How Consumer Perceptions of Network Size and Social Interactions Influence the Intention to Adopt Peer-to-Peer Technologies

Jaeki Song, Texas Tech University, USA

Eric Walden, Texas Tech University, USA

ABSTRACT

People join peer-to-peer networks for economic and social reasons. From an economic perspective, people join peer-to-peer (P2P) networks based on the size of the networks. However, from a sociological perspective, when people adopt technologies, they create an alternative social network motivated by extrinsic and intrinsic rewards. In this study, we develop a conceptual framework for measuring the impact of economic and social factors drawn from theories of network externalities and social exchange. The preliminary data analyses show that perceived size of network influences perceived network externalities, and in turn, network externalities have an impact on intention to adopt P2P technologies. In addition, we found that social benefit is also an important antecedent of adopting P2P technologies. Our preliminary results provide insights on how people reconcile economic and social considerations when choosing to adopt a P2P technology.

Keywords: network externality; network size; P2P technologies; social exchange

INTRODUCTION

Electronic commerce has opened information systems (IS) to a special category of users—customers—who are empowered with the decision to adopt or reject them in a way that traditional corporate users were not (Kauffman & Walden, 2001). Because of the power of customers to choose, it is increasingly important for IS researchers to understand what makes them choose in a particular situation. One new technology that is of particular interest is peer-to-peer (P2P) technologies, which can be defined as a sharing and delivery of user specified resources (information and content files)

among groups of people who are logged on to a file sharing network (Kwok, Lang, & Tam, 2002). In general, P2P technologies have been developed based upon Internet-based architecture (Asvanund, Clay, Krishna, & Smith, 2004). However, P2P technologies differ from the traditional Internet-based protocol, especially client-server-based technologies in terms of how to manage resources. Resources and their availability are managed by individual users, whereas those resources are managed by a central server (Asvanund et al., 2004). In other words, computers can act as client as well as server in a P2P environment (Loo, 2003). Thus, P2P technologies enable organizations to obtain competitive advantage by utilizing power of client side computers without further investment in new hardware (server) (Loo, 2003). These technologies allow tens of millions of people to share billions of files with others all over the world. In some cases, as much as 50% of Internet bandwidth is dedicated to P2P exchange (Lee, 2003). The largest such network, Kazaa (www.kazaa.com) claims to be the world's most downloaded software application.

Network externalities occur when a person's participation in a network creates benefits for others in the network. Thus, the value of the network increases as the number of members in the network increases (Economides, 1996). For example, a telephone has virtually no value if only one exists, but if billions of people have access to telephones, then being a member of the network is extremely valuable. Network externalities exist in P2P networks because the more users they have the more potential files they offer. Network externalities have been widely used to explain technology adoption in general (Brynjolfsson & Kemerer, 1996; Kauffman, McAndrews, & Wang, 2000; Parthasarathy & Bhattacherjee, 1998) and P2P adoption in particular (Clay, Asvanud, Krishnan, & Smith, 2002). Thus, we expect potential adopters to be concerned about the number of others on a P2P network when they themselves make a decision to adopt or not.

In addition, the sharing aspect of P2P makes these technologies fundamentally social in nature. Thus, we would expect anticipated social interactions and social motivations to play an important role in the adoption decision. The previous studies examined the effects of positive and negative network externalities in online services such as music sharing (Asvanund et al., 2004; Clay et al., 2002; Parthasarathy et al., 1998). However, based on our knowledge, there is a lack of studies investigating the combined economics and social aspects of P2P adoption. It is worthwhile to understand what makes people adopt this specific technology. In this article, we propose that there are two factors at work—network externalities and social effects. This article attempts to reconcile these two views and present work aimed at explaining how user perceptions of economic and social constructs influence the intention to adopt a P2P technology. What we find is that it is not an either-or situation. Rather, consumers take into account both social and economic factors when forming an intention to adopt.

This article will be organized as follows. We begin by reviewing literature on network externalities and social exchange theory and formulate hypotheses. Following the theoretical framework, we will discuss our research method including data collection procedures. We then present the results of our analysis. Following the presentation of our results, we discuss our findings and note the implications of our study. Finally, we conclude by noting the limitations of our study and directions for future research.

THEORETICAL BACKGROUND AND RESEARCH MODEL

Our purpose is to examine the cognitive factors that lead to formation of an intention to adopt a P2P technology. The most widely used information systems model for explaining technology adoption is the technology acceptance model (TAM) (Davis, 1989; Davis, Bagozzi, & Warshaw, 1989). TAM is based on the theory of planned behavior (Ajzen, 1991) and proposes that users form an intention to adopt based on the perceived usefulness of the technology and the perceived ease of use of the technol-

ogy. Davis's model specifically postulates that technology usage is determined by behavioral intention to use the technology, which itself is determined by both perceived usefulness and perceived ease of use.

Studies on TAM have been expanded in various contexts. In off-line contexts, TAM has been extended and synthesized with innovation diffusion theory (Plouffe, Hulland, & Vandenbosch, 2001) and cognitive absorption (Agarwal & Karahanna, 2000). It has been compared to the theory of reasoned action and the theory of planned behavior (Harrison, Mykytyn, & Riemenschneider, 2001; Mathieson, 1991; Taylor & Todd, 1995). TAM has been applied to different technologies' acceptance (Adams, Nelson, & Todd, 1992; Brown & Venkatesh, 2005; Chau, 1996; Igbaria, Guimaraes, & Davis, 1995) such as voice mail, e-mail, micro-computer, Word, Excel, data systems, information retrieval, and so forth (Adams et al., 1992; Brown et al., 2005; Chau, 1996; Igbaria et al., 1995). TAM has also been extended to online contexts (Gefen, Karahanna, & Straub, 2003; Koufaris, 2002; Lederer, Maupin, Sena, & Zhuang, 2000; Moon & Kim, 2001; Wang & Benbasat, 2005) with respect to trust issues, usability, virtual community, and shopping bots.

While it is a powerful and well-verified model, it is still a model and has some limitations in the current context. Namely, it does not define what *useful* is. With respect to P2P technologies, useful is the number of files that can be accessed and how they are shared. We are concerned with generating a model specific to the P2P context, rather than IS adoption in general. Also, TAM examines adoption based on interaction with software. Adoption in TAM can be characterized as *acceptance* of a technology after having some experience with the technology. In the context of Internet technology adoption, it is an interesting question to ask, "*what makes users even try a technology*?" In the organizational context, users are presented with some technology and have an opportunity to use or discontinue use of that technology. On the Internet, customers are presented with a dizzying array of technology options. Each is different and entails some switching costs, but at the same time, many perform very similar functions. This makes it interesting to ask why a decision maker would try a technology at all, which is a question that does not fit well into the TAM model.

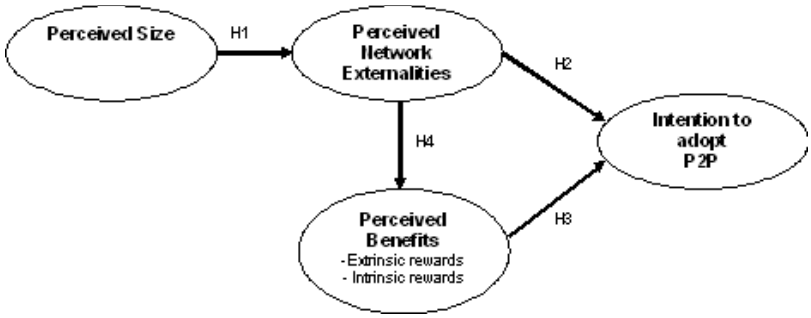
Thus, while TAM is an excellent model for examining a range of adoption decisions, it does not serve the purposes of this investigation. Therefore, it is necessary to look for other models to apply. We synthesize network externality theory (Katz & Shapiro, 1986) and social exchange theory (Blau, 1964) in conceptualizing our research model, as presented in Figure 1. Focus on the cognitive factors takes us closer to the action and allows us to probe the mental states of an individual, rather than hypothesize about mental states at a higher level of abstraction. This way we can effectively separate size components from social components.

Network Externality Theory

Network externality theory has been used by economists to model many organizational technology adoption decisions (Economides, 1996). The theory has been successfully imported into IS to explain the growth of Internet hosts (Gurbaxani, 1990), the joining decisions of banks vis-à-vis ATM networks (Kauffman et al., 2000), spreadsheet adoption (Brynjolfsson et al., 1996; Gandal, 1994), and, specific to our purposes, P2P adoption (Clay et al., 2002).

Network externalities occur when the value of a network increases as the number of users of the network increases. The externality occurs because each user increases the value of the network not only for her, but also for other users of the network. Economists created network externality theory to explain telecommunication adoption in the 1970's (Rohlfs, 1974), and the theory has been developed and refined since. The basic premises of the theory are (1) that the value to a user from joining the network is an increasing function of the total number of users who join the network, (2) that users perceive this value and (3) that they make their joining decision based on this perceived value.

Figure 1. A research model



P2P networks are clearly possessed of network externalities. The more users there are on a P2P network, the more likely any user is to find another user with a desired file. Though with older technologies more users could slow down the network (Clay et al., 2002), new P2P technologies allow users to download packets from multiple sources, so that more users actually speed up downloads. Thus, the economic approach to modeling P2P adoption makes sense.

Network externality theory posits an intuitive causal process. The first step in the network externality path is the formation of a perception of network size by an individual. The individual must examine the characteristics of the network and form some feeling of the *bigness* of the network. It is important that this is a subjective evaluation rather than an objective evaluation. We are trying to capture the subject's perception. From this perspective, we defined perceived network size as belief about current membership size of the P2P network. Also, we defined perceived network externalities as belief about how size influences potential benefits of the network (Katz et al., 1985; Parthasarathy et al., 1998). According to network externality theory, as the size of the network increases, the benefits of the network increase. Thus, if a consumer's mental processes follow network externality theory, then the perceptions of size must lead to perceptions of benefits.

Hypothesis 1: Perceived network size is positively associated with perceived network externalities

An individual's intention to adopt depends on how the technology will function for him or her if he or she adopts it. In other words, intention to adopt P2P technology can be defined as probability, likelihood, and willingness to adopt P2P (Song & Zahedi, 2005). As the perceived network externalities increase, the potential adopter should see adopting the P2P technology, which allows access to that network to be a better choice. Greater network externalities will give the user access to more files, make finding specific files more likely and increasing the likelihood those others will join in the future. The availability of files is the central means of usefulness in a P2P network, and thus we should expect that it will have a large impact on the intention to adopt. This is in contrast to a word processor or accounting system, for which access to files has less importance than other useful factors such as accuracy, cost, or functionality. That is not to say that word processors and accounting systems are unaffected by network externalities. Nor do we intend to suggest that accuracy, cost, and functionality are unimportant to P2P technologies. All we suggest is that network externalities are proportionally more important for P2P technologies than for other technologies. This yields our second hypothesis.

Hypothesis 2: Perceived network externalities are positively associated with intention to adopt.

Social Exchange Theory

P2P networks also connect people, thereby allowing them to participate in a social group. Garton, Haythornthwaite, and Wellman (1999) argued that a network is social when it connects people or organizations as follows:

Just as a computer network is a set of machines connected by a set of cables, a social network is a set of people (or organizations or other social entities) connected by a set of social relations, such as friendship, co-working, or information exchange. (p. 75)

From this perspective, people join P2P networks to exchange information, which results in a social network. Thus, we argue that there are motivations in adopting P2P technology, which can be accounted for by social exchange theory (Blau, 1964). Social exchange theory is based on the premise that actors will strive to balance what they put into a relationship with what they get out of the relationship. Hence, behavior is based on the social rewards one perceives in an exchange.

Social exchange theory (SET) posits that the exchange of resources in terms of rewards, costs, and resources is a basis of human interaction (Blau, 1964). The SET posits that the ability to obtain benefits in exchange framework is contingent on the ability to provide others with rewards. In other words, individuals in exchange framework are used to seek rewards in maximizing positive outcomes. Individuals, generally assumed rational human beings, calculate rewards and costs before acting within limited information.

Before proceeding with a discussion of social exchange benefits, we must first make a distinction between adopting and information sharing. Social exchange theory is concerned about information sharing in an existing relationship. Adopting is concerned with implementing a technology that creates a relationship. Adopting is a prerequisite to the relationship; however, one adopts because of the relationship, not simply for the joy of adopting. An analogy might help explain this. For example, an individual once purchased an exercise machine for his home. The machine was purchased based on notions about exercise. However, the purchase process involved going to a store, negotiating with a sales person, and writing a check. None of these things were related to exercise per se. However, all of them were done in the hopes of exercise. Thus, considering the purchase behavior requires a consideration of behavior. The important point here is that the equipment was only used twice, and then it was sold at a considerable loss. Thus, it was the perceptions of how it was going to be used prior to purchase that motivated the purchase. Even though those perceptions turned out to be wrong, they were based on the information available at the time.

Kankanhalli, Tan, and Wei (2005) argued that benefits consist of extrinsic and intrinsic benefits. Extrinsic benefits refer to benefits "sought after as means to ends desired by people" (Kankanhalli et al., 2005, p. 116). For example, each contributor in a P2P environment may receive rewards as a result of his or her contribution, such as enhancing the contributor's image or reputation. From this point of view, each contributor may receive reciprocal benefits (i.e., his or her future requests for resources being met by others because of the contributor's built-in image or reputation). Intrinsic benefits refer to benefits "sought after as ends by themselves" (Kankanhalli et al., 2005, p. 116). For example, each contributor may be satisfied in terms of his/her ability to provide valuable resource or his or her opportunity to help others. Such benefit is based on altruism in a sense of having pleasure by helping others (Blau, 1964). Extrinsic and intrinsic benefits have been studied in IS fields as well. The early studies applied social benefits in information sharing based on information technologies (Constant, Kiesler, & Sproull, 1994; Constant, Sproull, & Kiesler, 1996). Such studies identified self interests and reciprocity as antecedents of information

sharing. In advanced to information sharing, recently many studies have taken social exchange theory, especially extrinsic and intrinsic benefits in system design and knowledge management (Ba, Stallaert, & Whiston, 2001; Kankanhalli et al., 2005; Wasko & Faraj, 2005).

Analogously, social exchange theory focuses on the benefits of participating in the exchange, but the exact same anticipated benefits motivate the adoption decision. Therefore, when we examine social exchange theory, we are concerned with its anticipated effects on adoption, not on information sharing, though the construct is concerned with information sharing. Sharing files often means sharing interests and ideals. Posters of files frequently add their own personal touches, even if it is nothing more than a logo, to the otherwise generic files they share. Moreover, new technologies like BitTorrent allocate bandwidth based on sharing, forcing people to participate rather than free ride. Thus, the social approach to modeling P2P adoption makes sense.

In order to adopt new P2P technology from social exchange theory, people expect to obtain benefits for engaging in social exchange. Such benefits serve as motivations for adopting new technologies (Venkatesh, 2000). Previous studies provide evidence of the effect extrinsic and intrinsic motivations have on technology usage (Shang, Chen, & Shen, 2005; Teo, Lim, & Lai, 1999; Venkatesh, 2000). We argue that the two dimensions of social benefits (extrinsic and intrinsic benefits) are the dimensions of a second order construct. In this study, we consider reciprocity as an extrinsic benefits referring to an individual's beliefs about how contribution to P2P will lead to the fulfillment of future requests for information. Also, we consider enjoyment as an intrinsic benefit, which can be defined as an individual's belief about how pleasurable it will be to help others through P2P (Kankanhalli et al., 2005). Social benefits reflect potential users' perception of receiving benefits from the technologies, which influences their intention to adopt P2P technologies. This leads to our third hypothesis.

Hypothesis 3: Perceived benefit is positively associated with intention to adopt

In addition to the direct effect on intention to adopt, greater network externalities allow the generation of greater social benefits. As network externalities increase, there are more and higher quality social interactions possible. As the network itself becomes more viable, it buoys both the intrinsic and extrinsic benefits. Intrinsic rewards are increased because a user has a better audience with which to share information. There are more people in need, there are higher quality people in need, and there are more people who may not be in need, but will listen. Extrinsic rewards are strengthened because there are more and higher quality people available to help, and there are more and higher quality people who are likely to be indebted. Thus, any particular need is more likely to be resolved and more likely to be resolved well. Hence, we hypothesized that:

Hypothesis 4: Perceived network externalities positively influence perceived benefits.

DATA ANALYSES AND RESULTS

Construct Measurement and Instrument Development

Our research model contains five constructs: four belief constructs and the behavioral intention. The scales for measuring these constructs were developed based on an extensive review of literature to ensure their content validity, as reported in Table 1. All items used seven-point Likert scales anchored from "strongly disagree (=1)" to "strongly agree (=7)." The instruments are reported in Appendix A.

Research Methodology

The testing of the research model required a controlled setting in which the impacts of two different information about network size (1,000,000 vs. no information) on an individuals' perceptions about network externalities,

Table 1. Construct definitions

Constructs	Operational Definition	Sources
Perceived Size (PS)	Belief about current membership size of the P2P network	Specific to this study
Perceived Network Externality (PNE)	Belief about how size influences potential benefits of the network	Katz et al. (1985), Parthasarathy et al. (1998)
Perceived Benefits-Extrinsic Reciprocity (PBER)	Belief about how contribution to P2P will lead to the fulfillment of future requests for information	Kankanhalli et al. (2005)
Perceived Benefits-Intrinsic Enjoyment (PBIE)	Belief about how pleasurable it will be to help others through P2P	Kankanhalli et al. (2005)
Behavioral Intention to adopt P2P (BI)	Probability, likelihood, and willingness to adopt P2P	Song et al. (2005)

social benefits and intention to use P2P technologies, hence leading us to use controlled lab experiments as the research method.

We created two different experimental protocols, which contains different information about network size. In the experiments, the participants were told that the experiment was intended to help e-commerce companies improve their systems. At the beginning of the protocol, we introduced a new P2P technology for academic purpose, named University Universe (UU). Such UU allows users to specify certain files on the computer, which would be accessible to other users of the same software. For academic purposes, this would allow users of the software to share a variety of different school-related files. In addition, we also provided general characteristics about UU, including fee for use (free), unlimited bit rates, compatibility with all possible operating systems, stability, search functionality, integrated virus protection, direct messaging, privacy, etc., which have been identified in P2P studies (Kwok et al., 2002; Lee, 2003) as well as is based on the description that the largest P2P network offered potential adopters. The participants were randomly assigned to different experimental protocols. Participants were asked to read and to examine the description with care. After carefully reading the given descriptions of UU, the participants completed a questionnaire in which they measured the participants' perceptions about our research constructs. The participants took an average of 20-25 minutes to complete the experiment. Data collection resulted in a total of 105 completed observations. Among them, half of the subjects (52 subjects) were not offered details beyond the technical aspects of the P2P software. The other half (53 subjects), were given information indicating that the network size was one million users. A t-test indicated that the two groups had different perceptions of network size at $p = 0.001$ level (t-value of -3.49). In addition, to reinforce the social dimensions, we informed participants that some of their peers had adopted the technology.

Sample Characteristics

The participants in this study were graduate and undergraduate students in a large southern university in USA. To increase the seriousness of subjects' participation, the participants received extra credit.

The profiles of participants are reported in Table 3. Our subjects are students and the

Table 2. Profiles of participants (n=105)

Profiles	Mean	Standard Deviation	MIN.	MAX.
Age	22	3.7	18	38
Tendency of exploring new technologies [a]	2.39	1.57	0	7
Experience in using P2P Technologies (Years)	4.50	2.01	0	6
Gender	Male: 72	Female: 33		

[a] *In general, I am interested in trying out new technologies (1-strongly disagree, 7-Strongly agree)*

Table 3. Reliability measures and correlation of model constructs

Constructs	Cronbach Alpha	CFR[a]	1	2	3	4	5
1. PS	0.71	0.84	(0.80)[b]				
2. PNE	0.66	0.82	0.48	(0.77)			
3. PBER	0.72	0.85	0.20	0.68	(0.81)		
4. PBIE	0.82	0.89	0.19	0.64	0.71	(0.86)	
5. BI	0.92	0.95	0.10	0.69	0.53	0.49	(0.93)

[a]*Composite factor reliability* [b] *Diagonal elements represent the square root of AVE for that construct*

relatively younger age group. Using students as subjects always generates the question of external validity. However, many studies found that there are no significant differences between student and non-student subjects in individual behavior, organizational psychology, and so forth (Locke, 1986; Song et al., 2005). In addition, the GUV WWW survey 2004 characterizes Web users as highly educated (88% had at least some college experience), which matches the educational levels of our participants (all college students). Furthermore, participants in this study have the characteristic that defines the population being sampled, which is that they are P2P users. Approximately 95% of participants have joined at least one P2P network, and their average experience with P2P networks is approximately four and half years. Hence the subjects in this study do not present a significant threat to external validity and can be considered as a representative of the general customers who use P2P technologies.

Construct Reliability

Table 3 provides construct reliabilities. All of the constructs, except perceived network externalities, have Cronbach alpha values above the threshold of 0.70, and their composite factor reliabilities (CFR) are above the cutoff point of 0.70 (Nunnally, 1978; Segars, 1997). Furthermore, their average variance extracted (AVE), which indicates the amount of variance caused by the measurement error, exceeded the threshold of 0.50 (Fornell & Larcker, 1981). These values indicate a relatively high level of instrument reliability. The reliability check from this study indicates that we have a slight lack of reliability for the constructs of perceived network externality.

Convergent and Discriminant Validity

We first conducted a confirmatory factor analysis (measurement model), which specifies the links between the latent and manifest variables

(Anderson & Gerbing, 1982). The loading coefficients for all items were well above the recommended loadings of 0.7 (Fornell et al., 1981) as reported in Table 4. Also, the t-values for the loadings of manifest variables were well above the threshold of 2.33 (for p-value of 0.01). The factor loadings of the second-order factors are computed in the measurement model and are reported in Table 4 as well. Again, the high values for factor loading for the second-order factors, and their high and statistically significant t-value and R^2 values support the convergent validity of the second-order factors and their suitability to measure the second-order constructs in the model.

The fit indices for the CFA showed acceptable model fit. The normed chi-square was 1.38 (chi-square/degree of freedom, χ^2=113.51; d.f. =82), which is desirably below the cut-off value of 3.0. RMSEA (Root Mean Square Error of Approximation) was 0.060, indicating a satisfactory model fit (Bentler, 1989; Hu & Bentler, 1999). Also, CFI (comparative fit index) and TLI (tucker-lewis index) were 0.95 and 0.94, respectively, all above the cut-off values of 0.90 (Bentler & Bonnett, 1980; Hu et al., 1999).

We also checked discriminant validity. One guideline for discriminant validity is that the square root of AVE for each construct should be greater than the correlation values of the construct with other constructs (Fornell et al., 1981). As this table shows, every construct's square root of AVE was greater than the correlation with other constructs, providing further evidence for the discriminant validity of the constructs in the model. Another guideline for discriminant validity is that the original measurement model (CFA) can be compared

Table 4. Confirmatory factor analysis: Measurement model

Constructs	Items	Loading	t-value	R^2
First-order factor				
Perceived Size (PS)	PS1	0.815	6.429	0.488
	PS2	1.000	0.000	0.589
	PS3	0.786	5.612	0.325
Perceived Network Externality (PNE)	PNE1	1.000	0.000	0.597
	PNE2	0.736	4.334	0.240
	PNE3	0.895	6.951	0.436
Perceived Benefits-Extrinsic Reciprocity (PBER)	PBER1	0.806	6.832	0.380
	PBER2	1.000	0.000	0.749
	PBER3	0.796	8.254	0.604
Perceived Benefits--Intrinsic Enjoyment (PBIE)	PBIE1	1.000	0.000	0.702
	PBIE2	0.866	6.822	0.504
	PBIE3	0.902	8.293	0.622
Behavioral Intention to adopt P2P (BI)	BI1	1.000	0.000	0.837
	BI2	0.922	17.498	0.873
	BI3	0.851	11.447	0.702
Second-order factor				
Perceived Benefits (PB)	PBER	0.976	6.405	0.756
	PBIE	1.000	0.000	0.657

with other alternative measurement models, which included every possible combination of collapsing two constructs into one (Gefen et al., 2003). Based on Gefen et al. (2003), since combining two latent variables adds two degrees of freedom to the model, the chi-square differences between the original CFA and any alternative model should be greater than at least 7.38 at p = 0.025. The discriminant analyses showed that the minimum chi-square difference was 16.55 as shown in Appendix B. Therefore, the chi-square value in the original CFA was significantly better than the reduced measurement models. Hence, the test of discriminant validity was also met.

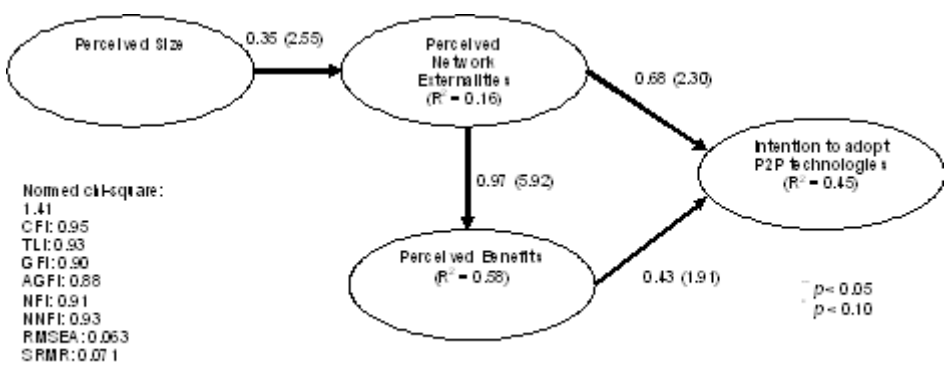
The Model Estimation

The hypothesized research model was tested using structural equation modeling (SEM) technique. Figure 2 shows the estimation results of the model, including fit indices.

The SEM estimation has a normed chi-square of 1.75 (χ^2=132.20; d.f. = 71), which is below the recommended threshold of 3 (Bhattacherjee, 2002; Bentler, 1989). GFI, CFI, and TLI indices were 0.90, 0.95, and 0.93, respectively, all above the cut-off values of 0.90 for the continuous outcomes case (Bhattacherjee, 2002; Hu et al., 1999). NFI and NNFI were above the cut-off point of .90 (Bentler et al., 1980), and AGFI index was 0.88, well above the cut-off value of 0.80 (Gefen et al., 2000). RMSEA was 0.063, which is slightly above the 0.06 cut-off, indicating a satisfactory model fit (Hu et al., 1999). In addition, we investigated the standardized root mean square residual (SRMR) index, which represents an overall badness-of-fit, based on the fitted residuals (Byrne, 1998). The SRMR for the measurement model was 0.071, which is well below the suggested threshold of 0.10, providing further support for the model fit (Bryne, 1998; Hu et al., 1999). These results suggest that the measurement model adequately fits the data.

Next, each hypothesis in the suggested research model and the variance explained (R^2-value) was examined. Hypotheses 1 posited that perceived size positively influences perceived network externalities. We found that perceived network externalities were positively influenced by perceived size (path coefficient = 0.35, t-value = 2.55). Hypotheses 2 posited that perceived network externality positively influences perceived benefits. We found that perceived network externality significantly influences perceived benefit (path coefficient = 0.97, t-value = 5.92). Hypothesis 3 and 4

Figure 2. The estimated model parameters with their t-values are shown on the links. Construct R^2 is reported under each construct.



posited that perceived benefits and perceived network externalities were antecedents of adopting P2P technologies. H3 and H4 were supported t-values of 1.91 and 2.30, respectively. The constructs within the model have relatively high R^2 values ranging from 0.16 to 0.58, which indicate that the research model has a reasonable explanatory power.

DISCUSSION OF FINDINGS

Our analysis suggests that consumers consider both economic and social aspects of P2P technologies when forming an intention to adopt. Consumers perceive that the total size of the network is an important determinant of the benefits of the network. The more total users there are of the network, the more likely individuals are to find the files that interest them. This causes consumers to form stronger intentions to adopt. At the same time consumers are concerned about the social rules and rewards of a network. It is important to consumers not only that they enjoy participating in the social network, but that the social norms are in place to encourage and reward participation. If consumers feel that the social benefits are strong, then they form a stronger intention to adopt.

The contributions of this work are twofold. First, we synthesize two models of how P2P technologies create value and show that individuals consider both the economic and social aspects of a network when forming adoption intentions. Second, and more importantly, we present a model that offers a strong basis for future research.

Limitations

Our study provides different aspects in technology adoptions, especially, a domain of P2P technologies. However, the current study has some limitations. The first limitation of this study is related to measurement. There is a lack of reliability in measuring perceived network externalities although the construct has a convergent validity. One possible conjecture would be our measurement does not count on various types of network externalities, such as negative network externalities, or indirect network externalities. Therefore, the extended study requires to refine our measurement for network externalities. Second limitation relates to sample size. We have relatively small sample size in analyze our research model using SEM. Therefore, we conducted additional analyses using multiple regressions as reported in Table B-2. We obtained same results from both analyses. However, the extended research needs to obtain more observations in order to appropriately analyze the research model using SEM.

DIRECTION FOR FUTURE RESEARCH

There are several directions for future research that we are currently following. The first is a determination of the antecedents of user perceptions of size. The obvious antecedent is actual size. However, prior research shows that changes in network size have little or no impact on intention to adopt (Song & Walden, 2003).

In addition to the lack of predictive power of actual size, research has shown that very small numbers of local adoptions can greatly influence the intention to adopt P2P networks (Song et al., 2003). It has been proposed that this is because of the information content of local adoptions. Consumers infer information about the goodness or badness of a P2P technology from the behaviors of those around them. However, the causal path is not clear. Consumers could infer information about size, network benefits, social benefits or other hedonic factors from those around them. Thus, it would be useful to include local adoption phenomenon and explain its path. Of course the usual caveat that larger sample size is desirable applies here. We used 105 subjects, but our tests would be more powerful with more subjects.

Another direction for future research is the generalizability of the results. Our subjects were college students, who are, in general, users of P2P technologies. We found no significant correlation between intention to adopt and experience in using P2P technologies (Pearson correlation 0.03). However, non-adopter's intentions may be formed based on something else, like ease of use. It would be worthwhile to see if groups

with low P2P adoption rates have low rates because they examine some other criteria or if it is because they perceive network sizes, network effects and social rewards differently.

Closely related to this is the notion of how other adoption research fits. In particular, a large body of research finds that perceived usefulness is important. How does usefulness play in the adoption of P2P technologies? We have argued that the core useful things about them are the ability to access files and the social interactions. However, there may be other things that make them useful. Moreover, the ability to access files may depend not just on the network size, but on some characteristics of the technology. For example, BitTorrent forces downloaders to share, whereas Kazaa allows them not to share, but rewards them for doing so. Thus, maybe there is an interaction between the technology and the network size that is worth investigating.

Contribution

Research often expands understanding by explaining how one construct causes another. However, in the realm of human behavior, causality is often not a single sufficient condition, but a group of necessary conditions. What we offer here is an integration of two necessary conditions for P2P adoption. Our contribution is neither to add to social exchange theory nor to add to network externality theory. Rather, we strive to add more predictive constructs to the theory of P2P networks. Thus, we strive to develop theory that informs electronic commerce theory broadly, rather than to focus on deep explanation of one element of theory.

What do we get from this? First off, we recognize that network externalities are not the only force driving electronic commerce in general and P2P networks in particular. Indeed, practitioners recognize that billions of dollars of wealth were destroyed on the mistaken assumption that network externalities were the primary driving force behind a variety of electronic commerce businesses (Useem, 2001). Even within the realm of P2P technologies, where network externalities should be a primary driver, social issues are important. P2P technologies can facilitate the social dimensions of exchange, and those that do will be more successful than those, which do not. We see this already with Bitorrent, which automates the norms of social capital theory by tying each user's ability to download to their actual amount uploaded. In spite of the fact that business has recognized that network externalities are just one part of the adoption equation, academics have been slow to incorporate other factors with network externalities. The bottom line is that network externalities are important, and people do attend to information about network size, however, they are only one part of the adoption decision. Hence to better understand adoption of electronic commerce technologies, including P2P technologies, we must develop adoption models, which include both network effects and other effects, particularly social effects. This article makes one small step in that direction.

Concluding Remarks

Potential adopters of P2P technology are concerned about the size of the network, the actual externalities presented by that size and the opportunity for social exchange. The network externalities influence the potential benefits of social exchange by providing a bigger and better pool of exchange partners. This is a model very specific to the context, but the context seems to include tens of millions of people. As we see electronic commerce grow, it behooves IS researchers to start to develop more specific models that focus on a domain that encompasses many people, but does not include all technology artifacts. P2P seems to be one of the few technologies that have become large enough to justify its own theories, but there are others (e.g. PDAs and cell phones) and there are likely to be others in the future. We hope that researchers recognize this and strive for specific, locally powerful theories of technology

REFERENCES

Adams, D. A., Nelson, R. R., & Todd, P. A. (1992). Perceived usefulness, ease of use, and usage of information technology: A replication. *MIS Quarterly*, *16*(2), 227-247.

Agarwal, R., & Karahanna, E. (2001). Time flies when you're having fun: Cognitive absorption and beliefs about information technology usage. *MIS Quarterly*, *24*(4), 665-694.

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, *50*, 179-211.

Anderson, G. D., & Gerbig, D. (1982). Some methods for respecifying measurement models to obtain unidimensional construct measurement. *Journal of Marketing Research*, *19*, 453-460.

Asvanund, A., Clay, K., Krishna, R., & Smith, M. D. (2004). An empirical analysis of network externalities in peer-to-peer music sharing. *Information Research*, *15*(2), 155-174.

Ba, S., Stallaert, J., & Whiston, A. B. (2001). Research commentary: Introducing a third dimension in information systems design--The case for incentive alignment. *Information Systems Research*, *12*(3), 225-239.

Bentler, P. M. (1989). *Structural equations program manual*. Los Angeles, CA: BMDP Statistical Software.

Bentler, P. M., & Bonnett, D. G. (1980). Significance tests and goodness of fit in the analysis of covariance structures. *Psychological Bulletin*, *88*, 588-606.

Bhattacherjee, A. (2002). Individual trust in online firms: Scale development and initial test. *Journal of Management Information Systems*, *19*(1), 211-241.

Blau, P. M. (1964). *Exchange and power in social life*. New York: John Wiley.

Brown, S. A., & Venkatesh, V. (2005). Model of adoption of technology in households: A baseline model test and extension incorporating household life cycle. *MIS Quarterly*, *29*(3), 399-426.

Byrne, B. M. (1998). *Structural equation modeling with LISREL, PRELIS, and SIMPLIS*. Mahwah, NJ: Lawrence Erlbaum Associated Publisher.

Brynjolfsson, E., & Kemerer, C. F. (1996). Network externalities in microcomputer software: An econometric analysis of the spreadsheet market. *Management Science*, *42*, 1627-1647.

Chau, P. Y. K. (1996). An empirical assessment of a modified technology acceptance model. *Journal of Management Information Systems, 13*(2), 185-204.

Clay, K., Asvanud, A., Krishnan, R., & Smith, M. D. (2002). An empirical analysis of network externalities in peer-to-peer music-sharing networks. The *Proceedings of 23rd International Conference on Information Systems* (pp. 49-58). Barcelona, Spain.

Constant, D., Kiesler, S., & Sproull, L. (1994). What's mine is ours, or Is it? A study of attitudes about information sharing. *Information Systems Research, 5*(4), 400-421.

Constant, D., Sproull, L., & Kiesler, S. (1996). The kindness of strangers: The usefulness of electronic weak ties for technical advice. *Organization Science, 7*(2), 119-135.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*(3), 319-340.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: A comparison of two theoretical models. *Management Science, 35*(8), 982-1003.

Economides, N. (1996). The economics of networks. *International Journal of Industrial Organization, 14*, 673-699.

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research, 18*, 39-50.

Gandal, N. (1994). Hedonic price indexes for spreadsheets and an empirical test for network externalities. *RAND Journal of Economics, 25*, 160-170.

Garton, L., Haythornthwaite, C., & Wellman, B. (1999). Studying online social networks. In S. Jones (Eds.), *Doing Internet research* (pp. 75-101), Thousand Oaks, CA: Sage.

Gefen, D., Karahanna, E., & Straub, D. (2003). Trust and TAM in online shopping: An integrated model. *MIS Quarterly, 27*(1), 51-90.

Gefen, D., Straub, D., & Boudreau, M. (2000). Structural equation modeling and regression: Guidelines for research practice. *Communications of the Association for Information Systems, 4*, 1-79.

Gordon, P. (2004). Numerical cognition without words: Evidence from Amazonia. *Science 306*, 496-499.

Gurbaxani, V. (1990). Diffusion in computing networks: The case of BITNET. *Communication of the ACM, 33*, 65-75.

Harrison, D. A., Mykytyn Jr. P. P., & Riemenschneider, C. K. (1997). Executive decisions about adoption of information technology in small business. *Information Systems Research, 8*(2), 171-195.

Hu, L., & Bentler, P. M. (1999) Cut-off criteria for fit indexes in covariance matrix analysis: Conventional criteria versus new alternatives. *Structural Equation Modelling, 6*, 1-55.

Igbaria, M., Guimaraes. T., & Davis, G. B. (1995). Testing the determinants of microcomputer usage via a structural equation model. *Journal of Management Information Systems, 11*(4), 87-114.

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica, 47*, 263-292.

Kankanhalli, A., Tan, B. C. Y., & Wei, K. (2005). Contributing knowledge to electronic knowledge repositories: An empirical investigation. *MIS Quarterly, 29*(1), 113-143.

Kauffman, R. J., McAndrews, J., & Wang, Y. M. (2000). Opening the "black box" of network externalities in network adoption. *Information Systems Research, 11*(1), 61-82.

Kauffman, R. J., & Walden, E. A. (2001). Economics and electronic commerce: Survey and directions for research. *International Journal of Electronic Commerce, 5*, 95-116.

Katz, M. L., & Shapiro, C. (1985). Network externalities, competition, and compatibility. *American Economic Review, 75*, 424-440.

Koufaris, M. (2002). Applying the technology acceptance model and flow theory to online customer behavior. *Information Systems Research, 13*(2), 205-223.

Kwok, S. H., Lang, K. R., & Tam, K. Y. (2002). Peer-to-peer technology business and service models: Risks and opportunities. *Electronic Markets, 12*(3), 175-183.

Lederer, A. L., Maupin, D. J., Sena, M. P., & Zhuang, Y. (2000). The technology acceptance model and World Wide Web. *Decision Support Systems, 20*(3), 269-282.

Lee, J. (2003). An end-user perspective on file-sharing systems. *Communications of the ACM, 46*(2), 49-53.

Liebowitz, S. J. (2002). *Re-thinking the networked economy: The real forces that drive the digital marketplace*. New York: Amacom Press.

Liebowitz, S. J., & Margolis, S. E. (1990). The fable of the keys. *Journal of Law and Economics, 33*(1), 1-26.

Locke, E. A. (1986). Generalizing from saboratory to field: Ecological validity or abstraction of essential elements? In E. A. Locke (Eds.), *Generalizing from laboratory to field settings.* Lexington, MA: Lexington Books, D. C. Heath and Company.

Loo, A. W. (2003). The future of peer-to-peer computing. *Communications of the ACM, 46*(9), 57-61.

Mathieson, K. (1991). Predicting user intentions: Comparing the technology acceptance model with the theory of planned behavior. *Information Systems Research, 2*(3), 173-191.

Monroe, K. R. (1994). A fat lady in a corset: Altruism and social theory. *American Journal of Political Science, 38*(4), 861-893.

Moon, J. W., & Kim, Y. G. (2001). Extending the TAM for a world-wide-web context. *Information and Management, 38*(4), 217-230.

Nunnally, J. (1978). *Psychometric theory*. New York: McGraw-Hill.

Parthasarathy, M., & Bhattacherjee, A. (1998). Understanding post adoption behavior in the context of online services. *Information Systems*

Research, 9(4), 362-379.

Plouffe, C. R., Hulland, J. S., & Vandenbosch, M. (2001). Research report: Richness versus parsimony in modeling technology adoption decisions: Understanding merchant adoption of a smart card-based payment system. *Information Systems Research, 12*(2), 208-222.

Rohlfs, J. (1974). A theory of interdependent demand for a communications service. *Bell Journal of Economics, 5*, 16-37.

Segars, A. H. (1997). Assessing the unidimensionality of measurement: A paradigm and illustration within the context of information systems research. *Omega, 25*, 107-121.

Shang, R., Chen, Y., & Shen, L. (2005). Extrinsic versus intrinsic motivations for consumer to shop online. *Information and Management, 42*, 401-413.

Song, J., & Walden, E. A. (2003). Consumer behavior in the adoption of peer-to-peer technologies: An empirical examination of information cascades and network externalities. *Proceedings of 9th Americas Conference on Information Systems* (pp. 1801-1810). Tampa, Florida.

Song, J., & Zahedi, F. M. (2005). A theoretical approach to Web design in e-commerce: A belief reinforcement model. *Management Science, 51*(8), 1219-1235.

Taylor, S., & Todd, P. A. (1995). Understanding information technology usage: A test of competing models. *Information Systems Research, 6*(4), 144-176.

Teo, T. S. H., Lim, V. K. G., & Lai, R. Y. C. (1999). Intrinsic and extrinsic motivation in Internet usage. *Omega, 27*, 25-37.

Useem, J. (2001). Our 10 principles of the new economy, slightly revised amended and (gulp) corrected. Business 2.0, August 13.

Venkatesh, V. (2000). Determinants of perceived ease of use: Integrating control, intrinsic motivation, and emotion into the technology acceptance model. *Information System Research, 11*, 342-365.

Wang, W., & Benbasat, I. (2004). Trust in an adoption of online recommendation agent. *Journal of the Association for Information Systems, 6*(3), 72-101.

Wasko, M. M., &Faraj, S. (2005). Why should I share? Examining social capital and knowledge contribution in electronic networks of practice. *MIS Quarterly, 29*, 35-47.

APPENDIX A

Instrument

All items were measured on seven-point likert scale.

Constructs	Items	Measures
Perceived Size	PS1	I believe that UU has enough users.
	PS2	I believe that there are many people using UU.
	PS3	I believe that UU has as many users as other similar sharing networks (P2P networks).
Perceived Network Externalities	PNE1	I believe that I could rely on UU technology to reduce time and effort for finding information because of many users.
	PNE2	I believe that UU technology will be dominant among P2P systems.
	PNE3	I believe that I could benefit by UU technology.
Perceived Benefit – Extrinsic reciprocity	PBER1	When I share my information through UU, I believe that somebody will respond when I am in need.
	PBER2	When I contribute information to UU, I expect to get back information when I need it.
	PBER3	When I share my information through UU, I believe that my queries for information will be answered in future.
Perceived Benefit – Intrinsic enjoyment	PBIE1	I believe that I enjoy helping others by sharing my information through UU.
	PBIE2	I believe that sharing my information with other through P2P gives me pleasure.
	PBIE3	I believe that it is good to help someone else by sharing my information through UU.
Behavioral	BI1	I plan to use the UU technology in the near future.
Intention	BI2	I expect my use of the UU technology to continue in the future.
	BI3	I predict that I would use the UU technology in the near future.

APPENDIX B

Supporting Tables

Table B-1. Pairwise discriminant analysis of constructs (*)

Models	χ^2_{df}	χ^2 difference from original
Original CFA Model	$\chi^2_{df} = 113.51$	--
Combining intention with intrinsic enjoyment	$\chi^2_{df} = 209.67$	96.16
Combining intention with extrinsic reciprocity	$\chi^2_{df} = 201.19$	87.68
Combining intention with network externality	$\chi^2_{df} = 150.82$	37.31
Combining intention with size	$\chi^2_{df} = 178.85$	65.34
Combining intrinsic enjoyment with extrinsic reciprocity	$\chi^2_{df} = 142.95$	29.44
Combining intrinsic enjoyment with network externality	$\chi^2_{df} = 150.72$	37.21
Combining intrinsic enjoyment with size	$\chi^2_{df} = 172.47$	58.96
Combining extrinsic reciprocity with network externality	$\chi^2_{df} = 149.21$	35.70
Combining extrinsic reciprocity with size	$\chi^2_{df} = 176.28$	62.77
Combining network externality with size	$\chi^2_{df} = 158.96$	45.45

(*) Based on Gefen et al. (2003), Appendix B shows that the chi-square of the original CFA is significantly smaller than the CFA of any alternative model. Since combining any two latent variables adds two degrees of freedom to the model, the chi-square values of the original measurement model (CFA) should be at least 9.21 at p = 0.01 . As appendix B shows, all differences are above 29.44.

Table B-2. Multiple regression analyses

Independent variables	Dependent Variables		
	PNE	PB	Intention
Intercept	-0.00	0.00	-0.00
Perceived size	0.49***		
Perceived network externalities (PNE)		0.79***	1.14**
Perceived benefits (PB)			1.27**
Adj-R^2 (%)	29.0	59.3	57.8
F-value	43.57***	152.64***	72.33***

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Jaeki Song (jaeki.song@ttu.edu) is an assistant professor of information systems and quantitative sciences at the Rawls College of Business Administration at Texas Tech University. His research interests include electronic commerce, Web design, information systems strategy, and technology adoption. His work has appeared in Management Science, IEEE Transactions on Professional Communication, Information & Management, International Journal of Information Management, Information Systems Frontier, Electronic Commerce Research, *and* Journal of Electronic Commerce in Organizations.

Eric Walden's (eric.walden@ttu.edu) research interests focus on developing a greater understanding of information systems in the organizational context. This includes issues within and among organizations. He combines strong theory from industrial organization in economics, with empirical validation within an organizational context. It is his hope that this focus will bridge a gap between pure analytic economics issues and softer, real world organizational issues, making each more accessible to the other and helping to develop real theory unique to the information systems literature. He earned a PhD at The University of Minnesota, and is currently an assistant professor at the Rawls College of Business at Texas Tech University. His prior research has appeared in Information Systems Research, MIS Quarterly, Harvard Business Review, International Journal of Electronic Commerce *and other outlets.*