The Structure of Society as a Determinant of the Rate of Economic Growth

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Abstract: The rate of growth is found to depend on the structure, or more specifically the size, degree of connection, efficiency, and 'community spirit' of the network of relationships that exists within the economy. This structure, which is assumed to be exogenously determined, is important because it determines how effectively news of productivity increasing technological change spreads throughout the economy. The extent to which exclusive groups or cliques exist within the economy is also found to be important, although they are not necessarily detrimental. The model provides an explanation of why growth rates vary between economies and between different regions, modern and informal sectors, classes and ethnic groups within an economy. It also suggests that there might be a policy link between social planning and economic growth.
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[A] country's potential for rapid growth is strong not when it is backward without qualification, but rather when it is technologically backward but socially advanced (Abramovitz (1986), p. 388).

1. Introduction

The model presented in this paper establishes a link between the structure of the network of relationships that link the agents in an economy together and the rate of growth of that economy. The structure of the network is important because it determines the extent to which new knowledge, the driving force behind productivity growth, spreads throughout the economy. Intuitively, the greater the number of agents who get to hear about a productivity increasing technological change, the greater the potential impact of that change on the aggregate output of the economy. In earlier models of knowledge accrual and economic growth it is always assumed that knowledge is a public good. Indeed, this characteristic of knowledge is central to this class of models. However, the questions of how knowledge becomes public and to what extent it becomes public have only partially been addressed. In each case the answer relates to the network of relationships between agents.

Relationships between economic agents have rarely been a topic of analysis for economists.¹ Sociologists, on the other hand, regard the study of relationships as vital for understanding human behaviour and the development of societies as a whole. When conducting empirical analysis they distinguish two types of data, attribute and relational.² Attribute data are information on the attributes of an individual, an economy or institution

¹ There are notable exceptions, one of which is Williamson (1979).

(e.g., the income of an individual is an attribute of that individual, the rate of growth of an economy is an attribute of that economy, and the efficiency of an institution is an attribute of that institution.) Such data can be either quantitative or qualitative. Relational data are information on the links between individuals within an economy or institution, between individuals and institutions, or even between economies. Again, this data can be quantitative (how many relationships) or qualitative (what type of relationships and between whom). Economists are familiar with the network of relationships that make up the market system. However, when analyzing this system they tend to focus on the attributes of the agents within the network and the goods they exchange (including their prices) rather than on the relationships between the agents. This is primarily because of the special nature of the market system and its coordinating price mechanism. In a perfect market system, agents are anonymous and one-to-one relationships either do not exist or do not matter.3

A notable and relevant example of how economists focus on the attributes of agents rather than the relationships between them relates to the quotation at the start of this paper. When expanding on the notion of social advancement or 'social capability' (following Ohkawa and Rosovsky (1973)), Abramovitz (1986) named three elements. At the micro level he equated social capability with the concept of human capital. At the macro level he considered the qualitative nature of political, commercial, industrial and financial institutions to be important. Finally, Abramovitz cited Olson (1982), who identified defeat in war with the sweeping aside of old vested interests and the consequent clearing of the way for new structures and modes of operation. Turning this around, Abramovitz' third factor was the degree of 'openness to competition, to the establishment and operation of new firms, and to the sale and purchase of new goods and services' (pg. 389). Many other authors, intent on explaining economic growth, have analyzed these and other aspects of social capability, but, like Abramovitz, all of them have focused on the attributional aspects of social capability.

There is a relational aspect to social capability that is yet to be analyzed by economists interested in economic growth. There are many goods exchanged in an economy for which

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3 See Ouchi (1980), Bradach and Eccles (1989) and Powell (1990) for discussions on the limitations of the price mechanism and the need for trust generated through long-term relationships.
the setting of a price is difficult. Where this is the case the relationships between agents who are party to the exchange become important. One good for which price setting is problematic is knowledge. While it is true that the publication of new knowledge is important, only a very small proportion is published. More often knowledge is exchanged between people who know one another. When knowledge flows between institutions, such as firms, it is again because there are relationships between individuals within those institutions. The degree to which the structure of the network of relationships within a society allows knowledge to flow to those who can make use of it is an important aspect of that society's capability with respect to the generation of growth.

In Section 2 I look at the role that knowledge plays in the new endogenous growth models, specifically those of Romer (1986 and 1990), and at the processes by which knowledge becomes public. In Section 3 I introduce the concept of an information network multiplier and explain how it relates to the structure of an information network. Two network structures, as well as the effect of breaking the population up into cliques, are analyzed. 'Clique' is another term borrowed from social network theory. Here, it is defined as a subgroup of a population that is characterized by a dense network of relationships within its bounds and significantly fewer or no relationships traversing those bounds. Also, in this section I explain the connection between the information network multipliers and the semi-public nature of knowledge. Section 4 contains a growth model that highlights the effect of the structure of the networks within the economy on the rate of growth. Section 5 briefly looks at the welfare and policy implications of the model. Section 6 presents a few examples illustrating how the theory might aid our understanding of why growth rates differ between economies and between different groups of agents within economies. Section 7 links the theory developed here to the literature on social learning. In Section 8, I reconsider the assumption that networks are exogenous and looking briefly at the effect of weakening this assumption to allow some aspects of network structure to be determined by rational choice. I conclude in Section 9.
2. The Role of Knowledge in Economic Growth

The simple growth model that I develop below is closely related to the one Romer (1986) presented in his paper 'Increasing Returns and Long Run Growth'. Consider a population of N symmetric firms with the production function

\[ y_i = L_i^{1-a} K_i^a K_i^b \]

where \( y_i \) is the output of the ith firm and \( L_i \) is the labour employed by the ith firm. The term \( K_i \) represents firm specific knowledge which is assumed to be quantitatively the same for all firms while being distinct with respect to its content. Finally, \( K_i \) is the general level or overall stock of knowledge as perceived by the ith firm. Knowledge may appear in aggregate form in each firm's production function because it is non-rival. The N firms are symmetric in that they quantitatively have the same \( y_i, L_i, k_i, \) and \( K_i \), whereas they are distinct with respect to the content of both their specific knowledge, \( k_i \), and their perception of the overall stock of knowledge, \( K_i \).

This production function corresponds to the one on page 1015 of Romer's (1986) paper except that, here, a Cobb-Douglas technology is assumed and for simplicity only two inputs, labour and knowledge, are considered. Also, for reasons that will be explained below, whereas Romer assumes that \( K_i \) is the same for all i with respect to both quantity and content (K with no sub-script appears in his model), here, each firm's \( K_i \) is different with respect to content (but the same quantitatively). The production function is homogeneous of degree one with respect to labour and firm specific knowledge but exhibits increasing returns when the overall stock of knowledge is included. Despite the increasing returns, this production function is consistent with a decentralized equilibrium because firms treat the overall stock of knowledge as exogenous.

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*It is even closer to the simplified version of Romer's (1986) model that was presented in a lecture by Dr. P. Aghion, at Nuffield College, Oxford, March, 1994.*

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The central questions in this and the next section are: 1) how does knowledge become public and 2) what is the relationship between firm specific knowledge, the general level or overall stock of knowledge and a particular firm's perception of that overall stock? In Romer's (1986) model the overall stock of knowledge, defined as the sum of all the firms' specific knowledge, enters the production function, i.e.,

\[ K_i = K = \sum_{i=1}^{n} k_i = Nk_i \quad \text{for all } i \]

Each firm's perception or comprehension of this overall stock of knowledge is partial, for each firm keeps their specific knowledge partially secret. It is for this reason that both \( k \) and \( K \) and not just the latter appear in the production function. In addition, each firm's partial perception of the overall stock is the same with respect to both quantity and content. So, there is assumed to be some mechanism by which knowledge diffuses evenly throughout the economy as soon as it comes into being. In Romer's later paper (1990), a similar mechanism is assumed to exist except this time comprehension is complete. Researchers have at their disposal the entire stock of knowledge, in the form of existing designs, when producing new designs. When knowledge is defined as designs deserving of a patent and freely accessible for citation by all, the assumption that knowledge diffuses evenly throughout the population is plausible.\(^5\) However, not all additions to the stock of knowledge can be characterized as designs deserving of a patent. This is particularly true in developing countries where there are often no patent laws and where R and D is far better characterized as the importation of information from external sources rather than as domestically based research.

How then does knowledge become public and to what extent does it become public? It seems plausible to suggest that the most common way for information to become public is through networks of interpersonal and inter firm relationships. Information might be shared

\(^5\) Even for the R and D business in the US there is evidence to suggest that information flows between research establishments via such routes more frequently and/or faster than it passes through the Patent Office. See Jaffe, Trajtenberg and Henderson (1993), "Geographical Localization of Knowledge Spillovers as Evidenced by Patent Citations."
by many agents at formally arranged meetings or might spread from one agent to another through a series of one-to-one meetings. In either case an agent with an initial endowment of knowledge will, as a result of being part of a network, be able to swap it for other knowledge and, bearing in mind that knowledge is non-rival, end up with significantly more than that with which she started.

To emphasize that I am solely interested in the role of these networks in the publicizing of knowledge I refer to them as information networks. However, networks do not exist for the sole purpose of sharing information. They may be social in nature or they may correspond to groups who have come together to protect vested interests, to offer mutual security, or for some other purpose. These ideas are closely related to the idea of exogeneity with respect to information networks. An information network is exogenous when its structure and workings are the consequence of imposed rules or choices made without reference to the value of the network as a provider of information. In this paper the focus is on exogenous information networks.

3. The Structure of Information Networks and the Information Network Multiplier

Consider a network with m symmetric members. All the members have a package of knowledge, k, that is specific to them. The packages of knowledge are quantitatively equal while being distinct with respect to content. Each member's specific knowledge is considered to be of equal value by all members. Of their specific knowledge they are willing or able to share a proportion, v. This proportion is generally less than one, either because some information gets lost in the telling or because the owner wishes to retain some for her sole personal use. The more efficient the network or the greater the 'community spirit' among the network members, the closer v is to 1. Through the process of networking, each member, while retaining her specific knowledge, gains further knowledge from her fellow members. Her knowledge is multiplied. So, the relationship between a representative member's specific
knowledge and the total amount of knowledge she ends up with, $K_n$, is the product of her specific knowledge and a factor that I call the information network multiplier, $H(B,m,v)$.

\begin{equation}
K_i = H(B,m,v)k_i
\end{equation}

The value of this multiplier depends on $m$ and $v$, which have already been defined, and on $B$. $B$ is the number of other agents with whom the representative agent has a direct link. Sociologists refer to this as the 'degree of connection' of a network member (see Scott, J. (1991), page 70). $B$, $m$ and $v$ define the structure of the information network, which is then summarized in the information network multiplier. The assumption that agents are symmetric relates not only to their attributes, but also to their relationships, i.e., it is assumed that $v$ and $B$ are the same for all agents. For this reason the network itself may also be described as symmetric.\(^6\) $B$, $m$ and $v$ are all exogenously determined.

The first thing to note about the relationship in Equation (3) is that the more specific knowledge each agent in the network has the greater each agent’s total knowledge holding. A marginal increment in agent’s specific knowledge leads to an increment in their total knowledge equal to the multiplier.

Another way of thinking about this process is to break $K_i$ up into the member’s specific knowledge and the additional knowledge she gains through the network, $K_{si}$.

\begin{equation}
K_i = k_i + K_{si} = k_i + h(B,m,v)k_i
\end{equation}

where $h(B,m,v)$ is the net information network multiplier and is equal to $H(B,m,v)$ minus 1.

The effect of $B$, $m$ and $v$ on the multipliers depends on how we characterize the network. Below, I look at two types of symmetric network, a formal club or association and an informal network.

\(^6\) Because of symmetry, $B$ is also closely related to what sociologists refer to as the 'density' of the network. The density of a network is defined as the number of links that exist between the members of the network divided by the maximum possible number of links. In this model of a symmetric network the density of the network equals $B/(m-1)$. Note that sociologists do not usually impose symmetry on the networks that they analyze.
3.1 A formal club or association

A formal club or association might be characterized by a group of members who meet all at once. Each member comes to the meeting with the information that she is prepared to share, \( v_k \), and goes away with the sum of all the bits of information that all the members are willing to share. In this case the network multiplier is

\[
H(B,m,v) = 1 + (m-1)v
\]

The first term on the right hand side of this equation, 1, reflects the fact that the representative agent retains her specific knowledge. This term is eliminated in the net multiplier. The second term states that the representative agent gets a proportion \( v \) of the specific knowledge originating from the other \( m-1 \) members of the network. Note that \( B \) does not appear on the right hand side of this equation. This is because through the meetings each agent has a direct link with all the other agents in the network, i.e. \( B = (m - 1) \). Turning to the first and second order partial derivatives, the larger the club the greater the multiplier, \( H_m = v > 0 \). This relationship is linear so \( H_{mm} = 0 \). Increasing the efficiency of the club at conveying information or the degree to which the agents are prepared to share their knowledge also has a positive effect on the multiplier, \( H_v = m-1 > 0 \), and again this relationship is linear, \( H_{vv} = 0 \). The second order cross partial derivative is \( H_{mv} = 1 \) suggesting a complementarity between the size and efficiency of and community spirit within the club.

3.2. An informal network

This network might be characterized by a series of bilateral interactions, with each member prepared to share a proportion, \( v \), not only of their own specific knowledge but also of all the other knowledge they hear through the network. So, if you hear it from the horse's mouth you get \( v \) of the story, if you hear it from a friend of the horse you get \( v^2 \) of the story, if you hear it from a friend of a friend of the horse you get \( v^3 \) of the story and so on. Sociologists