Digital Divide Initiative Success in Developing Countries: A Longitudinal Field Study in a Village in India

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Digital divide initiatives in developing countries are an important avenue for the socioeconomic advancement of those countries. Yet little research has focused on understanding the success of such initiatives. We develop a model of technology use and economic outcomes of digital divide initiatives in developing countries. We use social networks as the guiding theoretical lens because it is well suited to this context, given the low literacy, high poverty, high collectivism, and an oral tradition of information dissemination in developing countries. We test our model with longitudinal data gathered from 210 families in a rural village in India in the context of a digital divide initiative. As theorized, we found that the social network constructs contributed significantly to the explanation of technology use ($R^2 = 0.39$). Also as we predicted, technology use partially mediated the effect of social network constructs on economic outcomes ($R^2 = 0.47$). We discuss implications for theory and practice.

Key words: Internet kiosk; system use; economic benefits; digital divide; technology adoption; technology diffusion
History: Arun Rai, Senior Editor; Mariam Zahedi, Associate Editor. This paper was received on January 23, 2008, and was with the authors for 29 months for 3 revisions. Published online in *Articles in Advance* August 24, 2012.

Introduction

The digital divide is an economic and social issue that has seen great interest in recent years. *Digital divide* refers to the gulf between information and communication technology (ICT) *haves* and *have-nots* and exists across a variety of demographic, ethnic, and geographic dimensions (Hsieh et al. 2008, Katz and Aspden 1997, Lenhart 2002, OECD 2001). Prior generation ICTs, such as radios, played a critical role in early rural development of countries like India (see Chandar and Sharma 2003 for a review). In India, for instance, radios made it possible to provide national, regional, and local information and advice to people in general and farmers in particular. This was followed by televisions, which became available in rural areas after 1982 (see Rao 1992 for a discussion). Television programs targeting rural development, including farming practices, health, and general education, were broadcast daily. Like radio programming, these too were designed to meet national, regional, and local needs. Although they originated much earlier, cooperatives emerged early in the 20th century throughout India (e.g., Davis 1999, Desai 1969) and were used in parallel with radios and televisions to foster development. The basic idea of a

cooperative is a group of people pooling resources to gain economies and efficiencies of scale. Despite these benefits, for a variety of reasons, including increased intermediation and bureaucracy, cooperatives have several problems that often limit the benefits derived by the poorest of the poor (see Davis 1999). More recently, Internet-based initiatives are seen as a potential avenue for rural development. The widely popular and publicized e-Choupal (www.echoupal.com) across hundreds of villages in India is designed to empower farmers with information about agricultural markets and pricing. Such initiatives are expected to complement radio and television initiatives because of greater personalization and customization to fit information needs. Further, relative to cooperatives, Internet-based initiatives, which emphasize empowerment, help achieve disintermediation.

Overcoming the digital divide by successfully deploying ICTs in developing countries can have major socioeconomic implications for those countries (Keniston and Kumar 2004, UNDP 2004). In fact, it is hoped and expected that ICTs will be a cornerstone for the development of these countries by providing better quality of life through greater access to education, health care, and government (UN Millennium Project 2005). Estimates indicate that hundreds of

millions of dollars each year are invested in ICT for development projects and development infrastructure (e.g., Heeks 2009). ICT success, typically defined in terms of adoption and use, is rare, with up to 85%[1] failing to some degree in developing countries (Avgerou and Walsham 2000). Corporate social responsibility, a focal concern for organizations today (e.g., OECD 2000, Pentland et al. 2004, McWilliams et al. 2006), is a major source of funding for digital divide initiatives in developing countries. Specifically, in order to be more socially responsible, organizations spend billions of dollars each year on ICT implementations to bridge the digital divide in developing countries such as China and India (UNDP 2004, Zakaria 2006). Organizations such as the United Nations also invest a great deal in efforts to address the digital divide in developing countries (UNDP 2004). Thus, research on the digital divide in developing countries is of practical significance, with potentially far-reaching implications, including contributions to social responsibility (see Kelman 2005).

Much prior research on the digital divide has examined demographic differences that compare the privileged and underprivileged (Hsieh et al. 2008, Jung et al. 2001, Lenhart 2002). In the digital divide context, there is little empirical research on the determinants of technology use or the lack thereof (Heeks 2002). Prior research on the digital divide in developing countries has focused on describing specific technology innovation deployments and recounting their success or failure (e.g., Ahmed 2007, Heeks 2002, Keniston 2002, Keniston and Kumar 2004). These studies have identified potential benefits from successful deployments but provide limited insights into the predictors of success (Chinn and Fairlie 2006). Some have even called such work atheoretical (DiMaggio et al. 2001, Kvasny and Keil 2002, van Dijk 2006) and have issued calls for theory-driven studies. Recent digital divide research has begun building theories to address key gaps in prior research (e.g., Hsieh et al. 2008, Lam and Lee 2006). For example, Hsieh et al. (2008) used the theory of planned behavior and identified beliefs that predict continued intention to use technology and empirically tested their model in a small community in the United States. Also, Agarwal et al. (2009) found peer effects influence Internet use. Still, three key open issues remain. First, given the context of recent prior work (e.g., Hsieh et al. 2008), understanding the phenomenon in developing countries still merits attention. Second, although predicting citizens' intentions to use the technology is important, the ties of such intentions to actual technology

use and more importantly the predictions of such technology use must be examined. Last and perhaps most essential, whether or not digital divide initiatives lead to positive outcomes beyond use merits an answer. Although the expectations are that initiatives to bridge the digital divide in developing countries will produce economic, health, and quality of life benefits, there is limited systematic empirical evidence documenting that such benefits are indeed derived.

Frequently, it is assumed that focal issues will be the same among the disadvantaged as they are/were among the advantaged, although this is seldom the case (Hoffman et al. 2001). Further, there are unique cultural, regulatory, and socioeconomic conditions in developing countries (Lachman et al. 1994) that can cause a misfit between western-based theory and developing countries' practices. Although not in the context of digital divide research, there is evidence that developing countries, e.g., India, have cultural values that require thinking about ICT implementations quite differently from developed country contexts (e.g., Puri 2007, Silva and Hirschheim 2007, Venkatesh et al. 2010). Walsham and Sahay (2006) examined the current landscape of information systems (IS) research on ICTs in developing countries and identified one of the key future directions as the need to better understand actual "development outcomes" that ICTs are supposed to create. Specifically, in the context of developing countries, Internet kiosk initiatives in rural areas are more likely to see proxy use rather than direct use, which has been the focus of much of the work in developed countries (see Parikh and Ghosh 2006). Such proxy use also necessitates a focus on the diffusion of information and its impacts rather than use itself. Thus, research that sheds light on the success of digital divide initiatives in developing countries will be of substantial scientific significance.

In our effort to identify an appropriate theoretical perspective on which to anchor, we turned to the context because giving due consideration to the context is critical to rich theory development (Johns 2006). People in many developing countries have strong interpersonal ties and a strong sense of community (Hofstede 2001, Leung et al. 2005, Rozendal 2003). Further, given low literacy, high poverty, high collectivism, and an oral tradition of information dissemination, the close relationships and reliance on one another become particularly important on a day-to-day basis. For example, with regard to literacy in India, two-thirds of the population has no greater than a middle school education (eighth grade); in fact, more than 50% of the population has only a primary school education (fifth grade). In rural areas, these percentages are even lower. Further, much of this education is in local Indian languages. It needs to be

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[1] The definition of failure varies, but typically it denotes perceptions of an implementation being unsuccessful in terms of target populations using the technology to the degree expected and/or obtaining the expected benefits from use.

noted that the majority of information content from websites is offered only in English, in which much of the population in developing countries is not literate (Internet World Stats 2008). Such a context heightens the need for social bonds and oral transmission of information.

Using social networks as a theoretical lens allows us to richly theorize about and understand how interpersonal interactions influence human behaviors (see Borgatti and Foster 2003 for a review; Burt 2005, Brass et al. 2004, Kilduff and Krackhardt 1994, Scott 2000). The perspective provided by social networks helps us better understand the social forces (Kilduff and Krackhardt 1994) that influence behaviors and their outcomes—here, technology use and economic outcomes. Specifically, there are two sets of benefits from social networks—(1) power and influence and (2) access to information and resources—and these emerge from direct ties and indirect ties, thus resulting in specific complementary mechanisms by which outcomes are influenced. Our objectives are thus to

(i) develop a model of technology use and economic outcomes in the context of a digital divide initiative in a developing country and

(ii) empirically test the proposed model in a longitudinal field study in a village in India.

We expect this work to make several major contributions. We expect to gain a rich understanding of the success of ICT implementations in general, and digital divide initiatives in particular, in the context of developing countries. By focusing on economic outcomes as the ultimate dependent variable of interest, this work will complement extant prior research on the business value of technology that has primarily tended to be at the macro level (e.g., Aral et al. 2007, Dewan and Kraemer 2000) and digital divide research at the macro level (e.g., Dewan et al. 2005). In terms of contributions to ICT implementation and digital divide initiative research, it is important to go beyond technology use as a metric of success. Although the Hsieh et al. (2008) study plays a foundational role to our work, its primary goal was to identify beliefs that drive individuals' intentions to access the Internet via cable television connections within the United States. We extend their work by focusing on actual behavior and economic impacts of digital divide initiatives. Further, by shifting the context of study from a developed country to a developing country, we seek to expand our understanding to contexts where the divide is the greatest and ICT can potentially deliver its greatest benefits to society. To some extent, perhaps, as a by-product of the first two distinctions between their work and ours, we use a different theoretical lens that we believe is more suited to our context and focus. This work will complement what we

already know from the widely publicized and popular initiatives, such as e-Choupal in India, by focusing on the mechanisms and processes, especially related to information flow, by which the empowerment of farmers actually happens. Finally, we expect to complement and extend prior research on social networks by examining two new outcomes that are afforded by the context of our study, and we develop and test a theory by presenting mechanisms grounded in the context of the specific phenomenon of interest (see Johns 2006).

Theory

In this section, we first summarize prior digital divide research. We then present our theoretical lens—i.e., social networks. Specifically, we discuss our two constructs that capture the two key benefits of social networks—(1) power and influence and (2) access to resources—from both direct and indirect social ties. We then explain why social networks as a theoretical lens will be particularly suited to study the digital divide in developing countries. Next, we discuss our key dependent variables. Finally, we discuss our hypotheses development.

Background: Digital Divide
The Organization for Economic Co-operation and Development (OECD) defines the digital divide as "the gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard both to their opportunities to access ICT and to their use of the Internet for a wide variety of activities" (OECD 2001). The digital divide can be broken down further into two areas: (1) the primary digital divide that relates to ICT access and (2) the secondary digital divide that relates to patterns of ICT use and their consequences (Dewan and Riggins 2005). Many initiatives and associated research focus primarily on what is believed to be the main problem—i.e., the primary digital divide related to ICT access (see Agarwal et al. 2009, Hsieh et al. 2008, Kvasny and Keil 2002, van Dijk and Hacker 2003). With a focus on overcoming the primary digital divide in a developed country context (United States), Hsieh et al. (2008) used the theory of planned behavior to study the digital divide in a small community. They identified several attitudinal, normative, and control beliefs that would predict continued intentions to use technology among the privileged and underprivileged. One of their key findings was that facilitating conditions was particularly important among the underprivileged. Yet the failure rates of these initiatives suggest that it is a complex problem requiring a confluence of material, cognitive, and social resources to address it effectively (see Chinn

and Fairlie 2006, De Haan 2004, Hsieh et al. 2008, Payton 2003, van Dijk and Hacker 2003). Further, limited research has focused on the secondary divide, and thus little is known about the predictors and consequences of use in these contexts (Dewan et al. 2005, Dewan and Riggins 2005).

The early focus of digital divide research was primarily on identifying the socioeconomic characteristics of those who were on the wrong side of the divide (see Hsieh et al. 2008 for a review), with income and education emerging as key differentiators between the privileged and underprivileged. This work particularly highlights the importance of supporting resources for the disadvantaged in order to facilitate use (Kabbar and Crump 2006, Partridge 2007). In the context of developing countries, a majority of the work has focused on identifying areas that can, and should, be studied in future research (see Keniston 2002), such as scope of the technology being implemented, grassroots level implementation of technology, e-governance, and cultural issues. Other work on the digital divide in developing countries has examined and reports the results of specific ICT implementations. Given the high failure rates, the majority of such work has been ex-post facto analyses seeking to understand the causes of failure (Heeks 2002, Keniston and Kumar 2004). Overall, much work remains to be done to understand the use and consequences of technologies deployed as part of digital divide initiatives, especially in developing countries.

Social Networks as a Theoretical Lens

A social network is a map of the interrelationships among individuals (Scott 2000). Social network theory examines how individuals' ties with others in a given network context influence outcomes of interest. Explaining phenomena using the lens of social networks will complement the understanding gained from individual-level predictors. Social networks are conceptualized based on the type and context of the relationships being mapped—e.g., advice, friendship, and hindrance (Wasserman and Faust 1994). For example, advice networks are the interrelationships among individuals based on giving and getting advice from one another, and friendship networks are maps of affective social relationships among individuals. We focus on advice networks because they relate specifically to sharing information and providing support to other members of the network to achieve some goal. One particular construct from prior technology adoption research that is relevant to discuss in this context is social influence (see Venkatesh et al. 2003). Whereas social influence takes into account the broad role of peer pressure, advice networks are far more specific in terms of what they transmit and specifically focus on instrumental and utilitarian content. Further, social networks researchers argue that

social influence and other processes associated with social structure need to be examined more deeply by directly considering the structures found in all work settings that are based on formal and informal relationships (see Wellman 1983).

We now present the reasons why social networks in general, and advice networks in particular, are appropriate for our study context. First, our focus is on performance outcomes (i.e., benefits) of a digital divide intervention that we believe will be influenced by the patterns of power and influence of others within the network. Second, having greater access to resources will be of vital importance because of the novelty of and villagers' unfamiliarity with the digital divide intervention, i.e., technology, in most developing country contexts. Third, given the high level of collectivism and the importance of others in individual and household decisions in most developing countries, various aspects of social interactions, ranging from informational input to mimetic pressures to social support, will be important in ultimately influencing technology use. This thus makes both types of social network benefits—i.e., (1) power and influence and (2) access to information and resources—relevant to theory development in the context of the digital divide in developing countries. Fourth, given the low literacy rate in developing countries, social interactions become particularly important because information is passed from one individual to another via personal interactions (face-to-face discussions) rather than through written media. Fifth, peer effects have indeed shown to play a role in driving Internet use (Agarwal et al. 2009). Finally, because technology use is not the end in itself, rather the end is to use information obtained by using the technology as the means, there is an additional layer of social interactions that comes into play, driving whether an individual actually uses the information obtained from the technology. Thus it is important to consider a variety of social network interaction processes, particularly in a developing country context.

We focus on a particular type of network—i.e., advice network. Advice is important in our context, as noted earlier, because of low literacy, high poverty, high collectivism, and an oral tradition of information dissemination. Advice has an instrumental and utilitarian quality. If an individual finds advice from another person is helpful, then he or she is more likely to utilize that connection in future. However, if the advice is poor, then that connection is likely to be dropped. In contrast, because friendship ties are based on affective personal reactions to an individual, they are less likely to be pertinent to understanding instrumental help, other than the frequent overlap of friendship and advice ties. Given the nascent state of research on social networks and the digital divide,

we focus on the most instrumental type of network because we can expect that the instrumentality, more than affect, will be critical in driving behavior and benefits (Costanza et al. 2007). Although there is overlap between the various types of social networks, they are distinct from one another (Scott 2000). Our approach of choosing one type of network is consistent with a vast body of prior research on social networks (e.g., Sykes et al. 2009, see Borgatti and Foster 2003 for a review).

Key Constructs. Social networks research has related interpersonal interactions to various outcomes of interest, ranging from behavior to performance (Carrasco et al. 2007, Sparrowe et al. 2001). At the heart of the benefits of social networks in general, and advice networks in particular, are two core benefits: (1) *power and influence* resulting from one's ties with others in the network (Ibarra and Andrews 1993) and (2) *access to information and resources* that one does not have but could access through one's ties (Zagenczyk and Murrell 2009). Such power and influence and access to information and resources can result from *direct ties* or *indirect ties* (i.e., connections to those who have connections). Social networks research, including research specifically on advice networks, has typically anchored to one of these benefits through direct or indirect ties (see Borgatti and Foster 2003 for a review). For instance, Sparrowe et al. (2001) studied the effects of power and influence from direct ties on job performance. Likewise, Boxman et al. (1991) studied the effects of power and influence from indirect ties on income attainment in managers. Similarly, Siebert et al. (2001) studied the effects of access to information and resources from direct ties on career success, and Powell and Grodal (2005) studied the effects of access to information and resources from indirect ties on innovation. There are also cases where power and influence from direct and indirect ties have been discussed in the same work (e.g., Borgatti and Everett 2006). Similarly, there are cases where access to information and resources from direct and indirect ties has been examined in the same study (e.g., Lin 2001). However, our review of the literature did not reveal any studies that have simultaneously examined these related yet distinct and complementary benefits/aspects related to social networks. We believe that by examining both major types of benefits accrued from social networks through constructs that pertain to both direct and indirect ties to the network, we will be able to produce a more complete picture of the outcomes of a digital divide initiative.

In developing our model, we build on the fundamental mechanisms related to the two previously discussed sets of benefits—i.e., (1) power and influence and (2) access to information and resources—that we described earlier. We sought to identify constructs

to represent each of these critical benefits. However, because of the mathematically intricate nature of many of the social network constructs and their measurement that is tied closely to the conceptualization, it was necessary to combine direct and indirect ties for each of the two benefits. Direct and indirect power and influence is represented by eigenvector centrality—defined as the extent to which an individual is connected to influential others (Hanneman and Riddle 2005). Eigenvector centrality was chosen to represent power and influence rather than access to information and resources for several reasons. First, the construction of the variable does not assume that the flows through a network (information, resources, etc.) are indivisible—like a package. Instead, eigenvector centrality assumes that the flows through a network can take multiple pathways simultaneously—something a package could not do (Borgatti 2005). Power and influence are perceptual, gained from others' views, feelings, and beliefs about the focal individual. Such a consideration is appropriate to the divisible type of network flow. Second, eigenvector centrality is mathematically similar to several other power and influence metrics (Borgatti 2005, Coleman et al. 1966, Friedkin 1991, Hubbell 1965, Katz 1953, Taylor 1969). In the case of an advice network, others are more likely to see the focal individual as being influential because they are connected to others who are influential. If an individual is connected to someone who is, in turn, connected to well-connected others, then the individual is more likely to be perceived as having power themselves, such as in the case of being connected to individuals who are connected with managers within an organization. Although the focal individual may not have a direct connection to a manager, they are more likely to be perceived as having a connection (Kilduff and Tsai 2003). Prior research has examined the impact of eigenvector centrality on performance in different contexts—e.g., bank performance (Shipilov 2006), investment performance (Hochberg et al. 2007), performance of groups (Mizruchi and Potts 1998), and group leader reputation as it is affected by the leader's connections to the group (Mehra et al. 2006).

Access to information and resources explains how an individual's success is influenced by who he or she is connected to and the resources these others have. In other words, a person's value in terms of his or her social network is derived from who he or she interacts with and what these others can do for him or her (Borgatti and Cross 2003, Granovetter 1973). Direct and indirect access to information and resources is represented by closeness centrality. Closeness centrality describes how close or distant network actors are to every other actor within the network (see Freeman 1979). Individuals who are closer to all other actors would have greater access to resources and

information through shorter paths within the network than someone with lower closeness centrality. This construct reflects closeness within the entire network, with greater closeness centrality meaning that an individual is likely to have more possible access points for information and resources than someone more distantly connected. Closeness centrality assumes that the flows in the network cannot be divided—as a message or piece of information would not be—and will take the shortest path between two points. In the case of advice, a person who is high on closeness centrality (i.e., does have short paths to others) will be in position to get information early and quickly, thus maximizing its potential value (Borgatti 2005). An individual who has greater connectivity within the advice network (greater closeness centrality) is more likely to use the technology because it provides an opportunity to engage in exploratory information-seeking behaviors because he or she is more closely linked to all others within the network. Some prior research using closeness centrality has used it to examine the spread of disease through a population (Borgatti 2005), stakeholder interests (Rowley 1997), and reputational effectiveness (Bond et al. 2004).

Although each of the benefits related to social networks is distinct from the other, it is widely acknowledged, both conceptually and empirically, that they are correlated with each other (Dekker et al. 2007, Simpson 2001, Wasserman and Faust 1994). For instance, someone who wields high power and influence frequently has better access to information and resources. We will in this context, examine the complementary and potentially competing effects of these social network benefits on outcomes of interest.

Dependent Variables: Technology Use and Economic Outcomes

ICT success has been a widely researched topic area (see Delone and McLean 1992, 2003; Seddon 1997). Of the various success variables, technology use is perhaps the most frequently studied (Venkatesh et al. 2003), including recent calls to richly conceptualize this construct (see Burton-Jones and Straub 2006, Venkatesh et al. 2008). Consistent with the focus on technology use in prior research, we incorporate use as a key dependent variable. In our work, we will consider both direct and proxy use. Direct use refers to the interactions an individual has with a technology. Proxy use occurs when an individual has another person use the technology on his or her behalf (Crump and McIlroy 2003, Parikh and Ghosh 2006). Such proxy use is particularly pertinent in the developing country context because of low literacy rates and high collectivism (Parikh and Ghosh 2006). Parikh and Ghosh (2006) classify proxy use into four distinct sub-types: cooperative, dominated, intermediated, and indirect.

Cooperative interactions occur when multiple users gather around and have roughly equivalent access to the technology interface. Dominated interaction occurs when one or several users can dominate the rest and take greater control of the interface. Intermediated interaction involves a secondary user who accomplishes tasks without direct contact with the technology, instead sitting with a proxy user while the proxy searches for information/performs the task. Indirect interaction is similar to intermediate interaction except that the secondary user cannot see the proxy user's input or the technology's output. Parikh and Ghosh (2006) call for greater research into these types of use, explaining that this knowledge is vital to developing ICTs that can be utilized within the constraints of a developing world context.

We focus on intermediated use for important theoretical reasons that essentially render other types of use moot. Although Parikh and Ghosh (2006) have articulated different types of use that exist in developing countries, the context of a digital divide intervention in a rural developing country is laced with a desire to provide citizens of such communities with attention to their various individual needs. It seeks to remove their inhibitions to ask questions and obtain answers from an assistant, who is skilled at using the technology, and not overwhelm them or place burdens on them with details related to how to use a computer or the Internet, especially given the population's complete lack of computer literacy (Parikh and Ghosh 2006). Thus, direct use, cooperative use, dominated use, and indirect use fall outside the theoretical scope because of the need to focus on individual needs and lack of computer literacy.

There is a paucity of research on the consequences of technology use (see DeLone and McLean 2003 for a review). Assessing the success of a digital divide initiative in terms of technology use alone will provide a limited view of success and, as noted earlier, will completely overlook key outcomes of interest from a digital divide initiative standpoint. The goal of a digital divide initiative in a developing country is to create broader positive socioeconomic outcomes, such as increased socioeconomic status, higher degree of education for users of the innovation, decreased infant mortality rates, and decreased rates of infectious diseases (UNDP 2004). For example, a digital divide initiative designed to set up information kiosks in rural villages that provide health information on prenatal and infant health care to villagers would be considered to have reached its goal if there was an attendant significant drop in infant mortality rates over time. Conversely, if there was no significant change in infant mortality over time, the initiative would not be considered successful, even if the technology is fully deployed with all functionality the technical

designers intended and no sustainability issues, such as maintenance costs becoming too high (UNESCO 2002). This definition is a departure from what is commonly used by the information technology and computer science communities that have been primarily concerned with whether the ICT works as specified, does not experience cost overruns, and is sustainable in terms of the resources needed for maintenance and upgrades (Heeks 2002). If these cost considerations were satisfied, a traditional view would consider a digital divide initiative to be a success even if it fails to provide broader socioeconomic benefits. Our research focuses on a key economic outcome, namely income, as the ultimate dependent variable because it is, as noted earlier, a key indicator of the success of initiatives aimed at bridging the digital divide.

Hypothesis Development

In this section, we first present the justification for the hypotheses relating the social network constructs to technology use, followed by those relating technology use to economic outcomes. Figure 1 presents our model.

Impact of Social Network Constructs on Use. There are two pathways by which we expect the social network constructs to ultimately influence economic outcomes: (1) *behavioral pathway* and (2) *informational pathway*. The behavioral pathway is one that prompts better-connected individuals to engage in behaviors that could contribute to performance benefits. Here, this refers to the pathway from the social network constructs to technology use, both direct and indirect, that in turn contributes to economic outcomes. The informational pathway is one where performance benefits are derived through network position and the direct benefits it confers, which includes information or knowledge that others may have acquired as a result of behavioral performance, i.e., without behavioral performance—here either direct or intermediated use—by the focal ego. In other words, this refers to possible knowledge that someone using the kiosk has obtained that is more readily and quickly available to those who are better connected, thus providing them with the performance benefits even though they do not use the kiosk themselves. H1 and H3 together represent the behavioral pathway and H2 represents the informational pathway.

H1A and H1B represent the first step in the behavioral pathway—i.e., network position to technology use. Eigenvector centrality is an indicator of status, i.e., examining eigenvector centrality allows for the notion that all social network ties are not equal (Bonacich and Lloyd 2004). In the context of a rural area with low literacy rates, we expect being able to supply information to others within the network is one way to attain or maintain power and influence within the network because it has been shown that increased knowledge leads to increased status in the developing world context (Behrman and Wolf 1984, Rao 2001). Individuals who have power and influence are more likely to command resources and tend to survive better than those who lack them (Ernst and Kim 2002, Gadgil and Bossert 1970). Being connected to influential others in such environments where resources are scarce makes the focal (connected) individual more influential. In a developing country context when a new technology, particularly one that is quite different from any that citizens are familiar with, is introduced, people will seek out influential others for advice on whether the technology should be used and how the technology can be used, share problems that they encounter with one another, and share information they have obtained using the technology. Influential individuals thus have more opportunities to learn how others are using the technology, which gives them more opportunities to understand the technology and the benefits it provides (Hoang et al. 2006, Rogers 2003). Influential individuals are more likely to be innovative when encountering new ideas or practices (Knack and Keefer 2003), especially because such individuals can leverage their influence to get help as needed. This would allow them to become more comfortable with using the technology because they know that if they have difficulties, they can leverage their influence to get help. Such availability of help may lead to greater exploration of the technology features as well (Park et al. 2009). Such help is beyond facilitating conditions because the focus of that construct is on formal support (Hsieh et al. 2008, Venkatesh et al. 2003) rather than the informal support that social networks provide. For example, consider two villagers who each have three get-advice ties within the network. The first villager is connected to two people

Figure 1   Research Model
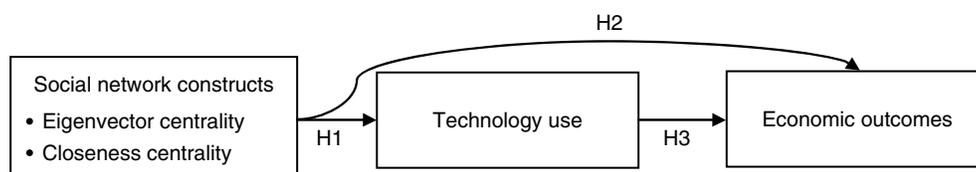
Note. H1 and H3 form the behavioral pathway, and H2 is the informational pathway.

who are both very well connected within the network and one that is moderately well connected. The second villager is connected to three individuals who are only modestly connected within the network. Compared to the second villager, the first villager is more likely to be approached for advice by others within the network because of his own connections to well-connected others. When others come to the first villager for advice, he will gain prestige and influence. He will also gain the benefits of seeing how others use the technology, what they gain from it, and what problems they have with it. The first villager, who is higher in status and influence, is more likely to continue to use the technology to continue to reap the benefits of being a source of advice to others. This is not to say that villagers lower in eigenvector centrality, like the second villager, would not or could not be inclined to use the new technology to increase their status. However, without the higher eigenvector centrality, technology use would be much harder to achieve because the opportunities afforded by power and influence would not be as readily available (Lin 1999). Thus, we hypothesize

HYPOTHESIS 1A (H1A). *Eigenvector centrality will positively influence technology use.*

As noted earlier, we conceptualize closeness centrality as a construct that reflects access to information and resources from the entire network, encompassing both direct and indirect access. An individual who has higher closeness centrality is likely to obtain information and resources more readily than would someone who has lower closeness centrality. Such a well-connected individual will receive information about the new technology quicker and more often because there is a greater likelihood of information traffic flow in a more closely linked network. In the case of finite physical resources, this means that someone with greater closeness centrality will be likely to obtain the resources diffusing through a network before they run out, unlike an individual with lower closeness centrality. It may also mean that important information will get to the person through one of several possible paths, whereas a less closely linked individual has fewer paths of information, which in turn limits the amount of information that flows to him or her in a timely fashion.

We expect closeness centrality to play a role in our context especially given that informal channels of communication are often the primary method of diffusing information among individuals, especially in developing countries (Parikh and Ghosh 2006). In such settings, those who are more closely connected to others in the network see a higher volume of traffic within the network because greater closeness means being in the path between others

more often than individuals who are less closely connected. Thus, someone with greater closeness centrality within an advice network has more rapid access to resources and a greater likelihood of encountering said resources because more traffic passes through the advice network of the focal individual. Individuals who are closely tied to the rest of the advice network will get access to more information about the technology and access to information on how individuals are using the technology earlier when it is most valuable (Borgatti 2005), which in turn could impact their own use of the technology. Whereas in developed countries, secondary sources of information, such as manuals and online help, play a major role in aiding in the use of a technology, in developing countries, these secondary sources are scarce and less useful because they require high levels of literacy and a certain level of technical proficiency in order to be useful. In developing countries, closeness centrality within the advice network will be critical to learning about, and interacting with, the proxy user and the associated technology, overcoming difficulties one faces while interacting with the proxy user, and harnessing the potential of such interactions by learning about the types of questions that can be asked of the proxy user. Specifically, knowing how others use the technology will serve as a key guide on the different types of benefits using the technology can bring to an individual. In the context of a digital divide initiative in a developing country, access to resources in terms of knowledge and technology use efficacy is of vital importance because these are rare commodities (Parikh and Ghosh 2006). As noted earlier, literacy rates, especially English literacy and computer literacy, are low in developing countries. An individual who is better connected, compared to someone who is less well connected, within the advice network is more likely, on average, to have a tie to someone who has knowledge of the benefits the technology can provide or who has used the technology with the help of a proxy user and can explain the procedures to access the technology and the types of questions that can be asked of a proxy user. Here is one example case: two farmers each have to make a decision of when to plant the next crop in their fields. They need to judge the weather for a three-day window, which is the length of time it takes to completely plant each of their fields. They need a time where no rain is imminent but within a few days of a previous bout of rain so that the soil will be ready to germinate the planted seeds. Villagers know that the new Internet kiosk is supposed to be able to give information about farming and weather. Farmer *A* is closely connected within the advice network and may have heard from many peers that weather forecasts for a week or longer are possible to get from the kiosk. He also has several

contacts who can tell him the kinds of questions he should have for the kiosk assistant. Farmer *B*, who is more peripherally connected in the advice network, may thus be less likely to know that weather forecasts are part of the kiosk's offerings. Farmer *A* is thus more likely to seek out the kiosk, and ask for and obtain the right information from the kiosk assistant, whereas Farmer *B* may rely on his instincts or other less specific, customized, or detailed sources, such as radio programs that may not provide the longer-term forecast that Farmer *B* seeks. Thus, we hypothesize:

Hypothesis 1B (H1B). *Closeness centrality will positively influence technology use.*

Impact of Social Network Constructs on Economic Outcomes. In addition to the direct effect of technology use on economic outcomes, we expect use to be a partial mediator of the effects of social network variables on economic outcomes, which represents the informational pathway, i.e., H2A and H2B. Social networks in general confer economic advantages and over time, economic advantages in turn enhance one's social networks (Granovetter 2001). Developing countries typically have hierarchical societies where economic advantages and strong network ties are highly correlated. In these countries, those with stronger networks are treated better and have more opportunities to advance themselves (Keniston and Kumar 2004). Further, over time, given the high degree of economic inequality that prevails in developing countries, those who are affluent develop strong network ties. Although the causality can indeed flow in both directions, we are particularly interested in the extent to which technology use contributes to economic outcomes above and beyond the impact of social network variables on economic outcomes, which is the focus of H3. Such an examination would be a more conservative test of the effect of technology use on economic outcomes.

The nature of our social ties has been shown to have profound impacts on several outcomes of interest (e.g., Boxman et al. 1991, Sparrowe et al. 2001). Social ties will influence economic outcomes through several mechanisms. First, the flow and quality of information plays a part in economic endeavors and related outcomes (Dutta and Jackson 2003). On the one hand, the most important predictor of economic outcomes is previous economic outcomes. This would imply that economically well-to-do villagers are likely to remain well-to-do. We believe that part of this is driven by the human desire to keep or improve one's social rank/place (Cooley 1964). When faced with choosing behaviors that can enhance their prestige or not, a villager of high social standing is likely to choose the behavior that will keep him at the head of the pack, socially and economically speaking (Cooley 1964). For

example, one of the wealthier villagers whose family has held the second wealthiest spot in the village for generations is likely to use whatever assets he has at his disposal to keep or improve his position. This would include using a new Internet kiosk if available. Greater eigenvector centrality is, in some sense, a reflection of the importance of a villager compared to all other villagers. A villager who is better connected in the advice network will receive relevant information, such as weather-related information or farming practices, that he could use from his advisors. In such cases, even though the villager did not actually use the technology (with or without the aid of the proxy user), he derives the benefits. Such access to relevant information is less likely to be the case for the less connected. Thus, we hypothesize:

Hypothesis 2A (H2A). *Eigenvector centrality will positively influence economic outcomes.*

Social ties influence who gets information and the speed with which they receive new information. When a farmer in the village hears that a strong storm that could destroy a crop is expected in three days, he has more time to go out and cover his plants compared to the next villager who hears about the storm only a day in advance. Another social network related mechanism through which economic outcomes can be influenced is trust related to the source of information. Someone who is more closely linked within the village network has a much easier time of getting advice from someone he trusts, as opposed to someone who is less closely linked to others in the village. People are far more likely to trust a close tie's information—i.e., having more advice available allows for, in theory, better decision making overall, thus enhancing one's ability to produce products, to invest wisely, and to use assets to the best outcomes possible. Such advice network benefits can also carry information that one's advisors obtain as a result of using the technology. In other words, someone who has high closeness centrality may hear about the weather information we describe above that was perhaps obtained by one of his or her advisors when the advisor used the kiosk. Consequently, the performance benefits accrue for the focal individual even though he or she did not use the technology. Thus, we hypothesize:

Hypothesis 2B (H2B). *Closeness centrality will positively influence economic outcomes.*

Impact of Use on Economic Outcomes. By focusing on the relationship between technology use and economic outcomes, H3 completes the causal chain that started with the effect of network position on technology use (H1A and H1B). Developing countries are termed as such because of the overall

socioeconomic status of their citizens. Such countries, as noted earlier, are characterized by low literacy rates and substantial reliance on nonprint media for information dissemination. In such cases, digital divide initiatives will face substantial challenges in producing favorable economic outcomes. However, through direct and intermediated use of the technology, the latter being technology use with the help of another person who is familiar with the technology and is literate, benefits can potentially be garnered. Information on the weather, health, farming practices, government subsidies, government programs, fair prices of products/commodities, and locations/times of markets, to name a few, will be available to contribute to favorable economic outcomes (Keniston 2002). In the past, in developing countries, televisions and radios have played such a role. Specifically, televisions and radios broadcast many educational programs targeted toward farming practices, health care, reading, and writing (e.g., Bollag 2001, Chaudhary 1992). However, one of the limitations of televisions and radios is the generic nature of the information available and the high degree of inflexibility given that programs are broadcast at specific times (see Bollag 2001, Chaudhary 1992). With newer technologies, e.g., Internet kiosks, these limitations can be overcome. An individual can access information that is specific to the situation that he or she faces. Further, an individual can access such information at a time that is convenient to his or her schedule. In sum, we expect technology use to contribute favorably toward economic outcomes. Thus, we hypothesize

Hypothesis 3A (H3A). *Technology use will positively influence economic outcomes.*

Hypothesis 3B (H3B). *Technology use will partially mediate the effects of social network variables on economic outcomes.*

Method

In this section, we describe the study context, sample, measures, and data collection procedure.

Context

We targeted a village in rural India because this provided a context to study a developing country in which several initiatives to bridge the digital divide are underway. Targeting a rural area was important because often in developing countries, urban centers are far more developed and can be somewhat similar to developed countries. Specifically, we identified a village where an initiative of the government of India was being deployed with support from a large multinational corporation. The village was primarily an agricultural community, with most of the families pursuing farming and related occupations. Not

unlike many agricultural villages in India, the village we studied was part of a large cooperative. The specific digital divide intervention included training of villagers, particularly those who were the heads of households, in using personal computers that were enabled with Internet access, which is termed Internet kiosks, that were centrally located in the village. The primary goal of the initiative was to give the villagers access to information regarding farming practices, weather patterns, and the fair pricing and market locations/times for agricultural products to help them market their goods. The Internet kiosks were available 16 hours a day. These kiosks were staffed by individuals who could serve as proxy users so that even those who were not literate could use the kiosks with the assistance of proxy users. Ten kiosks and six user assistants were available during the entire first year after the implementation, i.e., the duration of the study. In order to provide a basis for comparison, we also gathered data from a neighboring village (less than 10 miles away from our target village) that was part of the same cooperative and had very similar environmental conditions, including population, crops grown, and weather conditions.

Sample

The participants were residents of the above-mentioned village in India. There were 232 families in the village and a total of 1,260 residents. Given our focus on economic outcomes, we gathered data from the heads of the households, who were also the primary breadwinners in their respective families. Of the 232 heads of household, 210 provided the necessary data for a response rate greater than 90%, which is above the 80% threshold needed for network studies (Knoke and Yang 2008). Of the 210 heads of households who participated, 171 were men, which is consistent with the estimates for rural areas in India (Census of India 2001). The average age of the participants was just over 41. Most participants were married. The neighboring village that served as the benchmark had 252 families, with 1,390 residents. Of these, 220 heads of household provided data.

Measures

The questionnaire was created by assembling various questions related to the social networks and control variables. Consistent with acceptable translation practices (e.g., Brislin et al. 1973), the instrument was first translated by a native language speaker, from English to Tamil, the local Indian language in which the questionnaire was administered, and then translated back from Tamil to English by a second individual. Any discrepancies were discussed until a resolution was reached. The English version of the questionnaire from which the Tamil version of the questionnaire was created is shown in Appendix 1.

Depending upon the location and scope of the project under study, either open social network survey questions or a roster-style instrument can be used. We preferred the roster-style instrument because it allows individuals to remember everyone with whom they interact. We created the roster using the head of household information ($N = 232$) obtained from the local government office. Using the question shown in Appendix 1, advice network data were gathered. We constructed 210×210 matrices for both get-advice and give-advice questions from the usable responses and used UCINET, v6.29 (Borgatti et al. 2002) to calculate the scores for the social network constructs. The formulas for each of the social network measures are shown in Appendix 1, but we provide a discussion of the measurement/calculations here. Eigenvector centrality was calculated from the give-advice network because we are seeking to examine how influential or powerful individuals are within the network. It seems logical that individuals will gain prestige when others ask them for advice because they are seen as having helpful information/knowledge. UCINET uses factor analysis to identify factors of the distances among actors. The location of each actor on each dimension is called an eigenvalue that together determine eigenvector centrality. Closeness centrality was calculated from the get-advice network because it represents access to information and resources. If someone has many sources of advice he can turn to when faced with a question or problem, he is more likely to have access to the right information/answers compared to someone with fewer sources of advice. UCINET calculates the closeness centrality measure using Freeman's (1979) method of undirected geodesic distance (see Borgatti et al. 2002). The program generates closeness centrality scores as a distance measure (farness) and the sign was reversed to make the number interpretable as a closeness measure. Both measures are expressed on a 0–100 scale.

We measured technology use and economic outcomes, in the case of economic outcomes both before and after the digital divide intervention, from archival records. We measured both direct and intermediated use through logs maintained at the kiosk by the kiosk staffers. The practice of keeping detailed records is a common one in government organizations in India and thus was not likely to be perceived as unusual by the citizens. For instance, the government tracks the purchase of certain products, such as rice and sugar, by each family using a "ration card." The kiosk staffers logged the actual time of direct and intermediated use by each person. The data from these log books were then aggregated for the entire year. The baseline economic outcomes data were gathered through a combination of information from the local government office that assessed the annual produce of each farmer. Such a measurement of economic outcomes is consistent with suggestions in previous research. For example, in an information kiosk project whose goal is to provide farmers with better agricultural knowledge, long-term weather information, and access to information on markets for their goods, the economic outcomes are best assessed if they are closely tied to the expected benefits (Bhatnagar and Schware 2000). Follow-up economic data were gathered similarly. We then standardized the data to control for price fluctuations because of inflation of agricultural products (Index of Agricultural Products) using the government of India Index, with 1993/1994 as a baseline (India Agro Industry 2007)—thus allowing us to directly compare economic outcomes over time. It is important to note that we only included economic outcomes from the head of the household in each family. In our sample, no one else in any family earned more than 10% of what the head of the household earned, thus making our measure of income to be a fairly accurate reflection of household income, with little or no threat of the data not reflecting the economic well-being of the family.

We controlled for several variables associated with intention, use, and access in prior technology use, and digital divide research. These include various demographic and socioeconomic variables of the heads of households (where applicable): gender, age, family size, previous year's economic outcomes, and education level. We also included years of cell phone use as a control variable. We found that no one possessed any computer-related experience, and thus cell phone use was the closest technology-related experience variable that was appropriate. In order to control for knowledge gained through training, we controlled for number of training sessions attended. We measured five cultural characteristics (Hofstede 2001), namely uncertainty avoidance, long-term orientation, power distance, individualism/collectivism, and masculinity/femininity, for inclusion as possible control variables. Although they were originally conceptualized at the national level by Hofstede, more recent work has reconceptualized these constructs at the individual level (Srite and Karahanna 2006) and we measured them at the individual level. However, given the cultural homogeneity and very low standard deviation in the sample, they were excluded from the analysis. Finally, in order to benchmark the proposed model with models from prior research on technology use, we gathered data on constructs from the theory of planned behavior and the technology acceptance model (see Venkatesh et al. 2003).

Data Collection Procedure

The data were collected in two phases. The first phase, which lasted a month, was to establish a

baseline of economic outcomes and to gather data about the independent variables, including the social network variables. The baseline economic outcome data were gathered before the start of the training. Given the low literacy rate among the participants, which is, as noted earlier, characteristic of developing countries in general and of rural India in particular, it was necessary to collect data without using a traditional paper-and-pencil survey administration. We employed seven interviewers who visited the various families and administered the questionnaire by asking them responses to the various questions in the local language. Each survey administration took up to two hours to complete because of the involved nature of the data collection process and the length of a social network survey, which in this case required each responded to answer each advice network question in conjunction with each of the 231 other respondents, thus resulting in 231 questions to assess each network. Each respondent was offered an incentive of 200 Indian rupees (approximately US$5). This is a significant incentive given the low cost of living in India. Also, many families indicated that the incentive was the equivalent of their earnings for a few days. The nonrespondents were individuals, who despite repeated follow-up attempts, could not be contacted or were families that had experienced a recent catastrophic event (e.g., death in the family).

For a month following the baseline data collection, training sessions were conducted every evening to explain the benefits of the technology, the type of information available, and procedures related to direct and intermediated use of the technology. The training was conducted in the local language. Once again, given the low literacy rate, it was more important to make the technology available to facilitate intermediated use rather than to expect substantial direct use. During the training sessions, up to 10 assistants were available to demonstrate what type of information would be available and how use of the technology would be facilitated by the assistants in the future. Citizens were encouraged to attend multiple sessions and some did.

The second phase, approximately a year after the first phase, involved gathering use data and economic outcomes. The use data were gathered from the kiosk usage log books and the economic outcomes were gathered from local government records.

The exact same data (except technology use, which was not applicable) in the same time period were gathered from the neighboring village as mentioned earlier. This neighboring village's economic outcome data were to serve as a benchmark (control group) against which the progress of the village with the intervention (our target village) was to be assessed.

Results

We used UCINET, version 6.29 (Borgatti et al. 2002) to analyze the social network data. We used partial least squares (PLS) to test our measurement and structural models. The specific tool we used was Smart-PLS, version 2 (Ringle et al. 2005). Given the nature of the variables used in the model, all scales used one item only; thus, reliability and validity assessments were not necessary. In the case of all network measures that are calculated using formulas and other single-item scales, i.e., demographic variables, the assumed ICRs, average variances extracted (AVEs), and loadings are one.

Table 1 shows the descriptive statistics and correlations. The means and standard deviations were in the ranges expected. The demographic characteristics suggested families, on average, comprised a little more than five members. Only about a fourth of the head of households had completed the equivalent of an eighth grade education. Only four heads of households had completed high school. Only 25 heads of households were English literate. The literacy statistics of our sample were largely consistent with what is found in villages in India. The average pre-implementation annual income was slightly more than 17,000 Indian rupees (approximately USD$400). Compared to pre-implementation levels, the economic outcomes showed a significant increase a year after the digital divide initiative. We compared the average economic growth rate in the village to that of India in general and found the growth in the village to be significantly greater. Specifically, we compared the village economic growth rate to both the national GDP growth rate as well as the agricultural economic growth rates. The village's average income growth was significantly higher at 26%, compared to 9% growth in overall national GDP and 6% national agricultural economic growth rates for India as a whole in year 2005 (Indian Industry 2007). Also, the data from the neighboring village indicated an 8% income growth, which was consistent with the GDP and agricultural growth, but much lower than the growth in the target village, thus providing evidence for the effectiveness of the kiosk initiative. The social network variables were correlated with many of the socioeconomic variables. The social network variables were also correlated with each other. Because they are derived from essentially the same matrices, this pattern is to be expected and consistent with much prior social networks research (Dekker et al. 2007, Simpson 2001, Wasserman and Faust 1994). As noted earlier, we examined the variance inflation factors (VIFs) for all predictors in the various model tests and found them all to be less than five, thus suggesting that multicollinearity is not a concern in our analysis. Technology use and economic outcomes (pre and post)

Table 1   Descriptive Statistics and Correlations

	M	SD	1	2	3	4	5	6	7	8	9	10
1. *Gender* (0: men)	0.19	0.39										
2. *Age*	41.33	10.91	−0.20**									
3. *Family size*	5.15	1.73	0.06	0.19**								
4. *Education*	0.24	0.44	−0.21***	−0.10	0.05							
5. *Cell phone use* (years)	1.55	1.01	−0.16*	−0.22***	0.03	0.17**						
6. *Prev. year's economic outcomes*	17,645	5,222	−0.22***	0.20**	0.08	0.25***	0.08					
7. *Training sessions attended*	1.25	0.55	−0.17**	0.08	0.07	0.29***	0.04	0.23***				
8. *Eigenvector centrality*	24.22	8.83	0.14*	0.12*	0.14*	0.19**	0.03	0.23***	0.08			
9. *Closeness centrality*	−28.22	10.20	−0.20**	0.19**	0.15*	0.19**	0.07	0.21***	0.10	0.33***		
10. *Technology use*	6.64	2.90	−0.25***	−0.21***	0.03	0.24***	0.08	0.46***	0.22***	0.30***	0.31***	
11. *Economic outcomes* (rupees)	22,330	6,444	−0.32***	0.24***	0.05	0.11*	0.05	0.61***	0.25***	0.29***	0.30***	0.41***

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

were correlated with many of the variables. Specifically, technology use was positively correlated with both social network variables. Post-implementation economic outcomes were most strongly correlated with pre-implementation economic outcomes, and both variables were also positively correlated with technology use and the social network variables.

Table 2 shows the results of model testing using PLS. In predicting technology use, we see that the various control variables had a significant effect and explained 23% of the variance in use. Although some of the demographic characteristics were significant in explaining use, with the inclusion of the social network variables, the effect of the demographic variables became slightly weaker, indicating that these variables likely share explanatory variance with the social network variables. When the social network variables were included, the variance explained in technology use increased to 39%, with both social network variables being significant, thus providing strong support for H1A and H1B. Although we measured direct and intermediated use separately, we found that only 20 individuals engaged in direct use; even so, their direct use was limited, with the individual who had the highest amount of use logging only 20 hours during the entire year. Consequently, this does not really give us an opportunity to examine direct versus intermediated use in a meaningful way. However, we did partial out direct use entirely and found the pattern of results to be identical to what we have reported, quite likely because of the limited direct use—these results are shown in Appendix 2.

The second set of results examined economic outcomes as the dependent variable with technology use as a key mediator. Consistent with the approach suggested by Baron and Kenny (1986), we tested a series of models and found that the effects of the social network variables on economic outcomes were partially mediated by technology use. Part of the challenge in directly using Baron and Kenny (1986) is that when new models are estimated in PLS (i.e., by dropping the mediator variables), the latent variable

values (and descriptives, correlations, and even loadings) are reestimated. For instance, the latent score for previous year's economic outcomes could have different values in different models because the latent scores are reestimated by PLS in conjunction with the model being estimated. Such a reestimation of latent variable scores for different models would, of course, result in an inappropriate comparison across models. As a solution, we estimated the latent variable scores from the full PLS model test and used the same set of latent variable scores to test the various models. Such a two-stage approach is consistent with Agarwal and Karahanna (2000). We also conducted similar tests using ordinary least squares (OLS) and found the results to be identical. The model with only control variables explained 31% of the variance in economic outcomes. Not surprisingly, the previous year's economic outcomes strongly predicted post-implementation economic outcomes. The addition of technology use and social network variables *separately*, all of which were significant, increased the variance explained to 39% (models 2a and 2b). Finally, when both technology use and social network variables were included in the model simultaneously, the variance explained increased to 47%. In sum, technology use predicted economic outcomes, and the effects of social network variables on economic outcomes were partially mediated by technology use, thus supporting H2 and H3.

In order to provide a benchmark for how well the proposed model extends our understanding beyond what might be gained from models from prior research, namely the theory of planned behavior (TPB) and the technology acceptance model (TAM), we provide these results in Appendix 3. The PLS measurement model results for TPB and TAM, which are not shown here because of the clean factor structure and extensive previous validation, showed all loadings to be greater than 0.75 and all cross-loadings to be lower than 0.25, thus providing evidence for internal consistency and discriminant validity. The descriptive statistics, correlations, reliabilities, and

Table 2   **Structural Model Results**

	DV: *Technology use*		DV: *Economic outcomes*			
	Model 1	Model 2	Model 1	Model 2a	Model 2b	Model 3
R^2	0.23	0.39	0.31	0.39	0.39	0.47
ΔR^2		0.16***		0.08*	0.08*	0.08*
Control variables						
Gender (0: men)	−0.12*	−0.11*	−0.22***	−0.16**	−0.17**	−0.11*
Age	−0.11*	−0.07	0.18**	0.15**	0.17**	0.10
Family size	0.04	0.01	0.04	0.02	0.02	0.01
Education	0.16**	0.14*	0.12*	0.06	0.12*	0.03
Cell phone use (years)	0.02	0.02	0.05	0.03	0.04	0.01
Prev. year's economic outcomes	0.32***	0.32***	0.51***	0.46***	0.48***	0.43***
Training sessions attended	0.14*	0.13*	0.16**	0.14*	0.12*	0.07
Social network variables						
Eigenvector centrality		0.22***			0.20***	0.14*
Closeness centrality		0.29***			0.21***	0.17**
Behavior						
Technology use				0.39***		0.32***

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

AVEs are shown in Appendix 3(a). The reliabilities and AVEs were all greater than 0.70; also, all AVEs were greater than the correlations. Together, this provides further evidence of reliability and discriminant validity. In predicting technology use, TPB and TAM predictors were significant and explained 8% additional variance beyond the control variables, which is significantly lower than the additional 16% explained by our model (see Table 2). In the prediction of economic outcomes, neither the TPB predictors nor the TAM predictors were significant when technology use was included; although when technology use was excluded, TPB and TAM predictors were significant. The variance explained by TPB and TAM in economic outcomes was 37% and 38%, respectively, which is about 10% less than what is predicted by the model proposed in this work—i.e., model 3 in Table 2.

Discussion

We proposed a model of technology use and economic outcomes in the context of digital divide interventions in developing countries. We drew from social network theories and prior digital divide research to develop our model. We conducted a field study in a village in India. Our model received strong support, with all hypotheses being supported. Our models explained 39% and 47% of the variance in technology use and economic outcomes, respectively. The importance of the social network variables in predicting technology use was underscored because 16% additional variance was explained by these new variables. Interestingly, the prediction of economic outcomes showed that the social network variables had a direct effect on economic outcomes above and beyond what was mediated by technology use. This lent support to the importance of social network variables in

the context of digital divide initiatives in rural India and possibly in rural areas in developing countries in general.

Theoretical Implications

Our research makes important contributions to IS research in general and digital divide research in particular. We also contribute to social networks research. First, there is a growing interest in IS on the digital divide and developing countries (see Hsieh et al. 2008, Saunders 2007). The most severe forms of the digital divide exist in developing countries (UNDP 2004). By developing and testing a model of economic outcomes of digital divide initiatives in developing countries, after controlling for known predictors of technology use among the underprivileged, this work makes an important theoretical contribution to IS literature. As noted at the outset, this work complements prior research on the business value of technology and digital divide research at the macro level. Second, empirical evidence related to the success of digital divide interventions is limited to date. Most of the stories that abound relate to failure of initiatives. Therefore, obviously, an understanding of the drivers of success is limited. Our work addresses these gaps by conducting a longitudinal examination of the impacts of a digital divide initiative and complements previous research on this topic (e.g., Keniston 2002, Keniston and Kumar 2004). Third, our work complements the vast body of research on individual-level technology use in homes and organizations (e.g., Brown and Venkatesh 2005, Venkatesh et al. 2003). IS research seeks to understand outcomes of technology use (e.g., DeLone and McLean 2003). Our research contributes to this area by specifically examining an important outcome in the relatively

understudied context of the digital divide in developing countries. Besides expanding the nomological network by including economic outcomes as a dependent variable, we expand the theory bases used to understand technology adoption and use. Fourth, an equally important contribution is to social networks research—by being one of the first studies to examine both power and influence and access to resources and information, and to incorporate relevant constructs and empirically test the resulting model, we provide a test of two social network mechanisms and the relative contribution of the two predictors, particularly in the context of the phenomenon under investigation.

One of the cautions in concluding that this digital divide initiative is a success is the reproduction of social inequality or the accumulation of advantage, also known as the Matthew Effect (De Haan 2004). In other words, through introduction of modern technologies like computers and the Internet, are we making, relatively speaking, the rich richer and the poor poorer? The results of this study actually reveal some insights into this issue. For instance, in Table 1, previous year's economic outcomes positively correlate with various contributing social network constructs. In other words, those (within the social network) who were better off economically also had higher/better network connections prior to the digital divide initiative. As shown in Table 2, previous year's economic outcomes and the contributing social network factors all positively lead to economic outcomes, as well as technology use, in the following year. In this case, those who were better off one year earlier can better capitalize on their existing economic and social advantages and convert these resources into technology use, and more importantly, economic outcomes in the next year. This is not a surprise and is consistent with what diffusion researchers, e.g., Rogers (2003), have found across many contexts. The question then becomes is this really a success? Or are we enlarging the relative economic gap between the privileged and the underprivileged in this village? The concern is heightened when we compare the pre- and post-implementation standard deviations in income, with the latter being substantially higher.

Future Research. Although examining success in terms of economic outcomes is an important step, future research must assess other important potential outcomes, such as health outcomes. A one-year time horizon is a substantial methodological advance over prior research. Yet it is hardly a time window in which digital divide success can be firmly established. The inherent longitudinal nature of the phenomenon calls for future work that is conducted over several years. Further, such work is essential in order to examine and understand outcomes at broader societal levels.

We chose representative constructs for different social network benefits: (1) power and influence and (2) access to information and resources. Future work should examine other constructs that might capture other benefits or capture them in different ways. Future work should also examine the potential interrelationships among individual, household, and social network variables. Also, theory development around potential interactions will be of value both to IS and social networks research. As additional outcomes, such as health benefits, are explored, theory development around what predictors will play important roles will be essential. The generalizability of our theory to other contexts, e.g., other developing countries (say, China), where social networks play a role is important.

The work done here in predicting the success of a digital divide initiative using social network theory is a first step on a long journey. The next steps to fostering success involve studying potential interventions that will help individuals build the necessary networks. The fact that economic outcomes saw an upswing in our study bodes well, but the increased variance that we observed in the post-implementation phase suggests a need for caution and a call for action. Over time, if some people benefit from ICTs and can, for instance, as we observed, improve the yield from farmlands and can do so at a lower cost per unit of production, those who do not reap such benefits will suffer greatly because they may be unable to sell their products on the market because of an increased price differential with those who are leveraging IT effectively.

We benchmarked our results against prior models of technology use. However, because of the theoretical focus on social networks, we did not engage in a theoretical integration with these other models. Future work should focus on integrating the social network perspective with other individual-centric perspectives to gain a more comprehensive understanding of the underlying phenomenon. Like the model comparison in Venkatesh et al. (2003), work should focus on comparing a more elaborate set of models prior to reconciling these competing theories and perspectives in the context of digital divide initiatives.

Another issue is that of culture; although we measured Hofstede's (2001) cultural variables, the context of this study did not lend itself to much cultural variance. Future research should examine different contexts, including those that have greater cultural variance, because they may provide for a direct or moderating role for espoused culture (see Srite and Karahanna 2006). Finally, as mentioned earlier, different types of social networks are distinct from one another and tap into different facets of social processes, factors, and mechanisms. We chose to examine

a utilitarian advice network. However, friendship networks are likely to play a role in technology use, as well as many of the negative tie social networks (e.g., gossip, hindrance networks). Future work should seek to expand on the findings here and integrate them with constructs from other types of social networks that could be particularly important in contexts where collectivism is high. We believe interactions between and overlap across different networks could have interesting ramifications for the critical outcomes related to digital divide initiatives.

Limitations and Other Future Research Directions. Although our aim is to understand digital divide initiative success in developing countries, we can only, with caution, draw inferences and conclusions for rural India. We collected data in only one village in India. India itself is a culturally diverse country and future research is necessary to examine the generalizability of our work within India. Another limitation is the duration of the study. One year is perhaps not long enough to fully understand the phenomenon of a new technology implementation, especially in a setting where the use of technology has no precedent. Future work should focus on rectifying these limitations. Future research should study other countries, such as China, another Asian country with similar cultural dynamics in terms of extended family networks and issues related to a strong hierarchical structure, where we also expect social networks will provide a useful theoretical lens. Yet the specific predictors and mechanisms may be different. Although we have focused on the context of developing countries in our theory development (see Johns 2006), refinement of our model by considering the uniqueness of India versus China will be of scientific and practical significance. Future work should also theorize about and empirically examine digital divide initiatives in African and South American countries.

As we noted, there was limited direct use in our study, but this is to be expected given that the initiative was in its first year. Further, the literacy was low and there was no computer experience prior to the initiative. It can only be hoped and expected that this would change as the initiative matures. However, only future longitudinal studies over longer time frames can establish this. Further, although we focused on intermediated use, given the type of initiative and physical layout of the facility where the kiosks were located, other types of use discussed in Parikh and Ghosh (2006) were not possible. Future work on this topic should develop different models to explain and predict different types of use.

Practical Implications
One of the most important practical implications of this work stems from the role that technology can

play in influencing economic outcomes in a developing country. Initiatives to bridge digital divides abound and the benefits of such initiatives are touted to exist with a few case studies among small groups. Strong evidence of large-scale successes of digital divide interventions has been lacking (see Hsieh et al. 2008). Given the success story we report among more than 200 families, the findings of this work should give policy makers, governments, and multinational corporations the necessary impetus to continue the pursuit of such initiatives. This should, however, be tempered with the necessary caution that this initiative was clearly a success in terms of villagers using the technology as designed and economic benefits, perhaps because the facilitating conditions (see Hsieh et al. 2008) and social network conditions existed to foster such success. At the very least, practitioners should approach such initiatives with a view toward ensuring that the necessary facilitating conditions and social networks exist. In situations where such conditions do not exist, it may be prudent to first invest in creating an implementation environment tied to these factors.

The overarching goal of initiatives to bridge the digital divide is to aid developing countries in their advancement along many different dimensions, such as literacy, economic success, and available healthcare. In order for advancement to occur, programs intended for this purpose must be successful and actually offer tangible benefits. This research fills a gap in the literature by helping us understand the drivers of economic benefits of such initiatives, a necessary first step toward gaining the confidence and ongoing support of citizens. Improved economic conditions are a key ingredient and a prerequisite for improving the quality of life in developing countries, and thus our work contributes toward that important end.

Our work provides evidence that empowering farmers through the use of Internet kiosks can result in substantial benefits that may indeed complement the benefits that radios, televisions, and cooperatives can provide. Specifically, being able to get highly customized information, rather than general information, and doing so in a timely manner when a farmer needs it are obvious advantages of the Internet in general that are sure to be at play in this situation. As noted at the outset, the intermediation created by the cooperatives can be offset through Internet kiosks. This is not to dismiss the role of previous generations of technologies and initiatives. We suggest that the radio and the television can still play a role by complementing the role of the Internet: the former, traditional media can be used to provide advice on what type of information is available through portals and other sources online because these are moving targets. Training at the beginning of the initiative, even if it is

focused on the type of information alone, is hardly sufficient given that content and features are constantly added to various websites, thus making radio and television critical to keep farmers informed regarding what is available online. Finally, with regard to initiatives, such as e-Choupal, our work underscores the power of the social network as critical to the success of the initiatives. Rather than assess success in terms of amount of kiosk use or number of farmers using the kiosk, it is important to assess information diffusion and impacts on income and, in the long term, foster the diffusion of information so as to create positive impacts.

Corporate social responsibility is now a major thrust of many firms. Digital divide initiatives constitute one of the important approaches of organizations in their pursuit of social responsibility. To this end, multinational corporations are increasingly investing large amounts of resources on initiatives to bridge the digital divide in developing countries. This research has identified factors that can be manipulated to increase the success rates of these initiatives that will lead to better use of resources. Also, socioeconomic benefits accrued by the developing country population, such as increased literacy rates and improved skills, will provide these multinational firms with a greater pool of possible employees in developing countries.

Fostering the rapid socioeconomic development of developing countries is a key area of focus in the developed world (UN Millennium Project 2005, UNESCO 2002), and almost every year many developed countries make decisions about initiatives in which to invest. By identifying factors that are most relevant to objective beneficial outcomes of digital divide initiatives in developing countries, such monies could be invested in interventions, based on our findings, to bridge the digital divide. The benefits of furthering the socioeconomic development of developing countries contribute to increased trade with more developed countries, investment by multinational firms, and increased education levels of the people in the developing country, which in turn can lead to improved healthcare and higher paying jobs available because of increased skills. By understanding the factors that influence the success of initiatives to bridge the digital divide in developing countries, interventions can be implemented to ensure that actual socioeconomic benefits are achieved. A more ICT-literate workforce in a developing country and consequent increased deployment of ICTs will further help build the effectiveness and efficiency of business operations at the grassroots level through the increased use of ICTs in small and medium enterprises throughout a developing country.

Conclusions

This research sought to understand the success of digital divide initiatives in developing countries. By drawing from social networks and IS research, we developed our model that was supported in a longitudinal field study in a village in India. Our work contributes to IS, digital divide, and social networks research. We expand the nomological network around the widely studied IS success construct of technology use by including upstream—i.e., social network—and downstream—i.e., economic outcomes—constructs. We found that both social network constructs, i.e., eigenvector centrality and closeness centrality, influenced both technology use and economic benefits that were realized by citizens. Our results demonstrate the value that digital divide initiatives can bring to rural communities in developing countries.

Appendix 1. Items and Measures

Demographic Information
1. Gender: Male or female
2. Age
3. Marital status: Single or married
4. Number of family members living in the home
5. Education (How many years of school have you completed?)
6. How many months of experience do you have with using the cell phone?
7. Have you attended any of the training sessions to use the computer technology? If so, how many sessions have you attended?

Social Network Measures. Each of the measures below was calculated from advice networks that were obtained by having each head of household in a rural village in India fill out a named-roster. Participants were asked to answer two questions: (1) "On average I give advice or help to this person..." and (2) "On average I get advice or help from this person..." with responses being given on a Likert-type scale (1 = less than once a month, 2 = once a month, 3 = once a week, 4 = once a day, and 5 = many times a day) for each individual that was on the roster. The participants were asked to skip those to (from) whom they did not give (or get) advice. We dichotomized the responses, such that 4 and 5 were coded as 1, and 1, 2 and 3 were coded as 0 (see Sykes et al. 2009).

Eigenvector centrality (Bonacich 1972) is defined as the principal eigenvector of the adjacency matrix defining the give-advice network. The defining equation of an eigenvector is

$$\lambda \mathbf{v} = \mathbf{Av}$$

where $\mathbf{A}$ is the adjacency matrix of the graph, λ is a constant (the eigenvalue), and v is the eigenvector. The equation lends itself to the interpretation that a node that has a high eigenvector score is one that is adjacent to nodes that are themselves high scorers. UCINET calculates eigenvector centralities in a range of zero to one. We multiply this score by 100 to get a range from 0 to 100.

Closeness centrality is calculated based on Bonacich's power based centrality measure (Bonacich 1987). It was computed for every vertex in the get-advice network. Given an adjacency matrix A, the centrality of vertex i (denoted c_i) is given by $c_i = \sum_j A_{ij}(a + bc_j)$ where a is the normalization parameter and b is the attenuation factor. The adjacency matrix was constructed from the *get-advice* matrix. The attenuation factor was chosen as zero so that the centrality measure is directly proportional to the degree of each vertex because the ties in question represent both "zero-sum" relations as well as "non zero-sum" relations (Scott 2000, p. 88). Closeness is actually a distance measure of how far an individual is away from others in the network. Therefore, we reverse the signs of the distance measures so as to convert the distance scores to closeness scores for ease of interpreting the results.

Appendix 3. Benchmarking the Proposed Model
This appendix reports the results of tests of the theory of planned behavior and the technology acceptance model in this context.

Appendix 2. Structural Model Results: Incorporating both Direct and Proxy Use Into Technology Use

	DV: *Technology use*		DV: *Economic outcomes*			
	Model 1	Model 2	Model 1	Model 2a	Model 2b	Model 3
R^2	0.23	0.39	0.31	0.39	0.39	0.47
ΔR^2		0.16***		0.08*	0.08*	0.08*
Control variables						
Gender (0: men)	−0.12*	−0.12*	−0.22***	−0.16**	−0.17**	−0.11*
Age	−0.12*	−0.08	0.18**	0.15**	0.16**	0.08
Family size	0.02	0.01	0.05	0.03	0.02	0.01
Education	0.16**	0.14*	0.12*	0.06	0.12*	0.04
Cell phone use (years)	0.01	0.03	0.03	0.04	0.03	0.02
Prev. year's economic outcomes	0.31***	0.32***	0.51***	0.46***	0.46***	0.43***
Training sessions attended	0.15*	0.14*	0.17**	0.15*	0.12*	0.05
Social network variables						
Eigenvector centrality		0.21***			0.21***	0.15*
Closeness centrality		0.29***			0.21***	0.17**
Behavior						
Technology use				0.39***		0.32***

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

Appendix 3(a). Descriptive Statistics, Correlations, Reliabilities, and Average Variance Extracted

	M	SD	1	2	3	4	5	6	7
1. *Gender* (0: men)	0.19	0.39	NA						
2. *Age*	41.33	10.91	−0.20**	NA					
3. *Family size*	5.15	1.73	0.06	0.19**	NA				
4. *Education*	0.24	0.44	−0.21***	−0.10	0.05	NA			
5. *Cell phone use* (years)	1.55	1.01	−0.16*	−0.22***	0.03	0.17**	NA		
6. *Prev. year's economic outcomes*	17,645	5,222	−0.22***	0.20**	0.08	0.25***	0.08	NA	
7. *Training sessions attended*	1.25	0.55	−0.17**	0.08	0.07	0.29***	0.04	0.23***	NA
8. *Attitude*	3.22	1.45	−0.17**	−0.17**	0.10	0.30***	0.13*	0.16**	0.21***
9. *Social norms*	2.80	1.42	0.05	0.24***	0.09	0.23***	0.16**	−0.20**	0.19**
10. *Facilitating conditions*	5.22	0.88	0.09	−0.20**	0.05	0.25***	0.11*	0.21***	0.28***
11. *Perceived usefulness*	3.95	1.02	−0.14*	−0.15*	0.07	0.14*	0.12*	0.14*	0.21***
12. *Perceived ease of use*	3.20	1.50	−0.16**	−0.19**	0.02	0.14*	0.13*	0.19**	0.17**
13. *Technology use*	6.64	2.90	−0.25***	−0.21***	0.03	0.04	0.08	0.46***	0.22***
14. *Economic outcomes* (rupees)	22,330	6,444	−0.32***	0.24***	0.05	0.11*	0.05	0.61***	0.25***

Appendix 3(a). (Continued)

	8	9	10	11	12	13	14
8. *Attitude*	0.82/0.75						
9. *Social norms*	0.21***	0.80/0.70					
10. *Facilitating conditions*	0.23***	0.20***	0.83/0.71				
11. *Perceived usefulness*	0.21***	−0.13*	0.14*	0.93/0.84			
12. *Perceived ease of use*	0.17**	0.17**	−0.14*	0.24***	0.23***	0.94/0.87	
13. *Technology use*	0.24***	0.21***	0.28***	0.12*	0.28***	NA	
14. *Economic outcomes* (rupees)	0.14*	0.19**	0.26***	0.17**	0.24***	0.41***	NA

Note. Diagonals show internal consistency reliability and average variance extracted.

$^*p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

Appendix 3(b). Structural Model Results

	DV: *Use*		DV: *Economic outcomes*			
	TPB	TAM	TPB	TPB + *Use*	TAM	TAM + *Use*
R^2	0.28	0.28	0.30	0.37	0.29	0.38
ΔR^2	0.08*	0.08*		0.07*		0.08*
Control variables						
Gender (0: men)	0.11*	0.11*	0.19***	0.11*	0.18**	0.11*
Age	−0.08	−0.07	0.16**	0.10	0.13*	0.08
Family size	0.02	0.02	0.03	0.01	0.03	0.03
Education	0.13*	0.12*	0.11*	0.04	0.08	0.04
Cell phone use (years)	0.01	0.01	0.04	0.02	0.01	0.02
Previous year's economic outcomes	0.29***	0.30***	0.42***	0.38***	0.39***	0.39***
Training sessions attended	0.13*	0.13*	0.14*	0.04	0.13*	0.03
TPB/TAM variables						
Attitude	0.15**		0.12*	0.02		
Social norms	0.12*		0.11*	0.01		
Facilitating conditions	0.18**		0.07	0.03		
Perceived usefulness		0.21***			0.14*	0.08
Perceived ease of use		0.20***			0.11*	0.08
Behavior						
Technology use				0.33***		0.32***

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