From Tradition to Modernity: Economic Growth in a Small World

Ines Lindner[1] and Holger Strulik[7]

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 a 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.

[1]VU University Amsterdam, De Boelelaan 1105, 1081 HV Amsterdam, The Netherlands, email: ilindner@feweb.vu.nl
[7]University of Göttingen, Department of Economics, Platz der Göttinger Sieben 3, 37073 Göttingen, Germany; email: holger.strulik@wiwi.uni-goettingen.de.

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 $\nu = 0.1$ and $\xi = 0.1$ and all other parameters as specified in the main text, then the model exhibits two qualitatively different equilibria as long as firms of high productivity are at most 1.6 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 0.2 and rising.

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

	ν			
ξ	0.05	0.10	0.15	0.20
0.10	1.60	1.30	1.25	1.25
0.35	4.20	2.15	1.95	1.85
0.50	6.00	2.85	2.45	2.30

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. 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 the critical a responds relatively insensitive to changes of ϕ. The reason is that μ – the positive side of network evolution – declines anyway already at low levels of network density.

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

	ϕ		
n^H	1.00	1.5	2
0.03	2.35	2.35	2.35
0.05	2.15	2.20	2.20
0.07	2.05	2.10	2.10

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	2	3	6	10
1000	2.35	2.15	1.95	1.80
100,000	2.35	2.15	1.95	1.80
100,000,000	2.45	2.20	1.95	1.80

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. This observation 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 et al., 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.

References

Acemoglu, D., and Robinson, J. A., 2002, Economic backwardness in political perspective, NBER Working Paper No. 8831.

Blum, U. and Dudley, L., 2001, Religion and economic growth: was Weber right?.*Journal of Evolutionary Economics,*11, 207-230.

Putnam, R.D., R. Leonardi, and R.Y. Nanetti, 1993, *Making Democracy Work: Civic Traditions in Modern Italy*, Princeton University Press, Princeton.

Tabellini, G., 2008, The scope of cooperation: values and incentives, *Quarterly Journal of Economics* 123, 905-950.

Tabellini, G., 2010, Culture and institutions: economic development in the regions of Europe, *Journal of the European Economic Association* 8, 677–716.