

# The role of motorized transport and mobile phones in the diffusion of agricultural information in Tanggamus Regency, Indonesia

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Published online: 9 September 2015

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**Abstract** Limited access to agricultural information constrains the well-being of farmers in developing countries and leads to environmental deterioration. Although new information-communication technologies (ICTs) are expected to alleviate this problem, the importance of physical mobility is rarely considered. This study explores the roles of motorized transport and mobile phones in the diffusion of agricultural information within and between Indonesian farming communities. In 2012, we surveyed 315 household heads from 16 coffee and cocoa farming groups in Sumatra. The respondents identified 1575 sources from which they obtained agricultural information, the exact location of the sources, and the mode of contact. In 2013, we followed up with in-depth interviews of 20 farmers to obtain a qualitative description of their agricultural information-seeking behavior. Although 75 % of respondents had a mobile phone, the main mode of information sharing was face-to-face meetings for 97 % of the elicited relationships. Mobile phones were used to communicate with people living at the edge of the regular physical mobility radius enabled by motorbikes (approximately 10 km). A hierarchical logit model was applied to examine the implications of the respondents' tendency to use motorized transport vis-à-vis walking for information gathering. Respondents with a higher general preference for faster transport tended to have more extensive access to information from other communities. However, we also find weak evidence that individual motorized transport might decrease internal social contact and information exchange inside these communities. The policy implication for rural development in less-industrialized countries is that providing ICTs without increasing the inhabitants' mobility through appropriate means may not significantly improve the inhabitants' access to important information and the diffusion of successful agricultural practices.

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**Keywords** Personal networks · Information diffusion · Walking · Motorized transport · Community · Indonesia

## Introduction

Most people in developing countries are engaged in agricultural production (Central Intelligence Agency 2013). However, in many remote farming villages in these countries, basic resource-conserving and economic practices, such as the application of organic fertilizers, are unknown, and locally common uninformed and wasteful agricultural practices are leading to insufficient productivity and local environment degradation (Yila and Thapa 2008; Pretty et al. 2010; Beddington et al. 2012; Matouš et al. 2013b; Kassam et al. 2009).

The effectiveness of formal institutions in disseminating necessary agricultural information across vast underdeveloped rural regions has been questioned (Matouš et al. 2013b; Douthwaite et al. 2001; Leeuwis 2004; Warner 2007; Spielman et al. 2009; Gebremedhin and Swinton 2003), and informal social networks and social contact have been recognized as important channels for information-sharing about resource-conserving practices (Rogers 2003; Solano et al. 2003; Schneider et al. 2009; Ostrom 1990; Folke 2006; Janssen et al. 2006; Pretty and Smith 2004; Bodin and Crona 2009; Bodin and Prell 2011; Leeuwis 2004; Hoang et al. 2006; Isaac 2012; Isaac et al. 2007; Warner 2007; Spielman et al. 2011; Conley and Udry 2010; Bartholomay et al. 2011). However, communication connections among the inhabitants of areas with less developed infrastructures tend to be geographically constrained, and the potential for the diffusion of beneficial practices between communities is thus limited (Matous et al. 2013a; Apicella et al. 2012; Urry 2004b).

The international development literature is highly optimistic about the role of information-communication technologies (ICTs), specifically mobile phones, in increasing farmers' access to valuable information (Donner 2008; Juma 2010; Matous et al. 2014). Several evaluation studies have reported on the impacts of mobile phones on access to agricultural information (Arunachalam 2002; Bhavnani et al. 2008; Overå 2006). Mobile phones are expected to enable inhabitants of less-developed areas to expand their networks and to reach beyond the locus of their everyday face-to-face interactions to access information about production techniques and markets (Donner 2008; Ilahiane and Sherry 2012).

In contrast, little research is available on the role of motorized transport in access to information. Although the importance of effective transport for the economic development of rural areas is widely accepted (Starkey et al. 2002; Cook 2005; Plessis-Fraissard 2007; Porter 2002), the negative environmental impacts of motorized travel are well documented (Santos et al. 2010; Adams 1999), and the relationship between transport and social interactions has recently started to gain attention (Dugundji et al. 2008, 2011; Farber and Paez 2011; Axhausen 2008), the role of motorized transport in access to information and the creation and maintenance of knowledge-sharing ties in less-developed regions is not yet understood.

This paper uses originally collected quantitative and qualitative data from Indonesia to examine the roles of motorized transport and mobile ICTs in social contact and agricultural information diffusion within and between local communities in rural areas of developing countries. Specifically, the study uses quantitative survey data to examine the following relationships at the personal and interpersonal levels. At the personal level, we examine

how mobile phone ownership and motorbike ownership are related to the spatial extent of individuals' access to information through their networks. At the relationship level, we examine how the physical distance between the interlocutors and the characteristics of their relationships are related to their preferred main mode of contact and information exchange. Finally, combining these two perspectives, we examine how the overall personal inclination toward contact through motorized transport is related to access to information inside and outside one's own community. After the quantitative assessment, we use qualitative data from semi-structured interviews with the local inhabitants regarding their perceived reasons for choosing a particular contact mode and devise feasible policy implications.

## Literature review

The impact of ICT expansion on transport has been rigorously studied for decades in industrialized countries (Aguilera et al. 2012; Urry 2002; Mokhtarian 1990, 2002, 2009; Salomon 1986). Although these studies have provided many important insights into the substitution and complementarity of demand for telecommunication and transportation in regions with developed infrastructures, the claims by international development pundits regarding the augmentation of communication possibilities via ICTs in isolated rural regions of developing countries remain relatively empirically untested (Bhavnani et al. 2008).

ICT enthusiasts tend to neglect that information exchange cannot be always uncoupled from “being there” (Mokhtarian 2009). Face-to-face communication is often preferred because it is a rich multichannel medium that engages all the senses; seeing interlocutors' eyes is considered particularly sociologically important (Urry 2004a). Boden and Molotch (1994) argue that co-presence, which includes indexical expressions and facial gestures, is fundamental for social interactions and thus cannot be easily substituted with virtual travel. Physical co-presence is also considered to be crucial for the development of trust (Urry 2002).

Prominent social scientists have argued that the hypermobility enabled by modern means of transport produces a lack of connections, commitment, and emotional nearness and disturbs the local social fabric (see the reviews in Larsen et al. 2007; Adams 1999). Sustaining local civic activities can be challenging in neighborhoods with highly mobile inhabitants who lack attachments to their places of residence (Gray et al. 2006). The concern has been raised that new transportation and communication technologies will destroy the “social capital” of (geographically defined) communities by decreasing face-to-face socialization with neighbors (Putnam 2000; Turkle 2011). Moreover, a negative correlation between the amount of travel and social contact has been reported (Harvey and Taylor 2000), and the disconnecting social effects of roads intersecting urban neighborhoods have been described (Grannis 1998). In contrast to the negative social effects of motorized transport, walking has been found to enable spontaneous local social interactions that promote public respect, trust, and even health (Leyden 2003). Furthermore, face-to-face contact in public spaces is correlated with a sense of community, the success of collective actions, the subjective well-being of inhabitants, and feelings of safety and security (Grannis 2009; Nasar and Julian 1995).

The negative view of the social aspects of ICTs and motorized transportation can be partly connected to the emphasis on everyday face-to-face interactions and on short-range corporeal interactions in the social science literature (Urry 2004a). In contrast, social

scientists have devoted less attention to the question of how travel is used to sustain geographically extensive social connections (Urry 2004a). This lack of research is unfortunate because abundant evidence shows the importance of (typically weak) ties extending outside one's clique for access to valuable, original, diverse, and fresh information (Granovetter 1973; Burt 1995; Erickson 2001). Both intra- and intercommunal ties are necessary for community development (Woolcock 1998). High internal cohesion within localized cliques can come at the expense of external relations and cause wider social fragmentation (Forrest and Kearns 2001). Raising children in fragmented communities perpetuates intolerance and racism for succeeding generations (Grannis 1998).

New transportation and communication technologies are known to decrease the effects of physical distance decay by enabling physical and virtual travel (Ellegård and Vilhelmson 2004; Fotheringham 1981; Larsen et al. 2007); thus, whether and how their usage can contribute to the creation of connections across socially and geographically distant communities should be explored.

The international development literature has proposed that farmers in the most remote rural areas may benefit most from the use of mobile phones (Muto and Yamano 2009; Bhavnani et al. 2008). However, a study of farmers in a region of Ethiopia suggests that the instrumental value of mobile phones may be limited for hypomobile populations. Because of the lack of a transportation infrastructure, most social contact for the inhabitants of this pedestrian region was within 1 km of their households, and social and information-sharing links beyond approximately 3 km were rare (Matous et al. 2013a). Consequently, the farmers in these isolated villages with little external social contact until recently did not know several quintessential farming practices, such as composting and row planting, that have been known and used in other regions to the benefit of the environment and the farmers who adopted them (Mojo et al. 2010; Todo et al. 2013; Matouš et al. 2013c). In a field experiment, the researchers donated mobile phones to the local inhabitants and monitored their usage and the content of their calls over several months. The inhabitants preferred to call relatively geographically more distant individuals among the people whom they had already known for agricultural information, but the pool of potential phone communication partners was highly limited because the new phone users did not know many people beyond a walkable distance (Matous et al. 2014).

This study thus aims to determine the role of mobile phones and transportation in the formation and maintenance of agricultural information-sharing networks within and between communities in a relatively more mobile rural population of a developing country due to the availability of individual motorized transport.

## Methods

This paper is based on a combination of quantitative and qualitative data collected in Sumatra, Indonesia. This section introduces the local context, the surveyed communities, the gathered data, and the analytical methods.

Transportation in Indonesia has been dominated by heavily subsidized motorized road transport (Hook and Replogle 1996). The number of motorized vehicles in Indonesia has been growing at an annual rate of over 20 % (Susantono 2011). Motorcycles, which can operate even on roads in poor condition, are particularly popular (Hook and Replogle 1996). In 2012, there were already over 76 million registered motorcycles in Indonesia, i.e., approximately one registered motorcycle for every three people (Badan Pusat Statistik

2013). Non-motorized transport is often considered demeaning, primitive, and outmoded; sidewalks are mostly missing; and the safety of pedestrians has become a concern (Hook and Repogle 1996; Dick 2000). Increasing pollution has led to calls for transportation demand management (Susantono 2011). Mobile phone penetration has also been increasing rapidly in recent years: 81 % of Indonesians had a working mobile phone in their household in 2012—a significant increase from 67 % in 2011 (Broadcasting Board of Governors 2012).

### Surveyed communities and gathered data

We gathered data from farmer groups in two subdistricts, Sumberejo and Pulau Pangung, of Tanggamus Regency. A fixed-form face-to-face-administered questionnaire was targeted at all household heads in 16 coffee- and cocoa-producing farmer groups, which were randomly selected among all 36 groups present in the two subdistricts. The 16 selected farmer groups listed 398 households as their members in 2008, when the lists were first compiled by the government. During the survey in September 2012, we managed to access and administer the questionnaire to 315 of them (79 %).

The self-identified household heads were asked to name persons from whom they received agricultural information. Specifically, the English translation of the prompt is, “Please list all people you can recall from outside this household whom you seek for advice, whom you can learn from, or who can generally provide useful information regarding farming practices.” In total, 1575 information-sharing ties were elicited. We refer to the number of persons whom each respondent named (in network terms, the ego’s outdegree) as the total number of information sources in the manuscript. The information sources are further split into the number of information sources inside the respondent’s farmer groups and the number of information sources outside the respondent’s farmer groups in the main analysis (in network terms, the number of alters in the respondent’s personal network who are based inside and outside his farmer group). The exact household location of each information provider was also identified. To assess the strength of the ties, we asked the respondents how they would describe their relationship with the information provider, how long they have known each other, and how often they communicate. The respondents were asked about the main mode of contact (*menghubungi*) with each communication partner. If the respondent provided more than one mode, the interviewer asked which mode was the most common and recorded his or her answer. Based on the respondents’ descriptions, the interviewers classified the relationships into “family/relative”, “neighbor”, “community organization member”, “know through work”, and “other,” but these variables were not significant in the multivariate models.

In addition to the network component, 13 pages of the questionnaire were dedicated to detailed questions about the socio-economic characteristics of the respondents and their households. The GIS coordinates and altitudes of the respondents’ households were also recorded, and the straight distance between all respondents and their informants (both inside and outside of the interviewed sample) was calculated. The basic characteristics of the sample are presented in Table 1.

In August 2013, after statistically analyzing the data, we separately conducted qualitative interviews to substantiate the quantitative results. We interviewed 20 farmers from nine groups, averaging approximately two informants in each qualitative interview session. The interviews took a maximum of 2 h and were simultaneously interpreted between Indonesian and English by two interpreters to ensure accuracy. The informants described their information-gathering strategies and explained their attitudes toward different modes

**Table 1** Sample description

Characteristics of the household head	Number of valid observations	Mean	Standard deviation	Minimum	Median	Maximum
Income (million Rupiahs per annum)	296	29.40	42.10	0.00	176.00	449.00
Age (years)	299	45	12	16	43	87
Distance to paved road (min of walking)	271	4	7	0	1	60
Altitude (m)	309	422	108	245	418	688
Personal network						
Total number of information sources <sup>a</sup>	315	5.00	3.84	1	4	20
Number of information sources inside the respondent's farmer group	315	3.64	3.55	0	3	19
Number of information sources outside the farmer group	315	1.36	1.72	0	1	10

<sup>a</sup> The number of people outside the respondent's household from whom the respondent can receive information about farming practices

of contact. They also described the internal functioning of “farmer groups,” which are important elements in our theoretical framework, sampling, and analysis. We include a brief description of the farmer groups and the surveyed villages below.

Although some of the farmer groups have existed informally for decades, they were formalized mainly in 2007–2008 in response to a new governmental policy regarding the provision of official information, financial support, subsidized inputs, and equipment. According to information from the local government officials, government support to farmers, such as organic pesticides, fertilizers, or information about product competitions and training, is now channeled only through registered organizations. The typical size of a farmer group is approximately 20 households. The organizations have regular monthly meetings, which are held on a rotational basis in the members' houses. The current agricultural activities of the coffee and cocoa farming groups mostly focus on sharing their experiences with new bio-agriculture practices because demand for bio-agriculture products has increased. The meetings may include religious rituals and *arisan*. In the local version of this Indonesian tradition, households regularly contribute to a common fund, which is given every month to a randomly selected winner among the households.

Large villages have more than one farmer group, but each household joins only the nearest one. Multiple memberships are not allowed. Sumatran villages—and thus farmer groups—tend to be ethnically segregated owing to a legacy of massive government-led group migration programs from other parts of Indonesia by previous generations. Each village has one or more mosques for everyday worship.

According to our informants, motorbikes first appeared in the surveyed villages in the 1980s, when the first paved roads were built. They became more popular at the end of the 1990s and the beginning of 2000s, when affordable 100cc models became widely available. Mobile phone towers were erected in the surveyed subdistricts in the early 2000s, and according to the informants' explanations, mobile phones became widely popular in about 2005, partly owing to the farmers' increasing affluence because of rising coffee prices.

Motorbikes were present in 85 %, mobile phones in 82 %, bicycles in 36 %, and cars in 6 % of the surveyed households. Moreover, 75 % of respondents had both a mobile phone and a motorbike in their household, and 8 % had neither.

### Analysis

As described in Tables 1 and 2, our final dataset includes 1575 observations, i.e., 1575 links reported by 315 households, along with the geographical coordinates of the respondents’ households and their reported information sources. First, we create cumulative distribution functions to visualize the spatial extent of the relationships of mobile and motorbike owners and non-owners. We also compare the distance, the length of time, and the frequency of contact between different types of relationships, i.e., those in which walking, motorbikes, or mobile phones are the main modes of contact. We further display the distribution of geographical distance for the different types of relationships. This first

**Table 2** Description of agricultural information-sharing relationships

	Number of valid observations	Mean	Standard deviation	Minimum	Median	Maximum
Relationships with all agricultural information-providing communication partners	1575					
Straight distance (km)	1544	2.7	6.55	0	0.62	69.92
Length of relationship (years)	1553	18.73	11.18	1	20	60
Contact every day or every other day (yes = 1, no = 0)	1561	64 %				
Relationships with communication partners who are mainly contacted...						
By walking	1061					
Straight distance (km)	1049	1.62	3.5	0	0.43	64.04
Length of relationship (years)	1053	20.75	10.79	1	20	60
Contact every day or every other day (yes = 1, no = 0)	1061	77 %				
Through private motorized vehicle use	443					
Straight distance (km)	438	3.93	7.77	0	1.48	69.92
Length of relationship (years)	443	15.37	10.86	1	12	50
Contact every day or every other day (yes = 1, no = 0)	443	38 %				
By mobile phone	47					
Straight distance (km)	47	10.94	14.95	0.17	7.82	68.36
Length of relationship (years)	47	8.83	7.67	2	6	27
Contact every day or every other day (yes = 1, no = 0)	47	40.4 %				
By landline phone	5					
Through the use of public transport	5					

step shows that the local inhabitants highly value face-to-face contact; thus, mobile phones are extremely rarely used as the main mode of information gathering.

Second, using the relationship-level data, we examine how motorbike owners choose between motorized transport and walking as their main mode of information gathering. We focus only on relationships for which the main mode of contact is face-to-face meetings, which the interlocutors attend either by walking or by motorbike, and exclude relationships for which the main mode of contact is by mobile phone because mobile phones are used in less than 3 % of relationships. Moreover, the number of farmers who have ties via mobile phone was too low to conduct the multilevel logistic regression. Therefore, only an approximate analysis that disregards the personal-level variation could be conducted with all three contact options, and this analysis is presented in the “Appendix” section. The main analysis employs logistic regression with random intercepts to compare the two face-to-face options, while simultaneously considering both personal-level and relationship-level covariates. This “multilevel” approach is applied because error terms may not be mutually independent in a “single-level” model with only relationship covariates. In other words, because both personal and relationship characteristics affect the mode of contact, error terms of any single-level model include observed and unobserved characteristics of the respondent and are therefore correlated (see van Duijn et al. 1999). The use of multilevel analysis can alleviate the possible biases of single-level analyses, and the present results confirm that the variation at the personal level is considerable; thus, the multilevel approach is highly preferable.

Our personal-level covariates indicate the socio-economic status of the respondents (wealth, income, land ownership, and education) and other characteristics (age, migration experience) that have been found to be relevant in previous studies on technology adoption, usage, and mobility (Rogers 2003; Metz 2000). We also experimented with variables that may affect the ease of motorized transport usage (distance to paved and unpaved roads, household altitude, and distance to other households). Furthermore, our relationship-level variables indicate the distance between the interlocutors and the strength of their ties (kinship, frequency of contact, and length of the relationship) because tie strength has previously been found to be related (negatively) to information access (Granovetter 1973).

## Results

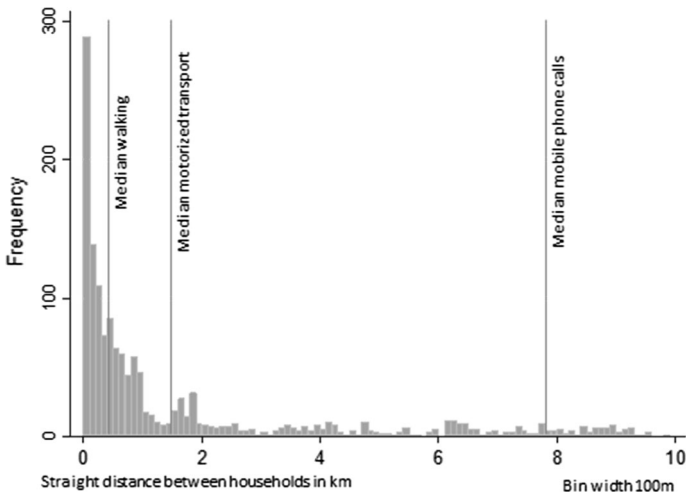
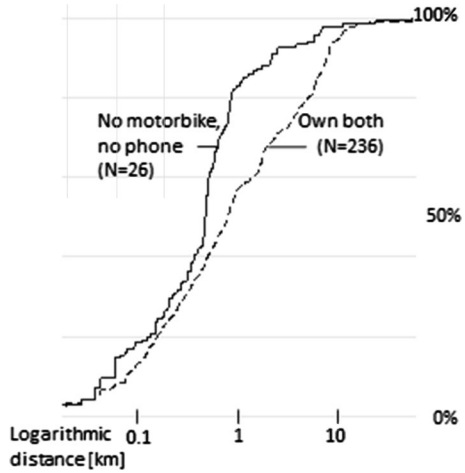
### Relationship-level analysis: transportation and communication technology usage

This section examines how motorbikes and mobile phones are used for communication with partners in the elicited information-sharing networks. First, Fig. 1 shows the cumulative distribution functions of the geographical distance of the information links for households who own both mobile phones and motorbikes and those who own neither. We find that households that own neither have a lower proportion of information sources beyond 1 km than do owners of both technologies, but both owners and non-owners of mobile phones and motorbikes have few links beyond a distance of 10 km.

Table 2 shows that mobile phones are the main mode of contact for less than 3 % of relationships (47/1575). For 97 % of information-sharing relationships, face-to-face meetings, which interlocutors attend either by walking or by motorbike, are still the main mode of contact. Even among respondents who own both a motorbike and a mobile phone,



**Fig. 1** Cumulative spatial distribution of the information-seeking ties of owners and non-owners of motorbikes and mobile phones. The curves show the proportions of ties within the logarithmic distance indicated on the horizontal axis



**Fig. 2** Histogram showing the spatial distribution of all information-seeking ties. The vertical lines mark the median length of information ties for each mode of contact

only 3.5 and 25 % use the phone and the motorbike, respectively, as their main mode of contact, while 71 % use walking.

The histogram in Fig. 2 shows that the density of information sources is highest within a 100-m radius from the respondents’ households. Between the first 100 m and 1 km, the density decreases sharply. The median geographical length of the relationships with contact predominantly conducted via walking, motorbikes, and mobile phones are 0.43, 1.45, and 7.8 km, respectively. The density of walking and motorbike ties decreases approximately exponentially with distance (Fig. 3). The number of calling ties increases sharply before approximately 10 km. However, only a small fraction of information links reach beyond this threshold, regardless of the mode of contact. No respondent mentioned an information source beyond 70 km (i.e., beyond the regional capital).

**Fig. 3** Cumulative spatial distribution of the information-seeking ties of phone and motorbike owners distinguished by the mode of contact. The curves show the proportions of ties within the logarithmic distance indicated on the horizontal axis

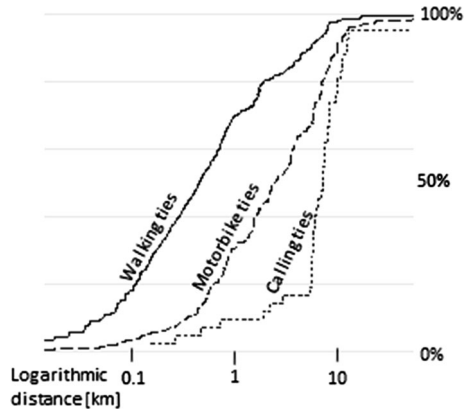


Table 2 also shows the relationship characteristics for different modes of contact. Most of the elicited information sources are people whom the respondents have known for a long time and whom they communicate with frequently. However, the information sources who are contacted face-to-face and the rest of the information sources differ in some respects. While frequently contacted partners are mostly met personally, phone communication tends to be the main mode of contact for less frequently contacted individuals (66 % of information sources who are contacted mostly face-to-face are contacted almost every day; 40 % of individuals who are contacted mostly by text messages and phone calls are contacted almost every day;  $t$  test  $<0.001$ ). Face-to-face contact is particularly preferred for people who have known each other for a long time. (Face-to-face meetings are the main mode of contact for partners who have known each other for 19 years on average; phone is the main mode of contact for partners who have known each other for 9 years on average;  $t$  test  $<0.001$ .)

The rarity of predominantly phone-based relationships is further explored in the “Appendix” section from the viewpoint of the value of time and money, and the results suggest that the cost of phone calls is unlikely the reason for inhabitants’ preferences for face-to-face contact. In the following section, we focus on the two most common motorized and non-motorized face-to-face contact options.

### Multilevel analysis: motorized transport and information networks

In this main analytical section, we conduct the multilevel logistic regression with random effects incorporating both personal- and relationship-level variables and report the estimated odds ratios in Table 3. This analysis is conducted for observations without any missing data, which include 240 individuals and 1214 relationships. Coefficients higher than 1 signify a higher probability of walking associated with an increase in covariates, and coefficients below 1 signify a higher probability of motorized travel. The results reveal that individual travel mode preferences are highly diverse; thus, a multilevel approach is necessary for accurate estimation. Ninety percent of the variance in the propensity to walk or ride a motorbike can be attributed to the difference in individual travel mode preferences rather than distance or other relationship characteristics. Unfortunately, the collected individual socio-economic, geographic, and migration data do not sufficiently explain this difference. The personal-level standard deviation (5.424, as shown in row [8] in Table 3),

**Table 3** Correlates of walking preference: multilevel multivariate logistic model

Correlates of walking	Model with variables in original units Odds ratio	Model with standardized variables (mean = 0, standard deviation = 1) Odds ratio	p >  z
Interpersonal relationship-level variables			
(1) Straight distance (km)	0.908	0.530	0.020
(2) Contact every day or every other day (yes = 1, no = 0)	47.488	6.350	0.000
(3) Length of relationship (years)	1.101	2.945	0.000
Personal-level variables			
(4) Age (years)	0.914	0.365	0.011
(5) Altitude (m)	1.008	2.462	0.026
Personal network variables			
(6) Number of information sources inside the farmer group	1.223	2.560	0.094
(7) Number of information sources outside the farmer group	0.451	0.170	0.001
Random effects			
(8) Personal-level standard deviation	5.413		
(9) Personal-level variance/total variance	0.899		
Number of relationships	1214		
Number of persons	240		
Number of relationships per person			
Minimum	1		
Average	5.1		
Maximum	20		
Log likelihood	−345.435		

expressed by the random effects in the model, remains large. Although we present only the final parsimonious model with the significant variables, we also tested models with an additional level for environmental and social group-level variables, but the results were not substantially different. Other possible determinants of the mode of contact, such as education level, income level, or kinship relation, were found to have an insignificant effect and were thus dropped from our analysis.

The results in rows [1]–[3] in Table 3 indicate that geographical neighbors, information providers who are met with frequently, and advisors who have been known for a long time tend to be met on foot. Row [4] indicates that older people walk less. An age increase by 12 years, i.e., one standard deviation, decreases the odds of walking to one-third of what the odds would be otherwise. (We also tested additional nonlinear effects of age, but these effects were not significant.) Considering the insignificant results for income, it appears

that the fitness or fondness of walking is a more important factor than the affordability of gasoline. (This result is consistent with the calculation in the “Appendix” section.) Individuals living in higher (and presumably more rugged) areas ride their motorbikes less for the same distance and the same type of relationship (row [5]). In this sample of motorbike owners, an increase in the household altitude by one standard deviation, i.e., by approximately 100 m, decreases the odds of walking a given distance by a factor of 2.5.

Next, we examine the main issue of interest, i.e., whether access to information and social contact within and between communities is related to the preferred mode of travel. The total number of information sources, i.e., the number of people whom the respondents named as information providers, is unrelated to individuals’ travel mode preferences ( $p = 0.81$ ; not presented here). However, when we distinguish between information sources within and outside of the community, we find that the two types of information sources are correlated with the mode of contact—with opposite signs. A high general preference for motorized transport is strongly associated with an abundant access to information outside the farmer group, even after controlling for the distance of the travel ( $p < 0.01$ ; row [6] of Table 3). An increase of one standard deviation in the number of information sources outside the farmer group is associated with six times greater odds of choosing a motorbike over walking a given distance for the same type of relationship. In contrast, an increase of one standard deviation in the number of information sources within the farmer group is, on average, associated with 2.6 times higher odds of walking a given distance ( $p < 0.1$ ; row [7] of Table 3).

### Findings from the qualitative interviews

In this section, we briefly report the most important findings obtained from the qualitative interviews regarding the use of available means of transport, the spatial reach of the inhabitants’ networks, and social contact within inhabitants’ communities, which could not be obtained from the analysis of quantitative data alone.

Regarding the available means of transport, although the survey data suggest that bicycles are relatively common, the qualitative interviews elucidated that the bicycles are mostly used by children who cannot yet reach the pedals of a motorbike. At present, it is uncommon for adults to ride bicycles—only one of the interviewed adult informants reported that he sometimes uses a bicycle (when his son is using his motorbike). In contrast, it is common for teenagers to ride motorbikes. The legal age for riding a motorbike is 17 years in Indonesia, but in the surveyed rural area, junior high school students customarily commute to school on family motorbikes.

Regarding the spatial reach of the inhabitants’ social networks, some informants stated that they had relatives and friends on other islands whom they can occasionally contact by phone. However, these distant relatives usually grow other types of produce under different conditions and are not instrumental as sources of agricultural information. The longest agricultural information-sharing links were with people living in the regional capital. These links were mainly to agricultural professionals who commute by motorized transport to the surveyed subdistricts. These agricultural professionals meet with the farmers on the fields, in their houses, or in public places to which the farmers can walk or ride a motorbike. Long-time friends and people who frequently interact typically share common social or work settings to which the respondents may walk (for example, mosques with daily prayers and weekly ceremonies). People who do not meet regularly in these local social settings or in local institutions and public spaces would typically need to be contacted by travelling all the way to their houses or offices when the need arises. Most informants in the qualitative

interviews explained that they would normally ride a motorbike if the location of the other person's house was beyond approximately 1 km.

Regarding the degree of contact within the communities, the accounts of the inhabitants indicate that their access to internal information may at least partially relate to their travel habits. The local settlements mostly stretch alongside roads. The farmers dry coffee beans and process other agricultural produce in front of their houses along these roads. Any walking trip typically involves meeting acquaintances on the road. The respondents reported that whenever they walk somewhere and see someone they know, they naturally exchange a few words and ask casual questions, such as, "how's the farm?" In contrast, if they notice someone whom they know while riding a motorbike, the normal reaction is merely to honk their horn as a greeting. Thus, the act of walking might facilitate information exchange in these communities. Motorbike travel rarely provides this byproduct, and mobile phone calls never do.

Several respondents expressed some discomfort with the exponential rise of individual motorized transport. Some complained about pollution, constant noise, and the perceived danger posed by motorbikes passing at high speeds when they walk on the road. Handmade bumps constructed from tires to limit the riders' speed could be seen around the surveyed villages.

The most important finding from these interviews concerns the importance of face-to-face communication. The informants repeatedly emphasized that asking someone for information without traveling to personally meet him or her is disrespectful and that physical presence is obligatory when a request is made. A text message can be sent or a phone call can be made to confirm availability, but the main conversation is conducted in person afterward. For more important meetings with more people, even the request for the meeting is made in person. In addition to the normative requirements, the informants said that they found phone communication to be very restrictive, "cold," difficult for communicating their ideas freely, and unreliable. Several informants mentioned that they could not be sure whether the other person understood what they meant if they could not see each other. (It would be interesting to examine whether the availability of video calls in the future could change the local inhabitants' reserved attitudes toward telecommunication.)

## Discussion and conclusions

In summary, the main quantitative results are as follows. The owners of motorbikes and mobile phones can acquire agricultural information from a greater number of people located at mid-range distances (approximately 1–10 km), compared with non-owners of these technologies. However, access to information over long physical distances (beyond 10 km) is similarly low for both groups. The relationship-level analysis showed that mobile phones are used as the main mode of contact for only a fraction of the geographically longest information-sharing links, but even these links rarely reach beyond approximately 10 km. A multilevel analysis showed that a stronger general preference among farmers for motorized transport vis-à-vis walking is associated with the existence of more agricultural information sources outside their own communities but fewer sources within their own communities.

Overall, the results highlight the overlooked role of transportation in communication in rural communities of developing countries. Although information exchange in rural Indonesia has become technically possible without physical travel, physical presence is

normatively necessary for information exchange, even if it involves significant time and monetary costs. Face-to-face meetings are still the predominant mode of information gathering; thus, motorized transport—and specifically motorbikes—is an important information-communication tool in the region.

We continue with a discussion of these results and their potential implications. Motorbikes appear to enable local farmers to reach outside the circle of their strong relationships that are regularly maintained by walking and to facilitate social contact between diverse communities. Because the local inhabitants can also meet others within their walking neighborhoods who travel by motorbike from other villages, the maximum distance to the households of information-exchange partners for both walkers and motorbike riders is determined by the maximum commuting distance of the motorbike riders (typically approximately 10 km). However, social contact beyond the walking distance (beyond approximately 1 km) is lower for non-owners of motorbikes.

Mobile phones are used mostly to communicate with individuals who live at the edge of the callers' physical mobility, as enabled by motorized transport. Mobile phones were not found to augment agricultural information sources beyond the radius of physical mobility. However, compared with walking, both motorbikes and mobile phones are used to gain agricultural information faster through relatively weaker ties (i.e., acquaintances who are contacted less frequently, who are less well known, and who do not live in the same community). Such weak ties can potentially provide access to precious new information that is not available in the spatially limited, dense web of strong intracommunal relationships (see Granovetter 1973).

Although phones are not used as the most frequent mode of communicating agricultural information, they are sometimes used to coordinate face-to-face meetings with relatively physically distant communication partners. The present findings and the findings of the comparable studies reviewed from contexts characterized by very limited mobility (Matous et al. 2011, 2013a, 2014) suggest that the advantage of ICT is its synergy with means of physical travel. We do not find support for international development policies of major donors that are based on the assumption that ICT development can substitute for inadequate or costly transportation (Bhavnani et al. 2008). The demand for telecommunication will most likely depend on the supply of transportation opportunities; if at least some individuals who operate in the region are mobile, the phone will have some uses. Thus, technological development in such regions should be balanced. Otherwise, the explosive expansion of ICTs without the accompanying development of adequate transportation options, which has been observed in many parts of the developing world (Matous et al. 2011, 2013a), may not achieve the expected increase in access to information that farmers living in these regions need.

Moreover, while the negative environmental effects of excessive motorized travel are clear, policies aiming to reduce these effects might also have unexpected negative side effects. Previous research has shown that the lack of social learning and interpersonal information exchange can result in a lack of awareness and the non-adoption of resource-conserving agricultural practices (Solano et al. 2003; Schneider et al. 2009; Janssen et al. 2006; Pretty and Smith 2004; Bodin and Crona 2009; Bodin and Prell 2011; Leeuwis 2004; Hoang et al. 2006; Isaac 2012; Isaac et al. 2007; Spielman et al. 2011; Conley and Udry 2010). Thus, limiting farmers' mobility may decrease farmers' access to new beneficial techniques in other communities, and farmers may in turn use less-informed and even environmentally harmful practices. Moreover, where alternative modes of transport are lacking, motorized transport reduction policies (such as the 2013 gasoline price hikes in

Indonesia) might slow down the progress from territorialism to pluralistic societies by obstructing interactions and information exchange between diverse communities.

Nevertheless, the increase in mobility via individual motorized travel may not always increase social contact and access to information. Although heavy motorbike users have significantly more extensive extra-communal access to information, as stated above, weak evidence suggests that people who shun walking have less contact and access to information within their own communities.

It is necessary to ensure that the increasingly heavy motorized traffic does not impede walking and neighborly interactions. Even when people can choose their interaction partners within a larger geographical radius, a general awareness of one's physical neighbors and reliable intracommunal relationships have positive social (Leyden 2003) and environmental (Pretty and Smith 2004) consequences. To keep motorized transport within sustainable limits without severing social contact and communication channels with neighboring communities, bicycles present unfulfilled potential. Most information-seeking motorbike rides are within a 1.5 km radius—a potentially convenient cycling distance. It is unfortunate that bicycles are currently not generally considered an adequate means of transport for adults. However, given that bicycles were popular in Indonesia before motorized transport became available (Dick 2000), with a well-organized intervention, the current perception of the bicycle might be easier to change than the deep cultural importance of face-to-face communication.

The gathering of more detailed longitudinal data on the combination of modes of contact to clarify the dynamics of the observed relations is ongoing. With concurrent exogenous shocks (e.g., new road and telecommunication infrastructure developments or price variations), it may be possible to confirm the causal relationships among mobility, telecommunication, and information diffusion in further research.

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## Appendix

The importance of face-to-face meetings for the local inhabitants can be very approximately ascertained through the prism of the alternative-specific conditional logit McFadden's choice model (1974). This “Appendix” section helps us to approximately examine the role of monetary and time costs in the respondents' contact mode decisions.

Because of the very rare occurrence of calling ties ( $n = 47$ ), these ties can be analyzed only coarsely. The model assumes that individuals can choose among up to three alternatives (walking, motorbike, and phone) to contact their advisors, depending on whether they own a motorbike and/or a mobile phone. The alternative-specific monetary and time costs are included together with the tie-specific variables among the independent variables in the regression.

In the presented model, we used the following input data based on the estimates obtained from the informants. Experimenting with higher and lower scenarios did not substantially change the main result that face-to-face contact is strongly preferred to phone calls. This result is consistent across diverse specifications despite the extremely simplified nature of this analysis.

Input data of the presented model:

1 l of gasoline = 6000 Rupiahs  
 Motorbike gasoline consumption = 25 km/l  
 Motorbike average travel speed = 30 km/h  
 Walking speed = 4 km/h

The phone call tariff structure is complex, but for conversations that are longer than approximately 3 min, buying a 1-h “packet” for one phone call, which costs 1500 Rupiahs, is advantageous.

Alternative-specific choice model output:

Standard errors	p >  z	Coefficients	
Cost (Rupiah)	0.000	0.000	0.510
Time (min)	-0.005	0.001	0.000
Base alternative = walking			
Motorbike			
Contact every day or every other day (yes = 1, no = 0)	-1.031	0.139	0.000
Length of relationship (years)	-0.027	0.007	0.000
Constant	0.960	0.163	0.558
Phone			
Frequent contact dummy	-0.862	0.347	0.013
Length of relationship (years)	-0.103	0.022	0.000
Constant	-1.523	0.326	0.000
Number of alternatives	3912		
Number of ties	1372		
Number of alternatives per tie			
Minimum	2		
Average	2.9		
Maximum	3		
Wald $\chi^2(6)$	178.28		
Prob > $\chi^2$	0.0000		
Log likelihood	-812.455		

Overall, the informants in the sample appear to have no preference between the two face-to-face options (the constant for this option is not significantly different from zero), but as expected, people prefer motorized transport relative to walking to save time when they contact distant information sources.

In contrast, the model suggests a strong disinclination to make contact without face-to-face meetings. Comparing the mean estimates of the constant for the phone option and the value of time, choosing a phone is as likely as walking only if it saves over 300 min or if walking involves traveling approximately 10 km and back, *ceteris paribus*.

The parameter signifying the importance of monetary cost in the choice of mode of contact is not significantly different from zero. This finding should not be interpreted to indicate that the local inhabitants do not care about the cost. The qualitative interviews showed that the informants knew the correct costs of the different contact options. They



found the cost of gasoline for meeting in person to be high but noted that it cannot be avoided if they want to ask for something from someone who lives far away.

The approximate analysis in this “Appendix” section suggests that the local inhabitants do not shun telecommunication for monetary reasons; they prefer face-to-face contact even if it is more costly.

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**Petr Matous** has been organising experimental interventions and social surveys in diverse communities across Asia and Africa to empirically elucidate the role of social networks in contexts constrained by limited resources or environmental disasters. Dr. Matous applies novel modeling methods to these unique data sets to explore the mechanisms of dynamic interactions between interpersonal or inter-organisational networks and their technological and natural environment.

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