

Social Capital and Growth*

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Abstract

We define and characterize social capital in a simple growth model. We capture social capital in a model where individuals in a community maximize their lifetime gains to trade. Each trade between two members of a community has the structure of the prisoners' dilemma. Trades are repeated indefinitely, but not necessarily each period. Social capital is defined as the social structure which facilitates cooperative trade as an equilibrium. The trading model is incorporated into a growth model to explore the connections between growth, labor mobility, and social capital. The key assumption is that technological innovation, which drives growth, involves a reallocation of labor that affects social capital. Modifying the responsiveness of labor to a technological shock, has implications for both labor efficiency and social capital.

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1 Introduction

Capital is an important determinant of prosperity. The improvement in the quality and quantity of tools and machines enhances the productivity of labor and, therefore, well being. However, capital need not be just physical. Human Capital, in the form of skills, education and training, is also an important component of productivity (Becker (1964)). Organizational Capital, the system of organizations to process information (Prescott and Visscher (1980)), or more generally, a business's technological know-how (Romer (1990)) are further examples of non-physical capital. Similarly, Coleman (1990) and Putnam, Leonardi, and Nanetti (1993) point out that the social structure is an important determinant of the feasibility and productivity of economic activity. Relationships between individuals, norms, and trust all help facilitate coordination and cooperation that enhances productivity.

The term “social capital” was coined by L.J. Hanifan, a social reformer, who in 1916 chose the word “capital” specifically to highlight the importance of the social structure to people with a business and economics perspective.¹ Despite its importance, there is no single accepted definition of social capital.² Coleman chooses to define social capital loosely in terms of its function. Social capital, he argues, is some aspect of the social structure “making possible the achievement of certain ends that would not be attainable in its absence.”³ A more useful starting definition is provided by Putnam, Leonardi, and Nanetti (1993). They define social capital as the social structure which facilitates coordination and cooperation.

Despite the difficulty in formulating a definition suitable for a tractable economic model, a great deal of research has been done to measure social capital and its effects. Putnam, Leonardi, and Nanetti (1993) argue that the success and failure of the regional governments established in Italy can be ex-

¹Putnam (2000), page 443.

²See Sobel (2002).

³Coleman (1990), page 302.

plained by social capital. They find that traditions of civic engagement, voter turnout, active community groups and other such measurable manifestations of social capital are necessary for good government. Social capital also influences economic and financial development. Guiso, Sapienza, and Zingales (2001) measure social capital using a variety of indicators like participation levels in associations, election turn-out, and other measures of civic involvement. They find that in Italy, the level of social capital is positively related to financial development. People with more social capital have higher investments in the stock market and have more access to formal financial institutions. Similarly, Hong, Kubik, and Stein (2001) find that in the United States, people who “know their neighbors” have higher stock-market participation rates. However, the connection between economic prosperity and social capital is not always clear. Putnam (2000) documents, in great detail, the large decline in social capital in the United States in the twentieth century. While, this fact is linked to some economic measures, it is hard to argue that the U.S. economy did not flourish over this same period. More specifically, Miguel, Gertler, and Levine (2001) focus on the connection between industrialization and social capital in Indonesia. Counter to Putnam’s view, social capital did not predict subsequent development and, in fact, in some cases industrialization increased levels of social capital.

One approach to modelling social capital is to focus on the “capital” aspect of social capital. Glaeser, Laibson, and Sacerdote (2000), for example, treats social capital as an asset (e.g., a Rolodex) that can be increased through investment and decreased through depreciation. The assumption that links the model to social capital is that returns to an individual’s social capital depend on the aggregate amount of social capital. This specification facilitates analysis of an individual’s investment in social capital but leaves the source of the externality unspecified. In contrast, in this paper, we focus more on the “social” aspect of social capital as in Bowles and Gintis (2000). Social capital exists within a community or between individuals. Rather than focus on an investment in social capital, our model has individuals making rational decisions (about location and trade) of which social capital is a by-product.

The inability to own or transfer social capital is what creates a role for policy.

Specifically, we focus on social capital as influencing cooperative behavior. The necessity of cooperation stems from the expense or difficulty in writing complete and enforceable contracts. In these situations, trust or cooperation reduces contracting costs. At the core of the model is bilateral trade where the gains from the trade are a prisoner's dilemma.⁴ Friendly trade is Pareto optimal but unfriendly trade is the dominant strategy in a one-shot game. In each period, any two agents from a community will meet at most once. However, trading opportunities are stochastic and an agent pair may go several periods without meeting. Since, the trading game is repeated indefinitely, cooperative or friendly trade may be an equilibrium. However, for friendly trade to be an equilibrium, trade must be frequent enough to induce agents not to act opportunistically. We define social capital as facilitating the Pareto optimal equilibrium. In our specific context, the social structure determines the probability that two individuals meet for trade. We use this framework to define social capital as influencing the frequent trade and study its effects on welfare in a simple trade environment and in a simple growth context.

In Section 2, we develop the trading model that defines social capital. Since social capital is a public good, social capital destruction can make everyone worse off, better off, or be Pareto non-comparable. The model highlights an important trade-off. In larger communities, which have more opportunity for trade or are more efficient, cooperative trade is harder to sustain. When choosing a community, individuals (rationally) do not give full weight to the effect their actions have on social capital. We develop this tension in more detail in Section 3 where the trading model is incorporated into a growth setting. The key assumption is that technological innovation, which drives

⁴Using a prisoner's dilemma to model gains to trade is related to the large body of research on institutions and transactions costs. The work of Williamson (1985), North (1987), (1991) focusses on measuring the size, nature, and determinants of transaction costs. Kranton (1996) is most closely related to our paper. Kranton's model allows traders to choose between reciprocal exchange, with a repeated prisoner's dilemma structure, or an anonymous market.

growth, involves a reallocation of resources. In particular, technological change is accompanied with higher labor turnover. This change in the social structure affects social capital. Modifying the responsiveness of labor to a technological shock, has implications for both labor efficiency and social capital. Since both impact welfare, it is not the case that frictionless labor mobility is optimal. In particular, it can be the case that reduced labor mobility, which results in decreased labor efficiency, increases welfare by increasing the proportion of trades that are cooperative. The benefit of the increased social capital can outweigh the cost of lost efficiency.

2 Simple Model of Social Capital

There are M communities each with N_m individuals.⁵ Initially, we focus on the activities in one community where, in each period, $t \in \{0, 1, \dots\}$, individuals may trade with some of the members of their community. Traders seek to maximize their expected lifetime gains from trade. Each transaction involves two agents who choose whether to trade in a friendly (cooperate or c) or unfriendly (exploit or d) manner. Gains from trade have the structure of a prisoner's dilemma whose payoffs, for concreteness, are shown in Table 1. This structure captures, for example, contracting cost. Friendly trade is more efficient since fewer resources are wasted on contracting, measuring, and enforcing. However, since trade without formal contracts involves trust, a friendly trade may be exploited by the other party. Unfriendly trade can be viewed as both parties attempting to exploit the other. The result is a less efficient trade where resources are consumed by formal contracting and measurement. However, the structure of payoffs is consistent with many types of externalities.

In any one period, any two agents will meet at most once. However, since each meeting is probabilistic, two agents may go several periods without trad-

⁵This section is adapted from Routledge and von Amsberg (1995).

Table 1: **Gains to trade per meeting.**

		<i>Trader j</i>	
		c	d
<i>Trader 0</i>	c	(2, 2)	(0, 3)
	d	(3, 0)	(1, 1)

Payoffs to the trade are shown as (*Trader 0*, *Trader j*). For concreteness, specific payoffs are used. This is without loss of generality.

ing with one another. Preferences are time-additive and risk neutral. The preferences for trader 0 are:

$$U_0 = (1 - \beta) \sum_{t=0}^{\infty} \beta^t \left\{ \sum_{j=1}^{N-1} \pi_{0j}(x_t) u(s_{0j}(x_t), s_{j0}(x_t)) \right\} \quad (1)$$

$\beta \in (0, 1)$ is a discount factor that, for simplicity, is the same for everyone. x_t represents the trading history or past actions of the traders in periods 0 to $t - 1$. What is included in the history, x_t , has important implications for our model and is discussed further below. $\pi_{0i}(x_t)$ is the probability that trader 0 and j meet at period t . Traders 0 and j can meet at most once in a period and, of course, $\pi_{0j}(x_t) = \pi_{j0}(x_t)$. The payoff, u , from the trade between 0 and j depends on the actions of the two traders and is given in Table 1. The actions of the traders, c or d , are determined by the strategies of the players. The strategy of individual 0 is $s_0 = \{s_{0j}\}_{j=1}^{N-1}$, where $s_{0j}(x_t)$ determines the action, c or d , when trading with individual j having observed the history x_t .

To focus on social capital, we make some specific assumptions. The goal is to link social capital to observable features of the economy in a relatively straightforward manner. There are many alternative assumptions that produce similar results. To avoid digression, assumptions are stated here but discussed in more detail in Section 2.3.

Assumption (i): *Trade is pair-wise.* Our model assumes that opportunities for gains from trade arise between two agents. There is no collective action or team production.

Assumption (ii): *Games are Private.* No agent can observe or obtain information on the trades between other agents. Even if information about past play is completely private, agent 0 could base his move with j on the past behavior of anyone in the population. However, we rule these strategies out. We restrict a strategy for trader 0 for playing j to depend only on the past trades between these two agents 0 and j .

Assumption (iii): *All gains from trade are non-negative.* It is important that the payoff when both agents play d is strictly positive. When agents do not meet, they earn zero since there is no trade. Individuals strictly prefer an unfriendly trade to no trade at all.

Assumption (iv): *Agents will trade cooperatively if it is an equilibrium.* The agents are playing a repeated prisoners' dilemmas (in fact N of them simultaneously). By the folk theorem, there may be many sub-game perfect equilibria. To highlight the role of social capital, we will concentrate on strategies that support only repeated cooperation or repeated defection along their equilibrium path. Unfriendly trade, where only (d, d) trades are observed, is always a sub-game perfect equilibria since it is a Nash equilibrium of the stage game. The strategy profile where all agents choose d for all trades regardless of history will be called s^d . Friendly trade is where only (c, c) trades are observed in equilibrium. A strategy profile which will potentially support friendly trade is for all agents to use a trigger strategy for play in all N games: When playing agent j , play c initially and play c as long as the history of trades with j with contains only (c, c) trades; otherwise play d . This strategy profile is denoted s^c . Whether or not all traders following s^c is an equilibrium will define the existence of social capital.⁶

⁶Since trigger strategies impose the maximum punishment on a person who defects from friendly trade, they support cooperation if it is feasible. To the extent trigger strategies are

Assumption (v): Probability of trade, $\pi_{ij}(x_t)$ is history independent. We assume $\pi_{0j}(x_t)$ is a constant, denotes π_{0j} , that depends on community size.

2.1 Social Capital Definition

As mentioned in the introduction, there is no standard definition of social capital. In our model, we define social capital as the social structure that facilitates cooperation. Social capital exists in a community when friendly trade, s^c , is an equilibrium. This occurs for players 0 and j when the probability that the two traders meet, π_{0j} , is high enough.

Proposition 1: For the trade of player 0 and player j , the strategies s_{0j}^c and s_{j0}^c are a sub-game perfect equilibrium if and only if $\pi_{0j} > \pi^c$ where $\pi^c = \frac{1-\beta}{\beta}$.

The proof, which is standard, is in the appendix. Cooperative trade, supported by s^c , is an equilibrium as long as each individual trader values the future cooperative trade more than the one-time gain of an exploitive trade (playing d when the other plays c) followed by unfriendly trade at subsequent meetings. For friendly trade to be an equilibrium, it must be the case that individuals meet frequently (π_{0j} is high) and are sufficiently patient (large β). The social structure determines the frequency of trade, π_{0j} .

2.2 Examples of Social Capital

In our model, social capital depends on the probability two individuals meet in a period, π_{ij} . To make the definition of social capital concrete, we need an assumption that links this probability of trade to a more primitive feature of the economy. Here, we will focus on community size. Larger communities

unrealistic, and individuals use a strategy with less punishment, social capital in our model will be overstated. Note van Damme (1989) shows that it is straightforward to construct renegotiation-proof strategy that are very similar trigger strategies.

provide more opportunity for trade, but trade is more anonymous. These features are captured in the following assumption:

Assumption (vi): *The probability of trade for all individuals i and j in a community of size N is given by:*

$$\pi_{ij} = \pi(N) = \min\left(1, \frac{\bar{N}}{N-1}\right). \quad (2)$$

Individuals have a maximum capacity for trade of \bar{N} trades per period. If they live in a community where $N - 1 < \bar{N}$ they will trade at most $N - 1$ times per period.

The following examples demonstrate that social capital is a public good that may be subject to both “under-investment” and “over-investment.” In each of the example, a financially viable project may destroy social capital. The examples are similar in that increasing the number of opportunities to trade can affect the equilibrium at which those trades occur and thus affect social capital.

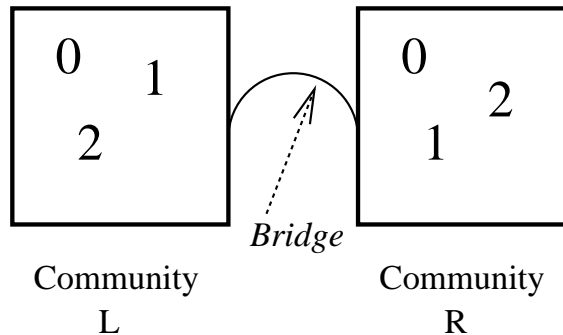
Two communities, L and R , are shown in Figure 1. Initially, the two communities are separate and the three individuals in L do not trade with the three people in community R . A bridge that allows individuals to emigrate from L to R changes the social structure (e.g., probability of trade) and affects the social capital.⁷

2.2.1 Inefficient Social Capital Destruction

The first example demonstrates how the construction of a bridge destroys social capital and leaves all the agents worse off. This example is parameterized by $\beta = 0.55$, each community initially has $N = 3$ individuals, and

⁷The model assumes the social structure to be fixed. In particular, π_{0j} are assumed to be constant. Formally, the construction of a bridge is not an anticipated change and is analogous to a comparative static exercise. This is just for expositional purposes. In Section 3 we formally consider changes in the social structure that arise from a technological shock that all agents correctly anticipate.

Figure 1: Two Community Example



Two communities, L and R , each with $N_L = N_R = 3$ individuals. Each person has $\bar{N} = 3$ trading opportunities per period (see equation (2)). The introduction of the bridge joins the two communities.

$\bar{N} = 3$ trading opportunities per period. Currently, each person trades twice. The critical probability required to support friendly trade is $\pi^c = 0.818$. In each community, the probability of meeting is sufficiently high to support friendly trade; that is $\pi(3) = 1 > \pi^c$. All individuals have utility of 4 (*2 trades per period \times 2 per trade*).

The bridge serves to unite the two communities, the new larger community has six people. In this case, the probability of any agent pair meeting is now $\pi(6) = 3/5$, less than $< \pi^c$, so friendly trade is no longer an equilibrium. In the larger community each agents' utility has decreased to 3 (*3 trades per period \times 1 per trade*). Despite the increased opportunities for trade, each agent is worse off since each trade now occurs on unfriendly terms.

Despite the fact that the bridge is Pareto decreasing, it is in each agents' individual interest to use the bridge. Instead of assuming the bridge simply unites the communities, we can consider an individual's choice to use the bridge to emigrate. Consider for simplicity, the situation where the bridge is temporary. Individuals in community L have a one-time opportunity to

emigrate to R .⁸ It is a dominant strategy for individual 0 in L to use the bridge to emigrate. If others choose not to move, by moving to R , she would increase her utility (and the utility of current residence of R) from 4 to 6 ($3 \text{ trades} \times 2 \text{ per trade}$). If at least one other person in L chooses to move, individual 0 must also move. Remaining in the now smaller community L yields a utility of 2 (one friendly trader per period) or 0 (no trade if both other agents move). Even though agent 0 realizes her decision to emigrate to R will result in unfriendly trade ($\pi(5) = 3/4$ and $\pi(6) = 3/5$ are both less than π^c), the greater number of opportunities for trade makes moving individually optimal, yielding a utility of 3 ($3 \text{ trades per period} \times 1 \text{ per trade}$). Since moving is a dominant strategy, everyone from L will move to R despite the loss of social capital.⁹

The introduction of a bridge leads to a sub-optimal community size since individuals ignore their externality on the social capital. Migration that leaves behind smaller, less viable communities captures part of the externality problem with social capital: "...[A] family's decision to move away from a community ... may be entirely correct from the point of view of the family. But because social capital consists of relations among persons, others may experience extensive loss."¹⁰ The other aspect of the externality problem is the effect on social capital in the growing community. In our example, community R can not support cooperative trade after the bridge is constructed.¹¹ However, the construction of a bridge between the two communities is not an

⁸We assume that people cannot discriminate based on the origin of the player. If agents can discriminate based on community of origin, then the bridge need not affect social capital. We revisit this point in Section 2.3.

⁹The assumption that individuals move from L to R can trivially be replaced with the assumption that people move from R to L . If however, we do not specify the direction of movement, there are multiple equilibria. If the bridge is a permanent structure which people can choose to use at any period as part of a repeated game, the resulting game is more complicated. However, given these parameters, the result is the same. The status quo with two communities with social capital (friendly trade) is not an equilibrium.

¹⁰Coleman (1990) page 316.

¹¹These two features are present in Kranton (1996) where a trader's choice between a reciprocal exchange market or an anonymous market makes one market larger and the other smaller.

unreasonable project. An entrepreneur could construct the bridge and charge a toll for its use and make a profit. The bridge is a financially viable project because the entrepreneur does not bear the cost of the destroyed social capital. More generally, mobility is an important component to labor productivity and growth. However, mobility also has important implications for social capital. The connection between technological change, labor mobility, and social capital is considered further in Section 3.

Migration is particularly important in developing economies. For example, Miguel, Gertler, and Levine (2001) document for Indonesia the reduction in the density of community credit cooperatives and other measures of “mutual cooperation” due to out-migration from communities that are located near to rapidly industrializing areas. Interestingly, the Miguel, Gertler, and Levine study does not find reduced social capital in the rapidly growing communities themselves. Rather, local industrialization increased measures of social capital. This may reflect two limitations of our model. First, communities in our model are defined exogenously. People do not, in our model, choose the probability of meeting. However, there is evidence to suggest that associations from rural villages often transfer to new communities.¹² In reality, probability of trade is not exogenous. This limitation is discussed in Section 2.3 below. Second, industrialization increases wealth. This wealth provides people with more resources to invest in community activities. Since our model abstracts from direct investment in social capital, we cannot capture this effect.

2.2.2 Efficient Social Capital Destruction

Social capital destruction need not always be welfare decreasing. If instead, there are three communities each with two agents, bridges connecting these communities would create a single large community with six agents. Each agent’s utility would increase from one friendly trade, yielding utility of two

¹²See Palloni, Massey, Ceballos, Espinosa, and Spittel (2001)

to three unfriendly trades giving a utility of utility of three. The increased opportunities for trade outweigh the costs of destroying social capital.

2.2.3 Pareto Non-Comparable Social Capital Destruction

In the first example, a change in social capital led to a reduction in each individual's welfare. In the second example, all agents were made better off by eliminating social capital. Changes in social capital, however, need not be Pareto comparable. Consider the situation with one small community with $N_L = 2$ people and a larger community with $N_R = 4$ people. The other parameters are the same as the previous examples. The construction of a bridge to link the two communities will improve the utility of the individuals in L (from two to three) and reduce the utility of agents in community R (from six to three). Social capital is destroyed since the bridge facilitates emigration to community R which eliminates friendly trade. The situation with and without the bridge are Pareto non-comparable.

The example highlights a difficult policy issue surrounding social capital. Putnam, Leonardi, and Nanetti (1993) point out that "Social inequities may be embedded in social capital. Norms and networks that serve some groups may obstruct others."¹³ In this example, the social structure (the isolation of community L) benefits one community at the expense of the other. Public policy goals of equity or equal opportunity may make social capital destruction (bridge construction) desirable. Equity considerations may be particularly predominant when the separation of communities is based on ethnic or racial discrimination. School desegregation in the United States is perhaps one such example where equity considerations were of primary importance.

More generally, it is helpful to distinguish between bridging and bonding social capital. Our model of trade focusses on bonding social capital that facilitates cooperative trade in the small community. Bridging social capital refers

¹³Putnam, Leonardi, and Nanetti (1993), page 42

to the social network that connects individuals to expand trade opportunities. Linking communities to increase trade opportunities increases bridging social capital.¹⁴ This example highlights that it is difficult to simultaneously build both bridges and bonds. One can expand the trading opportunities by joining communities, but it is hard to do so without affecting the nature of trade in the new, larger, community. As in the case of school bussing, the choice between small communities with (bonding) social capital and a larger community where people have more opportunities (bridging social capital) for trade is difficult.¹⁵

2.3 Discussion of Assumptions

The specific assumptions made in the previous section are stark. They boil membership in a community to the probability of trade parameter. The advantage is that social capital is directly tied to an observable trait of the community. It is helpful to consider how alternative assumptions would alter the model.

Assumption (i): *Trade is pair-wise.*

The analysis was constructed assuming that the agents play N separate (and simultaneous) iterated, two-person prisoner dilemma games. A large number of models where group size plays a role in the group's ability to achieve a Pareto efficient outcome are n -person or collective good games. In general, public goods are more easily provided when the community is small.¹⁶ This is similar to the difficulty in sustaining cooperation in larger communities in our

¹⁴For example, Granovetter (1973) points out that it is not your close friends who are most useful during a job search since their information is highly correlated with yours. Contacts that bridge networks are more useful. See also Burt (1992).

¹⁵Fearon and Laitin (1996) is an interesting model that combines the notions of bridging and bonding social capital by focusing on cooperation between ethnic groups

¹⁶Olson (1965) pioneered the work on problems of collective action and group size concluding that smaller groups are typically necessarily more effective at providing collective goods. However, Esteban and Ray (2001) point out that this conclusion is not independent of the production function for the good.

model. Pair-wise interaction is not crucial to our model. A setting where the N individuals in a community play n -person prisoner dilemma games ($n < N$) will share most of the salient features of the pair-wise model. If for example, n was fixed, then an increase in community size would reduce the chance that two agents would meet in the same group next period.¹⁷

Assumption (ii): *Games are Private.*

If the play of all individuals is public knowledge, then the viability of the cooperative equilibrium can be unrelated to community size. For example, suppose everyone plays a strategy of c until d is observed in any trade. Since trades do not become more anonymous as community size grows, the bridge in the previous examples would have no effect on social capital.¹⁸ While the assumption that games are private is important, there are less restrictive assumptions that produce similar results. In a large community, it becomes practically difficult to observe or gather information on the many trades which occur each period. An alternate assumption is that each trader observes some sub-set of the trades which occurred. If the proportion of trades observed decreases with community size, then trades become more anonymous as communities grow. As in the above examples, community size may grow large enough that friendly trade is no longer an equilibrium.¹⁹

For simplicity, we restricted strategies so that when trader 0 faced agent j , agent 0 could not condition her move on the past play of some third party i . For example, consider a strategy for 0 that plays c initially until d is played against 0. After observing a d by i , 0 plays d against all j in future trades.

¹⁷Alternatively, Bendor and Mookherjee (1987) model an infinitely repeated n -person collective good game. If agents cannot perfectly monitor the behavior of the n other agents, then group size matters. Larger group size increases the chance that an action is misinterpreted so larger group size leads to more frequent punishment and less cooperation.

¹⁸For example, in Fearon and Laitin (1996) inter-group cooperation is feasible trade is observable. In particular, people are punished within their group if they trade exploitively with a member of another group.

¹⁹Kocherlakota (1998) discusses the role that money can play in summarizing the history of trade. If money balances or any other identifying feature of a trader perfectly reveal past trades, then the viability of the cooperative equilibrium is unrelated to community size.

This strategy can support cooperative trade. However, analogous Proposition 1, this strategy will support cooperation only if the frequency of trade is high enough. In a large community, a trader has an incentive to deviate and play d against j since the likelihood of trading with j or anyone who has interacted with j (directly, or played someone that j played) is small in the near future. Again, as community size grows, the viability of friendly trade decreases preserving the key features of the social capital examples.

Assumption (iii): *All gains from trade are non-negative.*

It is important to all the examples that agents prefer unfriendly trade to no trade at all. Changing this assumption would significantly change the nature of our model since agents would no longer have the incentive to increase their opportunities for trade.

Assumption (iv): *Agents will trade cooperatively if it is an equilibrium.*

Whether or not agents actually play the Pareto optimal equilibrium is not crucial to the examples. As long as agents do not always play the unfriendly equilibrium when other equilibria are available ($\pi_{ij} > \pi^c$), social capital can be defined and measured. Focusing on the friendly trade equilibrium in the examples maximizes the relevance of social capital.

Assumption (v): *Meeting for Trade probability is history independent.*

We have ruled out agents taking actions to avoid trading with certain players while seeking trade with others. Agents are not allowed to ostracize others as in Hirshleifer and Rasmusen (1989). In their model, if trader 0 plays d , she is prevented from receiving any gains from trade in subsequent periods since the trader is ostracized with $\pi_{0j} = 0$. They find that the ability of agents to ostracize others can be powerful enough to support cooperative play even in finitely repeated prisoners' dilemmas. Alternatively, Carmichael and MacLeod (1997) model the influence of gift giving on the probability of trade. In their model agents may trade with only one agent per period. In contrast to our

model, traders can choose their partner; in effect they select π_{0j} . If there is no cost to switching trading partners, then cooperative trade is not possible in a large community since traders cannot commit not to play d and then seek a new trading partner. Carmichael and MacLeod point out that a dissipative gift exchange makes switching partners costly and allows agents 0 and j to credibly commit to $\pi_{0j} = 1$. In both these papers, the customs which facilitate friendly trade are different forms of social capital. However, since there is not a natural analog to community size, these models make it harder to address questions about changing social capital.

Assumption (vi): *The probability of trade for all individuals i and j in a community of size N is given by $\pi(N)$ in equation (2)*

The specific assumption that links the probability of trade to community size is not important. The important feature of the assumption is that the chance of trading with any one person decreases with community size, but the total opportunities for trade increase with size. This create the tension that drives the three examples. Individuals prefer the more abundant trading opportunities of a larger community, but more frequent trade is more friendly.

3 Social Capital, Technological Change, and Growth

To explore the public policy aspects of social capital, we consider the role of social capital in a growth model. The structure of the model is similar to Jones and Newman (1995). Technological innovations typically require a reallocation of labor. The reallocation of labor – turnover – changes the set of trading partners. The model demonstrates the connection social capital, technological change, and the mobility of labor. In particular, frictionless labor mobility leads to higher productivity. However, the mobility affects the community structure and changes the feasibility of cooperative trade. Labor mobility, to

some extent, is a policy variable. By setting laws that reduce mobility like a rigid seniority system or a harsh unemployment scheme, governments can increase the social capital at the expense of a less efficient allocation of labor.

3.1 Growth Model

The economy consists of a single community of a large number of individuals evenly distributed about a unit circle. For convenience, we assume a continuum of individuals uniformly distributed.²⁰ An individual's location on the circle determines who the person trades with as well as their efficiency. An individual's output in the economy is the product of three factors: (1) The state of aggregate technology, (2) an individual's labor efficiency, and (3) the resources acquired from trade. The state of aggregate technology is Γ_t . Aggregate productivity shocks arrive each period with probability λ . If a productivity shock arrives, productivity grows at the fixed rate of $\gamma > 1$.

$$\Gamma_{t+1} = \begin{cases} \gamma\Gamma_t & \text{with probability } \lambda \\ \Gamma_t & \text{with probability } 1 - \lambda \end{cases} \quad (3)$$

The average growth in the technology is constant at $\bar{\gamma} = \lambda\gamma + (1 - \lambda)$.

An individual's efficiency is determined by his location, i_t , on the unit circle at period t , relative to his "ideal" employment location, i_t^* . The model is intended to capture the need to match worker skills to the requirements of the job. Let

$$\rho(i, j) = 2 \min(|i - j|, 1 - |i - j|) \quad (4)$$

²⁰The continuum of traders assumption is important to the tractability of the model. If communities are discrete as in Section 2, then a decision to relocate is itself a strategic game. By assuming a continuum of individuals uniformly distributed about the circle, a decision to relocate does not effect the aggregate opportunities to trade. Relaxing this assumption may offer some interesting insights into the spatial concentration within industries as well as the more general economies of scale related to city size (e.g., "agglomeration economies." See Rosenthal and Strange (2002)).

be the shortest distance between i and j on the unit circle. Note that ρ is normalized so that all distances lie in the $[0, 1]$ interval. We define the efficiency of individual i_t at period t , $\epsilon_{i,t}$, based on this distance as,

$$\epsilon(i_t, i_t^*) = 1 - \rho(i_t, i_t^*). \quad (5)$$

As in Jones and Newman (1995), we assume that a technological shock changes the optimal allocation of workers in the economy. A shock uniformly redistributes the ideal employment locations about the unit circle. For simplicity, this re-shuffling is independent of the current location of the individuals. That is, if there is a technological shock at $t + 1$, then i_{t+1}^* can lie anywhere on the circle with equal probability.

Since the efficiency of individuals depends on their location relative to an ideal location, individuals want to alter their location. We assume a very simple relocation technology. With probability $r(\epsilon)$ the individual moves from i_t to the new location i_t^* . The function r captures, in a reduced form, labor market frictions such as a fixed cost for relocation.²¹ Below, we will consider three cases: Frictionless labor mobility ($r(\epsilon) = 1$), no labor mobility ($r(\epsilon) = 0$), and sticky labor mobility ($0 < r(\epsilon) < 1$).

The final element of production allows us to consider the role of social capital. As in the previous section, individuals will meet for trade. Each trade has the structure of the prisoner's dilemma and, for concreteness, has the payoffs listed in Table 1. Each period, individual i and j will meet to trade with a probability that depends on the distance between the two traders. An individual trades more frequently with near-by individuals. We capture this

²¹For simplicity, it is important that relocation decisions not be deterministic. A stochastic relocation decision preserves the indefinitely repeated nature of the trading game. The reduced-form function $r(\epsilon)$ is consistent with a stochastic fixed cost for relocation. If the benefits of relocating exceed the realized fixed cost, relocation occurs. Recall that the relocation decision is simplified by the assumption that there are a continuum of individuals. A model of stochastic fixed cost will yield a $r(\epsilon)$ function that is decreasing in ϵ and satisfies $r(1) = 0$. These features are present in the specific functional form, equation (12), we use in the numerical example below.

by assuming that the probability the i and j meet in period t is given by

$$\pi_{ij} = 1 - \rho(i, j) \quad (6)$$

This specification implies that individuals trade with their immediate neighbors each period, but rarely trade with individuals located on the opposite side of the circle. Finally, we maintain assumptions (i) to (iv) of Section 2.

Each of the three elements of production are reflected in the following time-additive risk-neutral preferences for individual 0,

$$U_0 = (1 - \beta)E \left[\sum_{t=0}^{\infty} \beta^t \left\{ \Gamma_t \epsilon_{i,t} \left[\int \pi_{0j} u(s_{0j}, s_{j0}) dj \right] \right\} \right] \quad (7)$$

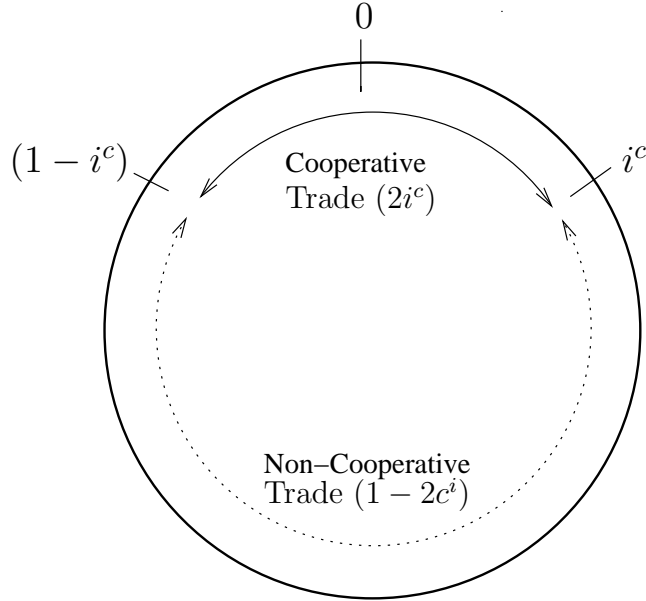
where β is the discount factor, and u is the outcome from the trade between 0 and j from Table 1. These preferences are analogous to equation (1). Expectations are required in (7) since the arrival of the technological shock and the related re-shuffling of ideal employment locations are stochastic. Finally, to ensure that utility is bounded, the expected growth rate in the technology, $\bar{\gamma} = \lambda\gamma + (1 - \lambda)$, cannot be too large. Specifically, $\beta\bar{\gamma} < 1$.

3.2 Frictionless Labor Mobility ($r(\epsilon) = 1$)

A high rate of technological growth is typically viewed as desirable. However, the technological shock changes the optimal allocation of workers in the economy. If workers can relocate to improve their efficiency, the technological innovation will affect social capital by changing the probability of trade between individuals. Cooperative trade is harder to sustain with your neighbor if she is likely to move next period. In this section we consider perfect labor mobility, $r(\epsilon) = 1$. After a technological shock, all individuals relocate to a new position on the circle to achieve maximum efficiency, so $\epsilon(i, i^*)$ always equals one.

Since a technological shock alters the location of the traders, to generate value functions, we need a conjecture about the likelihood of cooperative trade following a technology shock. Consider agent 0 and conjecture that trade is cooperative with individuals on the interval $(1 - i^c, i^c)$.²² See Figure 2. Since

Figure 2: Cooperative and Non-cooperative Region



For the case of perfect labor mobility, $r(\epsilon) = 1$, there is a region of length $2i^c$ around each individual, person 0 is shown, where cooperation is feasible.

the circle is of unit length, $i^c \leq 0.5$. Given this, the value function of trader 0 trading with an individual located currently at $i \leq 0.5$ is denoted $V(\Gamma, i, \sigma)$ where $\sigma = \{c, d\} = \{2, 1\}$ indexes the state of current trade between 0 and i as friendly or not. As in Section 2.1, assumptions (i) to (iv) allow us to focus on

²²After a shock, we can renormalize the circle to keep individual 0 at position 0. The circle is symmetric, so we can focus on the case of $i \leq 0.5$.

the trade between two individuals. Note that from equation (6), $\pi_{0i} = 1 - 2i$.

$$\begin{aligned}
V(\Gamma, i, \sigma) &= (1 - \beta)\Gamma(1 - 2i)\sigma \\
&+ \beta(1 - \lambda)V(\Gamma, i, \sigma) \\
&+ \beta\lambda(2i^c)E[V(\Gamma\gamma, \tilde{i}, c)|\tilde{i} \leq i^c] \\
&+ \beta\lambda(1 - 2i^c)E[V(\Gamma\gamma, \tilde{i}, d)|\tilde{i} > i^c]
\end{aligned} \tag{8}$$

The first line in equation (8) is the current payoff from being in friendly, 2, or unfriendly, 1, mode. The second line is the continuation value if there is no technological shock. The third and fourth lines are the continuation value given the arrival of a shock. If the new location of the trading partner, \tilde{i} , is close, cooperative trade occurs. Given the uniform redistribution assumption, the probability $\tilde{i} \leq i^c$ is $2i^c$. Alternatively, with probability $1 - 2i^c$, the trading partner will be located outside the cooperative region. Note that continuation value following a shock is independent of i . As in the simple setting in Section 2, the incentive compatibility condition determines where cooperative trade is feasible. This is stated below with the details in the appendix.

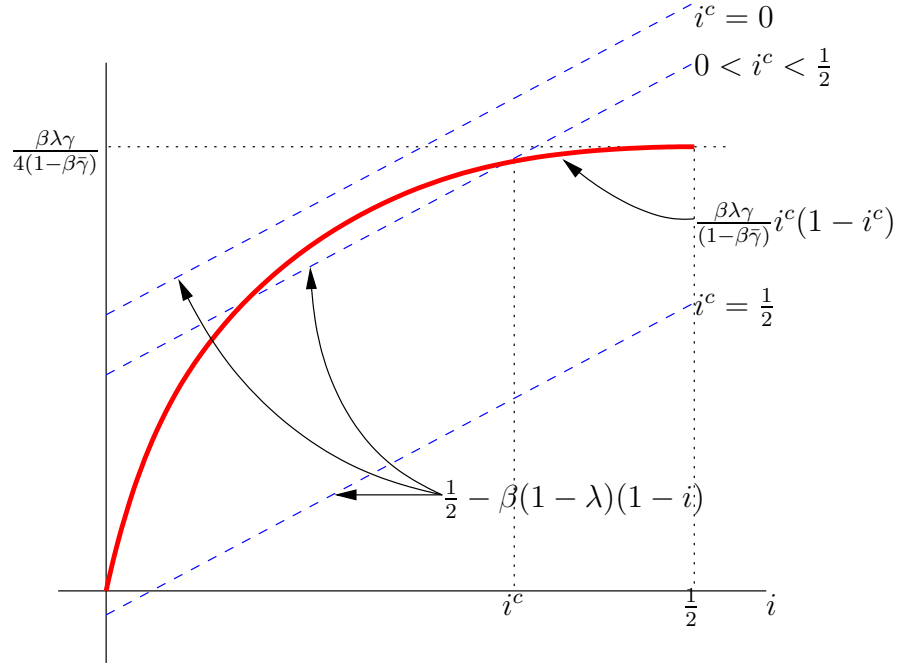
Proposition 2: *In the case of $r(\epsilon) = 1$, the cooperative trade is feasible in the region defined by i^c when*

$$\frac{\beta\lambda\gamma}{1 - \beta\gamma}i^c(1 - i^c) > \frac{1}{2} - \beta(1 - \lambda)(1 - i) \tag{9}$$

is satisfied for all $i \leq i^c$

Figure 3 displays condition (9) that is necessary for cooperation. The solid line in the figure is the left-hand-side of (9) plotted as a function of i^c . The three dashed-lines represent three different cases for the right-hand-side of equation (9). The first case is where cooperation is feasible on the entire circle. This occurs when equation (9) is satisfied for all $i \leq 0.5$ when $i^c = 0.5$. This is illustrated in the bottom dashed line in Figure 3. This occurs, for example, if the technological shock is very frequent (large λ) and traders are patient (large β). With a frequent shock, the fact that two traders do not currently

Figure 3: Characterizing i^c in Equation (9)



This figure characterizes the feasible cooperative region, plotting equation (9) which must hold for all $i \leq i^c$. The solid line is the left-hand-side of (9) as a function of i^c . The three dashed-lines represent three different cases for the right-hand-side of equation (9). In the top line, no cooperation is feasible ($i^c=0$). In the middle case, some cooperation is feasible ($0 < i^c < 0.5$). In the bottom case, cooperation is feasible on the full circle ($i^c = 0.5$).

meet frequently (recall that $\pi_{0,0.5} = 0$) is not salient since their locations will change after the shock.²³

The second case is where no-cooperation is feasible. Even at $i^c = 0$, equa-

²³Evaluating (9) at $i = i^c = 0.5$ requires that $\frac{\beta\lambda\gamma}{4(1-\beta\bar{\gamma})} > \frac{1}{2} - \beta(1-\lambda)(1-i)$. Let $\lambda \rightarrow 1$ while holding average growth rate, $\bar{\gamma}$, constant implies $\frac{1}{2} > \frac{1-\beta\bar{\gamma}}{\beta\bar{\gamma}}$. This is a similar condition to Proposition 1. Since $\lambda = 1$ implies that traders are uniformly redistributed around the circle each period, the unconditional probability that traders meet in the future is $\frac{1}{2}$.

tion (9) is not satisfied. This is the upper dashed line in Figure 3. This occurs, for example, if traders have low patience (i.e., low β).²⁴

The final case is where $0 < i^c < 0.5$ satisfies equation (9) for $i \leq i^c$. This is represented as the middle dashed line in Figure 3. For locations i outside the i^c region, equation (9) does not hold and cooperation is not feasible. In this case, only a fraction of the trades will be cooperative. After a shock, the probability that an individual i is in the cooperative region is $2i^c$ (see Figure 2). Trade is also more frequent with individuals close by. Therefore, the expected proportion of cooperative trades is $4i^c(1 - i^c)$.²⁵

3.3 No Labor Mobility ($r(\epsilon) = 0$)

In the previous example, labor mobility affects social capital. While technological shocks make the economy more productive, the change in social structure that accompanies the shock can make cooperative trade less frequent. Burt (2000) and (2001) document the rapid decay in social capital. He finds that, in the course of one year, there is a remarkably high turnover in the network of people an individual deals with. This churning in the social network can reduce the ability to sustain cooperation. Since labor mobility is, to some extent, a policy variable, it is possible that everyone can be made better off by reducing labor mobility. With labor-market frictions, labor is not efficiently allocated since agents cannot move instantly from i to i^* . However, since people are in their locations longer, trade is more stable and social capital can be higher.

²⁴No cooperation is feasible if $\frac{1}{2} - \beta(1 - \lambda)(1 - i) - \frac{\beta\lambda\gamma}{1 - \beta\gamma}i(1 - i) = 0$ has no real roots which occurs, trivially, if $\beta = 0$.

²⁵The probability of two individuals meeting is given by equation (6). The total expected number of trades is $2 \int_0^{0.5} (1 - 2i)di = 0.5$ (the circle is symmetric). Of these expected trades,

$2 \int_0^{i^c} (1 - 2i)di$ are cooperative.

As a base case, consider the example where individuals are fixed in their location and can not move to improve their efficiency ($r(\epsilon) = 0$). Here, the probability that individual 0 and i , is constant at π_{0i} (see equation (6)). A technology shock alters labor efficiency. As in the case of perfect mobility, we need to conjecture about the likelihood that cooperation is feasible following a technology shock. The feasibility of cooperation depends on labor efficiency. Define $\xi_{0i} = \max(\epsilon(0, 0^*), \epsilon(i, i^*))$ as the maximum efficiency of the two individuals. Conjecture that cooperation is feasible if $\xi_{0i} \leq \xi_{0i}^c$. Intuitively, cooperation is feasible if the one-time benefit from trading unfriendly (i.e., play a d when the other plays a c) is small relative to the value of future cooperative trade. A one-time unfriendly trade is most tempting when one's efficiency is high and less attractive when individual efficiency is low. Moreover, since cooperation must be incentive compatible for both parties, the maximum of the two individuals' efficiencies will determine if friendly trade is feasible. The critical level of labor efficiency, ξ_{0i}^c , depends on the probability of trade between the two traders.

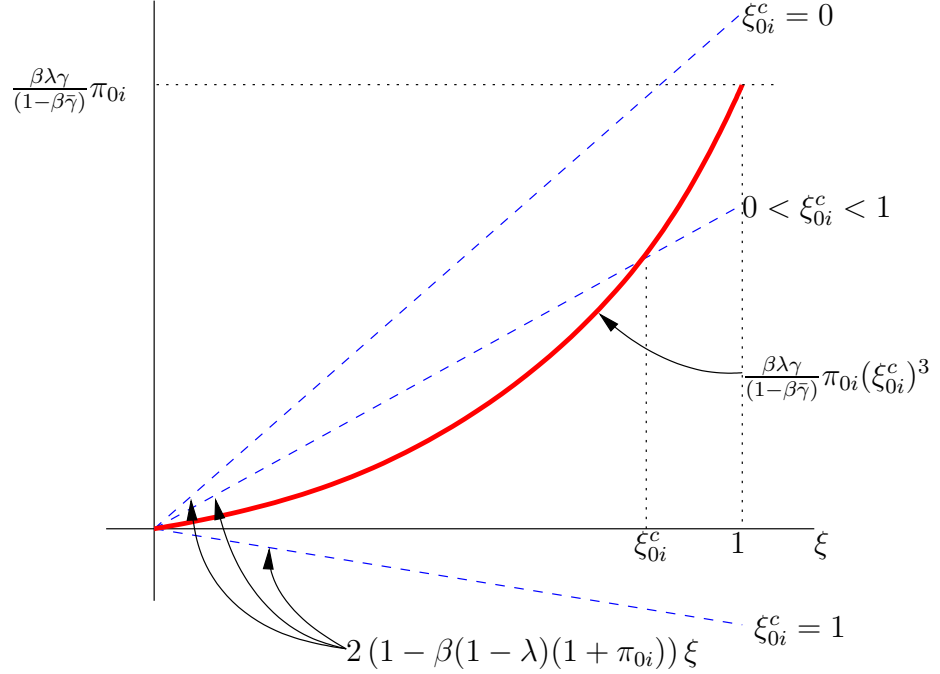
Proposition 3: *In the case of $r(\epsilon) = 0$, the cooperative trade is feasible if $\xi_{0i} \leq \xi_{0i}^c$ where*

$$\frac{\beta\lambda\gamma}{1-\beta\bar{\gamma}}\pi_{0i}(\xi_{0i}^c)^3 > 2(1-\beta(1-\lambda)(1+\pi_{0,i}))\xi \quad (10)$$

is satisfied for all $\xi \leq \xi_{0i}^c$ (i.e., $\epsilon_0 \leq \xi_{0i}^c$ and $\epsilon_0 \leq \xi_{0i}^c$).

Figure 4 displays the necessary condition for cooperation. The solid line is the left-hand-side of condition (10). As in the case of perfect labor mobility, there are three cases to consider. First, if $\pi_{0i} > \frac{1-\beta(1-\lambda)}{\beta(1-\lambda)}$, trade is frequent enough that cooperation is feasible for all level labor efficiencies ($\xi_{0i}^c = 1$). In this situation, individuals are patient enough that cooperation would be feasible even if all trade ceased after a technological shock. This situation is the lower dashed line in Figure 4. The second case is where cooperation is never feasible and $\xi_{0i}^c = 0$. This is the top dashed line in Figure 4. In this case $2(1-\beta(1-\lambda)(1+\pi_{0,i})) > \frac{\beta\lambda\gamma}{1-\beta\bar{\gamma}}\pi_{0i}$. This occurs, for example, if 0

Figure 4: Characterizing ξ_{0i}^c in Equation (10)



This figure characterizes cooperation, plotting equation (10) which must hold for all $\xi \leq \xi_{0i}^c$. The solid line is the left-hand-side of (10) as a function of ξ_{0i}^c . The three dashed-lines represent three different cases for the right-hand-side of equation (10). In the top line, no cooperation is feasible ($\xi_{0i}^c=0$). In the middle case, some cooperation is feasible ($0 < \xi_{0i}^c < 1$). In the bottom case, cooperation is feasible for all labor efficiencies ($\xi_{0i}^c = 1$).

and i are located far apart so that trade is infrequent (π_{0i} is small). Finally, it can be the case that some cooperation is feasible provided current labor efficiency of the individuals is not too high. This is the middle dashed line in Figure 4. Since both individuals must have low efficiency for cooperative trade, ($\epsilon_0 \leq \xi_{0i}^c$ and $\epsilon_i \leq \xi_{0i}^c$), the probability that trade between individual 0 and i that is cooperative is $(\xi_{0i}^c)^2$. Since this probability is location-specific, there is no simple closed-form expression for the overall proportion of trades

that are friendly.

Comparing the cases of perfect and no labor mobility highlights the basic tradeoff. In the case of perfect labor mobility in Section 3.2, labor is efficiently allocated ($\epsilon(i, i^*) = 1$). In the case of no labor mobility, labor is inefficiently allocated ($E[\epsilon(i, i^*)] = 0.5$). However, since the frequency of cooperative trade differs in the two cases, it is possible that welfare is higher in the case of no-labor mobility. To explore this tradeoff more carefully, we next consider the intermediate case of sticky labor movement.

3.4 Sticky Labor Mobility ($0 < r(\epsilon) < 1$)

The final case to consider is sticky labor movement. Following a technological shock, all individuals are inefficiently allocated. With probability $r(\epsilon)$, an individual can move to his or her optimal location. Solving for the equilibrium in this setting is complicated. Both location and efficiency determine the feasibility of cooperative trade. In particular, the equilibrium involves conjecturing that cooperative trade between individual 0 and individual i is feasible only if $i \leq i^c(\epsilon_0, \epsilon_i)$. This conjecture determines the value function as:

$$\begin{aligned}
V(i, \epsilon_0, \epsilon_i) = & (1 - \beta)\pi_{0i}\sigma(i, \epsilon_0, \epsilon_i) \\
& + \beta(1 - \lambda)(1 - r_i)(1 - r_0)V(i, \epsilon_0, \epsilon_i) \\
& + \beta(1 - \lambda)(r_i)(1 - r_0)E_i[V(\tilde{i}, \epsilon_0, 1)] \\
& + \beta(1 - \lambda)(1 - r_i)(r_0)E_i[V(\tilde{i}, 1, \epsilon_i)] \\
& + \beta(1 - \lambda)r_i r_0 E_i[V(\tilde{i}, 1, 1)] \\
& + \beta\lambda E_\epsilon[V(i, \tilde{\epsilon}_0, \tilde{\epsilon}_i)].
\end{aligned} \tag{11}$$

$\sigma(i, \epsilon_0, \epsilon_i)$ denotes the current payoff from Table 1. In equilibrium, $\sigma(i, \epsilon_0, \epsilon_i) = 2$ if $i \leq i^c(\epsilon_0, \epsilon_i)$ and $\sigma(i, \epsilon_0, \epsilon_i) = 1$ otherwise. Note that i^c appears in the calculation of the current trade payoffs as well as influences the continuation value by determining the likelihood future trade is cooperative. Since it is hard to characterize this setting analytically, we solve numerically for the

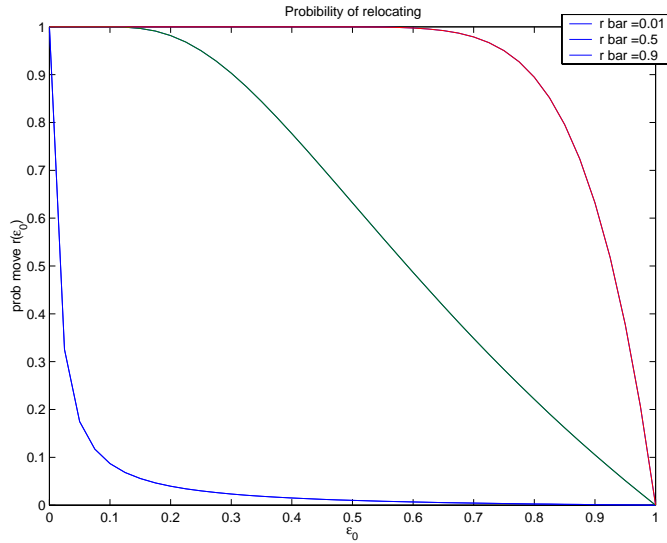
equilibrium value function, V , and the cooperative region, $i^c(\epsilon_0, \epsilon_i)$.²⁶

To parameterize labor mobility, let the probability that an individual moves be

$$r(\epsilon) = 1 - \exp\left(-\frac{\bar{r}}{1-\bar{r}} \frac{1-\epsilon}{\epsilon}\right) \quad (12)$$

where \bar{r} is the parameter that controls the stickiness in the labor market. Figure 5 plots equation (12) for the numerical examples we consider below.

Figure 5: Probability of relocating



The probability of relocating depends on current labor efficiency, ϵ , and the parameter \bar{r} using equation (12). Shown in the graph are the cases of $\bar{r} = 0.01$ where labor is relatively immobile, $\bar{r} = 0.9$ where labor is relatively mobile, and the intermediate case of $\bar{r} = 0.5$.

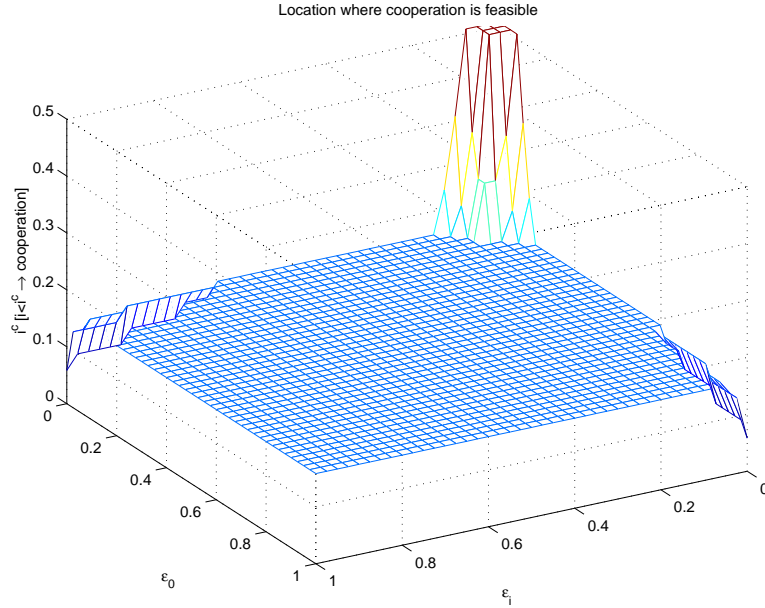
For low values of \bar{r} , the labor market is sticky, moves are less frequent, and labor is less efficiently allocated.

²⁶The numerical algorithm is as follows. For a given cooperative region at step n , $i_n^c(\epsilon_0, \epsilon_i)$, the value function $V_n(i, \epsilon_0, \epsilon_i)$ is calculated. The new cooperative region, $i_{n+1}^c(\epsilon_0, \epsilon_i)$, is determined by finding the largest value of i where cooperation is incentive compatible (for each of the discretized values of ϵ_0 and ϵ_i). The incentive compatible condition is analogous to equation (A6). Finally, the algorithm uses the symmetry imposed on i^c by the necessity that the incentive compatible condition holds for both 0 and i . That is $i^c(i, \epsilon_0, \epsilon_i) = i^c(i, \epsilon_i, \epsilon_0)$. As is standard, the algorithm halts when $\|V_n - V_{n+1}\|$ and $\|i_n^c - i_{n+1}^c\|$ are both small.

3.4.1 A Comparison of $\bar{r} = 0.01$ and $\bar{r} = 0.5$

Figures 6 and 7 show the equilibrium cooperative region $i^c(\epsilon_0, \epsilon_i)$ in the cases

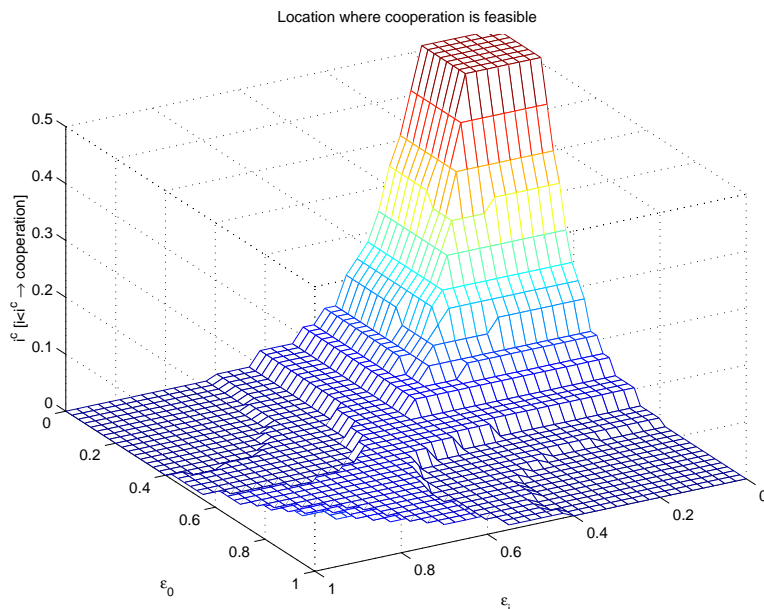
Figure 6: Equilibrium Trade Policy $\bar{r} = 0.01$



$i^c(\epsilon_0, \epsilon_i)$ is the critical distance for cooperative trade. That is cooperative trade between individuals located at 0 and i with respective labor efficiencies ϵ_0, ϵ_i is an equilibrium if and only if $i \leq i^c(\epsilon_0, \epsilon_i)$. Parameters in this example are: discount factor (β) is 0.65, average growth rate ($\bar{\gamma} = \lambda\gamma + (1 - \lambda)$) is 1.05 with a technological shock probability (λ) of 0.3. The probability individuals can relocate is given in equation (12) with $\bar{r} = 0.01$.

where $\bar{r} = 0.01$ and $\bar{r} = 0.50$. Parameters in this example are: discount factor (β) is 0.65, average growth rate ($\bar{\gamma} = \lambda\gamma + (1 - \lambda)$) is 1.05 with a technological shock probability (λ) of 0.3. The first example, in Figure 6, the labor market is relatively sticky and inefficient with $\bar{r} = 0.01$. The relative stability in location this induces allows for a high level of cooperation. For most levels of efficiency, cooperation is attained between neighbors within distance less than 0.2. Note

Figure 7: Equilibrium Trade Policy $\bar{r} = 0.50$



$i^c(\epsilon_0, \epsilon_i)$ is the critical distance for cooperative trade. That is cooperative trade between individuals located at 0 and i with respective labor efficiencies ϵ_0, ϵ_i is an equilibrium if and only if $i \leq i^c(\epsilon_0, \epsilon_i)$. Parameters in this example are: discount factor (β) is 0.65, average growth rate ($\bar{\gamma} = \lambda\gamma + (1 - \lambda)$) is 1.05 with a technological shock probability (λ) of 0.3. The probability individuals can relocate is given in equation (12) with $\bar{r} = 0.50$.

that for very inefficient workers, cooperation is more easily sustained. As is the case in Section 3.3, inefficient individuals are less tempted by the one-time gains from an exploitive trade.

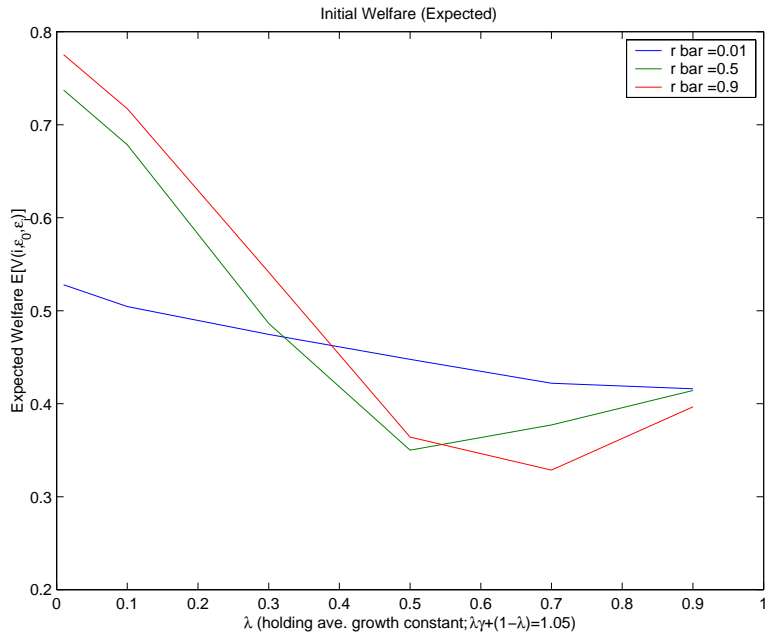
The second example is in Figure 7. In this case $\bar{r} = 0.50$ and the labor market is less sticky and inefficient individuals are more likely to relocate. In this case, the mobility of labor makes cooperation more difficult to sustain. For individuals with an efficiency above 0.6, no cooperation is feasible (i.e., $i^c(0.6, 0.6) \approx 0$).

Despite the difference in labor markets and social capital, welfare in the two cases is similar. Welfare is defined by calculating the expectation of the value function; that is $\int E[V(i, \tilde{\epsilon}_0, \tilde{\epsilon}_i)] di$. This is the average value across different levels for initial labor efficiency for trader 0 and all trading partners at locations i . In the first example (Figure 6), 60% of the trades are cooperative yielding a welfare of 0.4746. In the second example (Figure 7), only 30% of the trades are cooperative. However, since labor is on average more efficient, welfare is similar to the first example, at 0.4863. The higher level social capital in the first example does not necessarily dominate (recall Section 2.2.2). While the expected welfare is the same across the two examples, inequality is higher in the case with higher social capital. The sticky labor market means that getting a bad (or good) draw on the initial level of efficiency has a larger effect on welfare. In the first case, the standard deviation of welfare is 0.40. In the second case it is 0.15. As discussed in Section 2.2.3, social capital that comes from stable communities can be at the expense of equality.

3.4.2 Optimal Labor Mobility

In the first two examples, welfare across labor regimes was similar. In Figure 8, welfare differs across three values for \bar{r} of 0.01, 0.50, and 0.90. The parameters for this example are the same as the previous example except here, the frequency of the technological shock is varied. The welfare is plotted for different values for the probability a technological shock, λ , while holding constant the average growth rate, $\bar{\gamma} = \lambda\gamma + (1 - \lambda)$, at 1.05. When technological shocks are very infrequent, it is important that the labor market allow movement. First, given the infrequent shock arrival, there are large returns to efficiently allocated labor. Secondly, mobility in this case is not particularly harmful to social capital. Since individuals desire to move only after a technological shock, the low frequency of shocks means that the society is relatively stable and cooperation is sustainable. Figure 9 plots the percentage of trades that are cooperative. With a low frequency of technological shocks, the amount of cooperative trade or social capital is invariant to labor mobility.

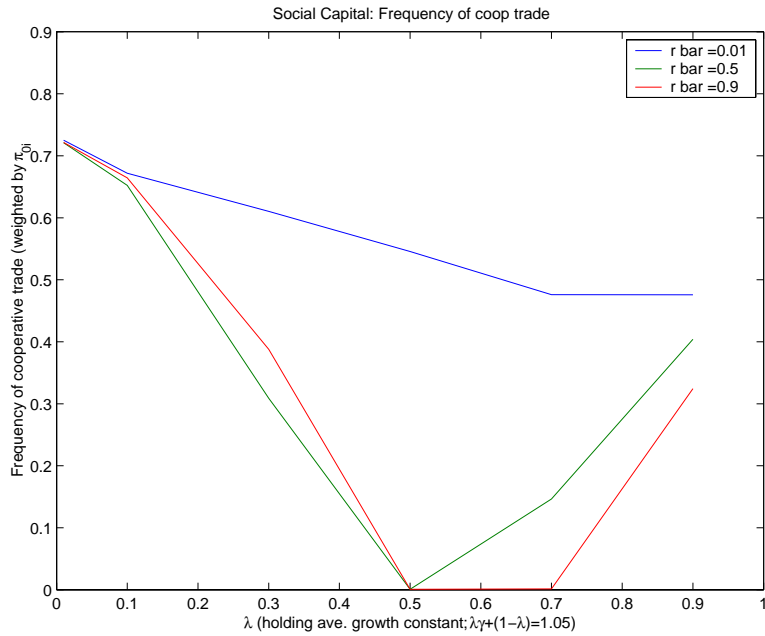
Figure 8: Expected Initial Welfare



Welfare is plotted as a function of the technological shock arrival probability, λ . λ is varied while holding the average growth rate, $\bar{\gamma} = \lambda\gamma + (1 - \lambda)$, constant at 1.05. Parameters in this example are: discount factor (β) is 0.65, with a technological shock probability (λ) of 0.3. The probability individuals can relocate is given in equation (12) with $\bar{r} = 0.01, 0.50$, or 0.90

When the technological shock is very frequent, there is also little welfare difference across labor markets. Here, a highly mobile workforce has little effect for two reasons. First, moving to an ideal location is not that important since the expected time until a new technological shock arrives is very small. Regardless of the frictions in the labor market, the frequency of the technological shock means labor is typically inefficiently allocated. Second, a high degree of mobility does not eliminate social capital. Some cooperative trade is sustainable since individuals meet frequently. A neighbor is likely to move away next period, but it is also likely they move back in a subsequent period.

Figure 9: Frequency of Cooperative Trades



The frequency of cooperative trade is plotted as a function of the technological shock arrival probability, λ . λ is varied while holding the average growth rate, $\bar{\gamma} = \lambda\gamma + (1 - \lambda)$, constant at 1.05. Parameters in this example are: discount factor (β) is 0.65, with a technological shock probability (λ) of 0.3. The probability individuals can relocate is given in equation (12) with $\bar{r} = 0.01, 0.50,$ or 0.90

The interesting region of Figure 8 is for intermediate values of λ . When the technological shock arrives with moderate frequency, a highly mobile labor market eliminates social capital and reduces welfare. Future trade with one's current neighbor is not sufficiently likely to sustain cooperative trade. In this region, a less mobile and, hence, less efficient labor market is desirable. The benefit of cooperative trade or social capital outweighs the labor inefficiency.

4 Conclusions

There has been much discussion of social capital over the past decade since Coleman (1990) and Putnam, Leonardi, and Nanetti (1993) sparked research into social structure as a form of capital. There is a body of evidence that points to links between social capital and economic activity. However, it is difficult to make policy conclusions without a complete picture of the costs and benefits of social capital. In the simple model of Section 2 increased social capital is at the expense of fewer trade opportunities. In Section 3, increasing social capital may require a less mobile, and therefore less efficient, labor force.

The interaction between growth and labor migration is particularly salient for developing economies where large-scale migration from rural to industrial areas is common. Policy recommendations for developing economies are difficult, however. First, the analysis in our model is specific to the utility/technology assumption we make in equation (7). The relative importance of labor efficiency and social capital is not easy to measure.²⁷ Second, in our model, a less mobile workforce is optimal only for intermediate values of technological change. A mobile work force is optimal for economies that are stable or rapidly changing. Measuring the stability of the economy (the parameter λ in our model) is challenging. Finally, even if reducing labor mobility increases expected welfare, it also increases inequality. China's restriction on migration, for example, is often harshly criticized as creating inequality and infringing on human rights.²⁸

There are, of course, limitations to the model we present here. A more complex model of social capital would allow for endogenous communities. People choose to join or form groups considering both trade opportunities (bridging social capital) as well as the frequency of repeated interaction (bonding social

²⁷For example, Miguel, Gertler, and Levine (2001) argue that social capital is an output of development. This in contrast to Putnam, Leonardi, and Nanetti (1993) who argue it is a driver of development

²⁸See "China Eases Rules Binding People to Birth Regions," New York Times, October 23, 2001, page A8.

capital). A richer model would incorporate both bridging and bonding social capital. Finally, the interpretation of social capital as facilitating cooperation in repeated play is a specific type of social capital. We have not considered other types of social capital like, for example, the role of social norms.²⁹ Despite these limitations, the model presented here underscores how social capital can influence economic activity and welfare.

²⁹There is more to social capital than the reciprocity we focus on here. As Yogi Berra said: “You should always go to other people’s funerals; otherwise, they won’t come to yours.”

Appendix

Proof of Proposition 1: This proof is standard. Assumptions (i) to (iv) imply that player 0 is effectively playing N separate infinitely repeated games. We can re-write (1) as:

$$U_0 = \sum_{j=1}^{N-1} \left\{ (1 - \beta) \sum_{t=0}^{\infty} \beta^t \pi_{0j} u(s_{0j}(x_t), s_{j0}(x_t)) \right\}. \quad (\text{A1})$$

Consider the game between 0 and j . Given the proposed profile strategy s^c (as well as for s^d), the expected utility of the repeated game with 0 for agent j can be represented recursively with a time independent value function. For agent 0, playing trader j , let $V(j, \sigma)$ be the value function where $\sigma = \{c, d\} = \{2, 1\}$ indexes the trade (and payoffs) as friendly trade or unfriendly. The value function is $V(j, \sigma) = \pi_{0j} \sigma$. Following Abreu (1988), we need only consider possible one shot deviations from the proposed equilibrium strategies for all possible histories. If agents are in the punishment phase (d, d), neither has an incentive to deviate, regardless of π_{0j} . In the cooperative phase, one deviating to play d yields the one-time payoff of 3 (see Table 1) but future trade is unfriendly. The incentive comparability condition is:

$$(1 - \beta)3 + \beta V(j, d) \leq (1 - \beta)2 + \beta V(j, c). \quad (\text{A2})$$

Both the left and right-hand sides of equation (A2) are the value functions conditional on 0 and j meeting in the current period. This inequality implies $\pi_{0j} \geq \frac{1-\beta}{\beta}$. ■

Proof of Proposition 2: To describe the strategy, normalize the circle so that agent 0 remains at position 0. Denote agent i 's location at period t as i_t . The strategy is characterized by a cooperative region with $i^c \leq 0.5$ (see Figure 2). The strategy is: play c if (a) $i_t \leq i^c$ and (b) all previous trades $\tau < t$ are (c, c) when $i_\tau < i^c$; and play d otherwise. To characterize the value function, denote: $\sigma = c$ for play when $i_t < i^c$ and all previous trades $\tau < t$ are (c, c) when $i_\tau < i^c$; $\sigma = d$ when $i_t > i^c$ and all previous trades $\tau < t$ are (c, c) when $i_\tau < i^c$; and $\sigma = D$ if history includes a d play when $i_\tau \leq i^c$. It is straightforward to verify that the value function is linear in current payoff and the expected payoff that follows a technological shock. Therefore, we can normalize to $\Gamma = 1$.

$$V(X) = \frac{1 - \beta}{1 - \beta\gamma} \bar{X}_\sigma + \frac{1 - \beta}{1 - \beta(1 - \lambda)} (X_\sigma - \bar{X}_\sigma) \quad (\text{A3})$$

Let X_σ be the current payoff (recall that the probability of meeting depends on location and is $\pi_{0i} = 1 - 2i$).

$$X_\sigma = \begin{cases} (1 - 2i)2 & \sigma = c \\ (1 - 2i)1 & \sigma = d \text{ or } D \end{cases} \quad (\text{A4})$$

Let \bar{X}_σ be the expected payoff following a technological shock given the strategy-state σ . Given the *i.i.d.* reallocation of individuals following a technological shock, \bar{X}_σ is constant. Note: $Prob(\tilde{i} \leq i^c) = 2i^c$, $E[\tilde{i} | \tilde{i} < i^c] = 1 - i^c$, and $E[\tilde{i} | \tilde{i} > i^c] = 0.5 - i^c$.

$$\bar{X}_\sigma = \begin{cases} 0.5 + 2i^c(1 - i^c) & \sigma = c \text{ or } d \\ 0.5 & \sigma = D \end{cases} \quad (\text{A5})$$

The incentive compatibility condition binds only when traders are to play c and must hold conditional on 0 and i meeting. The IC condition is:

$$(1 - \beta)3 + \beta(1 - \lambda)V(X_D) + \beta\lambda V(\bar{X}_D) \leq (1 - \beta)2 + \beta(1 - \lambda)V(X_c) + \beta\lambda V(\bar{X}_c). \quad (\text{A6})$$

Given the conjectured form of the equilibrium strategy, this condition must hold for all $i \leq i^c$. This implies condition implies:

$$\frac{\beta\lambda\gamma}{1 - \beta\gamma} i^c (1 - i^c) > \frac{1}{2} - \beta(1 - \lambda)(1 - i) \quad (\text{A7})$$

■

Proof of Proposition 3: The proof is parallel to Proposition 2. Consider individual 0 and i that meet with probability π_{0i} . Denote $\xi_t = \max(\epsilon_0(t), \epsilon_i(t))$. The strategy that is considered is: play c if (a) $\xi_t \leq \xi_{0i}^c$ and (b) all previous trades $\tau < t$ are (c, c) when $\xi_\tau < \xi_{0i}^c$; and play d otherwise. To characterize the value function, $\sigma = c$, $\sigma = d$, and $\sigma = D$ are defined analogous to Proposition 2. The form of the value function is identical to equation (A3) where, for individual 0,

$$X_\sigma = \begin{cases} 2\pi_{0i}\epsilon_0 & \sigma = c \\ 1\pi_{0i}\epsilon_0 & \sigma = d \text{ or } D \end{cases} \quad (\text{A8})$$

Given the *i.i.d.* reallocation of i^* , and hence ϵ_i , following a technological shock, \bar{X}_σ is constant. Note: $Prob(\tilde{\xi} \leq \xi_{0i}^c) = Prob(\max(\tilde{\epsilon}_0, \tilde{\epsilon}_i) \leq \xi_{0i}^c) = (\xi_{0i}^c)^2$, $E[\tilde{\epsilon}_0 | \tilde{\xi} < \xi_{0i}^c] = 0.5\xi_{0i}^c$, and $E[\tilde{\epsilon}_0 | \tilde{\xi} > \xi_{0i}^c] = 0.5\left(\frac{1}{1 + \xi_{0i}^c} + \xi_{0i}^c\right)$.

$$\bar{X}_\sigma = \begin{cases} 0.5((\xi_{0i}^c)^3 + 1) & \sigma = c \text{ or } d \\ 0.5 & \sigma = D \end{cases} \quad (\text{A9})$$

The incentive compatibility condition is the same as in equation (A6). Given the conjectured form of the equilibrium strategy, this condition must hold for both traders. Therefore it must hold for $\epsilon_0 \leq \xi_{0i}^c$ and $\epsilon_i \leq \xi_{0i}^c$.

$$\frac{\beta\lambda\gamma}{1 - \beta\gamma} \pi_{0i} (\xi_{0i}^c)^3 > 2(1 - \beta(1 - \lambda)(1 + \pi_{0,i})) \xi \quad (\text{A10})$$

■

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