From Tradition to Modernity: Economic Growth in a Small World *

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Abstract. This paper introduces the Small World model into the theory of economic growth and investigates how increasing economic integration affects firm size and efficiency, norm enforcement, and aggregate economic performance. When economic integration is low and local connectivity is high, informal norms control entrepreneurial behavior and more integration mainly improves search for investment opportunities. At a higher level of economic integration neighborhood enforcement deteriorates and formal institutions are needed to keep entrepreneurs in check. A gradual take-off to perpetual growth is explained by a feedback effect from investment to the formation of long-distance links and the diffusion of knowledge. If formal institutions are weak, however, the economy does not take off but stagnates at an intermediate income level. Structurally, the equilibrium of stagnation differs from balanced growth by the presence of relatively many small firms of low productivity.

Keywords: modernization, economic integration, firm size, norms, networks, knowledge spillovers, growth.

JEL: O10; O40; L10; L14; Z13.

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1. Introduction

The transition from a pre-modern or traditional to a modern society is frequently described as modernization. Modernization theory emphasizes the process of increasing social integration and its economic, social, and cultural ramifications. At the economics side, the notion of modernization encompasses the increasing movement of goods, people, and information among formerly remote subpopulations, which is typically accompanied by increasing efficiency, increasing firm size, and economic growth (Rostow, 1959, Kuznets, 1966).[1]

At the social and cultural side, modernization is characterized by a change of values and believes (Inglehart and Baker, 2000). The individual becomes more important and the family and local community decreases in importance. Strong local ties are augmented or replaced by weak long-distance links (Granovetter, 1973). Cultural change may have important repercussions on economic performance, in particular, if the vanishing power of local norm enforcement is not appropriately replaced by formal institutions. Modernization may entail vanishing trust and trustworthiness and lead to non-cooperative behavior and increasing inefficiency of the economy (Polanyi, 1957, Fukuyama, 1995).

The present paper offers a network-based theory of economic growth that integrates economic as well as social aspects of modernization. It treats cultural change as cause and consequence of economic development and investigates the process of modernization from a traditional society towards an economically fully integrated modern society. A traditional society is conceptualized as a largely localized network, in which people are predominantly interacting with their neighbors. High local connectivity prevents the search for high-yield investment opportunities and implies the existence of inefficiently many small firms. An advantage of high local connectivity, however, is a high degree of neighborhood monitoring which prevents entrepreneurs from misbehaving and guarantees investors a fair return on their investment.

A modern society, in contrast, is conceptualized as a global network with reduced importance local neigborhoods. Given the high presence of long-distance links it is relatively easy to search for high-investment opportunities. This effect of economic integration leads – taken for itself

[1]Theories of economic economic stagnation and growth and the associated transformation process of economies are offered by unified growth theory, see Galor and Weil (2000), Galor and Moav (2002), Galor and Mountford (2008); see Galor (2005, 2011) for comprehensive surveys. Modernization as social development is not addressed in this literature and the steady-state of stagnation is usually associated with an economy close to subsistence. Ashraf and Galor (2011) investigate in this framework the role of geographic proximity and isolation on cultural assimilation and on long-run economic performance before and after industrialization.

– to a higher concentration of capital at firms of high productivity, increasing average firm size, and the gradual extinction of small low-productivity firms. The loss of local connectivity, however, entails also a loss of neighborhood control. Strong formal institutions are needed to ensure honest (cooperative) behavior. Without such institutions in place, entrepreneurs have an incentive to enrich themselves at the expense of their "anonymous" investors. Anticipating this behavior, people are reluctant to invest and a suboptimally high number of small, inefficient firms persists.[2]

The economic consequences of social relationships and their basis on shared values and norms is frequently discussed under the heading of "social capital". Researchers of social capital thereby emphasize the crucial role of networks for a proper understanding of the phenomenon: "The study of social capital is that of network-based processes that generate beneficial outcomes through norms and trust" (Durlauf and Fafchamps, 2005). Over the last decade, the role of social capital for economic growth has been documented empirically (e.g. Knack and Keefer, 1997, Zak and Knack, 2001, Ahlerup et al., 2009, Tabellini, 2010) and certain aspects of social capital have been investigated theoretically (e.g. Zak and Knack, 2001, Annen, 2003, Routledge and van Amsberg, 2003, Francois and Zabojnik, 2005, Guiso et al., 2008, Tabellini, 2008, Kumar and Matsusaka, 2009). So far, however, an evolving network representing the pros and cons of strong and weak ties has not yet been integrated into the standard theory of economic growth.

The present paper offers a network-based theory of economic development by integrating the Small World model (Watts and Strogatz, 1998) into a standard model of economic growth. The Small World model is particularly suited for the analysis of economic integration because it relates important characteristics of networks – the ease of information exchange and the structure of local communities – to geographical proximity by means of characteristic coefficients which can be calculated analytically or approximated through mean field theory. This way, economic exchange through the net can be conveniently analyzed without any concrete specification of the network itself but by focussing on network properties summarized in simple coefficients, a fact that yields a great reduction of complexity.

Specifically, we consider a society of overlapping generations which is heterogenous with respect to entrepreneurial talent. High-ability entrepreneurs are scarce and in a completely localized world hard to find by potential investors. Consequently people either set up their own

[2]For evidence of the fundamental role of institutions for economic development see Hall and Jones (1999); Acemoglu et al., 2001; Rodrik et al., 2004; Acemoglu and Robinson, 2012.

firm or invest into the firm of their neighbors. With increasing economic integration – modeled as the formation of long-distance links in the Small World model – it becomes easier to search for high-ability entrepreneurs and people increasingly invest in high-productivity firms, implying that average firm size and income per capita increases and the number of low-productivity firms falls. Entrepreneurs have an information advantage which they may exploit at the expense of investors. At a low level of economic integration, with a lot of local connectivity, neighborhood enforcement limits the appropriation possibilities of entrepreneurs. At a higher level of economic integration, however, local clustering and therewith neighborhood enforcement deteriorates. Formal institutions (rule of law) are needed to keep entrepreneurs in check.

By introducing a feedback from investment and capital accumulation to the formation of long-distance links and the diffusion of knowledge, it is shown that the theory explains a gradual take-off to perpetual economic growth along which long-distance (anonymous) business relations become dominating and average firm size in the economy decreases. Perpetual growth, however, requires investor protection by the law. Without enforceable formal institutions an economy relying on community enforcement gets stuck in the midst of the process of economic integration. The disadvantage of integration from loss of local connectivity and local norm enforcement counterbalances the advantage from knowledge diffusion and efficient investment opportunities. The economy stagnates at a low level of trust and trustworthiness and at an industrial structure characterized by inefficiently many small firms of low productivity.

The novel theory shares perhaps most with the studies by Zak and Knack (2001) and Farmer and Kali (2007). Zak and Knack consider heterogenous interacting investors and investment brokers. Brokers have an information advantage and the incentive to enrich themselves at the expense of investors. They are kept in check by formal and informal institutions. With increasing social distance between broker and investor the power of informal institutions decreases and the incentive to cheat increases. As in the present paper the emphasis is on (social) distance as a determinant of trust, investment and efficiency. Business relations, however, are not modeled as a dynamic, evolving network and the theory is not embedded into an endogenous growth framework.[3]

[3]Recently, Karlan et al. (2009) investigated trust and investment (loans) in an explicit network which shares many characteristics with the Small World model. They do not address, however, general equilibrium issues and economic growth. Fogli and Feldkamp (2012) investigate innovation activities in two given i.e. non-evolving networks. Like us they are concerned with the impact of network structure on the flow of knowledge. But they do not consider how (evolving) network structure affects social norms, occupational choice, and investment activities.

Our network-modeling was to some extent inspired by Farmer and Kali (2007) who integrated the Small World model into a game-theoretic framework and investigated the consequences of (exogenous) network evolution on economic behavior. The present paper develops the original ideas further by integrating the Small World approach into a dynamic general equilibrium context and by establishing a feedback mechanism from investment behavior to the formation of long-distance links.

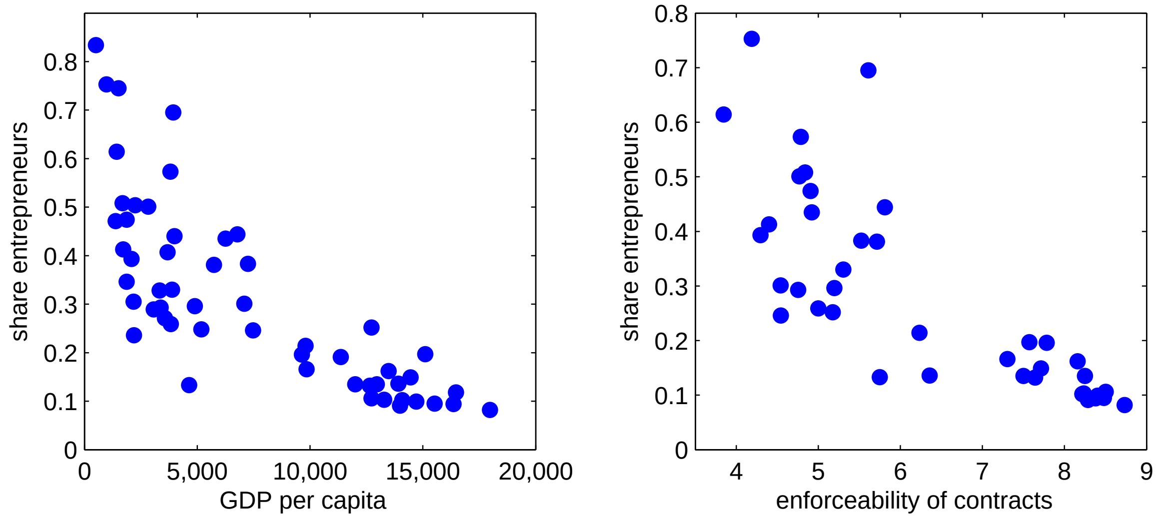
The present paper contributes also to the literature on firm size and development (e.g. Lucas, 1978, Kremer, 1993, Gollin, 2007). It offers a novel explanation for the negative correlation between the degree of economic development (GDP) and average firm size. As in the earlier literature, firm size is found to be negatively associated with TFP. But whereas the earlier literature assumes time-invariant TFP, the present paper treats TFP as endogenous and evolving over time. It suggests a less benign view on the relatively large number of small firms observable in many less developed countries. Small firm size is interpreted as an expression of inferior formal institutions. For societies relying to a large degree on informal (local) norm enforcement, at some stage further economic integration is predicted to lead predominantly to the erosion of local connectivity and trust and trustworthiness. Consequently these societies stagnate at an intermediate level of economic integration at which entrepreneurs can be kept in check by local norm enforcement, which implies the incidence of inefficiently many firms of small size and low productivity.

The new view on firm size can be illustrated with help of Figure 1. The available theory argues that it is efficient to have many small firms when TFP (and thus GDP) is low (Gollin, 2008, left hand side of Figure 1). The present theory argues that weak formal institutions (low index of contract enforceability) leads to the presence of inefficiently many small firms, which in turn leads to low aggregate TFP and GDP (right hand side of Figure 1).[4]

The remainder of the paper is organized as follows. The next section sets up the basic economic model. Section 3 introduces the Small World network and discusses how it can be used to model conveniently the idea of increasing economic integration and its impact on search efficiency and neighborhood enforcement. Section 4 integrates the network into the economic model and discusses dynamics and comparative statics of the steady-state for a given network.

[4]See La Porta et al. (1997) for evidence on the correlation of firm size, trust, and family ties. See Humphrey and Schmitz (1998) and Fafchamps (2001) for surveys on firm behavior and business networks in developing countries and in Sub Saharan Africa.

Figure 1: Proportion of Workforce of Entrepreneurs and Own-Account Workers Across Countries



Left: Proportion of entrepreneurs against GDP per capita 1985, Data from Gollin (2008). Right: Proportion of entrepreneurs against enforceability of contracts, Data from Gollin (2008) and Djankov et al. (2003).

Section 5 introduces the feedback effect from capital accumulation to network formation. It derives the main results of our theory of modernization and comparative economic development. Section 6 introduces a second feedback effect from network formation to knowledge spillovers and endogenous growth and illustrates how the theory of modernization explains the gradual take-off to perpetual economic growth as well as stagnation at an intermediate level of economic integration. Section 7 concludes. Longer derivations, proofs of the propositions, a the sensitivity analysis for the numerical part can be found in the Appendix.

2. The Basic Model

2.1. **Setup of Society.** Consider an economy populated by two overlapping generations. Members of the young generation supply one unit of labor, earn wages w_t, and decide how to divide labor income between expenditure for current consumption c_t^1 and savings for the second period of life. Members of the old generation do not supply any labor for wage work. They follow a career as either investors or entrepreneurs. Entrepreneurs operate firms and employ labor supplied by the young generation and capital provided by investors (and of course by entrepreneurs themselves). At the end of the second period of life investors and entrepreneurs receive the return on their investment and spend it on consumption c_{t+1}^2.

Suppose that the young individuals of period t maximize expected utility from life-time consumption $u_t = \log(c_t^1) + \beta \log(c_{t+1}^2)$ where β is the discount factor. They face the current period's budget constraint $c_t^1 = w_t - s_t$ and the next period's budget constraint $c_{t+1}^2 = R_{t+1} s_t$ where R_{t+1} is the expected gross interest rate and s_t are savings. This standard OLG setup provides the well-known solution for savings (1).

$$s_t = \frac{\beta}{1+\beta} \cdot w_t. \tag{1}$$

The introduction of occupational choice makes the rate of return on investment career- and situation-specific. To begin with, not everybody is equally talented as entrepreneur and not all firms at the market are equally productive. Moreover, entrepreneurs have an information advantage vis a vis investors and may use this fact in order to enrich themselves at the expense of low returns to investors, in particular if there is little monitoring by local communities and if formal institutions are weak and contracts are hard to enforce.

In order to integrate these ideas conveniently into the model we assume that a given (small) fraction n^H of the population is of high-ability as entrepreneur and runs a business with total factor productivity A^H. The high-ability types are randomly distributed in the economy. The remainder of the population has comparatively low entrepreneurial skills. A variable and yet to be determined fraction n_t^L nevertheless runs a business with total factor productivity $A^L < A^H$. The others become investor. Naturally, investors prefer to invest in high-productivity firms. For that purpose they search through the network for high-ability entrepreneurs. Let us suppose that they find one with probability μ_t. Since there are $1 - n^H - n_t^L$ investors, a share of $\mu_t(1 - n^H - n_t^L) + n^H$ of the population manages to allocate their funds to high-productivity firms while the remainder invests into low-productivity firms. The ratio of aggregate capital in the low-productivity segment vs. the high-productivity segment of the economy is thus given by x_t in (2).

$$x_t \equiv \frac{n_t^L k_t^L}{n^H k_t^H} = \frac{(1-\mu_t)(1 - n^H - n_t^L) + n_t^L}{\mu_t(1 - n^H - n_t^L) + n^H} \tag{2}$$

where k_t^H and k_t^L are the capital stocks of a high- and low-productivity firm.

Let R_t^H and R_t^L denote the gross rate of return of a unit of capital. We model the fact that entrepreneurs are able to appropriate a higher rate of return at the expense of investors by assuming that investors get the gross return $R_t^{H,I} = \lambda_t R_t^H$ and $R_t^{L,I} = \lambda_t R_t^L$, $0 < \lambda_t \leq 1$. The variable $\lambda_t \in [0,\ \lambda_{max}]$ measures the safety of investments. It is an indicator of investment protection (La Porta et al., 2008). For $\lambda_t = \lambda_{max}$ we say that investors get a fair return. The (correctly) expected λ_t serves also as a measure of trust and trustworthiness.

Investors in the high-productivity segment earn $\mu_t(1 - n^H - n_t^L)\lambda_t R_t^H$ per unit of investment implying that all high-ability entrepreneurs appropriate profits $[\mu_t(1-\lambda_t)(1-n^H-n_t^L)+n^H]R_t^H$ per unit of investment. From this and analogous reasoning for low-ability firms, we obtain the rate of return applicable to high- and low-ability entrepreneurs as shown in (3).

$$
\begin{aligned}
R_t^{H,E} &= \frac{\mu_t(1-\lambda_t)(1-n^H-n_t^L)+n^H}{n^H} \cdot R_t^H, \\
R_t^{L,E} &= \frac{(1-\mu_t)(1-\lambda_t)(1-n^H-n_t^L)+n_t^L}{n_t^L} \cdot R_t^L.
\end{aligned} \tag{3}
$$

While it is always rational for high-ability types to become an entrepreneur, there exists a trade-off for low-ability types. If many follow a career as entrepreneur, investment per firm is small implying that the total return that can be appropriated at the expense of investors is also small. This can be verified by taking the derivative in (3) with respect to n_t^L. Alternatively the low-ability types may consider to become investor. Such a career is particularly attractive if the probability to find a high-ability entrepreneur is high. More specifically, given free entry into entrepreneurship, an equilibrium condition requires that low-ability types are indifferent between becoming entrepreneur or investor. For that to be the case expected returns have to be the same in both occupations, as stated in (4).

$$
\mu_t R_t^{H,I} + (1-\mu_t) R_t^{L,I} = R_t^{L,E}. \tag{4}
$$

The modeling of investment allocation and occupational choice is certainly crude with respect to fully modernized economies in which investment is channeled to firms through the stock market. The model captures this fact in an abstract way by $\mu \to 1$, that is by the special case in which high-productivity firms can be found with certainty. For less developed countries, however, the present modeling of capital markets captures some elements of reality that are lost in abstraction in standard models of economic growth. For Sub-Saharan Africa, for example, Fafchamps (1994, pp. 8-9) concludes:

"Sub-Saharan Africa is generally characterized by the absence of a stock market altogether. Given that the modern sector is small and largely public owned, this is hardly surprising. But it means that small investors who wish to invest part of their savings in high-return/high-risk investments are not able to do so via any organized market. This has the interesting consequence that the only possible form of high-return/high-risk investment is either creating one's own enterprise, or financing the enterprise of close friends and relatives whose skills and performance can be monitored. In other words, the absence of a capital market redirects part of savings toward small enterprises. The available evidence indeed indicates the absolute predominance of own savings and, to a lesser extent, funds from friends and relatives as sources of ME [microenterprises] capital. The contribution of formal credit and moneylenders is extremely small."

2.2. **Firms and Markets.** Output (GDP) is produced competitively by high- and low-productivity firms. High-ability entrepreneurs manage to produce more output from any given vector of inputs, that is their firms display higher total factor productivity. Specifically, suppose firm $j \in \{L, H\}$ produces with Cobb-Douglas technology $y_t^j = A^j(k_t^j)^\alpha (h_t^j)^{1-\alpha}$, where k_t^j and h_t^j are capital and labor input. Homogenous labor earns a wage w_t according to its marginal product.

$$w_t = (1-\alpha)A^H(k_t^H/h_t^H)^\alpha = (1-\alpha)A^L(k_t^L/h_t^L)^\alpha. \tag{5}$$

Depending on whether submitted to a high- or low-productivity firm, each unit of capital earns the gross rate of return R_t^H or R_t^L.

$$R_t^H = \alpha A^H(k_t^H/h_t^H)^{\alpha-1}, \qquad R_t^L = \alpha A^L(k_t^L/h_t^L)^{\alpha-1}. \tag{6}$$

Inserting (5) into (6) we get the ratio of returns on investment in high- and low-productivity firms as determined by the differential between high and low entrepreneurial skills (7).

$$R_t^H/R_t^L = (A^H/A^L)^{1/\alpha} \equiv a. \tag{7}$$

Notice that $a > 1$. High-ability entrepreneurs achieve a higher rate of return on capital.

Finally, labor market clearing requires $n_t^L h_t^L + n^H h_t^H = 1$. Inserting (5) and then substituting (2) we obtain firm size of a high-productivity firm (measured by employment).

$$h_t^H = \frac{1}{n^H\left(1 + \dfrac{x_t}{a}\right)}. \tag{8}$$

Notice that x_t is a unique function of the share of low-ability entrepreneurs in the population, n_t^L. Thus, once n_t^L has been determined, we get equilibrium firm size from (8) and can then solve successively for all other macroeconomic aggregates.

2.3. **Equilibrium Number and Size of Firms.** Subdividing (4) by $R_t^{L,I}$ and inserting (3) and (7), the equilibrium condition for career choice becomes $\mu_t a + (1-\mu_t) = [(1-\mu_t)(1-\lambda_t)(1-n^H - n_t^L) + n_t^L]/(\lambda_t n_t^L)$, which can be solved for the equilibrium share of low-productivity firms.

$$n_t^L = \frac{(1-\lambda_t)(1-\mu_t)(1-n^H)}{(a\lambda_t - 1)\mu_t}. \tag{9}$$

A feasible solution requires that $n_t^L \geq 0$ and $n_t^L + n^H \leq 1$. This means that n_t^L provides the interior solution and the full solution, including corners, for the number of low-productivity firms is $\tilde{n}_t^L = \max\left\{0, \min\left(1 - n_H, n_t^L\right)\right\}$. In the following we mostly focus on the interior solution. The following propositions summarize the comparative statics for the number of low productivity firms.

PROPOSITION 1. *The number of low-productivity firms in equilibrium is decreasing in the safety of returns to investors (λ_t), the probability to find high-ability entrepreneurs for one's investment (μ_t), the relative productivity advantage of high-productivity firms (a), and the number of high-ability entrepreneurs.*

PROPOSITION 2. *The share of aggregate capital allocated to low-productivity firms in equilibrium x_t is decreasing in the safety of returns to investors (λ_t), the probability to find high-ability entrepreneurs for one's investment (μ_t), the relative productivity advantage of high-productivity firms (a), and the number of high-ability entrepreneurs. Consequently the size of high-productivity firms is increasing in λ_t, μ_t, and a.*

Intuitively, the incentive for a low-ability type to become entrepreneur is low if investors get a relatively large share of the return on capital (λ_t is high), if it is relatively easy to find high-yield investment opportunities (μ_t is high), and if the spread between low-ability and high-ability returns (a) is large. Naturally, there exist fewer low-ability firms when there are more high-ability entrepreneurs n^H. A higher incentive for low-ability types to become investor rather than entrepreneur at the micro-level implies that, at the macro-level, a lower share of aggregate capital is allocated to low-productivity firms, which in turn implies that high-productivity firms are bigger.

3. The Small World Model

The Small World model was originally developed by Watts and Strogatz (1998) and has since then been applied on a plethora of biological and social phenomena (see Newmann, 2003, for an overview). It is particularly suited for the analysis of economic integration because it relates important characteristics of networks – the ease of information exchange and the structure of local communities – to geographical proximity by means of simple characteristic coefficients which can be analytically calculated or approximated through mean field theory. This way, economic exchange through the net can be conveniently analyzed without any concrete specification of the network itself but by focussing on network properties summarized in simple coefficients, a fact that yields a great reduction of complexity.

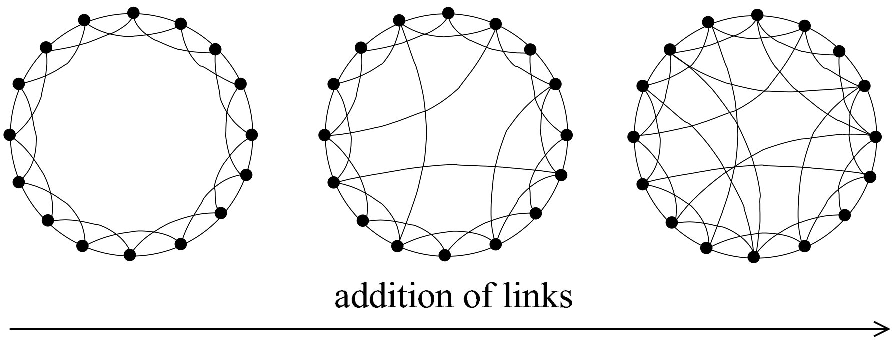
Consider a social network where nodes are persons and edges (links) indicate whether any two persons know each other. Two important coefficients that characterize such a network are the average path length L and the clustering coefficient C. The average path length is an indicator of social distance. It gives the average shortest path between any two persons in the net. Ever since Milgram's (1967) famous "Six Degrees of Separation' experiment it is known that this distance is short in modern societies. More specifically, one speaks of the "Small World" property when the average path length grows logarithmically with the size of the network (the number of persons). For our economic model the average path length is an appropriate and convenient indicator for the ease at which information about profitable investment opportunities can be gathered through the net.[5]

The clustering coefficient C is an indicator for the connectivity of local communities. It gives the average probability that two persons that are connected to any person are also directly connected with each other, that is the probability that someone's friends (trading partners) are also friends (trading partners) with each other. The clustering coefficient is thus a local property whereas the average path length is a global property. In Granovetter's (1973) famous terminology one could say that C is an indicator of the relative importance of strong ties. A high degree of social embeddedness (high C) implies that there is a lot of community monitoring and

[5]The literature distinguishes between the Small World *model* and the Small World *property*. A Small World model investigates network characteristics when links of an initially regular network on a lattice are randomly rewired or augmented randomly by long-distance links. The Small World property (or -effect) describes the phenomenon that a few long-distance links are already sufficient to establish a short average path length between edges in a network. In the Small World model the small wold property is observed at low p when $L(p)$ is already low but $C(p)$ is still high, that is, for example, in the central network of Figure 2; see Newman (2003).

control over one's activities. We use this fact for our purpose by assuming that entrepreneurs have an information advantage vis a vis investors about the return on capital and that the degree to which they can exploit this advantage to enrich themselves at the expense of investors is decreasing in the clustering coefficient.

Figure 2: Small World Model

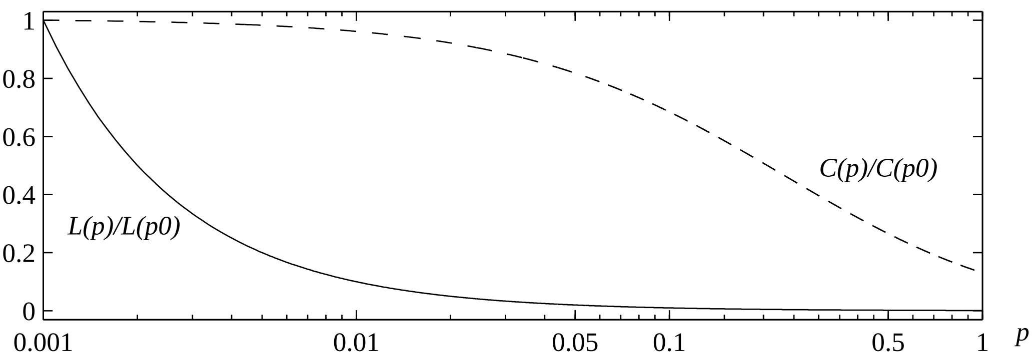


Left: one-dimensional lattice with connections between all node pairs by $m = 2$ or fewer lattice spaces away. A Small World is created by randomly adding shortcuts to the edges.

The Small World model interpolates smoothly between a "large world", i.e. a regular network in which average path length as well as the clustering coefficient assume their maximum values, and a small or globalized world, in which path length as well as clustering are minimal. The original model of Watts and Strogatz (1998) generates this feature by rewiring with probability p nodes with other nodes that are randomly chosen from the net. Here we consider a slight modification introduced by Newman et al. (2000) and illustrated in Figure 2, in which long-distance links are added between randomly chosen nodes. The variable p now gives the probability for a long-distance link per link of the underlying lattice. This means that for $p \to 1$ there exists one long-distance link per local link, i.e. altogether $2mL$ long-distance links. With increasing p the original Watts-Strogatz model creates long-distance links by destroying local ones whereas the modification of Newman et al. creates long-distance links while preserving local ones. Figuratively speaking, increasing economic integration, conceptualized as increasing p, is introduced in the original model by continuously destroying local neighborhoods and in the modified version by reducing the importance of local neighborhoods. Besides more realism the modified version entails the advantage that crucial network characteristics can be expressed analytically.

The idea of the Small World model can best be illustrated by considering a network on a one-dimensional lattice as in Figure 2. To begin with, any node (person) is connected with his direct neighbors that are m or fewer lattice spaces away. In the example of Figure 2, $m = 2$. Each person is connected to 4 neighbors, 2 at each side. Coming from low p adding more long-distance links has mainly the effect of reducing the shortest distance between nodes such that a low average distance $L(p)$ goes along with a yet high clustering coefficient $C(p)$. When p is high and $L(p)$ is already low, in contrast, further adding long-distance links has mainly the effect of reducing the importance of local neighborhoods, i.e. of reducing the clustering coefficient.

Figure 3: Average Path Length and Clustering Coefficient



The Small World model's network characteristics for alternative probabilities of shortcuts p. $C(p)/C(p_0)$: normalized clustering coefficient, $L(p)/L(p_0)$ normalized average path length. p runs from 0.001 to 1. Example for $m = 5$, $N = 100000$.

For any given p the clustering coefficient can be computed analytically as $C(p) = 3/2(m - 1)/[(2m - 1) + 4mp(p + 2)]$. Average path length, for which no explicit solution exists, can be approximated. Let N denote the number of persons in the network. The total number of shortcuts is then given by $z = pmN$ and an approximation of $L(p)$ is $L(p) = (N/2m)(z^2 + 2z)^{-1/2} tanh^{-1}(z/(z + 2))^{1/2}$, see Newman (2003). Figure 3 shows network behavior for $m = 5$ and $N = 100000$. As common in the literature we have normalized $C(p)$ and $L(p)$ by dividing by initial $C(0)$ and and initial $L(0)$. respectively. Note that the p axis is scaled logarithmically. The example thus demonstrates the crucial feature of the Small World model: At small p, average path length drops drastically while $C(p)$ falls only very gradually. In other words, for rising p, shorter average distance is the main observable outcome at low degrees of economic integration (low p) while lower clustering (lower social connectivity) is the main observable outcome at later stages of economic integration. The interplay of $L(p)$ and $C(p)$ will be the main driver in our model of modernization and economic growth. The following proposition summarizes this insight.

PROPOSITION 3 (Small World). *At low levels of p increasing p drastically reduces average path length $\ell(p)$ and leaves the clustering coefficient $C(p)$ almost constant. At higher levels of p further increasing p leaves average path length almost constant and mainly reduces the clustering coefficient.*

The model is closed by associating λ and μ with the characteristics of the Small World network. Specifically we assume that the probability to find high-ability entrepreneurs depends negatively on the average length of paths connecting people (trading partners) in the net, i.e. $\mu = \mu(L(p))$ and that the safety of returns of investors λ depends positively on the clustering coefficient, i.e. the connectivity of local neighborhoods, $\lambda = \lambda(C(p))$. In simple words, as the economy becomes more integrated, it becomes more likely to find high-return objects for one's investments because search through the net becomes easier; but it also becomes easier for entrepreneurs to cheat since there is less monitoring and control by local neighborhoods.

ASSUMPTION 1 (Network Characteristics). $\mu = \mu(L(p))$ *with* $\mathrm{d}\mu/\mathrm{d}p > 0$ *and* $\lambda = \lambda(C(p))$ *with* $\mathrm{d}\lambda/\mathrm{d}p < 0$ *and* μ *and* λ *continuously differentiable in* $[0, \ 1]$.

For Ines: to be shown: the above assumption is sufficient since $\ell \in 0, 1$ is a compact set. (Implication: $\mathrm{d}\mu/\mathrm{d}p = \frac{\partial \mu}{\partial \ell}\frac{\partial \ell}{\partial p}$ is well behaved in unserem Sinne, d.h. μ sinkt rasch, wenn λ noch relativ constant ist. Denn μ sinkt fuer $p \to 0$ mit unendlicher Steigung).

Besides the neighborhood-enforcement case, in which λ_t is determined endogenously by network structure, we consider also a strong-institutions case, in which λ_t is exogenously given by the enforced rule of law, $\lambda_t = \bar{\lambda}$. The parameter $\bar{\lambda}$ stands in for the quality of formal institution approximated, for example by the "rule of law" index or the "civil justice" index. Typically the index assumes a much higher value in fully developed countries than in less developed countries (World Bank, 2013). In most Sub-Saharan African countries $\bar{\lambda}$ is particularly low, such that African firms seldom use courts to solve contractual disputes (Fafchamps, 2001). In our notation this means that $\bar{\lambda} > \lambda(C(p))$ in a typical fully developed country and $\lambda(C(p) \geq \bar{\lambda}$ in the typical LDC. Subsequently we call the case in which the security of one's investment depends on how well the norm of good conduct and honest behavior is enforced by the local network the "neighborhood-enforcement case" and the case for which investor security is ensured by the rule of law the "formal-institutions" case. We speak of "strong" formal institutions when

$\bar{\lambda} > \lambda(C(0))$, i.e. when – with respect to investment security – formal institution outperform neighborhood enforcement for any given network structure.

The assumption that $\lambda(C(p)$ is positively influenced by the clustering coefficient is meant to capture the observation that informal trust is usually observed in tightly knit local networks at the family-, clan-, or village-level and not extended to outsiders. Economists argue that this is so because it is difficult to sustain cooperation in large groups, in particular if third party observability within the group is limited (Kandori, 1992; Greif, 1993). A dense network does not only help to monitor adherence to contracts but also to to penalize and exclude cheaters (Coleman, 1988; Johnson et al., 2002; Fafchamps, 2004).

Recently, Karlan et al. (2009) provided a micro-foundation for the clustering coefficient as a good measure of trust in informal borrowing. The idea is that common friends (business partners) are functioning as "social collateral". A person who fails to repay the debt (in our context who fails to pay the fair return on investment) does not only lose the lender/business partner but also the common friends/ business partners. This way a highly clustered network provides a high incentive for cooperation and a high level of trust, trustworthiness, and – in our context – high security of one's investment. Using data from Peru Karlan et al. confirm their theory by showing that network-based trust predicts informal borrowing. Similarly, Kinnan and Townsend (2012), study network data from Vietnam and find that kinship networks are important in financing investment because the potential punishments by kin ensures the lender that loans will are repaid.

The assumption that $\mu(L(p))$ is positively influenced by the average path length captures the observation that networks with many links and random link formation are particularly suitable to disseminate information efficiently (Jackson, 2010). The observation goes back to Granovetter's (1973) distinction between strong ties and weak links and the observation that weak links are most useful for job search. In our context, it are links that lead outside of the local neighborhood which are useful for the search of new investment opportunities. If these links are missing or sparse the search and and verification costs are high and people are more likely to invest in the local neighborhood or set up their own firm. Consequently firms are small and financed to a low degree with funds coming from outside the own community (as observed in particular for Sub-Saharan Africa by Bigsten and Soderblom, 2006, Fafchamps, 1996, 2001, La Porta and Shleifer, 2008).

The network structure relates also to Putnum's (2000) distinction between bonding and bridging social capital. A high clustering coefficient is associated a high degree of bonding social capital, which is beneficial for generating reciprocity between agents who know each other well. A network with low average path length, i.e. with many long-distance links, provides a high degree of bridging social capital which is beneficial for information diffusion and search.

As a rough approximation we could associate the different stages of network evolution with countries ordered by their index of social capability (Adelman and Morris, 1967; Temple and Johnson, 1998). We would then associate with the network shown on the left hand side of Figure 2, societies in which investment takes place locally within the clan or village or, in Adelman and Morris' words, "societies that are primarily tribal". With the network in the middle we would associate "countries in which the typical kinship structure is the extended family and in which the exchange sector of the economy is generally much larger than it is in the lowest group" and with the network on the right "countries that, although still underdeveloped in the late 1950s, are relatively advanced with respect to both social and economic development" (Adelman and Morris, p. 169). Temple and Johnson (p. 969) provide a list of the developing countries classified by their belonging to the three groups in the late 1950s.

4. Dynamics and Long-Run Equilibrium for Given Network

In this section we investigate the economy for a given network structure, i.e. for given p, implying that $\lambda_t = \lambda$ and $\mu_t = \mu$ are taken parametrically. This allows us to identify the unilateral impact of economic integration (modernization) on economic performance with means of comparative static analysis. In the next section we discuss feedback effects, i.e. the interaction of economic development and modernization. For given p the dynamics of the economy are isomorph to the standard overlapping generations model and can be represented in one equation. Next period's capital in the high-productivity sector is equal to this period's aggregate wage income spent on investment in high-productivity firms:

$$n^H k_{t+1}^H = \left[\mu(1 - n^H - n^L) + n^H\right] \frac{\beta}{1+\beta} w_t = \left[\mu(1 - n^H - n^L) + n^H\right] A (k_t^H)^{\alpha} (h_t^H)^{-\alpha}. \qquad (10)$$

The right hand side of the equation is obtained by inserting wages from (5) and subsuming all constants in the term $A \equiv \beta(1-\alpha)A^H/(1+\beta)$.

Inserting employment from (8) and noting that $x_t = x$ for an invariant network, we get a first-order difference equation for the evolution of capital per high-productivity firm.

$$k_{t+1}^H = \left[\mu(1-n^H-n^L)+n^H\right] A\left(1+\frac{x}{a}\right)^{\alpha}(n^H)^{\alpha-1}\cdot(k_t^H)^{\alpha}. \tag{11}$$

Inspection of (11) provides the following results.

PROPOSITION 4. *For given network structure p, the economy converges towards a globally stable steady-state.*

PROPOSITION 5. *At the steady-state an increase of λ or μ leads to an increase of the long-run capital-intensity, wages, GDP, and aggregate TFP, and to a decrease of the long-run rate of return on capital.*

Next recall from Proposition 1 and Figure 3 that the shortest path length $L(p)$ falls drastically at low p, that is at early stages of economic integration. On the other hand, $C(p)$ is high and almost invariant to p at early stages of economic integration. For high p, that is at advanced stages of economic integration, $L(p)$ has settled almost at a low level and further increasing p has the dominant effect of community disintegration captured by a falling clustering coefficient $C(p)$. From this characteristic of Small World network and Proposition 5 we obtain the following *non-monotonous* association of long-run economic integration and economic performance.

COROLLARY 1 (Modernization as Development). *When economic integration p is low rising p has the dominating effect of falling $L(p)$, i.e. high profit investments are found more easily ($\mu(p)$ rises). Rising p then leads to a lower share of low-productivity firms n^L, a lower share of aggregate capital allocated to low-productivity firms x, a larger size of high-productivity firms h^H and higher GDP y.*

COROLLARY 2 (Modernization as Degeneration). *At some intermediate stage of p further rising p has the dominating effect of falling $C(p)$, i.e. of less local monitoring and control ($\lambda(p)$ falls). Rising p then leads to a higher share of low-productivity firms n^L, a higher share of aggregate capital allocated to low-productivity firms x, a smaller size of high-productivity firms h^H, and lower GDP y.*

The two corollaries summarize the pros and cons of modernization. The degeneration phase, however, is predicted only for economies in which deteriorating informal institutions are not properly replaced by functioning formal institutions. If λ stays constant at a high value, there is no degeneration phase. Over time the model thus predicts that increasing economic integration leads first to a take-off from subsistence for all economies alike and subsequently to a degeneration phase in economies with weak formal institutions. For example, economies like South Korea and Bolivia are thus both predicted to take-off from subsistence but only Bolivia is predicted to suffer from late degeneration i.e. the existence of many low-productivity firms. Indeed, in 1993, the share of entrepreneurs and self-employed persons was 0.50 in Bolivia and 0.15 in South Korea, which was poorer than Bolivia in 1960 and about 4 times as rich in 1985 (Gollin, 2008).

But notwithstanding the drawback from weak formal institutions, we would not expect Bolivia, or any other country with weak formal institutions, to relapse to subsistence level. Instead we expect these countries to stagnate at an intermediate level of economic integration at which the pros and cons of modernization are counterbalancing each other. In order to develop such a notion of equilibrium, we have to extend the model by a feedback effect from investment to the formation of long-distance links, i.e. we have to establish a theory of endogenous network evolution.

5. Network Evolution and Economic Performance

In this and the next section we allow for feedback effects of economic development, measured by the capital stock held by high-productivity firms k^H, on economic integration, measured by p. The idea is that part of the capital stock alleviates communication, search, and travel through the net. More capital (more horses, ships, trains etc) leads to the establishment of more long-distance links and thus for any person to a higher probability of being connected with a partner from outside the own neighborhood. Specifically we assume that

$$p_{t+1} = g(k_t^H), \quad g(0) = 0, \quad g' > 0, \quad \lim_{k \to \infty} g(k) = 1. \tag{12}$$

Without capital the economy is fully localized and for capital approaching infinity the economy is fully globalized in the sense that average path length as well as the clustering coefficient are approaching their minima. For analytical convenience we have also assumed a "time to built" mechanism – this period's net investment has an impact on additional long-distance links next period – and that link formation depends on capital hold by high-productivity firms. This, however, is not restrictive since aggregate capital $k_t = n_t^L k_t^L + n^H k_t^H$ is a unique function of k_t^H via (2). The two simplifications allow for a straightforward presentation of the economy as a two-dimensional system of difference equations in the p–k^H–space, given by (11) and (12).

The evolution of the economy over time and existence and stability of steady-states can be analyzed in a phase diagram. From (12) we get the isocline along which $\Delta p = p_{t+1} - p_t = 0$ as $k^H = g^{-1}(p)$ with $k^H(0) = 0$, $g^{-1\prime}(p) > 0$, and $\lim_{p\to 1} k^H = \infty$. The positively sloped $\Delta p = 0$–isocline runs through the origin and has an asymptote where $p = 1$, as displayed in Figure 4. We can also infer that the arrows of motion point towards higher p above the curve and towards lower p below.

From (11) we obtain the $\Delta k^H = 0$-curve.

$$k^H = \left[A(n^H)^{\alpha-1} f(p)\right]^{1/(1-\alpha)}, \quad f(p) \equiv \left[\mu(p)(1 - n^H - n^L(p)) + n^H\right]\left(1 + \frac{x(p)}{a}\right)^{\alpha} \tag{13}$$

where n^L and x depend on p through the small-world architecture (Proposition 3) and the characteristics of the network (Assumption 1). The curvature of the $\Delta k^H = 0$ isocline is uniquely determined by $f(p)$. The shape of the $\Delta k^H = 0$ isocline can be discussed with help of the following Lemma (proven in the Appendix).

Lemma 1.

$$sgn \frac{\mathrm{d}f(p)}{\mathrm{d}p} = sgn\left[\frac{\mathrm{d}\mu}{\mathrm{d}p}(1 - n^H - n^L) - \frac{\mathrm{d}n^L}{\mathrm{d}p}\mu\right].$$

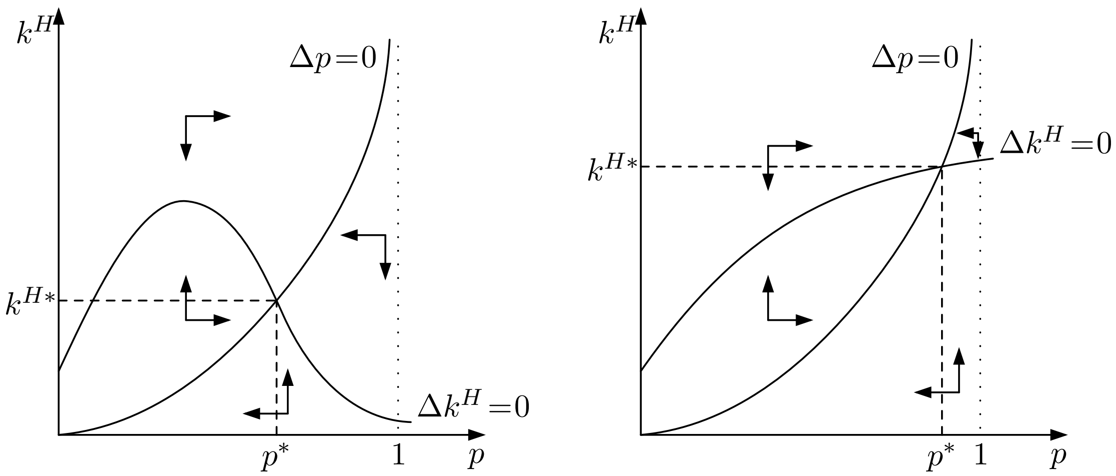
Building on previous insights, we know that for small p the expression $\mathrm{d}\mu/\mathrm{d}p$ is large and positive and that $\mathrm{d}\lambda/\mathrm{d}p \approx 0$. This means that $\mathrm{d}n^L/\mathrm{d}p$ is large and negative because average length of the shortest path is rapidly falling and high-profit firms can be found more easily when p rise. Taken together, this implies $\mathrm{d}f/\mathrm{d}p > 0$ for small p. Likewise, if p is large, $L(p)$ has (almost) settled down at its lower limit and thus $\mathrm{d}\mu/\mathrm{d}p \approx 0$. Without strong formal institution, however, $\mathrm{d}n^L/\mathrm{d}p > 0$ because decreasing local clustering (decreasing λ) is the dominating effect when p is large. Thus, without strong formal institutions, $\mathrm{d}f/\mathrm{d}p < 0$ for large p. Summarizing, the $\Delta k^H = 0$ isocline originates from a positive value $k^H(0)$ and is invertedly u-shaped as displayed on the left hand side in Figure 4.

The fact that the Δp–isocline exhibits a pole at $p = 1$ ensures that a unique steady-state exists at the intersection of the isoclines. Inspection of (13) reveals that the arrows of motion point towards lower k^H above the Δk^H–isocline and towards higher k^H below. The field of motion thus points towards the steady-state, which indicates stability.[6] From these observations

[6]Because the dynamics are in discrete time we cannot definitely conclude global stability from diagrammatic exposition. There might be overshooting behavior of trajectories, see Galor (2007) for a rigorous general discussion.

we conclude that the economy does not arrive at full economic integration. It converges towards an intermediate level of p, at which the negative effect of modernization on decreasing local norm enforcement (decreasing clustering) prevents further development. For p above p^* the denominating effect of increasing economic integration is the loss of trust and trustworthiness and the establishment of low-productivity firms, which deteriorates economic performance.

Figure 4: Phase Diagram: Evolving Network



Left hand side: investor safety determined by neighborhood enforcement, $\lambda = \lambda(C(p))$. Right hand side: investor safety determined by formal institutions, $\lambda = \lambda_{max}$.

Next consider an economy with strong formal institutions in which $\bar{\lambda}$ irrespective of network structure. As a consequence, $\mathrm{d}n^L/\mathrm{d}p < 0$ for all p. This means, diagrammatically, that the downward sloping part of the $\Delta k^H = 0$ is bent up as shown on the right hand side of Figure 4. At $p = 1$, the Δk^H- isocline assumes a high finite value. Since the isocline is monotonously increasing and originating at positive $k^H(0)$ there exists again a unique steady-state at the intersection of the isoclines. The vector field indicates again stability. Because the Δp–isocline is invariant to the existence of formal institutions and thus the same in both Figures, we conclude that the economy with strong formal institutions arrives at a higher degree of economic integration. These observations together with Proposition 5 lead to the following conclusion.

Corollary 3. *Consider two otherwise identical economies. In economy 1 entrepreneurial behavior is bounded by community structure, $\lambda = \lambda(C(p))$. In economy 2 entrepreneurial behavior is bounded by strong formal institutions, $\lambda = \bar{\lambda}$, $\bar{\lambda} > \lambda(C(0))$. Then economy 2 arrives at a higher degree of economic integration p and higher stage of economic development, i.e. at* *a smaller number of low-productivity firms, a larger size of high-productivity firms h^H, and a higher capital labor ratio, implying higher wages, higher GDP, and higher aggregate TFP.*

The network-based theory of modernization thus highlights the role of formal institutions for economic development as well as for social behavior, the density of the economic network, and industrial structure. In line with the evidence it predicts that in economies in which norms are enforce by neighborhood control there co-exist many small enterprises together with larger firms and that the small firms display (much) lower factor productivity (Fafchamps, 1994, Bigsten and Soderbom, 2006 La Porta and Shleifer, 2008). Strong formal institutions allow for convergence towards a higher level of economic development at which small low-productivity firms are largely extinct. In contrast to the earlier literature (Gollin, 2008) this difference in industrial structure across different levels of economic development is a result of inefficient factor allocation. If only formal institutions were stronger, backward countries could reach a higher level of GDP and aggregate TFP.

In the absence of good formal institutions, steady-state income is, ceteris paribus, higher in societies characterize by a dense network with large neighborhoods and a lot of clustering. To see this, notice that the clustering coefficient declines by less through the addition of a long-distance link when the local neighborhood is large. This means that λ declines less quickly with rising economic integration (rising p) and that the falling branch of the $\delta k^H = 0$–isocline falls less steeply with rising p, allowing for an intersection at higher k^H and thus higher income per capita. The reason is that social norm enforcement and therewith investment security are higher for the highly clustered network. High clustering coefficients (or strong ties) are thus good for economic development, but only so in a "second-best sense", i.e. when strong formal institutions are absent (Durlauf and Fafchamps, 2005).

This section has provided an explanation based on norm-enforcement, investment, and firm size for why the level of income is higher in economies with strong formal or informal institutions (Hall and Jones, 1999; Acemoglu, 2001, Tabellini, 2010), the next section pushes the argument further by introducing a network-based mechanism for perpetual growth and by showing that strong formal institutions and institutionalized trust can be conducive to the growth of income in the long run (Knack and Keefer, 1997; Zak and Knack, 2001).

6. Modernization, Knowledge Spillovers, and Long-Run Growth

This section introduces endogenous growth through learning-by-producing in the spirit of Arrow (1962) and Romer (1986). Specifically we assume that knowledge spillovers exist such that firm-specific TFP is an increasing function of the aggregate capital stock held by high-productivity firms. Since the number of high-ability entrepreneurs is given, TFP is thus a positive function of the capital stock hold by a typical high-productivity firm, $A^H = \tilde{A}^H(k^H)^\gamma$ and $A^L = \tilde{A}^L(k^H)^\gamma$ where the $\tilde{A}$'s subsume firm-specific productivity stemming from entrepreneurial ability.

In principle, we could allow high-productivity firms to benefit to a different (possibly higher) degree from knowledge spillovers. The present formulation however, simplifies the analysis tremendously since it keeps the productivity differential between firms constant (which is, as before, given by a). This way the differential between rates of returns on capital remains constant, a feature that allows us to go on with discussing the economy as a two-dimensional system of difference equations. In order to avoid exploding behavior we require $0 \leq \gamma \leq 1 - \alpha$. As it is well known from the literature, the knife-edge case of $\gamma = 1 - \alpha$ generates endogenous growth (see e.g. Barro and Sala-i-Martin, 2005).

In contrast to Arrow and Romer, however, the degree of knowledge spillovers is not treated as a given constant. Due to the endogenous network structure the present model is ideally suited to rationalize a "microfoundation" of non-constant, evolving knowledge spillovers. In order to implement this idea conveniently we assume a positive and linear association of γ with the current state of economic integration, $\gamma = \bar{\gamma} \cdot p$. The notion here is that more long-distance links lead to a greater ease at which knowledge travels through the net and thus to a higher degree to which a firm benefits from knowledge created elsewhere.

There exists corroborating evidence that the diffusion of ideas is indeed endogenous and possibly network-specific. For example, Keller (2002) and Bottazzi and Peri (2003) present evidence that knowledge spillovers are spatially localized and decay strongly with geographic distance. Keller also demonstrates that the degree of localization has shrunk substantially over time. Similarly, Jaffe et al. (1993) find localization effects for the links between patent creation and patent citation on the level of country, state, and metropolitan area, and that localization fades gradually over time. For DRAM production in fully developed countries Irwin and Klenow (1994) show evidence for international knowledge spillovers. At the same time, Foster and Rosenzweig (1995) present evidence that farmers in LDCs are still learning mostly from their neighbors. Andersen and Dalgaard (2011) show that across countries aggregate TFP and GDP per worker are strongly associated with the intensity of international travel.

In order to implement these insights we assume that there are no knowledge spillovers in a completely localized economy ($p = 0$). With increasing economic integration the degree of spillovers rises and γ converges to $\bar{\gamma} \leq (1-\alpha)$ as p converges to one. Taken this notion of knowledge spillovers into account equation (11) transform into (14).

$$k^H_{t+1} = \left[\mu(p)(1 - n^H - n^L(p)) + n^H\right] A \left(1 + \frac{x(p)}{a}\right)^{\alpha} (n^H)^{\alpha-1} \cdot (k^H_t)^{\alpha} \cdot (k^H_t)^{\bar{\gamma}\cdot p}. \qquad (14)$$

For phase diagram analysis the $\Delta p = 0$–isocline is kept from the previous section and the Δk^H-isocline is given by (15).

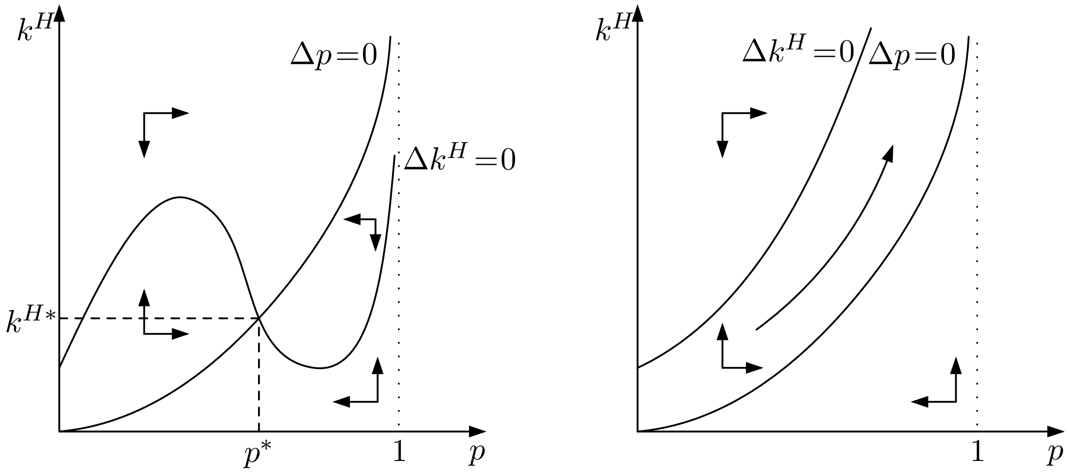
$$k^H = \left[A(n^H)^{\alpha-1} f(p)\right]^{1/(1-\alpha-\bar{\gamma}\cdot p)}, \qquad (15)$$

where $f(p)$ is defined as in (13). Thus, as long as $\bar{\gamma} < (1-\alpha)$, the new Δk^H-isocline is just an upward bent version of the original curve. Because the $\Delta p = 0$-isocline has a pole at $p = 1$ and $f(p)$ continues to be finite for all p, there is still a unique intersection at some level of p. In conclusion the analysis of the previous section remains completely intact for the extension by knowledge spillovers. The qualitative behavior of the economy does not change.

Qualitative behavior changes for the knife-edge case, $\bar{\gamma} = (1-\alpha)$. Here, the fully integrated economy coincides with a Romer (1986)–economy, which displays at the aggregate level (socially) constant returns with respect to capital. Perpetual growth is possible, but in contrast to the original approach, there exist adjustment dynamics and with potentially negative repercussions from modernization, it is not a priori clear weather an economy starting at a low level of economic integration will ever reach the Ak-growth limit.

Figure 5 shows the two possible cases. In the knife-edge case both isoclines have a pole at $p = 1$. Nevertheless, an intersection of the $\Delta k^H = 0$ and the $\Delta p = 0$–isocline may prevail as shown on the left hand side in Figure 5. In that case there exists a stable poverty trap despite the potential of long-run growth. On the other hand, if no such intersection exists, the economy always travels towards perpetual growth and full economic integration as displayed on the right hand side of Figure 5. Apply Lemma 1 to verify that $f'(p) > 0$ for all p for the case of invariant λ, i.e. in particular, in the case of strong formal institutions. This means that there exists no downward bending segment of the $\Delta k^H = 0$–isocline in the case of strong formal institutions. Apply Lemma 1 for the case of weak formal institutions and investor safety determined by community control ($\lambda = \lambda(C(p))$) to verify that the term in brackets in (15) is negatively sloped for large p. It is thus possible that an intersection of isoclines exist in the case of weak formal institution and neighborhood monitoring while no such intersection exists in the case of strong formal institutions.

Figure 5: Phase Diagram: Evolving Network and Knowledge Spillovers



Left hand side: stagnation at intermediate level of economic integration when investor safety is determined by neighborhood enforcement, $\lambda = \lambda(C(p))$. Right hand side: Perpetual growth when investor safety is ensured by formal institutions, $\lambda = \bar{\lambda} > \lambda(C(0))$.

Proposition 6. *For $\bar{\gamma} = 1 - \alpha$ there exists a set of initial values $k^H(0), p(0)$ and parameter values $\{A^H, a, n^H, \alpha, \beta, \phi, \nu, \xi, N, m\}$ for which an economy with strong formal institutions grows forever whereas an economy based on weak formal institutions and neighborhood enforcement converges towards stagnation.*

We prove this claim by way of example. For that purpose we consider a numerically specified version of the model. We set the capital share α to 0.4 and β to 0.35 implying a savings rate of 0.25. We set $\bar{\gamma} = 1 - \alpha$ in order to generate perpetual growth and $A^H = 2.1$ so that the economy converges towards an annual growth rate of 2 percent in the case of strong institutions. These values are thought to approximate a contemporaneous fully developed country. We set $a = 2$, i.e. we assume that the return on capital is twice as high for investment in high-productivity firms as for investment in low-productivity firms, see equation (2). This implies $A^L = 1.6$, i.e. total factor productivity in low-productivity firms is about 35 percent lower than for high-productivity firms. Furthermore we assume that high-ability entrepreneurs account for a population share of $n^H = 0.05$.

We assume $N = 100,000$ and $m = 3$, such that everybody has 6 neighbors. We next parameterize $\mu(p)$ and $\lambda(p)$. For that purpose we begin with assuming that people can perfectly observe ability of their nearest neighbors. Since any node has $2m$ neighbors, the probability of not having a high-ability entrepreneur in the neighborhood is $(1 - n^H)^{2m}$. The range that a random walker in the Small World network reaches in given period of time is proportional to the average path length $L(p)$ (Almaas et al., 2009). It thus seems reasonable to assume that high ability entrepreneurs are discovered by search through the net with a probability proportional to average path length, implying that the probability of not finding a high ability entrepreneur can be written as $(1-n^H)^{2m+\nu/L(p)}$, with $\nu > 0$ being an efficiency parameter (see Appendix for details). This means that the probability to find a high ability entrepreneur is $\mu(p) = 1 - (1 - n^H)^{2m+\nu/L(p)}$. The formulation takes the common reasoning into account that long-distance links improve the search efficiency in the network. For the strength of informal norms we assume, taking the reasoning from Section 3 into account, that it is given by a scaled transformation of the clustering coefficient $\lambda(p) = \lambda_{max} C(p)^{\xi}$. The parameter ξ controls how well a society is capable to sustain an informal norm for any given structure of the network. We set $\nu = 0.02$, $\xi = 0.5$ and $\lambda_{max} = 0.95$. For the strong-institutions case we set $\bar{\lambda} = \lambda_{max}$.

The simplest function $g(k)$ fulfilling the assumptions made in (12) is the logistic, $g(k) = 1 - e^{-\phi k}$. Of course, the choice of ϕ has an impact on dynamic behavior, which can already be inferred from Figure 5. The specification of ϕ determines the slope of the $\Delta p = 0$-isocline. If we set a higher value for ϕ we assume a larger impact of economic development on network formation. Diagrammatically, as ϕ gets larger, the $\Delta p = 0$–isocline intersects the $\Delta k^h = 0$–isocline at lower k^H and higher p. We set $\phi = 1$ implying that for weak formal institutions the model predicts stagnation at an intermediate level of economic integration of $p^* = 0.54$. For strong formal institutions the equilibrium of stagnation does not exist.

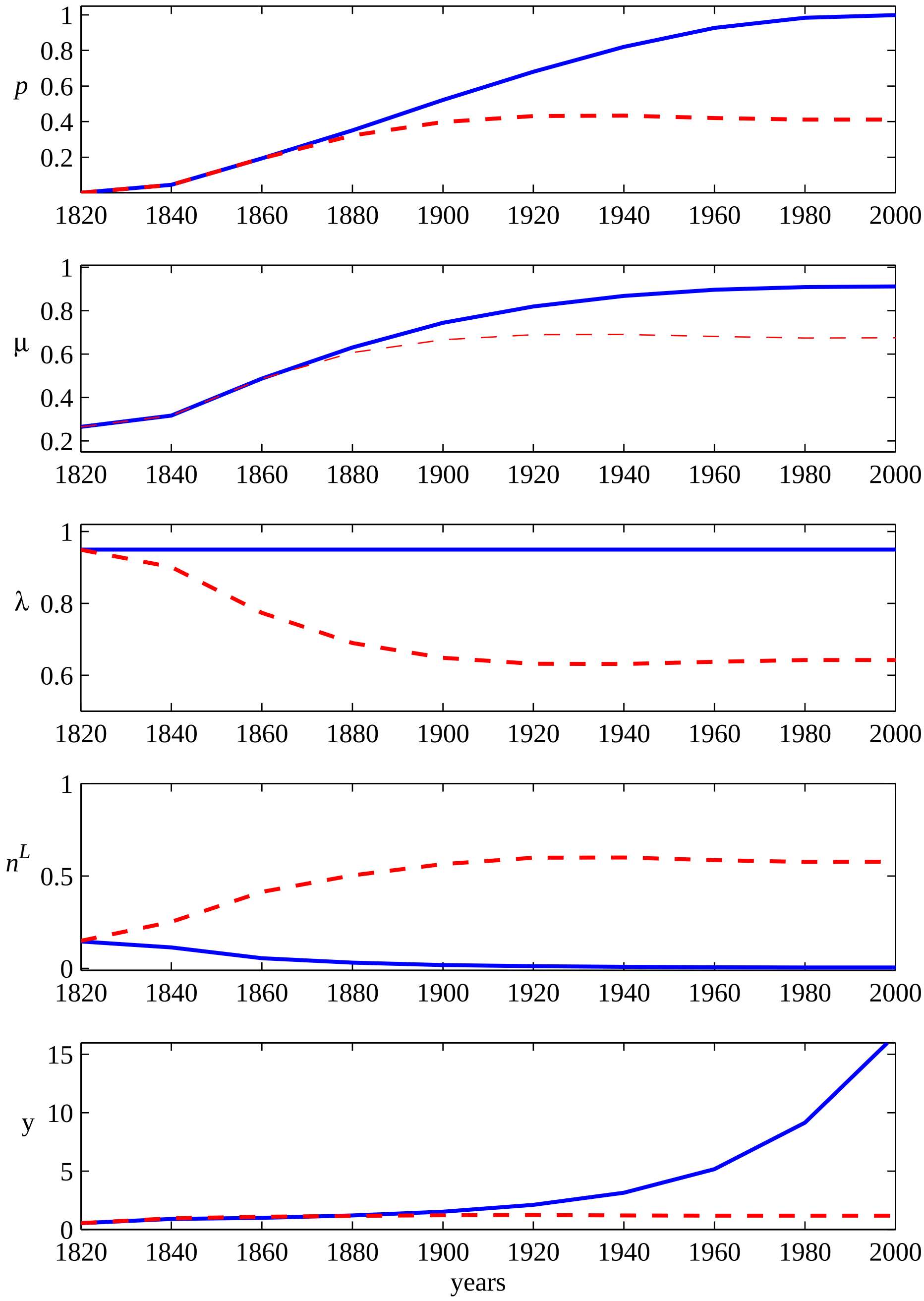
While there is little leeway to manipulate the economic parameters α, β, A^H, and n^H since they are pinned down by observables, the numerical specification of the network is admittedly arbitrary. The Small World model is a metaphor and too abstract to be " calibrated" to an evolving network in the real world. For our purpose this is not a drawback since the numerical examples is just an illustration of the general cases depicted in Figure 5. However, it might be nevertheless interesting to inspect how results response to parametric changes and how robust the main result of a qualitatively different steady-state for the neighborhood-enforcement economy is. We thus provide a detailed sensitivity analysis in Appendix B.

Figure 6 shows the predicted adjustment dynamics for the benchmark run, assuming that a generation takes 20 years. Solid lines show trajectories for the formal-institutions case and dashed lines show behavior of an otherwise identical economy in which λ is determined by neighborhood-enforcement. We set the initial time to 1820. Around the year 1820 people came up with a series of innovations (e.g. the railway, the telegraph) which, embodied in capital investment, drastically improved reach and communication and can be thought as having initiated the process of industrialization and increasing economic integration (the second industrial revolution). We have also normalized the resulting time series for GDP such that GDP is 1 in the year 1860. This makes the model results easier comparable with examples from the real world (see below).

Originating from initially low $k(0)$ and $p(0)$, behavior of both economies is observationally equivalent during the early phase of industrialization. Although the new capital equipment is initially creating only a few long-distance links, as can be seen from the initially small increase of p, these links are – due to the small-world property – sufficient to reduce average distance $L(p)$. This in turn leads to an increase in μ, the probability at which investors find high profit investments. Consequently, the share of low-ability entrepreneurs in the population of the formal-institutions economy falls quite drastically from almost 20 percent to almost zero. In the neighborhood-enforcement economy, however, increasing economic integration implies also, increasingly, the decrease of local clustering, leading to less trust and trustworthiness λ and an increasing incentive for low ability entrepreneurs for setting up an own firm instead of investing in other firms.

The model thus reflects the empirical regularity found by Ahlerup et al. (2007). While neighborhood-enforcement (there interpersonal trust) has a significant impact on economic performance when strong formal institutions are absent, it is of negligible consequence otherwise. The observable differences between both economies in the 19th century, however, are small, considering either income y or connectivity p. But in the second half of the 20th century we observe the *the great divergence* (Pomeranz, 2000, Galor, 2005). Growth of the formal-institutions econ-

Figure 6: Adjustment Dynamics: Modernization and Growth



Solid lines: strong formal institutions, $\lambda = \bar{\lambda}$ for all p. Dashed lines: neighborhood enforcement case, $\lambda = \lambda(C(p))$.

omy now really takes off, benefitting increasingly from further rising economic integration and increasing knowledge spillovers. Growth in the neighborhood-enforcement economy, in contrast, peters out.

Although both countries are much more economically integrated in 20th century than in the

18th century, the neighborhood-enforcement economy fails to fully reap the fruits of economic integration. Inferior social performance causes the economy to converge towards an equilibrium where about 50 percent of the population prefers to be low-ability entrepreneur. Industrial structure is dominated by many small firms of low-productivity. Since knowledge spillovers are created through links with high-productivity firms led by high-ability entrepreneurs, the community-enforcement economy cuts itself off from potential growth. Potentially, there are enough links to find high-profit investments with high probability as indicated by the μ-trajectory, which is similar for both economies. Investors in the neighborhood-enforcement economy, however, shy away from *using* these links because they are not protected by strong formal institutions. With small capital stocks allocated to high-productivity firms, learning-by-doing opportunities are small and the economy does not much benefit from knowledge spillovers. Most importantly, investment in high-productivity firms is so low that the economy is not capable of long-run growth. It behaves *qualitatively* different from the otherwise identical formal-institutions economy that grows perpetually.

With a pinch of salt we can interpret the results in light of Adelman and Morris' (1967) social capability index and imagine the depicted countries as, for example Japan and Columbia (or, for that matter, as South Korea and Peru). Both countries are about equally rich at the end of the 1930s and – although this is hardly visible in the bottom panel of Figure 6 – they have more than doubled their income since 1860. Even in the late 1950s income of both countries is not very different and both countries developed many long-distance links. Observing this, Adelman and Morris and Temple and Johnson (1998) put both countries into the third group of social capability. However, in order to arrive at perpetual growth it is necessary to converge towards full economic integration. This is the case for Japan, which grows by factor 16 from 1900 to 2000 driven by ample investment into high productivity firms, secured by strong formal institutions. In the Columbian case, however, investor safety is based largely on local norm enforcement, consequently there are many small firms of low productivity such that income is low and capital accumulation is not fast enough to arrive at full economic integration. In equilibrium the positive force of further economic integration through increasing knowledge externalities is counterbalanced by the negative force through deteriorating informal norm enforcement.[7]

[7]Actually, in 1985 the share of entrepreneurs in manufacturing is 0.24 in Columbia and 0.12 in Japan (Gollin, 2008). The rule of law index in 2000 is -0.98 in Columbia and +1.29 in Japan (World Bank, 2013).

7. Conclusion

This paper has proposed a network-based theory of economic development. A feedback effect from economic development to network formation has allowed us to discuss in a dynamic general equilibrium framework the pro and cons of modernization, understood as evolving economic and social integration. When economic integration is low and local connectivity is high, informal norms control entrepreneurial behavior and more integration mainly improves search for efficient investment opportunities. At a higher level of economic integration neighborhood enforcement deteriorates and formal institutions are needed to keep entrepreneurs in check. A gradual take-off to perpetual growth has been explained by a feedback effect from investment to the formation of long-distance links and the diffusion of knowledge. If formal institutions are weak, however, the economy does not take off but stagnates at an intermediate income level. In line with the available evidence the model predicts that economies with weak formal institutions end up in a situation where aggregate TFP is relatively low because there exist many small low-productivity firms. With contrast to the earlier literature on firms and development the presence of many small-scale firms has been identified as inefficient. If only deteriorating informal norms could be replaced by strong formal institutions, low productivity-firms would become eventually extinct, full economic integration would be established, and – given knowledge externalities are sufficiently strong – the economy would grow perpetually.

The analysis may also be useful to shed new light on the role of informal and formal institutions for growth and development. A dense network allows to sustain a high degree of investor security and trust and to realize a more efficient allocation of resources and higher income per capita than in a comparable sparse network. But clustering inevitably declines with increasing economic integration, which prevents to reap the full benefits from economic integration and perhaps even hinders the take off to long-run growth, a take-off that could be achieved under strong formal institutions. On the other hand, institutions are not *generating* economic growth. Our comparative study of the Small World in the neoclassical model and in the endogenous growth model suggests that institutions are *conducive* to growth. Growth is *generated* by perpetual technological change, which in turn grows at a higher rate when knowledge diffuses more easily through a dense network with many long-distance links.

Taking up the discussion of social capability from Temple and Johnson (1998) and from Section 3, the Small World model explains why less developed countries endowed with a higher index of social capability achieved higher income per capita in the late 1950s, in a world in which many long-distance had not yet been established. But it also explains, why subsequently, with increasing economic integration, especially the countries endowed with strong formal institutions displayed high economic growth, a detail ignored in the original analysis.

Several extensions of the proposed theory are conceivable. For example, while it seems to be justifiable to treat formal institutions as predetermined (Acemoglu et al., 2001; La Porta et al., 2008), they are certainly not constant in the very long-run. Another possible extension of the model is to allow entrepreneurs to bequeath their firm to their offspring. In this context, transactions costs as another cause for inefficiently many low-productivity firms could emerge (Grossmann and Strulik, 2010). These costs could include the loss of network relations and trustworthiness if firms are not continued by family members (Caselli and Gennaioli, 2013). In a multi-country setting it seems reasonable to assume that some knowledge spills over from leading-edge countries with superior institutions to backward countries with inferior institutions (Strulik, 2013). It then seem likely that the backward country experiences slow growth rather than stagnation. Finally, other forms of network evolution are conceivable. For example, if network evolution rewires links such that there are stars (leadership) established, it is no longer inevitable that decreasing average path length is ultimately followed by deteriorating local clustering. This effect could lead to a more optimistic view on the role of informal norms in modern societies. Integrating these ideas into the network-based theory of modernization is a potentially interesting task for future research.

Appendix A

Proof of Proposition 1. Taking derivatives of (9) we obtain

$$\frac{\partial n_t^L}{\partial \lambda_t} = -\frac{(a-1)(1-\mu_t)(1-n^H)}{(a\lambda_t-1)^2\mu_t} < 0, \qquad \frac{\partial n_t^L}{\partial \mu_t} = -\frac{(1-\lambda_t)(1-n^H)}{(a\lambda_t-1)\mu_t^2} < 0,$$
$$\frac{\partial n_t^L}{\partial a} = -\frac{\lambda_t(1-\lambda_t)(1-\mu_t)(1-n^H)}{(a\lambda_t-1)^2\mu_t} < 0, \qquad \frac{\partial n_t^L}{\partial n^H} = -\frac{(1-\lambda_t)(1-\mu_t)}{(a\lambda_t-1)\mu_t} < 0.$$

Proof of Proposition 2. Inserting (9) in (2) and taking the derivatives we obtain

$$\frac{\partial x_t}{\partial \lambda_t} = -(a-1)(1-\mu_t)(1-n^H)D < 0, \qquad \frac{\partial x_t}{\partial \mu_t} = -(a-1)(a\lambda_t-1)(1-n^H)\lambda_t D < 0,$$
$$\frac{\partial x_t}{\partial a} = -(1-\lambda_t)(1-\mu_t)(1-n^H)\lambda_t D < 0, \qquad \frac{\partial x_t}{\partial n^H} = -(a-1)(a\lambda_t-1)(1-\mu_t)\lambda_t D < 0,$$

with $D \equiv 1/\left\{1-\lambda_t\left[1-(1-n^H)(1-a)\mu_t-(1-a)n^H\right]\right\}^2$. Recall from (8) the negative association between the share of capital allocated to low-productivity firms x_t and the size of high-productivity firms h_t^H. The following proposition summarizes the result.

Proof of Proposition 3.

Proof of Proposition 4. Inspect (11) to see that 11) differs only by a constant from the standard model Diagrammatically, the unique, globally stable steady-state is found where the concave curve given by the right hand side of (11) intersects the identity line.

Proof of Proposition 5. In order to inspect the comparative statics it is useful to re-write (10) evaluated at the steady-state ($k^H = k^{H*}, h^H = h^{H*}$) in terms of the capital-intensity in the high-productivity sector: $\kappa^* \equiv \left(k^{H^*}/h^{H^*}\right)^{1-\alpha} = \left[\mu(1-n^H-n^L)+n^H\right] A\left(1+x/a\right)$. After inserting x from (2) this expression simplifies to (16).

$$\kappa^* = \frac{A}{a}\left\{1+(a-1)\left[\mu(1-n^H-n^L)+n^H\right]\right\}. \tag{16}$$

The remaining steady-state aggregates can be inferred from κ^*. To obtain the their comparative statics, take the derivatives of (16) and apply Proposition 1.

$$\frac{\mathrm{d}\kappa^*}{\mathrm{d}\lambda} = -\mu(a-1)\frac{A}{a}\cdot\frac{\partial n^L}{\partial \lambda} > 0, \qquad \frac{\mathrm{d}\kappa^*}{\mathrm{d}\mu} = (a-1)\frac{A}{a}\left[(1-n^H-n^L)-\mu\cdot\frac{\partial n^L}{\partial \mu}\right] > 0.$$

Then infer from (5) wages $w^* = (1-\alpha)A^H(\kappa^*)^{\alpha/(1-\alpha)}$ and from (6) capital returns $(R^H)^* =$

$\alpha A^H/\kappa^*$ and $(R^L)^* = \alpha A^L/\kappa^*$. Aggregate output (GDP) is defined as $y_t = n^L A^L (k_t^L/h_t^L)^\alpha h_t^L + n^H A^H (k_t^H/h_t^H)^\alpha h_t^H$. Using (5) this simplifies to $y = [n^L h_t^L + n^H h_t^H] A^H (k_t^H/h_t^H)^\alpha$. At a steady-state GDP is thus obtained as a unique positive function of κ^*, $y^* = A^H(\kappa^*)^{\alpha/(1-\alpha)}$. Let aggregate TFP be defined as $(n^H A^H + n^L A^L)/(n^H + n^L)$. Then $\partial \text{TFP}/\partial n^L = -n^H(A^H - A^L)/(n^H + n^L)^2 < 0$. Applying proposition 1 provides the comparative statics of TFP.

Proof of Lemma 1. From (13):

$$\frac{\mathrm{d}f(p)}{\mathrm{d}p} = \frac{\alpha}{a}\left(1+\frac{x}{a}\right)^{\alpha-1} \cdot \frac{\mathrm{d}x}{\mathrm{d}p} \cdot \left[\mu(1-n^H-n^L)+n^H\right] + \left(1+\frac{x}{a}\right)^{\alpha}\left[\frac{\mathrm{d}\mu}{\mathrm{d}p}(1-n^H-n^L) - \mu\frac{\mathrm{d}n^L}{\mathrm{d}p}\right].$$

Inserting

$$\frac{\mathrm{d}x}{\mathrm{d}p} = \frac{\mathrm{d}x}{\mathrm{d}n^L}\frac{\mathrm{d}n^L}{\mathrm{d}p} + \frac{\mathrm{d}x}{\mathrm{d}\mu}\frac{\mathrm{d}\mu}{\mathrm{d}p}, \quad \frac{\mathrm{d}x}{\mathrm{d}n^L} = \frac{\mu}{[\mu(1-n^H-n^L)+n^H]^2}, \quad \frac{\mathrm{d}x}{\mathrm{d}p} = -\frac{1-n^H-n^L}{[\mu(1-n^H-n^L)+n^H]^2}$$

the derivative simplifies to

$$\frac{\mathrm{d}f(p)}{\mathrm{d}p} = \frac{1}{a}\left(1+\frac{x}{a}\right)^{\alpha-1}\left[\frac{\mathrm{d}\mu}{\mathrm{d}p}(1-n^H-n^L) - \frac{\mathrm{d}n^L}{\mathrm{d}p}\mu\right] \cdot \left\{a + x - \frac{\alpha}{\mu(1-n^H-n^L)+n^H}\right\}.$$

Since $a > 1$, a sufficient condition for the term in curly parenthesis to be positive is

$$1 + x - \frac{\alpha}{\mu(1-n^H-n^L)+n^H} > 0.$$

After inserting x from (2) the condition simplifies to

$$\frac{1-\alpha}{\mu(1-n^H-N^L)+n^H} > 0,$$

which is true. The sign of $\mathrm{d}f(p)/\mathrm{d}p$ is thus determined by the sign of the term in square brackets, which gives Lemma 1.

Appendix B: Sensitivity Analysis

In general we know much more about the size of the economic parameters than about the size of the network parameters. Since the Small World network is a stylized metaphor for the evolution of relationships among individuals, it seems to be a futile task to try to "calibrate" the network parameters in order to fit some existing real world network. What we can do, however, is to use sensitivity analysis to explore to what extent the *qualitative* result of two different steady-states is robust, i.e. to identify the set of parameters mentioned in Proposition 6 for which the formal-institution economy grows forever while the community-enforcement economy stagnates.

The only economic parameter that is hard to pin down by observation is a, that is the factor by which the rate of return of firms led by high-ability entrepreneurs exceeds the rate return of low-ability firms. This observations inspired the following approach to sensitivity analysis. We compute for alternative pairs of the network parameters the critical value of a below which we obtain two different equilibria. For an intuition of why the equilibrium of stagnation collapses when a becomes sufficiently high, begin with the result from Proposition 1. A rising a reduces the incentive of low-ability individuals to set up a firm because the return on investment becomes relatively larger. This is true even at low probability to find a high-ability entrepreneur or when low neighborhood enforcement reduces the return. In fact from (9) we see that $\lim_{a\to\infty} n_t^L = 0$. Thus, when a becomes sufficiently high, deteriorating neighborhood enforcement does no longer lead to stagnation. The economic power of the few high productivity firms is strong enough to generate the take off to growth. Notice that neither the network parameters nor the parameter a has an influence on the steady-state growth rate. All numerical specifications of the model discussed below are thus comparable in that they imply the same steady-state of growth, which is calibrated by setting the values for α, β, γ and A^h as discussed in the main text.

We search for the critical values of a on 0.05-grid. This explains why all numbers end with either 5 or 0. Table 1 shows results for the parameters of the functions translating network structure p into search efficiency $\mu(p)$ and neighborhood enforcement (safety of investment) $\lambda(p)$. For example, if $\nu = 0.01$ and $\xi = 0.1$ and all other parameters as specified in the main text, then the model exhibits the two qualitatively different equilibria as long as firms of high productivity are at most 1.25 times as productive as low productivity firms. The critical a decreases with increasing ν. Intuitively, if ν, is high search for high-productivity firms is very effective, which reduces the incentive of low ability individuals to become entrepreneur. There seems to be convergence in the sense that the critical value of a changes only marginally when ν is larger than 0.02 and rising.

Table 1: Critical a's for alternative network parameters: ν and ξ

	ν			
ξ	0.01	0.02	0.04	0.08
0.10	1.25	1.20	1.20	1.20
0.30	1.85	1.65	1.65	1.65
0.50	2.65	2.25	2.25	2.25
0.70	3.75	3.10	3.05	3.05

With respect to $\lambda(p)$ the critical a is low when ξ is low. A low value of ξ means that, ceteris paribus, the society is able to sustain a higher value of λ at any given network structure p compared with a high ξ-society. The ξ value can be thought as capturing ulterior motives beyond local clustering that are decisive for trust and trustworthiness, as for example, religion. Blum and Dudley (2001) argue that cooperation with strangers – long distance links in our model – was historically easier in Protestant societies. In our model this observation would be reflected by a lower value of ξ for the protestant society such that λ decreases less sharply when the clustering coefficient declines. Stagnation is then only obtained for relatively low values of a. Or in other words, keeping the value of 2 for a from the benchmark calibration, a society with ξ of 0.3 or less would manage the take-off to growth. With respect to European societies at the dawn of the industrial revolution the cross-country variation of ξ would not only capture the stylized fact that predominantly Catholic societies industrialized later but also the stylized fact that they developed their railway network (their long-distance links) more slowly (Acemoglu and Robinson, 2002).

Table 2 shows the critical a's for alternative assumptions about the number of high-ability entrepreneurs in society (n^H) and about the ease at which the network expands with capital accumulation (ϕ). A high value of ϕ means that the network expands rapidly with capital accumulation. Perhaps surprisingly, Table 2 demonstrates that a rapidly developing network is not conducive to growth when the society is based on community enforcement of norms. The reason is that μ – the positive side of network evolution – declines anyway already at low levels of network density. This means that a quickly growing network affects mainly λ – the dark side of network evolution. If the network expands quickly, neighborhood enforcement deteriorates already at an earlier stage of development, which makes stagnation more likely.

Table 2: Critical a's for alternative ϕ and n^H

	ϕ		
n^H	1/3	1.00	3.00
0.03	2.25	3.05	12.2
0.05	2.25	2.45	5.75
0.10	2.25	2.25	3.80

If there are fewer high-ability entrepreneurs in society, stagnation becomes more likely, i.e. the critical value of a increases. A low value of n^H reduces the probability to find a high-productivity firm for one's investment and increases the incentive to become entrepreneur for low-ability individuals at any given network structure. Thus at any p there are more low-ability entrepreneurs and less high-ability entrepreneurs around, a factor that favors stagnation.

Table 3: Critical a's for alternative network parameters: N and m

	m				
N	1	3	6	10	50
1000	2.85	2.30	2.20	2.20	2.15
100,000	3.10	2.45	2.85	2.20	2.15
100,000,000	3.50	2.60	2.40	2.25	2.15

Finally, Table 3 shows results for the size of the network N and the size of the neighborhood m. Generally a larger network increases the critical value of a. It means that at high levels of p high-ability entrepreneurs are comparatively more difficult to find and that at medium values of p clustering deteriorates more quickly with rising p. A larger neighborhood, on the other hand, reduces the critical value of a because it implies higher clustering and slower norm deterioration under neighborhood enforcement. There are, however, decreasing returns in the seize of the neighborhood. From $m = 10$ onwards results change only marginally when further neighbors are added. The significant variance at lower levels of m may be useful to explain why clan-societies, in which neighbors could be interpreted as family or kin, developed more slowly or stagnated while citizens-societies in which neighbors could be interpreted as fellow villagers or townsmen, developed more quickly (Putnam, 1993; Tabellini, 2008, 2010). According to the model, increasing economic integration had more severe impact on norm enforcement in the clan-society, which consequently did not fully develop the full network and realized the full gains from technology spillovers but stagnated at an intermediate level in which firms are small and norms are enforced by the neighborhood.

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