

Social Network Capital, Economic Mobility and Poverty Traps

Sommarat Chantarat

and

Christopher B. Barrett

Cornell University

September 2006 Draft

Comments greatly appreciated

Abstract

The paper explores the role endogenous social network capital might play in facilitating poor agents' escape from poverty traps. We model endogenous network formation among households heterogeneously endowed with both traditional and social network capital who make investment and technology choices over time in the absence of financial markets and faced with multiple technologies featuring different fixed costs and returns. We show that social network capital can serve as either a complement to or a substitute for productive assets, enabling some poor households to escape poverty. However, the voluntary nature of social network formation also creates both involuntary and voluntary exclusionary mechanisms that impede some poor households' efforts to exit poverty, thus the ameliorative effects of social networks depend fundamentally on the underlying wealth distribution in the economy. In some settings, targeted public transfers to the poor can crowd-in private resources by inducing new social links that the poor can exploit to escape from poverty.

We thank Gary Fields and seminar participants at Cornell University for helpful comments on an earlier version. Any remaining errors are ours alone.

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1. Introduction

The persistent poverty widely observed in developing countries has motivated much research on poverty traps into which households may fall and have difficulty escaping. Two key common features of most poverty trap models are the existence of multiple equilibria and a financial market imperfect that prevents agents with poor initial endowments from reaching higher-level equilibria.¹ Meanwhile, a parallel literature suggests that social networks might facilitate productivity growth, access to (informal) finance, and economic mobility.² Advances in understanding the networks of social network formation could offer insights into how poor households might circumvent the poverty traps created by liquidity constraints and multiple equilibria; there have been some notable recent efforts to make these links explicitly.³ This paper further explores the intersection between poverty traps and social networks, most notably by endogenizing network formation across multiple agents, thereby allowing for the possibility of social exclusion and social isolation, and by demonstrating how the value of social network capital depends fundamentally on the underlying structure of the economy.

The basic structure and intuition of our model runs as follows. Households heterogeneously endowed with capital and (e.g., parents') social networks choose consumption, investment, production technologies and their social links with others in the

¹ Examples include Loury (1981), Banerjee and Newman (1993), Galor and Zeira (1993), Dercon (1998), and Mookherjee and Ray (2002, 2003). See Azariadis and Stachurski (forthcoming) or Carter and Barrett (2006) for helpful reviews of key threads in the poverty traps literature.

² Dasgupta and Serageldin (2000) and Durlauf and Fafchamps (2004) offer excellent reviews.

³ See, for example, the recent volumes by Barrett (2005) and Bowles et al. (2006) and the December 2005 special issue of the *Journal of Economic Inequality* on "Social Groups and Economic Inequality".

economy over multiple periods so as to maximize their lifetime utility. Social networks have no intrinsic value and are costly to establish and maintain. But social network capital – defined as the capital stock accessible through one’s social network – reduces the fixed cost of adopting the high-payoff technology. There are no financial markets.

In this setting, analogous to other poverty traps models, some initially poor households will be caught in a low-level equilibrium because they lack access, through either market or social mechanisms, to the productive assets needed in order for the most productive technology available to be the households’ optimal choice, albeit perhaps after a period of initial investment. Initially poor households without such access must resort to autarkic savings if they are to finance adoption of the improved technology. Some find such investment attractive and thereby climb out of poverty of their own accord. Others find the necessary sacrifice excessive and optimally choose to remain relatively unproductive and thus poor. A third subpopulation might find bootstrapping themselves out of poverty unattractive, but will make the necessary investment if they receive some help from others. A fourth subpopulation is able and willing to make the necessary investment autarkically, but will find it more attractive to invest in social relations that offer an alternate pathway to higher productivity. The initially poor are thus quite a heterogeneous lot, some enjoying independent growth prospects, others with socially-mediated growth prospects, with social relations either a complement to or a substitute for own capital, and still others with no real growth prospects at all.

The tricky part of the analysis stems from the fact that (i) social networks represent complex sets of dynamic links established non-cooperatively between mutually consenting agents, and (ii) a given link’s net value to any agent depends on the set of

other links operational at the same time. Because social network structure thus evolves endogenously and depends fundamentally on the structure of the underlying economy, the partitioning of the initially poor among the four subpopulations just identified will vary in both cross-section and time series. This complex interdependency in a setting with multiple and heterogeneous agents poses an analytical challenge to which we offer one reasonable solution technique.

This approach enables us to distinguish between static and dynamic asset poverty lines as a function of asset and social network capital, to describe heterogeneous patterns of economic mobility and how social networks can mediate household-level welfare dynamics, and to show how exclusionary mechanisms can arise in equilibrium, effectively barring some of the poor from reaching the high-level equilibrium. Among those trapped in poverty, some are involuntarily socially excluded while others voluntarily isolate themselves from the rest of the economy. Finally, we illustrate that because households' incentives to form social links depend on their position relative to others, households with identical initial endowments of productive assets and social network capital exhibit different mobility patterns in economies characterized by different initial endowment distributions. The endogeneity of social network structure further suggests that public transfers can crowd-in private assistance through social networks.

The remainder of the paper is organized as follows. Section 2 briefly summarizes the relevant economics literatures on social networks in low-income economies and social network formation. Section 3 then develops an interacting dynamic model of heterogeneous households with endogenous network formation. Section 4 then explains

the solution method we employ for the resulting noncooperative game approach and the equilibrium and stability concepts we employ. Section 5 then summarizes explicit solutions to the interacting intertemporal utility maximization problem and compares cases with and without social network capital, illustrating these with simulation results. We show how endogenous social network formation can turn familiar results on their head, as when public transfers to the poor no longer crowd-out private transfers but can, instead, crowd them in by inducing the creation of new social links. Section 6 concludes.

2. Social network capital

Despite its elusive definitions and applications, a rapidly growing literature on “social capital” emphasizes its potential to obviate market failures in low-income communities. Durlauf and Fafchamps (2004) distinguish between two broad concepts of social capital identifiable in the literature. First, social capital is sometimes referred to as a stock of trust and associated attachment(s) to a group or to society at large that facilitate coordinated action and the provision of public goods (Coleman 1988, Putnam et al.1993). A second conceptualization treats social capital as an individual asset conferring private benefits, such as reduced search and transactions costs, superior information, or informal credit or insurance (Onchan 1992, Berry 1993, Townsend 1994, Foster and Rosenzweig 1995, Fafchamps 1996, Ghosh and Ray 1996, Kranton 1996, Barr 2000, Bastelaer 2000, Carter and Maluccio 2002, Conley and Udry 2002, Fafchamps and Minten 2002, Isham 2002, Fafchamps 2004, Bandiera and Rasul 2006, Moser and Barrett 2006).

This paper employs this second conceptualization, sometimes referred to as “social network capital” so as to emphasize that agents derive benefits from knowing others with

whom they form social networks for mutual benefit (Granovetter 1995a, Fafchamps and Minten 2002). In particular, in the model developed in sections 3 and 4, “social network capital” reflects socially-mediated productive assets that households can exploit through their networks of social relationships, with some (imperfect) substitutability with traditional, privately possessed capital. We explain this in more detail in section 4.

The prospective benefits of socially-mediated capital access – analogously, of social insurance, informal credit, informal monitoring and enforcement mechanisms, or social learning – create material incentives to establish social relations with others, even when it is costly to establish and maintain such relationships. The formation of a network of bilateral relationships is thus a form of investment in social network capital, akin to more conventional investment in traditional financial, natural or physical capital. Note that we abstract here completely from the intrinsic value of social relations and focus purely on the instrumental value of social networks. Indeed, for the sake of simplicity in modeling, we isolate just one among the many possible pathways through which that instrumental value might manifest itself: by reducing the fixed cost of adopting a higher-return technology, by enabling one to learn from, share with, or borrow from others’ capital stock.

Social network capital necessarily evolves endogenously. A small but growing literature demonstrates this empirically in the case of poor agrarian communities (Conley and Udry 2001, DeWeerd 2004, Santos and Barrett 2005, Fafchamps and Minten 2001, Fafchamps and Gubert forthcoming). Because social networks are (at least partly) the consequences of individual’s cost-benefit calculus with respect to prospective links with others, and those costs and benefits depend on social distance and the underlying

structure of the economy, network structure is highly variable. As we demonstrate later, allowing for this endogeneity of social networks can turn some familiar results on their head. For example, public transfers may crowd-in private flows of capital when they induce new social links by reducing social distance.

Theorists have developed insightful models of network formation, building on seminal work by Aumann and Myerson (1988), Myerson (1991) and Jackson and Wolinsky (1996) to concretize the notion of a stable network based on pairwise stability in links and “strong stability” among larger coalitions of agents (Dutta and Mutuswami 1997). Recent advances in the literature, nicely reviewed by Jackson (2005), emphasize dynamic perspectives on network formation (Watt 2001, Jackson and Watt 2002a, Dutta et al. 2002, Watt 2002), but have focused to date almost entirely on applications in industrial organization and labor economics. The application of formal models of network formation in development economics remains rare.⁴

This is an unfortunate lacuna, especially because the literature on social capital strongly suggests that not everyone benefits from social networks and that there exist patterns to these gaps (Durlauf and Fafchamps 2004). Figueroa et al. (1996) point out that social exclusion has become a very active subject of debate concerning poverty in Europe. Carter and May (2001) and Adato et al. (2006) show that the voluntary and involuntary exclusion of poorer black households from social networks of wealthier whites in South Africa has prolonged the legacy of apartheid and minimized the prospective benefits to the poor of social capital in obviating barriers to entry into remunerative livelihoods. Santos and Barrett (2006) find that asset transfers through

⁴ Conley and Udry (2005) and Mogues and Carter (2005) are important exceptions.

social networks in southern Ethiopia systematically exclude poorer households, corroborating insights from anthropologists and historians studying similar systems across rural Africa.

Nonrandom patterns of unformed latent social links within a society reflect choices made by individuals to forego prospective relationships. We refer to the situation where an individual opts not to seek out partners as “social isolation”, reflecting voluntary self-selection out of prospective networks.⁵ In other cases, individuals desire links with others but are rebuffed by prospective partners, resulting in involuntary “social exclusion”.⁶ We demonstrate below how patterns of social exclusion and isolation may turn fundamentally on the initial wealth distribution in an economy, with significant consequences for the growth prospects for the poor.⁷ In this way, models of endogenous social network capital as an input into productivity growth provide a natural link between the social networks literature and that relating income distribution to economic growth.⁸

3. An interacting dynamic optimization model with endogenous network formation

Assume n households exist in an economy, $N = (1, 2, \dots, n)$. Each lives for two periods,⁹ $t = 0, 1$. Each household is initially endowed with two types of assets: traditional

⁵ Postlewaite and Silverman (2005), Kozminski (2001), Barry (1998), Wilson (1987), among others, similarly use the concept and term “social isolation” to reflect voluntarily non-participation in a society’s institutions.

⁶ Note that we use the term “social exclusion” very precisely, especially as compared to the literature on social exclusion as, more generally, “inability of a person to participate in basic day-to-day economic and social activities of life” (Chakravarty and D’Ambrosio 2006, p.397), as the term is used by, among others, Room (1995), Atkinson (1998), Atkinson et al. (2002), and Bossert et al. (forthcoming).

⁷ We only directly refer to social isolation and social exclusion with respect to those agents who remain poor over time and do not establish social networks. Extension to those non-poor who similarly do not link with others is straightforward, but omitted in the interest of focus on the paper’s core theme.

⁸ See, for example, Galor and Zeira (1993) or Mookherjee and Ray (2000), as well as the excellent review by Aghion et al. (1999).

⁹ Population growth is assumed zero for both periods.

productive capital representing a one-dimensional aggregate index measure of physical, natural, human and financial capital, denoted A_0 , and social network capital, denoted S_0 , referring to the traditional capital that might be borrowed from or shared with others with whom one has an active social link. There is thus just one type of individually owned asset, but people can have access to it directly through private ownership or indirectly through their social network. The economy's initial endowment distribution is denoted by $\phi(A_0, S_0)$. Households' preferences are identical, with utility derived solely from consumption, as is the set of available production technologies to generate income from one's capital stock.

3.1 Production technology set

The production technology set consists of two technique-specific production functions that generate low and high income, Y_t^L and Y_t^H , respectively, through

$$Y_t^L = f_L(A_t) \tag{1}$$

$$Y_t^H = f_H(A_t - F(S_t)) \tag{2}$$

Technology L is a low-cost, low-return technique that everyone can afford. Technology H is a high-return technology with a fixed cost entry barrier, $F(S_t) \geq 0$ with $F'(S_t) < 0$.¹⁰ Greater capital is required to make technology H attractive because one has to cover the fixed cost of adoption. Social network capital is only valuable in reducing the cost of using the high-return technology because one can borrow or share others' capital. One can thus think of the high-return technology as tractorized agriculture, motorized

¹⁰ We further assume $F(0) > 0$ is large constant and $F(\infty) = 0$.

transport, or even – if information embodied in human capital is included in the asset stock – a knowledge-intensive improved production technique.

Each production technology fulfills standard curvature conditions. For net productive assets, $NA_t^H \equiv A_t - F(S_t) \geq 0$ and $NA_t^L \equiv A_t \geq 0$, (almost everywhere) twice-differentiable functions $f_H(NA_t^H)$ and $f_L(NA_t^L)$ follow

$$f_H(0) = f_L(0) = 0 \quad (3)$$

$$\frac{\partial f_H(0)}{\partial NA_t^H} = \frac{\partial f_L(0)}{\partial NA_t^L} = \infty \quad \text{and} \quad \frac{\partial f_H(\infty)}{\partial NA_t^H} = \frac{\partial f_L(\infty)}{\partial NA_t^L} = 0 \quad (4)$$

$$\frac{\partial^2 f_H(NA_t^H)}{\partial (NA_t^H)^2} \leq 0 \quad \text{and} \quad \frac{\partial^2 f_L(NA_t^L)}{\partial (NA_t^L)^2} \leq 0 \quad (5)$$

$$\frac{\partial f_H(NA_t^H)}{\partial NA_t^H} \Big|_{NA_t=j} \geq \frac{\partial f_L(NA_t^L)}{\partial NA_t^L} \Big|_{NA_t=j} \geq 0 \quad \forall j. \quad (6)$$

In each period t , therefore, a household's aggregate production function can be described as

$$Y_t = \text{Max} [Y_t^H, Y_t^L] = \text{Max} [f_H(A_t - F(S_t)), f_L(A_t)] \quad (7)$$

which yields a non-convex production set, with locally increasing returns in the neighborhood of $\underline{A}(S_t)$, the asset threshold beyond which a household will optimally switch to the high-return production technology. $\underline{A}(S_t)$ thus satisfies

$$f_H [\underline{A}(S_t) - F(S_t)] = f_L [\underline{A}(S_t)] \quad (8)$$

Figure 1 presents this aggregate production function as an outer envelope of the two specific production functions, with the threshold asset stock $\underline{A}(S_t)$.¹¹

In this framework, social network capital reduces the asset stock necessary to make technology H optimal. As S_t increases, the high-return production function shifts in, lowering the minimum asset threshold needed to make high-return production optimal, i.e., $\underline{A}'(S_t) < 0$, which follows implicitly from (8) and the assumption that $F(\cdot)$ is decreasing in S_t . This effect is depicted in Figure 2.

The value of social network capital will therefore vary across households. For households with sufficient privately-held assets, A_t , adoption of H is optimal regardless of their stock of social network capital, but S_t nonetheless reduces the fixed costs they incur, thereby increasing the productivity of their asset stock. Social network capital is potentially most valuable for those households who possess insufficient assets themselves to adopt H , $A_t < \underline{A}(S_t)$, but who are “not too far” in some sense from $\underline{A}(S_t)$ so that investment in building social network capital can lower the critical threshold they face to the point that the high-return technology becomes optimal in the future. As one’s distance from $\underline{A}(S_t)$ increases, however, the benefit to a household from social network capital falls as it will not suffice to bring the threshold down to the level of their asset stock, and social network capital has no value for those not practicing technology H . For such

¹¹ This is in the spirit of Cooper (1987), Murphy, Shleifer and Vishny (1989) or Azariadis and Drazen (1990), each of whom exploits similar technologies to analyze multiple equilibria. Milgrom and Roberts (1990) discuss how this type of non-convexity can arise as firms internally coordinate many complementary activities. Durlauf (1993) explores the role of complementarities and incomplete markets in economic growth under non-convexities of this type and shows that localized technological complementarities, when strong enough, produce long-run multiple equilibria.

households, there is no incentive to invest in social network capital, thus they will rationally self-select out of costly social relations, thereby becoming socially isolated.

3.2 Household utility maximization

A household derives utility solely from consumption each period, maximizing

$$U = u(C_0) + \rho u(C_1) \quad (9)$$

where ρ is the discount factor. For simplicity's sake, we consider the extreme case where utility is linear in consumption, thereby maximizing a household's willingness to bear short-term reduction in C_0 in order to take advantage of a high rate of return on their savings. We further assume there are no financial markets, thus autarkic saving is the only investment strategy. A subsistent consumption constraint applies such that

$$u(c_t) = -\infty \text{ for any } c_t \leq 0 \text{ and } t \leq T. \quad (10)$$

This puts a minimal limit on the intertemporal consumption tradeoff available to the household by permanently penalizing non-positive consumption in any period.

In period 0 , a household with endowments (A_0, S_0) optimally chooses a technology and allocates the resulting income from production among consumption (C_0), investment in productive assets (I_0) and investment in its social network ($X'_0 K$), which is the product of the binary (0,1) column vector reflecting the network of social relationships it establishes during period 0 , X_0 , and the column vector of costs household has to incur to establish or maintain each link, K .¹² Note that the household incurs costs in period 0 for establishing X_0 , but it derives no immediate benefits, as we now explain.

¹² Both K and X_0 are described in more detail in section 4.

The laws of motion mapping initial endowments into stocks at the beginning of period 1 depreciate A_0 and S_0 at rates δ_A and δ_S , respectively, while period 0 investments add to the stock of both assets. The new stock of social network capital is a function of the household's social network at the end of period 0 and the benefit function, B , that maps assets held by members of the social network into social network capital, as described in section 4, below. In period 1 , the household again employs the optimal production technology and consumes all the resulting income.¹³

A key distinction between A and S is that the household unilaterally decides the stock of traditional capital it will own, but it does not unilaterally decide on its social network because each link involves bilateral decisions by both prospective partners. The household's social network is therefore the product of optimal social interactions, taking into consideration everyone in the economy's network preferences. A household's utility maximizing network might therefore prove infeasible because its preferred link partners do not have reciprocal desires for an active link. We thus define X_0^d as a household's desired network, represents their social network it would choose unilaterally, were that feasible. Note that this is not an equilibrium network.

For every possible desired network, X_0^d , a household can derive its corresponding optimal investment, $I_0^*(X_0^d)$. Specifically, the indirect utility that household i with endowments (A_{i0}, S_{i0}) derives from a possible desired network X_{i0}^d is

$$V_i^*(X_{i0}^d) = \underset{\{C_{i0}(X_{i0}^d), I_{i0}(X_{i0}^d), C_{i1}(X_{i0}^d)\}}{\text{Max}} u(C_{i0}) + \rho u(C_{i1}) \quad (11)$$

¹³ Zero investment in the terminal period is obviously an artifact of our simplifying assumption of a known, finite lifetime with no subsequent generations.

subject to:

$$C_{i0} \leq Y(A_{i0}, S_{i0}) - I_{i0} - X_{i0}^d K_i$$

$$A_{i1} = (1 - \delta_A) A_{i0} + I_{i0}$$

$$S_{i1} = (1 - \delta_S) S_{i0} + X_{i0}^d B_i$$

$$C_{i1} \leq Y(A_{i1}, S_{i1})$$

$$S_{i1}, A_{i1} \geq 0$$

$$C_{i0}, C_{i1} > 0.$$

The production function follows (7) and the subsistence constraint is incorporated into the final non-negativity constraint. Each agent in the economy can establish its preferences regarding each possible desired network based on the indirect utility $V^*(X_0^d)$. We then need an equilibrium concept for the social network and a corresponding method of non-cooperative social interactions to resolve this dynamic optimization problem.

4. Optimal social network structure

There are two fundamental questions underlying endogenous network formation. Who in the economy will a household consider for a prospective social link? And among those they consider, how do they choose with whom to link?

4.1 Who will a household consider as a prospective social link?

A broad literature suggests there exist boundaries to prospective social interactions. Santos and Barrett (2005, 2006), among others, suggest that not everyone knows everyone else, even in small, ethnically homogeneous rural settings in which households pursue the same livelihood. Akerlof (1997) and others emphasize the importance of

social distance, while many models of network formation emphasize local interactions within prescribed neighborhoods (Ellison 1993, Ellison and Fudenberg 1993, Fagiolo 2001). What then determine households' neighborhoods?

In our setting, each household is characterized by its (A_0, S_0) endowment, which is universally observable. Thus each household can identify its distance from every other household in (A, S) space. As in Mogues and Carter (2005), we use the geometric distance between households' endowments to reflect social distance, formally, defined as

$$d(i, j) = \sqrt{(A_{i0} - A_{j0})^2 + \alpha(S_{i0} - S_{j0})^2} \quad ; \alpha \geq 0, \quad (12)$$

for any pair of agents, i and j , where α establishes the relative weight of pre-existing social network capital in determining social distance. When $\alpha = 1$, the social distance between two households is simply the Euclidian norm between the two two-dimensional endowments.

Household i 's neighborhood, representing the set of households with which they might interact socially, is defined as

$$H_i = \{\forall j \in N, j \neq i / d(i, j) \leq \bar{d}\}. \quad (13)$$

The constant \bar{d} reflects a social distance threshold beyond which social interaction is not feasible. We assume that \bar{d} is economy-specific but universal to each household in the economy.¹⁴ It implicitly reflects physical and social barriers on the probability that individuals meet and interact. A low \bar{d} can represent an economy in which households cluster into many small groups of shared characteristics with low inter-group connectivity or an economy characterized by significant ethnic, racial or religious discrimination or

¹⁴ This assumption is reasonable give households' identical preferences.

physical isolation. A high \bar{d} , on the other hand, allows for greater social interactions. For a given \bar{d} , every household identifies its neighborhood accordingly.¹⁵

Social interaction between household i and j , $x(i, j) \in \{0,1\}$, is defined by joint agreement to establish a link within the feasible neighborhood, $x(i, j) = 1$, or failure to establish such a link, $x(i, j) = 0$. The network of household i is thus represented by the vector of its binary social interactions with every agent in its neighborhood:

$$X_i = (x(i, j); \forall j \in H_i, j \neq i) \quad \text{where } x(i, j) \in \{0,1\}. \quad (14)$$

By way of illustration, consider an economy with $N = \{1,2,3,4,5\}$ and the endowment distribution $\phi(A_0, S_0)$ illustrated in figure 3. For $\bar{d} = 9$, for example, household 3's

neighborhood is $H_3 = \{1,2,4\}$.¹⁶ Thus $X_3 = \begin{pmatrix} x(3,1) \\ x(3,2) \\ x(3,4) \end{pmatrix}$ with $x(3, k) \in \{0,1\}$ for all $k = 1,2,4$.

Hypothetically, $X_3 = \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}$ represents the case when their network consists of only a link

with household 1. $X_3 = \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix}$ arises when 3 links with everyone in its neighborhood, while

$X_3 = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$ presents the case where household 3 has no links. Defining household i 's set of

¹⁵ As social distance is symmetric, if individual i is in j 's neighborhood, then j is also in i 's neighborhood.

¹⁶ Similarly, for $\bar{d} = 9$, $H_1 = \{2,3\}$, $H_2 = \{1,3\}$, $H_4 = \{3,5\}$ and $H_5 = \{4\}$.

all possible networks as Ω_i , in this example $\Omega_3 = \left\{ \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}, \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix}, \begin{pmatrix} 1 \\ 1 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 \\ 0 \\ 1 \end{pmatrix}, \begin{pmatrix} 0 \\ 1 \\ 1 \end{pmatrix}, \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix} \right\}$.

The problem then arises, which network will the household prefer?

4.2 Choosing one's preferred network

In contrast to other endogenous network formation models, the optimal solution to network formation in our setting relies on three fundamentals. First, costs and benefits of links are realized intertemporally.¹⁷ A household's preference over possible networks therefore relies on the realized net intertemporal utility gains as reflected in their indirect utilities. Second, household i 's decision to link with household j is interdependent with its decision to link with others. A link with one household might complement or substitute for links with others. The multiple equilibria in our setting accentuate this interdependency because only those households that can accumulate enough resources to make the high-return production technology optimal will benefit from social network capital. Therefore, many households' valuation of a given link is conditional on their success in establishing other links as well. Network preferences must take into account these spillover possibilities, instead of just myopically considering each link separately. Third, decisions to link are not unilateral. It takes both partners to agree to establish a relationship.

Social interactions in this settings can thus be treated as a non-cooperative, multi-player game, with each player choosing its network of social links from its set of feasible

¹⁷ In existing network formation models, relationship payoffs occur within the period (Jackson and Wolinsky 1996, Johnson and Gilles 2000, Calvo-Armensol and Jackson 2001, Goyal and Joshi 2002).

strategies, Ω_i . Agents have reaction functions specifying their optimal choices as a function of others' actions. Specifically, each household i ranks all possible networks based on the corresponding indirect utilities. The resulting set of ranked networks, Ω_i^{Ranked} , is its reaction function.

Equilibrium involves a set of mutually consistent actions, that is, a situation in which all players are happy with their own choice, given the choices of other players. We apply the one-to-one matching concept, explained in more detail below, to sort for the set of optimal links in the economy as a whole. The resulting set of optimal links represents a stable network if no pair of households (i, j) can alter their link decision so as to make both households better off.

4.3 Costs and benefits of social relationship

The structure of the endogenous social network necessarily depends fundamentally on the costs and benefits households experience. A household incurs total costs $(X'_0 K)$ to establish its network of links, where K is a column vector of costs they have to incur to establish each active link. Specifically, the cost to household i to establish a link with household j is

$$K_i(j) = \theta_1(d(i, j)) \text{ for } j \in H_i \text{ with } \theta_1 > 0. \quad (15)$$

The idea is that it is easier to establish a link with people who are socially proximate. We assume symmetric costs for i and j , with no economies of scale or scope in building networks.

¹⁸ And so $K_i = (K_i(j); \forall j \in H_i, j \neq i)$.

The benefits to the household from its social network capital are reflected in the column vector B , which describes the benefit to household i from a link with household j as follows:

$$B_i(j) = \theta_2 A_j - \theta_3 |A_i - A_j| \quad \text{for } j \in H_i \text{ with } \theta_2, \theta_3 \in [0,1]. \quad (16)$$

As with the costs of links, we assume that social network capital benefits are link-specific and independent of all other links the household establishes. But unlike the costs of establishing a link, the social network capital gained from a link is not symmetric to both members of the dyad for the simple reason that a poorer household can call on more resources from their richer partner than vice versa. Extreme differences in wealth, however, may hinder mutual benefits, as reflected in the second term in (16). Intuitively, the specific capital of one partner might be inappropriate to a partner employing quite different practices due to stark wealth differences. More generally, however, the asymmetric specification of (16) fits the empirical pattern that wealthy households are more likely to opt out of links with much poorer partners than vice versa (Santos and Barrett 2005). In similar spirit, very poor households might not find it attractive to link with far richer ones with whom they share little (Mogues and Carter 2005). With symmetric costs and asymmetric benefits, the intertemporal net benefits of social links will, in general, be asymmetric under these assumptions.

4.4 Noncooperative game approach to endogenous network formation

Because the formation of links is a strategic decision affecting households' optimal consumption and investment decisions, it is appropriate to model network formation as a non-cooperative game. The mutual consent requirement for link formation poses a

hurdle, however, to the use of any off-the-shelf solution technique. The extensive form game that relies on structured ordering of moves (Aumann and Myerson 1988) is intractable beyond simple examples and the ordering of moves has a non-trivial impact on which networks emerge. Myerson's (1991) simultaneous move game results in a large multiplicity of Nash equilibria. Jackson (2005) thus identifies two major challenges to non-cooperative game theoretic approaches to network formation. First, the mutual consent requirement for link formation implies either some sort of coalitional equilibrium concept or an extensive form game with a protocol for proposing and accepting links in some sequence. The other serious challenge he proposes is that the game is necessarily ad hoc, and fine details of the protocol (e.g. the ordering of who proposes links when, whether or not the game has a finite horizon, players' patience, etc.) generally matter.

With these challenges in mind, we employ a one-to-one matching game¹⁹ in the domain of a coalitional game,²⁰ in which each player may be matched with many others. Ours is an extensive form game as it involves many stages of one-to-one matching processes. In each stage, agents play a simultaneous move game. This specification protocol yields a unique stable matching, which constitutes the model's stable network. In the context of a coalitional game, a set of every household in this economy constitutes

¹⁹ Our matching specification differs greatly, however, from Gale and Shapley's (1962) original approach. They consider a two-sided one-to-one matching game in which members of two sides are referred to as X s and Y s. Each X may be matched with at most one Y , and each Y may be matched with at most one X ; staying single is an option for each individual. The game starts with a proposal by either X s or Y s. The other side then applies a deferred acceptance procedure in response. Our specification also differs from marriage models in which individuals can match with only one partner.

²⁰ The concept of coalitional game, due to von Neumann and Morgenstern (1944), models interacting decision-makers by focusing on the behavior of groups of players. Generally, a coalitional game consists of a set of players, a set of actions for each coalition, and preferences over the set of all actions of all coalitions of which each player is a member. The optimal actions of players have to be compatible with the pressures imposed by the opportunities of each coalition, rather than simply those of individual players. An aggregate action of every player in a game is defined to be "stable" if no coalition can break away and choose an action that all its members prefer. The set of all stable actions is called "the core".

a grand coalition. A one-to-one matching of this set thus disaggregates it into subsets of size two (coalitions with two members). Each player belongs to only those two-member coalitions consisting of individuals in his neighborhood. The set of actions of each coalition is the set of binary link decisions of both partners. And so the set of actions of every coalition constitutes the set of all matchings in this economy. Each player cares about actions chosen by members of the coalitions to which he belongs. His preferences over those actions are governed by the set Ω_i^{Ranked} , derived directly from his intertemporal utility maximization. However, actions chosen by others may constrain his feasible strategy choice.

More specifically, in our matching protocol households interact with others based on their best response function, Ω_i^{Ranked} , as follows. Initially, households consider their top-ranked networks. They simultaneously propose to each other households with which they wish to link. The link between two households is established if and only if (1) both agents propose to each other, and (2) at least one of the two partners optimizes its network (i.e., has all of its proposals accepted). Once a household optimizes its network, its game is concluded. For any of its partners that do not likewise optimize their network, this link is binding. Such partners continue to play the game, with their utility maximization now constrained by the link commitment. All households that do not optimize their networks in a proposal stage move on to the next stage, when they make simultaneous proposals to each of those households still active in the game with whom it wishes to link in its top-ranked still-feasible network (which may include pre-existing link commitments from prior rounds with households that have concluded play). The same link formation rule is followed, and the game then repeats itself if there remain

households without optimized networks. If in a specific stage no household can optimize its network, and thus no binding link can be established, we assume that the poorest household (i.e., the one with lowest A_0) has to forego its top-ranked network and instead use its second-best network while the rest still play with their top-ranked networks. If still no one can optimize the network, the second poorest household then sacrifices its first-best network and must play make link proposals to its second-best network while all richer households still play their first-best strategy, and so on. The process of one-to-one matching continues until everyone optimizes their networks. For any preferences, the process eventually stops because there exists a finite set of households in this economy.

Note two interesting aspects of this game. First, even if proposals are matched, this does not guarantee the establishment of a link. Binding links are established only if (at least) one partner optimizes its network. This follows directly from the fact that households' preferences with respect to individual links are governed by their preferences over their broader networks, as reflected in Ω_i^{Ranked} . Second, households' optimal networks in equilibrium are not necessarily their first-best ones, due to the interactive nature of the link formation process and the spillovers inherent to the process economywide. This creates a stark contrast vis-à-vis the optimality conditions that would result from unilateral decisions regarding social network structure.

A unique “stable matching” in the core of this coalitional game can be found and has the property that no pair of households (i, j) can alter the link decision so that both

households are better off.^{21,22} Such a stable matching constitutes an economy's stable set of links, which also constitutes households' optimal networks in equilibrium. Figure 4 illustrates the numerical example of this game and its stable matching for the example economy from Figure 3.

This approach to endogenous link formation leads naturally to a two-stage optimality concept. The first stage involves unilateral intertemporal utility maximization conditional on a prospective social network structure. After establishing its set of all possible social networks, Ω_i , each household i computes its indirect intertemporal utility for each possible network realization, $(X_{oi} \in \Omega_i)$, then orders the feasible networks into Ω_i^{Ranked} . In the second stage, each household interacts with all other households following the one-to-one matching process, using its Ω_i^{Ranked} best response function. The resulting set of stable matches necessarily represents constrained optima for each household in the economy. The equilibrium of this model is, therefore, characterized by every household's accumulation decisions $\{X_{i0}^*, I_{i0}^*\}_{i=1, \dots, n}$, which determine current and future technology choice and consumption levels, and thus each household's level of well-being.

²¹ This equilibrium concept is parallel to the pairwise stability concept in the network literature. Using the notation in Jackson and Wolinsky (1996), a network, g , is pairwise stable with respect to the optimal allocation rule Y and value function v if

(i) for all $ij \in g$, $Y_i(g, v) \geq Y_i(g - ij, v)$ and $Y_j(g, v) \geq Y_j(g - ij, v)$ and (ii) for all $ij \notin g$, if $Y_i(g + ij, v) > Y_i(g, v)$ then $Y_j(g + ij, v) < Y_j(g, v)$. Because the establishment of a link requires mutual consent, this stability concept differs from the concept of Nash equilibrium stability, which requires that no single individual prefers to deviate.

²² Noticing that ours is an extensive form game with a well-specified protocol for simultaneously proposing and accepting links, this rules out the possibility that some set of multiple household pairs can all be made better off by some more complicated reorganization of their links. Therefore, the notion of strong stability is redundant in our game.

5. Household's optimal network and accumulation decisions

The preceding assumptions, equilibrium concepts and solution techniques prepare us now to study how social network capital influences households' economic mobility through their optimal network formation and capital accumulation decisions. Specifically, we consider household i , initially endowed with (A_{i0}, S_{i0}) , which faces the unilateral intertemporal utility maximization problem (11) with linear utility function of the form:

$$U_i = aC_{i0} + \rho aC_{i1} \quad (17)$$

and faces the non-convex production technology set satisfying conditions (1)-(6) in each period $t = 0, 1$:

$$Y(A_{it}, S_{it}) = \text{Max} [k_1(A_{it})^{\alpha_1}, k_2(A_{it} - Fk_3^{-S_{it}})^{\alpha_2}] ; \alpha_1, \alpha_2 \in (0, 1), \alpha_2 > \alpha_1, k_1, k_2 > 0, \\ k_3 > 1, F > 0. \quad (18)$$

For each possible network, $X_0 \in \Omega_0$, household i considers the first-order conditions for an interior optimum, yielding two equilibria: the low-level equilibrium (poverty trap) $U_L^*(X_0)$ and the high-level equilibrium $U_H^*(X_0)$ such that²³

$$U_L^*(X_0) = aC_{0L}^* + \rho aC_{1L}^* = \quad (19)$$

$$a \left(Y(A_0, S_0) + (1 - \delta_A)A_0 - X_0 K - (\rho \alpha_1 k_1)^{\frac{1}{1-\alpha_1}} \right) + \rho a \left(k_1 (\rho \alpha_1 k_1)^{\frac{\alpha_1}{1-\alpha_1}} \right) \quad \text{and}$$

$$U_H^*(X_0) = aC_{0H}^* + \rho aC_{1H}^* = \quad (20)$$

$$a \left(Y(A_0, S_0) + (1 - \delta_A)A_0 - X_0 K - (\rho \alpha_2 k_2)^{\frac{1}{1-\alpha_2}} - Fk_3^{-[(1-\delta_s)S_0 + X_0 B]} \right) + \rho a \left(k_2 (\rho \alpha_2 k_2)^{\frac{\alpha_2}{1-\alpha_2}} \right)$$

²³ In what follows, the subscript i is dropped for simplicity's sake.

We begin, in the next sub-section, by analyzing the benchmark case without social networks, in which the household's optimal welfare depends solely on its autarkic saving and accumulation capacity. We then expand the analysis to consider the case with optimal social network formation and its effects on economic mobility, especially among those who might otherwise be unable to reach the high-level equilibrium $U_H^*(X_0)$.

5.1 The benchmark case without a social network

The case where $S_t = 0 \forall t$ is a traditional poverty traps model. It implies an asset threshold \underline{A} such that those with $A_t \geq \underline{A}$ can optimally undertake high-return production, while others can only afford low-return technique and are thus trapped in poverty in the current period, t .²⁴ Intertemporally, we make three rather innocuous assumptions. First, a high-level equilibrium of well-being is always preferred to a lower one:

$$U_H^*(S_0 = 0, X_0 = \underline{0}) > U_L^*(S_0 = 0, X_0 = \underline{0}) \quad \Leftrightarrow \quad (21)$$

$$\left[\rho \left(k_2 (\rho \alpha_2 k_2)^{\frac{\alpha_2}{1-\alpha_2}} \right) - (\rho \alpha_2 k_2)^{\frac{1}{1-\alpha_2}} - F \right] - \left[\rho \left(k_1 (\rho \alpha_1 k_1)^{\frac{\alpha_1}{1-\alpha_1}} \right) - (\rho \alpha_1 k_1)^{\frac{1}{1-\alpha_1}} \right] > 0.$$

However, not every household can achieve U_H^* ; this depends on a household's feasible autarkic savings. Consider \underline{A} the static asset poverty line, which distinguishes *current* high-level equilibrium from low-level equilibrium.

We further assume that initially non-poor households (whose $A_0 \geq \underline{A}$) are always able to accumulate toward the high-return equilibrium,²⁵ thus for them

²⁴ \underline{A} satisfies a condition analogous to that in (8).

²⁵ This condition rules out the possibility of downward mobility of the initially non-poor, which is reasonable given there is no uncertainty in the model.

$$C_{0H}^*(S_0 = 0, X_0 = \underline{0}) > 0 \Leftrightarrow k_2(A_0 - F)^{\alpha_2} + (1 - \delta_A)A_0 - (\rho\alpha_2 k_2)^{\frac{1}{1-\alpha_2}} - F > 0. \quad (22)$$

For the initially poor, for whom $A_0 \leq \underline{A}$, we further assume that accumulation toward U_L^* may be feasible, thus

$$C_{0L}^*(S_0 = 0, X_0 = \underline{0}) > 0 \Leftrightarrow k_1(A_0)^{\alpha_1} + (1 - \delta_A)A_0 - (\rho\alpha_1 k_1)^{\frac{1}{1-\alpha_1}} > 0. \quad (23)$$

These initially poor households escape the poverty trap and graduate to the high-level of equilibrium through autarkic savings if and only if

$$C_{0H}^*(S_0 = 0, X_0 = \underline{0}) > 0 \Leftrightarrow k_1(A_0)^{\alpha_1} + (1 - \delta_A)A_0 - (\rho\alpha_2 k_2)^{\frac{1}{1-\alpha_2}} - F > 0. \quad (24)$$

This suggests the existence of a dynamic asset threshold A_0^* at which optimal household savings (i.e., asset accumulation) bifurcates. Those households with $\underline{A} > A_0 \geq A_0^*$ ²⁶ will save and escape poverty in the future (albeit not in the initial period), while others with $A_0 < A_0^*$ are trapped in long-term poverty. This dynamic asset threshold is analogous to the dynamic asset poverty line proposed by Carter and Barrett (2006). In the absence of social network capital, a household's initial endowment of productive assets, A_0 , determines its long-term equilibrium well-being.

²⁶ Given our assumptions, it is necessarily true that $A_0^* \leq \underline{A}$. By way of proof, suppose instead that $A_0^* > \underline{A}$ and consider an individual endowed with $\underline{A} < A_0 < A_0^*$. As $\underline{A} < A_0$, $k_1(A_0)^{\alpha_1} < k_2(A_0 - F)^{\alpha_2}$ and so the household can initially adopt the high-return production technology. But as $A_0 < A_0^*$, $C_{0H}^*(S_0 = 0, X_0 = \underline{0}) < 0$ implies $k_2(A_0 - F)^{\alpha_2} + (1 - \delta_A)A_0 - (\rho\alpha_2 k_2)^{\frac{1}{1-\alpha_2}} - F < 0$. This, however, contradicts (22).

5.2 The possibilities presented by social networks and their limitations

Let us now reintroduce the possibility of social network capital that reduces the fixed cost associated with using the high-return production technique, with the corresponding static asset poverty line $\underline{A}(S_t)$ such that any household with $A_0 \geq \underline{A}(S_0)$ optimally undertakes high-return production in period 0, while those with $A_0 \leq \underline{A}(S_0)$ optimally choose the low-return technique in the first period. $\underline{A}(S_0)$ thus solves

$$k_1[\underline{A}(S_0)]^{\alpha_1} = k_2[\underline{A}(S_0) - Fk_3^{-S_0}]^{\alpha_2} \quad (25)$$

with $\underline{A}'(S_0) < 0$, so that greater social network capital lowers the static asset poverty line, as previously discussed. In this way, one's inherited social network capital can make high-return production technologies, and thus a higher equilibrium standard of living, attainable when one's private stock of capital would not otherwise suffice.

Perhaps more interestingly, and less obviously, the household's ability to establish a network by investing in X_0 may affect the dynamic asset poverty line. Consider an initially poor household (whose $A_0 < \underline{A}(S_0)$). It can gradually accumulate resources toward the high-level equilibrium, and thus escape future (but not current) poverty, if it establishes a productive network such that²⁷

$$C_{0H}^*(X_0) > 0 \Leftrightarrow k_1(A_0)^{\alpha_1} + (1 - \delta_A)A_0 - (\rho\alpha_2k_2)^{\frac{1}{1-\alpha_2}} - Fk_3^{-[(1-\delta_s)S_0 + X_0B]} - X_0K > 0. \quad (26)$$

According to (26), there exist three avenues by which the initially poor can reach the

²⁷ If there exists a network $X_0 \neq \underline{0}$ such that $C_{0H}^*(X_0) > 0$, then $U_H^*(X_0) > U_L^*(X_0 = \underline{0})$ if $C_{0H}^*(X_0) > C_{0H}^*(X_0 = \underline{0})$ by (21), (22) and (23). Thus the benefit of reaching the high-level equilibrium induces the household to make costly links, if it can afford to do so. Of course, if $C_{0H}^*(X_0 = \underline{0}) > C_{0H}^*(X_0) > 0$, then it is optimal for the household to graduate from poverty through autarkic savings.

high-level equilibrium. First, a greater endowment of productive assets (A_0) expands the poor's autarkic savings opportunities, just as in the previous section without social network capital. Second, a greater endowment of social network capital (S_0) reduces the savings required to reach $\underline{A}(S_t)$ and thus to reach the high-level equilibrium in the future. Third, if the initially poor can establish productive network (X_0) that generates enough social network capital (S_1) to make the high-return technology optimal, they can escape from poverty in the future without necessarily even having to accumulate capital themselves.

This latter avenue indicates that the dynamic asset poverty threshold depends not only on initial endowments (A_0, S_0), but also on the poor's possibility to establish a social network, X_0 , that could generate the social network capital necessary for them to graduate from poverty. Thus factors that determine the poor's ability to establish a productive social network, such as the broader attribute distribution in the economy and the maximum social distance over which links are feasible in a given society, will also influence the initially poor's long-term well-being.

Intuitively, (26) suggests that there exists a dynamic asset threshold condition on a given network structure, $A_0^*(S_0 / X_0 = \underline{0})$, that satisfies

$$C_{0H}^*(X_0 = \underline{0}) = 0 \Leftrightarrow k_1(A_0)^{\alpha_1} + (1 - \delta_A)A_0 - (\rho\alpha_2k_2)^{\frac{1}{1-\alpha_2}} - Fk_3^{-[(1-\delta_s)S_0]} = 0. \quad (27)$$

Those households with $A_0 \geq A_0^*(S_0 / X_0 = \underline{0})$ gradually escape poverty without needing to invest in X_0 to build their social network. For them, new social links are attractive if and only if the network X_0 increases welfare by reducing fixed costs of production

enough to (at least) offset the costs of establishing social links. Therefore, the network X_0 they will consider needs to follow

$$C_{0H}^*(X_0) > C_{0H}^*(X_0 = \underline{0}) > 0 \quad \Leftrightarrow \quad \frac{X_0' K}{F k_3^{-[(1-\delta_s)S_0]}} + k_3^{-X_0' B} < 1. \quad (28)$$

For others with $A_0 < A_0^*(S_0 / X_0 = \underline{0})$, they cannot reach the high-level equilibrium without establishing new social network links so as to accumulate additional social network capital and thereby make future adoption of the high-return technology optimal. Any household that fails to meet condition (26) – because either it has inadequate endowments (A_0, S_0) or there is no potential $X_0 \in \Omega_0$ that would generate sufficient social network capital to let it reach the high-level equilibrium – will never consider establishing a social network with others. Because establishing social links is costly and the household will never benefit from these, very poor and socially distant households optimally self-select out of social networks, choosing instead self-imposed social isolation. This follows from

$$U_L^*(X_0 = \underline{0}) > U_L^*(X_0) \quad \forall X_0 \neq \underline{0}. \quad (29)$$

Social networks are no panacea and for many, they provide no viable escape route from long-term poverty, as Mogues and Carter (2005) and Adato et al. (2006) argue with reference to post-apartheid South Africa.

Among the initially poor households (whose $A_0 < \underline{A(S_0)}$), we can further identify initial asset positions for which social network capital complements or substitutes for productive assets in facilitating upward economic mobility. Because those endowed with $A_0^* \leq A_0 < \underline{A(S_0)}$ can escape from poverty even without building social network capital,

investment in X_0 is only optimal if it efficiently substitutes for productive asset accumulation – i.e., if establishing links is cheaper than capital investment for the household – in advancing economic mobility. For such households, social network capital reduces the savings required to graduate to the high-level equilibrium and thereby increases lifetime utility. In such cases, social network capital is a substitute for traditional capital accumulation in facilitating productivity and welfare growth.

For those endowed with $A_0 < A_0^*$ (and $A_0 < \underline{A(S_0)}$),²⁸ however, social network capital is a complement to traditional capital accumulation, in that it is needed in order to lower the asset poverty threshold and thereby enable the household to escape from poverty in the future. There are two distinct subpopulations among those for whom social network capital is a complement to traditional capital. First, some households are endowed with sufficient social network capital that, even with social network capital depreciation, $\delta_S, A_0^*(S_0 / X_0 = \underline{0}) < A_0 < A_0^*$, thus extant social network capital suffices to enable traditional capital accumulation enough to reach the high-level equilibrium in period I . Second, households with $A_0 < A_0^*(S_0 / X_0 = \underline{0}) < A_0^*$ need to form new social links – i.e., invest in X_0 – to augment their initial social network capital endowment in order to complement accumulation of other assets necessary to escape future poverty.

5.3 Patterns of social network-mediated economic mobility and immobility

So far we have characterized the conditions underlying each household’s optimal unilateral optimization for each of the potential network X_0 they consider. Now we

²⁸ Whether A_0^* is greater or less than $\underline{A(S_0)}$ depends on S_0 .

consider what happens as one inserts households into a broader society in which the mutual consent requirement governs social network formation, yielding an equilibrium network structure, X_0^* . Four distinct patterns of economic mobility and immobility emerge among the initially poor (whose $A_0 \leq \underline{A}(S_0)$) upon realization of their optimal network X_0^* . In the next sub-section we explore, via simulation, the process by which these patterns originate.

(1) *Households who escape from poverty without forming social networks*

One subpopulation of the initially poor enjoy sufficient initial endowments, $A_0^*(S_0 / X_0 = \underline{0}) < A_0 < \underline{A}(S_0)$, that they can accumulate resources autarkically, pulling themselves up to the high-level equilibrium in period I by their own bootstraps, without investing in accumulating further social network capital. Their optimality condition can be characterized as

$$X_0^* = \underline{0}, C_{0H}^*(X_0 = \underline{0}) > 0, U^* = U_H^*(X_0 = \underline{0}). \quad (30)$$

Among this group, some households never consider establishing a new network, as all of their possible networks would yield non-positive net utility gain, i.e., $U_H^*(X_0) < U_H^*(X_0 = \underline{0}) \forall X_0 \in \Omega_0$. Other households may be regrettably autarkic in their climb out of poverty, having failed to establish any preferred network, $\hat{X}_0 \in \Omega_0$ with $\hat{X}_0 \neq \underline{0}$ such that $U_H^*(\hat{X}_0) > U_H^*(X_0 = \underline{0})$. This latter subgroup's first-best arrangement proves socially infeasible, leaving them worse off than they might have been under a different equilibrium social network configuration, but still able to exit poverty in time.

(2) *Households who form social networks and thereby escape from poverty*

A second subpopulation of the initially poor successfully establishes networks with others, utilizing their accumulated productive social network capital so as to graduate from poverty. Their optimality condition can be characterized as

$$X_0^* \neq \underline{0}, C_{0H}^*(X_0^*) > 0, U^* = U_H^*(X_0^*). \quad (31)$$

This subpopulation's experience of a socially-mediated climb out of poverty is the phenomenon that excites the imagination of the most ardent fans of "social capital" as an instrument for poverty reduction.

(3) *Households who choose social isolation and remain trapped in poverty*

Based on (27), those who begin with especially meager endowments have no possibility to escape poverty no matter the social networks they create. None of their feasible networks, $X_0 \in \Omega_0$, would generate sufficient social network capital to complement traditional capital accumulation in fostering upward economic mobility. By (29), they do not value social network capital and therefore do not consider establishing a social network. Their optimality condition can be characterized as

$$X_0^* = \underline{0}, C_{0H}^*(X_0) < 0 \text{ for all } X_0 \in \Omega_0 \quad (32)$$

Since $X_0^* = \underline{0}$ is their top-ranked network choice in Ω^{Ranked} and they self-select out of social networks, rejecting any proposals made to them by others in the economy. The result is socially isolated, long-term poverty: $U^* = U_L^*(X_0^* = \underline{0})$.

(4) *Those involuntarily excluded from social networks who remain trapped in poverty*

The final subpopulation of the initially poor could escape from poverty if they were able to establish one or more of their preferred social networks. However, they are rebuffed by those they approach for possible links and in the absence of their desired social network capital, they are unable to accumulate enough traditional capital to climb out of poverty. Social exclusion thus conspires with meager initial asset endowments to trap these households in long-term poverty. A bit more formally, although there exists $\tilde{X}_0 \in \Omega_0$ such that $C_H^*(\tilde{X}_0) > 0$, none of these \tilde{X}_0 arise in equilibrium. Thus they must resort to $X_0^* = \underline{0}$, although this is not their preferred network, and $U^* = U_L^*(X_0^* = \underline{0})$.

These distinct mobility and immobility patterns are clearly a product of the underlying distribution of endowments in the society and the limits to social interaction. The next sub-section uses simulation methods to illustrate these patterns and further examine the underlying socioeconomic structures of social network formation that affect economic mobility.

5.4 Simulation of endogenous network formation and economic mobility

This section simulates endogenous network formation and derives an economy's stable set of bilateral social links for several randomly generated economies, based on the optimality conditions previously derived for households' unilateral intertemporal utility

maximization. The analysis assumes 17 households,²⁹ each endowed with randomly generated (A_0, S_0) , cumulatively representing the economy's endowment distribution, $\phi(A_0, S_0)$. The appendix reports the exact parameterization of this model. Our goal is to illustrate and explain the emergence of the distinct patterns of economic mobility and immobility among the initially poor. One core point we emphasize is that mobility and immobility patterns vary with the socioeconomic structure of the economy. Two otherwise identical households, dropped into quite different economies, can follow quite different patterns. Economic mobility is thus, at least in part, socially constructed.

Each figure that follows represents a randomly generated economy. Households are represented by their initial endowment positions plotted on (A_0, S_0) plane. Their long-run equilibria (either high- or low-level) are represented by the shapes in the plots. A dot represents a household that enjoys the high-level equilibrium in period I , a triangle represents a socially isolated household, and an "x" represents a socially excluded one. The equilibrium bilateral links are represented by lines connecting two link partners. In each figure, there is a downward sloping curve that reflects the static asset poverty threshold $\underline{A}(S_0)$. All those to the southwest of that line (shaded in blue) initially choose the low-productivity technology, in period 0 . We focus our discussion on this subpopulation, on the economic mobility (or immobility) of the initially poor.

²⁹ This arbitrary number was chosen for computational and presentational reasons, to generate a big enough population to demonstrate the complex interlinkages, but small enough to display visually and to remain tractable in solving the complex matching and optimization problem.

Figure 5 provides a simple illustration of the distinct patterns that emerge from this model.³⁰ The initially poor who escape from poverty without forming new social network are represented by the household with initial endowment (3,7). Those who form social networks and escape poverty fall into two sub-groups. Some climb out of poverty through solidarity among the initially poor (e.g., the cluster of the four households with the lowest S_0 endowments), while others successfully link to the initially non-poor (e.g., the household initially endowed with (6,5)). Then there are those who remain trapped in poverty, either due to social exclusion (the two households marked “x”) or to self-imposed social isolation (the three households with the lowest A_0 endowments).

Figure 6 then abstracts from the specific households and their links to map the space of these different mobility and immobility patterns. The horizontal line at the dynamic asset threshold A_o^* represents the dynamic asset poverty line in the absence of social network capital, as in Carter and Barrett (2006). Those households in area A have a large enough endowment of productive assets, A_0 , to save in the first period and thereby accumulate enough traditional capital to reach the high-level equilibrium without recourse to social network capital. Some households in region A might nonetheless establish social links as a substitute for savings and traditional capital accumulation. But households in region A are all independently economically mobile.

Those households beneath the dynamic asset threshold A_o^* all require social network capital in order to exit poverty. They can be divided into three distinct groups. Those in

³⁰ This particular set of random endowments, which we label “Economy 1”, will be used again in Figures 12 and 13 to demonstrate particular points. The label is meant to facilitate visual comparison across these figures.

area D, whose initial endowments place them above the static asset poverty line with social network capital, $\underline{A}(S_0)$, are initially non-poor because of their social network capital endowment in spite of their otherwise-insufficient endowment of traditional capital. Not only do they enjoy the high-level equilibrium in period I , but they are able to reach the high-level equilibrium in period 0 , unlike those with somewhat greater traditional capital but lesser social network capital endowments.

The dynamic asset threshold $A_0^*(S_0 / X_0 = \underline{0})$ distinguishes among the final two groups. Those (in area B) enjoy a sufficient social network capital endowment to complement productive asset accumulation and enable escape from poverty, even without forming new social links. While social network capital is necessary for their economic mobility, their initial endowment suffices to shelter them from depending on others' willingness to establish links with them. By contrast, others (in area C) can only make it out of poverty if they successfully establish new social links and thereby augment their initial social network capital endowment as a complement to saving to accumulate traditional capital. This group's economic mobility thus depends fundamentally on the underlying structure of the economy, in particular on their social distance from others and the feasible distance over which links can form within the economy. Figure 6's mapping of endowment space thus underscores the multiple roles social network capital can play in conditioning household economic growth paths, either serving as a substitute or a complement for traditional productive assets, enabling immediate or delayed exit from poverty, and ensuring independent, albeit social network-mediated mobility, or requiring the establishment of new social links non-cooperatively.

Figures 7-10 illustrate clearly the impact of the initial socioeconomic structure of the economy on the mobility of the initially poor. Each figure focuses on a distinct type of initially poor household – from group A, B or C in Figure 6 – and displays four panels that differ solely by the initial distribution of households in the economy. The southeastern panel in each figure shows the case of a highly polarized economy, so that we can underscore the impact of socio-economic polarization on the economic mobility of the poor, a point raised insightfully by Mogues and Carter (2005).

Figures 7 and 8 depict the initially poor who are autarkically mobile, in the former case irrespective of social network capital, in the case of Figure 8, thanks to their initial endowment of social network capital. Neither household *a* in Figure 7 nor household *b* in Figure 8 need to establish social links in order to climb out of poverty from period 0 to period 1. Their ability to reach the high-level equilibrium is thus not affected by structure of economy. But their choice as to whether or not to form new networks with others varies with the underlying structure of the economy in which they find themselves. In the (southeastern) case of the polarized economy, neither has any incentive to invest in links with others and thus climbs out of poverty without any new social relationships. In the southwestern case in each Figure, they choose to link with other initially poor households only, while in the northwestern case in each Figure they choose to link also with initially non-poor households. Their social arrangements are the byproduct of the underlying endowment distribution in the economy even though they in no sense depend on further social relations to reach the high-level equilibrium.

Figure 9 is perhaps the most interesting case. Here we see how the underlying structure of the economy conditions economic mobility for some of the initially poor,

those (such as household c) in what Figure 6 labeled area C. In the northwestern panel, a link with a socially proximate household that is initially non-poor enables socially-mediated exit from poverty. In the northeastern panel, economic mobility is achieved through multiple links with other, similarly initially poor households in area C. In the lower two panels of Figure 9, however, household c gets trapped in poverty. In the southwestern case, there are socially proximate households with which it would like to link, but it is rebuffed in its proposal to form a network. The result is social exclusion in equilibrium. In the polarized economy³¹ case, there is no socially proximate household with whom a connection would be beneficial, so the household prefers no links and thus settles into a socially isolated equilibrium. The subpopulation depicted in Figure 9 is thus the group for whom social networks and the underlying structure of society fundamentally shape economic mobility (or immobility).

Finally, as shown in Figure 10, some households are so destitute initially that they almost never find social relations sufficiently beneficial to enable a climb out of poverty. They are thus socially isolated in almost all configurations of the economy. The key thing to note about social isolation is that, at least under the parameterization we employ, it depends primarily on a household's initial endowment of traditional, productive capital. Those who begin too poor simply can't leverage their meager endowments no matter how skillfully they interconnect themselves with others. This is underscored more sharply in Figure 11 which plots the results from 100 randomly generated economies. There emerges a clear asset threshold below which individuals lose any incentive to establish social networks with others. Social exclusion and socially-mediated climbs out of poverty

³¹ We label this particular initial endowment "Economy 2" for further use in Figure 13.

are, however, generally quite difficult to predict due to the fact that those patterns depend so heavily on the underlying structure of the economy.

5.5 Crowding-in possibilities created by endogenous social networks

The endogeneity of social networks can quite fundamentally affect prospective interventions by governmental or non-governmental agencies. We illustrate this with reference to one specific problem of particular relevance to poverty reduction programs: transfers to the poor. Under the maintained (implicit) hypothesis that agents' social networks are exogenously fixed, Cox et al. (1995) and Cox et al. (2004), among others, argue that public transfers can crowd out private transfers because the altruistic or insurance motivation for a transfer is diminished by public support. Attempts to aid the poor could thus be thwarted by private responses to public interventions.

If, however, households' networks of social relationships are formed endogenously, then transfers could change the configuration of networks. Indeed, if social networks are endogenous, well-targeted public transfers may have the opposite effect to that posited in the existing literature. Transfers can crowd in private support by reducing the social distance between individuals and thereby encouraging the creation of new social links, enabling recipients to access newfound social network capital and to escape from poverty. Such crowding-in effects depend however, on the structure of the underlying economy, reinforcing a core point of the preceding section.

We illustrate this crowding-in possibility by repeating the previous simulations, but now adding targeted transfers to specific households. Figure 12 visualizes our base case without transfers, overlaying four specific households – *e*, *f*, *g* and *h* – with the regions

identified in figure 6. The upper two rows of Figure 13 then illustrate the possible crowding-in effects for four distinct cases of transfers to the households depicted in Figure 12 – using exactly the same initial endowments, i.e., economy 1. The bottom row of Figure 13 presents two different cases of transfers to every poor household in a polarized economy (economy 2, previously depicted without transfers in the southeastern quadrant of Figure 9).

The upper left example in Figure 13 shows the case of a household (e) that was previously too poorly endowed with capital to make costly formation of social networks attractive. In the absence of a transfer, it therefore chooses social isolation and persistent poverty, as shown in Figure 12. But with the benefit of a modest transfer,³² and given the social proximity of other households, this transfer encourages e to link to others, enabling it to leverage social network capital to escape poverty. Moreover, the induced re-formation of social networks also permits two other households to escape from poverty. These households were socially excluded in the no-transfer economy depicted in Figure 12 but now are able to band together, using newly created social network capital to access the high-level equilibrium in period 1. The central left graphic in Figure 13 shows a qualitatively similar result, this time with a 20% smaller transfer (0.8 units of A) because the recipient (household g) is more proximate to other households than household e was, ex ante, in Figure 12. It therefore requires less of a transfer to induce the creation of new social links, and thus an expansion of social network capital that not only lifts the transfer recipient out of poverty, but also two other households that would otherwise remain persistently poor. Targeting plainly matters, as we emphasize below.

³² This transfer is just one unit of A , worth one-quarter of the poor recipient household's initial capital stock and just 0.6% of the wealth of this 17-person economy.

The upper right example in Figure 13 shows a similar effect, in this case through a one unit transfer to household f , which was socially excluded in the no-transfer setting (Figure 12), but now links to three other households, one of which was already able to climb out of poverty through autarkic savings, another of which was, like f , socially excluded but can leverage its new social link to accumulate enough social network capital to climb out of poverty by period I , and the third of which expands its pre-existing social network.

Lest it seem that transfers have an automatic beneficial effect in inducing the creation of new social network capital, the right central graphic in Figure 13 illustrates how even relatively large transfers – 1.5 units of A to household h – can fail to generate poverty reduction gains when they are poorly targeted. Although the transfer brings household h right to the threshold of autarkic escape from poverty, makes social linkages attractive to it and clearly leave it better off than it would have been without the transfer, h 's relative social distance from other households leave it socially excluded and persistently poor even in the wake of a relatively large transfer.

Transfers do not have to induce the creation of social links with those who are already able to climb out of poverty in order to generate crowding-in effects. Even in a highly polarized economy, such as that previously depicted in the lower right quadrant of Figure 9, transfers to multiple poor households can stimulate the emergency of a solidarity network among the poor that enables several of them to escape poverty. This effect is shown in the lower left portion of Figure 13, which simulates the transfer of two units of A to each ex ante poor household. This transfer is clearly welfare-improving for all, but only facilitates an exit from poverty for some, the five households who establish a

solidarity network from which they optimally exclude one other poor beneficiary household and which three other poor beneficiaries do not wish to join, preferring social isolation to costly linkage to the new network.

However, the induced social network capital creation effect that stimulates economic mobility for some ex ante poor households is by no means automatic. Too meager a transfer can improve recipients' welfare but fail to generate the bigger gains associated with a leap to the high-level equilibrium, as illustrated in the lower right graphic in Figure 13, which shows the result of transfers to all poor households of just one unit of A instead of two units, as in the previous example. Collectively, these examples underscore how important core targeting questions – who? how much? – are to the poverty reduction effects of transfer programs and how endogenous social network formation fundamentally affects the efficacy of such programs. Well-targeted transfers can lift even non-recipients out of long-term poverty, while poorly-targeted transfers can fail to facilitate economic mobility even for recipients.

6. Conclusions

Social network capital can be an important avenue of upward mobility to escape persistent poverty. But costly social networking is no panacea. Not all households find it worthwhile to link to others and some will be rebuffed in their efforts to build a network. Moreover, the usefulness of social networks depends fundamentally on the underlying structure of the economy in which agents reside. In some settings, well-targeted public transfers to selected poor households can catalyze the creation of new social network capital, thereby multiplying the poverty reduction effects of interventions.

We illustrate these points by developing a highly stylized model of heterogeneous households that make consumption, investment and social networking decisions in a dynamic, interlinked setting. Depending on their initial endowment positions, social network capital substitutes for productive assets for some households, while for others it complements their productive assets in facilitating productivity growth and economic mobility.

One fundamental point that emerges from this exercise is that the exclusionary mechanisms necessary for people to be trapped in poverty (Carter and Barrett 2006) may arise endogenously due to the inherent costliness of establishing and maintaining social links. In our setting, with multiple technologies that create locally increasing returns to productive capital but no credit market to permit individuals to borrow the capital necessary to exit poverty in time, costless access to social network capital would provide an alternate pathway out of poverty, a socially-mediated solution to a market failure. When establishing social links is costly, however, some households may opt out of networks, choosing social isolation and persistent poverty instead. And when the net benefits of social links are asymmetric, other households may desire social links that would help them climb out of poverty, but are rebuffed by prospective links and thus left in a state of social exclusion and persistent poverty. These social exclusionary mechanisms are economy-specific, depending fundamentally on the underlying distribution of endowments that determine the net benefits to agents of social links.

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Figure 1: Locally increasing return production technology

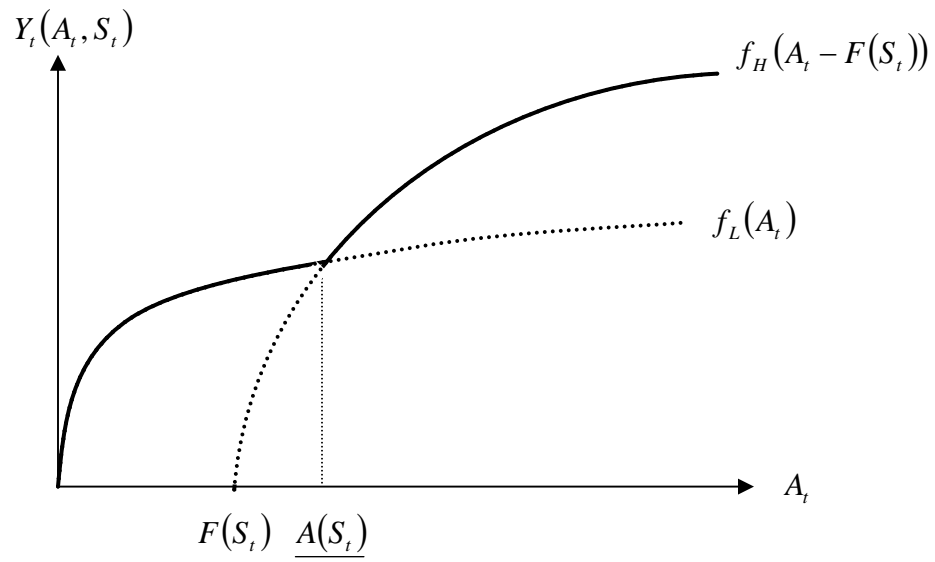


Figure 2: Locally increasing return production technology when acquiring more social networking capital ($S'_i > S_i$)

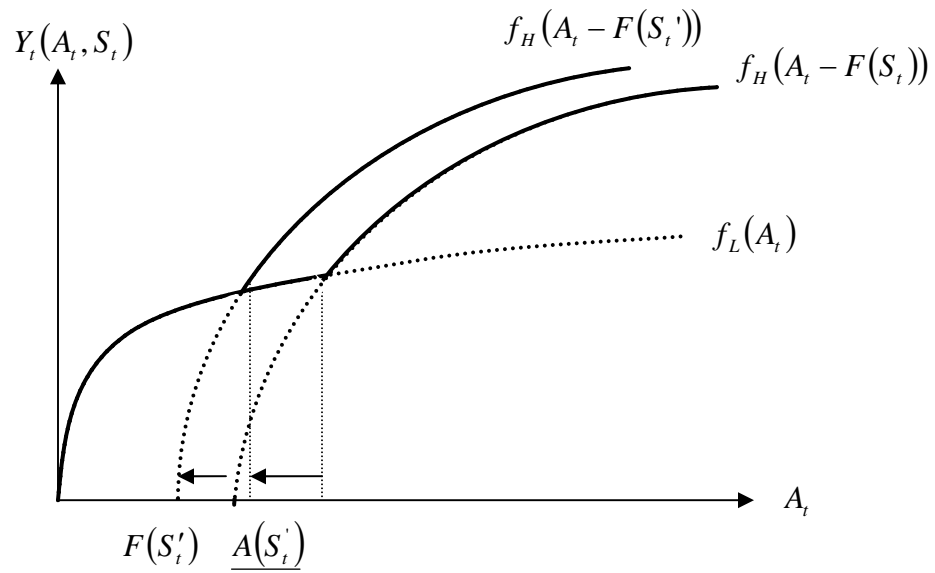


Figure 3: Example economy with $N = \{1,2,3,4,5\}$ and initial distribution $\phi(A_0, S_0)$

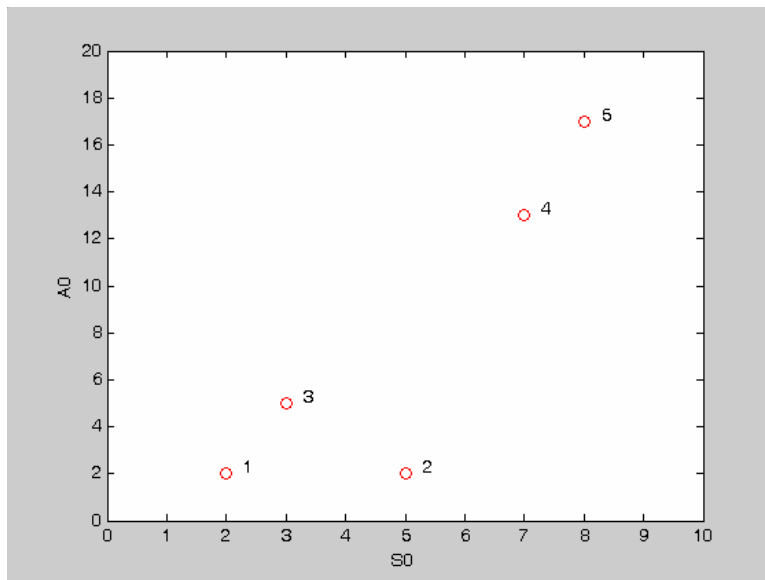
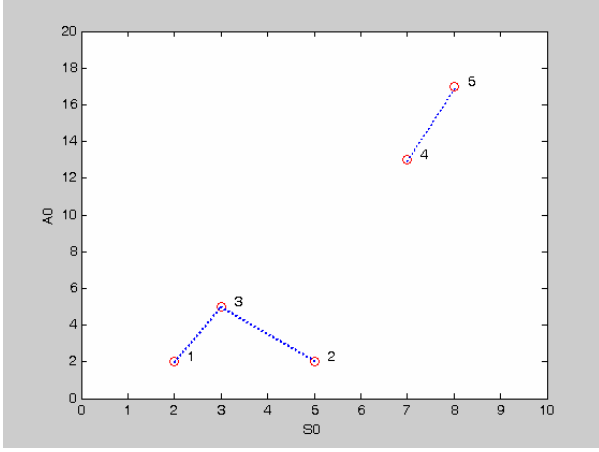


Figure 4: Example of endogenous network formation



$$\Omega_1^{Rank} = \left\{ \begin{matrix} x^d(1,2) \\ x^d(1,3) \end{matrix} \right\} = \left\{ \begin{matrix} (1, (0), (1), (0)) \\ (1, (1), (0), (0)) \end{matrix} \right\}$$

$$\Omega_2^{Rank} = \left\{ \begin{matrix} x^d(2,1) \\ x^d(2,3) \end{matrix} \right\} = \left\{ \begin{matrix} (0, (1), (1), (0)) \\ (1, (1), (0), (0)) \end{matrix} \right\}$$

$$\Omega_3^{Rank} = \left\{ \begin{matrix} x^d(3,1) \\ x^d(3,2) \\ x^d(3,4) \end{matrix} \right\} = \left\{ \begin{matrix} (1, (0), (0), (1), (1), (1), (0), (0), (0)) \\ (0, (1), (0), (1), (1), (0), (1), (0)) \\ (1, (1), (1), (1), (0), (0), (0), (0)) \end{matrix} \right\}$$

$$\Omega_4^{Rank} = \left\{ \begin{matrix} x^d(4,3) \\ x^d(4,5) \end{matrix} \right\} = \left\{ \begin{matrix} (0, (1), (0), (1)) \\ (1, (1), (0), (0)) \end{matrix} \right\}$$

$$\Omega_5^{Rank} = \{x^d(5,4)\} = \{1,0\}$$

The progress of interaction procedure is shown below, “→” stands for “propose to”

	Round 1	Round 2	Round 3
HH 1:	→ 2 No	→ 2 No	
	→ 3 Match	→ 3 Match	$\xrightarrow{\text{established}} X_1^* = \begin{pmatrix} 0 \\ 1 \end{pmatrix}$
HH 2:	→ 3 No	→ 3 Match	$X_2^* = \begin{pmatrix} 0 \\ 1 \end{pmatrix}$
HH 3:	→ 1 Match	→ 1 Match	
	→ 4 No	→ 2 Match	$X_3^* = \begin{pmatrix} 1 \\ 1 \\ 0 \end{pmatrix}$
HH 4:	→ 5 Match	$X_4^* = \begin{pmatrix} 0 \\ 1 \end{pmatrix}$	
HH 5:	→ 4 Match	$X_5^* = 1$	

Figure 5: Basic simulation illustration

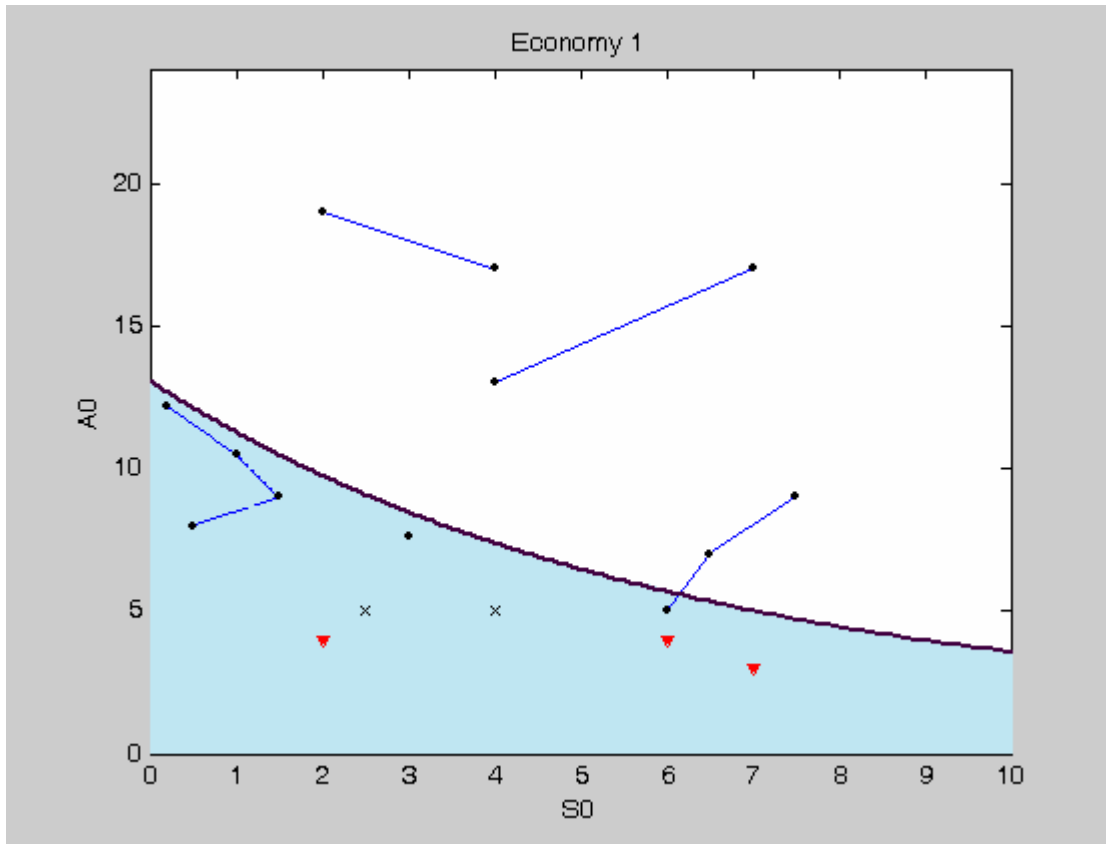


Figure 6: The space of social mobility and immobility in one simulated economy

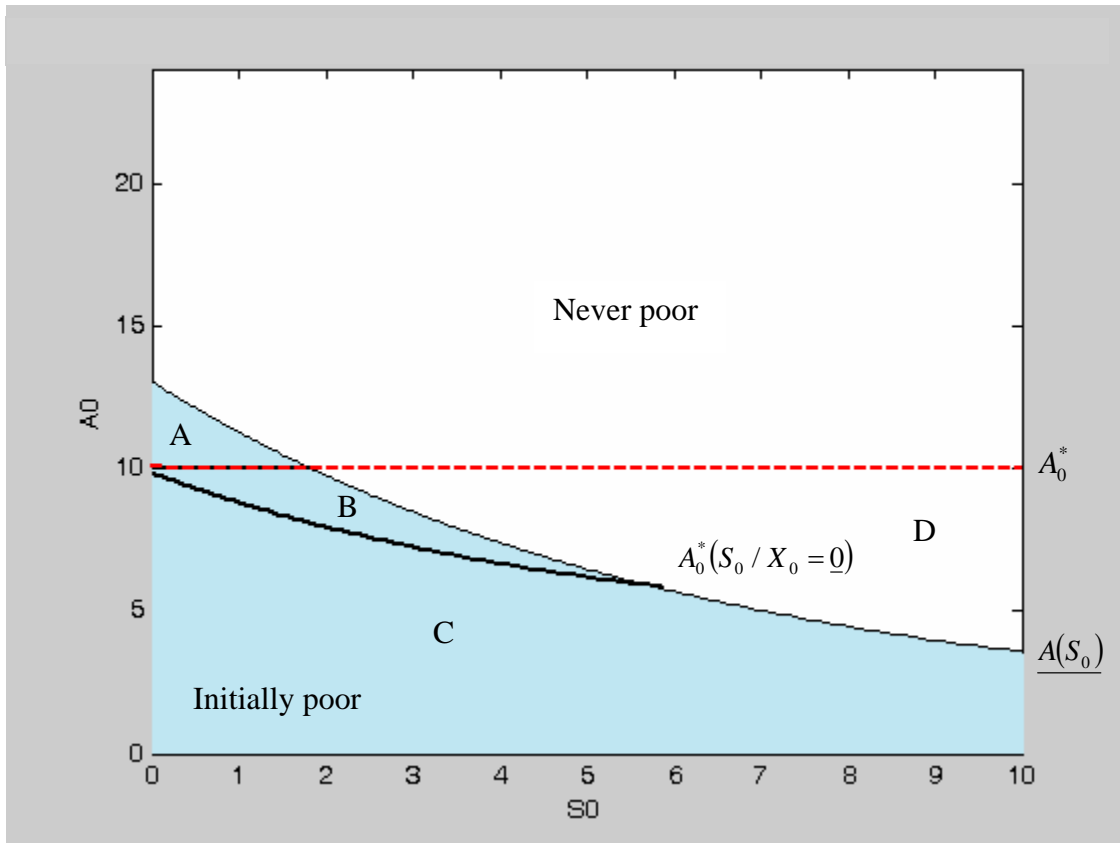


Figure 7: Different patterns for an autarkically mobile household

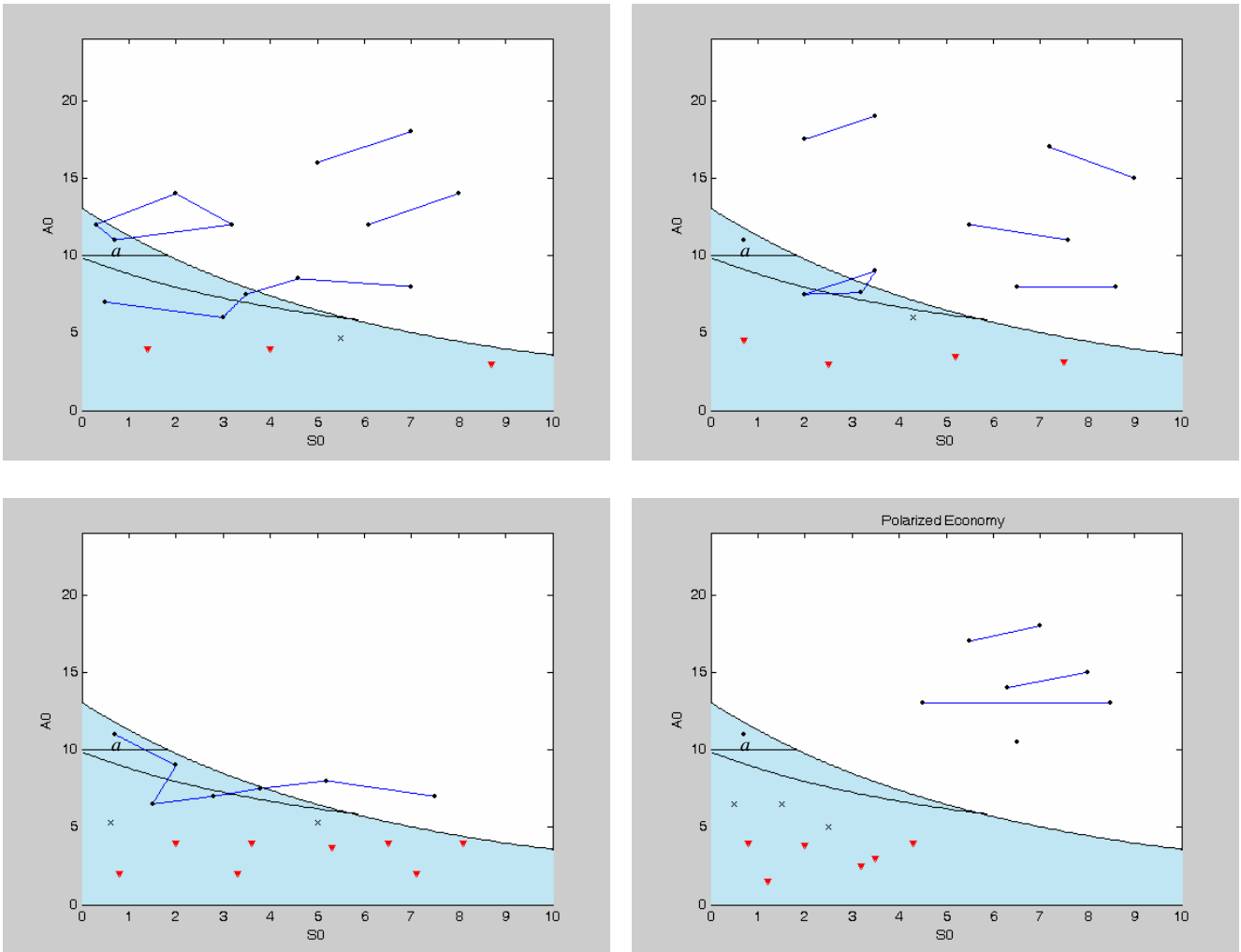


Figure 8: Different patterns for a household autarkically mobile given its S_0

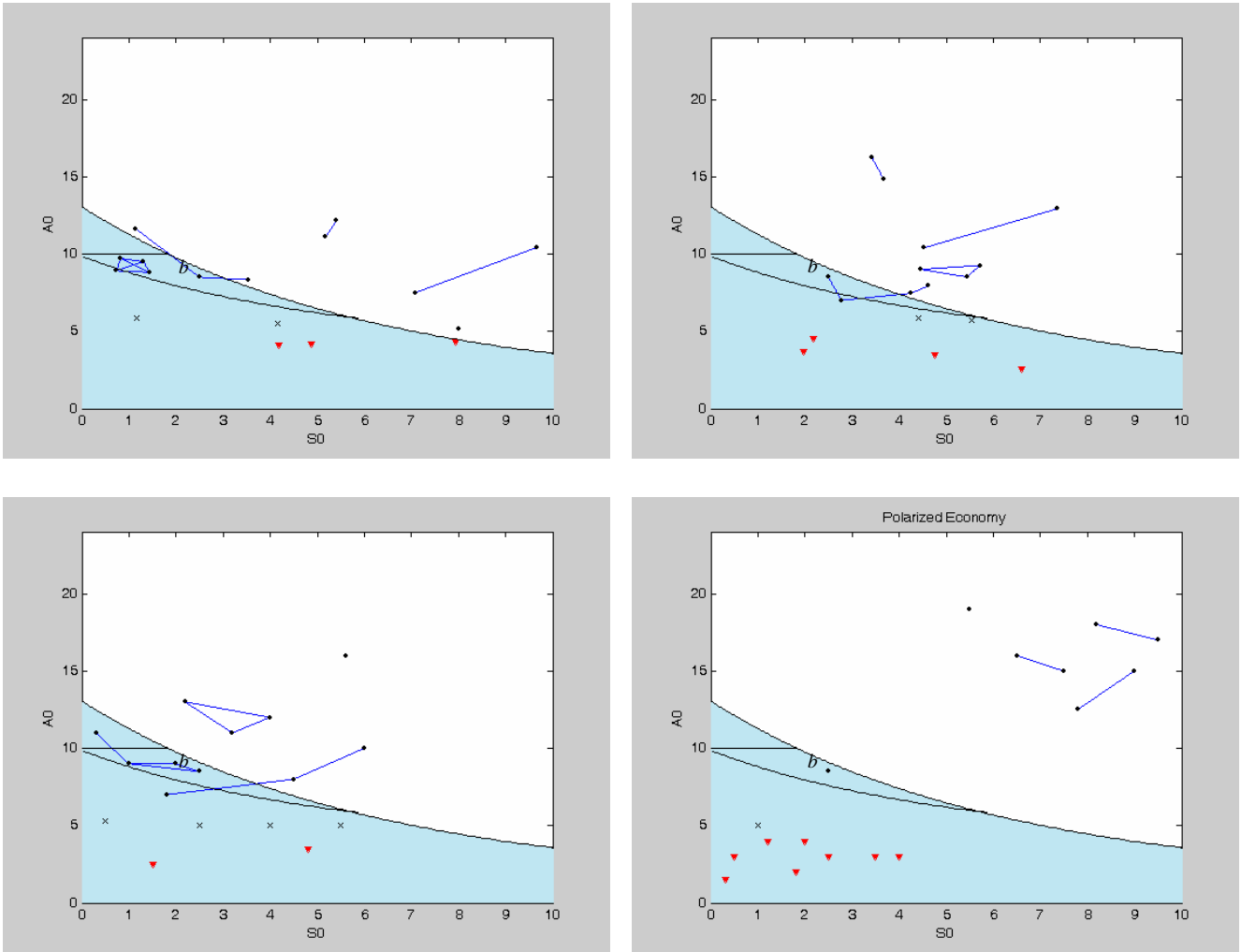


Figure 9: Different patterns for a household whose mobility depends on social links

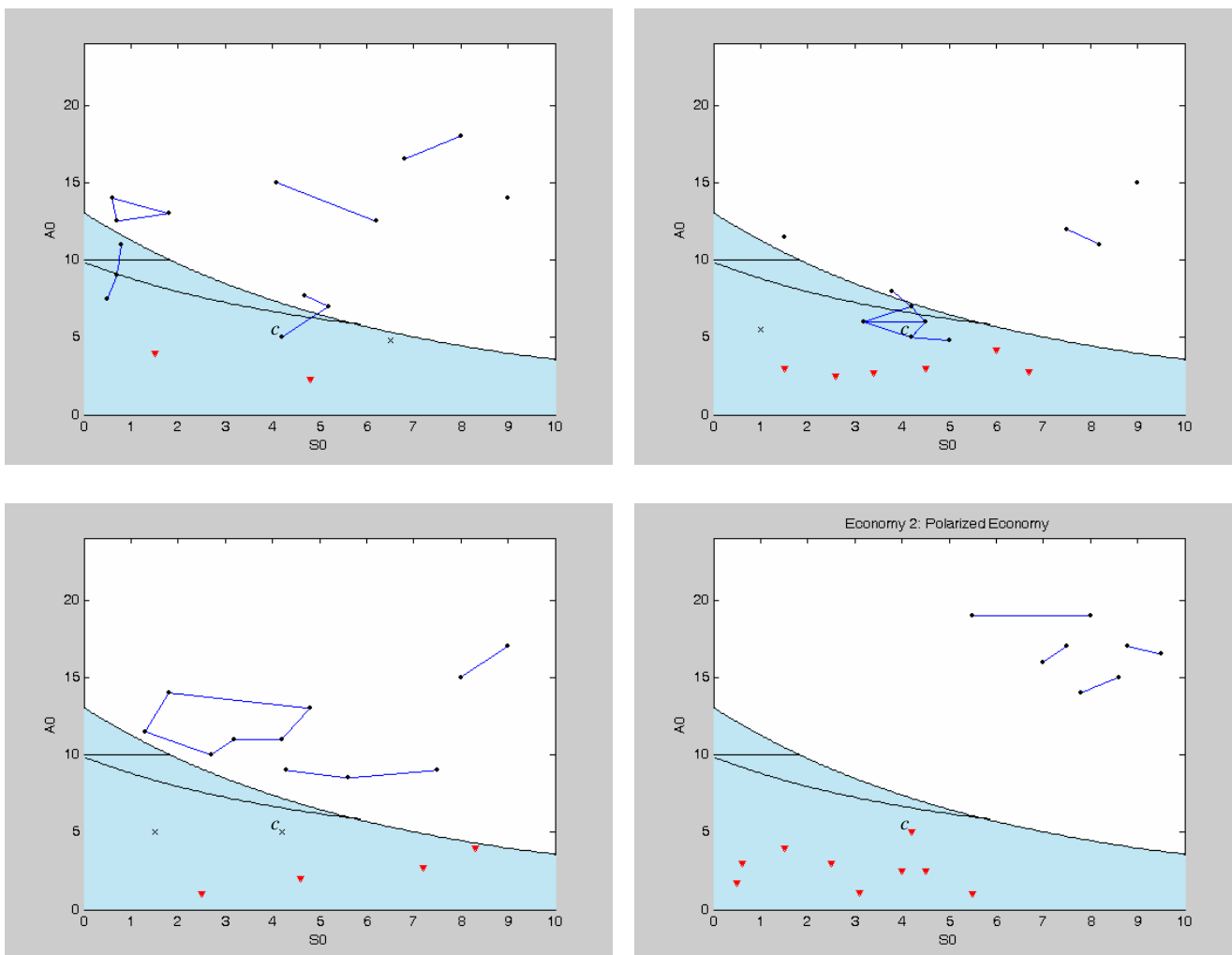


Figure 10: Different patterns for a destitute, economically immobile household

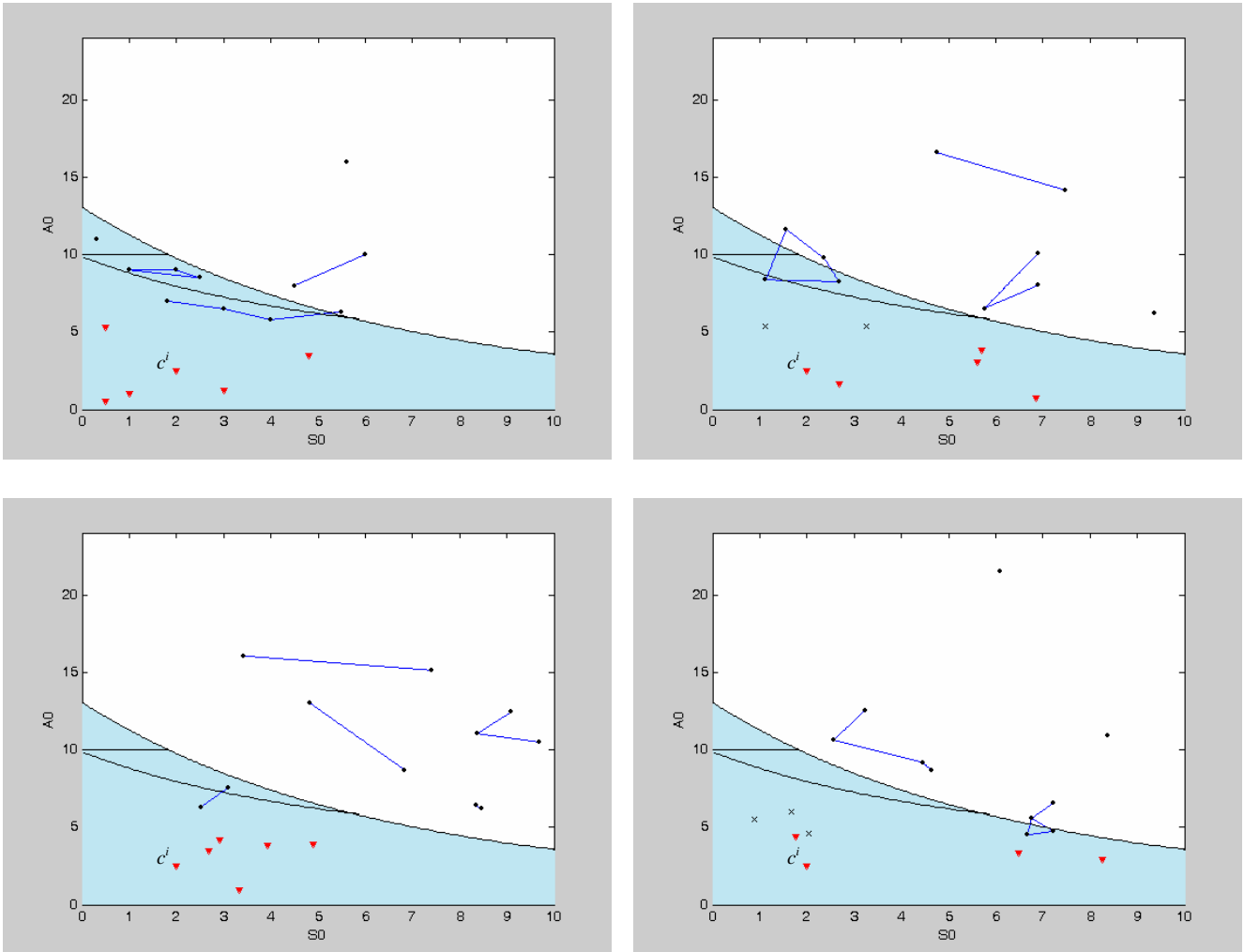


Figure 11: Equilibrium social networks and long-run equilibria for 100 economies

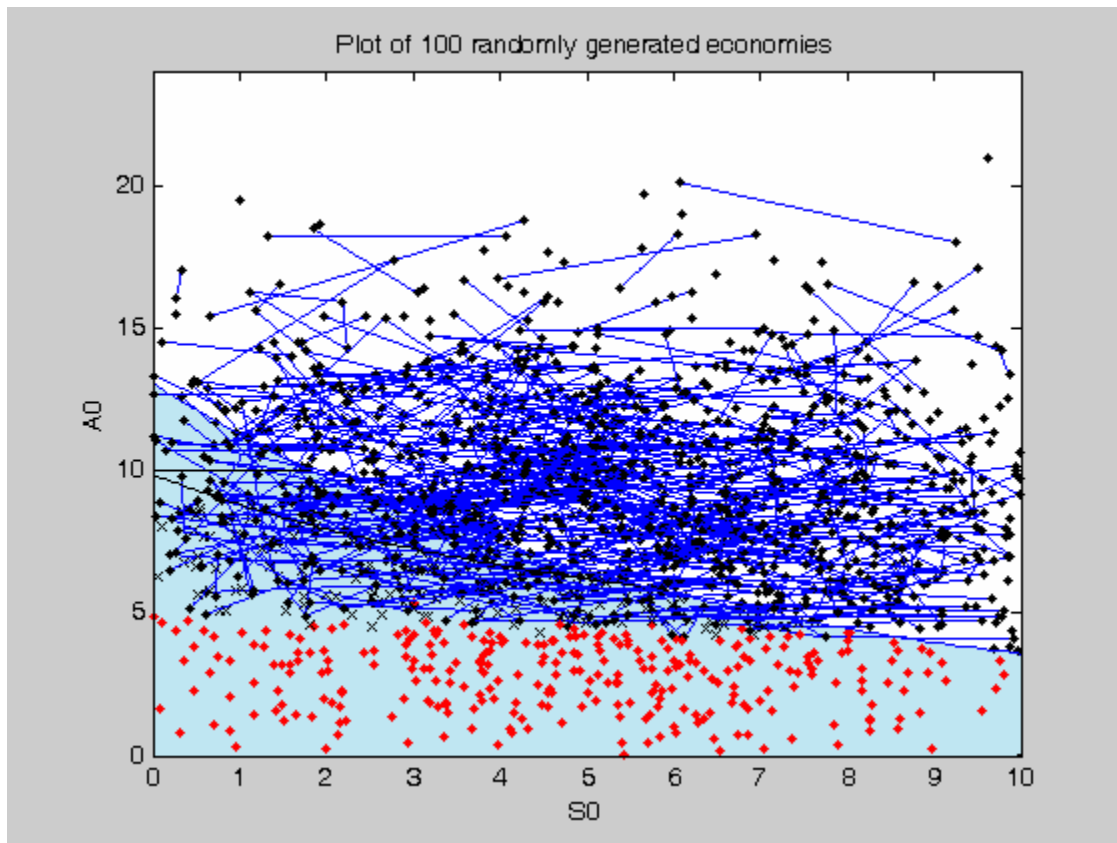


Figure 12: Households and regions combined in a simulated economy

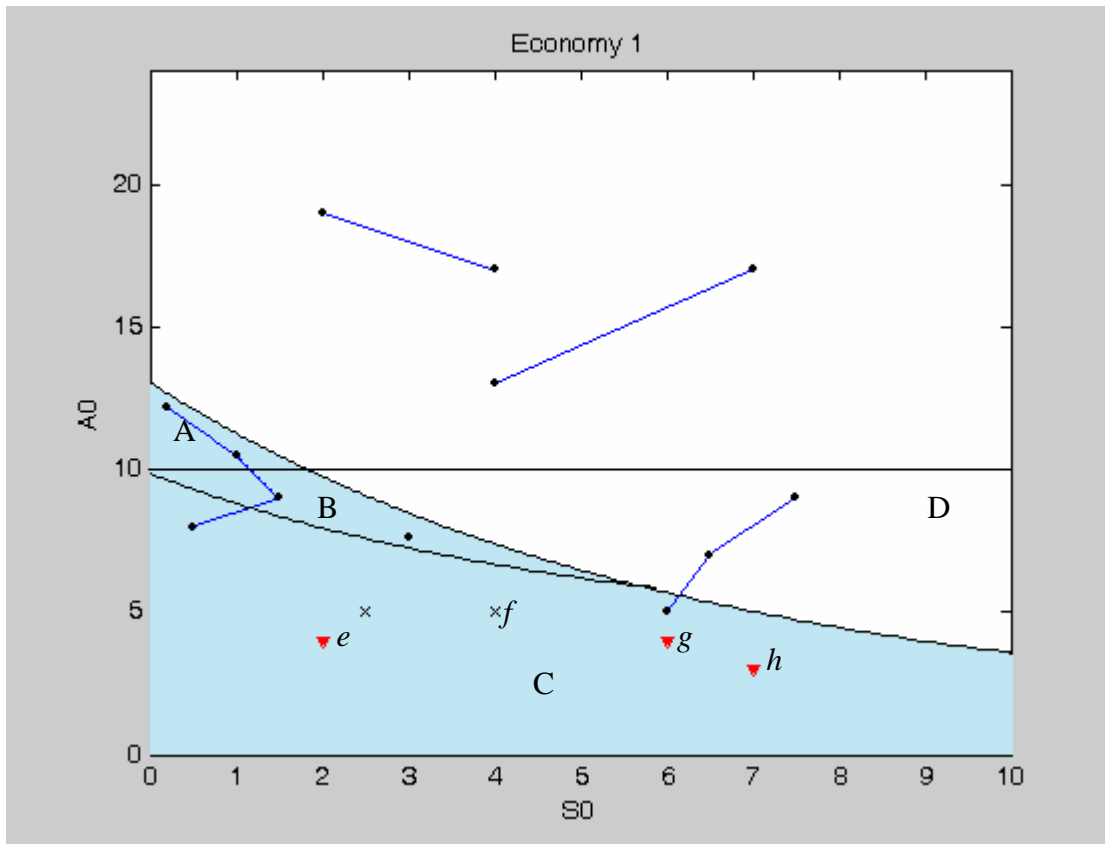
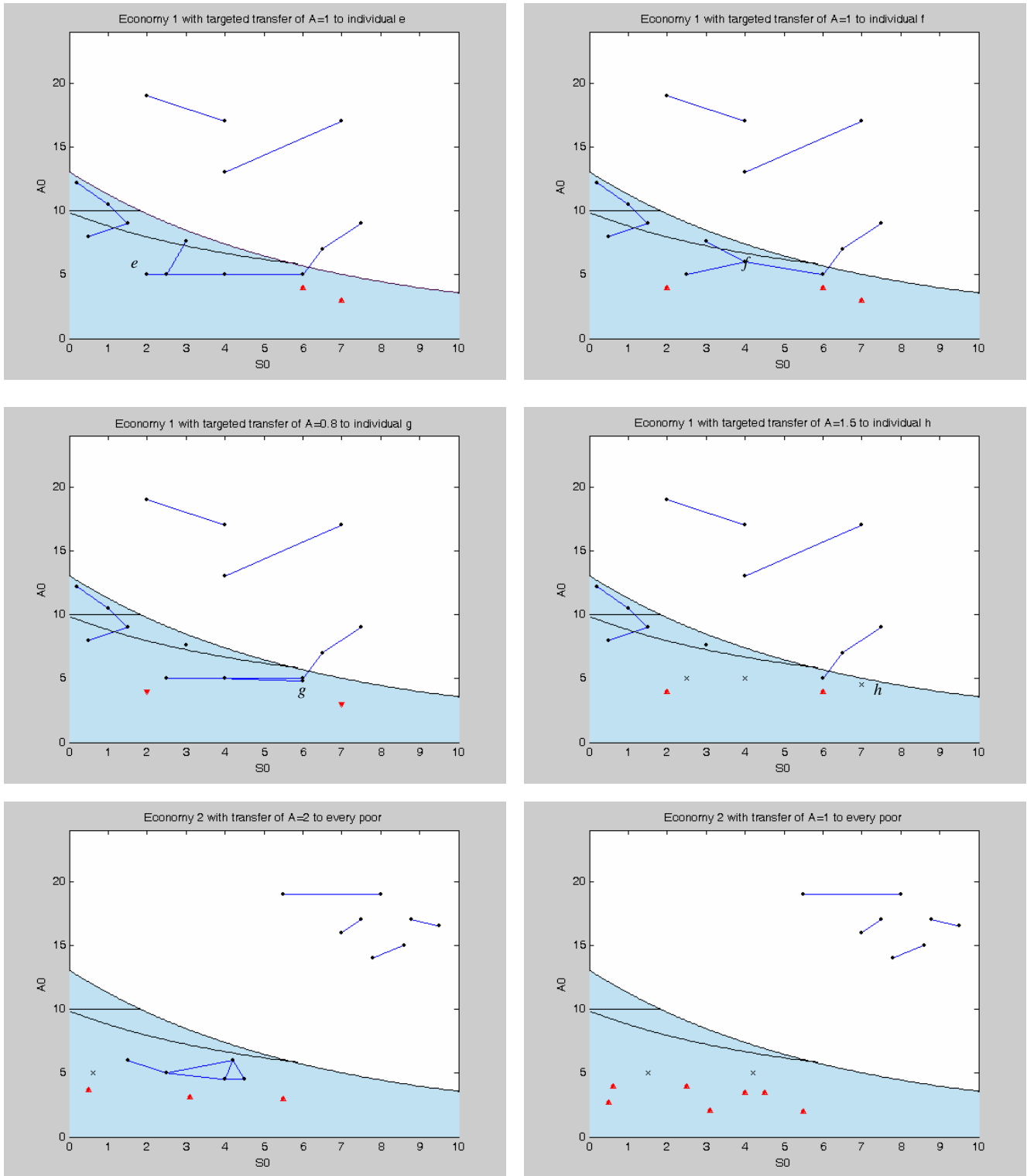


Figure 13: Targeted transfers and “crowding in” effects



Appendix: Parameterization of the simulation

1. Utility: $a = 1, \rho = 0.95$
2. Production function: $k_1 = 9, k_2 = 8.5, k_3 = 1.2, \alpha_1 = 0.25, \alpha_2 = 0.5, F = 9$
3. Cost/benefit of link: $\theta_1 = 0.125, \theta_2 = 1, \theta_3 = 0.33$
4. Asset accumulation: $\delta_S = \delta_A = 0.05$
5. For each randomly generated economy with $\phi(A_0, S_0)$, $N=17$ with randomly generated initial endowments (A_0, S_0) : $A_0 \in [0, 20]$, $S_0 \in [0, 10]$