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MEASUREMENT OF SOCIAL CAPITAL AND GROWTH: AN ECONOMIC METHODOLOGY*

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Abstract

This paper develops a measure of social capital based on economic relationships and analyzes its effects on growth. Investment in social capital is modeled by using the conceptual framework for measuring physical capital services. The measure of social capital depends on expectations of income, its investment cost, inequality in society, the density of trust networks, the size of the social network and the rate of depreciation of social capital. With this methodology a database is constructed for 23 OECD countries covering the period 1970-2001 and the positive effect of social capital on economic growth is tested.

JEL: Z1, E22

Key words: Social capital, Investment, Social networks, Economic Growth

Resumen

Este trabajo desarrolla una medida del capital social basada en las relaciones económicas y analiza sus efectos sobre el crecimiento económico. La inversión en capital social se modeliza utilizando el marco conceptual aplicado en la medición del capital físico. El indicador del capital social obtenido depende de las expectativas de ingresos, del coste de su inversión, de la desigualdad existente en la sociedad, de la densidad de las redes de confianza y de la tasa de depreciación del capital social. A partir de esta metodología se construye una base de datos para 23 países de la OCDE que cubre el periodo 1790-2001 con la que se contrasta el positivo papel del capital social sobre el crecimiento económico.

Palabras clave: Capital social, Inversión, Redes sociales, Crecimiento económico

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The literature on social capital, which has grown exponentially during recent years[1], reveals an imbalance between the volume of publications and the relative lack of progress in measuring the concept. Given the quantitative tradition of Economics, this contrast is even more striking, as economists have not so far made any significant methodological contribution to the measurement of social capital.

The measures of social capital most often used are those formulated by political scientists and sociologists based on Putnam measures of associative density (Putnam, Leonardi, Nanetti and Pavoncello, 1983; Putnam, Leonardi and Nanetti, 1993; Putnam, 1995) and on indices of trust obtained from general surveys (WVS by Inglehart[2], GSS, etc.). The main weakness of these two approaches is that the relation between the concept of social capital and the variable used to measure it (voluntary membership of groups or associations in the first case, and the manifestation of the degree of trust in *others* in the second) has not been established in such a way that enables us to identify a process of investment from which a capital stock is derived. Without this relation, any measure of capital would be imprecise and its meaning uncertain.

Methodological developments in the measurement of social capital from an economic standpoint have been very limited. Some recent studies model investment in social capital by adopting the general approach used in the measurement of other kinds of capital and consider its value as an asset equivalent to the present value of the expected future income (Glaeser, Laibson, Scheinkman and Soutter, 2000; Glaeser, 2001; Glaeser, Laibson and Sacerdote, 2002). No empirical estimations have yet been derived from this approach, even though they would give us a more precise understanding of the significance of the most frequent measures. Traditionally used measures suffer from serious limitations in their use in causality analysis, given the weakness of their foundations (Durlauf, 2002).

Starting from a conception of social capital similar to that in the studies cited in the above paragraph, the main objective of this paper is to develop a methodology for measuring social capital analogous to that employed in measuring other assets. Capital is a durable asset, the result of a costly investment, which depreciates and is valuable because it offers services or benefits of some kind. Taking this into account, both the theoretical and empirical elements of the method proposed for measuring social capital will be developed. The approach stresses the *economic* aspect in two senses: first, by

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[1] Winter (2000) enumerates more than a thousand articles on the subject between 1996 and 1999.
[2] See Inglehart, Basáñez, Díez-Medrazo, Halman and Luijkx (2004).

modeling social capital as a result of a process of investment or accumulation, which responds to the logic of maximizing individuals' expected benefits; and second, by considering that economic relationships are fundamental to the generation of social capital in developed economies, i.e. that economic relationships are part of the present social structure.

The proposed measure of the stock of social capital is based on two pillars. On the one hand, we start from an optimum decision-making model of the investment and accumulation process in social capital. Secondly, we use the conceptual framework developed for the measurement of physical capital services (OECD, 2001), which identifies the relevant variables to obtain a measure of productive capital. The methodology developed is applied to a broad set of countries for which the endowments of social capital during the period 1970-2001 are estimated. Lastly, with this data we evaluate the importance of social capital in economic growth, replicating the extension of the Mankiw, Romer and Weil (1992) model devised by Islam (1995). The objective is to examine whether the measure proposed explains part of the economic growth of the countries in the sample. Our findings confirm this to be the case.

The paper is structured as follows. The fist section sets out the approach used and describes the principal assumptions on which the proposed measure of social capital is based. In the second section we develop the theoretical model, from which we obtain an expression that allows the aggregated social capital stock of an economy to be proxied. The third section describes the empirical approach to the variables posited by the theoretical model as determinants of the stock of social capital. The fourth section presents the main features of the evolution of social capital in the economies analyzed, according to the estimations carried out. The fifth section tests whether the measure developed is capable of explaining economic growth and the sixth section concludes.

1. Economics and social capital

Only some approaches consider social capital to be a resource that accumulates as a consequence of decisions taken by rational agents who invest in it. From this *rationalist* perspective, measuring social capital requires us to identify how the process of investment operates. Although some of the most influential contributions to the concept of social capital in the sphere of sociology and political science underline its condition as a productive asset (Bordieu, 1980, 1985; Coleman, 1988, 1990; Putnam *et al.*, 1983, 1993; Putnam 1995), most contributions refer to *capital* in a generic sense. They affirm that social relationships *create value* and that it is possible to *invest in a* *network of relationships*, but the precise quantification of this process of investment is not the prime interest of their studies.

The economic literature on social capital has not covered this gap, and the lack of a precise methodology for measuring social capital means that most empirical studies start from vague definitions of the concept (Durlauf, 2002). The literature pays much more attention to the effects of social relationships on the results obtained by economies than to the role of economic relationships in the generation of social capital. In the studies of the economic consequences of social capital, interest focuses on its effects on growth, efficiency and productivity (Knack and Keefer, 1996; La Porta, López de Silanes, Shleifer and Wishny, 1997; Zak and Knack, 2001; Alesina and La Ferrara, 2002; Sobel, 2002).

These insufficiencies are more likely to be alleviated if economic relationships are considered as an important part of the social relationships that represent the source of social capital. We start from the hypothesis that advances in the living conditions enjoyed by developed societies generate *expectations of improvement and favorable mutual treatment* among their members. Since these relationships are frequent (even more usual than other social relationships), more attention should be paid to them as generators of social capital than has been the case hitherto.

According to the interdisciplinary definition of social capital proposed by the Social Capital Interest Group of the University of Michigan (SCIG, 2001), *social capital is the result of social relationships and consists of the expectation of benefits derived from preferential treatment between individuals or groups.* In other words, the social relationships that produce expectations of favorable behavior in other agents are an asset that produces different types of effects.

What are the reasons for the privilege hitherto given to the non-economic dimension (the family and voluntary associations) in the study of trust and social capital, from a macroeconomic perspective? Why have economic relationships not been considered to generate expectations of favorable treatment? Possibly one reason is that many economists have not shown much interest in a concept that forces them to reconsider the stylized versions of human behavior that they habitually deal with, focused on individualism and on rational agents that exchange goods or equivalent assets within a context of complete information. However, as Spence (2002) points out, in very substantial markets, such as those for durable goods, labor or finance, information is incomplete and trust plays an important role. Alongside this, repeated relationship between individuals is also present within economic organizations in which the asymmetries of information and uncertainty are also present. A direct consequence of these circumstances is that agents feel influenced by what others do when making decisions. For this reason, psychological and sociological factors become important, as do concepts such as *cognitive bias, impartiality, reciprocity, group identity, gregarious behavior or social status* (Akerlof, 2002).

Many authors on social capital, when stressing the determining role of social or political institutions and social relationships in the early phases of capital accumulation, have highlighted that *Economics* does not sufficiently recognize these aspects. Although this is true, it does not mean that *non-economic* social relationships are the exclusive source for the generation of social capital (as most of the literature seems to assume), nor that the importance of economic and non-economic relationships as the basis of trust will remain unchanged throughout the different phases of economic development. On the contrary, it is very important to pay attention to the capacity of economic exchanges to generate social capital in the advanced phases of development in economies with extensive experience of continued progress. This is recognized by part of the recent literature on the evolution of social capital in developed countries and approaches by some economists to the problem (Stiglitz, 1999).

Following this approach, investment in social capital is modeled in this article on the basis of three basic hypotheses:

1. Cooperation is favored by the economic incentives deriving from the expected increasing income resulting from continued growth. Past experiences of social and economic progress are projected into the future and become individuals' *expectations of favorable treatment*.

2. Individuals' incentives to cooperate are strengthened/weakened by two factors: a) by the effective opportunities for participation in the results (higher if income inequality is restricted by social practices and policies of cohesion); and b) by a *culture of fulfillment of duty* or *of reciprocity* that is increased and transmitted through access to education and the improvement of the population's human capital.

3. The effects of cooperation are extended if the density of the trust relationship networks between individuals is high. This density of trust relations is favored by the smooth running of long term economic relationships when uncertainty is inevitable and information costs are high, such as employment and financial relationships and the markets for durable goods.

2. The measurement of social capital: the theoretical model

In this section we develop the methodology used to obtain a measure of social capital. This revolves around two basic references. The first is the study by Glaeser, Laibson and Sacerdote (2002) in which they present a theoretical framework for the analysis of the determinants of social capital. This starts from the analysis of both the consideration of how social capital is formed using a model of optimal individual investment decisions and of the social capital accumulation process.

The second reference in our framework is the measuring of social capital in a similar way to physical capital (OECD, 2001). According to this methodology, once the investment decision and the accumulation of the net stock of social capital (wealth) have been analyzed, their productive contribution must be quantified by means of the flow of services. The flow of services from social capital depends on the degree of relation in the social relationships network. The aggregation of social capital across individuals poses problems similar to those faced in aggregating different assets of physical capital, which can be solved with the help of the appropriate prices (the user cost of capital). We thus obtain an expression for aggregated social capital which is a function of a set of variables that will permit us to empirically estimate the social capital.

2.1. The individual decision to invest in social capital

Glaeser *et al.* (2002) consider social capital as a characteristic associated directly with individuals, resulting from a process of investment and accumulation. Therefore the optimal investment Is in social capital ks of an individual i results, like any decision on investment in assets, from solving the problem of maximization of future (net) income expected by the investor. Consequently, to analyze social capital it is necessary to begin by making hypotheses about the income that an individual receives and the costs borne as a result of his investment in social capital.

If the individual possesses social capital he will expect to obtain, in the course of the years stretching from the present time to a horizon T, an income π over and above what he would obtain in other circumstances or with other conduct. The horizon T defines his expectations in respect of the duration of his economic relationships within that society or social network, which may be permanent, very long-lasting, or less long-lasting[3]. If his expectations are disappointed and the expected income is not obtained, his *ks* will depreciate at a rate of d[4].

We assume that the employed population represents the reference group of individuals, because they participate more intensely than other groups in economic relationships in their two roles, as workers and as economic decision makers in their families. As payment for his investment in social capital, the individual will earn a part of the income obtained, *y*, added to the remuneration for factors he contributes to the productive system (physical capital, human capital and labor). Furthermore, in his valuation of net expected income the individual takes into account the risk that this may not be achieved. In view of existing inequality, of the risks that he takes on is that of being excluded from the results of society and earning below the average income. By considering income and inequality simultaneously we assume that the individual takes the level of *well-being* provided by this society as a reference for his incentives to cooperate. By considering the well-known properties of the Gini index (*G*)[5], we calculate well-being as the income that everybody would enjoy if there were no inequality: $y(1-G)$.

With regard to the costs associated with investment in social capital, the cost of cooperating, measured by its equivalent in time worked, is denoted by $C(Is)$. For risk-averse individuals this cost is assumed to be increasing and, from a certain point onwards, convex ($C'(Is)>0$ and $C''(Is)>0$). Also, if the opportunity cost of the time dedicated to cooperating by a worker can be proxied by the wage $\overline{w}$[6], the direct cost attributed to investment in social capital will be $\overline{w}\,C(Is)$.

At the present time $(t=0)$ the individual plans his future path of investments in social capital up to the last period $(t=T)$ in such a way that he invests in social capital if the expected returns are greater than the costs associated with it. Therefore, given the social rate of discount ρ, investment in social capital occurs when the expected net value is positive:

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3 See in Di Pasquale and Glaeser (1998) the importance given to the duration of relationships in the study of the impact on social capital of home ownership and its effect on the permanence of individuals in a location.

4 Ostrom (1999) and Sobel (2002) consider that social capital does not depreciate, but appreciates with use. These authors point out that if the use of social capital produces good results, these will act as an incentive to new investment in social capital and, in this way, social capital increases. But in this, social capital would be no different from physical capital, in which more is invested if it is seen to be productive.

5 See the discussion in Sen and Foster (1997), chapter 2.

6 The reserve wage $\overline{w}$ is considered to include both the remuneration of labor and that of human capital.

$$\pi_i = \sum_{t=0}^{T} \frac{1}{(1+\rho)^t} \left(y_{it}(1-G) - rk_{it} - \overline{w}_t \left(1 + C(Is_{it})\right)\right) > 0 \tag{1}$$

where *k* is the stock of physical capital per employee and *r* is the return of capital.

To decide his optimal *Is* in each period, the individual must solve the following maximization problem, taking as given the endowments of physical capital and labor of the rest of society, on which the income generated, y_t depends (see paragraph 2.5 below).

$$Max_{Is_{it\in[0,...,T]}} \pi = \sum_{t=0}^{T} \left[\frac{1}{(1+\rho)^t} \left(y_{it}(1-G) - rk_{it} - \overline{w}_t \left(1 + C\left(Is_{it}\right)\right)\right)\right] \tag{2}$$

$$ks_{it+1} = \delta\ ks_{it} + Is_{it}\,. \tag{3}$$

Condition (3), which regulates the temporal evolution of social capital, is derived from the rhythms of investment and depreciation and the corresponding survival rate of investment, $\delta=(1-d)$, of *ks* accumulated in the past. The individual's stock of social capital is therefore the result of the accumulation of the corresponding investment flow over time.

2.2. The productivity of social capital: efficiency and social cohesion

As with other factors of production, to evaluate the contribution of capital assets to production we have to focus not on the stock itself, but on the flow of services provided by that capital. The productivity of social capital and its influence on costs and output derives from the services that this capital provides when it is used. The services of social capital consist of the reduction of transaction and supervision costs in the activities in which they are potentially most important because of problems of asymmetrical information and uncertainty. The capacity of an individual's social capital to perform services will depend on the relationships of mutual trust that he establishes with others, through which these costs are reduced.

As mentioned above, in drawing up the frame of reference to obtain a measure of the stock of social capital we were guided by the methodology used in the measurement of physical capital stock which, to measure *capital services*, proceeds in two stages. The first consists of converting assets of a certain type into *standard units of efficiency* to correct the effect of ageing on the productivity of the equipment. The second, to which we will refer later, combines the efficiency units corresponding to different assets in an aggregated index, weighting the services of each one of them by their respective user costs[7].

In the first stage, the conversion of a capital asset into standard units of efficiency requires us to consider the following two aspects:

a. The temporal profile of the accumulated investments and how they are affected by the loss of efficiency due to the passage of time, normal use and obsolescence. In the case of physical assets, the differences in productivity of the various *vintages* of capital are captured by the age-efficiency profile, resulting from a combination of hypotheses concerning the average life of the asset and the functional form of the loss of efficiency. However, in the case of social capital we do not consider there to be necessarily any reason for this loss to occur with the passage of time, so it would make no sense to attribute a stable average life to social capital, although it could be assumed. Alternatively, the hypothesis for dealing with this problem is to assume that loss of efficiency will occur if the trust accumulated by the individual is disappointed. The empirical problem to be solved will be the selection of an indicator of loss of trust.

   The *standard units of efficiency of a stock of social capital* ks_i result from correcting past investments in social capital by the loss of efficiency derived from the events that have affected trust negatively over time. To calculate the social capital at a moment of time t measured in units that take into account the effect of the loss of efficiency, we consider that d is the rate of depreciation of social capital, and $\delta=(1-d)$ the survival rate.

b. The flow of services provided by a certain stock, once corrected for loss of efficiency, depends on the *intensity of use or degree of utilization of the capacity installed*. In general, when measuring the services of physical or human capital we consider the degree of utilization of the capacity to be constant. With social capital, this simplifying hypothesis should not be used, since this would eliminate what may be one of the key aspects in measuring the effects of social capital: the amplitude of the relationships of mutual trust of any member of a social network. The extension of relationships of trust to individuals with whom there is no direct relationship is known as

[7] For a detailed description of the methodology for estimating physical capital, see Schreyer and Dupont (2005), together with the OECD Manual (OECD, 2001).

generalized trust [8] in the literature. The more generalized the trust, the more productive the social capital, since the network of connections will be wider and the opportunities to reduce transaction costs will reach a greater proportion of the economic relationships.

In the context of repeated games models, a player's social capital can be defined as his reputation for behaving cooperatively, or not, within a social network. A good reputation is an asset for the player as it makes him more likely to receive cooperative conduct from the agents he relates to (the favorable treatment to which the Michigan SCIG refers). However, as pointed out in Annen (2003), the value of a player's social capital depends on the density of the network of relationships of trust between him and the rest of the members of the social network, i.e. on his degree of relation with the social network to which he belongs.

The density of relationships of trust depends on three characteristics of social networks: a) their inclusiveness in the relationship of trust towards a greater or lesser number of members in the social network; b) the complexity of the social relationship network: when one of the properties of a social network is to simplify the complexity of its relationships, both the extent of cooperation and the value of the social capital are greater; and c) the capacity for communication existing within the network. Cooperation is more likely in social networks where the communication capacity is high. Consequently, to measure the amplitude with which social capital is used, it is important to value the *degree of connection* between each individual and the rest of the social network. To do this, elements considered in the studies of social networks and how they function[9] must be introduced into the methodology.

We consider individuals to be the nodes of the network of economic relationships, and let the connections of direct trust among them be the links, vectors or oriented edges that connect them. In formal terms, the network of direct connections of a population of dimension N can be represented as a *deterministic* graph, in the sense that from node i to node j either there is an oriented edge of trust $(c_{i,j}=1)$, or there is not $(c_{i,j}= 0)$. The elements $c_{i,j}$ (with value zero or one) form a matrix C of dimension ($N\times N$), called *adjacency matrix.* The value zero is assigned to the elements $c_{n,n}$ of the principal diagonal because the direct connection of an individual with himself is considered irrelevant. The oriented edges between individuals are assumed to be deterministic (they

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[8] On the concept of generalized trust see Kramer, Brewer and Hanna (1996), Kramer (1999) and Stolle (1998).

[9] See, for example, Marsden and Lin (1982), Wellman and Berkovitz (1988) and Wasserman and Faust (1992) and Hanneman (2000), Vega-Redondo (2002 and 2003) and Annen (2003).

may take the values zero or one), though the results could be extended to the case where the adjacency matrix is probabilistic.

Trust spreads through direct and indirect links. A *direct connection* (also called a *connection of order* 1) between two individuals is an oriented edge. An *indirect connection* (i.e., a connection of order p, for p=2, 3, 4,...) is a path from one individual to another (or itself) through a number p of oriented edges. To count indirect connections we can consider successive powers of C: given an integer p, C^p has entries $c^{(p)}_{i,j}$, being $c^{(p)}_{i,j}$ the number of p-th order connections from element i to element j. Connections of p-order are non-existent if $c^{(p)}_{i,j} = 0$.

Given that a higher order connection is somehow less relevant, we assume that its capacity to transmit trust will be lower the higher the order. To take this into account, we propose the construction of the following ($N\times N$)-matrix:

$$C^{\infty} = (c^{(\infty)}{}_{i,j}) = \sum_{p=1}^{\infty} \frac{C^p}{2^p (N-1)^p} . \tag{4}$$

The elements of C^{∞} are obtained by adding together all the connections of orders 1,2,3,... leaving an individual i. To do this we add elementwise the corresponding C^p's, duly weighted, so that the series that generates each element of C^{∞} will be convergent[10].

The *degree of connection* c_i of individual i with the rest of the individuals in the network is defined as follows:

$$c_i = \frac{1}{2}\left[\sum_{k=1}^{N} c^{(\infty)}{}_{i,k} + \sum_{k=1}^{N} c^{(\infty)}{}_{k,i} \right] . \tag{5}$$

We can observe that an individual's degree of connection depends not only on the oriented paths departing from him (the first sum, formed by the elements of row i of the matrix), but also on those ending at him (the second sum, formed by the elements of column i of the matrix. In this way we capture the idea of reciprocity that is highlighted by social capital. It should also be emphasized that not only do we compute an individual's direct and indirect relations with others, or of others with him, but also the relations of the other individuals with each other. Consequently, an individual's degree of relation also improves (worsens) if the degree of relation of the other individuals with each other improves (worsens). This characteristic of the proposed measure of the

[10] See the demonstration of the convergence of the series in Appendix 1.

degree of connection allows us to capture adequately the effect of the network of relationships of trust.

It follows that the degree of connection of any individual is a number in the interval [0,1]. If an individual *j* is isolated, i.e. if he trusts nobody and nobody trusts him, it will be true that $c_{j,i} = 0$ and $c_{i,j} = 0$, for every *i*. In this case, $c_j = 0$. On the other hand, if he is directly connected with all the others it will be true that $c_{j,i} = 1$ and $c_{i,j} = 1$, for each pair ($i \neq j$) and $c_j = 1$. If all the individuals are in this latter situation we say that the social network is *completely connected* and the *maximum degree of generalization of trust* has been reached. In this case, the matrix associated with the indicators of the degree of connection c_i will have values equal to one in all its elements, except in those of the principal diagonal, which will have zero value by construction[11].

2.3. The flow of social capital productive services

As mentioned above, the capacity of a unit of capital to contribute to the production of output depends on the *flow capital services (fks)* deriving from it. In this case*, fks* results from the utilization of social capital in a social network, and is given by the accumulated capital measured in units of efficiency ks_i and the individual's degree of connection, c_i:

$$fks_i = c_i ks_i . \qquad (6)$$

If the individual is completely related ($c_i=1$), the social capital makes the maximum contribution possible and the flow of services can be proxied by the stock[12]. If the individual is completely isolated ($c_i=0$) the contribution of his social capital will be nil, as occurs in the case of unused capital goods.

The economic value of the flow of social capital services is obtained, as in the case of physical capitals, by considering that the user cost of capital is an adequate reflection of its productivity (Jorgenson, 1963). The user cost is the price to be paid for the services of a capital asset and should cover, in equilibrium, the costs borne by the owner of that asset: the depreciation *d* and the financial opportunity cost ρ in real terms. Since we are expressing all magnitudes in real terms, we define the user cost u_i of a unit of social capital [13] as the sum of its two components:

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[11] For the formal justification of the above affirmations see Appendix 1.

[12] As we have mentioned, this is habitual in measures of physical capital that do not consider the problem of the utilization of installed capacity. See Schreyer and Dupont (2005).

[13] It is reasonable to assume that social capital has a financial opportunity cost because it had an investment cost that was evaluated in order to make it comparable with other labor or capital costs.

$$u_i = \rho_i + d_i \tag{7}$$

and therefore the value of the capital services, vks_i, will be

$$vks_i = u_i fks_i = (\rho_i + d_i) c_i ks_i \,. \tag{8}$$

2.4. The aggregation of individuals' social capital

The next step in calculating the index of social capital services of an economy is to aggregate the social capital services of the individuals participating in the social network. For this purpose we proceed, once again, in the same way as when we aggregate the services of different assets in the case of physical capital, using as weights in the aggregation the prices of the services, i.e. the corresponding user cost of capital (OECD, 2001).

Nevertheless, we must distinguish between the aggregation of individual capitals or their services, and the aggregation of the value of the capital services. When we aggregate values of the capital services, expressed in units of the same period, they can be added together without any problem:

$$VKS = \sum_{i=1}^{N} vks_i = \sum_{i=1}^{N} \left(\rho_i + d_i\right) c_i ks_i \,. \tag{9}$$

On the other hand, if we are aggregating the capitals or their services, as occurs in the case of different assets of physical capital, we have to bear in mind that these variables are heterogeneous and cannot be added together directly. The weight v_i of the user cost of i in the aggregated user cost is established by the values of capital services:

$$v_i = \frac{vks_i}{\sum_{j=1}^{N} vks_j} \,. \tag{10}$$

The aggregation of the various individual capital services into the aggregated social capital services KS is done by means of a multiplicative Tornqvist index, which uses the weightings we have just defined as exponents. Furthermore, in the aggregation of individual social capital we take into account that the benefits (services) of social capital reach more or fewer individuals depending on the size of the network of trust, measured by the number of its nodes that are connected *(N)*:

$$KS = N \prod_{i=1}^{N} fks_i^{v_i} \,. \tag{11}$$

Substituting (6) in the above expression, we obtain

$$KS = N\prod_{i=1}^{N} c_i^{v_i} ks_i^{v_i} \tag{12}$$

indicating that the aggregated social capital services depend on four variables: the accumulated individual stocks of social capital measured in units of efficiency, the amplitude of the network, the degree of connection of the individuals and the weight of the user cost.

A particular case, of special interest to the empirical application of this methodology at aggregated level, is that which considers a representative *agent* of a society in which all individuals are equal in their endowments of social capital, in their user cost and in their degree of connection. In this case $v_i = 1/N$, $ks_i = ks$, $c_i = c$, and we immediately verify that:

$$KS = N\, fks_i = N\, c\, ks. \tag{13}$$

The aggregated social capital services *KS* intervene in the production function and their quantity is a measure of the *volume of productive social capital* or, if preferred, a measure of the volume of productive social capital services in the terminology of the methodology for measuring physical capital (OECD, 2001). The larger the size of the social network (*N*) and the more connected it is, the greater *c*, (i.e. the greater the generalization of the networks of trust), the greater the contribution of social capital, *ks*, to production will be.

2.5. The optimal investment in social capital

Given all the above, the condition to be maximized by the individual investor in social capital shown in (2) can be rewritten taking into consideration the per-worker product function. The production function is assumed to be a Cobb-Douglas, in which the physical capital *(K)*, human capital *(H)*, labor *(L)* and aggregated social capital *(KS)* factors are combined to obtain the level of income. If the aggregated social capital is expressed as a function of the individual social capital using equation (12), the per-worker production function can be expressed as follows:

$$y_t = A_t k_t^{\alpha} h_t^{\phi} \frac{KS_t^{\ \beta}}{L_t^{\beta}} = A_t k_t^{\alpha} h_t^{\phi} N_t^{\beta} \frac{\left(\prod_{j=1}^{N} c_j^{v_j} ks_{jt}^{v_j}\right)^{\beta}}{L_t^{\beta}} \tag{14}$$

where the variables per worker are reflected in lower-case letters.

Thus, an individual i faces the problem of maximization defined by equations (2), (3) and (14). The first order conditions for each period t are as follows[14]:

$$\frac{1}{(1+\rho)^t}\overline{w}_t C'(Is_{it}) = \beta(1-G)\sum_{l=0}^{T-t-1}\frac{\delta^l}{(1+\rho)^{t+l+1}} y_{it+l+1}\left[\sum_{j=1}^{N} v_j \frac{\lambda_{ij}}{ks_{jt+l+1}}\right] \tag{15}$$

where $\lambda_{ij} = \frac{\partial Is_{jt}}{\partial Is_{it}}$ is the conjectural variation measuring individual i's expectation of the change that will occur in the decision of another individual j to invest in social capital, in response to changes in i's own investment in social capital.

According to this condition, investment in *ks* takes place up to the point where the marginal cost attributed in the period to the effort to cooperate (reflected on the left-hand side of the expression) equals, at present values, the marginal income expected with the passage of time (on the right hand side).

The marginal cost of cooperating depends on the equivalent, in working time, to the effort required by cooperation and the opportunity cost of that same time, proxied by wages, $\overline{w}$. The effort required by cooperation is subjective and depends on individuals' attitudes, predominating values and their degree of assimilation, the functioning of institutions, the system of social sanctions, etc. For an altruist, the cost of that effort would be zero, so he would trust (invest in social capital) without any cost constraint.

On the right hand side of the expression, the marginal income of the investment in social capital depends on the following: the well-being associated with the average income expected by workers (y) corrected for inequality (1-G); on the contribution of social capital to income (β); on the survival rate of the stock of social capital (δ); on the temporal horizon of the flow of net income from social capital (T-t); on the rate of discount to be applied to future income (ρ) and, finally, on the average of the quotient between the conjectural variation of individual j with respect to his social capital (λ_{ij}/ks_{jt}) weighted by each individual's participation in the user cost (v_j).

Depending on how it is assumed other individuals will react to the decision-maker's investment in social capital, the first order condition can take a different form.

[14] See Appendix 2.

Of the variety of solutions that may arise from equation (15) as a function of the values of λ, two particular cases stand out[15].

i) $\lambda_{ij}=0 \;\; \forall \;\; j \neq i$. In this case, agent *i*'s decisions on the magnitude of his investment in social capital do not alter the optimal investments of the other agents and the first order solution can be written as follows:

$$\overline{w}_t C'\left(Is_{it}\right)=\beta v_i \frac{y_t}{ks_{it}}\left(1-G\right)\frac{1-\left(\frac{\delta}{1+\rho}\right)^{T-t}}{1+\rho-\delta} \tag{16}$$

in which the marginal income of social capital depends, as well as on the factors commented above, on the weight of the user cost of individual *i*'s social capital in the user cost of total social capital.

ii) If we assume the case of the representative agent of a society in which all individuals are equal in their endowments of social capital ($ks_j=ks \;\; \forall \;\; j$), in the costs of use that they face ($v_j=1/N \;\; \forall \;\; j$) and in the response to the variations in social capital of any individual of the sample ($\lambda_{ij}=\lambda \;\; \forall \;\; j \neq i$), the condition defined by equation (15) can be written as follows:

$$\overline{w}_t C'\left(Is_{it}\right)=\beta\left(\frac{1+\lambda(N-1)}{N}\right)\frac{y_t}{ks_{it}}\left(1-G\right)\frac{1-\left(\frac{\delta}{1+\rho}\right)^{T-t}}{1+\rho-\delta}. \tag{17}$$

Now the optimal social capital also depends on the population and on the conjectural variation λ. We can establish an additional assumption whereby when one individual decides to invest in social capital he conjectures that the rest are going to act reciprocally towards him, making a similar investment ($\lambda=1$). In this hypothesis, the first order condition of the individual social capital does not depend on participation in the user cost of social capital. The condition of equilibrium in this case is represented by equation (18).

$$\overline{w}_t C'\left(Is_{it}\right)=\beta\frac{y_t}{ks_{it}}\left(1-G\right)\frac{1-\left(\frac{\delta}{1+\rho}\right)^{T-t}}{1+\rho-\delta}. \tag{18}$$

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15 In order to reach the following results it is assumed that individuals' expectations of the future evolution of *y*, *k* and *ks* respond to past trends and to the conditions of continuous growth in equilibrium (constancy of the capital / product ratio). See Appendix 2.

2.6. The determinants of the optimal stock of social capital

To analyze the determinants of the optimal stock of individual capital we will focus on the case of the representative individual –case *ii)* in the previous section. The stock of capital is derived from expression (17) by solving *ks, volume of social capital*, which will be given by the following expression.

$$ks_{it}^{*} = \beta\left(\frac{1+\lambda(N-1)}{N}\right)\frac{y_t}{\overline{w}_t C'(Is_{it})}(1-G)\frac{1-\left(\frac{\delta}{1+\rho}\right)^{T-t}}{1+\rho-\delta} \quad (19)$$

For the particular case of the representative agent, once *ks* have been calculated, the *volume of the aggregated social capital services KS* is

$$KS_t^{*} = N_t c ks_t^{*}. \quad (20)$$

Therefore, the equilibrium level of individual social capital depends on a set of economic and social circumstances represented by the following variables, which affect, *caeteris paribus*, the optimum of *ks,* as follows:

a. Social capital increases with the income per capita (and the productivity per worker), because the expected future payments of cooperation are greater.

b. Social capital decreases with an increase in inequality, because the risk of being excluded from the payments made by that society reduces incentives to trust.

c. Social capital decreases with the increase of the average age of the population, because the number of years during which positive payments can be obtained is reduced.

d. The investment in social capital increases with the number of years during which an individual expects to participate in the social network, because the horizon for obtaining net payments is widened. For individuals who do not intend to emigrate, *T* can be considered equal to life expectancy.

e. The investment in social capital decreases with the increase in the reserve wage, because the part of the remuneration considered *favorable treatment* is reduced and the subjective cost of investing in *ks* increases.

f. The investment in social capital increases with the reduction of the marginal cost of cooperation, because less effort is required to cooperate.

g. Increases in the contribution of social capital to the income generated (β) have positive effects on the social capital of the individual.

h. The effects of variations in the temporal rate of discount and in the rate of depreciation do not have a definite sign.

i. Social capital increases with the increase in the expected reciprocity of agents to the decisions by the rest of the individuals around them to invest in social capital (λ).

Aggregated productive social capital, KS^*, is also a function of the above variables and, additionally, depends positively on the dimension of the network, *N*, and its degree of connection, *c*.

3. The estimation of social capital: the empirical model

The model of investment and accumulation of social capital in the above section, specified for the case of the representative agent, provides a method for estimating its value on the basis of the variables intervening in expressions (19) and (20). However, applying this methodology to the calculation of social capital also requires a system of information suitable for estimating the values of each of the variables.

In general, the information necessary to calculate the stock of the various types of capital in economies is not available in its entirety, because the part of national accounts systems that refers to production and income, and their components, is much more advanced than the accounts referring to property, assets and wealth. In fact, not all the information needed to calculate physical capital is available in most countries, nor in the case of human capital do data banks exist with reliable estimations.

In social capital, information limitations are even greater, and for this reason the empirical application of the methodology developed in the previous section only represents an initial approximation. Nevertheless, some of the determinants of social capital are regularly estimated by economic statistics. Thus, it is possible for many economies to use standardized *proxies* of the variables *Y, L, y, r, w, T, t, G* by resorting to the figures of the National Accounts, labor, demographic or financial statistics, household surveys and so on. Other determinants of social capital are variables for which the information is not available and there is not even any agreement as to how they should be defined and measured. Such is the case for the degree of connection of the social network, *c*; the marginal cost of investing in social capital *C'(Is)*; the rate of survival δ; the reserve wage $\bar{w}$; the contribution of social capital to income β; and the response of agents to an individual's investments in social capital (λ). Consequently, to estimate social capital, proxies of these variables will have to be related, based on hypotheses that ensure the consistency of their values with certain economic relationships.

3.1. Selected proxies

Given the macroeconomic perspective of this paper, the proxies chosen for the five problematical variables are as follows:

The marginal cost of investing in ks, C′(Is)

The cost individuals attribute to investment in social capital is considered to depend on the scales of values, the individuals' preferences and the *average distance* between individuals in each society. In this study we choose to proxy this variable by estimating it using an indicator of human capital, for the reasons given by Coleman (1988) when he underlines the role of the *closure* in the effectiveness of social norms and the relationship between social capital and human capital. This is also the proposal to come out of recent studies into the relationships between human capital and social capital (Gradstein and Justman, 2000; Temple, 2001; Annen, 2003). Our empirical approach considers a measure of the cost of investing in social capital derived from the percentage of individuals with at least secondary education, on the understanding that this level of education (currently compulsory in many developed countries) ensures the transmission of a set of basic common values and knowledge. This percentage, in this interpretation, constitutes a basic indicator of a society's cultural homogeneity. The indicator of the marginal cost of the investment in social capital will be 100 minus this percentage.

Another alternative approach to the cost of trust is to consider that it decreases for individuals accustomed to participating in horizontal networks, such as voluntary associations. In this case we can use as a proxy of the cost of social capital the variable which, according to Putnam's approach, is in itself a measure of social capital Nevertheless, the limitations on the availability of information on this variable for the set of countries analyzed and its heterogeneity lead us to use the first indicator.

The rate of depreciation d and the rate of survival δ of social capital.

In social capital, the rate of depreciation depends on the frequency with which the expectations of favorable treatment are disappointed. The most important cause of this for most of the population is losing one's job, because it excludes the individual from the main source of access to income and from one of the basic circuits of social relations: work. We consider that the rate of unemployment proxies the rate of depreciation of social capital. The rate of survival of social capital depends on the rate of accumulated depreciation.

The degree of connection of the social network c

Unlike other approaches to social capital, the degree of connection is here *just one* determinant of social capital and not *the only* one. Since for the moment there are no data offering measures of the degree of connection that respond to the concept used in the theoretical model, we explore *proxies* in two directions:

Firstly, we can use the measures of the *degree of generalized trust* (*trust*) corresponding to the surveys by the WVS or GSS as a proxy of *c*. This is limited by the fact that annual series are not available in most of the countries in these surveys. Alternatively, it is feasible to proxy this variable by means of indicators of the degree of trust prevailing in financial or commercial relationships. In fact, *trust* games and experimental studies of trust often consider situations similar to those that occur in financial systems, in which an individual deposits funds and trusts their investment to the banks, or in which other individuals receive credits (Berg, Dickhaut and McCabe, 1995). If we consider the amplitude of the credit the economy grants in relation to the volume of transactions within it, we may have a reasonable *proxy* of what proportion of economic agents are connected by relationships of trust. Annual information on this indicator does exist in many countries, though the data also pose some problems of homogeneity[16].

The reserve wage $\overline{w}$

National Accounts statistics include information about the compensation of employees. However, this is not the variable that interests us here. Compensation of employees includes remuneration for labor in the strictest sense, for human capital and remuneration for social capital. The objective is therefore to analyze which part of the wage received is considered to be the cost of compensation for labor and which part remuneration of social capital. These variables, $\overline{w}$ and β, can be proxied as structural data of the economic system and obtained from the estimation of a production function.

[16] The volume of credit as an indicator of the extension of trust networks may be biased downwards in financial systems strongly oriented to the financial markets, in which credit has less weight. In any case, if this is a structural feature it will not have too much influence on the evolution of the indicator.

Let's suppose that the production function takes the form:

$$Y = AK^{\alpha} H^{\phi} KS^{\beta} L^{\gamma} . \tag{21}$$

If we assume, as is habitual, that the remunerations of the factors coincide with their marginal productivities, the following relation will be true:

$$\overline{w} = (\gamma + \phi)\frac{Y}{L} \tag{22}$$

from which the reserve wage $\overline{w}$ can be obtained on the basis of the usual income and employment statistics and the estimated value of γ and ϕ. In turn, parameter β is also obtained from the estimation of equation (21).

If β, γ and ϕ are constant they will not affect the variability of *ks,* and we could use an *index of ks* in the estimation of differences in the production function without knowing the value of these two variables. Using expression (22), equation (19) can be rewritten as follows:

$$ks_t^* = \frac{\beta}{\gamma + \phi}\left(\frac{1 + \lambda(N-1)}{N}\right)\frac{1}{C'(Is_t)}(1 - G)\frac{1 - \left(\frac{\delta}{1+\rho}\right)^{T-t}}{1 + \rho - \delta} . \tag{23}$$

in which, giving β, γ and ϕ arbitrary values (e.g. $\beta=1$, $\gamma=1$, $\phi=1$), it is possible to calculate the index of *ks*.

Having estimated equation (21) under these conditions, we know the value of $\beta/(\gamma+\phi)$, and on this basis can calculate the reserve wage, $\overline{w}$, and through (23), the level of *ks* and, therefore, of the aggregate *KS*.

Conjectural variation of the investment in social capital (λ)

As well as focussing on the case of the representative agent, we adopt the simplifying assumption that the individuals in a society act reciprocally to the investment decisions of any one of them, i.e. $\lambda=1$.

3.2. Estimation for a sample of countries

To illustrate the application of the proposed method, we estimated the social capital in a broad set of OECD economies. These are economies with powerful databases and with a variety of levels of development and trajectories, thus enabling us to appreciate different profiles of how social capital has evolved. The period studied covers the years from 1970 to 2001. Table 1 and Appendix 3 show the statistical sources used to obtain the proxies necessary for the determination of *KS* in accordance with expressions (20) and (23). When analyzing the results of these estimations, the necessary precautions to deal with problems of comparability of statistical sources must be borne in mind. To obtain the information shown in Table 1 we sought the highest degree of homogeneity in the data source, so that comparisons between countries would be as robust as possible, although this objective is not always completely guaranteed by international databases.

TABLE 1: Variables and data sources in the estimation of social capital

		Proxy used	OECD sample (1970-2001)
C	**Degree of connection of the network**[1]	Loans / GDP	Monetary Survey (International Financial Statistics, IMF) y OECD
C'(Is)	**Marginal cost of investment in social capital**	% of working–age population with at least secondary education	Barro-Lee (2002) database: International Measures of Schooling Years and Schooling Quality
G	**Income inequality index**	Gini Index	World Income Inequality Database (ONU) and own elaboration
d	**Social capital depreciation rate**	Unemployment rate	Labour Force Statistics (OECD) and Economic Outlook (OECD)
ρ	**Discount factor**	Constant discount rate 4%	
T-t	**Life expectancy at the average age of the population**	OECD Health Data, Eurostat and official statistical offices. *Life expectancy of the population of 40 years, corrected by the average age of the population.*	
N	**Employment**		Labour Force Statistics (OECD) and Economic Outlook (OECD)
Y	**GDP**	GDP	National Accounts (OECD)
w	**Compensation of employees**	Compensation of employees / Employment	National Accounts (OECD)
K	**Stock of physical capital**	Non-residential physical capital stock	ISDB (OECD), STAN (OECD) and Economic Outlook (OECD) databases *Gross Capital Stock*

[1] The variable c in the theoretical model is limited between 0 and 1, so the Credits / GDP ratios have been re-scaled by the maximum value for the countries of the OECD in the sample period.

As we have pointed out, the estimation of the social capital series depends on the product elasticities of social capital, β, and on the contributions of labor, γ, and of human capital, ϕ. If we assume that these unknown parameters are constant, as is usual in the literature on economic growth, we can use econometric techniques to estimate them.

By expressing all the variables in equation (21) in per-worker terms, taking logarithms and first differences and assuming a constant rate of technical progress, we obtain:

$$dy_t = \alpha dk_t + \beta dks_t + \gamma dl_t + \phi dh_t \ . \quad (24)$$

Given that the rate of growth of social capital (*dks*) does not depend on the values of the parameters of the production function as they are assumed to be constant, they can be estimated by econometric techniques on the basis of the information available. Table 2 shows the results of the estimation of the production function. The econometric specification adopted includes per capita income as a dependent variable and four productive factors –physical capital, labor, human capital and social capital – as independent variables. Constant returns to scale are imposed and the estimations are performed using the random effects model[17] of panel data techniques. The sample used for the estimation consists of all the countries for which physical capital data are available, i.e. the fifteen largest countries of the OECD. The parameters accompanying social capital, labor and human capital in this estimation are applied to the calculation of the social capital of the different economies considered. Additional estimations were performed for alternative specifications and the results showed very similar values of the ratios $\beta/(\gamma+\phi)$ around 0.05.

TABLE 2: Estimation of the production function

	1970-2001
Constant	0,0066 (5,00)
Dk	0,4267 (10,31)
Dks	0,0256 (3,21)
Dl	0,4710
Dh	0,0766 (2,23)
Adjusted R^2	0,23
Hausman Test	2,49
P-value	0,48
Observations	464

Note: Estimation in logarithmic first differences. Dependent variable: annual growth of real GDP. In parentheses: t-ratio. Random effects model is estimated. Constant return to scale are imposed

[17] The values of the Hausman test do not permit rejection of the null hypothesis of absence of correlation between the individual effects and the random disturbance; the random effects model is therefore consistent.

4. Evolution of social capital in the OECD countries

Many of the debates around the role of social capital take place from an international perspective. It is therefore of interest to have available estimations of social capital for a broad set of countries with substantial differences in their normative, cultural, and educational frameworks, in their levels of income or in the degree of unemployment. Appendix 4 presents the social capital series obtained with the methodology described in the two preceding sections for 23 OECD countries.

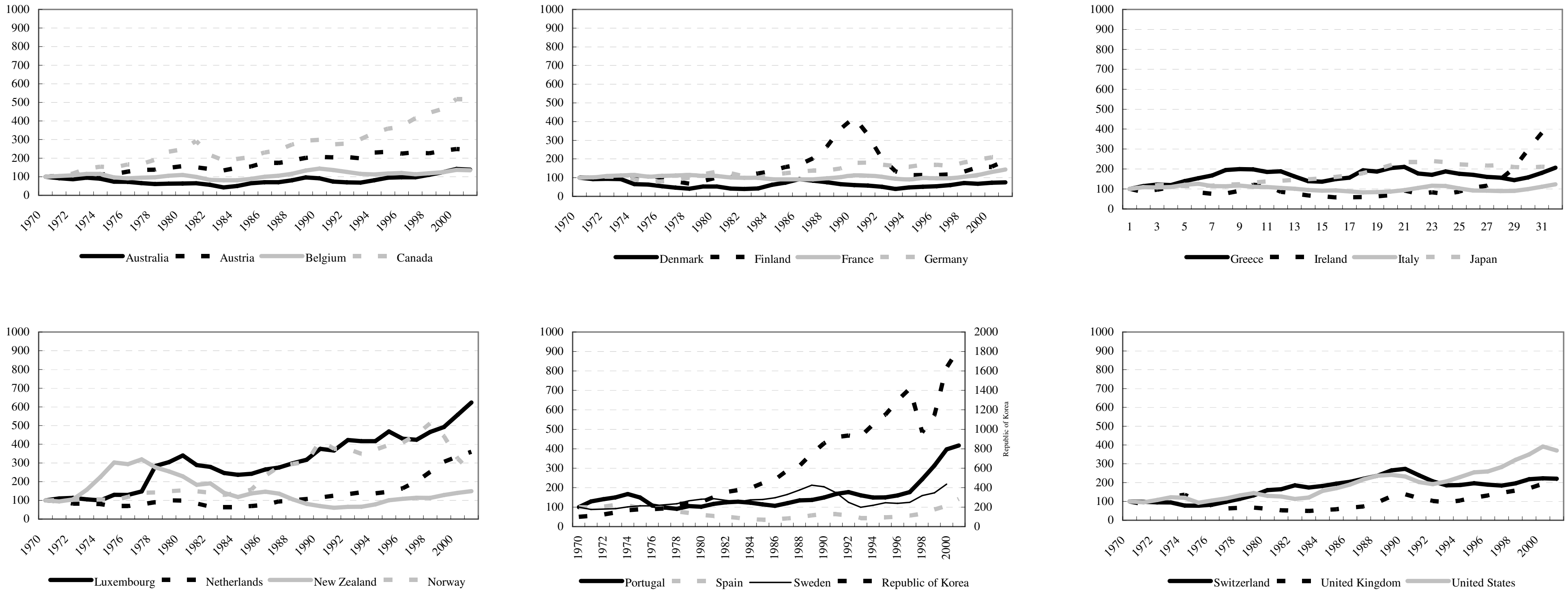
The various panels in Figure 1 show the evolution of the index of aggregated volume of social capital calculated, taking 1970 as the base year for each country and indexing all the data of each country in relation to this base year. We find that in all the countries except Denmark there were a growth in the levels of social capital during the more than thirty years included in the analysis. Nevertheless, during the time span analyzed, periods of decrease in the volume of services from social capital appear in many economies.

Figure 2 represents the ranking of the annual rates of variation in the countries included in the estimation. Among the countries with high rates of variation of social capital are Korea, Luxembourg, Canada, Ireland, Portugal, United States and Netherlands, while the lowest growths of social capital are observed in Italy, Belgium, Australia, Spain, France or New Zealand. Additionally, in Denmark social capital actually decreased over the period.

Certain countries stand out for their high levels of social capital resulting from the acceleration of accumulation in the 1990s. Such is the case of Korea, Netherlands, Luxembourg, Canada and Ireland in recent years. Others, such as Belgium, Finland, Greece, Japan, Norway, Sweden and Switzerland are characterized by the tendency to stagnate, or even the reduction, of their capital of trust in the last decade.

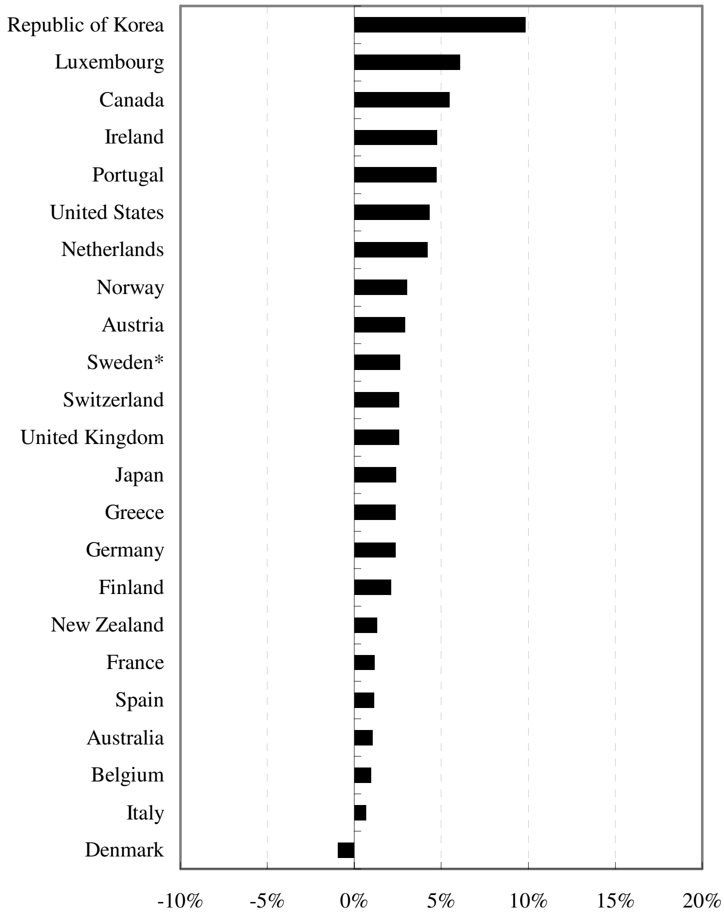
The literature on social capital has on occasions presented the United States as a country whose social capital is in decline, based on the most frequently used indicators of social capital (indices of associationism and responses to the GSS or WVS on trust in others). The evolution of our estimation (Figure 1, last panel) shows an increasing trend, although the index followed an irregular path, with an initial period of relative stagnation (from 1970 to 1984) and a second one of growth, showing significant acceleration in the early 1990s. Since social capital does not decrease significantly, except for short periods, we could say that the economic foundations of trust have not fallen during recent decades in that country. This is to be expected of an economy

FIGURE 1: Social capital in OECD countries. 1970=100.



Source: Own elaboration from statistical data sources in Appendix 3

FIGURE 2: Annual growth rate of social capital in the period 1970-2001



* *1970-2000*

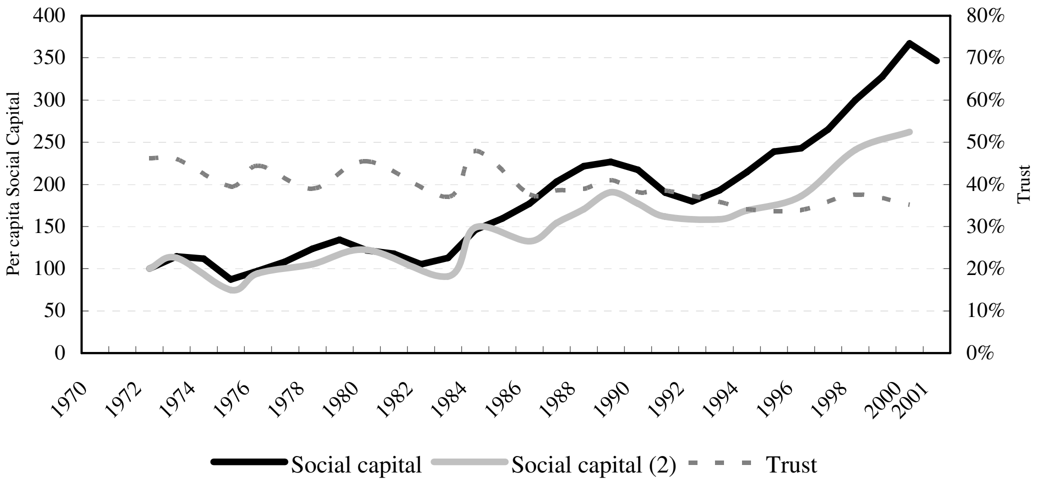
Source: Own elaboration from statistical data sources in Appendix 3.

whose income is growing, in which notable educational improvements took place during this period (which should favor cooperation), whose rates of unemployment were moderate and in which participation in financial relationships is widening.

This vision of the evolution of trust and social capital, based on the results of the estimation, is clearly different from one that would be derived from taking the responses to the question on trust in the *GSS* (*or WVS*) as an index of social capital. In the case of the USA, this variable has a long series, so it is possible to compare the two results. Figure 3 clearly shows the difference between the two indices and it is evident that the valuations affirming that trust is on the decrease –based on the evolution of the variable *trust*- are not endorsed by our indicator of social capital. We can also observe that, if we use the variable *trust* in the calculation of *KS* (as a *proxy* of the degree of social connection instead of the variable based on the credit granted), the increasing trend of social capital is maintained and its growth in the final period is also confirmed, albeit with a somewhat more irregular profile.

FIGURE 3: Social capital and trust in the US. Different hypothesis for c

Per capital volume index of social capital (1970=100) and Trust (%).



Note: Social capital (2): c is proxied by Trust instead of the ratio loans / GDP.

In the series of Trust and of social capital (2) years for which information is available are marked. The rest of the years data are interpolated.

Source: Own elaboration and GSS.

5. Social capital and economic growth

The aspect of social capital to which economists have paid most attention in the literature is its importance for economic growth. The complexity of present-day economies leads us to think that without an element that reduces transaction and supervision costs and limits the problems of asymmetrical information, it would be difficult for economies to progress. Consequently, it makes sense to explore whether the social capital estimated is able to explain part of the evolution of *output* and productivity. Some studies in the literature test the importance of social capital in explaining economic growth, although generally they do not use direct measures of social capital, but rather other types of institutional or social indicators. Thus, for example, Temple and Johnson (1998) use an indicator of "social capability" constructed from 25 economic and social characteristics from a sample of 74 developing countries. Knack and Keefer (1997) find that trust and civic cooperation are associated with stronger economic performance, whereas such a relationship is not found when using associational activity. Hall and Jones (1999) find a close association between output per worker and what they call "measures of social infrastructure". Zak and Knack (2001) also find a positive relation between trust and economic growth.

On the basis of the methodology developed to measure social capital, and its estimation, in this section we test the capacity of the proposed measure to explain economic growth. To do this we take an important reference in the literature as our starting point: the Mankiw, Romer and Weil (1992) model of growth. Since information on the stock of social capital is available for a broad set of countries for the period between 1970 and 2001, we use both the cross-section and the temporal dimensions of the data. Our analysis will therefore be similar to that of Islam (1995).

We consider an economy in which four *inputs* exist: labor (*L*) and three kinds of capital, physical (*K)*, human (*H)* and social (*KS*). We assume that the production function is a Cobb-Douglas, so that production at a moment in time *t* can be written as follows:

$$Y_t = K_t^{\alpha} H_t^{\phi} KS_t^{\beta} (A_t L_t)^{1-\alpha-\beta-\phi} \tag{25}$$

where A is the level of technology. L and A are assumed to grow exogenously at constant rates n and g:

$$L_t = L_0 e^{nt}\,;\; A_t = A_0 e^{gt}\,. \tag{26}$$

The model assumes that the rates of saving dedicated to investment in physical, human or social capital are constant. Let s_k, s_h and s_{ks} be the rates of saving corresponding to physical, human or social capital respectively, and k, h, ks and y the stock of physical, human, social capital and the level of income per effective unit of labor (*AL*). As in Mankiw *et al.* (1992) we assume that the three accumulative factors depreciate at the same rate[18] δ. Additionally, we assume that $\alpha+\beta+\phi<1$, meaning that there are diminishing returns on all types of capital. The steady state can be characterized by the following equations:

$$k^* = \left(\frac{s_k^{\;1-\beta-\phi} s_h^{\;\phi} s_{ks}^{\;\beta}}{\delta+n+g} \right)^{\frac{1}{1-\alpha-\beta-\phi}}\,;\; h^* = \left(\frac{s_k^{\;\alpha} s_h^{\;1-\beta-\alpha} s_{ks}^{\;\beta}}{\delta+n+g} \right)^{\frac{1}{1-\alpha-\beta-\phi}}\,; ks^* = \left(\frac{s_k^{\;\alpha} s_h^{\;\phi} s_{ks}^{\;1-\alpha-\phi}}{\delta+n+g} \right)^{\frac{1}{1-\alpha-\beta-\phi}}\,. \tag{27}$$

---

[18] In developing the measure of social capital we have assumed the existence of a certain rate of depreciation that would not necessarily coincide with the rate of physical or human capital. For the sake of simplicity, we adopt the assumption of equality in the rates of depreciation of the three types of capital, though the development of the model would be similar even if different rates of depreciation were assumed.

On the basis of these equilibrium values of the factors of we can write the per capita income corresponding to the steady state as a function of the rate of saving (rate of investment) and the volume of human and social capital stock:

$$\ln\left(\frac{Y_t}{L_t}\right) = \ln A_0 + gt - \frac{\alpha}{1-\alpha}(\delta + n + g) + \frac{\alpha}{1-\alpha}\ln s_k + \frac{\phi}{1-\alpha}\ln h + \frac{\beta}{1-\alpha}\ln ks\,. \tag{28}$$

Taking (28) into account we can write the equation describing behavior around the steady state. For this purpose, let $\hat{y}^*$ be the level of income per worker in the steady state and $\hat{y}_t$ the current value of the income per worker. Approximating around the steady state, the pace of convergence is given by:

$$\frac{d\ln \hat{y}_t}{dt} = \psi\left(\ln \hat{y}^* - \ln y_t\right) \tag{29}$$

where $\psi=(n+g+\delta)(1-\alpha-\beta-\phi)$. Operating on the basis of this equation we arrive at the equation that constitutes the base for our empirical test:

$$\begin{aligned}\ln y_{t2} &= \left(1-e^{\psi\tau}\right)\frac{\alpha}{1-\alpha}\left[\ln s_k - \ln(n+g+\delta)\right] + \left(1-e^{\psi\tau}\right)\frac{\phi}{1-\alpha}\ln h \\ &+ \frac{\beta}{1-\alpha}\ln ks + e^{-\psi\tau}\ln y_{t1} + \left(1-e^{\psi\tau}\right)\ln A_0 + g(t_2 - e^{-\psi\tau}t_1)\end{aligned} \tag{30}$$

where y_{t2} is the level of income per worker at a given time, y_{t1} the level of income at the start and $\tau=t_2-t_1$ the time between t_2 and t_1. As shown by Islam (1995), this equation corresponds to the usual formulation of a dynamic panel, $(1-e^{-\Psi\tau})\ln A_0$ being the individual effects (in our case countries) and $g(t_2-e^{-\Psi\tau}t_1)$ temporal effects.

Since the aim of this section is to test the results of the determinants of economic growth when social capital is included as a productive factor, we take the study by Islam (1995) as reference. To ensure that the results are coherent with those obtained in his study we proceed as follows. First we construct the variables necessary for the estimation following Islam (1995) as closely as possible. Then we replicate the estimations obtained in the reference study for the same period (1960-1985) and for the period for which we have been able to construct the bank of data on social capital (1965-2000). Thirdly, we repeat the estimations including social capital in order to value its capacity to explain economic growth.

The data panel is constructed, as in Islam (1995), by dividing the period of analysis into shorter intervals of five years. Periods of one year may be too short to allow an analysis of convergence. On the other hand, the longer the periods, the less realistic may be the assumptions of constancy in the rates of population growth and of depreciation. The period 1965-2000, therefore, contains seven sub-periods: 1965-1970, 1970-1975, 1975-1980, 1980-1985, 1985-1990, 1990-1995 and 1995-2000. The estimations are performed for 21 OECD countries, coinciding with Islam's (1995) third sub-sample[19].

The dependent variable, per capita GDP in real terms, and the rate of variation of population *(n)* between the two periods analyzed were obtained from Heston, Summers and Aten (2002). As in Mankiw *et al*. (1992) and Islam (1995) we use a constant value of 0.05 as proxy of $(g+\delta)$. The stock of human capital, *h*, is proxied by the average years of education of the population aged over 15 taken from the Barro and Lee (2000) data base. The rate of investment was also obtained from Heston *et al*. (2002) and corresponds to the investment share of GDP in constant terms.

To test whether the different statistical sources, definitions of variables and periods of analysis generate differences in the estimations results from those of Islam (1995), columns (1) and (2) of Table 3 give the results of the estimation of equation (30) using Least Squares Dummy Variables (LSDV) for the same period examined by Islam (1960-1985). The specifications do not include social capital because it was not possible to construct the variable for years prior to 1970. If the results are compared with the third column (OECD sample), restricted estimation, obtained by Islam (1995) in his table 4, we can verify that they are similar. The explanatory capacity of both models is high, in both cases over 0.96. On the other hand, we obtain an estimate of the elasticity of output with respect to capital of 0.35, whereas Islam (1995) reports a relatively lower level of 0.20. Similar results are obtained when human capital is included in the estimation. Islam's rate of convergence is 0.09, our estimation is 0.08, while the values of output elasticity relative to physical capital are respectively 0.35 and 0.20. In both cases, human capital presents a negative contribution to output (-0.04 in the case of Islam, 1995; and -0.09 in ours). The similarity between the results of the estimations with and without human capital is a phenomenon already highlighted by Islam (1995)

[19] We include all the countries in Islam (1965) except Turkey, for which we were unable to estimate the stock of social capital. Also, in the span 1965-1970 Germany is not considered because the population data for 1965 are not available. Specifically, the countries analyzed are the fourteen members of the European Union (except Luxembourg), Australia, Canada, Japan, New Zealand, Norway, Switzerland and the United States.

and derives from the non-significance of the coefficient of human capital in the regression. This result, also obtained in other studies, is generally attributed to the discrepancy between the theoretical variable *H* and the proxies used in the regressions[20]. The results obtained are therefore comparable to those of the reference article for the common period, though the rates of convergence are slightly lower, and the output elasticity slightly higher.

TABLE 3: Estimation of the Makiw, Romer and Weil (1992)-Islam (1995) model including social capital
Sample of 21 OECD countries

	1960-1985		1965-2000					
	LSDV		LSDV			GMM		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ln y $_{t-1}$	0.6670	0.3730	0.7686	0.7736	0.6923	0.5341	0.6042	0.5094
	(13.20)	(13.03)	(10.94)	(10.05)	(9.01)	(1.65)	(2.07)	(2.42)
ln k_i - ln (n+g+δ)	0.1767	0.1751	0.1811	0.1816	0.1740	0.2322	0.2514	0.2243
	(4.22)	(4.16)	(5.00)	(4.97)	(5.01)	(6.33)	(8.48)	(5.86)
ln H		-0.0470		-0.0125	-0.0252		-0.1237	-0.0994
		(-0.61)		(-0.16)	(-0.34)		(-1.47)	(-0.93)
ln KS					0.0526			0.0587
					(3.42)			(3.78)
Implicit λ	0.0810	0.0792	0.0526	0.0513	0.0736	0.1254	0.1008	0.1349
	(5.35)	(5.16)	(2.88)	(2.58)	(3.32)	(0.30)	(1.04)	(1.63)
Implicit α	0.3467	0.3488	0.4391	0.4451	0.3612	0.3326	0.3885	0.3137
	(4.83)	(4.77)	(4.99)	(4.56)	(4.85)	(1.91)	(2.05)	(2.55)
Implicit ϕ		-0.0935		-0.0305	-0.0524		-0.1911	-0.1390
		(-0.60)		(-0.16)	(-0.34)		(-1.02)	(-0.84)
Implicit β					0.1092			0.0821
					(3.34)			(2.75)
R^2	0.9865	0.9866	0.9752	0.9752	0.9779	0.3741	0.3495	0.4614
s.e. regresión	0.0436	0.0437	0.0495	0.0497	0.0471	0.0579	0.0590	0.0542
Statistics (p-values)								
Sargan Test						(0.14)	(0.24)	(0.49)
AR(1) test						(0.29)	(0.23)	(0.34)
AR(2) test						(0.65)	(0.54)	(0.50)
AR(3) test						(0.73)	(0.66)	(0.83)

Note: in brackets t-statistics. The data of each period are divided in 5-years time spans. The panel is fomed by the same 21 countries as the OECD sample in Isalm [1995] except Turkey. In the subperiod 1965-1970 Germany is also excluded. Time effects are included.

The GMM models (equations 6 to 8) have been estimated in first differences. The instruments used are the endogenous variable in levels with two, three and four lags

LSDV: Least Squares Dummy Variable

Equation Estimated:

$$\ln y_t = e^{-\lambda\tau} y_{t-\tau} + \left(1-e^{-\lambda\tau}\right)\frac{\alpha}{1-\alpha}\left(\ln s_k - (\delta+n+g)\right) + \left(1-e^{-\lambda\tau}\right)\frac{\phi}{1-\alpha}\ln h + \left(1-e^{-\lambda\tau}\right)\frac{\beta}{1-\alpha}\ln ks$$

[20] See Islam (1995), De la Fuente and Doménech (2001), Bassanini and Scarpetta (2001), Cohen and Soto (2001), Krueger and Lindahl (2001) and De la Fuente and Doménech (2002).

In columns (3) and (4) of Table 3 the two previous estimations are repeated by means of LSDV for the period 1965-2000, for which information on social capital is available. In the estimation, the rate of convergence stands out as lower than that obtained previously, at 0.05. Also, whereas in the previous sub-period the elasticity of output relative to capital showed levels in accordance with the theoretical model (1/3), in the estimations for the period 1965-2000 they are somewhat higher, around 44%.

Column (5) shows the effects of the inclusion of social capital in the estimations. Firstly, the rate of convergence increases, rising from 0.05 to 0.07. The elasticity of capital takes values that are more in accordance with the expected magnitude of one third (0.36) and human capital continues to present a negative contribution, although not significant. It should also be highlighted that the participation of social capital in the total income is 11%.

According to the results of column (5) of Table 3 social capital has a positive and significant effect when determining the level of income per capita of economies belonging to the OECD. Therefore, the fact that in an economy there are greater networks of trust which reach a substantial part of society generates reductions in transaction and supervision costs in economic relationships. These in turn have a positive impact on the per capita income levels of the population, as shown by the social capital sign in the estimation.

We chose the estimating technique, LSDV, from among those used in the reference study. But because the specification includes the lagged dependent variable, the estimations of the fixed effects model are inconsistent. To test the robustness of the results we present columns (6) to (8), in which the equations estimated for the period 1965-2000 are replicated using the Generalized Method of Moments (GMM). To obtain consistent estimations, we estimate the model in first differences and use as instruments the endogenous variable in levels from the second retard up to, at most, the fourth (Doornik, Arellano and Bond, 2002). The estimation of specification (8), in which social capital is included, is done in two stages (Arellano and Bond, 1991), as first order autocorrelation in the residuals of the estimation is detected in stage one, and must therefore be corrected in the second stage. In the estimations of equations (6) and (7) no autocorrelation is detected, so the two-stage procedure is not required.

Starting from the statistics shown we can verify that there is no autocorrelation in the estimations and that the Sargan test does not permit rejection of the validity of the instruments used. Given that the estimation is done in first differences (and therefore without fixed effects) the coefficients of determination are lower than those of LSDV, but are still high.

As to the results, in equations (6) and (7) we find that the paces of convergence are higher than the results obtained by LSDV and that the output elasticities of the factors of production are lower. Column (8) shows that social capital continues to have a positive and significant influence on the levels of per capita income in OECD economies. Its contribution to the generation of income is 0.08, slightly lower than that of the previous case. Human capital again presents a negative and non-significant sign and physical capital also presents an output elasticity of 0.31, somewhat lower than the above case. As a consequence of these lower output elasticities of the factors of production, the pace of convergence increases substantially compared to the estimation by LSDV, rising from 0.07 to 0.13.

6. Conclusions

A key characteristic of developed economies is the compatibility of rising levels both of (productive and technological) complexity and of efficiency, thanks to an effective conjunction of formal (legal norms, property rights) and informal rules. Both types operate through networks of social relationships and, in this sense, social capital plays an essential role in a well functioning economic system.

Social capital is generated through cumulative processes of trust, which are fed by shared experiences of mutual cooperation in which expectations of favorable treatment are reinforced. According to the thesis put forward in this paper, these expectations may be based on the good results obtained by the members of each society in their participation in the economic relationships that occur within it.

The study develops a theoretical model with the objective of obtaining a measure of social capital. The modeling is based, on the one hand, on analysis of the process of investment and accumulation in social capital in terms of its benefits and costs, as when considering any kind of physical or financial asset. The second key element in the methodology is the application to social capital of the conceptual framework and the procedures commonly accepted for the measurement of physical capital. In this context, the proxies for social capital most commonly used (such as the measures of trust of the *WVS* and Putnam's measures of associative density) would only be approximations to some of the relevant determinants of the volume of social capital, but not direct measures of it.

The theoretical model that upholds the proposed measure identifies the following variables as determinants of the level of social capital: the improvement of income and well-being; the rate of depreciation of social capital if expectations of favorable treatment or of cooperation are disappointed; the cost of cooperation; and the amplitude and connection in the networks of trust. These determinants have been used to obtain a measure of social capital. The empirical application of this methodology had to deal with a lack of information on certain variables, which led to restrictive assumptions being made on occasions.

The empirical approach to the measurement of social capital was carried out for most of the economies of the OECD countries over a long period, covering the years 1965 to 2001. It should be borne in mind that the social capital was estimated in spite of the limitations of information, with the twin objectives of evaluating the possibilities of overcoming these limitations, and of testing the potential role of social capital in growth.

The results indicate a general increase in the levels of social capital in the countries belonging to the OECD in the course of recent decades, but also indicate that the levels of trust go through periods of deterioration at different times in some countries. In the specific case of the United States, the hypothesis of the decline of its social capital, present in some of the literature, is not confirmed, although trust has been through periods of stagnation. On the other hand, we can appreciate a much more irregular evolution of social capital in other economies, such as Denmark, Switzerland, Belgium, United Kingdom or Spain, with periods of expansion and others of contraction. Using the extension of the Mankiw *et al.* (1992) model by Islam (1995), we have verified that social capital has the capacity to explain part of the economic growth in the OECD countries. The estimations performed enable us to value the output elasticity of social capital at around 7-10%.

Appendix 1. Definition of the degree of connection of the social network

The measure of social connection proposed in section 2.2 is based on the definition of the *degree of connection* to a graph developed in this Appendix. Let a graph G be formed by N *nodes* or vertices and by a certain number of *oriented edges* or arrows. In the classical terminology, this is a *determinist* graph in the sense that between node i and node j either there is a connection, or there is not. In the first case $c_{ij}= 1$ whereas in the second, $c_{ij} = 0$. The direct connection of an element with itself is considered irrelevant, so the value 0 is assigned to the element c_{ii}. We consider that there are N individuals, so the elements c_{ij} form an *adjacency matrix* C of dimension $N \times N$.

Given a natural number p, matrix C^p, the p-th power of matrix C, represents the state of the connections of order p. More precisely, denoting by $c_{ij}^{(p)}$ the element of matrix C^p in position (i,j), there are exactly $c_{ij}^{(p)}$ p-th order oriented connections from node i to node j. Connections of order p are non-existent if $c_{ij}^{(p)} = 0$.

We suppose that the importance of a connection from i towards j is less the higher its order, so a lower weight will be assigned to the connections of higher order. Starting from this consideration, we propose the construction of the following matrix:

$$C^{\infty} = (c^{(\infty)}{}_{i,j}) = \sum_{p=1}^{\infty} \frac{C^p}{2^p (N-1)^p} . \qquad \text{(A.1.1)}$$

Observe that C^{∞} can also be obtained as follows:

$$\sum_{p=1}^{\infty} \frac{C^p}{2^p (N-1)^p} = \sum_{p=0}^{\infty} \frac{C^p}{2^p (N-1)^p} - Id \qquad \text{(A.1.2)}$$

where Id is the identity matrix of dimension N. Therefore,

$$\sum_{p=0}^{\infty} \frac{C^p}{2^p (N-1)^p} = \left(Id - \frac{C}{2(N-1)^p} \right)^{-1} \qquad \text{(A.1.3)}$$

and hence

$$C^{\infty} = \left(Id - \frac{C}{2(N-1)^p} \right)^{-1} - Id . \qquad \text{(A.1.4)}$$

It is important to justify the convergence of the series defining matrix C^{∞} as well as the existence of the inverse of Id - $C/[2(N - 1)]$.

Proposition 1. *For the matrix C defined above associated with a graph G, the series in* (A.I.1) *is convergent. Matrix Id-C/*[2(*N*-1)] is invertible.

<u>*Proof of proposition 1.*</u> We consider first $C = CT$, the matrix associated with a completely connected graph. In IR^N we take the norm $\|\cdot\|_\infty$, defined as $\|x\|_\infty = \sup\{|x_n| : n = 1, 2,...,N\}$. Therefore, $CT: IR^N \Rightarrow IR^N$ obviously has norm $N - 1$ (in the corresponding $\|\cdot\|_\infty$-norm for operators), then $\|CT/[2(N - 1)]\|_\infty = 1/2$ if $N \geq 2$. Consequently, for an arbitrary matrix C we have $\|C/[2(N - 1)]\|_\infty \leq 1/2$ if $N \geq 2$. It is now obvious that the series defining C^∞ is convergent.

The fact that, for $N \geq 2$, the matrix $Id - C/[2(N - 1)]$ has inverse is a consequence of the fact that the linear application $Id - C/[2(N - 1)]$ is an isomorphism, which can be deduced precisely from $\|C/[2(N - 1)]\|_\infty \leq 1/2$ if $N \geq 2$ (see, for example, Jameson, 1974, Thm. 18.11). QED

Next we define the *degree of connection* c_i of element i as follows:

$$c_i = \frac{1}{2}\left[\sum_{k=1}^{N} c^{(\infty)}{}_{ik} + \sum_{k=1}^{N} c^{(\infty)}{}_{ki}\right]. \quad \text{(A.1.5)}$$

Proposition 2. *Properties of the degree of connection of the network:*

1. *If G is a completely connected graph, the degree of* connection c_i *of each element verifies* $c_i = 1$, $i = 1, 2,...,N$.

2. *The degree of connection of every element is a number in the interval* [0, 1].

3. *An individual i is an isolated node if and only if* $c_i = 0$.

<u>*Proof of proposition 2*</u>

1. Given $p \in IN$, it is simple to observe that if $CT^p = (ct_{ij}^{(p)})$, then

$$ct_{ij}^{(p)} = \begin{cases} a_p \ si \ i = j \\ b_p \ si \ i \neq j \end{cases} \quad \text{(A.1.6)}$$

where $i,j = 1, 2,...,N$, a_p and b_p being two values obtained inductively as follows: if a_p and b_p are known for a value $p \in IN$, then, for $p + 1$ the corresponding values are $a_{p+1} = b_p(N - 1)$, $b_{p+1} = (N- 2)b_p + a_p$. As $a_1 = 0$ and $b_1 = 1$, we obtain the expression of CT^p for any $p \in IN$.

Now let $s_p = \sum_{k=1}^{N} ct_{ik}^{(p)}$ (observe that the sum is independent of *i*). It is immediate, from the above description, that $s_{p+1} = (N- 1)s_p$. Given that $s_1 = (N- 1)$, we obtain $s_p = (N- 1)^p$, $p = 1, 2, \ldots$. Therefore, given the corresponding expression of CT^{∞} defined in (A.1.1), we have

$s_{\infty} = \sum_{k=1}^{N} ct_{ik}^{(\infty)} = \sum_{p=1}^{\infty} \frac{1}{2^p} = 1$ which gives the result.

2. Matrix *C* has all its entries positive or zero. The demonstration of this property of the degree of connections of the network is obtained directly from point 1 above.

3. The third affirmation is a consequence of the fact that, if in matrix *C* row *i* and column *i* are both zero, this is so in any power of *C*, and reciprocally. QED

Part 3 of the above result evidences the need to exclude as acceptable the edge of an element with itself. If these were counted the result would be that a graph formed by autistic nodes would have degree 1 of connection.

Appendix 2. Derivation of the condition of equilibrium

Equations (2), (3) and (14) of the main text define the following maximization problem:

$$Max_{Is_{t\in[0,\dots,T]}} \Pi = \sum_{t=0}^{T}\left[\frac{1}{(1+\rho)^t}\left(y_t(1-G)-rk_t-\overline{w}_t\left(1+C\left(Is_t\right)\right)\right)\right] \qquad (A.2.1)$$

$$\text{s.a. } ks_{t+1}=\delta\, ks_t+Is_t, \qquad (A.2.2)$$

$$y_t = A_t k_t^{\alpha} h^{\phi}\frac{KS_t{}^{\beta}}{L_t^{\beta}} = A_t k_t^{\alpha} h^{\phi} N^{\beta}\frac{\left(\prod_{j=1}^{N} c_j^{v_j} ks_{jt}^{v_j}\right)^{\beta}}{L_t^{\beta}} \qquad (A.2.3)$$

Assuming that N, c_i and v_i are constant, the maximization problem can be written for an individual i as follows:

$$\begin{aligned}
&Max_{Is_{ti\in(0,\dots,T)}} \Pi = \sum_{t=0}^{T}\left[\frac{1}{(1+\rho)^t}\left(y_t(1-G)-rk_{it}-\overline{w}_t\left(1+C\left(Is_{it}\right)\right)\right)\right]= \\
&Ak_0^{\alpha}h_0^{\phi}\left(\frac{N^{\beta}}{L_0{}^{\beta}}\prod_{j=1}^{N}c_j{}^{v_j\beta}ks_{j0}{}^{v_j\beta}\right)(1-G)-r_0k_{i0}-\overline{w}_0\left(1+C\left(Is_{i0}\right)\right)+ \\
&+\frac{1}{(1+\rho)}\left[Ak_1{}^{\alpha}h_1^{\phi}\left(\frac{N^{\beta}}{L_1^{\beta}}\prod_{j=1}^{N}c_j{}^{v_j\beta}ks_{j1}{}^{v_j\beta}\right)(1-G)-r_1k_{i1}-\overline{w}_1\left(1+C\left(Is_{i1}\right)\right)\right]+\dots+ \\
&+\frac{1}{(1+\rho)^T}\left[Ak_T{}^{\alpha}h_T^{\phi}\left(\frac{N^{\beta}}{L_T{}^{\beta}}\prod_{j=1}^{N}c_j{}^{v_j\beta}ks_{jT}{}^{v_j\beta}\right)(1-G)-r_Tk_{iT}-\overline{w}_T\left(1+C\left(Is_{iT}\right)\right)\right]
\end{aligned} \qquad (A.2.4)$$

The first order condition for a moment in time t is obtained by making the derivative of the objective function equal to zero with respect to the control variables Is_t:

$$\begin{aligned}
&\frac{\partial\Pi}{\partial Is_{it}} = \sum_{l=0}^{T-t-1}\frac{1}{(1+\rho)^{t+l+1}}\left[Ak_{t+l+1}^{\alpha}h_{t+l+1}^{\phi}\left(\frac{N^{\beta}}{L_{t+l+1}{}^{\beta}}\frac{\partial}{\partial Is_{it}}\left(\prod_{j=1}^{N}c_j{}^{v_j\beta}ks_{jt+l+1}{}^{v_j\beta}\right)\right)(1-G)\right]- \\
&-\frac{1}{(1+\rho)^t}\overline{w}_t C'\left(Is_{it}\right)=0
\end{aligned} \qquad (A.2.5)$$

One of the elements of expression (A.2.5) is the derivative of the social capital of individual j at time $t+l+1$, with respect to the investment in social capital of the maximizing agent i:

$$\frac{\partial}{\partial Is_{it}}\left(\prod_{j=1}^{N} c_j^{\,v_j\beta} ks_{jt+l+1}^{\;v_j\beta}\right)=\sum_{j=1}^{N}\left\{v_j\beta c_j^{\,v_j\beta} ks_{jt+l+1}^{\;v_j\beta-1}\frac{\partial ks_{jt+l+1}}{\partial Is_{it}}\prod_{\substack{z=1,\ldots,j-1\\ ,j+1,\ldots,N}}\left(c_z ks_{zt+l+1}\right)^{v_z\beta}\right\}. \quad \text{(A.2.6)}$$

Taking into account that the equation of accumulation of social capital at a moment $t+l+1$ can be written $ks_{it+l+1}=\delta^{t+l+1}ks_{i0}+\sum_{m=1}^{t+l+1}\delta^{t+l+1-m}Is_{im-1}$, we obtain that:

$$\frac{\partial ks_{jt+l+1}}{\partial Is_{it}}=\delta^{l}\frac{\partial Is_{jt}}{\partial Is_{it}}=\delta^{l}\lambda_{ij} \quad \text{(A.2.7)}$$

where the parameter λ_{ij} measures the variation in the investment in social capital of agents j in response to variations in the investment decision of agent i.

On the basis of (A.2.7), equation (A.2.6) can be rewritten:

$$\begin{aligned}\frac{\partial}{\partial Is_{it}}\left(\prod_{j=1}^{N} c_j^{\,v_j\beta} ks_{jt+l+1}^{\;v_j\beta}\right)&=\sum_{j=1}^{N}\left\{v_j\beta c_j^{\,v_j\beta} ks_{jt+l+1}^{\;v_j\beta-1}\frac{\partial ks_{jt+l+1}}{\partial Is_{it}}\prod_{\substack{z=1,\ldots,\\ ,j-1,j+1,\ldots,N}}\left(c_z ks_{zt+l+1}\right)^{v_z\beta}\right\}. \\ &=\prod_{j=1}^{N}\left(c_j ks_{jt+l+1}\right)^{v_j\beta}\sum_{j=1}^{N}\beta v_j ks_{jt+l+1}^{\;-1}\delta^{l}\lambda_{ij}\end{aligned} \quad \text{(A.2.8)}$$

Therefore, the first order condition of equation (A.2.5) is as follows:

$$\begin{aligned}\frac{\partial\Pi}{\partial Is_{it}}&=\sum_{l=0}^{T-t-1}\frac{1}{(1+\rho)^{t+l+1}}\left[Ak_{t+l+1}^{\;\alpha}h_{t+l+1}^{\phi}\left(\frac{N^{\beta}}{L_{t+l+1}^{\;\beta}}\left(\prod_{j=1}^{N}\left(c_j ks_{jt+l+1}\right)^{v_j\beta}\sum_{j=1}^{N}\beta v_j ks_{jt+l+1}^{\;-1}\delta^{l}\lambda_{ij}\right)\right)(1-G)\right] \\ &-\frac{1}{(1+\rho)^{t}}\bar{w}_t C'\left(Is_{it}\right)=0\end{aligned} \quad \text{(A.2.9)}$$

equivalent to:

$$\beta(1-G)\sum_{l=0}^{T-t-1}\frac{\delta^{l}}{(1+\rho)^{t+l+1}}y_{t+l+1}\left[\sum_{j=1}^{N}v_j\frac{\lambda_{ij}}{ks_{jt+l+1}}\right]-\frac{1}{(1+\rho)^{t}}\bar{w}_t C'\left(Is_{it}\right)=0. \quad \text{(A.2.10)}$$

Appendix 3. Statistical sources used

The estimations for the sample of OECD countries were made for the period 1970-2001. The approach to the variables that the theoretical model proposes as determinants of social capital, and the assumptions regarding them, are as follows:

Degree of relation of the network, *c* (Bank loans / GDP). The data on the volume of credit by countries are taken from the International Monetary Fund's International Financial Statistics database, specifically, from the Domestic Credit series (codes 32..ZF and 32..ZW) contained in the Monetary Survey. Given that the volume of domestic credit in the database presents discontinuities for some countries, we have adjusted them by maintaining the original rates of variation. Also, as the theoretical model posits that the *degree of connection in the network* variable must be limited between zero and one, we re-scale the credit / GDP ratios of all the countries by the maximum ratio of the sample.

Marginal cost of the investment in social capital, *C'(Is)*. We use as *proxy* a measure of human capital, the percentage of the total population that has at least secondary education: *Barro-Lee* (*International Measures of Schooling Years and Schooling Quality*). The data available are five-yearly, so we have had to interpolate the years in which information was not available. For the United States we used information from the US Census Bureau. The Barro and Lee database does not include information on Luxembourg, so for this country we used the values from the Netherlands. Moreover, in the case of Germany, for the years prior to 1991 a series corresponding to the reunified Germany had to be constructed.

Index of inequality of income distribution, *G*. The Gini indices of inequality of income distribution were obtained from the United Nations World Income Inequality Database, V 1.0. This base gathers together the results of several studies relating to the distribution of income. It therefore lacks a common methodology with regard to statistical sources, indicator of income used and the reference group for the calculation of the Gini indices. We obtain a series of the *inequality index* series on the basis of the predictions of a fixed effect regression model, in which the Gini indices have been made to depend on four variables: a trend, Government final consumption expenditure (National Accounts, OECD) as a percentage of GDP, per capita GDP and the rate of unemployment.

GDP and Compensation of employees, *w*. The data are taken from the OECD National Accounts database, and are transformed from national currency to constant 1995 PPP dollars.

Rate of depreciation of the stock of social capital, *d, and number of employed, N.* We use the rate of unemployment as *proxy* for the rate of depreciation of social capital. The rate of unemployment is taken from the *Labor Force Statistics* completed with *Economic Outlook* database (OECD)

Life expectancy at the average age of the population, *T-t*. We used the OECD information on the life expectancy of the 40-year-old population published in OECD Health Data. Given that this information is shown separately for men and women, we calculated the weighted mean of the two. In order to take into account the differences in age structure among the different countries, we added the difference between forty and the average age taken from different sources to the life expectancy of the 40-year-olds in each country.

Stock of physical capital. The data on the stock of physical capital are taken from OECD estimates collected in the *ISDB* database, and were completed with data from the two OECD databases *STAN* and *Economic Outlook*.

Appendix 4.

Volume Index of Social Capital. 1970=100.

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Australia	100,0	92,3	86,1	94,8	88,9	73,3	72,6	66,0	60,4	62,9	63,9	64,8	56,3	42,9	50,7	64,5
Austria	100,0	105,7	111,7	114,9	112,4	114,4	127,7	136,3	138,0	147,5	156,9	151,3	141,1	134,0	148,3	155,3
Belgium	100,0	103,6	107,3	115,2	114,6	96,3	90,9	94,6	97,3	105,1	109,7	98,6	82,8	80,7	80,3	88,2
Canada	100,0	104,4	116,7	141,3	154,1	150,0	165,2	169,3	190,1	234,6	247,5	291,7	217,4	187,3	195,9	207,0
Denmark	100,0	92,9	93,8	92,6	64,9	63,4	53,6	46,1	40,6	53,0	53,0	41,2	39,7	43,0	61,7	73,5
Finland	100,0	100,1	95,2	94,8	107,4	115,5	96,7	80,1	68,0	80,9	100,3	104,3	111,0	122,6	134,9	156,5
France	100,0	102,1	108,8	111,3	114,4	106,2	109,3	111,3	113,9	109,9	108,4	101,2	99,1	99,4	91,9	90,6
Germany	100,0	103,1	105,2	106,0	91,1	75,4	80,3	88,8	100,1	118,5	131,5	123,8	107,9	99,7	115,1	123,9
Greece	100,0	114,5	122,0	120,0	139,0	154,4	167,2	195,0	198,9	198,5	184,8	188,2	162,6	138,7	136,6	149,6
Ireland	100,0	84,5	96,7	107,8	124,0	82,3	75,9	77,9	90,4	121,3	114,5	85,7	77,2	67,3	62,7	57,7
Italy	100,0	109,2	108,4	110,1	120,5	125,8	114,4	113,1	117,0	110,8	109,8	105,0	101,3	94,6	91,7	92,9
Japan	100,0	110,8	119,0	119,0	114,4	114,5	117,0	120,1	124,3	131,7	137,7	140,6	145,4	148,7	152,9	160,3
Luxembourg	100,0	110,8	113,2	105,7	100,0	130,1	129,6	148,5	284,7	305,4	340,1	288,6	279,1	246,9	237,3	242,3
Netherlands	100,0	94,9	83,5	84,2	79,9	69,6	69,7	79,5	90,3	100,1	99,5	83,1	65,1	63,4	63,1	69,7
New Zealand	100,0	94,4	105,2	156,8	224,8	302,9	294,0	319,4	276,2	254,7	228,9	183,3	191,0	141,0	118,0	138,2
Norway	100,0	101,9	102,9	106,1	104,9	100,9	119,2	141,0	142,3	149,5	153,6	148,5	141,9	129,7	140,8	157,6
Portugal	100,0	128,8	141,0	150,0	167,2	148,7	108,5	98,4	90,9	105,5	101,7	116,6	124,1	127,9	122,6	113,5
Republic of Korea	100,0	110,6	124,3	142,8	167,9	177,1	178,8	185,4	232,7	238,8	252,7	301,2	353,6	376,1	395,8	446,9
Spain	100,0	98,7	101,9	110,7	108,4	95,5	101,3	93,5	77,5	70,0	60,4	54,6	50,5	44,1	37,3	35,5
Sweden	100,0	88,3	89,7	92,2	101,2	106,5	106,5	111,8	117,2	133,0	140,8	143,8	134,4	127,3	137,5	138,6
Switzerland	100,0	97,5	95,0	94,0	77,8	76,7	82,4	97,9	114,0	132,7	159,2	164,2	184,6	174,0	182,1	194,2
United Kingdom	100,0	86,4	97,5	123,6	135,1	103,7	77,3	62,9	64,7	66,6	61,2	52,8	50,3	49,1	53,1	58,5
United States	100,0	94,6	106,7	122,0	119,5	93,0	103,9	115,4	131,9	143,3	129,8	125,5	112,4	120,4	155,7	170,2

Volume Index of Social Capital. 1970=100. (Continuation)

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Australia	70,7	70,5	80,8	96,3	91,7	74,0	69,8	68,7	81,1	94,8	96,9	96,7	110,2	125,0	141,3	138,0
Austria	174,5	174,3	187,0	201,3	205,9	204,8	205,9	198,6	229,6	233,5	224,3	231,0	226,4	238,9	249,1	244,9
Belgium	99,8	105,9	115,8	132,9	143,4	135,9	125,5	115,2	112,1	116,9	119,5	113,2	119,2	124,1	137,3	134,9
Canada	229,8	244,1	272,7	293,3	298,4	273,5	278,8	302,2	335,2	357,9	371,8	414,8	443,2	465,2	518,0	519,5
Denmark	92,7	83,7	75,8	65,5	60,3	57,8	51,2	39,8	47,8	50,9	54,2	60,3	71,7	67,3	72,5	74,5
Finland	169,3	203,5	264,4	360,8	421,5	327,1	203,6	132,8	112,6	114,3	115,4	117,0	131,8	156,7	158,8	189,9
France	90,9	91,1	96,4	102,9	112,7	110,7	104,5	94,7	90,7	98,5	95,9	97,5	104,5	114,0	130,4	143,5
Germany	132,1	138,1	139,3	149,0	179,3	180,9	169,9	161,4	159,2	169,4	169,5	163,6	181,1	195,3	208,5	205,7
Greece	156,6	194,3	187,3	204,3	210,9	176,9	170,9	188,1	176,3	171,4	160,5	157,2	144,7	157,8	180,9	206,8
Ireland	58,8	59,5	63,2	69,1	91,2	77,3	83,0	74,4	87,1	107,2	116,1	148,4	204,7	296,6	381,1	418,4
Italy	87,6	83,2	84,0	87,1	94,3	105,0	115,9	114,9	103,0	92,4	90,9	89,5	90,4	98,8	110,6	123,1
Japan	167,5	178,5	197,1	218,7	234,8	235,1	239,9	233,8	223,4	220,6	216,7	218,6	209,6	208,3	212,1	208,0
Luxembourg	265,3	275,4	298,6	316,9	375,6	366,0	422,7	416,1	416,8	468,2	429,9	423,8	465,3	492,2	558,2	623,2
Netherlands	77,2	94,3	100,0	107,2	116,6	125,3	132,9	143,7	137,9	145,9	164,5	199,8	252,4	305,9	335,2	359,3
New Zealand	146,1	136,4	106,2	80,9	70,1	60,8	64,7	66,5	78,5	100,7	108,3	114,2	113,0	128,9	140,3	149,0
Norway	232,0	279,6	294,2	307,1	416,9	376,0	374,8	348,6	371,4	396,7	408,9	451,7	511,8	442,9	323,1	251,8
Portugal	106,7	119,9	134,5	136,3	149,1	167,7	177,2	160,5	148,7	149,5	159,8	176,8	243,1	313,5	396,8	416,7
Republic of Korea	483,7	574,2	625,1	747,2	855,7	920,1	935,4	924,2	1.048,8	1.149,8	1.296,0	1.415,3	969,1	1.143,5	1.635,5	1.827,13
Spain	36,7	42,0	48,1	56,9	63,4	63,7	56,1	43,8	43,3	46,9	50,0	56,2	66,7	87,4	106,3	141,7
Sweden	148,0	164,0	187,8	212,4	204,5	173,6	124,6	99,3	108,9	122,8	118,8	124,3	159,0	173,4	217,9	-
Switzerland	203,3	220,2	236,4	264,5	272,8	238,5	206,2	184,6	186,4	196,6	188,3	183,7	195,5	217,6	222,7	220,4
United Kingdom	66,8	73,1	95,6	127,1	137,2	116,8	102,5	95,5	104,0	120,0	131,0	145,9	157,9	168,5	193,9	220,0
United States	189,2	216,6	236,4	241,8	231,8	203,2	192,0	206,0	228,8	254,8	259,3	282,8	320,1	349,6	391,8	369,7

Source: Own elaboration from statistical sources in Appendix 3.

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