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Does Infrastructure Facilitate Social Capital Accumulation?
Evidence from Natural and Artefactual Field Experiments in a Developing Country

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Abstract

While social capital in general has been recognized as essential for economic activities, its accumulation mechanisms are largely unexplored. How does people's trust toward others, one of the core dimensions of social capital, emerge? To shed new light on this largely unanswered question, we investigate the impact of physical infrastructure on social capital accumulation by comparing two hypotheses: the habit formation hypothesis and the repeated interaction hypothesis. We use a unique dataset from an irrigation project in Sri Lanka under a natural experimental situation where a significant portion of irrigated land was allocated through a lottery mechanism. Also, we look at the level of social capital using artefactual field experiments by a strategy method based on a within-subject design. By combining these two instruments, we find that physical distance embedded by irrigation systems explain variations in trust across irrigation communities, suggesting that the level of particularized trust is significantly higher than that of general trust. Also, within-community variation in particularized trust is driven largely by each individual's years of access to irrigation and is not necessarily affected by social distance or repeated interaction among farmers. Our results indicate that social preference emerges from a technological environment set by physical access to irrigation, suggesting habit formation of pro-social behavior.

Keywords: Natural and artefactual field experiments; trust; social capital; irrigation

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1. Introduction

How does people's trust toward others, one of the core dimensions of social capital, emerge? This is an important but largely unanswered question in academic literature. In this paper, we aim to shed new light on this question by investigating the role of physical infrastructure in facilitating social capital, particularly trust among people, through two possible channels: first, within physical infrastructure, people are embedded and thus human habits of trusting others through collective actions are naturally formulated as "affordance"; [1] and second, infrastructure makes a set of people repeatedly interact with each other, i.e., "repeated game channel" to generate seemingly reciprocal behavior in a self-enforcing manner.

Social capital has become increasingly recognized as an essential element for the economic performance of people, communities, and countries (Dasgupta and Serageldin, 2000) and the effects of social capital on socio-economic outcomes have been investigated in a variety of existing studies.[2] Yet, determinants of creating, accumulating, and maintaining social capital are largely unexplored in existing literature (Miguel, Gertler, and Levine, 2006). There are only a few exceptions such as Olken (2009), Attanasio et al. (2009), and Feigenberg et al. (2013), which investigate the impact of television, a conditional cash transfer program, and a micro-finance program, respectively, on social capital accumulation.[3]

1. "Affordance" is a concept in cognitive psychology that can be defined by all "action possibilities" latent in the environment (Gibson, 1977). Such a channel is a consistent with the concept of habitus in sociology, which is defined as a set of acquired dispositions of thought, behavior, and taste through activities and experiences of everyday life (Bourdieu, 1977).

2. In general, social capital is defined as particular features of the formal and informal institutions and organizations that create shared knowledge, mutual trust, social norms, and unwritten rules. (Durlauf and Fafchamps, 2005; Hayami, 2009). Examples of such studies include those on community resource management (Ostrom, 1990; Bouma et al., 2008) and performance of micro-finance clients (Karlan 2005). Also, a number of micro and macro studies find positive returns to social capital in economic outcomes (Knack and Keefer, 1997; Durlauf and Fafchamps, 2005; Fafchamps and Minten, 2002; Ishise and Sawada, 2009).

3. Olken (2009) investigates the impact of time allocation to watching television and listening to the radio on social capital in Indonesia; Attanasio et al. (2009) examines the role of a conditional cash transfer program in Mexico, a.k.a., Progresa, in facilitating cooperation among community members; and Feigenberg et al. (2013) employs a randomized experiment to uncover the nexus between meeting frequencies of micro-finance programs and the degree of social capital accumulation.

In this paper, we place our particular focus on irrigation infrastructure because, among different physical infrastructure, irrigation is known to involve substantial cooperative work among community members, for example, in maintaining the irrigation system by regular cleaning of the canals (Coman, 1911; Ostrom, 2011; Aoki, 2001; Hayami and Godo, 2005). This feature of irrigation infrastructure helps us clearly identify determinants of social capital. Naturally, there have been studies hypothesizing the role of irrigation and other communal physical infrastructure in facilitating social capital accumulation (Aoki, 2001; Hayami and Godo, 2005; Hayami, 2009). Yet, to our best knowledge, there has been no rigorous empirical study conducted to uncover the causal impact of irrigation or other infrastructure on social capital. We aim to bridge the gap in the literature by investigating the impact of irrigation infrastructure on social capital accumulation.

Communal physical infrastructure such as an irrigation system may enhance the level of trust and social capital because people are physically built-in in the irrigation infrastructure system and thus are forced to interact with each other institutionally. More specifically, we compare two hypotheses in determinants of trusting behavior in irrigated farming areas. The first hypothesis is a habit formation hypothesis: people are embedded within a physical irrigation infrastructure where they naturally engage in collective work to maintain the irrigation system, and thus human habits to stimulate pro-social behavior are formulated. This may be called an "*affordance*" hypothesis. The second hypothesis is a repeated interaction hypothesis: infrastructure 'glues' people within the same social space, making a particular set of people repeatedly interact with each other. As a consequence of this "*repeated game setting*," seemingly reciprocal and cooperative behavior emerges in a self-enforcing manner.

By testing these hypotheses, we believe that we make three important contributions to the literature: first, since DellaVigna (2009) pointed that it has been difficult to distinguish in the field social preferences from repeated game strategies and other alternative explanations, we believe that we make an important contribution by distinguishing different mechanisms in the field. Second, since impacts of infrastructure on social relationships, mutual trust, and social norms are largely unknown (Durlauf and Fafchamps 2005), we believe we fill an important gap in the existing literature. Finally, since there has been emerging literature on endogenous formation of individual and social preferences (Fehr and Hoff, 2011), our explicit comparisons of the habit formation and repeated interactions channels in generating pro-social behavior would make an important contribution to the literature on social preferences. Indeed, there are a number of recent studies on habit formation of individual behavior in gym attendance (Charness and Gneezy, 2009) and saving (Ashraf, Karlan, and Yin, 2006) but, to the best of our knowledge, no study has been done in habit formation of pro-social behavior.

Yet, there are two technical difficulties in capturing the effect of irrigation on social capital. First, it is generally difficult to identify the causal effect of infrastructure on outcomes because it is almost impossible by nature to design randomized controlled trials to identify its causal effects.[4] Hence, natural experiments have been utilized to evaluate these infrastructure programs (Duflo and Pande, 2007; Dinkelman, 2011; Donaldson, 2013; and Banerjee, Duflo, and Qian, 2012).[5] Second, it is a challenge to precisely quantify the level of social capital by nature because the concept of social capital, which is a combination of intangible objects such as social relationships, mutual trust, and social norms, has remained elusive (Durlauf and Fafchamps 2005).[6]

In this paper, we try to explicitly handle these two issues. To tackle the first problem, we employ a unique dataset from an irrigation project in southern Sri Lanka where irrigated land distribution has been made through a lottery mechanism. By using this natural

4. A notable exception is Gonzalez-Navarro and Quintana-Domeque (2012), which employed a street asphalting randomized experiment to investigate the role of infrastructure in reducing poverty in the urban poor.
5. The use of geological information such as river gradient in Duflo and Pande (2007) as an instrument for dam placements may be appropriate to evaluate overall impacts across the whole country, but a strategy may not be applicable to identify the causal impact of irrigation access originated in a particular dam on the degree of social capital in small geographical units.
6. A popular approach is to use subjective questions such as the ones employed by the General Social Survey (GSS). Yet, existing studies place serious doubt on the strength of such self-reported information (Glaeser et al., 2000).

experimental situation, we identify the causal impact of irrigation construction. As to the second problem, we use carefully-designed artefactual field experiments such as trust game, and quantify unobserved social preference parameters from the behavior of the participants.[7] By combining natural experimental data on irrigation placements with artefactual field experiments data, we examine the causal impact of irrigation infrastructure on social capital.

To preview our results, three robust findings emerge. First, throughout the whole area, each farmer's experience in irrigation agriculture and physical distance embedded by construction of an irrigation system can explain the degree of trust. This suggests that the level of particularized trust is significantly higher than that of general trust (Yamagishi and Yamagishi, 1994). Second, within each local canal, variations of particularized trust are not necessarily driven by repeated interactions among neighbors as described by Routledge and von Amsberg (2003), but by each farmer's years of access to the irrigation canal, suggesting that social preference emerges as a habit based on physical constraints on people's behavior provided by irrigation infrastructure.[8] Finally, we find that trust is also related systematically to the level of altruism (Cox, 2004; Schechter, 2007).

The rest of this paper is organized as follows: in Section 2, we postulate our research strategy including hypothesis to be tested by natural and field experimental data. Section 3 shows descriptive statistics and empirical results. The final section summarizes the concluding remarks.

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7. We employ the trust game developed by Berg et al. (1995) to elicit social capital (Harrison and List, 2004; Levitt and List, 2009). The trust game has been adopted in a wide variety of contexts in the literature such as Glaeser et al. (2000), Cardenas and Carpenter (2008), Karlan (2005), Carter and Casitillo (2009), Ligon and Schecter (2012), Schecter (2007), and Barr (2003).
8. Such a situation may be captured by the concept of "social embeddedness" of Granovetter (1985), i.e., the degree to which individuals are enmeshed in an actual social network.

2. Research strategy

Study site

Our study area is Walawe Left Bank (WLB) in southern Sri Lanka, which is a part of the Irrigation Development Project in the Uda Walawe area initiated by the Government of Sri Lanka (GOSL) in the 1960s (Figure 1). Under the project, the government had a plan to maximize the use of land for agricultural cultivation. The government provided farmers with homogenous size land, i.e., 0.2 ha of land for residence, and 1.0 ha of irrigated paddy field or 0.8 ha of other food crop field. The Uda Walawe reservoir was constructed with GOSL funds from 1963 to 1968, and the development of a command area on the right bank was completed with the financial assistance of the Asian Development Bank (ADB) under the Walawe Development Project (1969-1977) and the Walawe Irrigation Improvement Project (1986-1994). While the development of the command area of the WLB was also started by the GOSL in the 1960s, the improvement of the canal structure and extension of irrigation facilities to the tail-end took significantly longer than that in the right bank area. Since the mid-1990s, the construction of the canals in the WLB gradually extended from the north toward the south through the assistance of Japan Bank for International Cooperation (JBIC) through its concessional development loans.[9]

Our WLB study area is composed of five blocks in a north-south direction: irrigated Sevanagala block, rainfed Sevanagala block, Kirribbanwewa block, Sooriyawewa block, and Extension Area (Figure 1). While the Extension Area located at the south tail-end of the WLB was the most recently irrigated area, each block, except Sevanagala (rainfed), has been connected to the left bank main canal and has its own irrigation scheme operation. In the irrigated areas, each water distribution canal (D-canal), the smallest active unit of a branch canal, has a Farmer Organization that facilitates irrigation management and organizes various activities such as collective procurement of farm inputs and religious festival preparations.

9. In October 2008, the development loan departments of JBIC were integrated into Japan International Cooperation Agency (JICA).

Hence, each D-canal can be regarded as the smallest active unit of community. A group of D-canal communities comprises a "Block." Presumably, while farmers in the same Block naturally form close relationships because of their physical proximities, farmers in different Blocks have little relationship by physical nature (Figure 2).

We conducted multi-purpose panel household surveys eight times in the WLB area between 2001 and 2009 and artefactual field experiments in the final round. Initially, we selected 858 representative households from approximately 75,000 residents in the whole WLB area by a block-level stratified random sampling strategy using a complete list of all households in each stratum based on five blocks shown in Figure 2 (Sawada, et. al, 2008; Sellamuttu, et al., 2014). The first to the fifth rounds of data were collected in 2001 and 2002. In 2007, we further conducted the sixth and the seventh surveys for 193 households who were randomly selected from the original 858 households. Finally, in March 2009, we conducted the eighth survey and artefactual field experiments to collect data on the social and household preferences for this study.[10]

2.1 Natural experiments

This study area has an important feature that enables us to identify the causal impact of irrigation construction, which is the random assignment of land within each irrigation canal block. Irrigation canal construction and water allocation have been made gradually from the north to the south (Figure 1). While the entire area of the WLB is agro-climatically and geographically similar, only around 67% of households had access to irrigation as of 2001 (JBIC Institute 2007). Yet, by the end of 2008, almost all households acquired irrigation access. Accordingly, the years of being connected to irrigation significantly vary across the blocks.[11]

10. The experiment participants are 268 farmers, including the above-mentioned 193 households.
11. There are some exceptions such as block 2 where it is technically difficult to construct irrigation channels because of the topography. As we can see from Figure 1, the north portion of Kiribbanwewa block is located closer to the reservoir than the southern part of irrigated Sevanagala block.

On each canal block construction, the government invited new settlement applications. A large number of farmers were randomly allocated to the canals by using a lottery. As can be seen in Table 2, while around half of the households could claim their preferences on lands at the plot level in the process of land distribution, the government used lotteries to distribute land for the settlement of 30% of the farmers. We confine our analysis to the households who received land by lotteries regardless of their wills. As a result, those who received upstream plots can get water access much earlier than those who received downstream plots, providing us with substantial and exogenous variations in years of access to irrigation facilities. This is confirmed by the results of a regression model with block fixed effects, v_B, by regressing farmer i's years of irrigation access, y, on D-canal dummies, d^D, where the superscript D stands for D-canal id, as well as canal location dummies within each D-canal, d^L, i.e., $L' \in$ {head, middle, and tail}:

$$(1) \qquad y_i = \alpha + \Sigma_D \beta^D d_i^D + \Sigma_L \beta^L d_i^L + v_B + \varepsilon_i,$$

where ε is an error term. The estimation results in Panel A of Table 3 show that the years of access to irrigation are significantly different across D-canals. In contrast, coefficients on canal location dummies are statistically insignificant, indicating years of irrigation access are not different within the same canal.

To test the exogeneity or randomization of land allocation within each block, we performed two tests. First, we check whether household characteristics are comparable across D-canals within each block and across different locations within each D-canal. To perform these tests, we regress each of the settlers' observed characteristics on D-canal dummies as well as canal location dummies within each D-canal. We separately employ three dependent variables: the timing to submit the application for an irrigated plot, the age of the household head, and the head's years of schooling. Panel B of Table 3 reports the estimation results. We fail to reject the null hypotheses that the estimated coefficients of D-canal dummies are jointly zero for all three dependent variables: the p-values are 0.1466, 0.5183, and 0.5954, respectively. These results indicate that, while household characteristics might be significantly different across blocks, they do not vary within the block across the canal communities. Also, in the same regression models, we test the statistical significance of coefficients on the canal location dummies within each D-canal, i.e., two indicator variables for head and tail locations with the middle location being taken as the reference category. We cannot reject the null hypotheses that the estimated coefficients on the location variables are jointly zero for all three dependent variables: corresponding p-values are 0.4666, 0.7203, and 0.7045, respectively.

Second, we follow Goldstein et al. (2013) to show our main variable of interest for each farmer's years of access to irrigation is uncorrelated with observed characteristics of the farmer. Table 4 shows the results of a cross-sectional regression of the years of access to irrigation variable on individual characteristics such as age, education, and gender as well as canal location dummies and block dummies. After controlling for block-specific unobserved heterogeneities, we find no evidence of a systematic relationship between the years of irrigation access and observed characteristics within each block. This result confirms our setting in which land allocation has been done randomly within each block.

These findings provide supportive evidence that, in each block, households were randomly assigned to different agricultural plots. We may conclude that, once we control for block fixed effects, sample selection errors due to selection on the observables are not serious and years of access to irrigation infrastructure are exogenously given. We use this natural experimental situation to identify the causal impact of irrigation construction.

2.2 Artefactual field experiments

In March 2009, we conducted carefully designed artefactual field experiments to capture the level of social capital. More specifically, we implemented trust and dictator games to quantify the degree of trust and altruism, respectively, using the strategy method, and also conducted a risk game to elicit participants' risk preference. We take within-subject design, and all the participants are exposed to every experiment. In the experiments, participants should make decisions on their behavior toward persons inside and outside their own community. In this setting, there are three potential factors affecting trust among people, i.e., physical distance across communities (Etang et al. 2011); pair-wise mutual trust generated by proximate social relationships (Leider et al. 2009); and generalized trust based on social preference determined by irrigation or community-related activities (Yamagishi and Yamagishi, 1994; Hayami and Godo, 2005).[12]Since the group of farmers in each D-canal is identified as the formal community, we select four types of counterparts of each participant in experiments as follows: (i) three persons in the same D-canal identified by showing their names and pictures, which we call "identified persons", (ii) an "unidentified" anonymous person in the same D-canal, (iii) an anonymous person in a different D-canal of the same Block, and (iv) an anonymous person in a different Block.[13] In the cases of identified persons, we also asked questions on the social relationship with the counterparts of the games, enabling us to capture social distance information. By changing the physical distance to each partner, we can compare the levels of particularized trust in the case of (i) and general trust in the case of (iv).

Our experimental procedure is explained as follows: first, following Berg et al. (1995), we conduct the standard trust game to measure trust and trustworthiness. In our trust game, all participants are initially endowed with Rs. 500 in ten Rs. 50 bills, which is equivalent to one

12 "Generalized trust" is defined as a belief in the benevolence of human nature in general and thus is not limited to particular objects (Yamagishi & Yamagishi, 1994, p. 139)

13. One person from each household surveyed in the 6^{th} and 7^{th} rounds is invited to participate in the experiments (Case A). Basically, participants are those who are in charge of the important decision making in their households. In cases where the number of participants from one distribution canal is not a multiple of four, new participants must be recruited randomly from the households that were included in the 1^{st} to 5^{th} rounds but not surveyed in the 6^{th} and 7^{th} rounds (Case B). If it is not possible to invite enough participants, households that have never been included in previous surveys may be invited (Case C). In cases where recruited participants do not show up on the day of experiments, we recruit other participants from the same distribution canal. Out of the total number of 268 participants, Case A, Case B, and Case C include 166, 22, and 80 participants.

day's wage for a typical farmer in the study area. We employ strategy methods, asking each participant, i, as a sender to decide the amount they would send to each of six potential receivers, j, of four different types, i.e., (i) three identified persons in the same D-canal, (ii) an anonymous person in the same D-canal, (iii) an anonymous person in a different D-canal of the same Block, and (iv) an anonymous person in a different Block. We denote this amount of transfer as $\tau_{ij} \in T$ where T= {0, 50, 100, 150, 200, 250, 300, 350, 400, 450, 500}. The committed amount of money is tripled and then one of the transfer decisions is randomly selected and actually sent to its corresponding receiver according to their stated strategies. We also employ a strategy method for each receiver j by asking return amounts, $\tau_{ij}' \in T'$ where T'= {0, 50, 100,…, $3\tau_{ij}$ }, to $3\tau_{ij}$ for each of six potential senders i. Note that all receivers j know only the tripled amount they received from their partner and nobody is informed of exactly who is his/her partner i. Since the set of zero transfers by a receiver, j, and a sender, i, i.e., $\tau_{ij}'=0$ and $\tau_{ij}=0$, satisfies a sub-game perfect Nash equilibrium, deviation from zero transfers of a sender and of a receiver can be interpreted as trust and trustworthiness, respectively (Levitt and List, 2007).

Second, in order to distinguish trust behavior from altruism and risk attitudes, trust games are accompanied by dictator and risk games (Ensminger, 2000, Carter and Castillo 2006, Cardenas and Carpenter 2008, Schechter 2007). In the dictator game, the sender, called the "dictator", is provided with Rs. 500 in Rs. 50 notes as the initial endowment that he/she can either keep or allocate to the receiver. Hence, the dictator must decide the transfer amount to his receiver from the possible transfer amounts, {0, 50, 100, 150, 200, 250, 300, 350, 400, 450, 500}. Since there is no self-interested reason for the sender to transfer money, the sender's zero transfers satisfy the Nash equilibrium. Hence, the actual positive amount of transfer is interpreted as the level of altruism (Camerer and Fehr, 2004; Levitt and List, 2007). We also adopt strategy methods, asking all participants as a sender the amounts they would send to each of six potential receivers in four different types as before.

While the dictator and trust games we employ are standard ones, we extended them by setting six different counterparts from four different types of each participant in experiments: (i) three persons, which we call "identified persons", in the same D-canal were identified by showing their names and pictures, (ii) an "unidentified" anonymous person in the same D-canal, (iii) an anonymous person in a different D-canal of the same Block, and (iv) an anonymous person in a different Block. These four types are a mixture of three different groups based on the physical distance in the irrigation infrastructure system with two settings of anonymity. Three groups are: people in the same D-canal; in a different D-canal in the same Block; and in a different D-canal in a different Block. We also incorporate social distance by including two sub-groups within the same D-canal: three identified persons in the same D-canal and an anonymous person in the same D-canal. Under such a partially non-anonymous setting, we observe whether trusting behavior changes depending on the physical distance between each pair and on anonymity.

To measure risk-aversion parameters, we follow Schechter (2007) to organize a risk game, in which each subject is given an initial endowment of Rs. 500 in ten Rs. 50 notes and decides how much (if any) of this endowment to make risky investments. The investor then rolls a six-dimensional dice to determine each investor's payoffs. Each number of the dice corresponds to a payoff of 0%, 50%, 150%, 200%, and 250% of the invested amount. Since the risk game is designed to replicate the first move in the trust game with risk but without trust, as the payoffs are decided by rolling a dice, invested amounts can be interpreted as measures of risk attitude.

2.3 Descriptive statistics

Table 5 shows descriptive statistics of variables used in this paper. We show results based on the farmers who receive land by lotteries (Table 2) and results based on the whole sample including non-lottery farmers are shown in the Appendix. Panels A, B, and C in Table 5 report the descriptive statistics of experiments, participant characteristics, and the relationships with their partners, respectively. As we can see in panel A of Table 5, it appears that, in the trust and dictator games, the amount of cash to send and return to partners is correlated with the physical distance between them.[14] In panel A of Table 5, the transfer amount is highest when sending or returning to individuals living in the same D-canal, i.e., type (i) and (ii), but it declines as the physical distance becomes further in type (iii) and (iv). Moreover, it is shown that the anonymity of partners significantly affects the result of experiments: the amount becomes even higher when we give the identities of the actual partners than the case where we only reveal that the partners come from the same D-canal. This pattern is confirmed by Figure 3, which depicts the cumulative density function (CDF) of the sending amounts in the trust game, suggesting the first-order stochastic dominances depending on the physical distance in the irrigation system. To test formally the observed pattern, we conduct the two-sample Kolmogorov-Smirnov test for each pair of CDFs. Table 5 presents the test results, showing that CDFs of the sending amount are differentiated significantly. Comparison of the other statistics – returning amount in the trust game and sending amount in the dictator game – also reveals the same patterns.

In panel C of Table 5, we present bilateral social relationship variables in the non-anonymous setting. 77% of participants answer that they join the same farmer organization as their partners.[15]

14. While the average sending amount of the trustor in our trust game is smaller than that in other existing studies reported in Cardenas and Carpenter (2008), it may be due to the nature of our subjects being new settlers in newly irrigated areas. Indeed, our data seems to be consistent with the level of trust elicited by Barr (2003) who found newly resettled villagers behave in a less trusting way than those in traditional villages.
15. While normally each D-canal community has only one organization and all households are supposed to join it, around 23% of participants answered that they join different farmers' organizations.

3. Empirical results

As we have seen in Tables 2, 3, and 4, we can safely say that settlement location and its timing were exogenously determined. Hence, we can utilize this natural experimental situation to identify the causal impact of the years of irrigation access on social capital accumulation. While results of the trust game presented in Table 4 and Figure 3 suggest that social capital has been strongly accumulated among the adjacently located farmers, to investigate the years of irrigation access effect as well as the location effect, we adopt regression frameworks. We separately perform two analyses: one for the whole area exploiting cross-community variations in physical distance; and the other for each D-canal community exploiting intra-canal variations. In the former analysis, we can compare the levels of particularized trust and general trust (Yamagishi and Yamagishi, 1994). In the latter, determinants of particularized trust will be investigated.

3.1 Estimation results for the whole area across communities

To investigate determinants of social capital accumulation captured by trust across communities, we estimate a linear regression model of the degree of trust as follows:

$$\text{(2)} \qquad \tau_{ij} = \alpha_1 + \alpha_2\, IRR_i + \alpha_3\, SameDC_{ij} + \alpha_4\, DifDC_{ij} + \alpha_5\, (IRR_i \times SameDC_{ij}) + \alpha_6\, (IRR_i \times DifDC_{ij}) + \boldsymbol{X}_i\beta + u_{ij},$$

where τ_{ij} is participant *i's* amount sent in the trust game to each potential partner *j*; *IRR* represents years since the participant *i* received access to irrigation facilities that are orthogonal to error term, u_{ij} for the farmers who received land based on lotteries; dummy variables capturing partner *j*'s identity to the sender *i* are denoted by *SameDC* and *DifDC*, which takes the value one if, to the sender *i*, partner *j* is an anonymous person in the same D-canal (type (ii)) and an anonymous person in a different D-canal but in the same block (type (iii)), respectively.

Note that an anonymous person in a different block (type (iv)) is taken as a reference category for these dummy variables. $\boldsymbol{X}_i$ is a set of the sender's characteristics such as the degree of altruism, risk preference, dummy for household head, age, sex, and education level. Altruism and risk preference parameters, which are elicited by experiments under a similar setting to the trust game, are included in the econometric model of Equation (2). Presumably, by including these preference parameters, we can control for potential unobserved heterogeneities.

Table 7 summarizes empirical results using pooled data of trust games in the whole areas. In specifications (1), (2), and (3), we used the trust game results with unidentified counterparts only. In specifications (2) and (3), we also add block and individual fixed effects, respectively. Since we do not use data from type (i) and all responses are based on an anonymous setting, we can interpret the results as a one-shot game. Hence, we believe we can rule out trusting behavior arising from repeated interactions among known people in the same community.

There are three main findings that emerged from the analysis (Table 7). First, the indicator variables of someone in the same D-Canal and someone in a different D-Canal within the same block take positive and statistically significant coefficients. The former coefficients are larger than the latter ones, showing that physical distance between sender and receiver negatively affects the degree of trust. In specifications (4), (5), and (6), we also included the trust game result with identified receivers within the same D-Canal (type (i)). The coefficients on the indicator variable for identified persons are positive and statistically significant with a larger magnitude than those for someone unidentified, suggesting that strong trusting behavior arises from long-term repeated interactions among known individuals.[16] Since the effect arising from "identity" is about Rs. 30, this effect can explain about 17% of the average amount of money sent, i.e., Rs. 175. This finding is also consistent with the predicted difference in

16. This is also consistent with the case of incentive-related motives in the risk sharing experiments of Ligon and Schechter (2012).

cooperative behavior between the circle network and the random network based on the social network theory of Möbius (2001). These estimation results are robust even when we control for unobserved heterogeneities using block or individual fixed effects.

Secondly, each individual's years of access to irrigation infrastructure significantly increase the level of trust and the result seems to be robust across different specifications. Also, this variable interacted with social distance variables are all statistically insignificant, suggesting that trust is not necessarily affected by social distance or repeated interactions among farmers. The results imply that pro-social behavior captured by trust emerges from habits formulated within a technological environment set by physical access to irrigation, rather than social interactions within each irrigation community.

Third, the sending amount in trust games is significantly and positively related to the degree of altruism quantified by the dictator game. The results, which are robust across different specifications and sample, imply that, at least partially, trusting behavior can be attributed to altruistic behavior. Noting that the average sending amount in the dictator game is Rs. 140 and the estimated coefficient of the sending amount in the game ranges from 0.44 to 0.54 in Table 7, more than a third of the average trust amount, i.e., Rs. 180, can be explained by altruism.

Trustworthiness

While we believe we can rule out trusting behavior arising from repeated interactions among known people in the same community by confining our analysis to data based on the anonymous games, strictly speaking, participants may assign probabilities of specific known persons on each anonymous receiver.[17] To mitigate estimation bias from this possible consideration, we add each sender's expected returns in the trust game or subjective "belief" on

17. Strictly speaking, each receiver can assign a probability of 1/6 for each sender. Knowing this, each sender may consider a particular relationship when deciding the sending amount.

the right-hand-side variables in regression equation (2). In fact, as Barr (2003) shows, the trusting behavior of a sender should be affected by his/her expected returns to sending a transfer to the receiver. This is especially so under the repeated game-type setting. Unlike Barr (2003), who does not have data on each first player's expectation, we have direct subjective assessments on the expected returns to transfers. We add the expected returns as one of the independent variables in Equation (1).[18] Estimation results are reported in Table 8. As we can see, the expected return variable has positive and statistically significant coefficients. The indicator variables for an anonymous person in the same D-canal or in a different D-canal become statistically insignificant. This suggests that the proximity effect of trusting behavior may reflect each sender's belief about the receiver represented by expected trustworthiness, possibly indicating a repeated-game-type mechanism. In contrast, even if we include this expected trustworthiness variable, the coefficient of the years of access of irrigation is unchanged qualitatively and quantitatively. This suggests that trust behavior itself changed beyond a mechanism of repeated strategic interactions, reflecting a change in preference due to experiences. We believe that this is consistent with the habit formation hypothesis of pro-social behavior.[19]

Consistent with real world decisions?

We also check the consistency of the experimental results with the real world behavior.[20] As a dependent variable of equation (2), we employ an indicator variable that takes one if a respondent participates in irrigation canal cleaning activities in the last farming season; and

18. We set the expected return at zero in two cases: first, when a sender invests nothing to his/her receiver; and second, when a sender expects nothing even if the amount sent to his/her receiver is positive.
19. We also regress the expected return rate in the trust game on years of irrigation access, finding an insignificant coefficient. This is consistent with the habit formation hypothesis that is orthogonal to the repeated game hypothesis.
20 The public health literature distinguishes two types of social capital, i.e., cognitive social capital and structural social capital (Harpman, et al., 2002). While the former corresponds to trust elicited by experiments, the real world decisions considered here corresponds to the latter.

zero otherwise, instead of the sending amount in the trust game. As Sawada et al. (2013) show, participation in canal cleaning involves substantial free riding by self-interested households with no landholdings: unlike monetary contributions, labor contributions such as canal cleaning cannot be easily tracked and verified, possibly leading to worse enforcement of collective action.

The estimation result is reported in Table 9.[21] As before, the years of irrigation access variable continues to be statistically significant. According to our point estimate, ten more years of getting access to irrigation infrastructure increases the probability of participating in irrigation canal cleaning by around 10 percentage points. Our results based on the real world data also support the habit formation hypothesis.

3.2 Habit or repeated game? estimation results for each D-Canal community

To further identify determinants and channels of trusting behavior, we employ dyadic data on the type (i) shown in panel A of Table 5, i.e., the identified persons within the same D-Canal and estimate a regression model of the trust amount. We focus on the social distance measured by the proximity of various bilateral relationships such as membership in the same organizations, such as farmers' organizations, rotating savings and credit associations (ROSCAs), a microfinance institution (MFI), and funeral association as well as bilateral credit and labor transactions shown in panel C of Table 5. The main econometric specification is:

$$(3) \qquad \tau_{ij} = \gamma_1 + \gamma_2\, IRR_i + \boldsymbol{X}_i\, \Phi_1 + \boldsymbol{X}_j\, \Phi_2 + \boldsymbol{D}_{ij}\Phi_3 + \varepsilon_{ij},$$

where $\boldsymbol{X}_j$ is a set of the receiver's characteristics such as age, sex, education level, and dummy for a leader of a farmers' organization; $\boldsymbol{D}_{ij}$ is a set of bilateral relationships between participant

21. Since we have only 60 observations for the lottery-assigned households, we employ both lottery and non-lottery samples to estimate the model.

i and *j* reported by *i*. Since $\boldsymbol{D}_{ij}$ may include the relationships that are determined endogenously, we also have specifications including block or individual fixed effects to control for unobserved heterogeneities.

Our estimation results are reported in Table 10 and show two main findings. First, as before, a farmer's longer years of access to irrigation infrastructure facilitate larger sending amounts in the trust game. This result seems to be robust even if we include block fixed effects and limit analysis. Out of the mean trust amount of Rs. 215, the years of irrigation access can explain around Rs. 53 if we evaluated at mean using the estimated coefficient of specification (6) (5.43×Rs. 9.8＝Rs. 53). Similarly, altruism can explain a significant proportion of the level of trust. These results also support the habit formation hypothesis.

Second, however, the proximate bilateral relationship may not necessarily enhance the level of trust. In estimating equation (3), among different bilateral variables, only a few variables become statistically significant with the right signs: the years of sharing the same field irrigation canal, the same ROSCA participation, the same farmers' organization membership, and frequent labor exchange are positively, but only mildly, related with the amount of transfers. We also reject the joint significance of bilateral relationship variables in 10 out of 18 specifications at a 10% level of significance (Table 10). These estimation results are mixed in supporting the repeated interaction hypothesis.

Repeated game?

To test the repeated interaction hypothesis more closely, we check theoretical implications of repeated games. According to the theory of self-enforcing cooperation arising from (infinitely) repeated interactions, we should observe a higher level of trust in the case of the following: first, a sender holds a lower subjective discount rate (Gibbons, 1994); second, if there is a higher meeting frequency among players (Kandori, 2008); and third, if participants are younger because there is a lower probability of the ending game; and fourth, players are more risk averse (Kimball, 1988; Coate and Ravallion, 1993); and income streams are less covariate (Coate and Ravallion, 1993; Kimball (1988) AER; Foster & Rosenzweig (2001) REStat).

Table 11 shows estimation results of equation (3) with proxy variables to test the theoretical implications of the repeated game. First, we add subjective discount rates elicited by time discount experiments following Anderson et al. (2004) and Tanaka et al. (2010). The estimated coefficients are largely insignificant. Second, we incorporate an indicator variable for bilateral meeting frequency, which takes one if a pair meet together every day and zero otherwise. The coefficient is not statistically significant. Third, to capture the age affect, we incorporated age and age squared of the sender and receiver. According to specifications (2) and (3), senders age 38 or older will send more and senders will send less if their receiver is age 64 or older.[22] Fourth, the risk game variable is positively related with the level of trust, indicating less risk aversion coincides with a higher sending amount. Finally, we employ the long-term panel data to compute the income covariance of each pair. However, our estimation results, which are not shown in this paper but are available upon request from the corresponding author, are not correlated with the level of trust. In sum, almost all of these estimation results are inconsistent with the theoretical implications of the repeated game. In Table 12, the expected level of trustworthiness is orthogonal to the amount sent in the trust game, which is also consistent with this interpretation.

Habit formation or wealth effects?

The empirical results so far are in favor of the habit formation hypothesis of pro-social behavior. Yet, an alternative channel is that the years of access to irrigation can improve income and help wealth accumulation and thereby increase the amount of transfers in the trust game. To test this wealth hypothesis, we add the income and wealth levels of the sender in equation (3). According to the estimation results in Table 9, the significance of the years of access to

22. We also incorporate a relative age variable of each pair, finding an insignificant coefficient.

irrigation infrastructure is maintained. This finding also supports the validity of the habit formation hypothesis.

4. Concluding remarks

In the existing rich literature on social capital, existing studies have investigated the role of social capital in improving the economic performance of people, communities, and countries. Yet, determinants of social capital accumulation are largely unexplored. This study tries to bridge this gap in the literature by investigating the impact of irrigation infrastructure on social capital accumulation. To identify the causal impact of irrigation, we use a unique natural experimental data set from an irrigation project in southern Sri Lanka where irrigated land distribution has been made through a lottery mechanism. In addition, we capture the level of social capital precisely using carefully designed field experiments such as trust and dictator games. By combining these two data sets, i.e., data from natural and artefactual field experiments, we examine the causal impact of irrigation infrastructure on social capital.

We find that, within the whole area, geographical and social distance can explain the degree of mutual trust where trust is also significantly affected by altruism, suggesting that the level of particularized trust is significantly higher than that of general trust. Moreover, in each distribution canal, within-community variation in trust is not necessarily driven by social distance or repeated interactions in the bilateral relationships but by the years of access to the irrigation canal. Social preference in the form of particularized trust seems to emerge from a technological environment set by physical access to irrigation, suggesting habit formation of pro social behavior. While the existing studies such as Yamagishi and Yamagishi (1994) characterized "generalized trust" by a subjective belief in the benevolence of human nature in general arising from an internal characteristic or disposition, our results show that particularized trust does not depend on reciprocity or evidence of another's trustworthiness too.

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Figure 1

A Map of the study area

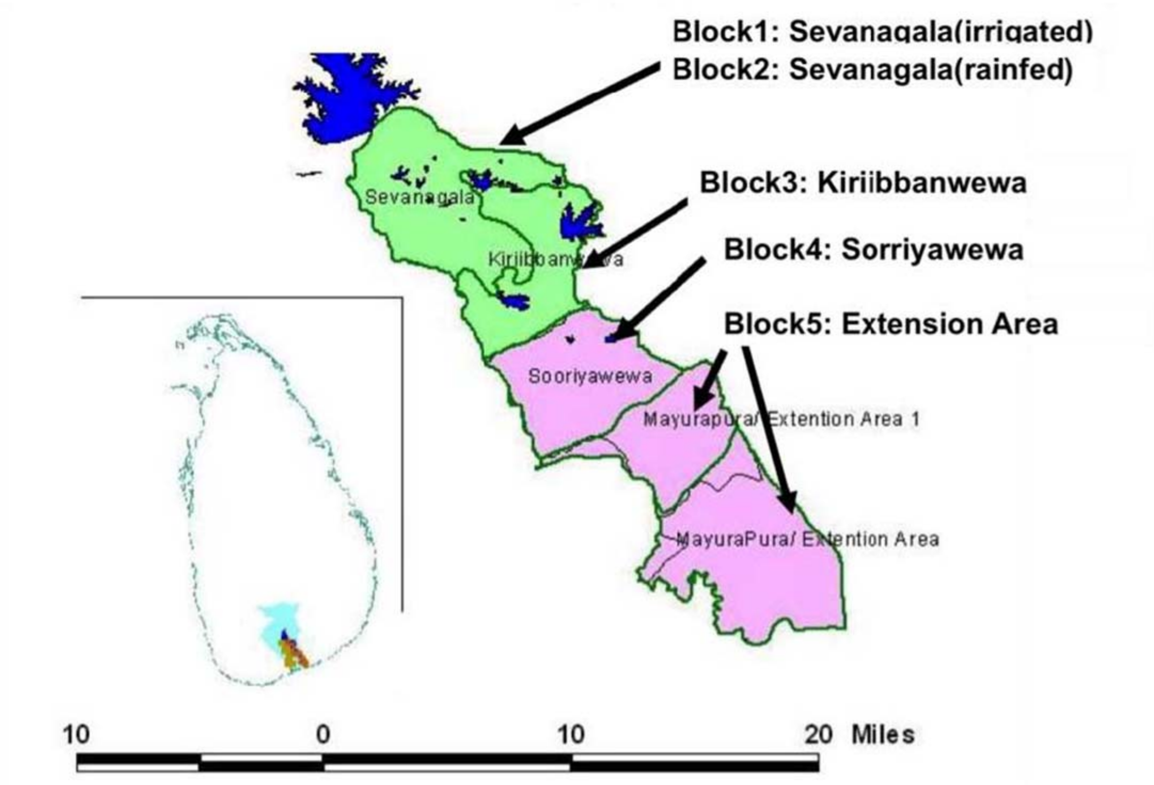

Figure 2
Sampling scheme of irrigation blocks and distribution canals (D-Canals)

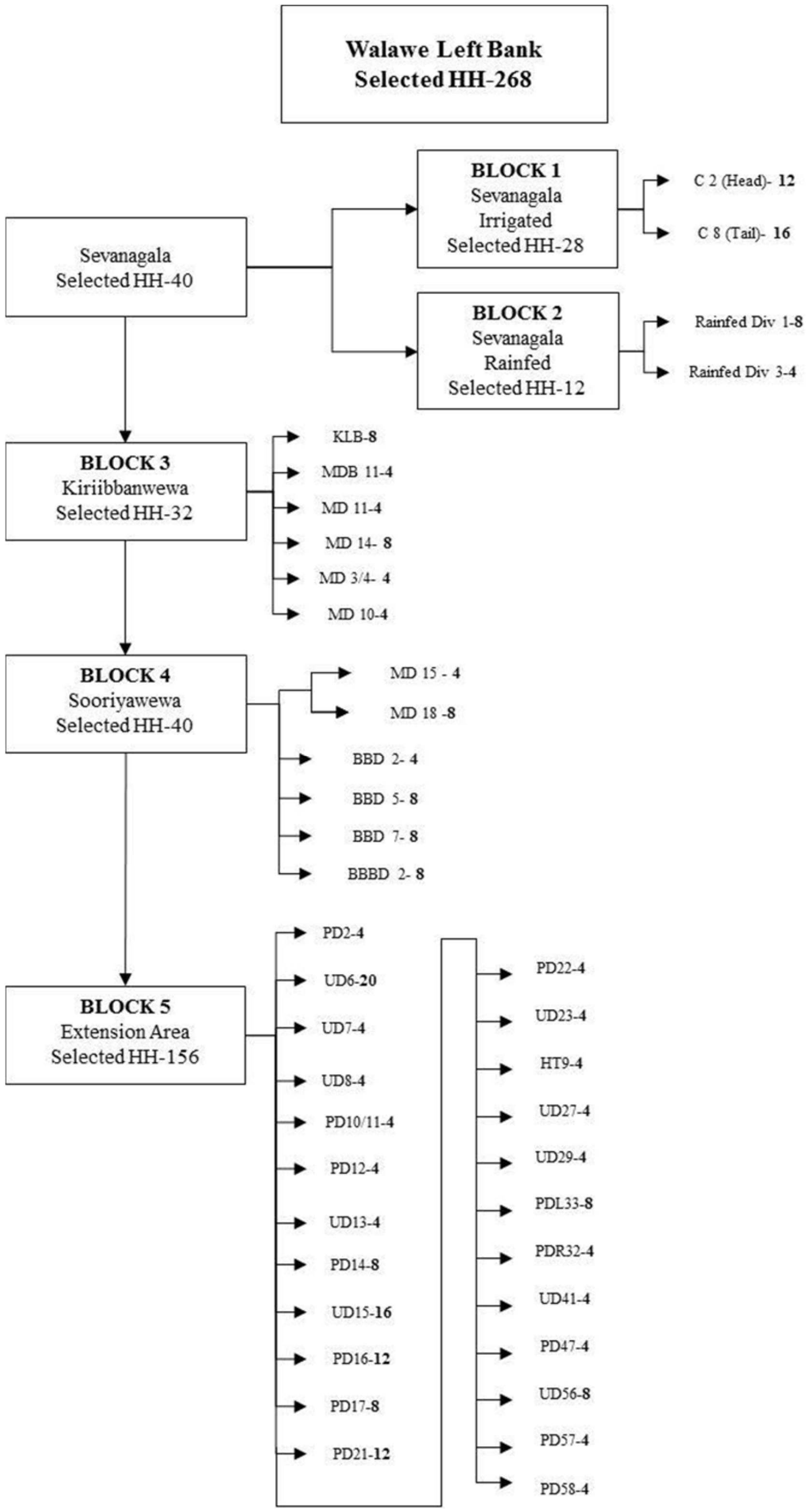

Figure 3
Results of experiments:
Cumulative distribution function of the amount sent in trust game

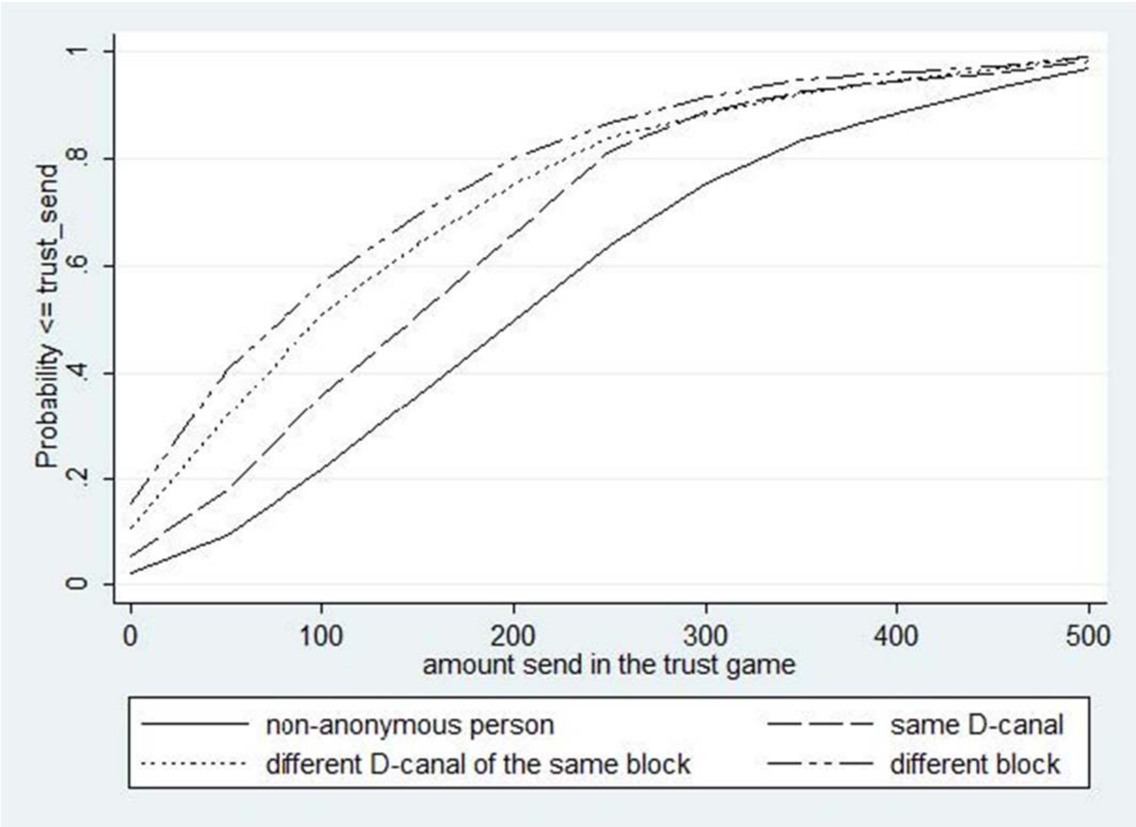

Table 1

Composition of participants in experiments

	Block	Freq.	Percent	Average years of access to irrigation
1	Sevanagala (irrigated)	14 (28)	20.9 (10.5)	19.1 (14.8)
2	Sevanagala (rainfed)	3 (12)	4.5 (4.5)	0 (1.6)
3	Kirribbanwewa	9 (32)	13.4 (11.9)	20.3 (18.7)
4	Sooriyawewa	3 (40)	4.5 (14.9)	15 (16.2)
5	Extension Area	38 (156)	56.7 (58.2)	6.3 (6.0)
	Total	67 (268)	100 (100)	11.0 (9.8)

Note: Numbers are those who receive land based on lotteries. Numbers in parentheses are including both lottery and non-lottery samples.

Table 2

Subjective assessments on implementation of land allocation using lotteries

	Residences	Irrigated Plots
Any chance to claim your preferences?	Percent	Percent
Not at all	29.83	32.59
Block level	10.5	11.16
Block-canal level	2.1	3.13
D-Canal level	1.26	1.79
Plot level	56.3	51.34
Total	100	100
Land allocation process?		
Acquired the preferred area without process	52.77	47.53
Lottery within the claimed area	20	22.87
Lottery including the possibility of outside of the claimed area	5.11	7.17
First come, first served basis	5.96	8.07
Negotiation among the resettlers	2.98	3.14
No formal permission regarding the land use	8.94	6.28
Others	4.26	4.93
Total	100	100
Did you obtain the land you really wanted?		
Yes	67.80	66.37
No	32.20	33.63
Total	100	100

Table 3
Exogeneity tests
Difference in treatment level across areas and its exogeneity

	Joint significance of D canal coefficients β^D (P-values)	Joint significance of head and tail coefficients β^L (P-values)	N
Panel A: Difference in the Treatment Level across Areas			
[1] Irrigation Access Year	0.000***	0.9324	235
Panel B: Exogeneity Tests			
[1] Timing of application	0.1466	0.4666	193
[2] Age of household head	0.5183	0.7203	233
[3] Years of schooling of household head	0.5954	0.7045	218

Table 4
Correlates years of access to irrigation infrastructure
dependent variable: years of access to irrigation infrastructure

	Coefficients [Standard error]
Age	0.09 [0.09]
Education	0.02 [0.19]
Males over 15	1.5 [1.00]
Females over 15	-0.22 [0.72]
Canal head	-0.71 [1.66]
Canal tail	-0.78 [1.51]
Block 1	15.67 [3.76]***
Block 3	22.21 [2.56]***
Block 4	15.99 [2.26]***
Block 5	5.18 [0.86]***
Constant	-4.64 [2.99]
Number of observations	164
Adjusted R-squared	0.45
Joint significance of HH characteristics coefficients (P-values)	0.1552

Note: D-canal-level Cluster-adjusted robust standard errors are reported. Block 2 is a default category.
* significant at 10% level; ** significant at 5% level; *** significant at 1% level

Table 5
Descriptive statistics

Variables	Obs	Mean	S.D.
Panel A: Experiment			
Trust Game (Sending amount)	402 (1608)	181.84 (175)	133.23 (133.98)
(i) to the identified person (showing pictures and names of partners)	201 (804)	228.86 (215.30)	132.53 (131.48)
(ii) to an anonymous person in the same D-canal	67 (268)	158.21 (161.38)	111.67 (119.73)
(iii) to an anonymous person in a different D-canal of the same block	67 (268)	143.28 (131.34)	124.59 (126.49)
(iv) to an anonymous person in a different block	67 (268)	102.99 (111.38)	107.27 (121.06)
Trust Game (Returning proportion)	378 (1524)	0.28 (0.25)	0.25 (0.23)
(i) to the identified person (showing pictures and names of partners)	189 (762)	0.34 (0.30)	0.25 (0.23)
(ii) to an anonymous person in the same D-canal	63 (254)	0.26 (0.23)	0.23 (0.23)
(iii) to an anonymous person in a different D-canal of the same block	63 (254)	0.21 (0.19)	0.23 (0.22)
(iv) to an anonymous person in a different block	63 (254)	0.19 (0.16)	0.22 (0.21)
Dictator Game (Sending amount)	402 (1608)	139.80 (137.41)	109.39 (110.18)
(i) to the identified person (showing pictures and names of partners)	201 (804)	166.92 (165.05)	109.26 (111.53)
(ii) to an anonymous person in the same D-canal	67 (268)	136.57 (140.11)	104.66 (101.05)
(iii) to an anonymous person in a different D-canal of the same block	67 (268)	115.67 (104.66)	108.44 (100.50)
(iv) to an anonymous person in a different block	67 (268)	85.82 (84.51)	89.53 (95.66)
Risk Game			
Betting amount to the risk game	67 (268)	211.19 (208.58)	111.40 (121.25)
Panel B: Participants Information			
Dummy if household head	67 (268)	0.73 (0.68)	0.45 (0.47)
Age	67 (266)	48.21 (48. 33)	14.76 (14.15)
Dummy if male	67 (266)	0.69 (0.65)	0.47 (0.48)
Years of schooling	67 (265)	7.31 (7.18)	3.86 (3.61)
Years of access to irrigation	67 (268)	10.96 (9.76)	10.34 (9.53)
Panel C: Relationship with Partners (Non-anonymous Setting)			
Years knowing each other	197 (776)	21.00 (21.33)	13.96 (12.14)
Dummy if knowing telephone number	201 (795)	0.12 (0.08)	0.33 (0.28)
Years sharing the same irrigation	201 (804)	3.30 (3.22)	6.59 (7.01)
Dummy if the same farmer organization	197 (786)	0.78 (0.77)	0.42 (0.42)
Dummy if the partner is the leader of FO	194 (770)	0.07 (0.06)	0.26 (0.23)
Dummy if the same ROSCA group	200 (794)	0.03 (0.05)	0.17 (0.22)
Dummy if the same MFI group (Swayan Bank)	201 (795)	0.05 (0.10)	0.23 (0.30)
Dummy if the same funeral group	201 (792)	0.42 (0.38)	0.49 (0.49)
Dummy if experience of lending money for 3 years	201 (792)	0.07 (0.08)	0.26 (0.27)
Dummy if experience of borrowing for 3 years	201 (795)	0.06 (0.09)	0.25 (0.29)
Dummy if experience of exchanging labor for 3 years	201 (804)	0.16 (0.16)	0.37 (0.36)

Note: Numbers are for those who receive land based on lotteries. Numbers in parentheses are including both lottery and non-lottery samples. Sample size in Panel C is slightly smaller than the number of actual pairs because some farmers who had not participated in the experiments answered the question on social relationships with their partners and we drop these farmers from the analysis.

Table 6
Two-sample Kolmogorov-Smirnov tests

	Identified persons vs. same D-canal	Identified persons vs. same block	Identified persons vs. different block	Same D-canal vs. same block	Same D-canal vs. different block	Same Block vs. different block
Trust Send	0.265***	0.396***	0.440***	0.175***	0.261***	0.090
Trust Return	0.119**	0.172***	0.235***	0.175***	0.261***	0.090
Dictator	0.194***	0.366***	0.474***	0.187***	0.295***	0.108*

Note: D-statistics are reported. * significant at 10% level; ** significant at 5% level; *** significant at 1% level

Table 7
Determinants of social capital measured by trust (lottery subsample)
Dependent variable: Amount sent in the trust game

	(1)	(2)	(3)	(4)	(5)	(6)
Method	Pooled OLS	Block FE	Individual FE	Pooled OLS	Block FE	Individual FE
Years of Access to Irrigation	2.615*	3.194**	.	2.434	3.073	
	[1.333]	[1.562]	.	[1.349]*	[1.486]**	
Identified * Irrigation Access Year				1.539	1.539	1.562
				[1.676]	[1.683]	[1.694]
Same DC * Irrigation Access Year	-1.064	-1.069	-1.15	-1.057	-1.058	-1.107
	[1.452]	[1.472]	[1.532]	[1.429]	[1.442]	[1.474]
Different DC * Irrigation Access Year	-0.994	-0.99	-0.92	-0.999	-0.999	-0.957
	[0.892]	[0.905]	[0.864]	[0.880]	[0.881]	[0.862]
Identified				69.686	69.719	73.414
				[20.642]***	[20.739]***	[20.703]***
Same DC	38.09*	38.40*	43.47**	37.685	37.713	40.806
	[20.77]	[20.57]	[19.29]	[20.499]*	[20.456]*	[20.107]**
Different DC	33.76**	33.84**	35.09**	33.660	33.667	34.432
	[14.30]	[14.41]	[13.88]	[14.247]**	[14.382]**	[14.006]**
Dictator Game	0.530***	0.525***	0.441***	0.537	0.536	0.485
	[0.106]	[0.104]	[0.101]	[0.095]***	[0.090]***	[0.091]***
Risk Game	0.129	0.109	.	0.146	0.120	
	[0.114]	[0.115]	.	[0.103]	[0.104]	
Household Head	27.45	28.63	.	12.034	7.401	
	[29.48]	[32.61]	.	[27.775]	[29.769]	
Age	-0.819	-0.627	.	-0.386	-0.251	
	[0.894]	[0.916]	.	[0.780]	[0.762]	
Sex (1 = male)	-30.6	-33.91	.	-19.996	-14.378	
	[29.89]	[32.49]	.	[29.983]	[31.071]	
Education (highest grade completed)	1.365	2.281	.	1.127	1.206	
	[2.903]	[3.465]	.	[2.896]	[3.085]	
Constant	32.43	24.9	64.15***	14.985	13.040	60.401
	[62.99]	[65.63]	[10.36]	[54.914]	[56.599]	[8.973]***
Number of observations	189	189	189	378	378	378
Adjusted R-squared	0.35	0.36	0.27	0.43	0.44	0.47

Note: Individual-level cluster-adjusted robust standard errors in brackets. * significant at 10% level; ** significant at 5% level; *** significant at 1% level

Table 8
Determinants of social capital measured by trust with expected trustworthiness (lottery subsample)
Dependent variable: amount sent in the trust game

	(1)	(2)	(3)	(4)	(5)	(6)
Method	Pooled OLS	Block FE	Individual FE	Pooled OLS	Block FE	Individual FE
Years of Access to Irrigation	2.554*	3.204**		2.406	3.084	
	[1.298]	[1.448]		[1.307]*	[1.405]**	
Expected Trustworthiness	108.6***	113.1***	16.55	98.665	104.519	27.498
	[30.30]	[30.80]	[35.72]	[30.475]***	[30.310]***	[35.852]
Identified * Irrigation Access Year				1.283	1.268	1.487
				[1.641]	[1.649]	[1.644]
Same DC * Irrigation Access Year	-1.206	-1.214	-1.161	-1.177	-1.184	-1.133
	[1.596]	[1.624]	[1.531]	[1.538]	[1.562]	[1.481]
Different DC * Irrigation Access Year	-1.012	-1.021	-0.966	-1.030	-1.034	-0.980
	[0.919]	[0.940]	[0.856]	[0.891]	[0.900]	[0.852]
Identified				62.109	61.660	70.750
				[21.682]***	[21.887]***	[22.879]***
Same DC	28.59	28.32	41.35*	28.440	27.892	37.767
	[21.83]	[21.58]	[21.60]	[21.697]	[21.679]	[22.180]*
Different DC	25.50	25.43	34.55**	26.148	25.765	32.442
	[16.69]	[16.97]	[16.48]	[16.157]	[16.422]	[15.971]**
Dictator Game	0.437***	0.431***	0.438***	0.463	0.458	0.472
	[0.0974]	[0.0973]	[0.101]	[0.090]***	[0.085]***	[0.088]***
Risk Game	0.137	0.111		0.154	0.125	
	[0.101]	[0.100]		[0.094]	[0.093]	
Household Head	13.32	12.70		0.514	-5.100	
	[25.82]	[28.47]		[26.499]	[27.611]	
Age	-0.377	-0.131		-0.098	0.074	
	[0.804]	[0.844]		[0.768]	[0.761]	
Sex (1 = male)	-26.71	-30.09		-16.917	-11.445	
	[27.68]	[29.17]		[28.264]	[28.893]	
Education (highest grade completed)	1.377	2.511		1.000	1.234	
	[2.678]	[3.099]		[2.817]	[2.923]	
Constant	-7.569	-16.80	59.64***	-17.032	-21.198	53.305
	[55.45]	[57.64]	[14.21]	[53.038]	[54.368]	[12.603]***
Number of observations	188	188	188	377	377	377
Adjusted R-squared	0.40	0.42	0.29	0.47	0.49	0.41

Note: Individual-level cluster-adjusted robust standard errors in brackets.
* significant at 10% level; ** significant at 5% level; *** significant at 1% level

Table 9 Real world decisions

Dependent variable: Participation in irrigation cleaning (Full sample)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Years of Access to Irrigation (*IRR*)	0.00907***	0.00858***	0.00890***	0.00857***	0.00934***	0.00933***	0.00878***
	[0.00301]	[0.00299]	[0.00305]	[0.00306]	[0.00298]	[0.00296]	[0.00301]
Dictator Game	-0.000103	-0.0000755	-0.0000906	-0.0000768	-0.000131	-0.0000945	-0.0000517
	[0.000114]	[0.000116]	[0.000113]	[0.000114]	[0.000118]	[0.000120]	[0.000121]
Risk Game	-0.000124	-0.000115	-0.0000258	-0.0000201	-0.000127	-0.000139	-0.000104
	[0.000134]	[0.000133]	[0.000115]	[0.000115]	[0.000135]	[0.000137]	[0.000132]
Household Head	-0.0694	-0.0486	-0.0113	-0.000191	-0.0677	-0.0730	-0.0731
	[0.0643]	[0.0614]	[0.0576]	[0.0567]	[0.0638]	[0.0657]	[0.0641]
Age	0.00347	0.00264	0.00278	0.00228	0.00325	0.00320	0.00491
	[0.00760]	[0.00753]	[0.00772]	[0.00762]	[0.00751]	[0.00747]	[0.00744]
Age^2	-0.0000552	-0.0000452	-0.0000522	-0.0000458	-0.0000513	-0.0000511	-0.0000637
	[0.0000798]	[0.0000796]	[0.0000814]	[0.0000805]	[0.0000786]	[0.0000777]	[0.0000791]
Sex	0.164***	0.142**	0.101**	0.0904*	0.154***	0.163***	0.155***
	[0.0585]	[0.0547]	[0.0485]	[0.0468]	[0.0578]	[0.0589]	[0.0588]
Education	-0.00152	-0.00277	-0.00355	-0.00402	-0.000811	-0.00199	0.000835
	[0.00606]	[0.00604]	[0.00549]	[0.00549]	[0.00614]	[0.00606]	[0.00602]
Asset & Wealth							
Income		0.0529**		0.0375			
		[0.0243]		[0.0245]			
Asset			0.0168	0.0107			
			[0.0118]	[0.0122]			
Discount Rate (%)							
2,500Rs tomorrow					0.00378		
					[0.00313]		
2,500Rs 3 months					0.230**		
					[0.107]		
2,500Rs 1 year					-0.196		
					[0.209]		
25,000Rs tomorrow						0.00113	
						[0.00471]	
25,000Rs 3 months						0.543*	
						[0.310]	
25,000Rs 1 year						-0.727	
						[0.523]	
100,000Rs tomorrow							0.0121**
							[0.00596]
100,000Rs 3 months							-0.750*
							[0.448]
100,000Rs 1 year							0.727*
							[0.428]
Constant	0.677***	0.117	0.497*	0.167	0.636***	0.659***	0.624***
	[0.224]	[0.359]	[0.270]	[0.368]	[0.229]	[0.225]	[0.222]
Number of observations	248	248	244	244	248	246	247

Note: Linear probability model is employed. Robust standard errors are shown in brackets. Block-level fixed effects are included. * significant at 10% level; ** significant at 5% level; *** significant at 1% level

Table 10

Determinants of social capital using dyadic data (lottery subsample)

Dependent variable: the amount sent in the trust game

	(1)	(2)	(3)	(4)	(5)	(6)
Method	Pooled OLS	Block FE	Indi. FE	Pooled OLS	Block FE	Indi. FE
Years of Access to Irrigation (*IRR*)	3.941***	5.469***		3.498***	5.032***	
	[1.460]	[1.955]		[1.304]	[1.484]	
Respondent characteristics (X_i)						
Dictator Game	0.480***	0.521***	0.550***	0.487***	0.575***	0.453***
	[0.151]	[0.135]	[0.153]	[0.155]	[0.127]	[0.130]
Risk Game	0.172	0.0929		0.258**	0.156	
	[0.128]	[0.145]		[0.126]	[0.128]	
Household Head	19.73	-6.029	.	33.19	-7.145	.
	[38.04]	[42.05]	.	[40.94]	[46.77]	.
Age	-6.350*	-2.304	.	-9.227***	-4.613	.
	[3.659]	[3.570]	.	[3.362]	[4.162]	.
Age^2	0.0682	0.0278	.	0.103***	0.0597	.
	[0.0425]	[0.0408]	.	[0.0368]	[0.0409]	.
Sex (1 = male)	-29.31	-16.00	.	-32.44	-15.92	.
	[39.65]	[39.70]	.	[38.83]	[38.35]	.
Education (highest grade completed)	1.185	-0.0891	.	-0.653	-3.192	.
	[4.264]	[4.671]	.	[4.331]	[4.339]	.
Receiver characteristics (X_j)						
Age	4.165	4.061	3.179	6.698**	5.841*	4.140*
	[3.394]	[3.348]	[2.548]	[3.155]	[3.030]	[2.329]
Age^2	-0.0491	-0.0423	-0.0195	-0.0621**	-0.0471	-0.0288
	[0.0341]	[0.0339]	[0.0253]	[0.0307]	[0.0300]	[0.0237]
Sex (1 = male)	3.481	-9.222	-1.507	-0.477	-15.05	1.934
	[18.84]	[18.24]	[17.62]	[20.26]	[20.67]	[18.72]
Education (highest grade completed)	-2.455	-1.638	4.246	-1.901	-1.137	3.050
	[3.339]	[3.440]	[2.981]	[3.367]	[3.489]	[3.097]
Leader of FO	41.36	39.72	-5.876	41.00	35.20	-0.869
	[40.20]	[40.74]	[14.50]	[39.17]	[38.41]	[23.78]
Bilateral relationships (D_{ij})						
Year – Sharing Irrigation		-1.238	0.933	1.135	0.0667	2.676
		[1.821]	[1.433]	[1.804]	[1.851]	[1.845]
FO Member		6.025	18.78	16.24	6.264	-0.0294
	[26.14]	[23.87]	[45.64]	[26.72]	[24.94]	[52.62]
Funeral Group Member	20.11	24.34	17.04	46.03	62.03*	6.440
	[28.82]	[34.68]	[33.89]	[28.18]	[32.35]	[42.60]
Year – know				-1.311	-1.768**	0.516
				[0.862]	[0.813]	[0.886]
Know Telephone No.				-5.348	-9.463	-0.533
				[38.25]	[36.08]	[37.12]
ROSCA Member				137.0***	165.6***	-66.21
				[41.44]	[44.54]	[52.03]
Swayan Bank Member				-105.6**	-139.3***	69.10*
				[39.60]	[47.50]	[40.28]
Lending Money				65.51	31.49	57.64
				[42.42]	[48.49]	[38.60]
Borrowing Money				88.09	97.65*	-16.06
				[53.22]	[56.45]	[35.73]
Exchange Labor				8.854	-7.041	-0.291
				[25.61]	[24.02]	[1.798]
Constant	119.0	59.14	-16.13	70.35	39.70	18.80
	[161.7]	[160.1]	[83.82]	[142.4]	[145.1]	[81.39]
Number of Observations	163	163	163	160	160	160
Adjusted R-squared	0.403	0.445	0.275	0.508	0.563	0.189
Joint significance of receiver characteristics (P-values)	0.516	0.675	0.413	0.284	0.099	0.280
Joint significance of bilateral relationships (P-values)	0.693	0.652	0.791	0.000	0.001	0.087
Joint significance of receiver characteristics and bilateral relationships (P-values)	0.721	0.752	0.609	0.000	0.002	0.096

Note: Individual-level cluster-adjusted robust standard errors in brackets.

* significant at 10% level; ** significant at 5% level; *** significant at 1% level

Table 11
Testing repeated game
Determinants of social capital using dyadic data with additional variables

	(1)	(2)	(3)	(4)	(5)	
Method	Block FE	Pooled OLS	Block FE	Pooled OLS	Block FE	Block FE
Years of Access to Irrigation (*IRR*)	3.479**	3.870***	5.149***	3.994***	5.586***	5.003***
	(1.332)	(1.401)	(1.584)	(1.362)	(1.541)	(1.523)
Expected Trustworthiness	35.51	24.62	35.3	23.12	41.35	38.52
	(48.35)	(47.13)	(57.76)	(49.71)	(52.87)	(55.00)
Respondent characteristics (X_i)						
Dictator Game	0.467***	0.488***	0.653***	0.524***	0.594***	0.545***
	(0.157)	(0.167)	(0.154)	(0.136)	(0.130)	(0.135)
Risk Game	0.258**	0.242*	0.137	0.274**	0.126	0.153
	(0.125)	(0.130)	(0.132)	(0.122)	(0.130)	(0.124)
Age	-8.720**	-7.684**	-2.29	-8.075**	-2.107	-3.69
	(3.515)	(3.723)	(4.035)	(3.792)	(4.330)	(4.082)
Age^2	0.0979**	0.0864**	0.0356	0.0917**	0.0331	0.0495
	(0.0380)	(0.0376)	(0.0387)	(0.0393)	(0.0413)	(0.0395)
Receiver characteristics (Xj)						
Age	6.650**	6.425**	6.255**	6.253**	5.894*	6.031*
	(3.173)	(3.170)	(3.099)	(3.095)	(2.978)	(3.127)
Age^2	-0.0621**	-0.0585*	-0.0524*	-0.0566*	-0.0464	-0.0491
	(0.0309)	(0.0306)	(0.0307)	(0.0300)	(0.0294)	(0.0309)
Meeting Frequency (Everyday = 1)						-12.23
						(21.15)
Discount Rate (%)						
2,500Rs tomorrow		-5.713	-3.504			
		(3.515)	(3.423)			
2,500Rs 3 months		-6.824	420.2**			
		(185.3)	(194.1)			
2,500Rs 1 year		215	-96.75			
		(233.3)	(210.7)			
25,000Rs tomorrow				-10.48*	-10.31**	
				(5.887)	(4.306)	
25,000Rs 3 months				274	738.3**	
				(369.4)	(282.1)	
25,000Rs 1 year				-34.86	-696.6	
				(659.6)	(557.6)	
Bilateral relationships (D_{ij})	FULL	FULL	FULL	FULL	FULL	FULL
Number of observations	160	160	160	160	160	160

Note: Individual-level cluster-adjusted robust standard errors in brackets.
* significant at 10% level; ** significant at 5% level; *** significant at 1% level

Table 12
Determinants of social capital and wealth effects

	(1)	(2)	(3)	(4)	(5)	(6)
Method	pooled OLS	Block FE	Indi. FE	pooled OLS	Block FE	Indi. FE
Years of Access to Irrigation (*IRR*)	3.564***	5.449***	3.500***	5.097***	3.560***	5.130***
	(1.305)	(1.487)	(1.291)	(1.494)	(1.306)	(1.517)
Respondent characteristics (X_i)						
Dictator Game	0.455***	0.525***	0.496***	0.588***	0.495***	0.589***
	[0.160]	[0.129]	[0.154]	[0.125]	[0.154]	[0.126]
Risk Game	0.332**	0.253*	0.308***	0.214*	0.274**	0.178
	[0.139]	[0.130]	[0.115]	[0.119]	[0.122]	[0.125]
Household Head	48.54	16.56	43.57	4.858	35.22	-6.208
	[40.89]	[44.21]	[37.82]	[42.07]	[40.70]	[45.95]
Age	-10.22***	-6.038	-10.76***	-6.207*	-10.28***	-5.506
	[3.020]	[3.797]	[3.117]	[3.607]	[3.184]	[3.743]
Age^2	0.113***	0.0749*	0.117***	0.0741**	0.113***	0.0683*
	[0.0320]	[0.0375]	[0.0337]	[0.0363]	[0.0344]	[0.0369]
Sex (1 = male)	-59.98	-59.82*	-56.08	-42.91	-45.59	-29.59
	[37.79]	[35.27]	[36.63]	[32.62]	[37.91]	[35.22]
Education (highest grade completed)	-3.766	-6.204	-3.388	-5.467	-2.541	-4.665
	[4.931]	[4.638]	[4.666]	[4.915]	[4.728]	[4.963]
Income	10.79	-0.938	5.325	-5.422	8.288	-2.394
	[17.49]	[17.10]	[18.80]	[18.03]	[18.64]	[17.80]
Asset1	16.95	26.06***				
	[10.82]	[9.304]				
Asset2 (asset1 + building)			19.52	23.83*		
			[12.95]	[11.92]		
Asset3 (asset2 + bank saving + brick)					13.27	18.12
					[13.76]	[12.58]
Receiver characteristics (X_j)	YES	YES	YES	YES	YES	YES
Bilateral relationships (D_{ij})	FULL	FULL	FULL	FULL	FULL	FULL
Number of Observations	160	160	160	160	160	160

Note: Individual-level cluster-adjusted robust standard errors in brackets.
* significant at 10% level; ** significant at 5% level; *** significant at 1% level

Abstract (in Japanese)

要約

インフラストラクチャーはソーシャルキャピタルを蓄積させるか？

ある途上国における自然実験・フィールド実験のデータから

ソーシャルキャピタル（社会関係資本）は広い注目を集めてきたが、その蓄積のメカニズムに関する研究は数少ない。本論文では、「他人への信頼」というソーシャルキャピタルの最も重要な側面について、その決定要因を探るため、インフラストラクチャーが社会関係資本に与える影響について、「習慣形成仮説」と「繰り返しゲーム仮説」の二つの仮説の妥当性という側面から分析を行う。我々は南部スリランカの灌漑プロジェクト地域において、開拓地がくじによって無作為に分配されたことを自然実験として用い、被験者内設計（within-subject design）のトラストゲームというフィールド実験によって把握された信頼感データと結合することで分析を行った。結果から第一に、灌漑システムの内部における距離が信頼感を有意に決めることが分かった。このことは、一般的信頼（general trust）よりも個別的信頼（particularistic trust）の方が一般に強いことを示唆している。また、同じ灌漑分配水路内における信頼感については、各農民の灌漑アクセス年数が有意に関連しているものの、農民間の関係性は統計的に有意な関係を示さなかった。このことは、個別的信頼であらわされるソーシャルキャピタルについても、繰り返しゲーム的なメカニズムを通じてではなく、習慣形成を通じて蓄積されることを示している。

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