of Network Externalities in Network Adoption", *Information Systems Research* 2000, 11 (1), p. 61-82.

Majumdar, S., and Venkataraman, S., "Network effects and the adoption of new technology: Evidence from the U.S. telecommunications industry", *Strategic Management Journal* 1998, 19 (11), p. 1045-1062.

Mohr, J., Sengupta, S., and Slater, S., *Marketing of High-Technology Products and Innovations* (2nd ed.), Upper Saddle River (New Jersey): Pearson Prentice Hall, 2005.

Moore, G.C., and Benbasat, I., "Development of an Instrument to Measure the Perceptions of Adopting an Information Technology Innovation", *Information Systems Research* 1991, 2 (3), p. 192-222.

Padmanabhan, V., Rajiv, S., and Srinivasan, K., "New Products, Upgrades, and New Releases: A Rationale for Sequential Product Introduction", *Journal of Marketing Research* 1997, 34 (4), p. 456-472.

Redmond, W.H., "When Technologies Compete: The Role of Externalities in Nonlinear Market Response", *Journal of Product Innovation Management* 1991, 8 (3), p. 170-183.

Rogers, E.M., *Diffusion of Innovations* (5th ed.), New York: Free Press, 2003.

Schilling, M.A., "Technological lockout: An integrative model of the economic and strategic factors driving technology success and failure", *Academy of Management Review* 1998, 23 (2), p. 267-284.

Schilling, M., "Winning the Standards Race: Building Installed Base and the Availability of Complementary Goods", *European Management Journal* 1999, 17 (3), p. 265-274.

Schilling, M.A., "Technology success and failure in winner-take-all markets: The impact of learning orientation, timing, and network externalities", *Academy of Management Journal* 2002, 45 (2), p. 387-398.

Shurmer, M., "An investigation into sources of network externalities in the packaged PC software market", *Information Economics and Policy* 1993, 5 (3), p. 231-251.

Song, M., Parry, M.E., and Read, S., "Do relative advantage and trialability mediate the relationships between network externalities and adoption?", *Article in press*.

Song, M., and Read, S., "DINAM: Direct and Indirect Network Externalities Adoption Model", *Unpublished paper*.

Van Slyke, C., Ilie, V., Lou, H., and Stafford, T., "Perceived critical mass and the adoption of a communication technology", *European Journal of Information Systems* 2007, 16 (3), p. 270-283.

Venkatesh, V., and Davis, F.D., “A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies”, *Management Science* 2000, 46 (2), p. 186-204.

Venkatesh, V., Morris, M.G., Davis, G.B., and Davis, F.D., “User Acceptance of Information Technology: Toward a Unified View”, *MIS Quarterly* 2003, 27 (3), p. 425-478.

Appendix A: Questionnaire Items and Cronbach's α 's

Image $\rightarrow \alpha = 0.80$

IM1: People who own a car navigation system would have more prestige than those who do not.

IM2: People who own a car navigation system have a high profile.

Extremely Unlikely	Neutral						Extremely Likely			
0	1	2	3	4	5	6	7	8	9	10
0	1	2	3	4	5	6	7	8	9	10
0	1	2	3	4	5	6	7	8	9	10

Relative Advantage (Reversed)

RA1R: Compared to Internet route planners, the total costs of owning a car navigation system would be higher.

0	1	2	3	4	5	6	7	8	9	10
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Complexity

CO1: It would be frustrating for me to operate a car navigation system.

0	1	2	3	4	5	6	7	8	9	10
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Observability $\rightarrow \alpha = 0.72$

OB1: It is easy for me to observe others using car navigation systems.

OB2: I have had plenty of opportunity to see the car navigation system being used.

0	1	2	3	4	5	6	7	8	9	10
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0	1	2	3	4	5	6	7	8	9	10
---	---	---	---	---	---	---	---	---	---	----

Compatibility $\rightarrow \alpha = 0.86$

CA1: Using a car navigation system fits into my life style.

CA2: Using a car navigation system fits well with the way I like to drive.

CA3: Using a car navigation system is compatible with all aspects of my driving style.

0	1	2	3	4	5	6	7	8	9	10
---	---	---	---	---	---	---	---	---	---	----

0	1	2	3	4	5	6	7	8	9	10
---	---	---	---	---	---	---	---	---	---	----

0	1	2	3	4	5	6	7	8	9	10
---	---	---	---	---	---	---	---	---	---	----

Triability

TR1: It would be easy for me to find a place to satisfactorily try out various uses of car navigation systems.

0	1	2	3	4	5	6	7	8	9	10
---	---	---	---	---	---	---	---	---	---	----

Direct Network Externalities

DE1: I would be willing to pay more for a car navigation system if more people own such a system.

0	1	2	3	4	5	6	7	8	9	10
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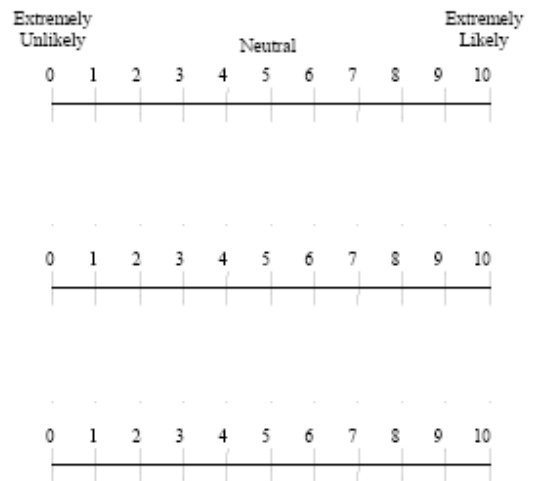
Indirect Network Externalities → $\alpha = 0.77$

IE1: The more up-to-the minute traffic information (traffic-jams, free parking places) available, the more valuable is a car navigation system to me.

IE2: A car navigation system is more valuable to me when also up-to-the minute traffic information (traffic-jams, free parking places) becomes available.

Intention to Adopt

AD1: How likely will you purchase a car navigation system in the next 12 months?



Appendix B: Results Exploratory Factor Analysis

◆ Rotated Component Matrix^a

	Component			
	1	2	3	4
CA2	.876			
CA3	.863			
CA1	.835			
IM2		.908		
IM1		.888		
IE1			.892	
IE2			.862	
OB1				.890
OB2				.846

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

^aRotation converged in 5 iterations.

◆ Total Variance Explained

Component	Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.304	36.709	36.709	2.344	26.042	26.042
2	1.571	17.458	54.167	1.673	18.591	44.634
3	1.240	13.781	67.948	1.636	18.179	62.812
4	1.111	12.346	80.294	1.573	17.482	80.294
5						
6						
7						
8						
9						

Extraction Method: Principal Component Analysis.

Appendix C: Results Confirmatory Factor Analysis

◆ Goodness of Fit Statistics

Degrees of Freedom = 21

Minimum Fit Function Chi-Square = 23.244 (P = 0.331)

Normal Theory Weighted Least Squares Chi-Square = 22.762 (P = 0.357)

Estimated Non-centrality Parameter (NCP) = 1.762

90 Percent Confidence Interval for NCP = (0.0 ; 17.571)

Minimum Fit Function Value = 0.0515

Population Discrepancy Function Value (F0) = 0.00391

90 Percent Confidence Interval for F0 = (0.0 ; 0.0390)

Root Mean Square Error of Approximation (RMSEA) = 0.0136

90 Percent Confidence Interval for RMSEA = (0.0 ; 0.0431)

P-Value for Test of Close Fit (RMSEA < 0.05) = 0.985

Expected Cross-Validation Index (ECVI) = 0.157

90 Percent Confidence Interval for ECVI = (0.153 ; 0.192)

ECVI for Saturated Model = 0.200

ECVI for Independence Model = 3.947

Chi-Square for Independence Model with 36 Degrees of Freedom = 1762.239

Independence AIC = 1780.239

Model AIC = 70.762

Saturated AIC = 90.000

Independence CAIC = 1826.262

Model CAIC = 193.490

Saturated CAIC = 320.116

Normed Fit Index (NFI) = 0.987

Non-Normed Fit Index (NNFI) = 0.998

Parsimony Normed Fit Index (PNFI) = 0.576

Comparative Fit Index (CFI) = 0.999

Incremental Fit Index (IFI) = 0.999

Relative Fit Index (RFI) = 0.977

Critical N (CN) = 756.399

Root Mean Square Residual (RMR) = 0.112

Standardized RMR = 0.0183

Goodness of Fit Index (GFI) = 0.989

Adjusted Goodness of Fit Index (AGFI) = 0.976

Parsimony Goodness of Fit Index (PGFI) = 0.461

Appendix D: Results Full Model Estimation

◆ Goodness of Fit Statistics

Degrees of Freedom = 47

Minimum Fit Function Chi-Square = 90.479 (P = 0.000143)

Normal Theory Weighted Least Squares Chi-Square = 88.802 (P = 0.000221)

Estimated Non-centrality Parameter (NCP) = 41.802

90 Percent Confidence Interval for NCP = (19.042 ; 72.373)

Minimum Fit Function Value = 0.201

Population Discrepancy Function Value (F0) = 0.0927

90 Percent Confidence Interval for F0 = (0.0422 ; 0.160)

Root Mean Square Error of Approximation (RMSEA) = 0.0444

90 Percent Confidence Interval for RMSEA = (0.0300 ; 0.0584)

P-Value for Test of Close Fit (RMSEA < 0.05) = 0.729

Expected Cross-Validation Index (ECVI) = 0.454

90 Percent Confidence Interval for ECVI = (0.404 ; 0.522)

ECVI for Saturated Model = 0.466

ECVI for Independence Model = 5.681

Chi-Square for Independence Model with 91 Degrees of Freedom = 2533.907

Independence AIC = 2561.907

Model AIC = 204.802

Saturated AIC = 210.000

Independence CAIC = 2633.499

Model CAIC = 501.396

Saturated CAIC = 746.937

Normed Fit Index (NFI) = 0.964

Non-Normed Fit Index (NNFI) = 0.966

Parsimony Normed Fit Index (PNFI) = 0.498

Comparative Fit Index (CFI) = 0.982

Incremental Fit Index (IFI) = 0.983

Relative Fit Index (RFI) = 0.931

Critical N (CN) = 362.103

Root Mean Square Residual (RMR) = 0.159

Standardized RMR = 0.0263

Goodness of Fit Index (GFI) = 0.973

Adjusted Goodness of Fit Index (AGFI) = 0.939

Parsimony Goodness of Fit Index (PGFI) = 0.435