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IZA DP No. 11413

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ABSTRACT

Social Interactions and Stigmatized Behavior: "Donating" Blood Plasma in Rural China

Despite the resultant disutility, some people, in particular, the poor, are engaged in behaviors that carry social stigma. Empirical studies on stigmatized behavior are rare, largely due to the formidable challenges of collecting data on stigmatized goods and services. In this paper, we add to this limited empirical evidence by examining the behavior of "donating" blood plasma in exchange for cash rewards in China. We do so using two primary data sets: the first is a three-wave, census-type household survey that enables us to examine the evolving patterns and determinants of "donating" plasma. The second is data on detailed gift exchange records of all households. The data allow us to define reference groups, measure the intensity of social interactions, and identify peer effects using a novel network structure-based instrumental variable strategy. We find that peer effects influence decisions to "donate" plasma. For example, a one-standard-deviation increase in income from "donating" plasma in the peer group increases the value of own plasma "donation" by 0.15 standard deviations. Families with sons have more incentives to "donate" plasma to offset the escalated costs of getting their sons married in a tight marriage market that favors girls.

JEL Classification: O1, Z1, R2, D8

Keywords: social stigma, social networks, peer influence, plasma "donation", China

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"*Everyone was rendered both victim and supporter of the system.*" Václav Havel, 1978

1. Introduction

Certain markets exist, especially in impoverished environments where economic concerns outweigh moral values, for goods and services that are associated with significant social stigma (Edlund and Korn 2002; Kanbur 2004). Markets for body parts, child labor, prostitution, abduction and human trafficking, drug abuse, and toxic waste are just some examples. However, empirical economic studies on stigmatized behavior are rare, in large part due to the difficulty in collecting relevant data.

In this paper, we study a particularly stigmatized behavior in Chinese society—"donating" blood plasma for cash. Blood banks provide significant cash compensations to plasma "donors". It has become widespread in China since the early 1990s, as the rapid economic growth in China in the past three decades and its integration into the global economy have been accompanied by strong demand for blood products. Despite the rapid income growth, some poor households are lagging behind. They are more likely to be enticed to "donate" plasma, in exchange for cash rewards. For these poor individuals, the marginal utility of cash rewards is often higher than the marginal disutility of the social stigma associated with "donating" plasma, which is recognized as immoral in the Chinese culture.

One of the attractions of blood plasma "donation" is that through plasmapheresis, a process to obtain blood plasma without depleting the donor of other blood constituents, the remaining components are returned to the donors. Donors are able, therefore, to more frequently give plasma.[1] Plasma obtained by plasmapheresis stations is not used in clinical blood transfusions, but is instead sold to biopharmaceutical companies that produce high-profit human blood products, such as albumin, intravenous immunoglobulin (IVIG), anti-inhibitor coagulation complex, globulin, and hematoblasts. Since the opening of paid plasmapheresis stations in China in the early 1990s, their operations have proven highly profitable for the enterprises that run them. However, there has also been a proliferation of plasma collection operations that do not follow prescribed procedures; standards of practice for sterilization are often neglected, accurate virus detection methods are not employed, and there is often improper sharing of centrifuge machines and non-disposable needles (Prati 2006).

Although "donating" plasma is legal (albeit often the process takes place in an under-regulated context), the stigma with the behavior originates from three considerations. First, the offer of large financial incentives is seen as inducing a highly risky behavior among those in need of money. Thus, paid plasma "donors" are often labeled as both poor and viewed by others in the community as engaging in a desperate behavior to improve their economic situations. Related to that, relying on "donating" plasma as a main source of income signals laziness. Second, people connected to plasma "donors", whether they are family members or close social contacts, are concerned about the likely spread of (deadly) infectious diseases, since it is well understood that plasma "donation" has contributed to epidemics, including HIV/AIDS and hepatitis (Shao 2006). Third, blood has a spiritual and symbolic meaning in Chinese culture. "Donating" blood is essentially regarded as giving one's body, unlike in the

[1] The national regulations for plasma and blood "donation" stipulate that individuals are ineligible to give plasma if they are older than 50 or younger than 20, weigh less than 50kgs for males and 45kgs for females, or seriously disabled. In addition, an interval of 15 days between "donations" is required for plasma, and 3 months for whole blood (Asia Catalyst 2007).

West, where it is largely viewed altruistically and where blood is a commodity without any strong sense of it being integral to the physical or spiritual sense of self or personal identity.

In keeping with our expectations, we find that “donating” plasma is concentrated among those with low economic status. Interestingly, however, “donating” plasma is also observed to be concentrated among people with close social relations. We are interested, therefore, in testing the hypothesis that the disutility associated with “donating” plasma for cash subsidies may be lower when peers engage in the same behavior. That is, we test the hypothesis that plasma “donation” becomes ethically acceptable when more people, in a clan or a community in which plasma “donors” are concentrated, engage in what would normally be considered unacceptable behavior.

Our focus on the extent to which social interactions may motivate people to give more blood represents an issue that, to date, has not been explored in the theoretical literature on stigmatized behaviors (Basu and Van 1998; Edlund and Korn 2002). This lack of integration of the literature on stigmatized behaviors and social interactions is largely due to the historical difficulty of extending standard models of individual utility maximization, so as to allow pairwise, triadic, or more complex interactions that shape behavior and explain social concepts (Akerlof 1976; Basu 1986). Although the literature has started more recently to include research on the structure of social networks and behavior (Ballester, Calvó-Armengol , and Zenou 2006; Calvó-Armengol, Patacchini, and Zenou 2009), our application in explaining stigmatized behaviors is new. And, more generally, our focus on identifying peer effects on plasma “donation” may be important not only in the Chinese context, but may help understand observations, such as in Kanbur (2004), that stigmatized behaviors also persist in richer contexts.

Our focus on identifying the role of social interactions in plasma "donation" remains challenging due to the reflection problem and correlated effects that may confound the analysis of peer effects (Manski 1993). To address this issue, we take advantage of unusually comprehensive social network data, which enable us to circumvent the reflection problem by using spatial instruments on partially overlapping peer groups. Specifically, the intuition behind our identification strategy is twofold. First, we rely on partially overlapping groups to generate peers' peers (or excluded peers), whose characteristics act as exclusion restrictions in solving the reflection problem. Second, a large set of instruments, i.e. those exogenous characteristics of the excluded peers naturally generated from the group structure, correlate with peers' behavior by means of social interactions but are uncorrelated with the individual group shock. These instruments allow us to partially deal with correlated effects (De Giorgi, Pellizzari, and Redaelli 2010). Through direct and indirect peer fixed effects, an average of all relevant characteristics in a network, including those of direct peers and excluded peers, are further subtracted from each individual equation to remove unobserved characteristics and the potential impact of the institutional environment on behavior (Bramoulle, Djebbari, and Fortin 2009).

We collected two unique data sets for this study. The first details gift exchange records from all households in five villages during the period 1994–2012, which include all gift links within and across the five villages, as well as all gift links between the five villages and the outside world. Keeping a written record of gifts received has been a tradition in China for thousands of years. This social norm has also been preserved in many neighboring countries, such as Vietnam, Korea, Japan, Thailand and Cambodia, where people engage in reciprocal gift exchanges (Chen 2014). The records kept by each household generate data, whereby the peer groups vary at the household level, which guarantees the presence of excluded peers. Additionally, the gift network data effectively gauges intensity of social interactions through accurate and complete network information on the size of pairwise gift exchanges. Thus, we define reference groups, measure intensity of social interactions, and identify peer effects.

Our approach to utilizing partially overlapping reference groups, identified from gift records, differs from co-authorship network data (Goyal, Van Der Leij, and Moraga-Gonzalez 2006), technology adoption network data (Conley and Udry 2010), and risk-sharing network data (De Weerdt and Dercon 2006) in that it possesses the feature of excluded peers. While Bramoulle, Djebbari, and Fortin (2009) and De Giorgi, Pellizzari, and Redaelli (2010) make use of the same strategy, the former only allows a maximum of 10 people in the nominated friendship networks, and the latter has little information on social interactions.

The second data set is a longitudinal survey of all households in the villages in which we gathered detailed data on the patterns and determinants of “donating” plasma. Matching the two datasets enables us to track how decisions to “donate” plasma are affected by the nature of social networks.

Thus, our paper is among the first attempts to collect data that allows for the modeling of stigmatized behaviors, applying a spatial identification strategy to estimate the effect of social interactions. Our unique data enables us to measure real reference groups, test peer effects for stigmatized behaviors, and understand how the intensity of social interactions drives peer effect estimations.

Our results indicate that in addition to poor people being more likely to “donate” plasma, there is strong evidence of the presence of peer influence on “donating” plasma. However, the intensity of social interactions does not seem essential to peer effect identification. Moreover, peer effects appear to be partially driven by social interactions that reduce stigma.

The remainder of this paper is organized as follows: in Section 2, we present the details of “donating” plasma for cash subsidies in rural China. Section 3 derives illustrative models for the impact of peer influence on “donating” plasma. Section 4 describes the longitudinal household survey and gift-exchange network data, the identification of peer influence, and the empirical framework. In Section 5 we report estimation results. Finally, Section 6 concludes.

2. Plasma “Donation” and Epidemics in Rural China

In China, there are separate markets for whole blood and blood plasma. The former is mainly supplied by voluntary donation and is destined primarily for hospitals and blood transfusions. Plasma “donors”, in contrast, are offered cash compensation, since the plasma is primarily used by commercial enterprises such as biopharmaceutical companies. Current regulations forbid pharmaceutical companies and commercial enterprises from extracting plasma from voluntarily donated whole blood, a policy designed to preserve the supply of blood for patients in need. It is therefore no surprise that with the growing demand for plasma among commercial enterprises in this lucrative market, “donating” plasma is more popular than voluntarily giving whole blood.

Another reason for the popularity of plasma “donation” is the nature of its process. Whole blood is taken from the “donor”, and thereafter, the plasma is separated from the whole blood.

The red blood cells are then reinjected back into the "donor" intravenously. To speed up the process and reduce time costs incurred by the "donors", they are often given red blood cells from different, previous "donors" with the same blood type who were sent on their way, while their blood is being processed in a centrifuge machine to be reinjected into a later "donor".

One troubling concern is that in the 1990s and early 2000s, the health status of blood plasma "donors" was not strictly screened and unsanitary conditions for "donating" plasma were widespread (Shao 2006). This was allowed despite regulations that plasma from infected "donors" be segregated (Watts 2006) and presumably, not reinjected back into another "donor". Consequently, some people with hepatitis and HIV infection were allowed to "donate" blood, resulting in outbreaks of HIV infection and hepatitis C (Wu, Rou, and Detels 2001; Prati 2006). Contamination of red blood cells during the process of obtaining plasma was associated with outbreaks of HIV infection among plasma "donors" as early as 1994 (Wu, Rou, and Detels 2001). In fact, "donating" plasma in the 1990s and the 2000s has accounted for over one-fifth of China's HIV cases (Cohen 2004; Yan et al. 2013). There has been a strong regional component to both "donating" plasma and the resultant outbreak of diseases. For example, a widespread HIV/AIDS epidemic in Henan province occurred in China in the 1990s, where estimates indicate that over 1.2 million people contracted AIDS, and blood transfusion in unsanitary blood banks are considered prime suspects for this epidemic (Asia Catalyst 2007; Gao 2009).

The Chinese government responded rapidly to the epidemic by reducing the number of commercial blood banks and tightening regulations. In response, many blood banks in Henan province moved their operations to southwest provinces, such as Guizhou, where we conducted our surveys. It is not surprising that the blood banks chose Guizhou as a major source of supply of blood plasma (Yin 2006), since it is one of the poorest provinces in China. The most recent figures indicate that plasma stations in Guizhou have supplied 40 percent of the total blood plasma since 2006, rendering it the largest plasma market in the country. However, despite the efforts of the government to ensure safety of “donating” plasma, a rapidly growing epidemic of infectious diseases, particularly hepatitis C in early 2006, has affected Guizhou.[2] In response the government temporarily shut down all blood banks in Guizhou, only to allow them to be reopened in 2007, after steps were taken to improve the sanitary conditions of “donating” plasma in the region. Since then, the commercial enterprises running the blood banks have aggressively moved to increase plasma “donation”, including raising cash rewards for each “donation” and offering bonuses to those “donating” regularly. In addition to the incentives for regular “donation”, cash penalties have been imposed on those “donors” who do not “donate” biweekly. The objective of those running the plasma stations thus has been to create a regular group of “donors”, using both incentives and penalties that encourage them to give plasma biweekly throughout the year. For those that sign up for this commitment, giving plasma thus generates a steady source and sizable proportion of income. The reliance on plasma “donation” is further reinforced by regular “donors” often lacking energy to do farm work, further increasing their reliance on “donating” plasma.

3. Conceptual Model

[2] In January 2006, statistical data showed that the incidence, the number of deaths, and the fatality rate of infectious disease, respectively, increased by 21.36%, 65.38%, and 36.28% on a year-on-year basis. In March 2006, the three numbers further increased to 30.01%, 73.17%, and 33.20%, respectively.

Our starting point is a static model of stigmatized behavior in which peer pressure impacts plasma giving decisions, and the decision to “donate” plasma is subject to constraints on labor supply. Suppose there is a continuum of agents in an economy. Each agent makes decisions on labor market participation and “donating” plasma. Agents are heterogeneous in labor productivity θ_i,[3] ranging from $\theta_{\min}$ to $\theta_{\max}$, with the cumulative distribution function $F(\theta)$. Therefore, wage income is denoted by $\theta_i w$. “Donors” are subject to a maximum legal “donation” level and, therefore, a maximum possible income from “donating” plasma B. The actual level of plasma “donation” ranging from 0 (not “donating”) to 1 (“donating” at the biweekly level) is denoted by h_i. We follow the basic household decision model that incorporates the social stigma associated with plasma “donation” and an exogenous wage rate,

$$\max_{h_i} \; U(c(h_i,\theta_i,w), S(h_i,\bar{h})) \qquad (1)$$

$$s.t. \; c \le \theta_i w + h_i B \; ,$$

where $\mathrm{U}(\cdot)$ is the utility function. The standard assumption for utility from consumption c follows, i.e., $U_c > 0, U_{cc} < 0$. $S(\cdot)$ is the social stigma function representing disutility from “donating” plasma. The standard assumption $U_{cS} = U_{Sc} < 0$ follows, meaning that: (1) the greater the disutility is from “donating” plasma, the lower is the marginal utility of consumption, and (2) the marginal disutility from “donating” plasma becomes greater as consumption increases. In other words, wealthier people suffer more from an increasing social stigma than

[3] For simplicity, in this static model, labor productivity is not a function of “donating” plasma.

their poorer counterparts. Utility is decreasing in stigma, and the marginal disutility from stigma is increasing in stigma, i.e., $U_S < 0$, $U_{SS} < 0$ [4].

The average level of plasma "donation" in the reference group is $\bar{h}$. The wage rate in productivity term is w. A person with labor productivity θ_i receives $\theta_i w$ from labor provision.[5] The social stigma function $S(\cdot)$ satisfies two conditions: $S_h > 0$, $S_{\bar{h}} < 0$; $S_{hh} > 0$, $S_{h\bar{h}} < 0$. The first simply states that stigma increases in own "donation"; the second is that stigma decreases in peers' "donation". It is further assumed that a person does not have any compulsion or guilt associated with a decision not to "donate" plasma, regardless of the average plasma giving in the reference group, i.e. $S(0, \bar{h}) = 0$. The only effect exerted by peers is therefore operating through stigma. Thus, in combination, these conditions lead to the following proposition:

$$\frac{\partial h_i(\theta_i, \bar{h}, w)}{\partial \bar{h}} > 0 \qquad (2)$$

This proposition, which we test empirically and elaborate on in Appendix II, states that an individual's level of plasma "donation" increases in average "donation" in the reference group.

4. Data and Empirical Strategy

4.1 Data collection

Guizhou is one of the poorest provinces in Western China with its population comprised of more than 20 ethnic groups. Our study uses matched longitudinal household survey data

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[4] This assumption is supported by the survey data. In the survey, subjective questions on happiness and satisfaction were asked to each individual household member. Peers' plasma "donation" rate (a proxy of stigma) against these subjective ratings (a proxy of utility) are plotted in Appendix I. The first and second order conditions of utility with regard to stigma are consistent with the shapes of Appendix I.

[5] All the households in our census-type survey have access to only one blood bank that sets a unique price and maximum legal plasma income *B*; but human capital and, therefore, wage income vary across individuals.

collected in Guizhou.[6] The first data set collected gift records from all households in five randomly selected villages over a period from 1994–2012, including rich information on senders, receivers, and size of all cash and in-kind gifts. These records include all gift links within and across all 184 households from the five villages. In addition, we have rich information on gift exchanges between the 184 households and those in other villages. A total of 251 households are included in the gift-giving data set. The data were recorded by hosts at the time they were presented with gifts by guests, on the days that they hosted social events, including weddings, funerals, coming-of-age observances, childbirth, and house-moving ceremonies. Relatives were responsible for recording gifts, if the hosts were illiterate. Gift-receiving records were routinely kept for a long periods by recipients in order to serve as reminders to reciprocate in future gift giving when attending events. In total, more than 11,000 gift links among households in 2000–2012 were identified.

Second, a longitudinal survey of all 251 households involved in these gift exchanges was conducted in 2007, 2009, and 2012. In each wave, the survey collected household-level data on demographic characteristics, cash and in-kind transfers, and incomes and consumption, in addition to rich community-level information on public facilities, investment, and institutions. Descriptive statistics on the sample are shown in Table 1, and we present Foster-Greer-Thorbecke poverty measures on the sample in Table 2. These tables show that poverty was widespread, although, it decreased by half between 2007 and 2012. In contrast, inequality was increasing in the villages surveyed.

[6] This survey was jointly conducted by the International Food Policy Research Institute (IFPRI), Chinese Academy of Agricultural Sciences (CAAS), and Guizhou University.

The three rounds of household survey included information on plasma “donation”, including cash received. Information on “donating” plasma was collected on each family member, including those who were away at the time of survey. Given the sensitivity of collecting data on “donating” plasma, we made great efforts to ensure the accuracy of these data, including extensive training of local enumerators to effectively communicate with and elicit accurate information from the residents in our sampled villages.

Table 3 summarizes this information so that we can see that, in 2007, 10.3 percent of all households were engaged in plasma “donation”. The money received accounted for 4.5 percent of total income among all households, whether they “donated” plasma or not (Table 4). The 2010 follow-up survey of the same households indicated that 13.0 percent of households were engaged in plasma “donation” and that they contributed 8.7 percent to the total income, a doubling since 2007. This large increase was due mainly to an increase in the share of households with two or more individuals “donate”. By the time of the 2012 follow-up survey, 25 percent of households gave plasma, although there was a slight decline in the share of total income that those giving represented, down to 7.4 percent of the total income (Table 4). The explanation for the drop in the share of plasma “donation” in the total income is that the number of households with two or more “donors” dropped from 6.0 to 3.8 percent. Overall, unlike for the rich, the payment for plasma is significant, and the incentive to be a plasma “donor” is strong for the poor.

Appendix III depicts the dynamics of plasma “donation” in an example network using the matched longitudinal household survey data and the gift networks data. It is evident that households surrounded by more plasma “donors” in their networks are more likely to “donate” plasma in the following period.

4.2 Reference groups

Substantial ethnographic evidence documents social interactions at the village level in less developed rural communities. Foster (1967) argued that village interactions might be a more credible assumption than studies that use city blocks, census tracks, schools, or classrooms when villages are small. In a recent study, Mangyo and Park (2011) suggested that village reference groups are salient for rural residents living in close proximity. Therefore, we first define reference groups at the village level. The mountainous condition in our surveyed region further isolates connections with the outside world.

Apart from our defining the reference group by the village boundary, we exploit the rich information on gift networks to further define reference groups per each household’s corresponding gift receivers, which we refer to as *alters*, in keeping with the standard terminology in social network analysis. This alternative definition of gift receivers as the reference group has the advantage over the village-based definition, since it characterizes individual social interactions with multiple, partially overlapping reference groups.

Figure 1 illustrates the gift links for one of the five villages from which we collected network data. Gift exchange networks are more intense within clans and villages, perhaps due to their lower enforcement cost. A majority of residents may have kinship ties with each other in a traditional rural community, which largely determines social norms and shapes behavior. Though “donating” plasma is recognized as immoral in the Chinese culture, it becomes ethically acceptable when more people in a clan, and the communities in which they are concentrated, engage in what would be considered stigmatized behavior. This could explain our observation, drawn from mapping the data, that “donating” plasma is usually clustered among people with close social relations.

Proximity to other “donors” alone, however, may not compel households to become plasma “donors”, even if they have very similar socioeconomic characteristics, unless they are part of the same social network. To illustrate this more concretely, Figure 2 plots the positive relationship between average plasma “donation” decisions in the reference group (defined by village boundary) and own plasma “donation” decisions over the three waves of the survey. Each subfigure plots one of the plasma “donation” factors of the peers that we investigate in this paper—that is: (1) whether to “donate” plasma; (2) the income earned from “donating”; and (3) the number of household members “donating” plasma—against the mean of the own plasma “donation” decisions in the village. The positive relationship is strongest between the number of family members “donating” plasma in the network and own plasma “donation” decisions.

4.3 Empirical strategy: Identifications of peer influence

As we discussed in the introduction, the strength of our paper rests on our ability to tackle the identification problem that arises, since behavior is determined by behavior, which brings a circularity of cause and effect. Thus, parameters in classical peer effect models are not uniquely identified (Manski 1993 and 2000). We therefore need to circumvent the reflection problem that hinders disentangling endogenous from exogenous effects in estimating the impact of peer influence on "donating" plasma.

The conventional instrumental variable strategy might *partially* address this challenge, since part of the difficulty arises from the endogeneity of the behavior that enters both sides of the econometric equation. Lagged community-level instruments that directly affect lagged average group behavior, but arguably have no direct link to current individual behavior under evaluation, can be employed. However, this conventional strategy assumes that individuals interact in a partitioned group with a common boundary, and no influence comes from outside the group. Peer effects in this setting may not be identifiable (Manski 1993).

There has been growing recognition that social interactions within partitioned groups are very particular and not likely to fully represent the breadth of social interactions, while interactions in *partially* overlapping groups yield an identification strategy. Lee (2007) explored the role of variations in group sizes in identifying social interactions. De Georgi et al. (2010) assumed social interactions with multiple reference groups to identify peer effects. Following the literature in spatial econometrics (Case 1991; Anselin, Florax, and Rey 2004; Bramoulle, Djebbari, and Fortin 2009), we consider a linear-in-means peer effects model where each household has its specific reference group, and the average behavior and characteristics of the group influence one's own behavior. Interactions are structured through a directed social network. The relaxation of a group interactions assumption allows us to separate endogenous effects from exogenous effects and resolve the reflection problem.

Specifically, we estimate the following model for plasma "donation" decisions:

$$y_{i,P_i,t} = \alpha + \beta \frac{\sum_{j \in P_i} y_{j,t-1}}{n_{i,t-1}} + \gamma x_{i,P_i,t} + \delta \frac{\sum_{j \in P_i} x_{j,t}}{n_{i,t}} + \lambda_i + \phi_t + \varepsilon_{i,P_i,t} \ , \tag{3}$$

or in matrix notation,

$$Y = \alpha \iota + \beta GY + \gamma X + \delta GX + \lambda + \phi + \varepsilon \ , \tag{3'}$$

where an agent's plasma "donation" decision, $y_{i,P_i,t}$, is a linear function of the average behavior of its peers in a heterogeneous group P_i of size n_i, which partially overlaps with others' peer groups, own characteristics, x_i, and mean characteristics of the peer group. Agent *i* is excluded from the group defined by directed gift-exchange networks.

The term, $y_{i,P_i,t}$, denotes three indicators of "donating" plasma for household *i*: a dichotomous variable defined by whether or not it "donates" plasma; income from "donating" plasma; and number of household members engage in "donation". Both "donation" value and the number of members "donating" plasma measure engagement intensity. Average plasma "donation" decisions in peer groups are constructed in three ways to measure peer behavior: the first takes the simple average over peers' "donation" behavior; the second weighs peers' plasma "donation" decisions by row-normalized, pairwise gift values in the adjacency matrix and then takes the weighted average over peers' "donation" behavior for each individual; and the third weighs peers' plasma "donation" decisions by their centralities in the network.

β captures the endogenous peer effect of "donating" plasma, and δ, the exogenous effect of the peers' characteristics on individual's plasma "donation". The Generalized Spatial Two Stage Least Squares (GS2SLS) estimation is implemented to deal with the simultaneity in identifying peer effects β, as individual decisions might indirectly affect the average decision in the reference group. The reference groups are defined on gift networks with spatial instruments generated from the network structure. Specifically, we adopt a set of excluded peers' relevant characteristics as exclusion restrictions. Appendix IV derives and illustrates this spatial instrumental variable strategy in greater detail. Standard errors in all estimations are clustered at the network level. There are 42 independent networks in the gift exchange data.

X denotes a set of covariates, including the gender of the household head, their age, education, ethnicity, and information on cadre and party membership, household size, household per capita income (excluding "donating" plasma),[7] ratio of local wage to per 580cc plasma price, and whether any household members experienced major health shocks, death, or death of livestock.[8] The share of all household members, comprised of unmarried sons aged 11–29, is also included, with the expectation that when this value is high, it is associated with greater expenses associated with their getting married. This is expected to raise the incentive to "donate" plasma. Note that the plasma donors' age profile suggests that none of the unmarried sons give plasma, avoiding any direct effect of unmarried sons as potential "donors". The elderly persons (as a share of all household members) are controlled for due to the official stipulation that prohibits them from "donating" plasma. We further control for travel time to the local blood bank to capture nonmonetary cost.[9]

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[7] If a person is turned away because he/she looks sick, this could simultaneously affect his/her income, as the same appearance makes them look ill. Though it is unlikely that people were ever turned back from "donating" plasma, we replace income with its predicted value through regressing on family background and productive assets.

[8] Years between the three-wave household survey has witnessed significant changes in these characteristics, especially per capita income (due to high income growth, worsening income inequality, and high income mobility), household size (due to massive migration), relative wage (due to rapid rise in labor market wage and plasma "donation" compensation after the reopening of the blood bank), exposures to shocks and travel time to the local blood bank (due to improving public infrastructure that reduces time to commute), which give us sizable variations to identify the effects.

[9] Plasma "donation" behavior is often concentrated where local transportation conditions permit. Transportation conditions vary among villages. In villages with better road access, farmers use carts to transport people to the

Unobserved variables common to households who belong to the same social environment may be correlated with households' background, which causes an additional identification problem. To address this issue, we take the difference of equation (3) for people within the same network to eliminate unobserved factors at the network level.[10] Two types of within network differences can be derived: the *local* difference which expresses the model in deviation from the mean equation of one's direct contacts and the *global* difference which expresses the model in deviation from the mean equation of one's direct and indirect contacts.[11] Bramoulle, Djebbari, and Fortin (2009) showed that the *global* difference imposes less restrictive conditions to obtain identification. The endogenous peer effect (β) and exogenous effect of peers' characteristics (δ) can be distinguished on most networks when the *global* difference is adopted.

This strategy, however, does not address the concern over self-selection into the networks. Though randomizing reference groups may solve the endogenous formation of the peer group, one limitation is the irrelevance of assigned groups in many interactive decisions (Fletcher 2010). Our study relies on observational social network data. Neglecting endogenous friendship selection may overestimate peer effects to a large extent (Fletcher and Ross 2011).

Our partial solutions to endogenous network formation are twofold. First, it is possible that some unobserved factors, e.g., popularity, affect both the likelihood to form links and individual plasma "donation", but still differ among individuals in the same network. The

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county seat and the nearby blood bank, while for ethnic minority groups living in the mountains, people are less likely to "donate" plasma regularly.

[10] Note that our approach to remove correlated effects goes further than De Georgi et al. (2010), who argued that the instruments, i.e., characteristics of excluded peers, uncorrelated with the individual group shock suffice to solve endogeneity due to unobserved correlated effects.

[11] Both differences assume that no household is isolated, and the results are generally valid for any row-normalized matrix G.

network will not be exogenous, conditional on α and x. To avoid the resulting inconsistent estimates of social interactions, we assume that these unobservables do not change over time and estimate a fixed effect model to remove unobserved factors at the household level. Results not reported in the paper suggest that peer effects still account for within-household variations in plasma “donation”. Second, stigma associated with “donating” plasma may affect network formation and can be captured by the error term. We mitigate this concern by using the gift-exchange network data between 1994 and 2003, which predates the opening of a local blood bank. In other words, the formation of gift networks was established well before individuals were making decisions regarding whether or not to “donate” plasma.

5. Empirical Results

5.1 Main results

Tables 5a–5c present the main results on three plasma “donation” decisions, presenting OLS (column R1) and GS2SLS estimates (columns R2–R5) with the non-weighted adjacency matrix. Column R1 of Table 5a is a parsimonious specification and shows that the marginal effect of peers’ decision to “donate” plasma on the own probability of doing so is biased upward. Columns R2 through R5 present the results of the GS2SLS estimates, with the first stage and second stage estimations of our preferred specification in column R5 presented in Appendix V. F-tests of the excluded instruments indicate that weak instruments are not a concern. Overidentification tests fail to reject the validity of the spatial instruments.

Column R2 presents the same specification using the GS2SLS estimation strategy in which peers’ average probability to “donate” plasma is instrumented by characteristics of excluded peers generated from the network structure. The identified peer effects in columns R3 through R5 are robust to controlling for the rich set of individual and household characteristics, contextual covariates, and network fixed effects,[12] although the marginal effect decreases as we move across the columns, especially when we add individual and household controls in column R3 and contextual controls in column R4. Our preferred specification in columns R5 controls for the extensive set of individual and household covariates, contextual factors, and network fixed effects. The results suggest that a higher rate of 10 percentage points of plasma "donation" among peers raises the probability of an individual "donating" plasma by approximately 2.5 percentage points, or 13.9 percent.

Tables 5b and Table 5c present corresponding results on plasma "donation" value and the number of family members "donating", respectively. The GS2SLS estimates in our preferred specification in column R5 suggest that a 10.0 percent increase in peers' income from "donating" plasma raises individual income from "donating" plasma by 3.0 percent (Table 5b). Evaluated when the first family member begins giving plasma, one more peers' family member then giving plasma, on average, leads to a higher chance, by 46.9 percentage points, that a second family member in a household gives plasma (Table 5c). We should note that the actual magnitude of increase in the number of additional family members "donating" is still relatively small, since only 25.8 percent families "donating" plasma have more than one member engaged in such a practice.

[12] Beyond column R2, controlling for individual and household characteristics in column R3 reduces the peer effect estimate by 24 percent (1–0.390/0.513). Column R4 further includes contextual controls, and the peer effect estimate reduces by 23 percent (1–0.297/0.390). Further controlling for network fixed effects in our preferred column R5, the peer effect estimate drops by 16 percent (1–0.250/0.297).

Throughout columns R1–R3 in Appendix V, none of the exogenous effects, other than exposure to livestock deaths, is significant, suggesting social interactions mainly operate through peers' behavior.

Key individual and household characteristics are worth noting. Having an unmarried son is associated with a greater incentive to give plasma, which is probably due to the strong motive to earn extra money to get the son married in the competitive marriage market, with skewed sex ratios favoring females. Households with more elderly persons are less likely to "donate" plasma, as are those with higher income and of minority status.

Table 6 reports the impact size as a 1 standard deviation change in peers' average behavior in terms of the impact on individual behavior, as expressed in standard deviations. The effect sizes vary across 3 plasma-giving decisions, ranging from 0.124 for plasma "donation" probability to 0.232 for the number of family members engaged in. Unfortunately, the lack of empirical evidence from other similar studies on peer effects of stigmatized behavior prevents us from making a more meaningful comparison of these effects, though there is little question of their importance.

5.2 Additional analysis and robustness

Table 7 relaxes the prior assumption that all links or contacts impose the same influence over an individual under investigation. Specifically, we next assume that strength of the link matters in terms of the influence over the individual's plasma-giving behavior. In specification 2, each peer's plasma-giving decision is weighed by the size of the gift that they send to another individual. An alternative assumption we make is that peers' positions in the networks have influence over the individual, so each peer's plasma decision is weighted by measures of their network centrality, including out-degree centrality (specification 3), in-degree centrality (specification 4), and the Bonacich centrality (specification 5; see Table 1 for summary statistics). Correspondingly, the adjacency matrices for social interactions are all row-normalized. In Table 7, GS2SLS estimations with these differently weighed adjacency matrices are compared to that with a non-weighted adjacency matrix in Tables 5a–5c. Overall, surprisingly, we do not find any larger or more significant peer effect estimates in Table 7 than the baseline results reported in Table 5. While the existence of a gift link matters to social interactions, this result may in part reflect that gift size and individual's position in the gift networks are relatively homogeneous and are indicative of the well-recognized norm of ceremonial gifting in these traditional, agrarian communities (Chen, Kanbur and Zhang 2011).

Robustness checks are presented in Table 8. First, as a falsification test, we randomly assign households to placebo peer groups. Peer effects disappear, reassuring us that the real gift network data we collected captures the domain of social interactions and that our identified peer effects are causal. Second, more nuanced checks are done, and the main results do not vary. For example, similar to De Giorgi, Pellizzari, and Redaelli (2010), we change the set of excluded peers' characteristics as instruments. All these checks indicate that the results on peer effects are robust to changes in the set of instruments.[13]

Studies have argued that exploiting directionality in networks is a useful identification strategy to test spurious correlations (Christakis and Fowler 2007; Bramoulle, Djebbari, and Fortin 2009). Our identification so far relies on defining peers as people to whom one sends

[13] These results are available upon request.

gifts (also known as an ego-perceived network, in which an ego identifies an alter as a friend via giving a gift). An alter-perceived network, however, consists of alters who identify egos as friends via sending gifts to egos. If contextual effects do not spuriously drive the relationship observed between the individual and peers' plasma "donation" behavior, we should observe weaker or even no relationship between the two when peer effects are identified using alter- but not ego-perceived peers. Results reported in Table 8 indeed show no evidence of any effect. This provides suggestive evidence in favor of a causal interpretation regarding peer influences on "donating" plasma.

5.3 The potential mechanisms of peer effects

The presence of endogenous interactions arguably might be too broad to be very helpful to guide policy (Manski 2000). There are distinct channels whereby group interactions affect individual behavior. First, preference interactions determine that the disutility associated with "donating" plasma declines (increases) as more (fewer) peers engage in the practice, which promotes (discourages) individual plasma "donation". Second, information disseminated on the profit and risk associated with "donating" plasma may shape expectations through social interactions. Households with more "donors" in their networks may increase "donation" if profit dominates.

Prescriptions for appropriate public policy differ between preference interactions and expectation interactions. If expectation interactions are at play, an educational intervention curbing frequent plasma giving might be useful, if information on its devastating health effects or potential risks is constrained. However, the same educational intervention becomes superfluous later on, when information is abundant and preference interactions become the major channel. More attention should then be given to policies that change preference.

Expectation interactions *alone* may not provide a satisfactory explanation in our context. In 2006, a hepatitis C epidemic affected the region, and all blood banks were shut down due to blood contamination. During the epidemic the local government made every effort to publicize information on the situation and the associated health risks, including sending officials to speak individually with each family. An open-ended survey in 2007, designed to elicit individuals' perceptions of “donating” plasma, indicated that information on both benefits and costs of “donating” plasma had been effectively transmitted to the public through such outreach. Specifically, 96 percent of all respondents in our study correctly recalled the size of cash compensation for plasma “donation”; and 97 percent of respondents also listed potential devastating impacts of regularly “donating” plasma, such as lack of strength, disease infection, appetite loss, fatigue, nausea, and vomiting. Among migrants vulnerable to work-related accidents, almost all believed that “donating” plasma was riskier than an industrial injury. Other evidence that demonstrates the role played by information dissemination is that, compared to rate of plasma “donation” in 2006 of 31.2 percent before the shutdown of the blood bank, the rate of plasma “donation” dropped to 10.3 percent initially after the reopening of local blood banks in 2007. However, the doubling of plasma “donation” rate in five years, between 2007 and 2012, suggests that the channel of information diffusion could be seriously time-limited.

Preference interactions are likely a main mechanism at work in explaining peer effects. As we discussed above, disutility from social stigma may decline when more peers participate, which promotes more plasma “donation”. What we are unable to substantiate is the exact cause of the stigma: is it that a person is labeled as being poor and lazy due to large financial incentives to "donate", the potential spread of infectious diseases due to operational scandals and epidemics, or a range of possible cultural taboos? The only real empirical insight we get into this issue is based on the 2007 open-ended survey, in which approximately 90 percent of respondents (including both plasma "donors" and those who had never "donated" plasma) reported that it was difficult to talk to others about plasma giving. A majority of the plasma "donors" and "non-donors" responded that people may avoid the "donors", judge them badly, or misunderstand them, and a few answered that they did not want or think people should take pity on them. Though we are not able to locate the exact stigma that may drive the identified peer effects, they all support the strong effect we observe in our analysis.

6. Conclusions

Information on stigmatized behavior is often too sensitive to collect. Combining two unique sources of primary data on long-term social networks and a rich census-type panel survey that includes data on one kind of stigmatized behavior, "donating" plasma in rural China, we are able to add to the limited number of empirical studies on stigmatized behavior with rich information on individual engagement. We also uniquely collected long-term spontaneous gift-receiving records kept by each household to provide early evidence on how social interactions may shape stigmatized behavior.

Our novel identification strategy relies on spatial instruments that are naturally generated from the network structure in order to gauge peer influence on "donating" plasma. The strategy effectively solves the reflection problem and distinguishes correlated effects that are problematic in empirical studies on peer effects. The unprecedented, rich information on real social connections through long-term gift exchanges enables us to probe into the intensity of social interactions.

We find strong evidence of peer influence, which enriches our understanding of social determinants of "donating" plasma. The intensity of social interactions, however, plays a trivial role in identification. Peer influences are salient in ego-perceived networks but not in alter-perceived networks, which reassures us that contextual effects may not drive the results. In addition to social interactions, poorer families tend to give more plasma. Families with unmarried sons give more plasma, presumably to create a better position for their sons in the highly competitive marriage market in China. They use the proceeds from the "donation" to buy bigger houses, pay higher bride prices, and throw more lavish wedding banquets. All these actions occur, despite the fact that the stigmatized behavior of "donating" plasma often evokes popular discomfort, distrust, and even outrage among the public.

Our results indicate that individual plasma "donation" may increase with peers' average "donation" via both expectation interactions and preference interactions. Contextual interactions and correlated effects, however, imply no such feedbacks. Programs targeting popular agents in the networks and, therefore, curbing indulgence in stigmatized behavior may be effective in reducing risky plasma "donating" behavior. This action may indirectly reduce plasma giving from peers with feedback to further decrease "donation" from the targeted households.

The issue of plasma "donation" under unhygienic conditions is important in its own right. It engenders devastating impacts on "donors", including adverse effects on health and labor supply, and at the same time does little to alleviate poverty and intergenerational inequality. The devastation of the HIV crisis in Henan Province in China in the 1990s and the hepatitis C crisis in Guizhou Province in the 2000s, in which plasma "donation" contributed to both crises, are episodes that warrant careful reflection to avoid similar events in the future. Having shown the significance of social interactions, understanding its exact mechanisms and consequences will be valuable questions open to future research.

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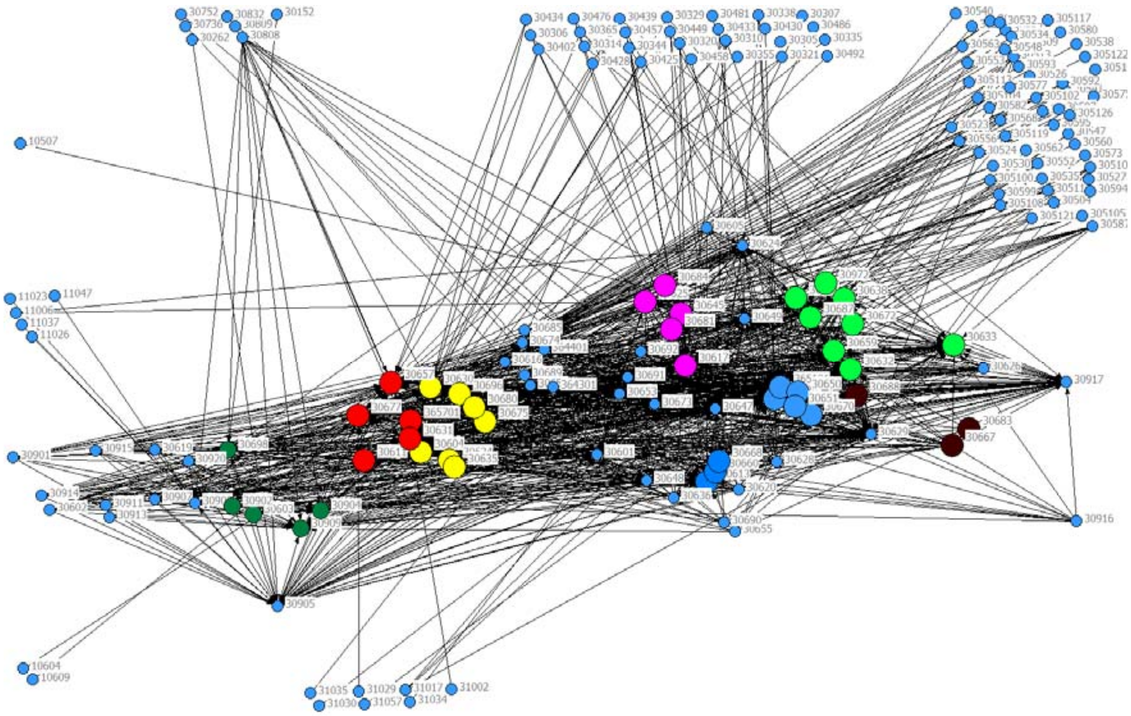


Figure 1. Long-term Gift Exchange Network in One Village

Source: Authors' gift network data from one of the five villages.
Note: Dots of the same color show households in the same clan. Dots to the boundaries show households from other villages. The dots (households) are based on actual geographic locations.

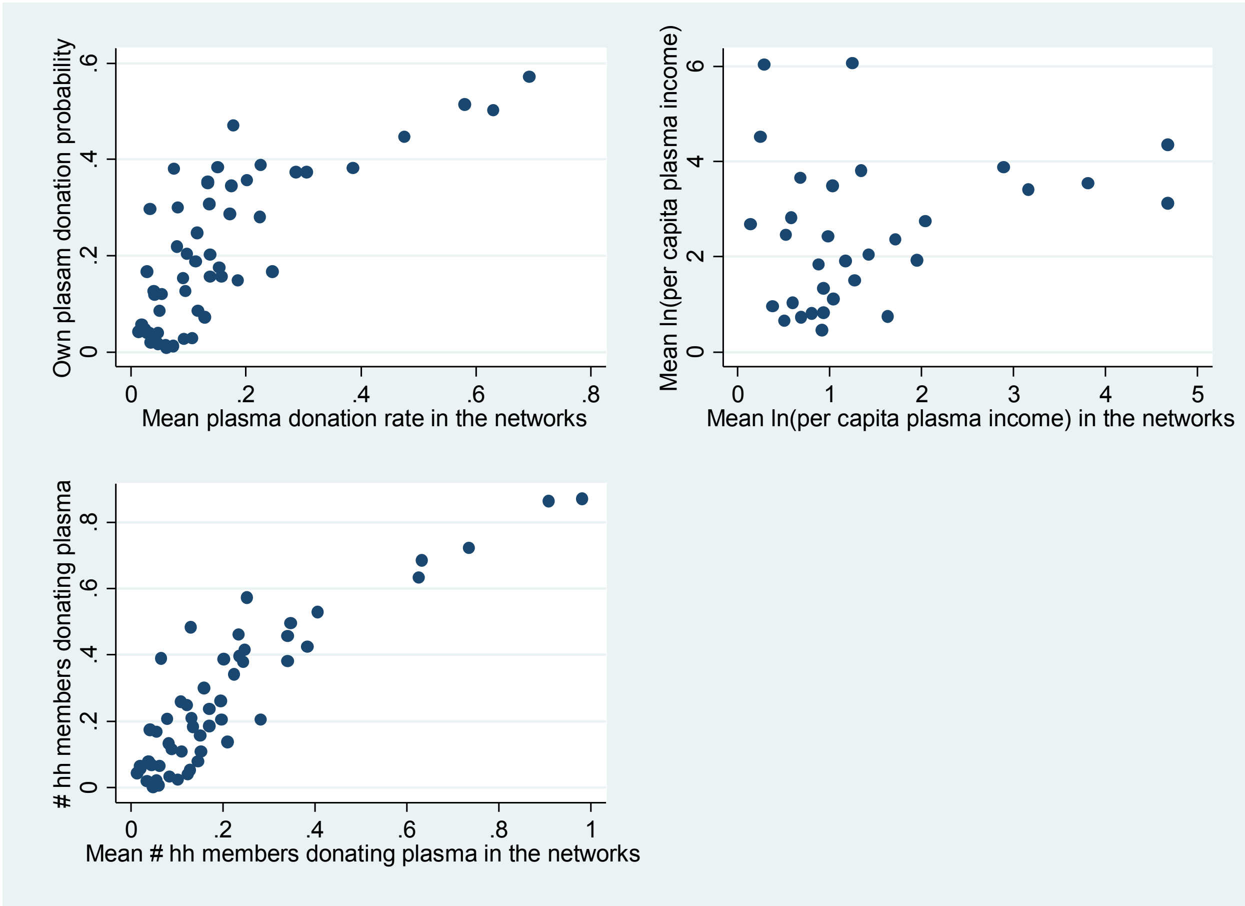


Figure 2. Peer Influence on Household Plasma "Donation"

Source: Authors' survey data

Notes: The horizontal axes denote peers' mean plasma "donation" decisions, including whether to "donate" plasma, income earned from "donating" plasma, and the number of household members who "donate" plasma. The vertical axes denote own plasma "donation" decisions. Each dot represents one village, which takes the mean of own plasma "donation" decisions and peers' mean plasma "donation" decisions at the village level.

Table 1. Summary Statistics (2007–2012)

Variables	*Mean*	*S.D.*
Distance to the county seat (km)	5.58	3.25
Share of minority households (%)	0.32	0.47
No. of household members	4.30	1.64
Household head age (years)	47.12	12.81
Village leader or party member (Y/N)	0.09	0.29
Share of household members aged 11–29, unmarried (%)	0.21	0.23
Share of household members aged 60 and above (%)	0.13	0.27
Male head of household (dummy)	0.93	0.26
Education of household head (year)	4.15	3.20
Per capita cultivated land (mu)	1.05	1.05
Own farm machine (Y/N)	0.01	0.11
Own cow (Y/N)	0.24	0.65
Own horse (Y/N)	0.03	0.23
No. of occurrences of major disease among family members in last 2 years	0.46	0.68
No. of occurrences of livestock deaths in last 2 years	0.38	0.60
Normalized in-degree centrality (popularity)	0.04	0.22
Normalized out-degree centrality (influence)	0.04	0.06
Normalized Bonacich centrality	7.56	15.60

Source: Authors' survey data

Table 2. Summary Statistics on Poverty and Income Inequality (2007–2012)

	Total		
Poverty and income inequality measures	*2007*	*2010*	*2012*
Per capita annual income (RMB)	1,817.3	2,795.7	3,004.2
Income inequality (Gini)	48.2	55.2	57.1
Income inequality excluding "donating" plasma (Gini)	49.0	56.6	58.3
Income below poverty line of 892 RMB (%) (P0)	36.3	22.4	18.3
Poverty-gap below poverty line of 892 RMB (P1)	15.0	10.1	8.5
Squared poverty-gap below poverty line of 892 RMB (P2)	8.3	6.4	5.5

Source: Authors' survey data.

Table 3. Summary Statistics on Households "Donating" Plasma (2007–2012)

	2007	*2010*	*2012*
Participation rate in "donating" plasma (%)	10.3	13.1	25.0
% households with one plasma "donor"	7.6	7.1	21.2
% households with two or more plasma "donors"	2.7	6.0	3.8
Mean per capita income from "donating" plasma (RMB per year)	82.2	242.4	222.5
Gross cash benefit from "donating" plasma (per 580cc)	150	150	150

Source: Authors' survey data

Note: The gross cash benefit from "donating" plasma (per 580cc), 150 RMB, is before deducting any cost incurred around each plasma giving. However, all direct costs incurred around plasma giving, such as transportation fee, lodging fee, and basic nutrients intake to minimize damage to health, are supposed to be deducted to generate the mean per capita income from "donating" plasma (RMB per year).

Table 4. Main Sources of Income (Percent) (2007–2012)

	Total		
	2007	*2010*	*2012*
Main Sources of Income (percent)			
Farming	31.4	33.1	33.3
Livestock	6.8	6.9	8.1
Local non-farm and self-employment	30.0	23.8	24.0
Remittance from migrants outside the county	13.1	8.8	8.0
Disaster relief, anti-poverty programs, deforestation subsidies	2.0	5.4	2.8
Gift income	9.1	8.2	6.6
Income from "donating" plasma	4.5	8.7	7.4
Other income (including land leasing)	3.1	5.1	9.8

Source: Authors' survey data.

Table 5a. Impact of Peer Effects on Probability of "Donating" Plasma (2007–2012)

	R1	*R2*	*R3*	*R4*	*R5*
		Network Peer Group + Link			
	OLS	*GS2SLS*	*GS2SLS*	*GS2SLS*	*GS2SLS*
Lagged peers' mean rate of plasma "donation"	0.801***	0.513***	0.390**	0.297**	0.250**
	(0.097)	(0.100)	(0.175)	(0.128)	(0.125)
Individual and household controls	No	No	Yes	Yes	Yes
Contextual controls	No	No	No	Yes	Yes
Direct and indirect network fixed effects	No	No	No	No	Yes
F test excluded instruments	-	103.13	61.20	11.83	12.13
p-value over-identification test	-	0.265	0.186	0.184	0.247
(Pseudo) R2	0.064	0.198	0.330	0.339	0.363
N	753	753	753	753	753

Notes:
[1] Linear probability models (LPM) are estimated. Marginal effects from LPM are presented.
[2] Robust standard errors are clustered at the network level. *significant at 10%; **significant at 5%; ***significant at 1%.
[3] Excluded instruments in the GS2SLS estimations include the following characteristics of peers' peers: per capita income excluding plasma "donation" compensation, household size, ethnicity, education, share of the elderly, share of unmarried son, relative market wage to plasma "donation" compensation, cadre status, travel time to the local blood bank, and major shocks (including major diseases, livestock deaths, natural disasters, and family member deaths).
[4] Village fixed effects and year fixed effects are included in individual and household controls.

Table 5b. Impact of Peer Effects on Income from "Donating" Plasma (2007–2012)

	R1	*R2*	*R3*	*R4*	*R5*
	Network Peer Group + Link				
	OLS	*GS2SLS*	*GS2SLS*	*GS2SLS*	*GS2SLS*
Lagged peers' mean income from "donating" plasma	0.834***	0.558***	0.445***	0.367***	0.303**
	(0.101)	(0.101)	(0.173)	(0.127)	(0.123)
Individual and household controls	No	No	Yes	Yes	Yes
Contextual controls	No	No	No	Yes	Yes
Direct and indirect network fixed effects	No	No	No	No	Yes
F test excluded instruments	-	103.17	61.34	11.36	11.65
p-value over-identification test	-	0.223	0.136	0.143	0.197
(Pseudo) R2	0.078	0.208	0.329	0.344	0.366
N	753	753	753	753	753

Notes:
[1] Robust standard errors are clustered at the network level. *significant at 10%; **significant at 5%; ***significant at 1%.
[2] Village fixed effects and year fixed effects are included in individual and household controls.

Table 5c. Impact of Peer Effects on Number of Household Members "Donating" Plasma (2007–2012)

	R1	R2	R3	R4	R5
		Network Peer Group + Link			
	OLS	*GS2SLS*	*GS2SLS*	*GS2SLS*	*GS2SLS*
Lagged peers' mean no. of household members "donating" plasma	0.924***	0.673***	0.537***	0.525***	0.469**
	(0.130)	(0.122)	(0.195)	(0.135)	(0.135)
Individual and household controls	No	No	Yes	Yes	Yes
Contextual controls	No	No	No	Yes	Yes
Direct and indirect network fixed effects	No	No	No	No	Yes
F test excluded instruments	–	123.37	60.72	14.67	15.00
p-value over-identification test	–	0.447	0.104	0.397	0.535
(Pseudo) R2	0.110	0.225	0.358	0.361	0.384
N	753	753	753	753	753

Notes:

[1] Marginal effects are presented. Robust standard errors are clustered at the network level. *significant at 10%; **significant at 5%; ***significant at 1%.

[2] Village fixed effects and year fixed effects are included in individual and household controls.

Table 6. Effect Sizes

	(1)	(2)	(3)	(4)
	S.D. Plasma "Donation" σ_Y	*S.D. Peers' Plasma "Donation"* σ_{GY}	*Peer Effects* $\hat{\beta}$	*Effect Size* $\sigma_{GY}\hat{\beta}/\sigma_Y$
Plasma "donation" probability	0.368	0.182	0.250	0.124
Plasma "donation" value (log)	2.488	1.241	0.303	0.151
No. of household members "donating"	0.496	0.245	0.469	0.232

Notes: The estimates of peer effects in column (3) are taken from the scenario R5 in Table 5 (a) – (c).

Table 7. Peer Effects with Alternative Weightings

	R1	*R2*	*R3*
Lagged Peers' mean rate of plasma "donation"	*"Donate" or not*	*"Donation" value*	*No. of hh members "donating"*
1. Baseline	0.250**	0.303**	0.469**
	(0.125)	(0.123)	(0.135)
2. Weighed by pairwise link intensity (gift size)	0.153	0.205*	0.297**
	(0.119)	(0.117)	(0.129)
3. Weighed by out-degree centrality based on number of links	0.236**	0.284**	0.438***
	(0.121)	(0.119)	(0.129)
4. Weighed by in-degree centrality based on number of links	0.234**	0.280**	0.381***
	(0.115)	(0.113)	(0.123)
5. Weighed by Bonacich centrality based on pairwise link	0.249**	0.298**	0.501***
	(0.127)	(0.125)	(0.135)

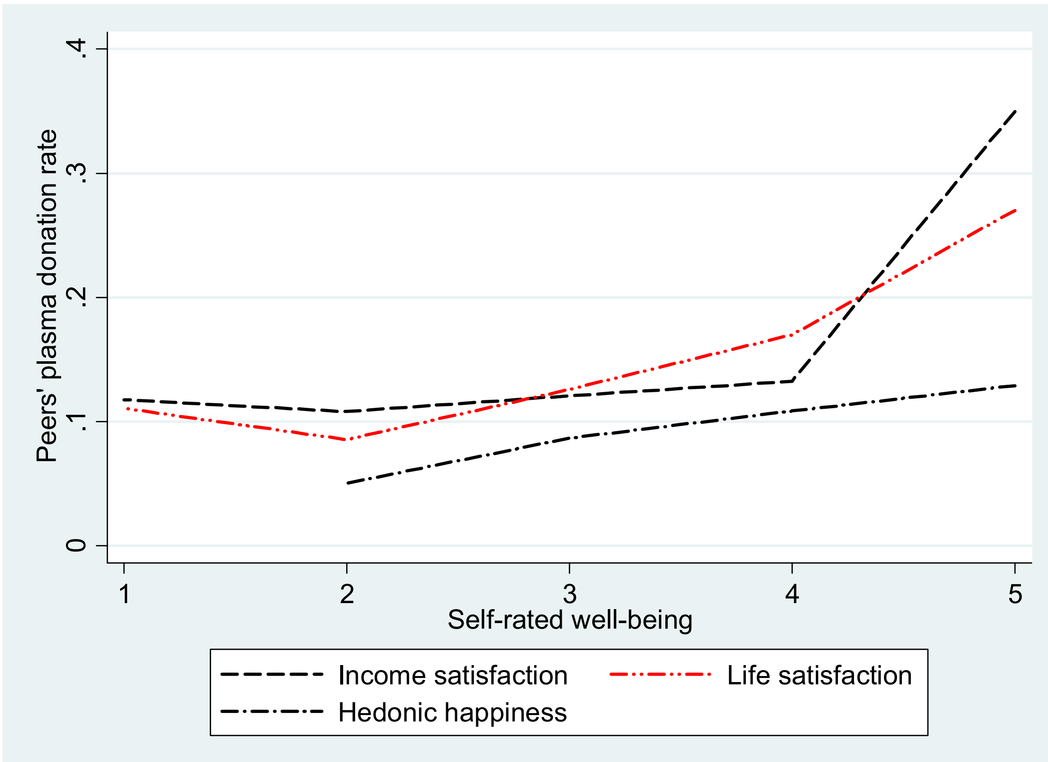
Notes:
[1] In-degree centrality is defined as (normalized) number of links the respondent receives from peers, which measures one's influence over peers.
[2] Out-degree centrality is defined as (normalized) number of links the respondent sends out to peers, which measures one's popularity in the network.
[3] Centrality comprehensively measures direct and indirect connections one has in one's neighborhood. In addition to direct links, the more connections the actors in one's neighborhood have, the more central one is (Bonacich 1987).

Table 8. Other Tests on Peer Effects

Lagged peers' mean plasma "donation"	*R1* *"Donate" or not*	*R2* *"Donation" value*	*R3* *No. of hh members "donating"*
1. Baseline	0.250**	0.303**	0.469**
	(0.125)	(0.123)	(0.135)
2. Testing reference groups: Using placebo groups	-0.095	-0.102	-0.055
	(0.118)	(0.118)	(0.117)
3. Testing peer effects using alter-perceived but not ego-perceived peers	0.099	0.128	0.120
	(0.167)	(0.164)	(0.163)

Notes:
[1] Robust standard error in parentheses.
[2] Other notes follow Table 5a

ONLINE APPENDIX



Appendix I. Peers' Higher Plasma "Donation" Rate (or Lower Stigma) and own Subjective Well-Being

Data: Authors' household survey data.

Note: The vertical axis, i.e., peers' average plasma-giving rate, inversely approximates social stigma. The horizontal axis, i.e., three subjective well-being (SWB) measures in the survey, approximate individual utility. 5 points to being the most satisfied or happiest, 1 points to being the least satisfied or least happy. This figure suggests that utility may decrease in stigma, and most SWB measures indicate that the marginal disutility from stigma is increasing.

Appendix II. Proof of the Proposition

The first order condition for an interior solution is:

$$B\frac{\partial U(c(h_i,\theta_i,w),S(h_i,\overline{h}))}{\partial c}+\frac{\partial U(c(h_i,\theta_i,w),S(h_i,\overline{h}))}{\partial S}\frac{\partial S(h_i,\overline{h})}{\partial h_i}=0\,, \tag{A1}$$

which solves optimal level of "donating" plasma $h^*(\theta_i,\overline{h},w)$, given the labor productivity (θ_i), the average level of "donating" plasma in the reference group ($\overline{h}$), and the wage rate (w). The second order condition is satisfied. Let $\underline{\theta}$ denote the lower threshold of labor productivity below which an agent "donates" the maximum legal level, while $\overline{\theta}$ denotes the upper threshold of labor productivity, above which an agent does not "donate" plasma.

Considering the corner solutions for h, if an individual "donates" the maximum legal plasma ($h \to 1$), according to Kuhn-Tucker condition we have:

$$B\frac{\partial U(c(1,\theta_i,w),S(1,\overline{h}))}{\partial c}+\frac{\partial U(c(1,\theta_i,w),S(1,\overline{h}))}{\partial S}\frac{\partial S(1,\overline{h})}{\partial h_i}\geq 0\,, \tag{A2}$$

where the labor productivity is low enough that the marginal utility of consumption dominates the marginal disutility of social stigma for the whole range of h. The equality (A2) holds with $\underline{\theta}$. In contrast, if the labor productivity is high enough that the marginal utility of consumption is dominated by the marginal disutility of social stigma for the whole range of h, the following inequality holds. The following equality holds with $\overline{\theta}$:

$$B\frac{\partial U(c(0,\theta_i,w),S(0,\overline{h}))}{\partial c}+\frac{\partial U(c(0,\theta_i,w),S(0,\overline{h}))}{\partial S}\frac{\partial S(0,\overline{h})}{\partial h_i}\leq 0\,. \tag{A3}$$

Finally, to achieve the interior market equilibrium of peer Influence, an ex-ante expectation of average plasma "donation" should coincide with the resulting average plasma "donation" given the expectation:

$$\overline{h}=\int_{\theta_{\min}}^{\theta_{\max}} h_i(\theta,\overline{h},w)dF(\theta)\ , \tag{A4}$$

where $\theta_{\min}<\underline{\theta}<\overline{\theta}<\theta_{\max}$. Meanwhile, a stable equilibrium of the peer Influence requires that $\partial h_i/\partial\overline{h}<1 \quad \forall\theta_i,\overline{h},w$.

Differentiating LHS of (1) with respect to w yields:

$$B[U_{cc}(c_h \frac{\partial h_i}{\partial w} + c_w) + U_{cS} S_h \frac{\partial h_i}{\partial w}] + U_S S_{hh} \frac{\partial h_i}{\partial w} + S_h [U_{Sc}(c_h \frac{\partial h_i}{\partial w} + c_w) + U_{SS} S_h \frac{\partial h_i}{\partial w}] = 0 \quad \text{(A5)}$$

Collecting the term $\partial h_i / \partial w$, we have:

$$\frac{\partial h_i}{\partial w} = -\frac{B\theta_i U_{cc} + S_h U_{Sc}\theta_i}{BU_{cc}c_h + BU_{cS}S_h + U_S S_{hh} + S_h U_{Sc} c_h + (S_h)^2 U_{SS}} = -\frac{B\theta_i U_{cc} + S_h U_{Sc}\theta_i}{SOC} < 0 \quad \text{(A6)}$$

$$sign(\frac{\partial h_i}{\partial w}) = sign(\frac{\partial h_i}{\partial \theta_i}) < 0 \quad \text{(A7)}$$

Therefore, both the rising wage rate (w) and labor productivity (θ_i) have a negative impact on "donating" plasma. First, growth in consumption induces a fall in marginal utility of consumption; second, a rise in consumption makes marginal disutility of the social stigma greater.

To derive the impact of peer pressure on plasma "donation", we differentiate LHS of (A1) with respect to $\bar{h}$, which yields:

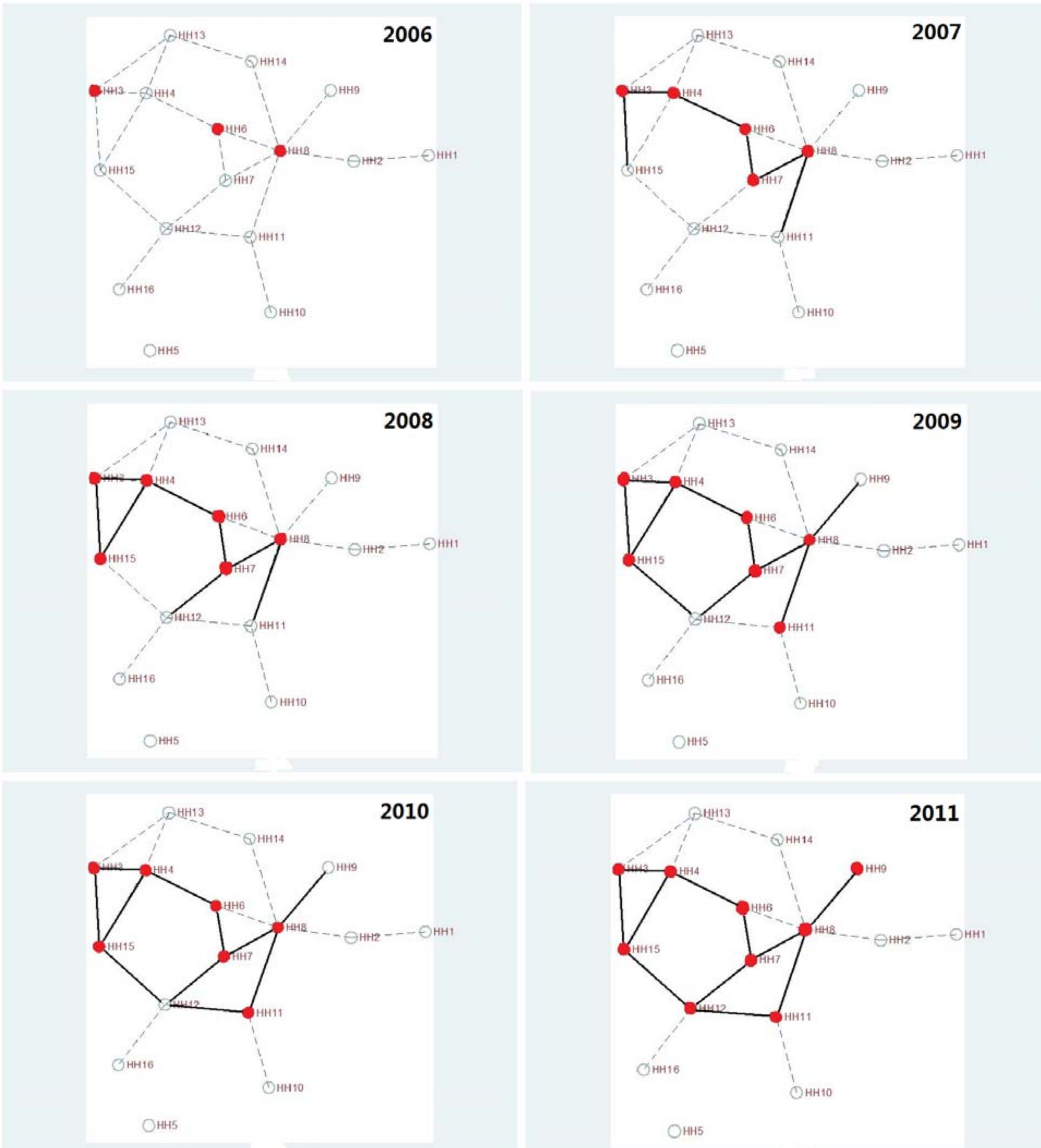
$$\begin{aligned} &BU_{cc}c_h \frac{\partial h_i(\theta_i, \bar{h}, w)}{\partial \bar{h}} + BU_{cS}[S_h \frac{\partial h_i(\theta_i, \bar{h}, w)}{\partial \bar{h}} + S_{\bar{h}}] + U_S[S_{hh} \frac{\partial h_i(\theta_i, \bar{h}, w)}{\partial \bar{h}} + S_{h\bar{h}}] \\ &+ S_h[U_{Sc}c_h \frac{\partial h_i(\theta_i, \bar{h}, w)}{\partial \bar{h}} + U_{SS}(S_h \frac{\partial h_i(\theta_i, \bar{h}, w)}{\partial \bar{h}} + S_{\bar{h}})] = 0 \end{aligned} \quad \text{(A8)}$$

Collecting the term $\partial h_i / \partial \bar{h}$, we get:

$$\frac{\partial h_i(\theta_i, \bar{h}, w)}{\partial \bar{h}} = -\frac{BU_{cS}S_{\bar{h}} + U_S S_{h\bar{h}} + S_h U_{SS} S_{\bar{h}}}{BU_{cc}c_h + BU_{cS}S_h + S_{hh}U_S + S_h U_{Sc} c_h + (S_h)^2 U_{SS}} = -\frac{BU_{cS}S_{\bar{h}} + U_S S_{h\bar{h}} + S_h U_{SS} S_{\bar{h}}}{SOC} > 0 \quad \text{(A9)}$$

More intense plasma "donation" in the neighborhood induces *i* to more actively "donate" plasma.

Appendix III. Plasma “Donation” Decisions Transmitting through Social Networks



Data: Authors’ household survey data matched with gift networks data.
Notes: This appendix provides a real example of plasma “donation” transmitting via gift networks during 2006–2011. Each dot represents a household, and red dots indicate that the households “donate” plasma. Each (dashed or solid) line represents a gift. There are four cases: (1) a solid line between two red dots means a gift between two plasma “donors”; (2) a solid line between a red dot and an empty dot means a gift between a current plasma “donor” and a future “donor”; (3) a dashed line between two empty dots means a gift between two “non-donors”; and (4) a dashed line between a red dot and an empty dot means a gift between a plasma “donor” and a “non-donor”.

Appendix IV. Derivation and Illustration of Spatial Instruments Identification

Appendix IV derives and illustrates our spatial instrumental strategy to overcome the reflection problem. We also discuss the additional strategy to mitigate correlated effects that may complicate our peer influence identification.

Ignoring correlated effects for a moment, our structural model for plasma "donation" decisions is:

$$y_i = \alpha + \beta \frac{\sum_{j \in P_i} y_j}{n_i} + \gamma x_i + \delta \frac{\sum_{j \in P_i} x_j}{n_i} + \varepsilon_i, \qquad \mathrm{E}[\varepsilon_i \mid X] = 0$$

The meanings of mathematical notations follow equation (3) in Section 4.3. Other than assuming the strict exogeneity of the regressors, i.e., $\mathrm{E}[\varepsilon_i \mid X] = 0$, no assumption is made on the error terms within a network. The model in matrix notation defined over all networks is:

$$y = \alpha\iota + \beta Gy + \gamma x + \delta Gx + \varepsilon, \quad \mathrm{E}[\varepsilon_i \mid x] = 0,$$

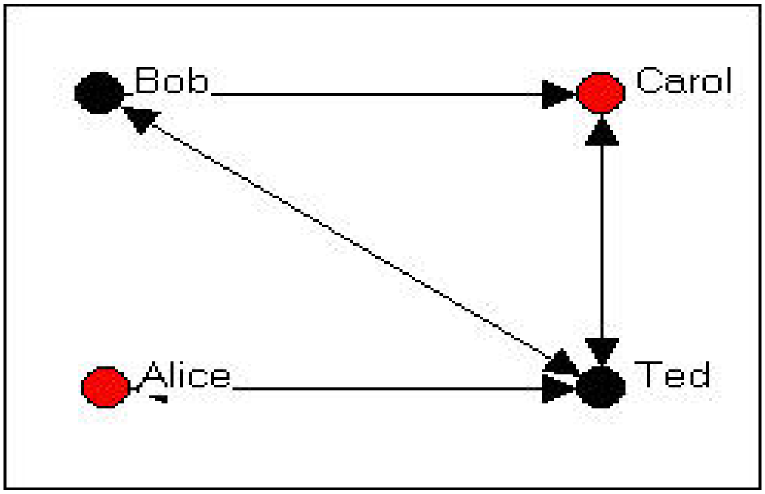
where G is an $\mathrm{n}*\mathrm{n}$ interaction matrix (or *adjacency matrix*) with $G_{ij} = 1/n_i$ if *i* send gifts to *j* and 0 otherwise. ι is a $\mathrm{n}*1$ vector of ones. The corresponding reduced form is:

$$y = \alpha(I - \beta G)^{-1}\iota + (I - \beta G)^{-1}(\gamma I + \delta G)x + (I - \beta G)^{-1}\varepsilon$$

$\sigma_{Gy}\hat{\beta} / \sigma_y$ quantifies peer effects as the impact of a one standard deviation (SD) change in peers' average behavior in terms of SDs of the individual behavior. σ_y indicates variations in own behavior, σ_{Gy} shows variations in peers' average behavior, and Gy denotes peers' average behavior (Ammermueller and Pischke 2009).

Bramoulle, Djebbari, and Fortin (2009) showed that the model is identified if $E[Gy \mid x]$ is not perfectly collinear with (x, Gx). A necessary condition for identification is that the matrices I, G, and G^2 must be linearly independent. If so, peers' peers' characteristics, $G^2 x$, are valid instruments. A sufficient condition for identification is that individuals interact through a heterogeneous network that has an intransitive triad. In other words, there are individuals whose peers' peers are not all their friends (De Georgi et al. 2010).

We illustrate the identification with a fictitious network example. Our peer group definition is directional, depending on whether a gift is sent or not. In this fictitious case, Bob sends a gift to Carol and Ted, but not Alice; Carol only sends a gift to Ted; Ted sends to Bob and Carol and Alice; and Alice only sends to Ted. For Bob, Carol and Ted are in the peer group, while Alice is a peers' peer. For Carol, Ted is in the peer group, while Alice and Bob are peers' peers. For Ted, all other agents are in the peer group. For Alice, only Ted is in the peer group, while Bob and Carol are peers' peers. For all four agents, their excluded peers' characteristics can serve as instruments for their own peers' characteristics.



To remove correlated effects, a within network difference is taken by pre-multiplying $J = I - G = I - \frac{1}{n}\iota\iota'$, and the structural model becomes:

$$Jy = \beta JGy + \gamma Jx + \delta JGx + J\varepsilon,$$

where $\mathrm{E}[\varepsilon \mid x]$ is allowed to be any function of x. Conditional on α, x is strictly exogenous. The matrix G is assumed to be exogenous conditional on α and x, i.e., $\mathrm{E}[\varepsilon \mid x, G, \alpha] = 0$. The reduced form is:

$$Jy = J(I - \beta G)^{-1}(\gamma I + \delta G)x + J(I - \beta G)^{-1}\varepsilon$$

The model is identified if the matrices I, G, and G^2 are linearly independent, and JG^2x are valid instruments. It is sufficient to conclude that peer effects are identified when the diameter of a network (i.e., maximal gift exchange distance) is greater than or equal to 3, meaning, for example, that at least two agents, i and j, are separated by a friendship network of distance 3.

Appendix V. Spatial Identification on Peer Effects (Full Estimation Results, 1st and 2nd stages)

	R1		R2		R3	
	"Donate" or not		*"Donation" value*		*No. of hh members "donating"*	
Endogenous Social Effects = (I–G)Gy	0.250**	(0.125)	0.303**	(0.123)	0.469**	(0.135)
Own Characteristics = (I–G)x						
Per capita income	-0.042***	(0.014)	-0.282***	(0.098)	-0.072***	(0.021)
Cadre status	-0.05	(0.045)	-0.429	(0.289)	-0.111**	(0.056)
Household size	0.026**	(0.011)	0.134*	(0.076)	0.033**	(0.015)
Education	0.004	(0.003)	0.026	(0.023)	0.005	(0.004)
Ethnicity status	-0.164***	(0.061)	-1.100***	(0.394)	-0.299***	(0.075)
Share of elderly	-0.062	(0.079)	-0.525	(0.581)	-0.139	(0.106)
Share of unmarried son	0.180**	(0.077)	1.234**	(0.517)	0.204**	(0.098)
Ratio of farm wage to plasma income	-0.183	(0.145)	-1.279	(0.979)	-0.277	(0.173)
Exposure to big diseases	-0.051*	(0.030)	-0.328	(0.205)	-0.033	(0.043)
Exposure to livestock deaths	-0.033	(0.030)	-0.21	(0.202)	-0.026	(0.044)
Exposure to family member deaths	-0.007	(0.051)	-0.114	(0.341)	-0.087	(0.061)
Exogenous social effects = (I–G)Gx						
Mean per capita income	-0.044	(0.065)	-0.266	(0.444)	0.042	(0.099)
Mean cadre status	0.236	(0.259)	1.797	(1.817)	0.644	(0.471)
Mean household size	-0.077*	(0.043)	-0.451	(0.278)	-0.074	(0.047)
Mean education	0.008	(0.034)	0.046	(0.220)	-0.008	(0.042)
Mean ethnicity status	-0.122	(0.177)	-1.189	(1.189)	-0.125	(0.191)
Mean share of elderly	0.208	(0.452)	1.127	(3.176)	0.226	(0.566)
Mean share of unmarried son	-0.397	(0.290)	-2.814	(2.036)	-0.471	(0.431)
Mean ratio of farm wage to plasma income	-0.122	(0.341)	-1.048	(2.559)	-0.054	(0.627)
Mean exposure to major diseases	0.431	(0.270)	2.808	(1.820)	0.375	(0.362)
Mean exposure to livestock deaths	0.585***	(0.199)	3.746***	(1.288)	0.692**	(0.312)
Mean exposure to family member deaths	0.364	(0.343)	2.448	(2.354)	0.616	(0.475)
Excluded Instruments – Exogenous Characteristics of Excluded Peers (I–G)G^2x						
Mean per capita income	-0.068*	(0.036)	-0.013	(0.236)	-0.066	(0.042)
Mean cadre status	-0.031	(0.174)	-2.877***	(1.128)	-0.170	(0.205)
Mean household size	0.063*	(0.036)	1.355***	(0.257)	0.100**	(0.046)
Mean education	-0.054**	(0.027)	-0.732***	(0.179)	-0.044	(0.032)
Mean ethnicity status	-0.273	(0.197)	-1.934	(1.288)	-0.283	(0.231)
Mean share of elderly	-1.250***	(0.225)	-3.348**	(1.476)	-1.335***	(0.265)
Mean share of unmarried son	0.545***	(0.144)	5.483***	(0.941)	0.419***	(0.159)
Mean ratio of farm wage to plasma income	0.038	(0.097)	0.359	(0.635)	0.023	(0.114)
Mean exposure to big diseases	0.601***	(0.116)	2.324***	(0.758)	0.667***	(0.136)
Mean exposure to livestock deaths	0.398***	(0.107)	0.116	(0.700)	0.451***	(0.126)
Mean exposure to family member deaths	0.203	(0.183)	-0.654	(1.201)	0.017	(0.216)
Network, Year, and Village Fixed Effects	Yes		Yes		Yes	
N	753		753		753	

Notes: The full estimations in Columns R1, R2, and R3 correspond to column R5 in Table 5a, Table 5b, and Table 5c, respectively.