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DOI 10.1007/s11135-012-9791-3

A network approach toward literature review

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Abstract This study introduces a method that uses a network approach towards literature review. To employ this approach, we use hypotheses proposed in scientific publications as building blocks. In network terms, a hypothesis is a directed tie between two concepts or nodes. The network emerges by aggregating the hypotheses from a set of articles in a specific domain. This study explains the method and its potential for reviewing literature in a particular domain. As a proof of concept, we provide a case study reviewing the research literature on the adoption of eGovernment services. Our analyses show that a network approach towards literature review provides novel insights into the current state of a research domain. Although there are limitations, this approach has the potential to help scholarly communities focus their research and formulate new research questions.

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Published online: 10 November 2012

Keywords Network analysis · Literature review · Meta-analysis · eGovernment

1 Standing on the shoulders of giants

One of the critical steps in any scientific enterprise is a literature review. By building on the theoretical and empirical findings of others, researchers situate their proposed intellectual advances within existing theoretical frameworks. 'Standing on the shoulders of giants' is a metaphor that is used to express how future research projects are shaped by the insights of researchers from the past. More formally, De Groot (1969) defines the development of scientific knowledge as the incessant movement of induction and deduction between the empirical and theoretical world. Hypotheses form the link between these two worlds.

While taking these starting points into account, we can see that the exponential growth of research, and as a consequence academic literature, across the scientific enterprise has drawbacks along with benefits. One negative consequence is the increasing difficulty of maintaining an overview of all available research results in a specific area. Using search engines and bibliometric tools such as Google Scholar, Scopus or the Web of Science, we are able to find published research, but this stops short of enabling us to synthesize what we know about relevant relations among the large and growing corpus of results. An additional challenge posed by the extensive growth of academic literature is that for virtually any claim a researcher wants to make there are numerous citations available. Therefore it is increasingly challenging for a 'classic' literature review to comprehensively catalog the vast amount of available knowledge.

Fortunately, more systematic ways of conducting literature research are available. Meta-analysis (Light and Pillemer 1984) and longitudinal meta-analysis (Maas et al. 2004), for example, combine the results from several studies that address a single hypothesis. The strength of meta-analysis lies in the fact that it uses the hypothesis (defined as a proposed explanation for an observable phenomenon) as the core building block of scientific knowledge. This allows for a more robust aggregated estimate of the true effect across multiple studies as compared to those derived from a single study under a single set of assumptions and conditions. Meta-analysis then, results in a systematic overview of effect sizes for a specific hypothesis.

Although meta-analysis helps us to conduct a more objective and systematic form of literature review, it tends to focus on either a single hypothesis or a small set of hypotheses. However, theoretical frameworks in social science tend not to consist of a single hypothesis, but rather form sets of interrelated hypotheses, expressed in conceptual models (Dooley 2009). Empirical research studies typically test five to ten interrelated hypotheses, rather than a single one.

The need for a systematic approach towards literature review as well as the interrelatedness of hypotheses suggests that a network approach toward literature research would be appropriate to generate insight into the theoretical foundations of a specific research domain. The goal of this study, therefore, is to introduce a method for using a network approach towards literature review. This method combines the strengths of meta-analysis (objective, systematic) with the visual-analytics offered by network methods. The method seeks to simplify mapping the complexity of research in the social sciences as well as to reveal knowledge gaps in existing research in a specific research domain or paradigm. In this study, we leverage our experiences reviewing literature combined with network analysis in different research areas (Bouwman et al. 2006; Van de Wijngaert et al. 2006, 2008). To provide a proof of concept, we present, as a case study, a network approach to review the literature on the adoption of eGovernment services. Next, we elaborate on ways to test the reliability and validity of the method. We conclude by discussing some limitations as well as directions for further research.

2 A network approach toward literature review

Hypotheses that have been posed, empirically tested and published in academic journals articles or book chapters are central to the proposed method for literature review. A hypothesis is conceptualized as a relationship between two concepts. Al-adawi et al. (2005), for example, hypothesize that the intention to 'get online government information' is influenced by trust, perceived risks, and perceived ease of use. Using these and a number of other concepts, Al-adawi et al. developed a set of related hypotheses and presented them as their conceptual model. In total, they defined 15 different hypotheses using 12 different concepts. The original model they tested is shown on the left side, and the network representation on the right side of Fig. 1.

Taking a network approach (Wasserman and Faust 1994), we define the two concepts in a hypothesis as nodes in the network and the hypothesis relating one to the other as a directed tie. Conceptual causal models such as structural equation modeling (SEM) reflect the network structure for a single study.

The network representation of the conceptual model by Al-adawi et al. (2005) bears a structural resemblance to the conceptual model. However, the network representation includes additional information, that can be computed using network metrics. The additional information relates to the notion of independent and dependent concepts. Dooley (2009) points out that any theory must choose certain concepts as starting points. These are called exogenous constructs or independent concepts because their causes are outside the purview of the theory or model.. Dependent concepts are endogenous constructs because their causes appear in the model and are dependent on others. In a network approach, these notions translate to in-degree and out-degree (Wasserman and Faust 1994). In network terms, in-degree is the number of incoming ties. In this study, in-degree indicates that the extent to which a concept has served as a dependent concept among hypotheses. That indicates the extent to which a concept is the object of explanation. In Fig. 1, we size concepts that are more frequently posed as dependent concepts as larger nodes. Out-degree reveals the extent to which a concept is used as an explanatory concept. The shape and color of nodes refer to the ratio between in-degree and out-degree. A white circle represents an independent concept, while a dark square represents a dependent concept. The mid-grey diamond-shaped nodes represent mediating concepts, which are both explained by other constructs and in turn explain other concepts.

Using this approach, in addition to mapping the network of van Al-adawi et al. (2005) study, we can generate a network that cumulatively maps the network of concepts and causal relations across a corpus of studies within a particular domain. By doing so, we extend the advantages of meta-analysis which summarize the effect sizes of single hypotheses (or "dyads" in network terms), by cumulatively examining the effect sizes of multiple hypotheses within a particular domain (or "structure" in network terms). Later we will present a case study of such a network. But before we discuss this case study, we outline in the next section the type of analyses that can be done and some practical guidelines for performing a literature study using network analysis.

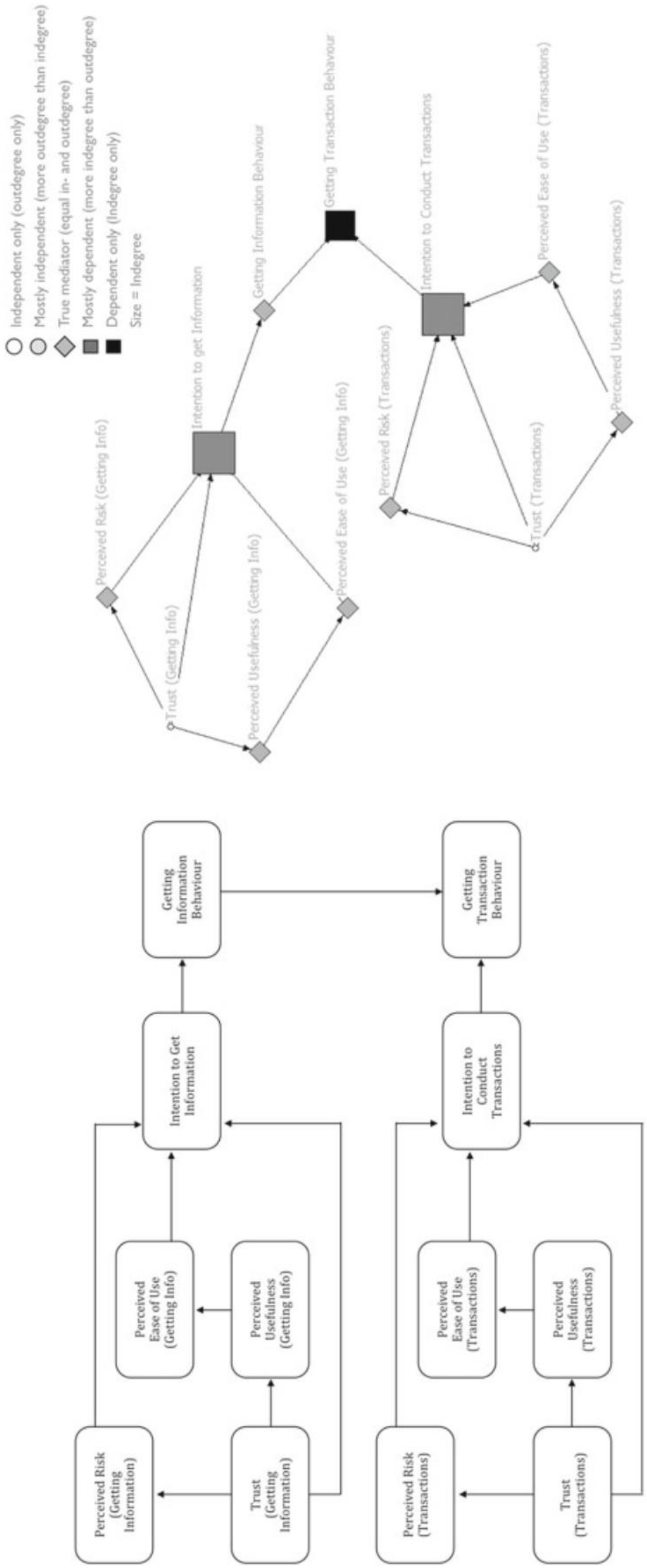


Fig. 1 The conceptual model of Al-adawi et al. (2005) (*left*) and its network representation (*right*)

2.1 Network measures

In addition to visualizing the network we can also analyze network, using metrics computed at the node, dyad and network levels. These metrics provide a descriptive overview of the work that has been done in a specific research area.

2.1.1 Measures at the node level

We can identify different roles played by concepts in a network by investigating their in- and out-degree. We can, for example, see which concepts are used most frequently as endogenous or exogenous factors. A concept with (mostly) outgoing relations can be considered an exogenous concept. Concepts with (mostly) incoming relations are endogenous. Concepts that have both incoming and outgoing relations are mediating concepts. Additionally, we can investigate how different concepts are positioned within a network (e.g. as brokers or bridges). Other measures that can be used are, for example, closeness (the total distance to all other nodes) and betweenness (the probability that a specific node occurs on the shortest path between two nodes) and structural holes (Burt 1995). Wasserman and Faust (1994) provide a comprehensive description of these measures. In terms of the concept networks that we are using here, there measures provide us with information regarding their role in the network. For example, betweenness indicates the degree to which a concept functions as a crucial explanatory mediating variable between other concepts. These measures may provide insight into the possibility of omitting concepts or showing the need for new ones.

2.1.2 Measures on the dyadic and subgroup levels

At the dyadic and subgroup level, we can, for example, investigate how a hypothesis is positioned within the network. Measures that might be used here include distance, components and cliques (clusters of concepts that are connected more strongly to each other than to other clusters of concepts in the network). These can show subareas within a specific research area.

2.1.3 Measures on the network level

At the network level, one can, for example, look at density or investigate the presence of transitivity or recursive reasoning. The most common measure at the network level is density, which is especially relevant when comparing different parts of the model. A dense network would indicate lack of parsimony in the theoretical framework. Typically core concepts of certain theories or paradigms will be heavily researched, while new contributions to theory development, illustrated by more recently added concepts, will show a more peripheral position. One can also compare the density of the network of hypotheses that were posed to the density of the network of hypotheses that were supported (or empirically validated). The difference in density between the network of hypotheses posted and those supported provides insight into the robustness of the theory: a large difference indicates that hypotheses deduced from the theory are not supported..

The network approach enables us to characterize a theoretical framework within a single domain, across domains, and across time. We discuss each of these scenarios next. First, it is possible to use network approaches to characterize the nature of conceptual relationships within a domain by investigating the structural signatures within the network of hypothesized relations. From the analysis of the network structure we gain insights such as: to what

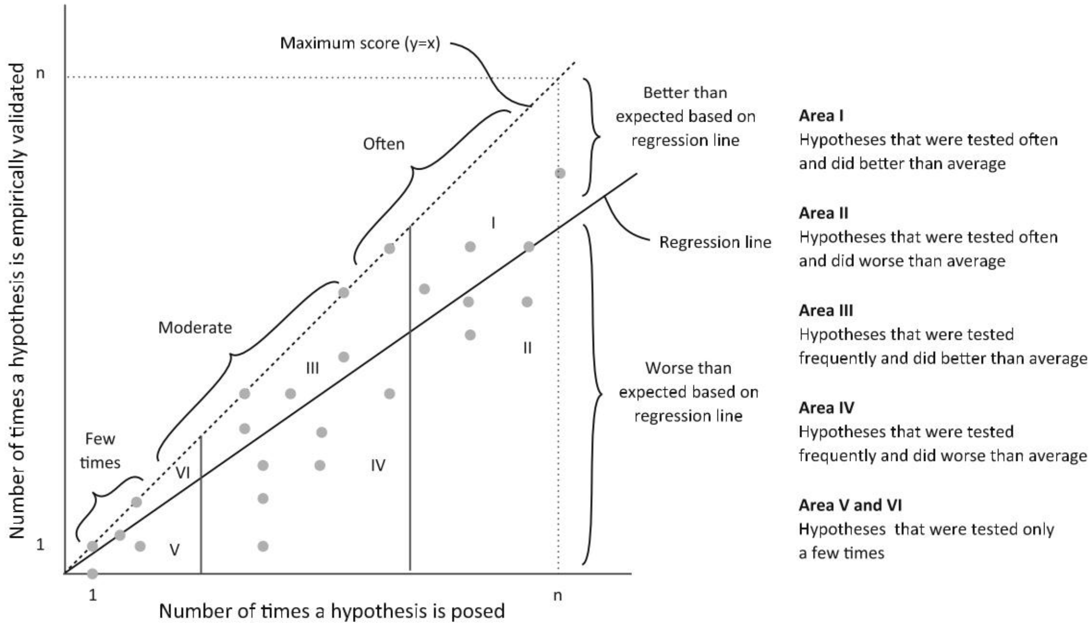


Fig. 2 Value of different concepts

extent is the theoretical focus structured around a few core concepts? To what degree are the hypothesized relations transitive (A causing B causing C, implies that A also causes C), or cyclic (A causing B causing C causing A)? Or, to what degree do the attributes of concepts (cognitive versus behavioral for instance) explain why they might be connected. Question such as these can be statistically addressed using Exponential Random Graph (or p*) models (Contractor et al. 2006; Frank and Strauss 1986; Robins et al. 2007; Wasserman and Pattison 1996).

Second, the network approach enables investigation about the generalizability of a theoretical framework across domains. One example is to compare the research on the Technology Acceptance Model (TAM) in the domain of eGovernment to the research on TAM in the domain of ecommerce. We can use correlational approaches to assess the extent to which hypothesized relations between concepts were more, less or equally likely to be confirmed between these two distinct domains. Alternatively we might explore why different concepts are used or how the same concept may play a different role in the theoretical network of hypothesized relationships for different research domains.

Third, the network approach enables us to characterize changes in a theoretical domain over time. For instance, when, where, and how are concepts and hypotheses introduced over a period of time. By examining the data annually, we can for example investigate if some core concepts have become more or less centralized, or if new concepts and hypotheses are attracting more attention. This can be interpreted as a shift of focus on a more limited, more broader or a more specific set of concepts. These patterns would suggest a future trajectory of research within a theoretical paradigm. A stochastic oriented model to study longitudinal networks proposed by Snijders (2005), is particularly appropriate to address these questions.

Finally network approaches also afford the possibility to assess the extent to which hypotheses that have been posed (or tested) are empirically validated. Figure 2 shows a visual representation (using hypothetical data) of this idea. The x-axis shows the number of times a hypothesis was posed. The y-axis shows the number of times a hypothesis was empirically validated. Consequently, the dotted line (y = x) represents the scenario where all proposed hypotheses are empirically validated score. The solid line shows the actual regression line and partitions those hypotheses that score above what is expected from those that score below what is expected. By (roughly) dividing the x-axis into three parts, we can distinguish between the core hypotheses (which have high scores on the x axis), the hypotheses that are frequently tested (which have medium scores on the x axis) and concepts that are tested only a few times (which have low scores on the x axis). The different areas in the scatter plot offer insights into the empirical validity of various components of the theoretical framework. Area I, for example, forms the core of the theoretical framework. It includes hypotheses that are both posited and empirically validated with high frequency. Further research testing these hypotheses is not likely to provide any new knowledge. On the other hand, hypotheses in Area III may be very promising for further research. These concepts have been tested a moderate number of times but are empirically validated more frequently than would be expected for the entire theoretical domain. In contrast, hypotheses in Area IV do not appear to contribute to the understanding of a specific phenomenon. Hypotheses in Areas V and VI can be considered as ‘up and coming’. They have been tested only a few times and could ‘grow’ into Areas III or IV. Of course this comparison does not take the amount of variance a hypothesis explains into account.

2.2 Practical guidelines

While the previous section focused on the conceptual basis for the network approach towards literature review, this section outlines some practical guidelines for performing a literature review using the network approach. These guidelines will be illustrated in the following section using as a case study a review of the literature on the adoption of eGovernment services.

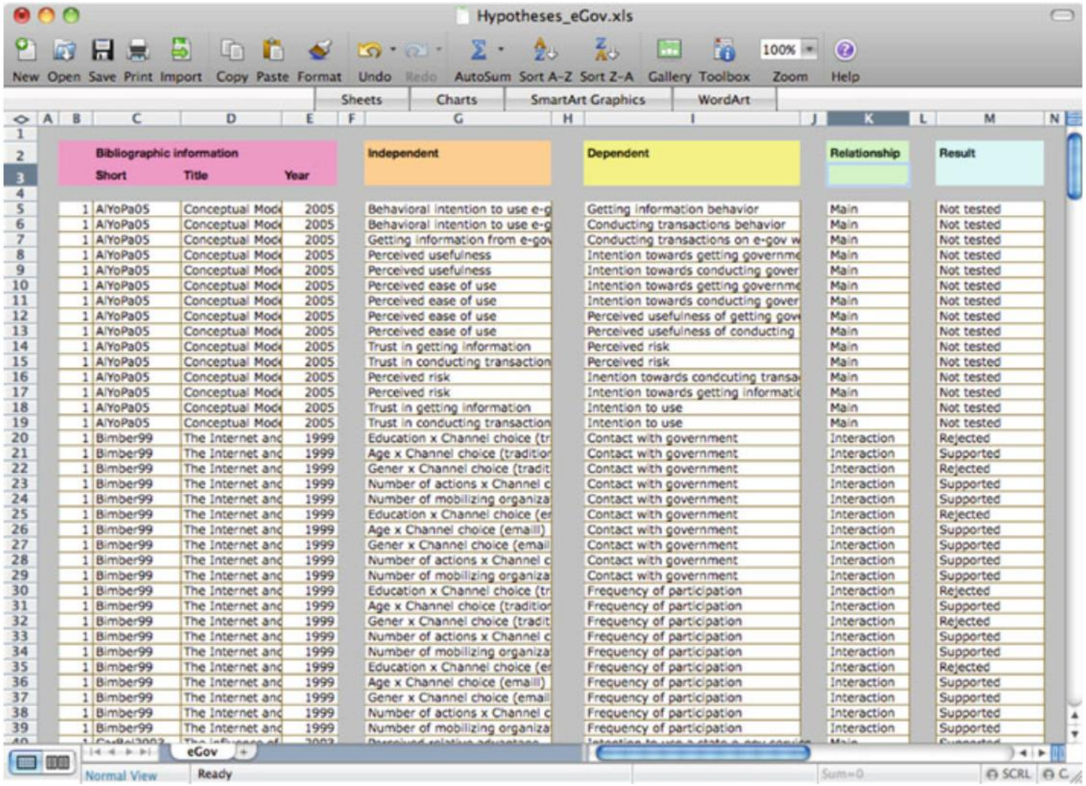
2.2.1 Selection of studies

The first issue at hand when doing a literature review is the question of which studies to include. Here, the normal rules (and limitations) for study selection apply. Some studies formulate explicit hypotheses, making it relatively easy to extract nodes and relations. Other studies focus on a specific aspect. For instance, Terpsiadou and Economides (2009), do not propose explicit hypotheses but clearly focus on gender differences in eGovernment use. Yet others studies have a more narrative structure and/or take a more qualitative approach. However, that does not mean that no concepts or relations can be extracted. West (2004), for example, does not formulate any explicit hypotheses but clearly argues that a relationship exists between use of eGovernment services, democratic responsiveness and public attitudes. For the sake of simplicity, we only use studies that have formulated explicit hypotheses in our case study.

2.2.2 Data gathering

Once we know which studies we want to include, we begin the phase of data extraction. We used a spreadsheet to gather information about the paper. These included:

- *bibliographic information* e.g. short title, long title, year, authors and name journal;
- *information about the research project* e.g. sample type and size, research design, theoretical framework;



Hypotheses_eGov.xls

		Bibliographic information: Short	Title	Year	Independent	Dependent	Relationship	Result
5	1	AlYoPa05	Conceptual Mod	2005	Behavioral intention to use e-g	Getting information behavior	Main	Not tested
6	1	AlYoPa05	Conceptual Mod	2005	Behavioral intention to use e-g	Conducting transactions behavior	Main	Not tested
7	1	AlYoPa05	Conceptual Mod	2005	Getting information from e-gov	Conducting transactions on e-gov w	Main	Not tested
8	1	AlYoPa05	Conceptual Mod	2005	Perceived usefulness	Intention towards getting governme	Main	Not tested
9	1	AlYoPa05	Conceptual Mod	2005	Perceived usefulness	Intention towards conducting gover	Main	Not tested
10	1	AlYoPa05	Conceptual Mod	2005	Perceived ease of use	Intention towards getting governme	Main	Not tested
11	1	AlYoPa05	Conceptual Mod	2005	Perceived ease of use	Intention towards conducting gover	Main	Not tested
12	1	AlYoPa05	Conceptual Mod	2005	Perceived ease of use	Perceived usefulness of getting gov	Main	Not tested
13	1	AlYoPa05	Conceptual Mod	2005	Perceived ease of use	Perceived usefulness of conducting	Main	Not tested
14	1	AlYoPa05	Conceptual Mod	2005	Trust in getting information	Perceived risk	Main	Not tested
15	1	AlYoPa05	Conceptual Mod	2005	Trust in conducting transaction	Perceived risk	Main	Not tested
16	1	AlYoPa05	Conceptual Mod	2005	Perceived risk	Inention towards condcuting transa	Main	Not tested
17	1	AlYoPa05	Conceptual Mod	2005	Perceived risk	Intention towards getting informati	Main	Not tested
18	1	AlYoPa05	Conceptual Mod	2005	Trust in getting information	Intention to use	Main	Not tested
19	1	AlYoPa05	Conceptual Mod	2005	Trust in conducting transaction	Intention to use	Main	Not tested
20	1	Bimber99	The Internet and	1999	Education x Channel choice (tr	Contact with government	Interaction	Rejected
21	1	Bimber99	The Internet and	1999	Age x Channel choice (traditio	Contact with government	Interaction	Supported
22	1	Bimber99	The Internet and	1999	Gener x Channel choice (tradit	Contact with government	Interaction	Rejected
23	1	Bimber99	The Internet and	1999	Number of actions x Channel c	Contact with government	Interaction	Supported
24	1	Bimber99	The Internet and	1999	Number of mobilizing organiza	Contact with government	Interaction	Supported
25	1	Bimber99	The Internet and	1999	Education x Channel choice (e	Contact with government	Interaction	Rejected
26	1	Bimber99	The Internet and	1999	Age x Channel choice (emaill)	Contact with government	Interaction	Supported
27	1	Bimber99	The Internet and	1999	Gener x Channel choice (emai	Contact with government	Interaction	Supported
28	1	Bimber99	The Internet and	1999	Number of actions x Channel c	Contact with government	Interaction	Supported
29	1	Bimber99	The Internet and	1999	Number of mobilizing organiza	Contact with government	Interaction	Supported
30	1	Bimber99	The Internet and	1999	Education x Channel choice (tr	Frequency of participation	Interaction	Rejected
31	1	Bimber99	The Internet and	1999	Age x Channel choice (traditio	Frequency of participation	Interaction	Supported
32	1	Bimber99	The Internet and	1999	Gener x Channel choice (tradit	Frequency of participation	Interaction	Rejected
33	1	Bimber99	The Internet and	1999	Number of actions x Channel c	Frequency of participation	Interaction	Supported
34	1	Bimber99	The Internet and	1999	Number of mobilizing organiza	Frequency of participation	Interaction	Supported
35	1	Bimber99	The Internet and	1999	Education x Channel choice (e	Frequency of participation	Interaction	Rejected
36	1	Bimber99	The Internet and	1999	Age x Channel choice (emaill)	Frequency of participation	Interaction	Supported
37	1	Bimber99	The Internet and	1999	Gener x Channel choice (emai	Frequency of participation	Interaction	Supported
38	1	Bimber99	The Internet and	1999	Number of actions x Channel c	Frequency of participation	Interaction	Supported
39	1	Bimber99	The Internet and	1999	Number of mobilizing organiza	Frequency of participation	Interaction	Supported

Fig. 3 Screenshot of the raw data

- *information about the hypotheses* independent and dependent concepts as defined by the authors in the hypotheses;
- *characteristics of the relationship* e.g. main or interaction, positive, negative, correlational, causal;
- *results* e.g. supported, rejected, not tested, *p*-value, strength of the relationship;
- *remarks* any other issues, such as the researcher's opinion about the research.

Figure 3 shows a snippet of the spreadsheet of the data that were gathered for the eGovernment case used in this paper.

The more information that is added to the spreadsheet, the more opportunities a researcher has to analyze data in different ways. An obvious comparison would be to compare supported and rejected hypotheses. Other opportunities might be to compare the hypotheses from A (high impact)-journals to those from B- or C-rated journals and/or to perform a year-by-year analysis. This analysis could provide insight into the degree with which journals are innovative (or replicative) in terms of the hypotheses that are studied.

2.2.3 Unification and aggregation

An issue that requires attention is the aggregation of data that is gathered from different studies. Different research projects have different objectives and are executed in different contexts. Moreover, the research procedures followed and measurements of concepts may differ. Different researchers may measure the same or a closely related concept in different ways, or even use different scale items for similar concepts. This raises the question of whether aggregation across studies can be carried out while taking into account the fact that different assumptions may underlie different measurements. Although this is a challenge for the proposed method, this issue also applies to other methods, such as meta-analysis, that review literature on concepts and their measurement across multiple studies.. For network analysis it is important to avoid getting too large a set of nodes, e.g. concepts that partly overlap. Therefore, the unification and aggregation of different concepts into a single node is an important step in the research process.

Unification refers to the fact that different researchers may use different labels for the same phenomena. One researcher may use 'gender' as a term whereas another may use 'sex' or even 'm/f'. While some may consider these as different concepts, if we want, we can rename these concepts to get a single node for a single concept. This unification process is fairly straightforward. More problematic is the aggregation of concepts that are measured based on measured and un-measured (latent) scales. The degree of aggregation is arbitrary, as it is in other methods to review literature, and depends on the evaluation by the researcher who does the analysis. By adding an extra column in the spreadsheet for the aggregated concepts, researchers can always go back and forth between the concepts as depicted by the original authors and their own (aggregated) concepts. Making the aggregation decisions explicit, enables reviewers and readers to gain insights and assess the plausibility and correctness of the choices made by the researcher. . From a more practical point of view, we define the selection of studies based on the same theoretical basis or paradigm, in the same or closely related research domain(s). This approach provides systematic insight into the state of the art of existing research.

2.2.4 Interaction effects

Hypotheses that include interaction effects is another issue that needs special attention. Two concepts interact if the effect of one of the concepts differs, depending on the level of the other concept. This effect is not easily modeled in network terms because it is only possible to connect one node to another. To solve this problem, we use the same approach that is used in a regression analysis. Here the interaction effect of, say Concept A and Concept B, is denoted as an additional node in the network labeled 'Concept A × Concept bA'. In the future, hypergraphs approaches may help address this problem since a hyperedge, unlike a regular edge, allows for an edge to exist between more than two nodes.

2.2.5 Analysis of the data

Once the data are extracted from the studies, we transform the list of hypotheses from the datasheet into network data. We do this by making use of the edgelist format in which an edges are defined by the combination of an independent and a dependent variable on each line in the dataset. For this, we use the DL format (Borgatti et al. 2002). The first lines of a DL file are shown below for the hypotheses of main effects that were empirically validated:

This DL-file can be imported in social network software such as UCINET and Netdraw (Borgatti et al. 2002), which enables the computation of network metrics and the possibility to create visualizations of the network. Of course also other software tools such as Visone could be used.

3 Case study eGovernment adoption

This section describes how the method works in practice using the TAM as a theoretical basis and the case of adoption of eGovernment services as a research domain. In the following

```
dl nr=26
nc=26
format=edgelist1
labels embedded
data:
"Ease of use"  "Behavioral intention"
"Ease of use"  "Credibility"
"Ease of use"  "Usefulness"
"Self efficacy"  "Credibility"
"Self efficacy"  "Ease of use"
…etc
!
```

subsections, we will describe specific parts of the method: selection of studies, data gathering and results. Before we do this, we will first motivate the choice for the case of eGovernment adoption and TAM in more detail.

3.1 The choice for eGovernment adoption and TAM

There is a growing belief that by implementing online services the Government becomes easily accessible to citizens as well as more effective. This vision is used to justify investments in online services in an effort to improve service quality for citizens and businesses alike. In recent years, governments both on a national as well as on a local level have invested in developing a basic infrastructure for the electronic exchange of information between governments, citizens and businesses. By the end of 2010, this development had progressed well and a basic infrastructure was implemented in many countries. Additionally, this infrastructure offers a large number of online services. Although the familiar adage has been that development should be driven by the demands of citizens and business, development, in practice, was mainly driven by new technological possibilities and the hope rather than the belief to achieve savings. This practice has been problematic leading to the use of online services lagging behind the supply of services. To explain the actual use of online services, a user perspective is needed. According to such a perspective, actual needs and wants are central, rather than the assumption that individuals and businesses increasingly prefer to use the digital channel to conduct their affairs with the government.

A possible, and often used, theoretical starting point for a user perspective is the TAM (Davis 1989). TAM builds on two psychological theories: the theory of reasoned action (TRA) (Fishbein and Ajzen 1975) and the theory of planned behavior (TPB) (Ajzen 1991). The original model states that the adoption of an IT system is determined by the user's intention to utilize the system. Behavioral intention (BI), in turn, depends on the user's attitude toward the system. Attitude is influenced by two beliefs: the system's perceived ease of use (PEOU) and its perceived usefulness (PU). Perceived ease of use is defined as the degree to which a person believes that using the system will be effortless. The extent to which a person believes that the use of a system increases personal productivity, performance and/or effectiveness is known as perceived usefulness. Perceived usefulness is also said to have a direct effect on behavioral intention in using the system. In cases where both factors are highly rated by an individual, it is more likely that the system will be accepted and consequently adopted. Although the model has received criticism (Hirschheim 2008), TAM is used frequently to explain users' behaviors toward IT or IT-related systems. Initially it was used mainly in an organizational context, but more recently TAM has also been used in a broader consumer context. TAM has been primarily applied in adoption research where it had been expanded and labeled TAM2 (Venkatesh and Davis 2000) and UTAUT (Venkatesh et al. 2003). These expansions include constructs such as individual characteristics (e.g., age, gender and experience) and contextual factors, such as social influence and voluntariness of use, that share the traditional constructs of PU and PEOU.

TAM has been applied and acknowledged in a wide range of contexts in information system (IS) studies. Throughout the years, a variety of information systems have been subjects of study, including communication systems (e.g. email, Karahanna and Straub 1999), office systems (e.g. groupware, Malhotra and Galletta 1999), mobile services and applications (e.g. Lopez-Nicolas et al. 2008) and general-purpose systems (e.g. the WWW, Gefen and Straub 2000). For a more detailed overview of the types of information systems researched in TAM studies by related authors, we refer to the work of Lee et al. (2003). Moreover Schepers and Wetzels (2007) and Schwenk and Möser (2009) conducted meta-analyses for TAM related research. For our paper selection, we will combine the TAM-UTAUT paradigm in combination with the eGovernment research domain focusing on adoption studies published in the period 2002–2010.

3.2 Study selection

Studies on the adoption of eGovernment services were searched via Web of Science and Google Scholar, by combining concepts like TAM, UTAUT and adoption with eGovernment (services). Only those studies available through the (electronic) university library were used for further analysis. While scientific studies take very different formats, varying from essays, qualitative research, modeling studies to traditional research studies, we only included studies that formulated explicit hypotheses. In total, we found 15 studies on the adoption of eGovernment services (see Appendix I for a complete list of references). On average, studies had 18 hypotheses leading to a total of 266 hypotheses. A majority of hypotheses (59 %) described main effects, while the remaining 41 % described interaction effects. A majority of the studies used SEM to test the hypotheses (51 %), followed by Ordinary Least Square Analysis (29 %). Of the hypotheses that were tested empirically, 69 % were accepted, and 31 % were rejected (see Fig. 4).

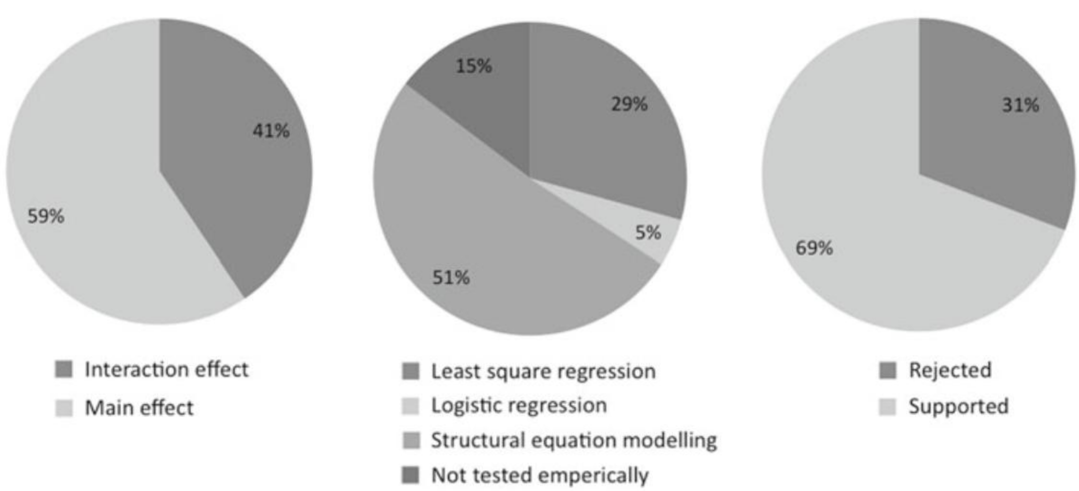


Fig. 4 Descriptive statistics regarding hypotheses

In the 266 hypotheses, 238 concepts were introduced. After unifying and aggregating, the analysis was limited to 33 different concepts that were tested for main effects. Of these, a total of 26 concepts were part of hypotheses that were empirically supported. Interaction effects were mostly concerned with demographics such as age, gender, education and ethnic background. Interestingly, demographic concepts are much less common in hypotheses that describe main effects. Concepts that appear both as main and interaction effect are trust in technology and trust in government. Overall, the interaction effects were empirically validated in 61 % of the cases (as opposed to 76 % of the main effects).

3.3 Different types of concepts

In Fig. 5 we present the network of empirically validated main effect hypotheses.

The core concepts of the TAM model clearly play a central role in the network of hypotheses: intention to use, perceived usefulness and perceived ease of use, and their hypothesized interrelation are often empirically validated. To further analyze the network we will first look at the node (concept) level. Figure 6 shows four different types of concepts: independent only, mostly independent, mostly dependent and dependent only. By analyzing the figure, we gain insight into which concepts are used to explain other concepts.

When we consider together the results reported in Figs. 5 and 6, we can draw several conclusions. There are quite a number of independent concepts that are validated in only one or two (separate) studies. Although their numbers are small, if all of these concepts play a role, one might conjecture that adoption of eGovernment services is a complex phenomenon that cannot be grasped easily by a few factors. Moreover, these may suggest other factors that should be added to the TAM model. Figures 5 and 6 suggest:

- Technology (both infrastructure and implementation) plays an important role both as independent and the dependent concepts.
- Accessibility is a technology related concept that is often used as an explanatory factor.

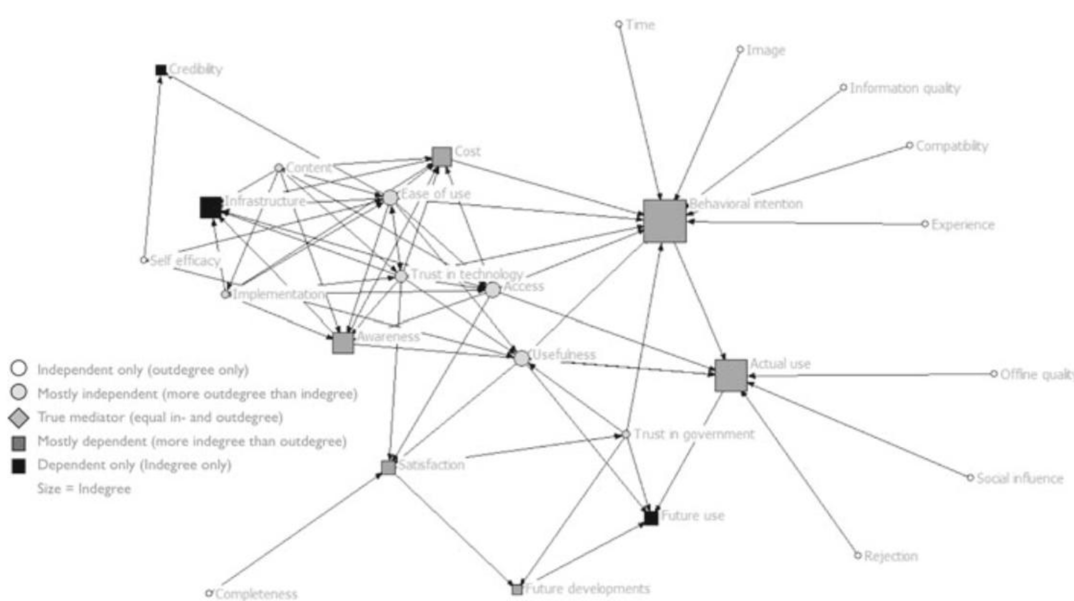


Fig. 5 Visualization of the supported (or empirically validated) main effects

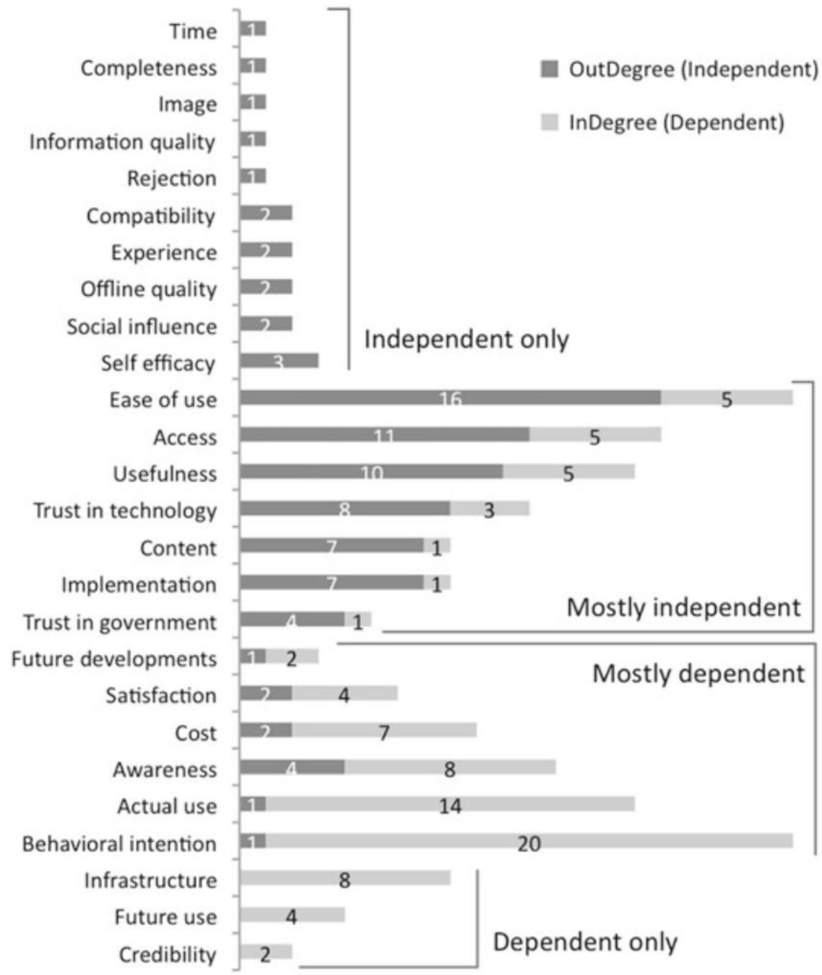


Fig. 6 Descriptive statistics regarding hypotheses

- Trust in technology and in government are important factors. Both are mostly proposed as exogenous concepts. Trust in technology is empirically validated more often than trust in the government.
- The predominant focus of this literature is on intention to use rather than actual use and/or future use of eGovernment services. Although the goal of most research projects is to obtain insight into the factors that predict the actual use of online governmental services, the projects often ‘stop’ at the point of intentional use. Our findings suggest that to have intellectual value, future research should take actual use into account.

3.4 Empirical support for proposed hypotheses

The analysis above is based on hypotheses that were empirically validated. As explained in Fig. 2, networks can be compared based on the number of times a hypothesis was proposed with the number of times a hypothesis was empirically validated. This comparison tells us about the ‘robustness’ of a single hypothesis or a set of hypotheses within the theoretical domain. The results for our eGovernment case are presented in Fig. 7.

When analyzing the results in Fig. 7, we observe that

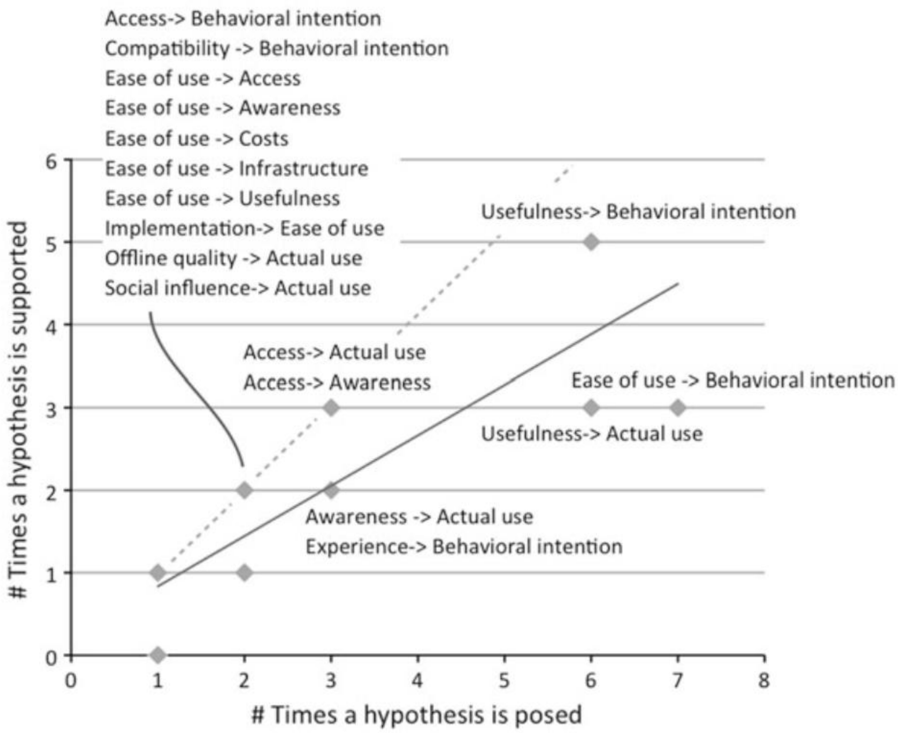


Fig. 7 Comparison of hypotheses proposed versus hypotheses supported

– Overall, a strong linear correlation exists between hypotheses posed and hypotheses that are empirically validated ($r = 0.79$, $p < 0.00$). The significance test for the correlation between the network of proposed hypotheses and network of supported hypotheses can not be computed using traditional techniques because the network ties (in this case, the hypotheses) are not independent observations. Instead, as is common in network analysis, we assess the significance of this correlation using Quadratic Assignment Procedure techniques (Krackhardt 1987) Part of the reason for this high correlation, of course, is that the score on the validated axis cannot, by definition, be higher than the score on the posed axis. While it is possible to have a link between two concepts in the proposed hypotheses network but not in the supported hypotheses network, it is by definition not possible to have a link in the supported hypotheses network but not in the proposed hypotheses network. After all, one cannot find support for a hypothesis that was not proposed! Furthermore we find that hypotheses that are posed more often are also validated more often. An examination of the causal structure of this result is instructive. It is common practice to include a hypothesis because researchers expect it to 'do well' according to a given theoretical paradigm, reinforcing the 'validity' of the paradigm instead of trying to refute the core hypotheses. This practice has implications for the (scientific) goal of actually refuting a hypothesis, as proposed by Popper (1959). In summary, Fig. 7 suggests the following insights:
– The hypothesis between Usefulness and Behavioral Intention is frequently tested and frequently supported. On the other hand, Ease of Use in contrast is not a very good predictor for Behavioral Intention. Typically Ease of Use could become less relevant for the TAM paradigm over time. A potential explanation for this would be that information technology has become easier to use due to its ubiquitous presence and hence its explanatory power is decreasingly salient.

Table 1 Monte Carlo MLE results of empirically validated relations

	Estimate	Std. error MCMC	s.e.	*p*-value
Edges	–1.28	0.12	0.02	< 1e–04***
Gwidegree	–3.34	0.5	0.14	< 1e–04***
Gwodegree	–1.06	0.23	0.01	< 1e–04***
Triadcensus 021C	–0.24	0.02	0	< 1e–04***

Significant codes: 0 '***', 0.001 '**', 0.01 '*', 0.05 '.', 0.1 ' ' 1

– Usefulness is not very influential in predicting actual use. On the other hand, awareness and accessibility are more influential in predicting actual use.

3.5 Exponential random graph models (p*/ERGM)

The results reported so far utilize network methods to identify key concepts and classify the extent to which they are exogenous (high outdegree), endogenous (high indegree), mediating (high indegree and outdegree) or exclusive mediators (high betweenness). We also demonstrated how network methods can be used to correlate the extent to which the network of hypothesized relations were empirically supported by investigating its correlation with the network of empirically supported hypotheses. In this section we explore structural signatures or patterns across the hypotheses. We used Exponential Random Graph Models (ERGM) or p* models to explore the structural signatures of the network of hypotheses using the ERGM package in R Studio. Table 1 shows the results of an analysis testing the prevalence of the following four structural signatures:

(i) the baseline likelihood of a hypothesis being supported between any two concepts (number of edges in the network of supported hypotheses (*SupportedNet* ∼ *edges*));
(ii) the likelihood that a large number of exogenous (or independent) variables are used to preferentially influence a few endogenous (or dependent) variables. This is computed as a geometrically weighted indegree (*Gwidegree*);
(iii) the likelihood that a few exogenous (or independent) variables are used to explain a large number of endogenous (or dependent) variables. This is also computed as a geometrically weighted outdegree (*Gwodegree*); and
(iv) the likelihood that the only hypotheses among three Concepts A, B, and C are a hypothesis from Concept A to Concept B, and a hypothesis from Concept B to Concept C. This structural signature reflects the prevalence of many chain-like structures in the theoretical model where the mediating Concept B completely explains the effect of Concept A to Concept C. This structure is formally referred to in network parlance as *Triadcensus 021C*, that is triads where there are 0 mutual ties, 2 asymmetric ties and 1 null tie that are configured in a chain (Davis and Leinhardt 1972). Significant coefficient estimates indicate that the corresponding structural signatures are more (or less) likely to occur than by random chance. To assess the extent to which our model captures the structures of the observed networks of hypotheses, we performed a goodness of fit analysis on degree distributions. Appendix II summarizes the discrepancy between the degree distributions in the observed networks and the degree distribution predicted by the estimated model. The degree distribution of the observed network of hypotheses (represented by solid lines) are mostly within the 95 % confidence interval of the distributions simulated by the model.

The results in Table 1 show that there is a significant negative coefficient for *Edges*. This indicates that in general the likelihood of a hypothesis being posited between any two concepts is lower than expected by chance suggesting a tendency towards parsimony in the theoretical framework. Table 1 indicates that there is a negative effect for the geometrically weighted in-degree (*Gwidegree*) indicating that there is no tendency for a large number of exogenous (or independent) variables to preferentially influence a few endogenous (or dependent) variables. In other words, there is no statistical evidence that some endogenous variables are being explained by many more explanatory variables than other endogenous variables. There is also a negative effect for the geometrically weighted out-degree (*Gwodegree*) indicating that there is no tendency for a few exogenous (or independent) variables to explain a large number of endogenous (or dependent) variables. In other words, there is no statistical evidence that some exogenous variables are explaining many more endogenous variables than other exogenous variables. Taken together, this means that there is no evidence that only a few concepts, both dependent and independent, receive a lot of 'attention'. Finally, there is a significant and negative effect for the *Triadcensus 021C* which means that we see very few chains in the network. This would suggest that the research literature in this area have a low likelihood of positing hypotheses that result in mediating variables (such as Concept B) that exclusively serve to explain the influence of an antecedent variable (such as Concept A) on an outcome variable (Concept C). In other words, there is a lower than expected likelihood that the only hypotheses relating Concepts A, B, and C are a hypothesis from Concept A to Concept B and a hypothesis from Concept B to Concept C. This tendency would suggest that there might be additional unexplored mediating variables that might explain the influence of antecedent variables on outcome variables when the TAM is applied to study use of eGovernment services. While these four structural signatures might be visually apparent from the network of hypotheses depicted in Fig. 5, the analyses reported in this section provide a statistical test for their prevalence.

4 Discussion

In the previous sections, we presented a method for doing literature research by analyzing hypotheses from scientific studies using network analysis methods. This method offers a systematic way to accumulate the results of scientific studies in a research domain. The method was illustrated using the case of adoption of eGovernment services. The results indicate that while a number of different mediators have been successfully added to the TAM they do not fully capture the influence of the hypothesized relations they seek to mediate. In addition, results show that demographics are used as interaction effects rather than as main effects. In addition to domain related insights we can also draw conclusions on a more general level regarding the TAM paradigm. The analyses showed that there is a strong core in the network. This core is surrounded by a large set of concepts that are added to the model. This in part may explain the success of the TAM: individual researchers can easily add a concept and refine the model, while the core of the model is largely irrefutable. This can be considered as both a strength and a weakness. The strength lies in the fact that there is evidence of efforts to refine the model, the weakness is that no fundamental changes with regard to core concepts are being explored. This could be because hypotheses among the core variables in the model are largely supported. Hence, the analysis of the network of hypotheses suggests that the research literature seeks to reinforce rather than refute TAM,. From a critical perspective, one might argue that this practice of fitting data to the model is not opening new avenues for research. This also relates to an issue with regard to meta-analysis in a broader sense, i.e. the role of dominant paradigms (Kuhn 1962). Because the core hypotheses of the TAM paradigm are largely supported, reviewers may be more receptive to studies that reinforce this approach rather than be open to alternative models. The validity of an alternative paradigm is more likely to be demonstrated when studies explain more variance by combining different established conceptual paradigms These types of studies are not very common (for an example, see Bouwman and Van de Wijngaert 2009).

In the rest of this section we focus on some limitations with regard to the reliability and validity of the proposed network method. Validity focuses on the degree to which the method provides insight into the theoretical knowledge that is available in a specific scientific domain. Reliability of the method focuses on how it relates to other methods of literature research. To test reliability and validity of the method, we propose four different studies.

Reliability of data extraction The first reliability test of the method relates to the question of whether different researchers interpret the raw material (the scientific studies) in the same way. A more practical question is whether different researchers extract the same hypotheses from literature. In addition, we need to investigate whether different researchers make the same unification and aggregation choices. In this case reliability was based on peer review by co-researchers. To obtain an answer to the reliability question, we need to set up an inter-coder reliability study.

Comparison with traditional literature research The proposed method intends to provide an alternative to the classic method of literature review. We therefore need to test how the results from this method compare to the results of classic methods or alternative method, for instance based on keyword search and business intelligence tools.

Comparison with citation and full text analysis Aside from traditional literature review, our proposed method can be compared to full text analysis and co-citation analysis. The latter uses co-citations in scholarly studies to establish links to other studies or other researchers to examine patterns in scientific research. Full text analysis does the same but uses the co-emergence of words in scholarly studies. Both methods allow for an in-depth analysis of how studies and researchers relate to one another.

The method we propose also allows for an analysis at the level of individual studies by examining how many concepts (nodes) and/or hypotheses (relations) are shared across different studies. Here again, a new network can be mapped, where the nodes are the studies, and a relation indicates the number of hypotheses shared by the two studies. By exploring the same set of studies with the three methods (full text, co-citation and hypotheses), we can see to what degree our method yields similar results compared to two well-established methods of scientometrics—citation and full-text analysis. This will help assess the reliability of the proposed method.

5 Conclusion

This paper offers three contributions. First we proposed a method for literature review using a network approach. Secondly, we presented a case study to illustrate the method. Our case study focused on the TAM paradigm and on diffusion of eGovernment services. Although the illustrative case is limited in the number of studies included and in the research focus, the method is generic, and can be applied for many different conceptual paradigms as well as research domains. Third, we proposed a number of studies to test the reliability of the method as well as show explore further possibilities for analyzing the (network) data.

With this study we have attempted to illustrate a method that we believe offers great complementary advantages to contemporary approaches for conducting a literature review. We enumerate a few of these advantages below:

- The method is a relatively easy, systematic and transparent way of doing literature research.
- The method allows for comparisons between different domains or timeframes.
- The method allows for analysis at both the content and paper level.
- By using network measures, new types of insights (e.g., regarding the question of how a theory develops over time) can be gained.
- Many possibilities exist for accumulating and sharing the results from the literature review.

In addition to these advantages, our method poses certain questions regarding its reliability. We believe that with further elaborations, the advantages offered by the method outweigh possible shortcomings.

Acknowledgments The authors wish to thank Bart van den Hooff and Guido Ongena for their early efforts regarding the development of the method, Scott Gaonkar for assistance with coding and Yun Huang for his guidance on the analysis. The authors also wish to acknowledge the following funding sources that contributed to the development of materials presented in this article: Army Research Laboratory under Cooperative Agreement Number W911NF-09-2-0053; National Institutes of Health awards UL1RR025741-04**S3** and UL1RR024146-06S2 and National Science Foundation Grants: CNS-1010904, OCI-0904356, IIS-0838564.

Appendix I

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Appendix II

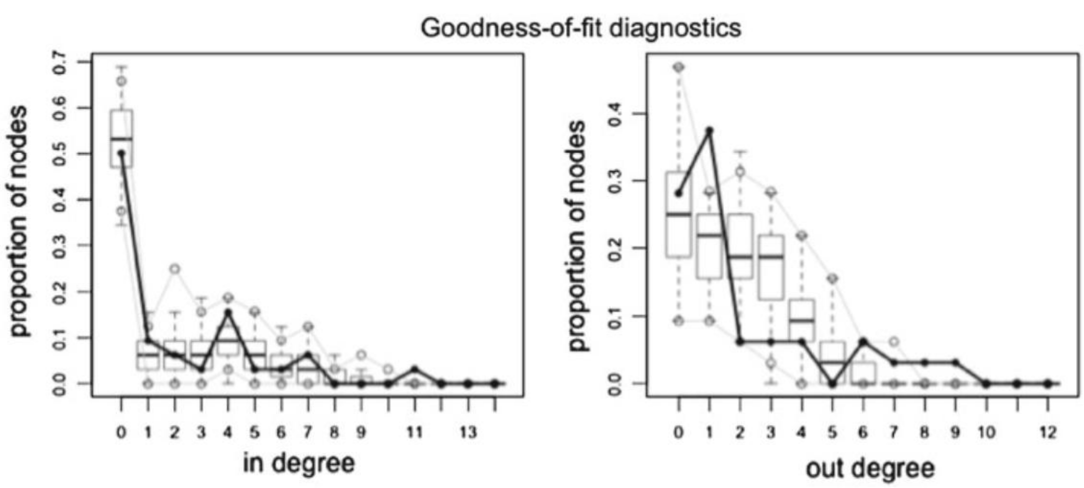

Fig. II.1 Goodness of fit for the basic model

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