# Contacts, Social Capital and Market Institutions - A Theory of Development

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**Abstract**

We propose a growth model, that incorporates both an individual and a communal aspect of Social Capital. In our model, *sold* output increases with the stock of business contacts (Relational Capital as one aspect of Social Capital). The modelling of contact creation is based on matching theory. The cost of creating contacts decreases with more Community level Social Capital and Market Institutions.

We argue that innovation needs the purposeful destruction of old contacts. Political interference and centralization can provide disincentives to break old contacts and hence affect innovation. Simulations show that our model is able to explain empirical observations on social capital and development.

**Keywords:** Social Capital, Relational Capital, Matching/Search Theory, Development, Economic Systems

**JEL:** O11, O41, P51

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# 1 Introduction

In this paper we propose a theory of social capital and economic development. Our model uses matching theory to capture the role of social capital in the presence of search frictions between market parties. In a nutshell, we argue that contacts with trading partners are a productive input. We name these contacts Relational Capital. Breaking contacts with old trading partners is done by rational profit maximising firms and is a necessary aspect of the upgrading of technology, but has a negative externality on the former trading partners. We call this creative destruction. The costs of making new contacts are affected by Community Level Social Capital and by Market Institutions. Higher levels of either decreases the cost of information and hence increase the arrival rate of contacts per unit of labour. The main difference between political systems in our model stems from interference with creative destruction. This may occur through hindering market institution development, through corruption, or through direct political interference. We set up and simulate a growth model with these ingredients and base most of its elements on micro search arguments. As variations, we endogenise the role of politics in frustrating creative destruction, and we model a feed-back between the total stock of RC and the labour costs of making more contacts.

This paper relates to many literatures - empirical and theoretical - and we defer a discussion of most items till after the model description. Here, we only want to discuss the relation with the theoretical literature on social capital.

The two dominant views of social capital in the literature differ mainly in the level of aggregation of social capital.[1] In the first approach, social capital is defined as individuals' number of contacts and their ability to generate contacts. The second approach describes social capital as a set of community

[1]For recent reviews, see Sobel (2002), or Durlauf (2002). Sobel, noting the confusion in the literature about the meaning of social capital, calls it 'multi-faceted'. Durlauf (2002) seems sceptical about the whole literature and wants 'sharper theoretical modelling' to bring the analyses up to 'the standards in the field'.

norms, such as trust. Our model relates to both.

The individualistic view of social capital is exemplified by Glaeser et al. (2002), who define social capital as ‘a person’s social characteristics - including social skill, charisma, and the size of his Rolodex - which enable him to reap market and non-market returns from interactions with others’. By doing so they implicitly concur with Arrow’s (1999) point that ‘capital’ suggests a resource that can be individually accumulated. They take this to imply that the term social capital should not be used for attributes that are not accumulable at the individual level. In their analysis, Glaeser at al. (2002) mostly focus on individual contacts, identified by Putnam (2000) and Burt (2000) as the size of one’s network of contacts, and they essentially treat investments in contacts on a par with investments in education.

Our notion of Relational Capital is also individualistic.[2] RC is the stock of relations that households and firms need for selling outputs and buying inputs. We model this by having RC as an input in the production of *sold* output. RC as an individual asset is close to Glaeser et al.’s (2002) notion of social capital, and like them we provide a theory for why and how it changes over time. The main difference between our model and that of Glaeser et al. (2002) is that the destruction of RC is not only possible, but necessary for technological growth.

The second view of social capital is that it measures ‘trust’, ‘community networks’, or, more generally, some form of adherence to community norms. For instance, Robison et al. (2002) argue that social capital should be viewed as ’sympathy’ among agents in a society. Likewise, Bowles and Gintis (2002) argue that social capital does not equate with an individual asset, but is a form of capital on the community level. The proponents of this view hold that the costs of finding trading partners is affected by (community) social capital. We incorporate this second concept by modeling a matching process where frictions depend on the level of community level social capital (CSC). We

[2] Frijters(2000) introduces a related concept of relational capital on the firm level and analyses the consequences for the wage and age structure of employees within a firm.

argue that CSC determines the efficiency of searching for new contacts, which is a point we share with Bowles and Gintis (2002). Unlike them however, the same search-improvement role is also performed by Market Institutions, which we hence view as substitutes for CSC. Additionally, in our simulations we model a thick-market externality by including a feedback from levels of RC and production on the costs of making contacts, via a change in CSC and MI. This feedback creates a poverty trap, where an economy can be stuck for a long time in a situation of a small stock of RC coupled with high labour costs of creating more RC.

One of the classic references to social capital, Coleman (1988), also includes an individual/communal dichotomy. Coleman (1988) writes that agents in a functioning economy need to advance resources to other agents and receive virtual 'credit slips' in exchange. On the individual level, the number of 'credit slips' agents hold is a measure of their social capital. Community norms, a form of CSC, ensure that debts are repaid. Coleman's concept of credit slips does have a productive aspect to it in the sense that they promote specialisation: Coleman states that within a relationship partners exchange these 'credit slips' in different dimensions, such that within a partnership one party can be a creditor with respect to one dimension (for example providing a financial credit) but a debtor in another (for example market information). This differs from our conception of RC because even someone whose balance of 'credit slips' is zero can have many trading relations (high RC) and hence also enjoy the advantages of specialisation.

With respect to innovation and social capital, Routledge and von Amsberg (2003) provide a game-theoretical model of social capital. They, too, look at contacts between trading partners and argue that technological innovation needs the replacement of contacts. One difference is that in their model entities only have a fixed number of trading partner whilst in ours, the number of partners can be expanded to allow for more specialisation and this is always production increasing. Hence, in our model there is additional scope for output growth due to higher stocks of RC. Furthermore, their concept of social capital relates only to the communal aspect, namely to the degree of trust in potential partners, whereas in ours it relates to the search technology. The greatest difference though is that our model incorporates other aspects of the economy too: we have labour costs of making contacts, savings, (endogenous) political interference, and Market Institutions. Both models serve different purposes. Whilst Routledge and von Amsberg (2003) focus on a very particular contact replacement mechanism, our model aims at an economy-wide analysis of long-term patterns of development.

This paper fits into a wider research agenda that looks at creative destruction and contacts. In Bezemer et al (2003), we thus study the transition from socialism to capitalism using a model that includes creative destruction but ignores the issue of social capital.

The article proceeds with the presentation of our model. The subsequent section discusses our assumptions and concepts in more detail and provides empirical illustrations and connections to other literature. We study the role of RC and CSC in different development paths and political environments in a series of simulations in Section 4. We distinguish between exogenous 'big bang' transitions, exogenous transitions of slow but inevitable change, and endogenous developments. In the latter case, political interference and the development of market institutions depend on the stocks of relational capital in the economy. Section 5 concludes and raises issues for further research.

# 2 A Model of Relational Capital and Growth

Our economy consists of a continuum of representative firms maximizing their profit. Consumption is not explicitly considered, but firms can be viewed as owned by households who provide a fixed endowment of labor to the economy. Households consume all of their income except a constant share $s$ as specified below. Firms produce a homogeneous good with unit price. Technology is described by a production function with three inputs: labor, physical capital and contacts of the firm. Thus, Relational Capital ($RC_t$) is a capital stock, and can be thought of as the number of business contacts. It is an input in *sold* output $y_t$.

The difference to the standard definition of output is that market frictions necessitate business contacts. Having RC as an input is our way of modelling the search costs of finding partnerships needed for buying inputs and selling output. We define sold output by

$$y_t = y(A, L_t - L_t^{rc}, RC_t, K_t) \tag{1}$$

where $y_t$ is sold production at time t; $L_t$ is the labor force, $L_t - L_t^{rc}$ is net labor input into physical production (blue collar labor); $L_t^{rc}$ is (white collar) labor devoted to the creation of $RC_t$; $A_t$ is the technology parameter; $K_t$ is physical capital. $y(.)$ is a constant-returns-to-scale function with all the usual Inada-properties: any input faces decreasing positive marginal returns and is technically complementary to any other input.

The economy has a continuum of such firms with a measure of 1. This allows us to use $\bar{y}_t$, $L_t$, $K_t$, and $\overline{RC}_t$ as the total amount of output, labor and capital stocks in the whole economy. As in standard macroeconomic growth models we assume the following functional form for our analysis

$$y_t = y(A_t f(L_t - L_t^{rc}, RC_t), K_t) \tag{2}$$

where $A_t f(L_t - L_t^{rc}, RC_t)$ is a single composite input: technology $A_t$ is the productivity of the combination of labor and contacts, similar to a labor augmented (or Harrod-neutral) technology in the standard textbook model. Assumptions on $f(.)$ are implicitly given by the assumptions on $y(.)$.

Firms select levels of $L_t$ and $K_t$ and invest in the stock of $RC_t$ by allocating labor $L_t^{rc}$. We distinguish between $D_t^{rc}$, the amount of contacts replaced, and $N_t^{rc}$, the amount of contacts added. Replacing contacts implies destroying an old contact and creating a new one, as illustrated in figure 1 below.

Firms selecting positive levels of $D_t^{rc}$ and $N_t^{rc}$ meet on a markets for contacts. Firms, and therefore business contacts, are taken to be heterogeneous, leading to search frictions in the matching process. As in most of the search literature (e.g. Pissarides, 1990; Petrongolo and Pissarides, 2001), we do not explicitly model this heterogeneity.[3] We capture its effect by positing contact search costs in terms of labor time to replace or add business contacts:

$$\lambda_t L_t^{rc} = \varphi_t D_t^{rc} + N_t^{rc} \text{ with } \lambda_t > 0, \varphi_t \geq 1 \tag{3}$$

where $\lambda_t$ denotes the conversion rate of labor $L_t^{rc}$ into relations. In terms of search theory, $\lambda_t$ can be interpreted as the arrival rate of contacts. We capture the relation between business contacts and social or market networks by positing that $\lambda_t$ depends positively on both Community Social Capital ($CSC_t$) and Market Institutions ($MI_t$). In the next section, we elaborate on this and provide references to the literature.

Since destroying an old contact constitutes a negative externality (the loss of a contact) on the old business partner, these have an incentive to preempt by making contact destruction costly. ($\varphi_t - 1$ ) is the cost a firm incurs when breaking a contact with another firm, over and above the costs of just finding a new contact. We assume that raising the cost of breaking contacts is only possible via the political process. If there is some degree of political interference in firms' matching choices, $\varphi_t \geq 1$ denotes the degree to which the political process frustrates the replacement of contacts. In completely decentralized economies, firms have no power to raise the cost of breaking contact with them, and $\varphi_t = 1$: replacing and adding contacts are equally costly to the firm doing it. Political interference in matching choices amounts to some degree of centralization of markets. The more an economy is centrally controlled, in this sense, the higher $\varphi_t$. We discuss this assumption in the next section in more detail.

Contact replacement is inextricably linked to technological progress. When-

[3] This differs from social network models such as Jackson and Wolinsky (1996) or Vega-Redondo (2003) or the growth model of Routledge and von Amsberg (2003). In those models the stability and/or trustworthiness of specific links between agents is analyzed. We abstract from identities of partners by assuming these problems are captured implicitely by a matching function.

ever a firm increases its efficiency by initiating a new production method, producing new products, or changing its internal organization, it will typically make new demands on its input suppliers or output buyers. Since old 'transaction partners' were selected so as to match old production and sale processes, switching transaction partners will be optimal under new production or sale conditions. In short, firms tend to replace contacts as they improve their technology $A_t$. As in Schumpeter (1934) and Routledge and von Amsberg (2003), the destruction of old contacts is an inevitable by-product of the creation of new production and sale methods.[4] We therefore term the replacement of RC *creative destruction*. We explicitly model technological progress as depending on the extent of contact replacement $D_t^{rc}$:

$$A_t = A_{t-1} + (A^*_{t-1} - A_{t-1})g(\frac{D^{rc}_{t-1}}{L_t}) \tag{4}$$

where $A^*_t$ denotes the production frontier at time t. The function $1 > g(.) \geq 0$ denotes technological 'catch-up' resulting from the replacement of relational capital per unit of $L_t$. The lag between $D_t^{rc}$ and $A_t$ reflects the technology take-up time. We assume that there are decreasing returns in technological investment: $\frac{\partial g(.)}{\partial D_t^{rc}} > 0$, $g(0) = 0$, and $\frac{\partial^2 g(.)}{\partial^2 D_t^{rc}} < 0$. Appendix 1.3 provides micro-arguments for this equation.

Because of the externality connected to replacing contacts, the level of RC does not only depend on own investment decisions, but also (negatively) on others' contact replacement decisions. We capture this by

$$RC_t = RC_{t-1}e^{-\beta\frac{\bar{D}_t^{rc}}{RC_{t-1}}} + N_t^{rc} \tag{5}$$

[4] Routledge and von Amsberg (2003) provide a game theoretic model of SC based on the idea of cooperation in a repeated Prisoner Dilemma game. To model growth they assume too that new trading partners are necessary for technological advancement. In their model faster technological development implies shorter times of interaction and hence a destruction of CSC in the form of trust. We argue that only RC diminishes through an externality of replacing contacts. In our model CSC can help to reduce the cost of the externality much in line with empirical evidence (see for example Miguel's (2003) comment on Routledge and von Amsberg).

where the term $e^{-\beta\frac{\bar{D}_t^{rc}}{\overline{RC}_{t-1}}}$ equals the probability of an old contact being destroyed by the creative destruction decisions of other firms. This probability is derived endogenousely given a stochastic process on the micro level which we develop in detail in Appendix 1.1. The parameter $\beta$ equals the net number of contacts that get destroyed when one firm replaces an old contact, destroying his previous partner firm's contact. When that firm is part of a large value chain of interdependent firms, $\beta$ is large.

Figure 1 illustrates the difference between $N_t^{rc}$ and $D_t^{rc}$. For simplicity, we take $\beta = 1$. This reflects the simplifying assumption that production is pairwise, i.e. that value chains have a length of two firms. There are four firms in total. Initially, there are productive contacts between firms 1 and 2, and between firms 3 and 4. The top example shows what happens with creative destruction: firms 1 and 3 both replace one contact and form a new contact through search and matching. Both firms improve their technology $A_t$ by doing so. Both abandon the contact they previously had with other entities. The net effect of this creative destruction is a loss of one contact. As noted, we can extend this example to situations where the net number of contacts that are destroyed is larger. If some of these entities are part of a chain of contacts, the whole chain may become worthless when a single entity in the chain pulls out. The bottom example shows what happens with making extra contacts: without changing production processes, both entities 1 and 3 increase their number of contacts. The new contact between these entities does not force either of them to abandon their previous contacts. The net effect is an increase in the number of contacts by one.

To close our model, we make some standard assumptions about the movement of total labor units, the technological frontier and physical capital formation:

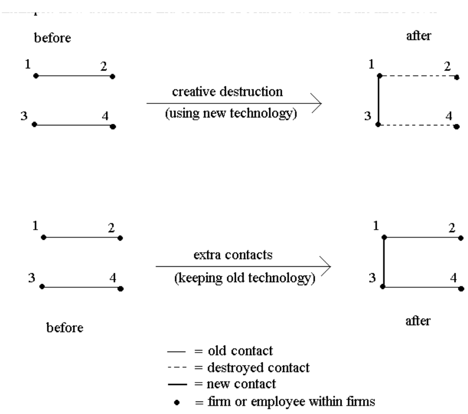



Figure 1: Creative destruction (replacing an old contacts) and network extension

$$L_t = L$$
$$K_t = (1-\delta)K_{t-1} + sy_{t-1}$$
$$A_t^* = (1+a)A_{t-1}^*$$

We take labor to be constant and capital to follow the Swan-Solow-assumptions of fixed depreciation, constant savings rate and exogenous technological frontier progress. This specification reflects assumptions on the economy of exogenous savings, no outside investment and a given technological frontier.

We make the standard assumption that firms maximize the discounted stream of profits equal to $\sum_{t=0}^{\infty}(\frac{1}{1+r_t})^t\{y_t - w_tL - r_tK_t\}$.This is independent of the economic system, which is here reflected in the centralization parameter $\varphi_t$. This implies that we assume that economic systems do not affect optimization behavior, but they do affect the constraints firms face. For a similar assumption on firm behavior under socialism, see Roberts and Rodriguez (1997).

# 3 Social Capital, Market Institutions and Politics

Our model attempts to capture key aspects of several literatures. The concept of RC formalizes the idea of transaction costs and the value of information put forward, for example, by Williamson and Masten (1999). The idea is also implicitly present in transition models, such as those of Blanchard and Kremer (1997) and Roland and Verdier (1999), where firms need relations to achieve sold output.

As noted in the Introduction, RC also connects to the large empirical social capital literature, where households with more linkages (e.g. in local associations) are found to have higher incomes (Grootaert et al, 2002 among others); that regions with more dense associational networks are more prosperous (Putnam, 2000); and that civil society in general is conducive to economic growth (see Durlauf and Quah, 1999, for a survey of growth regressions). These findings concur with our assumption that sold output relies on RC.

The value of RC lies in the heterogeneity of trading parties. Once a relation is discontinued, parties cannot easily find other suppliers and clients because their buying and selling transactions were partner-specific. The notion that it takes time to find suitable buyers is also present in the literature on capacity utilization (Fagnart et al, 1999), where it is argued that not all production is automatically sold.As in the literature on forward and backward linkages (Hefner and Guimaraes, 1994), our externalities arise from contact replacement.

We suggested that the costs of making new contacts are determined by two factors: Community Social Capital (CSC) and the quality of market institutions (MI). We will now argue this in more detail. Informal networks, which constitute CSC, provide a particularly direct route for making new business contacts because, as Malecki (2000) writes, 'through the economic and social relationships in the network, diverse information becomes less expensive to obtain'. The more widespread the network, the lower the costs of making contacts in terms of labor time.

Another reason why CSC lowers search costs is that CSC allows trust to develop. Trust grows in the context of family, ethnic, religious, and civil ties. It can be defined as a rational expectation that others keep their promises (as in Nooteboom, 2002). Trust thus reduces individuals' search, monitoring and contracting efforts. These are labor costs of contracting and enforcement. The larger the trust developed in such networks, the faster a network of business contacts is made, with all the associated advantages. Sobel (2002) summarizes the large empirical literature on this issue.

Consider three empirical case studies on the importance of CSC. Murphy (2002) reports that social networks of business people in Tanzania support innovation in manufacturing firms. He finds that trust in these relations is especially important as it improves the quality of information exchanges. Grooteart et al (2002) investigate the importance for the welfare of rural households in Burkina Faso of CSC in the form of local associations and networks. They find that higher densities of local associations and networks are associated with higher per capita household expenditures and better access to credit. This replicates a finding by Helliwell and Putnam (1995) for Italian regions.

As a graphical illustration of the trust-growth link, Figure 2 shows a scatter plot of a 1981 survey measure of civic cooperation plotted against average annual GDP growth in the 1980s for 28 middle and upper-income countries, based on World Values Survey data (Knack and Keefer 1997). The civic cooperation measure is a score based on answers to questions on voluntary adherence to civic norms, such as not taking advantages of loopholes in social benefits system. It measures the extent to which citizens are prepared to 'play by the rules'. As noted by Nooteboom (2002) and Knack and Keefer (1997), rule adherence is an important dimension of trust. The correlation coefficient between log(CIVIC) and average growth in the 1980s

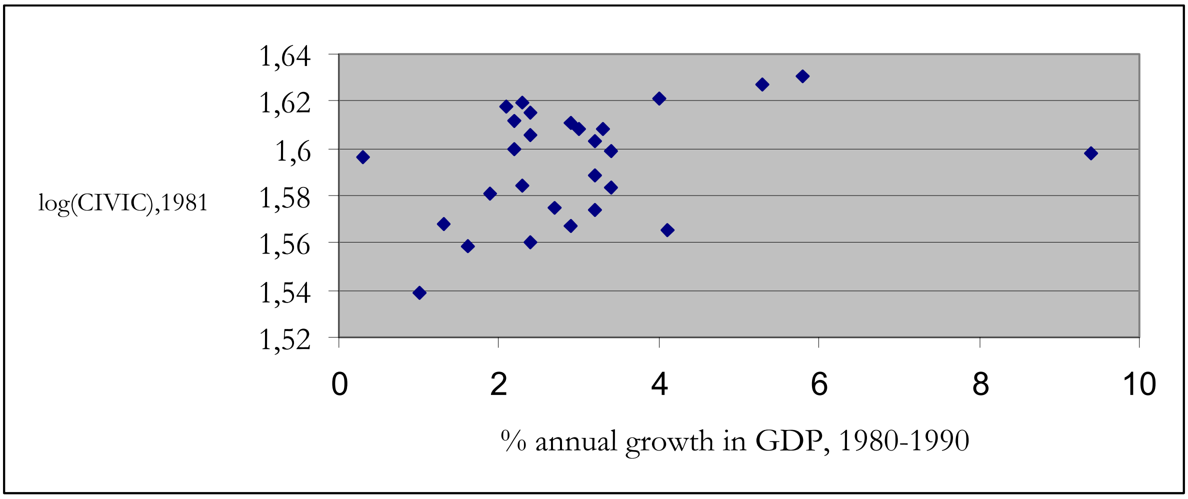



Figure 2: Strength of civic co-operation norms and economic growth, Source: Knack and Keefer (1997)

is 0.33 and highly significant[5]. In our interpretation, this is so because trust facilitates contact creation and contact replacement which, in turn, is essential for technological progress and growth. We support this argument below with simulations.

We now turn to Market Institutions (MI)[6]. They also determine the costs of making contacts, similar to CSC, because they likewise decrease the costs of forming linkages between economic entities. To illustrate this point, consider traditional models of perfect markets. These abstract from the difficulty of finding contacts and from externalities of creative destruction. The notion of perfect markets can be interpreted as the limit of having exceedingly fast arrival rates of contacts where the creation of RC is virtually costless. The stock of RC existing in the perfect economy is very large. Adaptation

[5] Knack and Keefer (1997) analyse the relation in depth in a regression analysis, controlling for a number of other variables, and also find a positive and significant coefficient for CIVIC across specifications and outlier treatments.

[6] We use the word institution not merely for the rules that these formal organizations enforce (as in North, 1990), but also for the organizations themselves.

of technology is fast and the economy is perennially at the technological frontier.

If there are information frictions, heterogeneity in the quality of products and of firms - their credit-worthiness or their reliability - matters, and so do search costs. This creates free-riding behavior of low-quality firms on the existence of high-quality suppliers or clients (Akerlof 1970). Market institutions can overcome such information problems and associated search costs by screening and monitoring. Private market institutions include business associations that screen and monitor members as well as banks that control creditors and lenders. Public market institutions include credentialist systems, such as education certification and food standard agencies. Both private and public MI reduce search costs by taking advantage of economies of scale in monitoring firms, typically more so than CSC. Increasing returns to formal screening and monitoring may explain why societies with well developed market institutions and a lower level of CSC can faster create RC, and thereby grow at higher rates, than societies with weak MI but well developed CSC. The former are developed market economies, the latter is a characterization of a typical developing country.

We illustrate our interpretation of MI with the importance of financial intermediation, measured as the average 1989-1996 ratio of total assets of deposit money banks to 1990 GDP. We plot this against per capita GDP levels for 40 countries. The scatter plot in Figure 3 shows the positive relation, most clearly in the lower-income countries[7]. In our interpretation, this is so because the relative benefit to GDP of using MI is especially large in countries where the less efficient CSC-based contacts are more prevalent.

We now turn to the link between the political system and economic growth through contact replacement. We have defined a perfect, decentralized market as one with abundant RC and negligible search costs. In particular,

[7]Demirguc-Kunt and Maksimovic (2002) show in an extensive analysis that both of the relations shown in Figures 2 and 3 hold also if controlling for other variables.

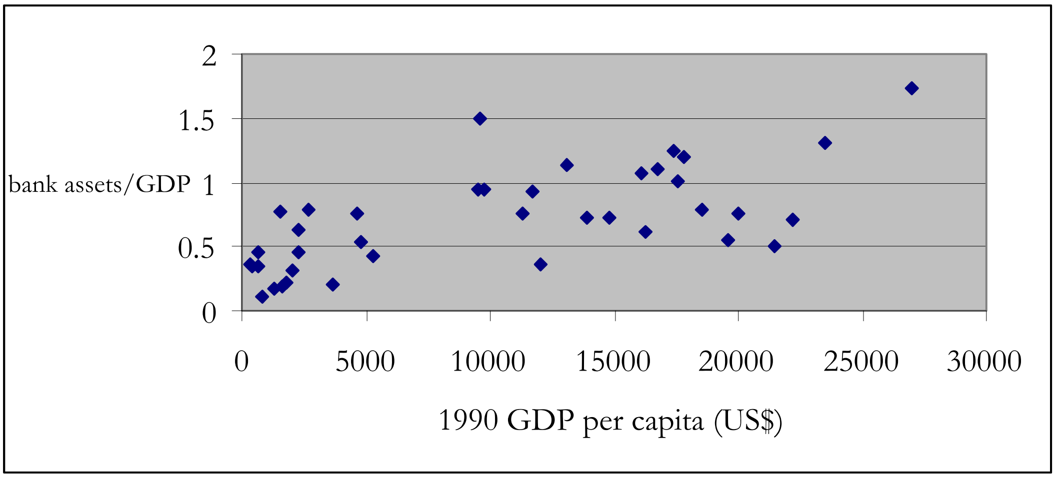



Figure 3: Formal financial Intermediation and economic development, Source: Demirguc-Kunt and Maksimovic (2002)

perfect markets are without politically supported costs of breaking contacts. Political-economic systems may deviate from this benchmark if enterprise decisions threaten key political interests. If creative destruction threatens the rents of those in power, MI that foster creative destruction will be politically curtailed. Creative destruction may also be more directly impeded politically in two ways.

The first is sheer corruption. Politicians and the bureaucrats simply veto changes in the network of contacts if these affect them negatively. To put it bluntly: one does not easily break up contacts with the dictator's firm.

The second way in which contact replacement may be hindered is the inefficiency of direct political control. When politicians aim to steer or control production, they effectively engage in economic planning. The literature on central planning argues that the span of control of the center is typically not sufficient to gather and absorb all the information necessary to make optimal enterprise-level decisions, among them decisions on the breaking and making of contacts. Especially the recognition of new technological opportunities is a matter of local information.[8]

For socialist economies, this argument is well-known (e.g. Aslund 2002), and socialist-style central planning constitutes the extreme case. But also under dictatorial regimes, political enforcement of business contacts occurs. In developing countries, property is often concentrated. Firms are not free to dispense with their RC because the political center can punish them for it. Because of this control, firms negatively affected by creative destruction can lobby the political center not to allow creative destruction in other firms. Such lobbying has indeed been observed in developing and transition economies (Rama, 1993; Braguinsky and Yavlinsky, 2000; Gros and Steinherr, 1995) and was prevalent in socialist systems (Nove 1987). This directly increases the cost of creative destruction.

Both arguments amount to the same thing: the 'quality' of the political system, in terms of the economy's growth capacity, can be seen as reflected in the additional labor costs of replacing a contact over and above finding a contact. This additional cost incurred by the firm includes additional lobbying, bribery, administrative, or legal work involved in replacing a former business contact. A higher 'price' of breaking up and replacing contacts leads to endogenous technological backwardness. It is now widely accepted that this was a reason for low growth in the former socialist economies. We suggest that this may also be the case in many developing countries, which typically have relatively high levels of political interference in enterprise-level decision making, either through corruption or through purposeful central coordination, or both.

In this section we provided arguments and empirical illustrations for the assumptions made in the model section 2. To summarize, we argue that firm contacts are a productive input. The costs of making new contacts are affected by Community Level Social Capital and by Market Institutions.

[8] A similar conclusion follows from the discussion of incentives and technological property rights. The more centralized a system, the less likely it is that those at the firm level can reap the benefits of improved technology and replaced contacts.

The main difference between political systems stems from interference with creative destruction. This may occur through hindering MI development, through corruption, through direct political interference, or through raising the costs of replacing contacts in some other way. All this amounts to decreasing the scope for truly decentralized decision making. A less decentralized system will have higher costs of engaging in creative destruction than a decentralized system.

# 4 Scenarios of Economic Development: Simulations

The steady-state equilibrium of the model is derived in Appendix 2. As long as $\varphi_t < \infty$, there is perpetual creative destruction and investment in new relations to compensate for the losses of RC due to creative destruction. Output will eventually grow at the rate of technological progress. Output will be higher when saving rates, initial levels of production factors, and contact rates are higher. Output will be lower the higher the discount rate and the higher the $\varphi_t$. Because these findings are trivial and tell us little about the dynamic properties of developing economies with systemic change, we relegate a brief discussion to Appendix 2.

Here we concentrate on simulations. Our functional form specification is:

$$
\begin{aligned}
y_t &= [A_t(L - L_t^{rc})^{\gamma_0} RC_t^{1-\gamma_0})]^{\gamma} K_t^{1-\gamma} \\
A_t &= A_{t-1} + g_1(1 - e^{-g_0 D_{t-1}})(A_{t-1}^* - A_{t-1})
\end{aligned}
$$

which presumes a standard Cobb-Douglas production function and a simple catch-up process for technological progress. We take: $\gamma_0 = 0.65$, $\gamma = 0.7$, $g_0 = 0.25$, $g_1 = 0.8$, $\lambda(.) = \lambda_0 = 0.1$, $\rho = 0.06$, $s = 0.3$, $\beta = 1$, and $\alpha = 0.02$ for the first scenario. We later discuss alternative scenarios and change $\lambda_t$ accordingly.

As to the initial condition, we presume in all scenarios that the economy starts with $\varphi_t = \varphi = 1000$.[9] The technological gap with the technological frontier at the start of each development trajectory is presumed equal to 100 years of steady state technological development. At 2 percent technological growth per year, this works out at a technological ratio of about 1:7, which appears a reasonable guesstimate. We note that the productivity per unit labor has a much higher ratio than this, because the level of RC per unit of labor will also be low at the start of the development trajectory.

Parameter assumptions are selected to reflect reality in various ways. First, they imply that physical capital accounts for 30% of output, production labor 45% and RC 25%. This measure of the importance of RC is conservative. In a pioneering study, Machlup (1962) estimated the share of all economic activity in the United Sates devoted to discovering and distributing information at 29 %. Porat (1977) put it close to 50 %. Second, values for $\lambda_t = \lambda$ and $g_0$ are sufficiently high for any economy to be able to catch up with the technological frontier within two decades if it would invest all its resources (hence forgoes all output today, which is obviously not realistic) into technological progress via RC replacement. Third, parameter values reflect standard assumptions about discount rates (6% a year), saving rates (30% a year), and the rate of technological progress (2% a year). There remains arbitrariness especially with respect to $\varphi_t$ and $\lambda_t$. We discuss robustness of our results in the last subsection of the simulations.

In many models of development, it is difficult to capture the notion of systemic change. The two parameters in our model that capture systemic change are $\varphi_t$ and $\lambda_t$. A 'big-bang' systemic change can be represented as a one-off unanticipated change in $\varphi_t$ and\or $\lambda_t$. A continuous 'improving' systemic change is one where $\varphi_t$ and $\lambda_t$ continuously change, presumably in the direction of perfect markets, i.e. low $\varphi_t$ and high $\lambda_t$. Endogenous sys-

[9] This $\phi$ is so high that no creative destruction has taken place before the start of any scenario, i.e. the starting situation is the same as the steady state situation of having $\phi = \infty$.

temic change is one where $\varphi_t$ and $\lambda_t$ themselves are endogenous. In order to organize the discussion, we will simulate various scenarios:

*Scenario 1.* The development path of an economy that was initially characterized by the steady state of high $\varphi_t$ and a low $\lambda_t$, where overnight all political control is removed. Three are no costs of breaking contacts so that $\varphi_t = \varphi = 1$ while also the labor costs of matching $\lambda_t = \lambda$ remain constant over time. In additional to this laisser-faire development path, we also show the theoretically optimal path a social planner would choose. This serves as a benchmark of what an optimal policy may be able to accomplish.

*Scenario 2.* The development path of an economy that was also initially characterized by the steady state of a high $\varphi_t$ and a low $\lambda_t$, which sets upon a trajectory of ever decreasing $\varphi_t$ and ever increasing $\lambda_t$. By letting $\varphi_t$ decrease we now allow for the gradual development of MI which lower contact matching costs, while simultaneously labor costs of contacting are falling. Again, not only the actual development path, but also the theoretically optimal path is shown.

*Scenario 3.* The development path of an economy that was initially characterized by the steady state of a high $\varphi_t$ and a low $\lambda_t$, which sets upon an trajectory of endogenous change in $\varphi_t$ and $\lambda_t$. More specifically, we insert the assumption that the larger the market network (reflected in the value of the $RC_t$ stock), the smaller $\varphi_t$ and $\lambda_t$. Technically, we introduce a variation on Diamond's (1982) thick-market externality, which acknowledges that larger networks make it less costly to form new contacts. In our context, the intuition is that larger non-state networks (whether of a business of civil society nature) influence politics such that the political process becomes more conducive to creative destruction. We elaborate on this interpretation below.

## 4.1 Scenario 1: a transition

Scenario 1 is apt for describing some event - a systemic collapse, a coup, a sudden policy change - that ends economic control over the economy. The outstanding example would be the post-socialist transition countries, with sudden and comprehensive introduction of liberalizing policy measures. We assume throughout that firms maximize discounted-profits and have rational expectations after the shock. We contrast the outcome of their behavior with what the optimal solution would be that an all-knowing social planner would implement.

Concretely, we assume that at t=0, $\varphi_t$ suddenly changes from 1000 (virtually total political control) to 1 (no political interference at all), whilst nothing else changes and $\lambda_t = \lambda$ remains constant. Figures 4a and 4b show the simulation results for a decentralized transition; Figures 4c and 4d depict the 'optimal' path.

**Figure 4a: the laisser-faire development path**

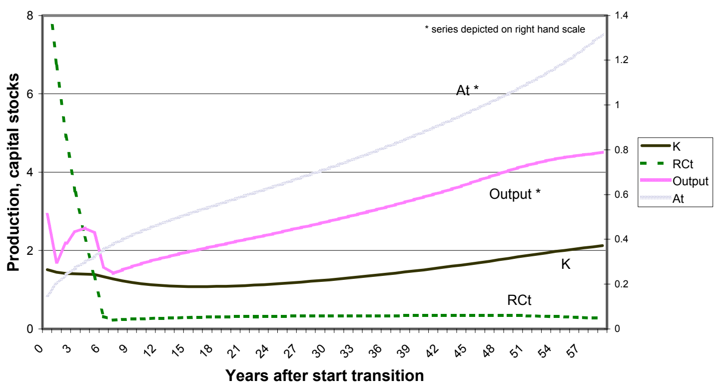


Figure 4b: relational capital investments during the laisser-faire development path

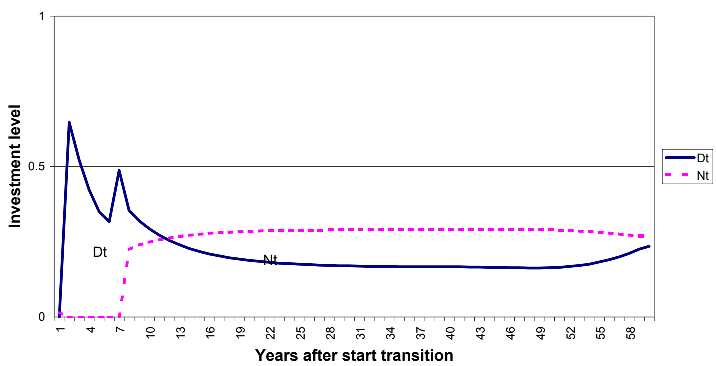



Figure 4c: 'the optimal' development path

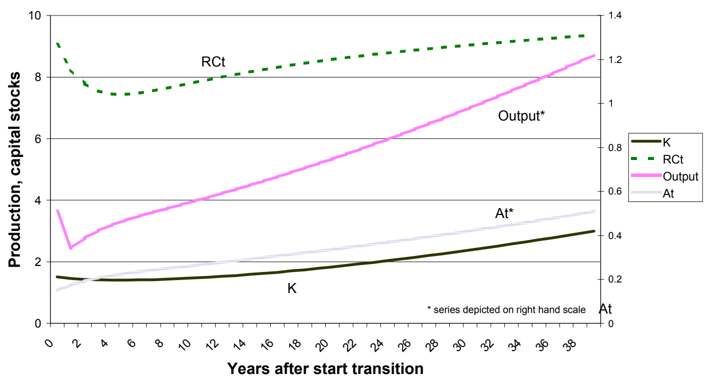
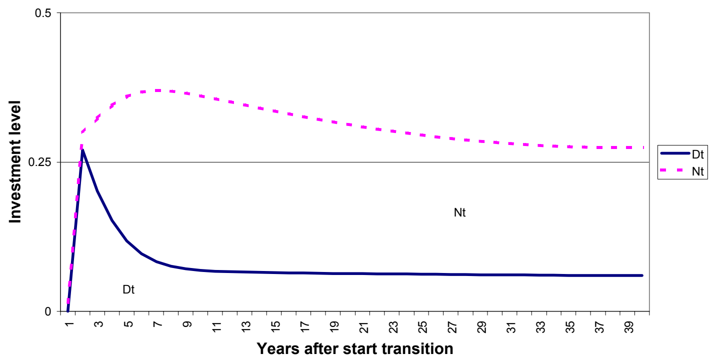



Figure 4d: relational capital investments and contact rates during the 'optimal' development path




The decentralized development path is characterized by a large initial decline in output, sustained over several periods. The decline in output in the first 7 periods is about 50%, which is mainly due to the reduction in RC and partly due to labor used in creative destruction. Output returns to the initial output level only after 20 periods. These figures qualitatively mimic the real patterns of output fluctuations in formerly centrally planned economies. The start of reform led in all 27 transition countries to a fall in output during three to eight years, a fall 'never before experienced in the history of capitalist economies (at least in peacetime)' (Mundell, 1997; see EBRD, 2003 for figures). More generally, Greenaway et al (2002), survey the experience of 25 developing countries which implemented 'deep' market liberalization programmes. In a panel data analysis, they demonstrate that market liberalization is typically followed by an J-curve output response over time: output falls steeply initially and recovers afterwards. More recently, Indonesia after the fall of Suharto and his network in 1998 exhibited a similar response.

For other parameter choices too[10], we find that the sudden drop in $\varphi_t$ without a change in $\lambda_t$, i.e. the advent of laisser-faire capitalism, destroys much of the existing networks in the economy. The reason is that the new system inherits a large network and backward technology. Maximizing firms have an incentive to upgrade their technology via high $D_t^{rc}$, which rapidly destructs old networks.

Beyond the evidence on transition and developing countries quoted, another empirically verifiable implication of this model is that the lifting of barriers to creative destruction should lead to high demand for labor involved in networking, i.e. $L_t^{RC}$., as opposed to production work. This should be observable as swift changes in rewards for making contacts. Such an immediate change has indeed been documented for Slovenia (Orazem and Vodopivec 1997), Russia (Brainerd, 1998; Sabirianova and Sabirianova, 2003 ) the Czech Republic (Flanagan, 1998) and China (Lee, 1999). These demonstrate that the returns to management skills, and more generally the skill wage premium, rose quickly and immediately after the start of the institutional changes.

[10]We searched amongst the grid defined by $\gamma_0 \in \{0.5, 0.65, 0.8\}$, $\gamma \in \{0.6, 0.7\}$, $g_0 \in \{0.2, 0.5, 1\}$, $g_1 \in \{0.5, 1.5, 4\}$, $\lambda(.) \in \{0.2, 0.4, 0.8\}$, $\beta = \{1, 5\}$, $y(.) \in$ {Cobb-Douglas,CES} .

The negative effects of high levels of creative destruction on the total level of $RC$ in the first periods generate a strong contraction in $y_t$. Because of complementaries, it is accompanied by a reduction in the marginal value of other production factors labor and capital. This concurs with observed increasing incidences of poverty and capital flight after market liberalization measures, of which the post-socialist transition is again an extreme example.

After liberalization, productivity would increase in the surviving firms due to the creative destruction they implement. Pavcnik (2000), using plant-level panel data on Chilean manufacturers, finds evidence of within plant productivity improvements following the Chilean liberalization of the early 1980s. She attributes this to 'the reshuffling of resources and output from less to more efficient producers'. Similarly, Lall (1999) researches the garment industry in Kenya, Tanzania, and Zimbabwe, based on firm-level data, and finds technology upgrading and improving firm performance in response to liberalization. Grant (2001) similarly reports reallocation of enterprise relations in Ghana after reforms. In particular, his analysis points to increasing service-sector performance. Abandoning local control in particular lead to rapid re-alignments in Ghana, with foreign companies establishing joint ventures, developing local products, and joining national stock markets. These are indications that constituent firms were changing their production processes, their input suppliers and their clients. This may be interpreted as evidence of much contact replacement $D_t$.

We now turn to the optimal development path, i.e. the path of a social planner who would take the externalities of creative destruction into account. In Figure 4c, the super-planner chooses $D_t^{rc}$ such that there is an initial output fall of about 30%. The initial levels of creative destruction are about 30% of that of the decentralized transition. The economy recovers to its old level after 10 periods, with high growth levels recorded in the early years. Growth in this period is fuelled by growth in the technology used. As in the earlier simulation, output growth eventually tails off to the level of exogenous progress of the technological frontier.

The interesting question is how any realistic policy can mimic the super-planner solution. The dilemma is that in practice no planner can engage in creative destruction since this requires decentralized information; but decentralized creative destruction overshoots. An observed policy is a dual track approach. In the case of China some restrictions on the mobility of labor and capital are maintained (Tian, 1999). As Roland and Verdier (2003) comment, such "...dualism follows the scenario of Chinese transition where the government keeps direct control over economic resources and where a liberalized non-state sector follows market rules". In terms of our model, the Chinese experience is a way to restrict the actions of a sizeable proportion of the firms in the economy, allowing only a fraction to engage in creative destruction, hence avoiding a cumulation of the external effects.[11]

The simulations above suggested that our model is capable of capturing observed economic dynamics after a momentous liberalization. Obviously, the speed of recovery varies tremendously with parameter variations, but the qualitative finding of an output drop caused by a collapse of RC followed by a recovery appeared in all parameter values examined.

## 4.2 Scenario 2: gradual but inevitable system changes

In Scenario 1, it was effectively presumed that political institutions changed suddenly and completely, whilst there was no change in the rate at which individuals could make contacts. For many developing countries, it would seem more apt to assume that both political barriers and contact rates move slowly towards perfect markets. We leave the question of the endogeneity of such changes till the next subsection and here take them as inevitable.

More precisely, starting from the same conditions as above, we assume that from $t = 0$ onwards $\varphi_t = 1 + \varphi_0 e^{-\alpha\varphi * t}$ and $\lambda_t = \lambda_3 * (1 - e^{-\lambda_2 - \lambda_4 * t})$.

[11] Additionaly, after the reform often local party members obtained the means of production form state companies (Lin, 2001). This realigns incentives and implies in our model a reduction of $\varphi$. Lee (1999) shows that these companies experience high growth rates.

This describes slowly adjusting $\varphi_t$ and $\lambda_t$. We take $\varphi_0 = 1000$, $\alpha\varphi = 0.05$, $\lambda_4 = 0.01$, $\lambda_2 = 0.05$ and $\lambda_3 * (1 - e^{-\lambda_2}) = \lambda_0$. These assumptions mean we allow $\varphi_t$ to halve its distance towards 1 about every 8 years, and $\lambda_t$ to halve its distance towards $\lambda_3$ every 40 years. We show simulations with different choices later.

**Figure 5a: the decentralized, exogenous-reform, development path**

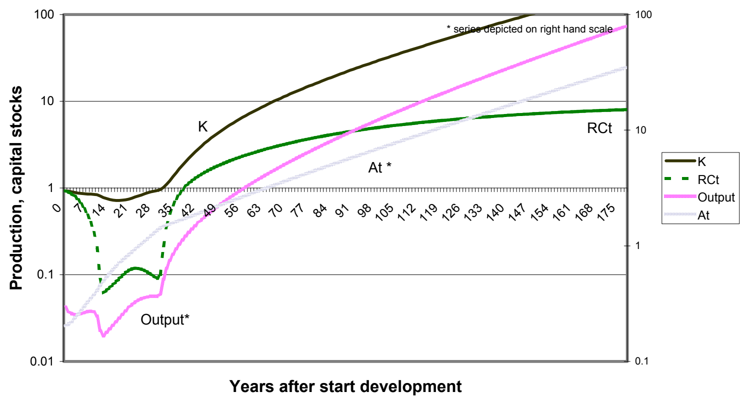
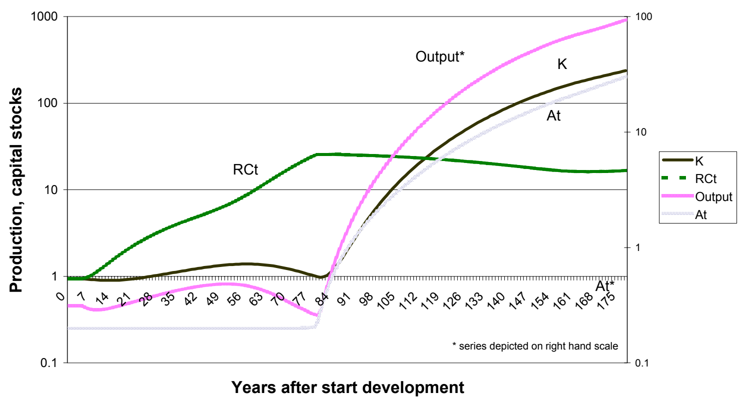



**Figure 5b: the 'optimal' development path with exogenous reforms**




Again we find a sharp decrease in RC with the decentralized path. It is interesting that the optimal path includes maintaining RC for the first 20 years, illustrating the large negative externality of creative destruction on growth.

We here leave aside the actual composition of the increases in community social capital and market institutions (captured by a growing $\lambda_t$). In practice, market institutions may well replace CSC due to increasing returns to scale.

Case studies document such substitution in banking (Ferrary 2003) and legal systems in the case of China (Winn 2002).

### 4.3 Scenario 3: endogeneity of system change

We here model politics, CSC, and MI, as the result of the aggregate of individual choices and thereby as externalities of individual economic choices.

The first endogeneity in this simulation is that the total size of the relational capital network affects the contact rate positively, making RC and $\lambda_t$ part of an autocatalytic process. Such an argument arises from both classic search theory and the social capital literature. Diamond (1982) argued in a seminal article that the arrival rate of contacts in search economies is likely to be linked to the number of units in the market. With more buyers and sellers in a market, the probability of finding a match increases. This thick-market externality argument also appears in Howitt and McAfee (1992). The argument carries over to relational capital building in developing economies, and we model this explicitly in Appendix 1.2.

Market institutions with economies of scale have this feedback. Their set-up costs can only be afforded once the market for contacts is sufficiently large. The social capital literature provides a similar argument about informal networks and trust. The growth of informal networks increases exponentially. The larger the number of contacts of each entity in a network, the faster the network grows and the more trust evolves. Sobel (2002) describes how having many business contacts makes it easier to access information about other individuals, which in turn promotes the returns to reputation. These arguments suggest that there is a self-enforcing mechanism whereby growth in the overall network increases the contact rate, which spurs further growth in the network. This may create a virtuous circle until a maximum contact rate is reached. Conversely, in very small networks the feedback may lead to a downward spiral that accentuates any exogenous drop in the stock of relational capital in the economy.

The second endogeneity we allow is that more $RC$ leads to reduced political barriers to creative destruction. Contacts can be used as channels of information and manipulation, and are therefore a means to influence politics (Guy, 2000).[12] This power can be used to decrease the costs of creative destruction costs by on the one hand lobbying for MI and on the other hand by controlling politicians (for example via the press). This argument follows the literature on the importance of civil society for growth. We argue that growing entrepreneurial networks transform the nature of the polity to decrease political interference. This appears to be occurring in present-day Cuba, Vietnam, and China.

The consequences of these feedback effects are *ex ante* ambiguous. By making creative destruction cheaper, the political activities of a growing network can lead to more creative destruction and hence a contraction of the network. The feed-back can lead to cyclical behavior in creative destruction and $\varphi_t$, until at some point the network becomes so large, even after periods of large creative destruction, that the political feedback of changes in RC becomes of marginal importance.

We model this endogeneity by taking $\varphi_t = 1 + \varphi_0 e^{-\beta_\varphi * \overline{RC}_{t-1}}$ and $\lambda_t = \lambda_5 \ln(e+\overline{RC}_{t-1}) \ln(e+\bar{y}_{t-1})$ where $\beta_\varphi = 0.4$, and $\lambda_5 \ln(e+\overline{RC}_{-1}) \ln(e+\bar{y}_{-1}) = \lambda_0$ which means $\lambda_5 = 0.2846$. Again, we will vary these assumptions later. Simulation presented in figures 6a and 6b result.

[12] For a more developed model on this specific issue, see Dulleck and Frijters (2003), who stress the importance of rents from a resource sector (e.g. oil or minerals) to the behavior of politicians.

**Figure 6a: the decentalized, endogenous reform, development path**

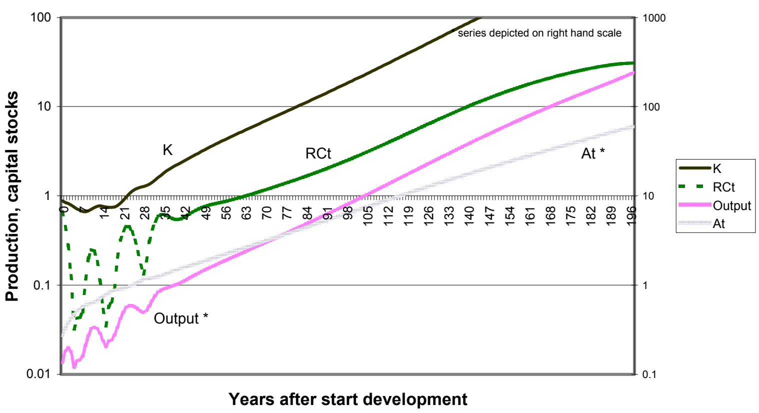
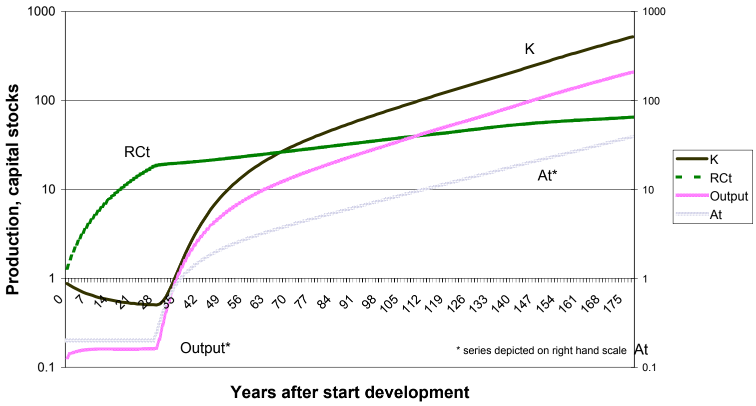



**Figure 6b: the 'optimal' endogenous reform development path**




Note the political cycles in the decentralized case, where only after 50 years the economy escapes the trap noted above.[13] Note also that the optimal development path first entails a period in which the RC network is expanded until $\phi$ is very low, i.e. first the political influence of politicians on the economy is removed. Only after that does the economy follow a path reminiscent of the decentralized path.

[13]Political cycles and the frequent un-doing of reforms after elections is, according to the historical analysis of Block (2002), a frequent phenomenon in African countries.

## 4.4 Robustness analysis

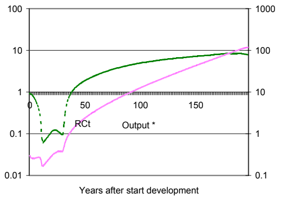
We had some empirics to guide us with respect to basic economic parameter assumptions. Yet there is simply nothing as yet to base $\lambda_t$ and $\varphi_t$ upon. For this reason, we give below the decentralized results for alternative assumptions. The main point we take from this is that results change commensurately with changes in the key parameters.

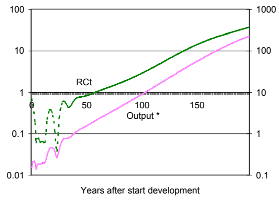
In the second endogenous simulation, for instance, the growth trap due to political institutions is so deep, and the contact rates so low, that even after 200 periods, the economy has not yet realized fast growth (average growth is less than 1.5% a year in this period). In the fourth endogenous growth path, the political growth trap is so small that the economy virtually immediately starts catching up and enters the steady state growth path after about 60 years.

In the first three exogenous growth paths, we see qualitatively a similar growth path to the one in the main text, i.e. initial decades of very low RC due to initial creative destruction. Only after 20 years does the growth in $\lambda_t$ allow the economy to achieve high growth levels. Interestingly, in the exogenous simulations where the political reform is slower ($\alpha_\varphi$ is low in simulations 4 to 5), the initial collapse of RC does not occur and sustained growth appears almost immediately.

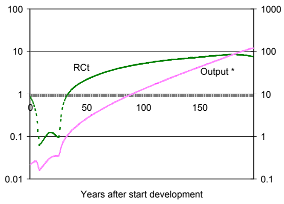
This dependence of development paths on parameter choices reflects the importance of initial conditions but also the importance of contact rates - depending, in turn, on market institutions and CSC - and the level of political interference with the market.

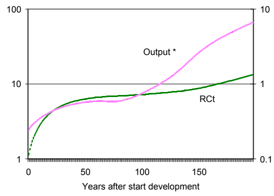
Exogenous systemic growth: Endogenous systemic growth:






1.



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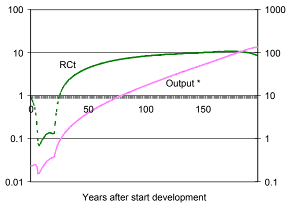

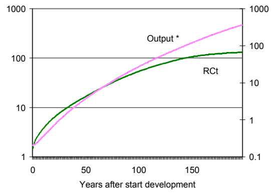


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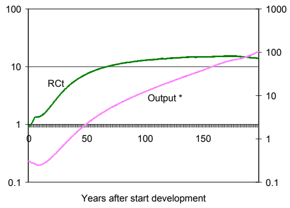

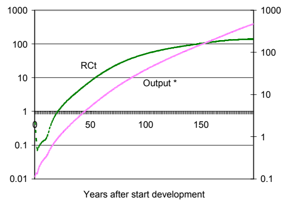


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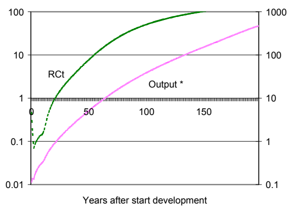

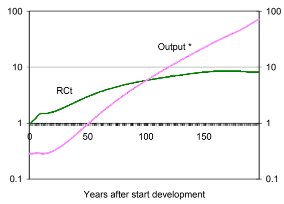


5.

With 1.: $\alpha_\varphi = 0.1$, $\beta_\varphi = 0.8$; With 2.: $\alpha_\varphi = 0.1$, $\lambda_2 = 0.1$, $\beta_\varphi = 0.2$.

With 3.: $\alpha_\varphi = 0.1$, $\lambda_2 = 0.1$, $\lambda_4 = 0.02$, $\beta_\varphi = 0.2$, $\lambda_5 = 2 * 0.2846$

With 4.: $\alpha_\varphi = 0.025$, $\lambda_2 = 0.1$, $\lambda_4 = 0.02$, $\beta_\varphi = 0.4$, $\lambda_5 = 2 * 0.2846$

With 5.: $\alpha_\varphi = 0.025$, $\lambda_2 = 0.1$, $\lambda_4 = 0.005$, $\beta_\varphi = 0.8$, $\lambda_5 = 2 * 0.2846$

# 5 Conclusions

As our centerpiece in this paper, we introduce the notion of Relational Capital. RC represents the stock of contacts of individuals in an economy. By most accounts, this is an important component of social capital. In our model, RC is an input into sold output. Community Social Capital (CSC), which is constituted by informal networks, as well as Market Institutions enhance the labour efficiency of creating RC. Political interference in our model increases the costs of breaking up contacts among firms. We argue that this breaking up of contacts is an integral part of technological advancement. If the political process restricts such creative destruction by raising its costs, technological backwardness results.

In our approach, economic systems that exhibit high degrees of centralization, bureaucratic interference, regulation or corruption, lag behind in the level of technology employed. If these economies liberalize, they are likely to experience an initial output fall: technological catch-up potential implies high initial levels of destroyed and replaced relational capital - which incorporates a large negative external effect. In the simulations such drops indeed occurred endogenously from the optimising behaviour of rational firms. A policy conclusion of our model is support for smoother reforms such as 'dual track' approaches discussed in the literature. Complete systemic change only in new sectors of the economy is one policy instrument to restrict some of the externalities created by creative destruction.

The simulations revealed another interesting empirical implication. With endogenous feedbacks from the size of the economy to the costs of replacing and making contacts, we find cycles. These quasi business cycles reveal an interesting coordination phenomenon. When an economy is close to the technology frontier, investment in new contacts is more productive than replacing a contact. Once the economy is far from the frontier the opposite is true. Coordination of activity follows from the observation that new contacts live longer if most of the economy refrains from replacing contacts, hence the relative cost of replacing a contact is high. Vice versa, new contacts have a low survival rate if the economy engages heavily in replacing contacts. In this situation replacing a contact is relatively cheap. A full dynamic analysis of these endogenous cycles constitutes an interesting extension of our analysis.

In our analysis, the political system was implicitly defined as a function of the total stock of RC. The feedback from large networks to less political frustration of the replacement of contacts needs a further foundation. These might develop as a result of maximizing behavior. In ongoing work (Dulleck and Frijters 2003) we study how and to what extent those in power frustrate the growth of relational capital, simply because it poses a political threat to their power.

Another avenue for further investigation centers around parameter $\beta$. We assume that the complexity of production is exogenous to the model and time-invariant. In our model $\beta$ measures the length of a production chain as a proxy for such complexity. It determines the number of firms that are affected by the creative destruction of one element in the chain. A further step in the analysis would be to endogenize $\beta$. The endogeneity of this parameter may capture the development of productivity in relation to the division of labor. Empirical observations by Hedlund and Sundstrom (1996) show that liberalization mostly affects those firms with the highest value-added, which usually have the most complex production processes. The 'primitivization' of transitional economies can be seen as an endogenous reduction of $\beta$.

This set of applications and open questions shows the potential of our framework. We offer this as one way to go beyond the aggregation question in the social capital literature, and to connect the debate to the political economy of growth and development.

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# Appendix 1: a search model of relational capital.

## Appendix 1.1 The basic model of RC

In this appendix we motivate the macro-model of creative destruction by a micro-search model. We will borrow arguments from the search literature by exploiting the analogy with the matching process of vacancies and job-seekers (Petrongolo and Pissarides, 2001).

Denote the number of contacts a representative individual firm $i$ has by $C_i$. Denote the number of extra contacts a firm makes by $N_i$ and the number of contacts it replaces by $D_i$. Take the number of firms $M$ to be large, such that the proportion of contacts any firms has is approximately zero. When firm $i$ replaces an old contact with a new one, it looses a previous contact. The firm $j$ with whom firm $i$ makes a replacement contact also loses a previous contact. Hence both firm $i$ and $j$ remain with the same number of contacts as before. The externality is that the two firms that $i$ and $j$ were previously connected to, lose a contact. If these former contacts were necessary links in a network of $k$ contacts, the net loss of contacts is $\beta = 2k - 1$. The number of existing, new, and destroyed contacts is assumed large enough to be able to abstract from indivisibilities.

The timing is as follows. At the beginning of the period, firms seek extra contacts and replacement contacts. Then, these latent contacts materialize, after which production takes place. Then, the technology to be used next period is updated.

The probability of any contact surviving the process of creative destruction is equal to $(1 - \frac{1}{\sum_i C_i})^{\sum_{j \neq i} \beta D_j}$ which is in the limit $(M \to \infty)$ equal to $e^{-\beta \frac{\bar{D}}{\bar{C}}}$. The number of contacts of firm i after creative destruction and extra contacts is equal to $C_i * e^{-\beta \frac{\bar{D}}{\bar{C}}} + N_i$. Adding time subscripts and re-labelling, this is the same as the formula for $RC_t$ given in the main text. Note that here the replacement contacts are treated as cumulative, i.e. it is possible to replace the same initial contact several times in one period, leading to a larger technological improvement. In contrast, extra contacts are additive.

## Appendix 1.2 Modelling the endogeneity of contact rates

We can similarly give a micro-foundation for $\lambda(.)$, i.e. the relation between labor invested into making new contacts, the number of old contacts and the number of new (extra and replacement) contacts. We again exploit the analogy with job search. We thus envisage the process of finding contacts as follows: denote the amount of labor firm $i$ allocates towards creating extra contacts by $L_{N,i}$ and the amount allocated towards replacing contacts by $L_{D,i}$. This labor is directly and linearly transformed into 'active contact vacancies' whereby the old contacts involved in replacements are only actually destroyed if a partner for the replacement contact is found. We can hence also use $(L_{N,i} + L_{D,i})$ to denote the number of contact vacancies firm $i$ has. We then have a symmetric matching situation whereby $L_{N,i}$ number of potential contacts of each firm get matched to the $\sum_{j\neq i} L_{N,j}$ potential extra contacts of other firms. The total amount of extra contacts can then be represented by a matching function $m(\sum_{j\neq i} L_{N,j}, \sum_{j\neq i} L_{N,j})$. As Petrongolo and Pissarides (2001) show, there are several micro-mechanisms via which we can arrive at a linear matching function, implying that the total number of extra contacts is linear in the number of potential extra contacts. One such possible mechanism is that each individual latent contact has a fixed probability $\lambda$ of being 'noticed', which is a 'fixed advertisement space' assumption. All these 'noticed' latent contacts then get randomly matched to each other. This then indeed would imply a constant returns to scale matching function and a linear relation between the amount of labor devoted to making extra and replacement contacts and the number of new extra and replacement contacts.

The political process can now be summarised by the assumption that politicians allow a contact replacement to go ahead with probability $\frac{1}{\phi_t}$. Together with the above, this means we get $\lambda_t {*} (L_{N,it} + L_{D,it}) = \phi_t D_{it} + N_{it}$, which is the same formula as the one in the text.

Now, we can also endogenize $\lambda$ in a way that links it to the number of contacts already existing in the economy. A natural possibility is to assume that it is the two sides of an 'old' contact via which latent contacts get noticed. Assume for instance that there is a constant probability that a latent match is productive termed $\lambda_0$. The probability that a latent contact is observed by an existing contact is infinitesimally small and denoted by $\lambda_1$. The probability that an individual latent contact gets labelled as a 'noticed and productive' contact is then equal to $\lambda_0 * (1 - (1 - \lambda_1)^{\sum_{j \neq i} C_j})$ which converges to $\lambda_0 * (1 - e^{-\lambda_1 M\bar{C}})$. In terms of the formulas in the text, this would mean the function $\lambda(RC_{t-1}) = \lambda_0 * (1 - e^{-\lambda_1 RC_{t-1}})$ is a natural candidate which has the standard convexity properties. Various other micro-mechanisms leading to such relations also exist however. The key aspect is that the thick-market externality of Diamond (1982) is incorporated. In the example above, this thick-market externality is incorporated in the assumption that each side of an existing contact has an independent probability of noticing a latent contact. This is a network externality of having many existing contacts.

### Appendix 1.3 Foundation of the process of technological change

Finally, we can think of the following stylized micro-foundation to our process of technological change. Take each representative firm to consist of a fixed number of labour units, say $Z$ units. The technology used by each labour unit $i$ depends on one contact (eg. the machine provider or the service department of another firm). Different units in the same firm may or may not use the same contact as the technology source. Each labour unit $i$ then combines the other contacts and capital to produce sold output. Economies of scale ensure that at the firm level $y_t$ increases with $RC_t$. Now, the technology of the match between unit $i$ and her contact is on average $A_{t-1}$. The firm can search for more contacts ($N_t$) and/or to find different technology contacts ($D_t$). If a unit $i$ changes a technology contact, her previous technology contact becomes redundant because economies of scale in doing any specific task make the productivity of unit $i$ highest when working only with one technology contact (eg. using one word processing program is more efficient that working with two simultaneously). The firm observes two equally sized sets of candidate contacts it can search from, one for $D_t$ and one for $N_t$.

The equal size assumption means the symmetry assumed in the matching stories above between $D_t$ and $N_t$ remains valid, and the previous matching arguments go though after appropriate normalisation. The distribution of technical productivity of potential 'different' contacts is in continuous flux: every period, the productivity that unit $i$ would have with a different technology contact $j$ is drawn from a c.d.f. $H_t(.)$, where $H_t(A_{t-1}) = 0$ and $H_t(A_{t-1} + g_a(A^*_{t-1} - A_{t-1})) = 1$. This means a firm can observe 'a region of potential better matches' that lie within a fraction $g_a$ between the productivity of a current match and the technological frontier. One can think of $H_t(.)$ as the result of an exogenous, random, and continuous learning process that other potential matches undergo whilst they are inactive. The expected technical productivity of the 'different' technology contacts would thus be $A_{t-1} + E[\frac{H_t(.)-A_{t-1}}{A^*_{t-1}-A_{t-1}}](A^*_{t-1} - A_{t-1})$. Within one period, the process of finding a different set of matches starting from the current (potentially latent) technology can be repeated many times in the same period until the eventual set of contacts is finally effectuated and the old ones are severed. If $g_0$ is small, then the expected result of one period of technological change goes to $A_{t-1} + (1 - e^{-g_0})(A^*_{t-1} - A_{t-1})$ where $g_0 = M_t E[\frac{H_t(.)-A_{t-1}}{A^*_{t-1}-A_{t-1}}]$ and $M_t$ is the number of 'rounds of innovation' per labour unit in the period. When $M_t$ is reasonably small, the probability of any contact surviving the contact destruction by other firms will approach $e^{-\beta\frac{D}{C}}$.

If we add an exogenous probability $(1 - g_1)$ that the firm is completely mistaken about each unit's set of potential new technology contacts (where the mistake is revealed only after all rounds of innovation), and relate $M_t$ to $D_t$, then we get the technological progress function specified in the simulations.

# Appendix 2: Steady state.

Because of creative destruction, there will be long term technological progress equalling the rate of progress in the technological frontier. This growth in technological progress is taken advantage of by a non-zero steady state level of $D_t^{rc}$. This in turn leads to a non-zero steady state level of $N_t^{rc}$ because the relational capital destroyed by the actions of other firms has to be replenished.

More formally, when the steady state levels of $D_t^{rc}$, $N_t^{rc}$, and $RC_t$ are denoted as $D^*$, $N^*$, and, $RC^*$, then we can write $\frac{A_t}{A_t^*} = \frac{(g(D^*)}{\alpha+g(D^*)} = 1 - \frac{\alpha}{\alpha+g(D^*)}$. We will use that in the steady state $\frac{\partial A_t}{\partial D_s} = (1-g(D^*))^{t-s-1}\frac{A_t^* g'(D^*)\alpha}{\alpha+g(D^*)}$ for any $s < t$. The first order conditions after simple manipulations read:

$$r_t = \frac{\partial y_t}{\partial K_t}$$

$$w_t = \frac{\partial y_t}{\partial (L_t - L_t^{rc})}$$

$$\frac{1-\rho}{\rho+g(D^*)}\frac{\partial y_T}{\partial A_T f(L - \frac{\varphi D^* + N^*}{\lambda}, RC^*)} f(.) \frac{A_T^* g'(D^*)\alpha}{\alpha+g(D^*)} = \varphi \frac{w_T}{\lambda}$$

$$\frac{1}{1-(1-\rho+\alpha)e^{-\beta\frac{D^*}{RC^*}}}\frac{\partial y_T}{\partial RC^*} = \frac{w_T}{\lambda}$$

The first two equations are self-explanatory. The third equation solves $RC^*$ to equate the benefit of improved technology via increasing $D_T$ to the individual wage cost of $D$. Because maximization is done on the individual level, the cost an individual firm uses does not include the externality of $D^*$ on the level of RC of others. The fourth equation solves $RC^*$ and thereby $N^*$ by equating the discounted benefits of extra $RC_t$ to the wage costs. Because of the convexities in $g(.)$, and $y(.)$, existence of equilibrium is assured (though it may not be stable or unique). In the steady state $w_t = (1+\alpha)^{t-T}w_T$, $r_t = r^*$, and $A_t = (1+\alpha)^{t-T}A_T$. We make no claim about the stability of the economy close to this steady state, or indeed about the uniqueness of the development path under all parameters.