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ABSTRACT

We address a grand economic challenge faced by women in rural India. We hypothesized about the interplay of women's social networks (ties to family, ties to community, and ties to men in power), information and communication technology (ICT) use, and time in relating to the initiation and success of women's entrepreneurial ventures. The results from a 7-year field quasi-experiment in 20 rural villages in India provided substantial support for the model. Ties to family and community positively, and ties to men in power negatively, related to ICT use, entrepreneurial activity, and entrepreneurial profit. The ICT intervention also had a strong effect on entrepreneurship, with 160 new businesses in the 10 intervention villages compared to 40 new businesses in the control villages. The results also provide evidence of the dynamic interplay of social networks and ICT use. For ties to family and community, an amplification effect was found such that the highest levels of entrepreneurial activity and success were observed among women with high centrality and ICT use, effects that were stronger over time. For ties to men in power, ICT use was associated with increased entrepreneurial activity only when ties to men in power were low, but these interactive temporary temporal patterns did not emerge for profit. We address the implications of our research for the grand challenges of empowering women in less developed countries.

The United Nations formulated eight Millennium Development Goals (MDGs[1]) in pursuit of the grand challenges of eradicating poverty and improving quality of life in the world's lesser-developed and newly industrialized countries (http://www.un.org/millenniumgoals/). Eight goals were established with progress targets set for assessment a decade later (United Nations, 2008). The 2010 and 2015 assessments uncovered progress, but short of targets, on many fronts (United Nations, 2010; United Nations, 2015). In September 2015, the MDGs came to a conclusion and world leaders adopted 17 Sustainable Development Goals (SDGs), an expanded set of goals that go beyond the MDGs by addressing the root causes of poverty and the "universal need for development" (UNDP, 2015). The SDGs incorporate information and communication technologies (ICTs) with the view that various ICTs, including future advances (e.g., the Internet of Things, robotics, artificial intelligence, 3-D printing), will provide tools for additional "unprecedented advances in healthcare, education, energy services, agriculture and environmental monitoring and protection" (Ericsson, 2015). Although several SDGs include gender-sensitive targets, one of them (SDG 5), is devoted specifically to women's issues, in particular related to improving the lot of women, through improved life quality, eradication of income restrictions, and elimination of gender pay gaps. The challenges faced by women are more severe in less developed countries, especially in rural areas, where centuries-old sociocultural impediments limit access to education and information that can aid in their development. These challenges in turn result in women in these countries being highly underrepresented in government, land and property ownership, and in credit and financing (IFAD, 2011; Lopez-Carlos & Zahidi, 2005; Moyi, 2003; Obayelu & Ogunlade, 2006). Of the

[1] The eight MDGs were: eradicating extreme poverty and hunger, achieving universal primary education, promoting gender equality and empowerment, reducing child mortality, improving material health, combating diseases such as HIV/AIDS and malaria, ensuring environmental sustainability, and developing global development partnerships.

less developed countries, India is of particular interest because it is an emerging economy that has seen a surge in its urban development, whereas rural citizens, especially women, continue to struggle due to a widening economic gap. Achieving SDGs in India is a particularly high priority. More than 400 million people in India live in abject poverty, more impoverished people than live in all 26 sub-Saharan African countries combined. More than two-thirds of India's population reside in the countryside or in one of the country's approximately half a million rural villages.

An approach to promoting empowerment of women is to identify ways for women to generate and maintain their own income streams—viz., women's entrepreneurship (Bullough, de Luque, Abdelzaher, & Heim, 2015; Pines, Lerner, & Schwartz, 2010). Because gainful employment opportunities in existing, stable organizations in impoverished, rural areas of India and other developing countries are limited (Babbitt, Brown, & Mazaheri, 2015), entrepreneurial ventures among women provide potentially fruitful avenues for achieving such empowerment. Women also venture into entrepreneurship because they want to be independent or they want the flexibility that being self-employed provides (Babbit et al., 2015). When there is no threat of loss to an individual's social structure, for example due to poverty, then family and social ties are stable and this has also been shown to a strong influence in a decision to engage in entrepreneurship (George, Kotha, Parikh, Alnuaimi, & Bahaj, 2016). In addition, conditions of desperate poverty (for reasons such as drought, disease and death) lead to the disintegration of social structure that in turn gives rise to a desire to improve the family's economic position thus motivating some to search for new opportunities for income gain (George et al., 2016). Potential solutions are numerous and indeed various plans have been implemented to facilitate the achievement of these goals (e.g., microfinancing; Chowdhury, 2009; ILO, 2008). Although

valuable, sociocultural constraints frequently inhibit women's access to information, opportunities, and funding (Powell & Eddleston, 2013; UNIDO, 2008). A promising approach to eliminating disadvantages is the use of ICTs, including Internet-enabled computers, to provide information to rural citizens, especially women (Best & Maier, 2007; Cecchini & Scott, 2003; Sharma, 2003). The availability of information is important in the entrepreneurial process. Information can allow entrepreneurs greater awareness of business opportunities and access to data that can help them grow and manage their businesses (Corno, Lal, & Colombo, 2014). Women can use information from ICTs to speak to clients and suppliers, expand their markets, communicate to their mentors in their business networks, and obtain skills and training to help build their entrepreneurial capacity (Malhotra, Kanesathasan, & Patel, 2012). Despite the prevalence of such ICT-based initiatives, the reported success rate of these initiatives is low (Gichoya, 2005; Nkohkwo & Islam, 2013). As such, it is important to understand how ICTs can be successfully used to further women's interests and well-being. Toward these ends, we offer a socio-structural view of ICT use and examine how social networks facilitate ICT use, and how social structure and ICT use can jointly facilitate or hinder entrepreneurial activity and success among women in these contexts.

The entrepreneurship literature has noted that firms headed by women tend to be smaller and grow more slowly (Jennings & Cash, 2006), women-owned businesses generally underperform men-owned businesses (Watson 2002), and that although men and women entrepreneurs possess similar socioeconomic backgrounds, women business owners are subjected to discrimination in various ways including funding decisions (Buttner & Rosen, 1992). These problems of women entrepreneurs are even more pronounced in less developed countries face, with many barriers not often experienced by men, be they in less developed or

developed countries. For example, women lack access to financing, markets, training and policy makers, while their dual responsibilities at work and at home to their families may impede their earning potential (United Nations, 2006). In general, inherent attitudes of patriarchal societies, such as rural India, create formidable challenges for women to pursue any role other than being a homemaker (Goyal & Prakash, 2011; Sharma, 2013). The challenges include negative social norms against them, limited time, capital and skills, limited access to markets, and limited business networks (Malhotra et al., 2012). Women experience greater difficulties than men do in accessing bank loans and other sources of capital (Kuada, 2009), information, training, and know-how, as well as assistance from government agencies (Della-Giusta & Phillips, 2006; Jiggins, 1989; Roomi & Parrott, 2008)—restrictions that are arguably even more pervasive in male-dominated rural India than in other cultures (Goyal & Prakash, 2011; Mehta & Mehta, 2011; Sharma, 2013). These gender biases, *in toto*, have been shown to impede the growth of micro and small enterprises among women (Chirwa, 2008; Goyal & Prakash, 2011; Prasad, 2009; Sharma, 2013). Finally, addressing grand challenges surrounding poverty can be expected to take time. The role of time has been acknowledged in prior research as important for theory building (George & Jones, 2000). A temporal focus allows researchers to understand how people shift attention within different time periods and how they differ in their perceptions of the past, present and future, thus help predict behavior (Shipp, Edwards, & Lambert, 2009). Thus, any investigation into such a phenomenon needs to provide a key role in the theory, study design, and analysis (see Ancona, Goodman, Lawrence, & Tushman, 2001; George & Jones, 2009; Johns, 2006; Shipp et al., 2009).

Against the backdrop of these grand challenges, we integrate two streams of research to move the literature forward. First, given the central role of the social context in rural India, we

draw on social networks theory and research. It is a well-accepted notion that social networks can both facilitate and constrain behavior while conferring resource benefits (Khayesi & George, 2011; Kilduff & Brass, 2010). Rural India is characterized by low literacy, a collectivist culture, and an oral tradition of information dissemination. Such a context suggests that interactions among individuals, especially women, will be vital to facilitating or even hindering most behaviors, including entrepreneurial activities. Building on these ideas and the sociocultural conditions in rural India, we examine the role of three distinct communication networks for women: ties to family, community, and men in power (viz., connections to government officials). Each of these networks has the potential to both facilitate and constrain women's access to various key resources necessary for entrepreneurial activity and continued success. We focus on communication networks and the associated frequency of communication, rather than friendship or advice, given our interest in interactions among women and concomitant information dissemination (see Ortiz, Hoyos, & Lopez, 2004; Venkatramani & Dalal, 2007; Zhang & Venkatesh, 2013). Second, in order to break traditions and constraints in rural India, introducing new information into the networks is crucial. Given that ICT is a linchpin of interventionist approaches worldwide, we incorporate and investigate the role of ICT use. We extend existing views and present an interplay between ICT use and women's network positions in each of the three networks, such that ICT use can complement (substitute) the favorable (adverse) effects of network positions on entrepreneurial outcomes. By identifying the predictors and their interplay, we contribute to the scientific and practical knowledge on sociotechnical interventions that can aid women's entrepreneurship in less developed countries, especially rural India. Third, we theorize about the role of time and examine its interplay with networks and ICT use to understand its impact on entrepreneurial outcomes. Such an examination allows us to understand

how outcomes the role of ICT can evolve over time to alleviate poverty and promote women's entrepreneurship.

We describe the results of a 7-year longitudinal field quasi-experiment among women in 20 villages in rural India. Women in 10 of these villages had access to a staffed Internet-enabled computer (hereinafter, ICT kiosk) that allowed access to information and resources via the Internet; the other 10 villages served as a control condition. The control villages were geographically proximal and similar in size to the corresponding villages in the experimental condition. Positions in family and village networks, ICT use (in the 10 experimental villages), and entrepreneurial activity and profit were tracked over time. We demonstrate that in addition to relating directly to ICT use, network position in the three networks interacts with ICT use over time to influence entrepreneurial activity and profit.

BACKGROUND AND THEORY

Social networks, which focus on various types of relationships among entities, here, individuals, can either provide opportunities or create constraints that affect important outcomes, e.g., life expectancy, susceptibility to infection, organizational performance (Kilduff & Brass, 2010). There are different types of networks that have been examined in prior research—advice, communication, friendship, hindrance, etc. We focus on communication networks (see Ortiz et al., 2004; Venkatramani & Dalal, 2007; Zhang & Venkatesh, 2013) given our interest in interactions of women with various others in the village and how information is disseminated among these women, and how the ties with various others and the concomitant communication affects their ICT use and entrepreneurial outcomes. In a large, cohesive network, individuals can leverage connections, trust, and embeddedness to optimize performance; it may be more difficult to create such advantages or to optimize performance in smaller or more disconnected network

(Podolny & Baron, 1997). People who are central in networks are frequently said to benefit from higher levels of trust, richer transfers of information, and greater problem-solving capabilities than those who hold peripheral network positions (Kilduff & Brass, 2010). Further, greater network centrality reduces the time and cost of acquiring new information (Seghers, Manigart, & Vanacker, 2012) and can be an important avenue for recognizing new ideas and identifying lucrative opportunities (Elfring & Hulsink, 2003; Stuart & Sorensen, 2005), leading to better jobs, higher performance ratings, and better salaries (Kilduff & Tsai, 2003). Interaction and contact between people in different networks or different generations within organizations could potentially have positive impacts through the successful transfer of knowledge, skills, and/or resources (Joshi, Dencker, Franz, & Martocchio, 2010). Network position has been shown to facilitate ICT use in organizational settings (Sykes, Venkatesh, & Gosain, 2009). Indeed, recent meta-analytic evidence shows that network centrality is more strongly associated with career success than brokerage network positions are (Fang, Landis, Zhang, Anderson, Shaw, & Kilduff, 2015), countering a dominant theoretical view that less constrained networks lead to better career outcomes (e.g., Burt, 1992).

These positive aspects of centrality notwithstanding, large, closed connected networks can also be disadvantageous. For example, in organizations, resistive intergenerational interactions reflect the unsuccessful transfer or knowledge or resources (Joshi et al., 2010). In particular, large networks can result in greater monitoring of behavior from others; this monitoring may, in turn, serve to reinforce cultural norms, expected patterns of behavior, and create pressures for conformity. The result is that the connections that one builds over time may serve to constrain the range of behaviors that one if expected to, or able to, engage in, especially as it relates to trust but limit the input of novel information and the ability to broker relationships

(Kilduff & Brass, 2010). This may be especially true for women in the traditional sociocultural milieu in rural India. We advance the notion that numerous connections in certain types of networks may serve to constrain women's access to innovative interventions and, eventually, their ability to generate unique streams of income for themselves and their families.

In the literature, several researchers offer commentaries on the opportunities and constraints of networks as they relate to different network positions—viz., centrality or network size, brokerage, or closeness (e.g., Carnabuci & Dioszegi, 2015; Cullen, Gerbasi, & Chrobot-Mason, 2015; Feldman & Ng, 2007). We view opportunities and constraints through a different lens, focusing on the advantages and disadvantages of network position as they vary across different networks (family, community, and men in power) for the same structural position continuum (network [degree] centrality). We identified and selected these networks because they are especially relevant in the rural Indian context for women; the value and constraints are rooted in the centuries-old patriarchal traditions. They may benefit or present women with challenges in terms of going outside the traditional role as a homemaker or in aiding their husbands in the operation of the family's farm. Each of these three networks represents critical resources that can either foster or hinder the entrepreneurial efforts of rural Indian women. In the next section, we describe how centrality in these networks can influence access to and use of an ICT intervention.

Prior research explains that the moderating role that ICT use plays beyond networks and these are affected by factors that can be explained by individual-level behavioral models both among traditional consumers in homes (Venkatesh, Thong, & Xu, 2012), employees in organizational settings (e.g., Venkatesh, Morris, Davis & Davis, 2003; Venkatesh, Thong, & Xu, 2016), and among the underprivileged (Hsieh, Rai, & Keil, 2008). These factors include attitudinal beliefs, social influence, behavioral control and their antecedents (Hsieh et al., 2008;

Venkatesh et al., 2003). In addition, extant research reveals that for ICT use to influence the relationship between networks and economic outcomes, there is a behavioral pathway that prompts better-connected individuals to engage in performance-enhancing behavior and an informational pathway that explains how knowledge is made available to better-connected individuals (Venkatesh & Sykes, 2013). Together, these factors may explain for any variance in ICT use not accounted for by the networks. Following this, we develop theory regarding the interplay of network position and ICT use in relating to entrepreneurial activity and profit.

Finally, the nature and role of time in theory development has been long acknowledged (e.g., Ancona et al., 2001; George & Jones, 2000; Johns 2006; Shipp et al., 2009). Even more than in traditional organizational phenomena, as noted earlier, when dealing with grand challenges, e.g., poverty, it can be reasonably expected that it will take time for interventions to take effect. It thus calls for the theory to give consideration to the role of time. In keeping with this, we present a hypothesis of the interplay being moderated by time. Figure 1 shows our proposed research model.

Network Position, ICT Use, and Women's Entrepreneurship

Family ties are defined as a woman's connections with her family members (Tseng, Hemenway, Kawachi, & Subramanian, 2010), centrality in this network being family network centrality. In many parts of the developing world, like rural India and sub-Saharan Africa, family and kinship networks include nuclear and extended family members. Family ties represent the closest bonds that exist for rural Indian women. They are frequently homogeneous on various dimensions, such as education and social class (McPherson, Smith-Lovin, & Cook, 2001), especially for rural Indian women.

India has seen an increase in the number of women entrepreneurs. Entrepreneurship allows women to engage in home-based work so they can continue with domestic work but still support their families financially (Bertaux & Crable, 2007). The barriers to entrepreneurial success for women in India including social norms that make it inappropriate for them to frequent public places, limited time for engaging in entrepreneurship due to the dual burden of household and productive work, limited skills and training due to illiteracy, limited access to markets and information, and limited business networks (Malhotra et al., 2012) can be addressed by access to ICTs and to networks. Women's access to ICTs and networks provides them with information on how to attain access to financing, markets, etc. (Hinson, 2011). In rural India, which is more collectivist than other societies, women are often able to leverage value from ties to family to obtain resources and support necessary. We contend that family centrality will be an important facilitator of ICT kiosk use in intervention villages, as well as have direct effects on entrepreneurship. This is supported by prior literature that reveals that social networks positively influence ICT use (Venkatesh & Sykes, 2013). In particular, we focus on the literature related to network size and strength. Prior studies have shown that network size and strength determine resources available in the network (Nordman & Pasquier-Doumer, 2015)—hence, family size has a bearing on centrality in that the larger the family, the greater the potential centrality and the more the resources available to them. In addition, with a healthy level of family support, women will have the ability to form bonds with others outside the family (Caligiuri, Hyland, Joshi, & Bross, 1998) that may help them obtain additional help with their entrepreneurial activities. More and varied interactions with extended family members can provide women with support such as taking care of children so they can engage in entrepreneurial activities. In our work, the ICT kiosk was centrally located in the village, requiring travel, primarily on foot, to the central

location in order to access the kiosk. Moreover, given the general and computer illiteracy of the women in these villages, the process of queuing for ICT kiosk access for receiving help from the kiosk attendants required a significant amount of time away from the women's activities as homemakers. A large number of family members should allow more opportunity for initial and repeated ICT visits with family members providing support for the woman's typical activities at home (see Jiggins, 1989).

In terms of direct effects on entrepreneurial activities, women entrepreneurs frequently prefer to use family members in advisory capacities (Spinder, 2000). Such support will be particularly crucial in the early stages of entrepreneurial activity as rural Indian women are usually illiterate and have limited exposure to business activities. Beyond the knowledge contributions, family centrality can be crucial to women to garner financial support because, as noted earlier, obtaining bank loans can be challenging for women in rural India. In addition to being important in the early stages of entrepreneurial activities, such ties and concomitant support are essential to allow the business and profit to grow. Growth is likely to mean the entrepreneur will have to spend more time away from home and possibly invest more capital, which will reinforce the importance of family centrality over time. Even more important than in facilitating ICT kiosk use, family support in the form of help with various activities a woman performs as part of her role of as a homemaker will be crucial to aid her in performing entrepreneurial activities because such support will be necessary on an ongoing basis. Family and community ties are also an important source of information for recognizing entrepreneurial opportunities and/or for overcoming uncertainties and risks that entrepreneurs face (Batjargal, Hitt, Tsui, Arregle, Webb, & Miller, 2013).

Prior research has found centrality to be a strong direct predictor of individual performance, for instance, linking an employee's position in a social network to performance, advantage, and promotion (see Fang et al. [2015] for a meta-analytic review). In family-owned businesses, performance (financial, social, and family goal) is directly influenced by the centrality of the founder—i.e., a founder's influence and power (centrality) is most important in determining the firm's performance (Athanassiou, Crittenden, Kelly, & Marquez, 2002). More general entrepreneurship research shows that family networks are important influences on the start of new entrepreneurial activities as well as for the survival of existing businesses (Mahajar, Yunus, & Razak, 2013). Although family ties could be a constraint to women because family members are more likely to demand compliance with traditions, they can also help overcome the negative social norms. For example, family support can have a positive effect on new venture success due to the strong sense of obligations, loyalty, commitment, and reciprocity within a family (Batjargal et al., 2013). They can provide direct, critical and constructive feedback (Aldrich & Cliff, 2003; Elfrin & Hulsink, 2007), infuse the activities with primary or ancillary capital, and something of a social safety net (Bruderl & Preisendorfer, 1998; Stuart & Sorenson, 2005). Thus, we hypothesize:

Hypothesis 1a: Family centrality will be positively related to ICT use.

Hypothesis 2a: Family centrality will be positively related to entrepreneurial activity and profit.

Community ties are defined as social and informal interactions among adult women in the village (Rovai, 2002), with centrality in this network being community network centrality. Although some social network researchers consider an individual's family ties to be part of their community ties, in our conceptualization of community ties, we do not consider family ties but only those in the social and informal interactions who are not related by blood or marriage

(Wellman & Wortley, 2013). We choose to focus on women in the community network because prior research shows that initiatives that enhance women's access to and control of income enhances the welfare of their children, which in turn has long-term implications for the economic development of the society (Bertaux & Crable, 2007). In rural India, networks among women play a crucial role in advice and associated interactions (Renzulli, Aldrich, & Moody, 2000), especially given cross-gender communication is often limited and governed by strong sociocultural constraints (Best & Maier, 2007; Fletschner & Kenney, 2014). Although community could be a constraint because cultural norms and community customs could hinder women from gaining access to things like financing and opportunities, we contend that community networks will be particularly vital to women in these villages because they can be usefully deployed to strengthen the quantity and quality of enterprising action at each stage, from motivation, to information acquisition, opportunity perception, idea validation, resource identification, initial business negotiations, and the birth and survival of the business (Dodd & Keles, 2014). Somewhat similar to family support, ties with other women in the community can provide support in terms of help with home activities, particularly related to children, and business activities. Community groups, such as self-help groups, can enable members with no educational, industrial or entrepreneurial background become self-dependent and self-reliant (Sharma, Dua, & Hatwal, 2012). High centrality in the community network can provide the supportive links necessary for encouraging women to experiment with the ICT kiosk and can provide social "sounding boards" for ideas that women may have based on ICT use. In some cases, the community network may provide vital mutual support to overcome the general sociocultural resistance to women's engagement with such innovations. Such conversations may promote further ICT use as well as provide the fuel for entrepreneurial ventures. According to

prior literature, high centrality has been shown to positively influence ICT use because those who are well connected will receive information about ICTs faster and more often given the nature of information flow in a closely linked network (Venkatesh & Sykes, 2013).

Community networks have been shown in prior literature to encourage women's entry into entrepreneurship (Ghani, Kerr, & O'Connell, 2012). Centrality in the informal community communication network will be important as women are underrepresented in formal government and business positions, and are frequently denied access to formal sources of community status and power and resources, such as bank loans. In India, informal networks in the community provide information and opportunities e.g., building influence, social credentials and garnering identity and recognition (Fang et al., 2015; Lin, 1999). The more community network ties women have, the greater the information about opportunities and resources available to them as more networks means a greater diversity of sources of information (Burt, 2004) and can also provide buffers against the abandonment of ideas during difficult times. Given the limited cross-gender communication in rural India, the community networks are crucial for women to sustain their interest in the entrepreneurial activity and to cope with challenges along the way. Thus, we hypothesize:

Hypothesis 1b: Community centrality will be positively related to ICT use.

Hypothesis 2b: Community centrality will be positively related to entrepreneurial activity and profit.

Ties to men in power are defined as relationships with men who are political leaders, officials in industrial bureaus, officials in regulatory bodies of commercial administration, officials in legal institutions (e.g., police departments) and officials in state-owned banks (Zhao, Frese, & Giardini, 2010) located within a particular village. Not every woman in the village may

be connected to men in power, hence we distinguish these ties from ties to others in the community. Ties to men in power could include ties to those related by blood or marriage or family ties, but is not always the case. An individual could have ties to influential others who are not members of their own family. Specifically, in this network, we exclude ties to family members, even if they are men in power, as ties to family members are already accounted in another network. We focus on women's centrality among men in power because rural areas in many developing countries, especially in rural India, practice traditional, patriarchal forms of government where men occupy most, if not all, local government positions and women fill traditional homemaker roles and that is the foremost priority for women. Especially in rural India, traditional gender roles expect women to be docile, dependent and self-sacrificing, and men to be assertive, dominant, competitive and decision-makers (Joshi, 2015). Members of local government (predominantly men) tend to reinforce sociocultural traditions that favor men and perpetuate the status quo. Further, men are more easily able to secure loans, whereas women experience greater difficulties in accessing bank loans and when they do, they face higher interest rates and unfavorable conditions (Muravyev, Talavera, & Schafer, 2009; Prasad, 2009). Women in South Asia, Middle East, and North Africa tend to have less access to formal financial institutions and savings mechanisms than men do (World Bank, 2015) and even find it more difficult to find employment (Jayachandran, 2014). Similarly, in sub-Saharan Africa, patriarchal social structures deny women real property rights in land, limit women's access to and control over the proceeds of their own labor and constrain their decision-making roles (Jiggins, 1989). For men, ties to other men in power are therefore positive and beneficial; whereas for women, they constrain the ability to break away from the traditional homemaker role. Further, various macro-level constraints, such as lack of government support and legal constraints related to

extensive government procedures to register a business, make it difficult for women entrepreneurs (Jamali, 2009). In many countries, such gender discrimination leads women to look to the informal sector, including smaller or informal businesses, for viable income-earning opportunities (see Babbitt et al., 2015). Although prior literature shows that ties to those who have power and influence positively influence ICT use among men (Venkatesh & Sykes, 2013), this has not been shown for women. We argue that rural Indian women with more ties to men in power will face hindrances in using the ICT and in engaging and succeeding in entrepreneurial action.

Although one could argue, based on intuition, that direct connections to power holders can help women in rural India overcome such barriers, we expect the reality to be quite the contrary, serving as a constraining role rather than one of opportunity. The role of the local government and its members in rural India is significant. The local government, the "Panchayat," views its role with great pride and tries to operate largely independently of more central governments (district, state, etc.). In fact, even in the case of criminal proceedings, the process of the trial and punishment are often meted out by the Panchayat—and the processes used are not necessarily in sync with the Indian law (Islamia, 2013; Iyengar, 2013; Yardley, 2011). Such local/village governmental institutions often hinder women's access to resources that are necessary because these institutions view themselves in roles that uphold traditions, which emphasize the role of women exclusively as homemakers.

Network centrality in terms of ties to men in power—viz., members of the local government—may impede ICT use and entrepreneurial activities for the following reasons. Individuals in governmental positions in rural India typically have a role in preserving the traditions rather than in promoting innovations. Ties to men in power are likely to result in

efforts to persuade women to maintain their traditional roles and avoid exploration of the ICT kiosk and business opportunities. With more ties, the women may even face risks of being ostracized for a breach of the sociocultural norms. Even if a government official is a woman (a rarer, but increasingly common occurrence in recent years, given India's emerging system to promote women's greater representation in various governments), they are seen within cultural boundaries as "proxies for husbands or powerful men within their family or caste" (Kabeer, 2005). This occurrence is similar to the well-known "first lady syndrome" where women's personal influence is diminished through connections with powerful men (Ibrahim, 2004). In India, the attitudes of officials toward women often compel them to give up. For example, financial institutions discourage women entrepreneurs based on the belief that they could leave at any time and go back exclusively to their homemaker role again (Goyal & Prakash, 2011; Sharma, 2013). Even over time, the success and sustained growth of women's entrepreneurial activities could be hindered by men in power who will primarily seek to restore the status quo. Thus, we hypothesize:

Hypothesis 1c: Ties to men in power will be negatively associated with ICT use.

Hypothesis 2c: Ties to men in power will be negatively associated with entrepreneurial activity and profit.

ICT Use and Entrepreneurial Activity and Profit

Prior literature reveals that ICT use has led to increases in economic gain and a sense of self-worth among women in many developing countries, e.g., Indonesia (Melissa, Hamidati, Saraswati, & Flor, 2015) and Mozambique (Macueve, Mandlate, Ginder, Gaster, & Macome, 2009). ICT use has also been shown to be important for a number of activities that can be linked to entrepreneurial outcomes, including community organizing, policy advocacy and other

economic and social issues for women (Grace, Kenny, & Ojiang, 2004). Further, ICT use has been useful for gaining access to government websites, e.g., knowing where to look for licenses and licensing information for starting new entrepreneurial ventures. Many e-government portals and websites provide information on government programs that are available, e.g., business training, available investment opportunities and government efforts to encourage entrepreneurship as well as funding available for entrepreneurship. Finally, ICTs are effective for helping women entrepreneurs save time and access new markets (Macueve et al., 2009).

In recent times, in rural India, significant efforts are underway to leverage ICTs to improve the lives of the underprivileged (Crabtree, 2016; Deloitte, 2015; McKinsey, 2014). ICT was expected to play a central role in meeting MDG targets and is now seen as central to meeting the SDG targets (Ericsson, 2015; ICTworks, 2015; Internet Society, 2015). E-government, bank, and various NGO portals in India offer a vast array of information about opportunities for women. For example, www.sheroes.in is a women-oriented job portal; www.ngoportal.org provides information about Indian and international funding agencies, financial and legal aid, grants management, etc.; www.eprocure.gov.in provides information about government tender application; www.startups.in offers information on how to start up a business venture. ICT can allow women to learn about current business opportunities, governmental programs to promote empowerment of women through entrepreneurship, and loans that may be available through various governmental programs, banks and NGOs. In addition to facilitating initial entrepreneurial action, as women continue with entrepreneurial activities, ICT use can alert them to best practices, allow them to seek support and counsel of NGOs (using technologies such as Skype to communicate), and learn about additional financial support and growth opportunities. Thus, we hypothesize:

Hypothesis 3: ICT use will be positively related to entrepreneurial activity and profit.

Interplay of Social Networks and ICT Use

Given the challenging sociocultural conditions for women in rural India, we expect the interplay of social networks and ICT use to be crucial in driving entrepreneurial activity and profit. Specifically, we expect ICT use to have complementary effects with ties to family and community and substitution effects with ties to men in power in influencing entrepreneurial activity and profit.

The complementary effects of ICT use and both family and community networks in rural India are based on the idea that effect of ICT use can be augmented in the presence of such network support. As noted earlier in H1a and H2a, when women have their family and community network support, they will be encouraged to engage in and have more time for ICT use. With knowledge gained through ICT use, women can go back to their family with ideas that they acquire from such ICT use. Together, the interplay of the social and technical components will result in better ideas for possible entrepreneurial pursuits. Further, as challenges are encountered during their business functioning, the iteration between knowledge obtained from ICT use and the network members, be they family members or others in the community, will result in better business decisions being made. Thus, we hypothesize:

Hypothesis 4a: ICT use will moderate the relationship between family centrality and entrepreneurial activity and profit such that positive relationship between family centrality and entrepreneurial activity and profit will be stronger when ICT use is high.

Hypothesis 4b: ICT use will moderate the relationship between community centrality and entrepreneurial activity and profit such that positive relationship between community centrality and entrepreneurial activity and profit will be stronger when ICT use is high.

Earlier, we discussed the negative effects of men in power on women's ICT use and entrepreneurial activities. ICT use may allow women who are more connected to men in power to bypass some traditional gender role expectations and obtain specific information about business opportunities, business plans, and even business partners outside of the family and community. ICT use can play a critical role in overcoming the negative effects of ties to men in power because through ICTs, women can obtain information about various opportunities and sources for financial support. The wide variety of critical information that is available through e-government portals (discussed in H3) can help overcome any hindrances placed by men in power. Further, through the use of the ICT, women can overcome efforts by men in power to conceal information or provide misleading information. Thus, we hypothesize:

Hypothesis 4c: ICT use will moderate the relationship between ties to men in power and entrepreneurial activity and profit such that negative relationship between ties to men in power and entrepreneurial activity and profit will be weaker when ICT use is high.

Moderation by Time

A final element of our model concerns the role of time, in particular, the relative importance of social network connections and ICT use on entrepreneurial outcomes over time. There have been calls for research that gives time a more central role in theory development because phenomena are inherently dynamic (Ancona et al., 2001; Zaheer, Albert, & Zaheer, 1999). Specifically, Zaheer et al. (1999) have noted various time-related intervals that should be identified and justified in the theory development and method. First, by theorizing about interactions with time, we can indeed better understand the phenomenon more in line with the existence interval (i.e., the interval during which the phenomenon exists)—given that interventions, such as this one in rural India, take time to have an effect. Without a role for time,

not only would our theory to explain the phenomenon be limited to short-term impacts, but also we would not be able to get a richer picture of impacts or perhaps observe any impacts at all. Second, insofar as the validity interval (i.e., the interval during which the theory is valid) is concerned, by theorizing about the interaction with time, we develop a theory that is more dynamic and valid over a longer period of the lifecycle of the intervention. The observation, recording, and aggregation intervals relate to how the researcher engages with the phenomenon and context—we explain this in greater detail in our method section. We obtained yearly measurements of various model variables, with the exception of ICT use that was gathered continuously and aggregated for each year. Through our data collection over a 7-year period, we were able to test a theory that better reflected the underlying phenomenon.

There is growing consensus that as the entrepreneurial activity shifts from establishment and emergence to growth and expansion, the relative importance of forms of social networks, information, and access changes. As Hite and Hesterly stated, prospective entrepreneurs "must overcome the resource acquisition challenges of each stage in order to successfully survive and grow" (2001: 276). As individuals consider the possibility of starting a new business or progress through the initial stages of entrepreneurial activity, network ties to family and community, and, in our context, a lack of ties to men in power, are likely to be strong predictors of establishment and success. Researchers have argued that strong, identity-based networks where individuals have ties that "stem from preexisting relationships with social, family, or historically long-held sources and are heavily composed of strong, embedded ties with a network high in closure and cohesion" (Hite & Hesterly, 2001: 278) are critical in the formation stages of new ventures (see also, Uzzi, 1996). This notion of identity-based networks conforms well to the elements of family and community centrality as facilitating factors, and ties to men in power as a

constraining factor, in our model. In shorter time windows, these social networks may provide the necessary affective support, feedback for new business establishment and initial emergence. The network benefits notwithstanding, as noted earlier, ICT use can provide quicker access to necessary information on types of businesses, success stories, bank programs and loans, and government and NGO programs—all of which can help a woman entrepreneur fill informational gaps quickly—and also help communicate with individuals. Further, by using an ICT a woman can fill forms online—i.e., use e-government services (e.g., licensing).

In contrast, sources of information and resources of a broader nature are needed as time passes. Family and community centrality contain valuable resources, but have limited scope. They may be unable to provide the range of resources necessary for new ventures to be successful over time. Thus, calculative, rather than affective or identity-based, resources and information are needed to sustain and grow entrepreneurial activities. The advantages from embeddedness in affective networks that serve the purpose of resource accessibility during formation and emergence, serve to limit the growth and development of the new venture over time (Afuah, 2000). Although Hite and Hesterly's (2001) view is grounded in bridging ties as a calculative resource that grows in importance over time, ICT use serves as a reasonable proxy for these calculative functions. Accessible information obtained via the kiosks will allow the prospective entrepreneur to better identify sources of goods and services beyond the local community, to find ways of lowering internal costs, as well to locate new customer bases beyond the local community. These benefits from ICT use are likely to be relatively more important than the various network ties (family, community, and men in power) over time. Even women with favorable centralities in the three networks are likely to find the complementary information available through the ICT kiosks to be particularly helpful in promoting innovation and growth,

as their business needs and questions may become more unique to the point that their networks may not be able to sufficiently help in the pursuit of their ideas. The same will likely be true with challenges that may be encountered. Thus, we advance the notion that the interplay of networks, ICT use, and time will relate to entrepreneurial activity and success over time. We expect the network ties and ICT use to interact in predicting entrepreneurial activity and success, and that the effects of these interactions will become stronger over time. Thus:

Hypothesis 5: Time will further moderate the interaction between social networks (family centrality, community centrality, and ties to men in power), ICT use, and entrepreneurial activity and profit such that the two-way interactions between networks and ICT use become stronger over time.

METHOD

We conducted a field quasi-experiment over a 7-year period in 20 villages in rural India. This paper is part of a larger research project being conducted to understand how ICT can be used to address various grand challenges in rural India—related published papers have studied income among farmers (Venkatesh & Sykes, 2013; Venkatesh, Rai, Sykes, & Setia, in press) and infant mortality (Venkatesh et al., 2016). However, none of the key variables used in the current paper are used in those are other working papers. Social networks and entrepreneurial activity data were collected annually via structured interviews. Data on entrepreneurial profit were also obtained also from the interviews, but cross-validated, whenever possible, with information from government filings. A staffed ICT kiosk intervention was deployed in 10 villages. The other 10 villages, each of which was geographically proximal to one of the intervention villages, served as controls—no intervention was deployed in these villages. The data were obtained with the assistance of 10 research assistants who were trained in field data collection techniques and

interviewing. The research team was closely engaged with the context, visiting the villages several times each year to monitor and observe the data collection procedures. At the end of the 7-year period, four additional trained interviewers were employed to validate the interviews and associated stories of successful entrepreneurship that emerged.

Sample

The sampling frame for the 10 intervention villages comprised 8,330 adult women. These villages were identified by the NGO implementing the intervention based on some specific characteristics that represented desperate poverty—i.e., small remote villages that were lacking in basic infrastructure including access to running water and electricity; all of the identified villages also did not have cooperatives that were prevalent in larger villages—such cooperatives offered citizens (most families pursued farming for a living) the advantage of being able to access more modern farming equipment (e.g., tractors) and even schools and healthcare clinics. The response rate ranged from 78% to 83% in each of the intervention villages, with measurements taken annually over the 7 years. The women who did not respond in all waves included those who voluntarily dropped out or died. The sampling frame from the 10 control villages comprised 8,600 women. The range of the response rate was similar in the control group villages also. The sample size across all intervention villages combined was 6,662; the sample size was 6,801 across all control group villages.

Procedure

ICT intervention. The ICT intervention (ICT kiosks) was the availability of three Internet-enabled desktop computers installed in each of the 10 villages in the intervention group. The intervention villages were randomly selected from the 20 participating villages. The kiosks were each staffed by trained attendants for 16 hours each day, 7 days a week. The attendants

were mostly women serving on a volunteer basis from nearby towns. The attendants were typically well-educated retirees who staffed the kiosks as a form of community service. They were trained for their roles by the research team. Their role was to facilitate information access for the villagers because most villagers were not literate. Indeed, none of the women in our final sample could read or write. As such, the kiosk attendants played a crucial role in facilitating information access, which is known as proxy use (Parikh & Ghosh, 2006). Although both women and men could seek information from the kiosks and various types of information were indeed solicited, we focused specifically on women's kiosk use because our research question focused on women's issues, namely entrepreneurial activity and success.

Prior to the installation of the ICT kiosks, training was offered to the villagers on how the ICT kiosks worked—not from the perspective of point-and-click but rather from the perspective of the types of information that would be available. An incentive of 500 Indian Rupees (INR) was offered to any villager who attended a training session—a substantial incentive given that the average income of many farmers at the time of the start of our study was only about 20,000 INR a year. The training sessions were conducted each day for one month.

Social networks and entrepreneurial activity. Once each year for 7 years, one of 10 interviewers hired by the research team interviewed each woman in the sample to obtain information about their social networks and other aspects of their lives, including the decision to start their own business. Detailed information about the entrepreneurial activity was gathered during the interviews by the research assistants to ensure accuracy and completeness related to informal businesses as well (e.g., food delivery, milk delivery) that were created by women that served the village and potentially did not require much support through the ICT intervention. For instance, women sometimes started a business where they sold and delivered milk [to some other

citizens of the village] produced by the cows that they owned. In such a scenario, this only took a little time each day, thus possibly requiring only some family support; but little to no community support or other forms of governmental support; and little information was necessary to run the business. Such women seldom reported their income to the government for the purposes of taxes. Our interviews helped us unearth and include such businesses also. The first wave of data in the intervention villages was obtained just before the month-long training for the ICT kiosks and about the same time in the 10 control villages. The interviews were conducted in private to ensure that the women shared information about their networks honestly. There was a natural time lag built into our data collection, with the network variables captured at the beginning of each year, ICT use captured over the course of the year, and entrepreneurial activity and profit captured at the end of the year. Each interview lasted about 2 hours. An incentive of 500 INR was offered for participation in each wave of data collection.

Entrepreneurial profit. Data on the revenue generated in a specific year from entrepreneurial ventures was collected from government filings in the villages. Four trained research assistants traveled to the local government offices to collect these data. In addition, personal interviews conducted for the purpose of data collection each year served as a way to cross-validate profit data. Because some entrepreneurial activities were informal, such interviews were important, as noted earlier, to gather information about entrepreneurs who did not necessarily report their income to the government. Further, the ceiling for reporting income to the government for the purpose of taxation was higher than what most village citizens, especially women running small businesses, earned annually.

Measures

Centrality—family, community, and men in power. A roster method was used to collect data about ties. We developed a roster of the entire community using information from government registries. Possible family members were adults and included parents, grandparents, in-laws, siblings, siblings' spouses, and siblings' children. The community included all adult women in the village. Men in power were members of the local government, i.e., Panchayat; interestingly, all members of the local government in our study villages were men. In order to ensure the networks were exclusive, we first excluded family members from the other two networks. The men in power and community networks were already mutually exclusive because the local village governments in all the villages we studied comprised only men. During the structured interviews, each participant was asked to note the degree of communication she had with each member of the community. The response options ranged from 1 to 5 (1: less than monthly, 2: monthly, 3: weekly, 4: daily, and 5: multiple times a day). If a participant indicated they did not communicate with an individual, a 0 was entered. The instrument was developed in English, translated into the local language by a native language speaker, and then back-translated to English by a different native language speaker (Brislin, Lonner, & Thorndike, 1973). Translation discrepancies were discussed and resolved by the two native language speakers. We used UCINET 6.29 (Borgatti, Everett, & Johnson, 2013) to calculate centrality scores weighted by tie strength for *family* (ties to nuclear and extended family members), *community* (ties to non-family community members) and *men in power* (ties to men of the local community government, i.e., Panchayat).

ICT use. For women in the 10 intervention villages, ICT use was assessed as the total number of hours each participant used the ICT kiosks in each year of the study. The kiosk attendants maintained a physical ledger of visitors to the kiosk. These logs were matched with

Internet logs recorded by the computers. ICT use was set to zero for the participants in the control group villages. To further delineate the distinction that arises from ICT intervention vs. control villages, we coded a dummy variable 0 for control and 1 intervention—such a variable would allow us to examine the distinction that comes from ICT use being zero in the control group (due to no access) and treatment group (by choice).

Time. We coded time from 1 to 7 in keeping with the year of data collection. As we noted earlier, most variables were measured each year, with the exception of ICT use that was aggregated each year.

Entrepreneurial activity and profit. Entrepreneurial activity was coded as 1 if a woman started a new business venture in a particular year, and zero otherwise. Specifically, a 1 was entered if a woman had an operational business. Entrepreneurial profit data were obtained each year in the interviews. Because the businesses were, in general, small and the women in all cases kept their own books, the entrepreneurs were in the best position to report their profits. These data were cross-validated with the businesses' government or bank filings in conjunction with loans obtained, where available. The correlation between the interview-based profit measure and the archival measure was greater than .80 for each year, lending credence to the self-reported measure. Further, as noted earlier, the interviews were an important way for us to collect data about the entrepreneurial activity and profit for informal business ventures.

Control variables. We measured and included a number of controls that could potentially relate to social networks and entrepreneurial activity. In particular, we sought to account for the factors relevant in our context, but also to control for potential confounds and key predictors from George et al. (2016), the recent major contribution to the literature in the area of entrepreneurship in rural villages. We included the woman's age, number of children above the

age of 5, number of children below the age of 5, and husband's education (attending 5th grade or higher, i.e., the way literacy is tracked by the Indian government: yes or no) because they had the potential to relate to social networks in the family and community as well as entrepreneurial outcomes. Older women could have greater power and thus, access to resources; children above the age of 5 could help support entrepreneurial activity by working; children below the age of 5 could hinder entrepreneurial activity as they would need care; and husband's education could result in greater support both financially and in overcoming other family/sociocultural obstacles.

Following George et al. (2016), we included a control for *natural shocks* (e.g., household flooding, livestock death), the number of adults and children in the nuclear family (*family size*), and *social structure disintegration* (e.g., major changes to the family structure such as deaths, divorces), *annual income lost* (income lost as a result of various shocks), *other shocks* (e.g., accidents, burglary), *economic shocks* (e.g., nonpayment of salary by a family member, end of government assistance, emigration of a family member), *savings*, *wealth*, and *income* by coding the data we gathered from our annual interviews with women in the sample (these were time-varying controls). We also controlled for whether the household *owned another business* and whether the *woman was the head of the household*. These were also time-variant controls. Two of the control variables from George et al. (2016) (education and community institution membership) were constants in our sample—none of the women in the sample had attended school and none were members of community institutions. Finally, we also controlled for the key interaction prediction terms in George et al.'s (2016) study—social structure disintegration by income lost and by head of household.

Analysis Approach

Given our repeated-measures design, we used Generalized Estimating Equations (GEE) to test the predictions. GEE is particularly suited for the structure of our data; it not only allows for the modeling of time (here, year), but also accounts for the systematic biases, non-independence, person-level, and person-year variance introduced by repeated measures from the same participants over time (see Ballinger, 2004). Entrepreneurial activity was dichotomous within each person-year and was therefore estimated using GEE's logit function. We collected the network data at the start of the year and used it to predict entrepreneurial activity and profit at the end of the year, thus building a time lag into the model. We chose to use GEE instead of hierarchical linear modeling (HLM) because we do not make any predictions about time-invariant higher-level (here, individual-level) variables. In addition to the dummy variable that allowed distinguishing between control and intervention group villages, we pooled the data across both intervention and control group villages, setting ICT use as 0 in the control group. For the analysis on entrepreneurial activity, we used the data from entrepreneurs who operated a business during our study period only. The equations that were tested for the various models are shown in Appendix 1.

RESULTS

Table 1 presents the descriptive statistics for, and correlations among, the variables in the study. Table 2 shows the results for ICT use. Tables 3 and 4 include the results for entrepreneurial activity and entrepreneurial profit.

In terms of descriptive results, 160 new businesses were started by women in the intervention villages. All but 7 of these new businesses were active at the end of the study period. Of these businesses, 42 were informal businesses that operated without any specific registration or licensing. The types of businesses ranged across a broad spectrum to include

restaurants, handicrafts, and farming support (e.g., fertilizer supply). In contrast, 40 businesses were started in the control villages (30 of them were active at the end of the study period). There were also differences in the time to initiation of new businesses. The average duration before the start of the business was about 2 years in the intervention group and about 4 years in the control group. Descriptively, average annual profit of the businesses in the intervention group was 73,300 INR; the average was 37,200 in the control group. The intervention group businesses employed, on average, 6 individuals at the end of the study period, whereas the control group businesses employed, on average, 1 individual.

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Insert Tables 1-4 about here

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Main Effect Predictions—Networks, ICT Use, and Entrepreneurial Outcomes

The first three hypotheses concerned the main effects of ties to family, community, and men in power on ICT use. These predictions were supported. As shown in Model 2 of Table 2, family centrality (b = .29, p < .01) and community centrality (b = .42, p < .01) were positively associated with ICT use. Also as predicted, ties to men in power was negatively related to ICT use (b = -.25, p < .01).

Model 2 in Tables 3 and 4 show these main effect results for the prediction of entrepreneurial activity (Table 3) and profit (Table 4). As shown, family centrality increased the odds of entrepreneurial activity by 26% (p < .01) and community centrality by 30% (p < .01). Entrepreneurial activity had a negative association to ties to men in power (odds ratio = .26, p < .01). Similarly, family centrality (b = .19, p < .01), community centrality (b = .18, p < .01), and

ties to men in power (b = -.15, p < .05) were significantly related to entrepreneurial profit. Thus, Hypotheses 1 and 2 were supported.

Hypothesis 3 concerned the main effect of the ICT use on entrepreneurial activity and profit. Model 2 in Tables 3 and 4 show these results. ICT use had a strong and positive effect on entrepreneurial activity, with a 73% (p < .01) increase in likelihood of entrepreneurial activity, and profit (b = .60, p < .01). Thus, Hypothesis 3 was supported.

Interaction Predictions—Networks, ICT Use, and Entrepreneurial Outcomes

Hypotheses 4a through 4c concerned the interactions between the social network variables and ICT use on entrepreneurial activity and profit. Model 4 of Tables 3 and 4 show these results. In Table 3, the two-way interactions in Model 3 for ICT use with family centrality increased the likelihood of entrepreneurial activity by 37% (p < .01) and community centrality increased it by 32% (p < .01). ICT use with ties to men in power was negatively associated with entrepreneurial activity (odds ratio = .84, p < .05). In terms of the odds ratios at low and high levels of the moderators, the pattern of relationships for family and community centrality was similar. We used simple slopes to calculated the odds ratios at low and high levels of the ICT use moderator. When ICT use was high, was a significant positive relationship between family centrality and entrepreneurial activity (63% increase), but not when ICT use was low. For community centrality, there was a 57% increase in likelihood of entrepreneurial activity when ICT use was high, but again no relationship when ICT use was low. Contrary to our prediction, the negative relationship between ties to men in power and entrepreneurial activity was significantly stronger when ICT use was high (odds ratio = .26) than when it was low (odds ratio = .37).

In Table 4 (entrepreneurial profit), the two-way interactions in Model 3 for ICT use with family centrality (b = .21, p < .01), community centrality (b = .19, p < .01) were significant, but the interaction with ties to men in power (b = -.11, n.s.) was not. The nature of the interactions was such that the relationship between family and community centrality and entrepreneurial profit was significant and positive when only when ICT use was high. Thus, we concluded that Hypothesis 4a and 4b were supported, and Hypothesis 4c was not supported. Further, in every regression that included an interaction with ICT use, we included similar interaction terms with this dummy variable like the interaction term with ICT use (e.g., family centrality by ICT intervention; family centrality by ICT intervention by time). In all regressions, the interaction with this dummy variable was non-significant, likely because the ICT use interaction was the more important predictor; we then dropped the interaction with the dummy variable and re-estimated the model, given the non-significance and the shared variance with the ICT use interaction terms.

Three-way Interaction Predictions with Time

Model 4 shows the full model with three-way interactions including time for entrepreneurial activity (Table 3) and profit (Table 4). In Model 4 of Table 3, the three-way interactions were significant for family centrality (odds ratio = 1.16, p < .05), and community centrality (odds ratio = 1.28, p < .01), while there was a negative association with ties to men in power (odds ratio = .30, p < .01). To illustrate the pattern, Figure 2 shows the relationships between family centrality, ICT use, and time in predicting entrepreneurial activity. We illustrate the pattern using odds ratios in Figure 2. As the figure shows, only when ICT use and family centrality are both high does the likelihood of such entrepreneurial activity increase over time. The same pattern of results was found for community centrality. For ties to men in power, the 3-

way interaction pattern is shown Figure 3. The likelihood of entrepreneurial activity increases over time for those with high ICT use and low levels of ties to men in power. In other combinations, including when ties to men in power are high, likelihood of entrepreneurial activity is low. In general, the results for entrepreneurial activity provide support for Hypothesis 5 in the cases of family and community centrality, but not our interactive prediction for ties to men in power. The results show evidence of synergistic, complementary effects between family and community centrality and ICT use over time—the relationship between these social network variables and entrepreneurial activity was strongly positive when ICT use was also high. The results are more complicated when ties to men is power is considered. ICT use increased the likelihood of entrepreneurial activity over time only when ties to men in power were low.

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Insert Figures 1-4 about here

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The three-way interactions for entrepreneurial profit are shown in Model 4 of Table 4. As the table shows, the three-way interaction involving family centrality (b = .16, p < .05) and community centrality (b = .19, p < .01) were significant, but the three-way interaction involving ties to men in power was not significant (b = .10, n.s.). For the family and community centrality, a pattern like those found in the entrepreneurial activity results was found. Figure 4, as an example, depicts the form of the interaction for community centrality as the network variable. The upward-sloping fan effect is evident and the increase in profit over time is observed among women with high use of the ICT kiosk and high community centrality. A substantively identical pattern was observed when family centrality was the network variable in the three-way interaction. Thus, Hypothesis 5 was supported in the case of family and community centrality for

entrepreneurial profit, but was not supported in the case of ties to men in power. In these three-way interaction estimations also, we included interaction terms with the intervention dummy variable and found it was non-significant and thus dropped it.

Robustness Checks: Additional Analyses Summary

We performed the analysis using HLM by nesting individuals within villages and time within individuals. The pattern of results in terms of coefficients and significance levels were substantively identical to those we report and are available from the authors upon request. Another concern is that ICT use is set to zero for about half the sample because of the impossibility of ICT use in the control group. To alleviate this issue, we conducted a split-sample analysis (intervention group and control group separately) and examined moderation effects using beta differences tests. The pattern of results was substantively identical to those we report and are available from the authors. One final concern surrounds endogeneity as it relates to the potential reverse causality between the network variables over time and ICT and entrepreneurial outcomes. To examine the robustness of our findings to endogeneity, we used Heckman's two-step procedure and conducted extensive additional analyses. We report these results in an appendix—as we report there, the patterns reported in Tables 2 through 4 are largely unaltered even after accounting for endogeneity.

DISCUSSION

We sought to tackle the grand economic challenge faced by women in rural India. Based on our 7-year field quasi-experiment in 20 villages in rural India, we found strong evidence for the interplay of social network variables and an ICT intervention in promoting entrepreneurial activity and success among women. Women in the intervention villages started more new business ventures and made more profit over time than those in the control villages. In terms of

social network variables, we found consistent direct, positive effects for family and community centrality on ICT use, entrepreneurial activity and profit, and consistent negative relationships between ties to men in power and these same outcomes. We also found substantive relationships between ICT kiosk use and entrepreneurial activity and profit. Beyond these main effects, we found that ICT use interacted with the social network variables to influence entrepreneurial activity and success, with the effects becoming stronger over time. In terms of family and community centrality, a facilitating effect was found such that the positive relationship between social network variables and entrepreneurial outcomes was stronger among women who used the ICT kiosk more frequently. In terms of ties to men in power, the interactions were not significant. Instead ICT use was associated with more entrepreneurial activity over time only when ties to men in power were low.

In a recent major contribution to the area, George et al. (2016) demonstrated that social structure disintegration—major, negative life events such as death, divorce, and job loss—resulted in greater entrepreneurial activity in the context of desperate poverty. We extend these findings here. In particular, we control for these losses, other key controls and interaction effects in the George et al. (2016) study, and show that social networks and ICT use are critical for the formation and success of women's new businesses, and that these effects operate independently and jointly. In theoretical terms, our findings reinforce some prior work that family and community centrality serve as catalysts in facilitating new business success, but that ICT use serves as a critical accelerator of entrepreneurial activity and success. We observed that the interplay of these factors provides a more thorough explanation for the dynamics of new venture initiation and success over time, than either in isolation. Most effects strengthened over time.

In terms of further theoretical implications, we departed from the norm of advocating only for the beneficial role of social networks by focusing on the potential negatives of women's connections to local government leaders. Contextualized to the rural Indian context, we argued that, in general, ties to men in power would signify a significant constraint and pressure to conform to the status quo. This contention was strongly supported as a main effect. In the interaction tests, the results were more complicated. In later time periods, new businesses were more common when ICT was used, but when those women did not have strong ties to men in power. We are unable to disentangle the complex mechanisms underlying the cultural constraints of having such ties. We encourage future work, perhaps through detailed qualitative analysis, to examine how women with ties to men in power can overcome sociocultural barriers to new business initiation over time. We found that the predominant effect of these ties on new business initiation is negative and ICT seems only to be useful when women are not connected to the dominant local government. We encourage future research on these mechanisms.

We make key contextual contributions surrounding the role of networks. These are along the lines articulated by Johns (2006), who noted that identifying specific constructs and mechanisms in important contexts represent important advances to theory. The particular similarities and differences between developed and developing countries, and particularly between women and men are noteworthy. The particular networks identified here may be relevant in both developed and developing countries but the negative impact of ties to men in power is unique to women in developing countries. The issues or puzzles in entrepreneurship for women include lack of access to financing, markets, networks, time, skills, and training—and women's access to ICTs helps alleviate these challenges (Hinson, 2011). Our findings can form the basis of social or policy interventions that can be studied in future research.

Another key contribution of this work is demonstrating the efficacy of an ICT intervention in the pursuit of the grand challenge facing women in less developed countries. In addition to desperate poverty that characterizes the lives of people in rural India, the oppression of women is a serious issue. We found that this challenge can be combated and conditions of women improved by helping women with their entrepreneurial pursuits. Specifically, we demonstrate that through an ICT intervention not only can we disseminate useful information that promotes entrepreneurial activity among women, but also provide information that can aid in achieving higher profits. The benefits of the ICT intervention were apparent in at least four distinct ways. First, there was a strong main effect of the ICT use on entrepreneurial activity and profit, with this effect becoming stronger with time. Second, the findings related to the impact of ICT use are complemented by the prediction of ICT use by the network variables and in the same pattern as the prediction of entrepreneurial activity. Third, ICT use appeared to help women overcome the sociocultural barriers prevalent in such rural settings that manifest in terms of lack of support from family and community and even the opposition of the powerful people (i.e., village government officials who were all men). Fourth, our engagement in the context revealed that in the intervention villages where there was a good number of successful women entrepreneurs, we learned of a positive side effect based on our interviews and engagement in the villages: such women helped in getting much greater voice and recognition for women in the community including a presence for women in the local government, which was completely unheard of at the beginning of our study. Together, these findings provide crucial evidence of the interplay between the social and technology components in the achievement of the MDGs and should be vital as the pursuit of the SDGs continues over the next 15 years.

Although much is known about the entrepreneurial activity and success in developed countries, less is known about entrepreneurship in developing and newly industrialized countries, especially among women. Our work contributes to this nascent body of work (e.g., George et al., 2016). Beyond the social structure disintegration that was found to contribute to entrepreneurial activity, we extend our understanding to include how such activity can be fostered both through social networks and an ICT intervention that can complement and substitute for traditional social ties. Another step forward that we take with this work is the examination of entrepreneurial profit and over an extended period of time. Specifically, the interactive effects (social network variables, ICT use, and time) that we found in predicting entrepreneurial activity, with the complementary effects becoming stronger with time, were not found in predicting profit—rather, we found two-way interactions such that the effect of social ties and ICT use became stronger with time, with the strongest effect being that of the ICT intervention. Taken together, our findings demonstrate the utility of and the need for further inquiry into ICT interventions in promoting entrepreneurial activity and profit in these contexts.

The success of the ICT intervention in promoting entrepreneurial activity can serve as the springboard for a broad array of future research. The first set of future research questions relate to addressing the other grand challenges. We found some anecdotal evidence to indicate that women in the intervention villages achieved greater voice due to the success of the few women entrepreneurs. This suggests that overcoming the grand challenges can be intertwined and research should investigate such potential pleasant side effects as they can greatly speed up progress in the rural areas of less developed countries. Specifically, problems surrounding women's health require attention, given the extremely high maternal mortality rates in less developed countries. Related to this are problems of population control, malnourishment, and

high infant and child mortality rates that could potentially be examined in conjunction with interventions targeted at the empowerment of women.

A second set of questions relate to the examination of other interventions. For instance, it would be useful to know the impact of complementary investments/interventions, such as government programs, non-government organizations' initiatives, and other media activities. Although it is likely that such programs also had an effect in the villages we studied (and the effects were similar in all villages), we did not specifically isolate such effects to identify ones that were helpful. Other similar investigations would be valuable in the pursuit of the other grand challenges as well. For example, if an ICT intervention can or is found to reduce maternal mortality, what complementary investments are important given that the government of India is making big investments in healthcare education and mobile clinics to improve the health of citizens in rural India? Another issue worth pursuing is how to effectively address the desperate poverty that characterizes much of rural India. With the primary breadwinners in rural India being in the farming and fishery industries, understanding the long-term effects of interventions, such as the one studied here, on the income of these primary breadwinners will be valuable.

Our findings could spur a third set of questions beyond management and entrepreneurship research, in related fields such as information systems where the focus includes the design of ICT systems. Given our interest in social networks and the impact of the ICT intervention itself, we treated the design of the intervention as a black box. With the emergence of mobile technologies and lower cost of data access, researchers could develop alternative ICT interventions and study which of the interventions have the strongest impacts, including potentially synergistic impacts on different grand challenges and explorations of which design is best to address each different grand challenge. Our work certainly provides the initial proof that

an ICT intervention can promote entrepreneurial activity. But, alternative designs, especially mobile technology designs, have the potential to be scalable, which is important given that there are about 500,000 villages in rural India. Our intervention was resource intensive as it required the support of a proxy user/kiosk attendant, which raises the issue of scalability. Future work should develop and test scalable solutions spurred by the evidence that has emerged in this work.

A fourth set of questions relate to the types of networks and ties that could be relevant. We studied communication networks but advice, friendship and hindrance could be other relevant networks that could be studied. Further, we kept each of the three networks (family, community, and men in power) to be unique and distinct. However, in practice, some overlap is possible, here between family and men in power. The multiplex nature of these ties will be interesting to investigate in future work.

A final set of questions emerge from considering generalizability. Acknowledging that more than 400 million Indians live in desperate poverty, addressing grand challenges in rural India is vital. But moving outside India is sure to bring some similar and some different problems. Issues related to women's empowerment exist in various parts of the world, such as sub-Saharan Africa. Some similar problems, such as limited role of women in tribal government, may exist. But, other constraints, such as polygamy, may play a role in how this challenge is tackled in some countries. Going to a country like China may introduce governmental regulations/considerations. Overall, tackling grand challenges will require systematic studies in various countries/contexts so that a rich body of knowledge about possible solutions can emerge. Such future contextual work will be crucial to addressing the grand challenges in these other environments, while making key theoretical contributions as the context is better understood and

current theory breaks down, allowing for the emergence of new knowledge (Alvesson & Karreman, 2007; Johns, 2006).

Prentice and Miller (1992) argued that small effects can be impressive, especially when the experimental design includes only minimal manipulations of independent variables. Thus, perhaps the greatest practical implication of our results is that that a weak intervention (very few computers located in a public place) was able to spur significant change in entrepreneurial activity and profit among women in the intervention villages. We believe therefore that what we observed and explained is particularly significant—we underscore that effecting change in rural India is quite challenging and financial resources required to implement such an intervention is relatively small as well. Our findings suggest that ICT use will result in increased savings and wealth, thus improving access to ICTs for women will be beneficial. Locating Internet centers in locations that are accessible to women, keeping in mind mobility restrictions for women in India will be helpful; in addition, staffing such centers with women can ease cultural restrictions and concerns about cross-gender communication (Best & Maier, 2007). Conducting separate "women-only" training on how to use ICTs and how to gain access using the Internet can also contribute to greater participation and less restraint on the part of women because it also eliminates the possibility of interaction with men who are not part of their families.

In terms of other practical implications, the success observed in the intervention villages provide a window into the importance of complementary aspects that are necessary—not just the right network conditions, but also some level of ICT use; but, beyond that, the importance of staffed kiosks deserves particular mention. Frequently, the typical view that "build and they will come" has failed consistently in less developed countries because there is no facilitator for ICT use. Identifying "ICT champions" during training sessions and encouraging these champions in

their efforts or providing them with more advanced training may increase their ability to help other women. Being helpful increases centrality because advice is important in rural India where there is a high collectivism, low literacy, and a rich oral tradition.

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Table 1
Descriptive Statistics and Correlations

		Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1.	Age	54.29	14.22																					
2.	Children below age 5	2.81	1.75	-.17**																				
3.	Children above age 5	4.04	2.92	.25**	.13*																			
4.	Husband's education	0.29	0.45	-.19**	.07	.11*																		
5.	Natural shocks	1.83	2.35	.17**	.12*	.07	.10*																	
6.	Other shocks	1.21	1.07	.04	.07	.10	.08	.10*																
7.	Economic shocks	1.31	1.04	.10	.15*	.06	.13*	.07	.15*															
8.	Savings (000 INR)	27.40	11.81	.17**	.07	.13*	.16**	-.08	-.05	.14*														
9.	Wealth (000 INR)	43.12	32.93	.19**	.12*	.14*	.19**	.10*	-.12*	.09	.19**													
10.	Income (000 INR)	28.63	14.90	.22**	.10	.08	.23**	.06	.12*	.13*	.24**	.17**												
11.	Family size	4.19	2.78	.13*	.08	.12*	.10*	.05	.07	.14*	.07	.14*	.14*											
12.	Soc struc disintegration	2.07	3.50	.19**	.10*	.10*	.06	.10*	.13*	.15*	.17**	.16**	.13*	.05										
13.	Income lost (000 INR)	21.49	13.29	.14*	.09	.12*	.13*	.06	.08	.17**	.15*	.10*	.07	.08	.10*									
14.	Head of household	0.08	0.27	.12*	.12*	.14*	.04	.09	.10*	.08	.04	.07	.05	-.10*	.05	.09								
15.	Intervention (1: interv. village)	0.49	0.50	.08	-.21**	.25**	.17**	.25**	.09	.07	.11*	.17**	.13*	.24**	-.15*	.14*	.19**							
16.	Family centrality	23.28	11.30	.26**	.12*	.12*	.13*	.10*	.08	.16**	.22**	.12*	.09	.17**	.13*	.08	.15*	.21**						
17.	Community centrality	142.10	46.21	.23**	.14*	.13*	.15*	.12*	.10*	.19**	.20**	.17**	.24**	.19**	.14*	.17**	.18**	.17**	.15*					
18.	Govt official centrality	11.35	7.98	.17**	.14*	.13*	.27**	.20**	.07	.20**	.27**	.13*	.14*	.06	.08	.13*	.06	-.19**	.14*	.17**				
19.	ICT use	17.13	39.95	.10*	-.27**	.31**	.22**	.28**	.11*	.10*	.14*	.22**	.15*	.29**	-.19**	.17**	.21**	.38**	.26**	.30**	-.25**			
20.	Time	4.00	2.00	.07	.08	.11*	.08	.10*	.12*	.06	.17**	.15*	.17**	.08	.06	.10	.12*	.07	.11*	.19**	.13*	.22**		
21.	Entrepreneurial activity	0.02	0.12	.12*	-.12*	.23**	.17**	.27**	.18**	.19**	.15*	.17**	.24**	.28**	-.13*	.15*	.11*	.35**	.19**	.28**	-.23**	.44**	.20**	
22.	Entrepreneurial profit (000 INR)	66.08	35.41	.16**	-.21**	.22**	.24**	.17**	.13*	.17**	.20**	.18**	.25**	.20**	-.19**	-.11*	.13*	.40**	.24**	.31**	-.24**	.50**	.24**	.17**

Notes: *N* = 94,241 for all except profit where N=1,400. * p < .05, ** p < .01, NA not applicable.

Table 2
GEE Results for ICT Use

	ICT Use	
	Model 1	**Model 2**
Age	.04 (.02)	.04 (.02)
Children below age 5	-.17** (.03)	-14* (.03)
Children above age 5	.19** (.02)	.15* (.02)
Husband's education	.14* (.03)	.12* (.03)
Natural shocks	.16** (.01)	.13* (.02)
Other shocks	.07 (.04)	.05 (.05)
Economic shocks	.05 (.05)	.03 (.05)
Savings	.05 (.04)	.03 (.06)
Wealth	.13* (.02)	.11* (.02)
Income	.05 (.04)	.02 (.05)
Family size	.17** (.01)	.14* (.01)
Social structure disintegration (SSD)	-1.07 (.30)	-1.05 (.33)
Income lost	.07 (.05)	.06 (.06)
Head of household (yes or no)	.13* (.02)	.11* (.02)
SSD * Income lost	.17** (.03)	.13* (.03)
SSD * Head of household	.05 (.11)	.02 (.12)
Intervention (1: intervention village)	.20** (.02)	.14* (.02)
Family centrality		.29** (.04)
Community centrality		.42** (.03)
Ties to men in power		-.25** (.04)
R^2	.17	.31
ΔR^2		.14**

Notes: N = 94,241. * $p < .05$, ** $p < .01$. Unstandardized b's are reported with robust standard errors in parentheses.

Table 3
GEE Results for Entrepreneurial Activity

	Entrepreneurial Activity			
	Model 1	**Model 2**	**Model 3**	**Model 4**
Age	1.05	1.04	1.04	1.02
Children below age 5	.92	.92	.92	.95
Children above age 5	1.21**	1.14*	1.14*	1.13*
Husband's education	1.16*	1.14*	1.12*	1.07
Natural shocks	1.21**	1.17**	1.13*	1.14*
Other shocks	1.10	1.08	1.07	1.04
Economic shocks	1.08	1.05	1.05	1.05
Savings	1.06	1.05	1.04	1.02
Wealth	1.08	1.06	1.03	1.04
Income	1.07	1.06	1.04	1.03
Family size	1.26**	1.21**	1.18**	1.16*
Social structure disintegration (SSD)	.34	.34	.33	.34
Income lost	1.13	1.09	1.08	1.04
Head of household (yes or no)	1.07	1.05	1.05	1.01
SSD * Income lost	1.22**	1.13*	1.10	1.12
SSD * Head of household	1.06	1.06	1.04	1.02
Intervention (1: intervention village)	1.25**	1.06	1.04	1.03
Family centrality		1.26**	1.21**	1.19**
Community centrality		1.30**	1.23**	1.19*
Ties to men in power		.26**	.30*	.32*
ICT use		1.73**	1.65**	1.55**
Family centrality * ICT use			1.37**	2.83
Community centrality * ICT use			1.32**	1.08
Ties to men in power * ICT use			.84*	1.14*
Time				1.13*
Family centrality * Time				1.19**
Community centrality * Time				1.08
Ties to men in power * Time				1.02
ICT use * Time				1.32**
Family centrality * ICT use * Time				1.16*
Community centrality * ICT use * Time				1.28**
Ties to men in power * ICT use * Time				.30**
Pseudo R^2	.19	.38	.43	.50
ΔR^2		.19**	.05*	.07**

Notes: N = 94,241. * $p < .05$, ** $p < .01$. Odds ratios are reported.

Table 4
GEE Results for Entrepreneurial Profit

	Entrepreneurial profit			
	Model 1	**Model 2**	**Model 3**	**Model 4**
Age	.12* (.01)	.08 (.02)	.06 (.02)	.07 (.08)
Children below age 5	-.16** (.02)	-.13* (.04)	-.13* (.05)	-.10 (.07)
Children above age 5	.16** (.02)	.13* (.03)	.12* (03)	.05 (.08)
Husband's education	.19** (.02)	.14* (.03)	.12* (.03)	.08 (.11)
Natural shocks	.08 (.02)	.08 (.03)	.06 (.04)	.01 (.10)
Other shocks	.09 (.03)	.09 (.02)	.06 (.05)	.05 (.05)
Economic shocks	.08 (.04)	.07 (.04)	.09 (.05)	.04 (.06)
Savings	.12 (.07)	.10 (.08)	.08 (.10)	.07 (.12)
Wealth	.14 (.08)	.13 (.09)	.12 (.10)	.09 (.12)
Income	.12 (.10)	.12 (.12)	.08 (.13)	.08 (.14)
Family size	.16** (.01)	.12* (.02)	.09 (.03)	.07 (.04)
Social structure disintegration (SSD)	-.15* (.03)	-.13* (.04)	.10 (.07)	-.08 (.08)
Income lost	-.05 (.05)	-.01 (.05)	.04 (.07)	-.03 (.10)
Head of household (yes or no)	.06 (.03)	.02 (.04)	.01 (.06)	.03 (.10)
SSD X Income lost	.10 (.03)	.06 (.02)	.05 (.06)	.04 (.09)
SSD X Head of household	.08 (.10)	.07 (.14)	.08 (.17)	.05 (.28)
Intervention (1: intervention village)	.32** (.04)	.14* (.04)	.10 (.05)	.06 (.05)
Family centrality		.19** (.02)	.17** (.02)	.19** (.02)
Community centrality		.18** (.03)	.15* (.03)	.11 (.04)
Ties to men in power		-.15* (.02)	-13* (.02)	-.02* (.02)
ICT use		.60** (.03)	.53** (.04)	.48** (.03)
Family centrality * ICT use			.21** (.03)	.05 (.22)
Community centrality * ICT use			.19** (.02)	.17** (.02)
Ties to men in power * ICT use			.11 (.07)	.07 (.08)
Time				.29** (.02)
Family centrality * Time				-.08 (.03)
Community centrality * Time				.13* (.05)
Ties to men in power * Time				.04 (.05)
ICT use * Time				.33** (.02)
Family centrality * ICT use * Time				.16* (.02)
Community centrality * ICT use * Time				.19** (.02)
Ties to men in power * ICT use * Time				.10 (.04)
R^2	.17	.31	.35	.46
ΔR^2		.14**	.04*	.11**

Notes: N = 1,400. * $p < .05$, ** $p < .01$. Entrepreneurial profit in '000 Indian Rupees. Unstandardized b's are reported with robust standard errors in parentheses.

Figure 1. Research Model

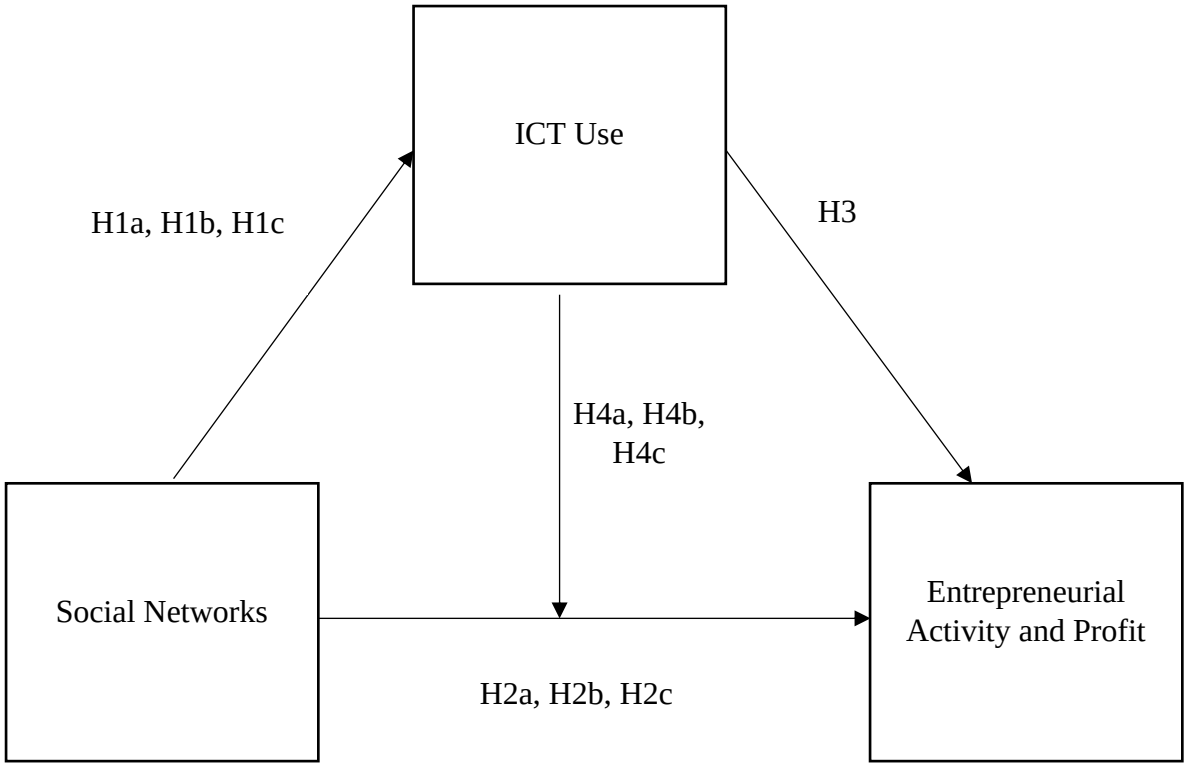


Figure 2. Interaction of family centrality, ICT use, and time predicting entrepreneurial activity

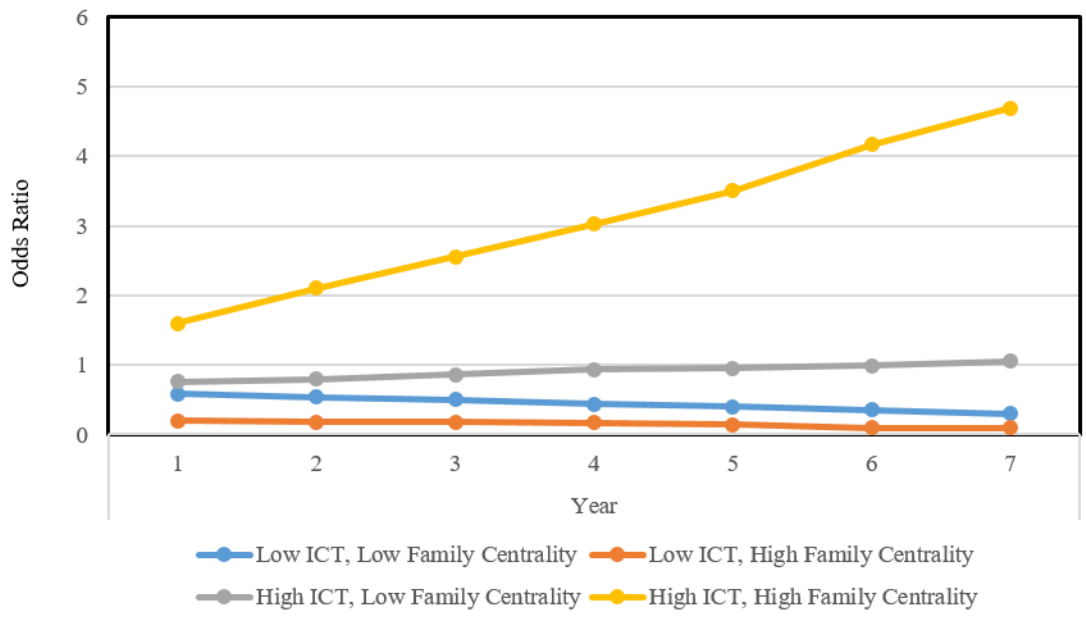


Figure 3. Interaction of ties to men in power, ICT use, and time predicting entrepreneurial activity

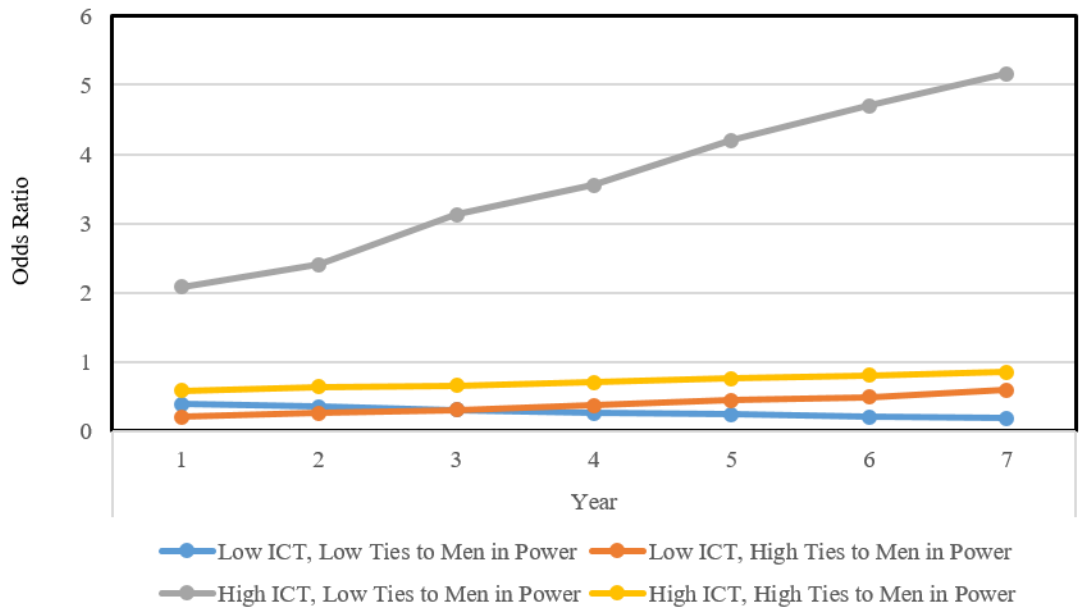
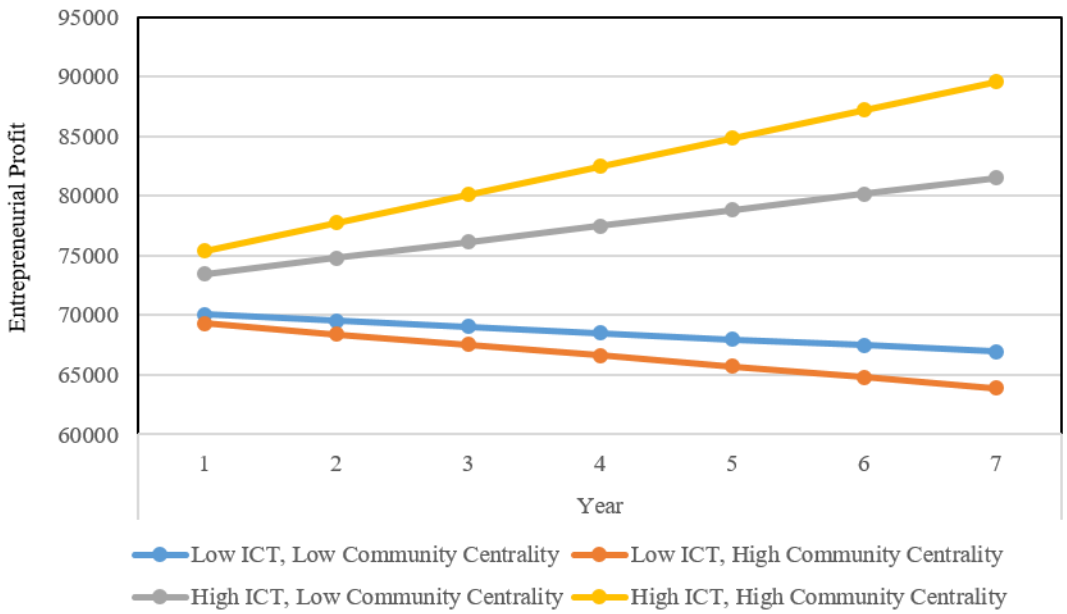


Figure 4. Interaction of community centrality, ICT use, and time predicting entrepreneurial profit



APPENDIX 1. EQUATIONS TESTED

Predicting ICT use:

Model 1

ICT use = b_0 + b_1 age + b_2 children below age 5 + b_3 children above age 5 + b_4 husband's education + b_5 natural shocks + b_6 other shocks + b_7 economic shocks + b_8 savings + b_9 wealth + b_{10} income + b_{11} family size + b_{12} SSD + b_{13} income lost + b_{14} head of household + b_{15} (SSD * income lost) + b_{16} (SSD* head of household) + b_{17} intervention + ε

Model 2

ICT use = b_0 + b_1 age + b_2 children below age 5 + b_3 children above age 5 + b_4 husband's education + b_5 natural shocks + b_6 other shocks + b_7 economic shocks + b_8 savings + b_9 wealth + b_{10} income + b_{11} family size + b_{12} SSD + b_{13} income lost + b_{14} head of household + b_{15} (SSD * income lost) + b_{16} (SSD* head of household) + b_{17} intervention + b_{18} family centrality + b_{19} community centrality + b_{20} ties to men in power + ε

Predicting entrepreneurial activity:

Model 1

Entrepreneurial activity = b_0 + b_1 age + b_2 children below age 5 + b_3 children above age 5 + b_4 husband's education + b_5 natural shocks + b_6 other shocks + b_7 economic shocks + b_8 savings + b_9 wealth + b_{10} income + b_{11} family size + b_{12} SSD + b_{13} income lost + b_{14} head of household + b_{15} (SSD * income lost) + b_{16} (SSD* head of household) + b_{17} intervention + ε

Model 2

Entrepreneurial activity = b_0 + b_1 age + b_2 children below age 5 + b_3 children above age 5 + b_4 husband's education + b_5 natural shocks + b_6 other shocks + b_7 economic shocks + b_8 savings + b_9 wealth + b_{10} income + b_{11} fdataamily size + b_{12} SSD + b_{13} income lost + b_{14} head of household + b_{15} (SSD * income lost) + b_{16} (SSD* head of household) + b_{17} intervention + b_{18} family centrality + b_{19} community centrality + b_{20} ties to men in power + b_{21} ICT use + ε

Model 3

Entrepreneurial activity = b_0 + b_1 age + b_2 children below age 5 + b_3 children above age 5 + b_4 husband's education + b_5 natural shocks + b_6 other shocks + b_7 economic shocks + b_8 savings + b_9 wealth + b_{10} income + b_{11} family size + b_{12} SSD + b_{13} income lost + b_{14} head of household + b_{15} (SSD * income lost) + b_{16} (SSD* head of household) + b_{17} intervention + b_{18} family centrality + b_{19} community centrality + b_{20} ties to men in power + b_{21} ICT use + b_{22} (family centrality * ICT use) + b_{23} (community centrality * ICT use) + b_{24} (ties to men in power * ICT use) + ε

Model 4

Entrepreneurial activity = b_0 + b_1 age + b_2 children below age 5 + b_3 children above age 5 + b_4 husband's education + b_5 natural shocks + b_6 other shocks + b_7 economic shocks + b_8 savings + b_9 wealth + b_{10} income + b_{11} family size + b_{12} SSD + b_{13} income lost + b_{14} head of household + b_{15} (SSD * income lost) + b_{16} (SSD* head of household) + b_{17}

intervention + b_{18} family centrality + b_{19} community centrality + b_{20} ties to men in power + b_{21} ICT use + b_{22} (family centrality * ICT use) + b_{23} (community centrality * ICT use) + b_{24} (ties to men in power * ICT use) + b_{25} time + b_{26} (family centrality * time) + b_{27} (community centrality * time) + b_{11} (ties to men in power * time) + b_{12} (ICT use * time) + b_{28} (family centrality * ICT use * time) + b_{29} (community centrality * ICT use * time) + b_{30} (ties to men in power * ICT use * time) + ε

Predicting entrepreneurial profit:

Model 1

Entrepreneurial profit = b_0 + b_1 age + b_2 children below age 5 + b_3 children above age 5 + b_4 husband's education + b_5 natural shocks + b_6 other shocks + b_7 economic shocks + b_8 savings + b_9 wealth + b_{10} income + b_{11} family size + b_{12} SSD + b_{13} income lost + b_{14} head of household + b_{15} (SSD * income lost) + b_{16} (SSD* head of household) + b_{17} intervention + ε

Model 2

Entrepreneurial profit = b_0 + b_1 age + b_2 children below age 5 + b_3 children above age 5 + b_4 husband's education + b_5 natural shocks + b_6 other shocks + b_7 economic shocks + b_8 savings + b_9 wealth + b_{10} income + b_{11} family size + b_{12} SSD + b_{13} income lost + b_{14} head of household + b_{15} (SSD * income lost) + b_{16} (SSD* head of household) + b_{17} intervention + b_{18} family centrality + b_{19} community centrality + b_{20} ties to men in power + b_{21} ICT use + ε

Model 3

Entrepreneurial profit = b_0 + b_1 age + b_2 children below age 5 + b_3 children above age 5 + b_4 husband's education + b_5 natural shocks + b_6 other shocks + b_7 economic shocks + b_8 savings + b_9 wealth + b_{10} income + b_{11} family size + b_{12} SSD + b_{13} income lost + b_{14} head of household + b_{15} (SSD * income lost) + b_{16} (SSD* head of household) + b_{17} intervention + b_{18} family centrality + b_{19} community centrality + b_{20} ties to men in power + b_{21} ICT use + b_{22} (family centrality * ICT use) + b_{23} (community centrality * ICT use) + b_{24} (ties to men in power * ICT use) + ε

Model 4

Entrepreneurial profit = b_0 + b_1 age + b_2 children below age 5 + b_3 children above age 5 + b_4 husband's education + b_5 natural shocks + b_6 other shocks + b_7 economic shocks + b_8 savings + b_9 wealth + b_{10} income + b_{11} family size + b_{12} SSD + b_{13} income lost + b_{14} head of household + b_{15} (SSD * income lost) + b_{16} (SSD* head of household) + b_{17} intervention + b_{18} family centrality + b_{19} community centrality + b_{20} ties to men in power + b_{21} ICT use + b_{22} (family centrality * ICT use) + b_{23} (community centrality * ICT use) + b_{24} (ties to men in power * ICT use) + b_{25} time + b_{26} (family centrality * time) + b_{27} (community centrality * time) + b_{11} (ties to men in power * time) + b_{12} (ICT use * time) + b_{28} (family centrality * ICT use * time) + b_{29} (community centrality * ICT use * time) + b_{30} (ties to men in power * ICT use * time) + ε

APPENDIX 2. RESULTS OF ENDOGENEITY TESTING

Our model posits that social network variables will influence ICT use and the network variables will interact with ICT use to influence entrepreneurial outcomes. One of the challenges with panel data such as what we have is the potential endogeneity in that it is possible that over time, greater levels of ICT use or entrepreneurial activity could lead to better network position; likewise, it is possible that entrepreneurial success will lead to greater ICT use and network position. Although GEE accounts for the correlations over time, it does not account for such endogeneity. To address such endogeneity, a few different approaches are available, such as instrumental variable regression (two-stage least squares) and/or Heckman's two-stage approach, which although developed originally to correct for selection bias has been used to correct for endogeneity (Heckman 1979; see also Hsieh et al. 2011, Appendix EC-1, electronic companion). To provide additional robustness to our conclusions, we conducted a series of 2SLS regressions for each year's observations. However, 2SLS is not designed to account for time. But a pattern of results that confirms the two-way interactions (i.e., because the data are not pooled across years, the three-way interactions cannot be estimated) while accounting for endogeneity would add to the robustness of our findings. Because we had used several control variables, there were no options remaining as suitable instrumental variables. Consequently, we re-estimated the model by dropping two variables that had served as control variables in the original estimation that could serve as instrumental variables: age and husband's education, both of which can reasonably be expected to influence social network variables, but age and husband's education cannot be caused by ICT use or entrepreneurial outcomes. We followed the procedures outlined in Hsieh et al. (2011, Appendix EC-1, electronic companion) to apply the two-stage Heckman's approach. The chosen instrumental variables were evaluated for relevance and exogeneity in stage 1. We computed the concomitant Inverse Mills Ratio (IMR) and added it to the model to account for the potential endogeneity with each regressor. In each case, the three social network centralities, the stage 1 model (not shown) was a probit estimation of the potential endogenous regressor that was used to compute the IMR. In the 2nd stage model (shown in

Tables A1, A2, and A3), after controlling for the IMR, the coefficients of the independent variables remained largely consistent. As an illustration, we show the results of the estimation for year 4 data. The pattern of coefficients for other years was similar in direction, with the magnitude varying somewhat over time, which can be expected given the interactions with time. The results thus provided support for our proposed causal flow even after accounting for potential endogeneity.

Table A1. Predicting ICT Use

	Original Pooled Model Estimation (Table 2, Model 2)	Estimation of Year 4 Data Dropping Instrumental Variables	Heckman's 2nd Stage Results (Endogenous Regressor Noted on Next Row)		
			Family Centrality	Community Centrality	Ties to men in power
Age	.04 (.02)				
Children below age 5	-14* (.03)	-.12* (.03)	-.12* (.03)	-.13* (.03)	-.14* (.02)
Children above age 5	.15* (.02)	.10 (.02)	.08 (.03)	.12* (.02)	.13* (.02)
Husband's education	.12* (.03)				
Natural shocks	.13* (.02)	.17** (.02)	.17** (.03)	.16** (.02)	.15** (.01)
Other shocks	.05 (.05)	.08 (.05)	.08 (.06)	.07 (.07)	.07 (.07)
Economic shocks	.03 (.05)	.06 (.07)	.06 (.08)	.05 (.07)	.04 (.08)
Savings	.03 (.06)	.02 (.08)	.02 (.09)	.02 (.08)	.02 (.09)
Wealth	.11* (.02)	.06 (.03)	.06 (.04)	.05 (.05)	.06 (.06)
Income	.02 (.05)	.08 (.04)	.07 (.05)	.07 (.04)	.07 (.05)
Family size	.14* (.01)	.19** (.01)	.17** (.01)	.17** (.02)	.16** (.01)
Social structure disintegration (SSD)	-1.05 (.33)	-1.08 (.37)	-1.08 (.36)	-1.08 (.35)	-1.08 (.31)
Income lost	.06 (.06)	.04 (.08)	.03 (.09)	.03 (.08)	.03 (.07)
Head of household (yes or no)	.11* (.02)	.13* (.02)	.13* (.02)	.13* (.02)	.13* (.01)
SSD * Income lost	.13* (.03)	.14* (.02)	.13* (.02)	.15* (.02)	.17** (.02)
SSD * Head of household	.02 (.12)	.07 (.10)	.06 (.10)	.06 (.08)	.04 (.09)
Intervention (1: intervention village)	.14* (.02)	.13* (.02)	.13* (.02)	.12* (.02)	.06 (.05)
Family centrality	.29** (.04)	.24** (.03)	.23** (.03)	.25** (.03)	.23** (.03)
Community centrality	.42** (.03)	.35** (.02)	.34** (.02)	.33** (.02)	.31** (.02)
Ties to men in power	-.25** (.04)	-.19** (.02)	-.17** (.02)	-.19** (.02)	-.22** (.02)
Inverse Mills Ratio	.31		.17** (.02)	.20** (.02)	.23** (.03)
	.14**				
R^2	.04 (.02)	.25	.26	.29	.29

Notes: N = 94,241. * p < .05, ** p < .01. Tabled values are b's with robust standard errors in parentheses.

Table A2. Predicting Entrepreneurial Activity

	Original Pooled Model Estimation (Table 3, Model 3)	Estimation of Year 4 Data Dropping Instrumental Variables	Heckman's 2nd Stage Results (Endogenous Regressor Noted on Next Row)		
			Family Centrality	Community Centrality	Ties to men in power
Age	1.04				
Children below age 5	.92	.91	.92	.93	.92
Children above age 5	1.14*	1.15*	1.14*	1.15*	1.09
Husband's education	1.12*				
Natural shocks	1.13*	1.07	1.07	1.11	1.09
Other shocks	1.07	1.09	1.08	1.09	1.08
Economic shocks	1.05	1.06	1.05	1.04	1.06
Savings	1.04	1.04	1.03	1.05	1.04
Wealth	1.03	1.05	1.05	1.05	1.05
Income	1.04	1.04	1.05	1.04	1.05
Family size	1.18**	1.22**	1.22**	1.21**	1.22**
Social structure disintegration (SSD)	.33	.35	.35	.35	.35
Income lost	1.08	1.11	1.10	1.11	1.11
Head of household (yes or no)	1.05	1.11	1.11	1.08	1.09
SSD * Income lost	1.10	1.07	1.07	1.06	1.07
SSD * Head of household	1.04	1.05	1.03	1.04	1.05
Intervention (1: intervention village)	1.04	1.04	1.03	1.03	1.02
Family centrality	1.21**	1.15*	1.14*	1.14*	1.15*
Community centrality	1.23**	1.27**	1.27**	1.27**	1.25**
Ties to men in power	.30*	.39*	.29*	.30*	.31*
ICT use	1.65**	1.73**	1.73**	1.69**	1.70**
Family centrality * ICT use	1.37**	1.26**	1.24**	1.22**	1.23**
Community centrality * ICT use	1.32**	1.23**	1.23**	1.25**	1.26**
Ties to men in power * ICT use	.84*	.76**	.75**	.74**	.79**
Inverse Mills Ratio			1.16*	1.21**	1.30**
Pseudo R^2	.43	.35	.35	.37	.38

Notes: N = 13,463. * p < .05, ** p < .01. Odds ratios are reported.

Table A3. Predicting Entrepreneurial Profit

	Original Pooled Model Estimation (Table 4, Model 3)	Estimation of Year 4 Data Dropping Instrumental Variables	Heckman's 2nd Stage Results (Endogenous Regressor Noted on Next Row)		
			Family Centrality	Community Centrality	Ties to men in power
Age	.06 (.02)				
Children below age 5	-.13* (.05)	-.17** (.02)	-.17** (.02)	-.16** (.02)	-.17** (.02)
Children above age 5	.12* (03)	.12* (03)	.13* (03)	.11* (01)	.12* (02)
Husband's education	.12* (.03)				
Natural shocks	.06 (.04)	.09 (.03)	.07 (.03)	.08 (.05)	.09 (.05)
Other shocks	.06 (.05)	.08 (.05)	.07 (.05)	.06 (.06)	.05 (.05)
Economic shocks	.09 (.05)	.06 (.05)	.06 (.05)	.06 (.06)	.06 (.05)
Savings	.08 (.10)	.08 (.10)	.09 (.10)	.07 (.11)	.08 (.12)
Wealth	.12 (.10)	.13* (.03)	.12* (.03)	.13* (.02)	.06 (.03)
Income	.08 (.13)	.07 (.13)	.07 (.12)	.07 (.10)	.06 (.10)
Family size	.09 (.03)	.12* (.03)	.13* (.03)	.11* (.01)	.10 (.04)
Social structure disintegration (SSD)	.10 (.07)	.13* (.02)	.12* (.02)	.08 (.04)	.08 (.05)
Income lost	.04 (.07)	.02 (.07)	.02 (.08)	.02 (.08)	.02 (.08)
Head of household (yes or no)	.01 (.06)	.05 (.07)	.02 (.07)	.04 (.07)	.05 (.07)
SSD * Income lost	.05 (.06)	.05 (.07)	.04 (.08)	.04 (.08)	.04 (.08)
SSD * Head of household	.08 (.17)	.06 (.17)	.06 (.19)	.03 (.15)	.06 (.16)
Intervention (1: intervention village)	.10 (.05)	.09 (.05)			
Family centrality	.17** (.02)	.20** (.01)	.19** (.01)	.18** (.02)	.19** (.02)
Community centrality	.15* (.03)	.21** (.02)	.20** (.02)	.20** (.02)	.17** (.02)
Ties to men in power	-13* (.02)	-.14* (.02)	-.13* (.02)	-.13* (.02)	-.16** (.01)
ICT use	.53** (.04)	.51** (.04)	.49** (.03)	.47** (.03)	.42** (.03)
Family centrality * ICT use	.21** (.03)	.24** (.03)	.23** (.03)	.21** (.03)	.20** (.02)
Community centrality * ICT use	.19** (.02)	.21** (.01)	.22** (.01)	.21** (.01)	.20** (.01)
Ties to men in power * ICT use	.11 (.07)	.16 (.10)	.15 (.11)	.13 (.11)	.11 (.14)
			.19** (.02)	.25** (.02)	.28** (.02)
R^2	.35	.37	.38	.40	.39

Notes: N = 13,463. * p < .05, ** p < .01. Unstandardized b's are reported with robust standard errors in parentheses.