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Territorial Capital and Regional Growth: Increasing Returns in Cognitive Knowledge Use¹

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Abstract

Knowledge drives the growth of nations and regions in a competitive space-economy. Hence, we would expect a strong correlation between investments in R&D, knowledge and learning processes, on the one hand, and productivity increases, on the other. However, the empirical evidence shows consistent discrepancies between knowledge inputs and economic performance across geographical units. This paper addresses this intriguing issue at the regional level, by highlighting both theoretically and empirically the strategic importance played by cognitive elements as part of “territorial capital” in mediating between knowledge production and regional growth. The main proposition of the paper, subject to empirical testing, is that cognitive elements as part of territorial capital magnify the contribution of knowledge by determining the formation of increasing returns to knowledge exploitation.

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1. Introduction

Regions are strategic workhorses in a competitive economy. And they are – in a globalizing and open economic world – increasingly seen as magnets of economic growth and innovation. At the same time, it should be recognized that the distribution of the rise in productivity and of economic growth is unequal across regions in an open space-economy. In many cases, we even observe that spatial-economic disparities – measured in terms of GDP per capita, employment or unemployment – are rather persistent over time. However, such structural spatial disparities cannot exclusively be attributed to a less efficient use of mobile or flexible production factors such as capital or labour, but may be deeply rooted in inertia conditions in a regional system. It seems plausible that at least two such conditions play an important role, viz. (i) local-regional production and the use of appropriate and advanced knowledge (i.e. a cultural-cognitive condition); and (ii) the availability and effective implementation of tailor-made territorial capital (i.e. geographically- and locally-bounded amenities and conditions. The latter provide an efficiency-enhancing contribution to growth, such as a traditional entrepreneurial orientation in the region concerned, a sense of openness and creativity, a business attitude of opportunity-seeking, local institutional systems geared towards ‘challenge and response’, etc.).

Thus, management of knowledge and of territorial capital can be seen as critical success factors for innovation and the growth of regions; these factors enhance the ability to manage information in order to appropriately identify and solve problems, or, more precisely in the economic domain, the ability to transform information and inventions into innovation and productivity increases, through co-operative or market interaction. In this context, the ‘learning’ region is regarded as the place where such cognitive processes play a crucial role, by combining existing but dispersed know-how, interpretations of market needs, and information flows with intellectual artifacts, such as theories and models, and allowing the exchange of experiences and co-operation (Lundvall and Johnson, 1994). Especially in contexts characterized by a plurality of agents – like cities or industrial districts - knowledge evolution “*is not the result of individual efforts in R&D within individual firms, but rather the combination of complementary capacities and of widespread interactive learning processes, which involve many ‘customers’ and ‘suppliers’ along a well-defined filière or supply chain*” (Cappellin, 2003a, p. 307). Consequently, knowledge is a critical production factor that adds to the comparative advantage of nations and regions, and contributes to regional competitiveness.

The management of knowledge and of territorial capital can adequately explain why, despite many theoretical and conceptual approaches developed over the last 20 years, empirical evidence still shows consistent discrepancies between knowledge inputs and economic performance across regional systems; in particular, higher R&D efforts do not seem to be positively (and consistently) correlated with regional growth. The recent debate on the so-called Triple Helix concept aims to highlight the importance of integrated innovation and knowledge initiatives.

This paper aims to present a conceptual and applied modelling framework for analysing the relationship between knowledge, local cognitive capital, and growth. It is organized as follows. First, the paper reviews the literature on innovation, knowledge and regional growth, highlighting the major testable propositions that originate from our approach (Section 2). On the basis of a rather new concept, that of territorial capital, we identify the elements that, conceptually speaking, have to be present in a region in order to measure the positive effects of knowledge on the economic performance (Section 3). An original empirical analysis then tests empirically our conceptual framework for all regions in Europe, using two complementary approaches (Sections 4 and 5, respectively). The paper ends with some concluding results (Section 6).

2. Knowledge and regional growth: state of the art

Innovation accounts for that part of output growth, which cannot be directly attributed to an increase in production factors, in equilibrium and with constant returns to scale². A thorough and well founded innovation theory is therefore of crucial importance for explaining why local systems grow; any profound and appropriate theory of regional development must be able to specify the sources of innovation and the factors that provide a local system with innovative capacity.

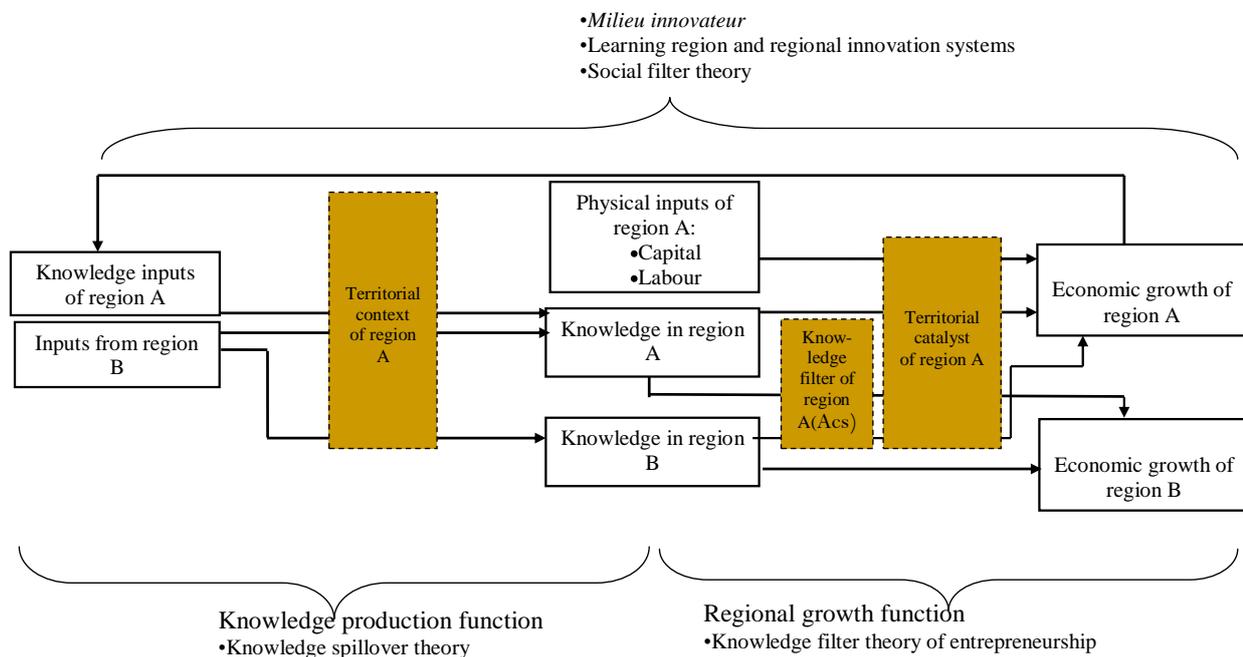


Figure 1: A synthesis of existing approaches to innovation and regional growth

² In a seminal study, Solow (1957) showed that more than 40 per cent of US growth between 1900 and 1949 was caused by a factor (Solow's famous 'residual') which could not be explained in terms of factor growth. In subsequent years, empirical surveys carried out at the national, regional and local level showed that more than one-third of output growth in the second half of the 20th century was caused by the growth of factor productivity achieved through technological progress.

Over the years, a vast variety of theories have been developed on the local sources of innovation. Studies on innovation, knowledge, and regional growth can be divided into three different approaches (Figure 1). The first is a pure *knowledge production approach*; it is more oriented towards the explanation of knowledge creation, linking knowledge inputs to knowledge outputs, through a classical production function. The influence of the empirical analyses developed in innovation economics is evident in this approach (Dasgupta and Stiglitz, 1980; Antonelli, 1989; Griliches, 1990), where the level and quality of knowledge inputs of a region explain, together with the traditional labour and capital inputs, the level of knowledge outputs.

The role of space in the knowledge production approach has evolved over time. In the first studies, where the approach was sector-based and, subsequently, function-based, space was the container of specific sectors and of specific innovation-oriented functions: regions hosting high-technology sectors were considered as “advanced” regions leading to the transformation of the economy. In the second stage, which developed mainly during the 1980s and 1990s, the preference was for a function-based approach (even though it overlapped conceptually with the knowledge production approach), which stressed the importance of pervasive and horizontal functions such as R&D and higher education. ‘Scientific’ or knowledge regions, with large and well-known scientific institutions, were studied in-depth, and the relationships between these institutions and the industrial fabric were analysed, with some disappointing results, however, as far as an expected but not often visible direct linkage was concerned (MacDonald, 1987; Massey et al. 1992; Monk et al., 1988; Storey and Tether, 1998). Indicators of R&D inputs (such as public and private research investment and personnel) and increasingly indicators of R&D output (such as patenting activities) were used in order to understand the engagement of firms and territories with knowledge, which is considered as a necessary long-term precondition for continuing innovation (Camagni and Capello, 2008).

More recently, during the 1990s, a new approach in the knowledge production context has come to the fore, emphasising the role of physical proximity to knowledge production units. The *theory of technological spillovers*, developed in the 1990s, linked the spatial concentration of innovative activities with the increasing returns that concentrated location generates for those innovative activities themselves. Cross-fertilization, dynamic interactions between customers and suppliers, synergies between research centres and local production units occur within particular geographical areas such as highly-specialized metropolitan areas. They do so as the result of the rapid exchange of information and transmission of tacit knowledge made possible by face-to-face encounters. In a concentrated location, the beneficial effects of a firm’s R&D activities are not confined within the boundaries of firms: they ‘spill over’ into the surrounding environment, to the advantage of innovative activity by other firms. A large number of empirical analyses, mainly econometric, have successfully measured the technological spillovers and the knowledge advantages enjoyed by spatially-concentrated firms.³ Space is purely geographical in this approach,

³ Among the numerous empirical studies on knowledge spillovers, to be mentioned in particular are the seminal work by Jaffe (1989) and a series of later studies: Acs et al. (1994), who examined the differing abilities of small and large

a physical distance between actors, a pure physical container of spillover effects which come about – according to the epidemiological logic adopted – simply as a result of contacts among actors. The probability of such spillovers occurring increases in a limited geographical area. A well-known criticism has been voiced about this approach: it concerns itself only with the diffusion of innovation, given the same receptivity all over space, and ignores the most crucial aspect of the innovation process: how people (or the context) actually learn, an aspect of overriding interest to explore the possibilities of normative action to promote local development.

A second important approach to *the role of knowledge in regional growth* involves a group of theories linking knowledge to regional growth. These theories take for granted that, if knowledge is produced, regional economic performance increases (see Figure 1). This is the richest field of conceptual and applied analyses in innovation and regional growth. Included in this group are well-known theories like the “milieu innovateur theory” and the “learning region” or “regional innovation systems”.⁴ All these theories have in common the idea that there is a positive relation between knowledge created in one region and its economic performance. The main difference between these theories is in the way in which space is conceived. Although the “learning region” approach envisages a system of homogeneous socio-economic and institutional conditions in the region, and interaction and cooperation among actors, it is nevertheless markedly a-spatial. Nothing in the theory explains how and why these relations must necessarily be local; nor does it explain what territorial conditions must be in place for the ‘organized market’ to arise; or what territorial factors fuel the process of interactive learning.

In the *milieu innovateur* theory, attention is focused mainly on the construction of knowledge through cooperative learning processes, nourished by spatial proximity (“atmosphere” effects), network relations (long-distance, selective relationships), interaction, creativity and recombination capability. Knowledge flows and information channels are investigated, and the role of the local *milieu* becomes clear: abstract space becomes real territory, a relational space where functional and hierarchical, economic and social interactions take place and are embedded in geographical space. The *milieu* becomes, therefore, a “cognitive engine” and possibly an innovation place: its characteristics enhance interaction and co-operation, and reduce: uncertainty (especially concerning the behaviour of competitors and partners); information asymmetries (therefore reducing mutual suspicion among partners); and the probability of opportunistic behaviour under the threat of social sanctioning (Camagni, 1991, 2004), all elements that are confirmed by many regional economics schools (Bellet et al., 1993; Rallet and Torre, 1995; Cappellin, 2003b).

Other reflections on the role of spatial elements in determining the capacity of regions to develop innovation are present in the concept of the “social filter” developed by Rodriguez-Pose

firms to exploit knowledge spillovers; Audretsch and Feldman (1996) and Feldman and Audretsch (1999), who distinguished between scientifically diversified and specialized spillovers; and Anselin et al. (1997), who defined the distance beyond which spillover effects disappear. For a recent critical review of the role of knowledge spillovers in regional development see de Groot et al. (2001).

⁴ Aydalot, 1986; Aydalot and Keeble, 1988; Bellet et al., 1993; Camagni, 1991 and 1995; Camagni and Capello, 2002; Camagni and Maillat, 2006; Ratti et al., 1997; for the learning region theory, see Lundvall and Johnson, 1994.

(1999). The main idea of this approach is that certain social conditions, embedded in the local systems, determine the speed with which each society adopts innovation and makes business out of it. Each nation and region has its unique “social filter” that hampers or sustains innovation in that area (Rodriguez-Pose, 1999; Crescenzi et al., 2007).

What is so far missing in the literature is, in our view, a thorough analysis of the cognitive capacity of a region to translate innovation into “increasing returns” to growth. In particular, our main interest lies in the analysis of the territorially embedded elements that allow a region to size the opportunities provided by the creation of new innovation and new knowledge and achieve through them *increasing returns to growth*. We will now outline this third approach.

Some attempts of this kind are already present in the literature. The knowledge filter theory of entrepreneurship, put forward by Acs and Audretsch⁵, is an example of this kind. In this conceptual approach, the theory provides an explicit link between knowledge and entrepreneurship within the spatial context. It posits that investments in knowledge by incumbent firms and research organizations such as universities will generate entrepreneurial opportunities, because not all of the new knowledge will be pursued and commercialized by the incumbent firms. The knowledge filter (Acs et al. 2004) refers to the extent that new knowledge remains un-commercialized by the organization which creates that knowledge. It is these residual ideas that generate the opportunity for entrepreneurship.

The interesting aspect of this theory is that the capabilities of economic agents within the region to actually access and absorb the knowledge and ultimately utilize it to generate entrepreneurial activity are no longer assumed to be invariant with respect to geographic space, as has always been thought. In particular, regions that are particularly expected to gain more from new knowledge are diversified areas, in which differences between people that cause them to look at and appraising a given information set differently, thereby resulting in different appraisal of any new idea.

The present paper goes a step further in this direction and aims to enlarge the identification of the spatial elements that explain the differences between territories to grasp innovation and translate it into growth, thus giving rise to increasing returns. Our main idea is that this capacity resides more in intangible, strongly territorialized and un-imitable assets, like local trust and sense of belonging than in pure availability of capital, more in creativity than in the presence of a skilled labour force, and more in connectivity than of pure accessibility (Camagni and Capello, 2008). The expertise to be a “cognitive engine” resides in the ability of a region to enable economic actors to work together under conditions of uncertainty, or solidarity, mutual assistance, and the co-opting of ideas that often develop in clusters of small and medium-sized enterprises working in the same sector (social capital), or in highly creative environments like cities; both cities and specialized areas provide an intangible factor, ‘something in the air’, which is the outcome of a combination of institutions, rules, practices, producers, researchers and policy makers that make a certain level of creativity and innovation possible (North, 1990; OECD, 2001, p. 15). Regional receptivity of growth opportunities resides in the presence of this intangible factor which makes it possible:

⁵ Acs et al. (2004) and (2005); Acs and Plummer (2005).

- to convert external inputs into the needs of local firms;
- to transfer success stories of other regions to solve local problems, through a process of creative adoption;
- to search and signal interest to the external environment in strategic complementary assets.

The next section provides a more in-depth conceptual analysis of this idea.

3. Territorial capital and increasing returns: the role of cognitive elements

Regional growth results nowadays from the balanced presence of tangible and intangible elements originating in the economic and social spheres: the endowment of production factors, infrastructures, and human capital should be linked to the presence of social capital, a propensity for cooperation among actors, and the ability of people, firms and local institutions to learn. Of equal importance in this ‘balanced development’ is the endowment of production factors, the ability of suppliers and customers to establish synergies and cooperation, the infrastructural endowment, the tacit diffusion of information, the availability of real or financial capital and processes of collective learning in workforce training, the evolution of managerial styles, and the use of new technologies.⁶

Hence, the success of a territorial system does not depend solely on the quantity and quality of the material resources with which it is endowed. It also, and crucially, depends on the richness of cognitive elements, or the way individuals think and behave. Because capital is hyper-mobile, the competitiveness of regions depends on intangible resources and their development. Intangible elements connected with culture and innovative capacity accumulate through slow processes of individual and collective learning fuelled by information, interaction, and investments in research and training. Such elements are therefore intrinsically localized and cumulative, embodied in human capital and local relational networks, in the labour market, and in the local context – and they are consequently highly selective in spatial terms.

All these aspects are nowadays conceptualized in the concept of territorial capital. Territorial capital was first proposed in a regional policy context by the OECD in its *Territorial Outlook* (OECD, 2001), and has been recently reiterated by DG Regio of the Commission of the European Union: “*Each region has a specific ‘territorial capital’ that is distinct from that of other areas and generates a higher return for specific kinds of investments than for others, since these are better suited to the area and use its assets and potential more effectively. Territorial development policies (policies with a territorial approach to development) should first and foremost help areas to develop their territorial capital*” (European Commission, 2005, p. 1, cited in Camagni, 2008).

⁶ For the concept of collective learning, see, among others, Camagni (1991, 1995), Camagni and Capello (2002), Keeble and Wilkinson (1999, 2000).

The concept of territorial capital is useful since it entails all material and non-material, private and public assets that play a role in defining economic performance. An interesting taxonomy of territorial capital assets has been proposed recently by Camagni (2008) (Figure 2). The elements on the four corners of the square are the easiest to identify. They often come in quantities (physical capital, labour and infrastructure) or have a solid background in the economics and sociology literature (social capital); they can enter directly into a traditional production function. Elements on the cross, on the other hand, are characterized by less sharply defined boundaries and more complex definitions. They form the glue of a society, stemming from complex cognitive processes that are cumulated in a society over time. Our impression is that, as such, they act on knowledge creation and knowledge exploitation, and therefore on the way in which physical factors (capital, labour and human capital) are combined, giving rise to increasing returns.

| | | | | |
|-----------------------|---------------------|---|--|---|
| Rivalry | High rivalry | <u>Private fixed capital stock</u> <u>Pecuniary externalities</u> (hard) <u>Toll goods</u> (excludable) | <u>Relational private services operating on:</u> - external linkages for firms - transfer of R&D results <u>University spin-offs</u> | <u>Human capital:</u> - entrepreneurship - creativity - private know-how <u>Pecuniary externalities</u> (soft) |
| | (private goods) | | | |
| | (club goods) | | | |
| (impure public goods) | | <u>Proprietary networks</u> <u>Collective goods:</u> - landscape - cultural heritage (private 'ensembles') | <u>Cooperation networks:</u> - strategic alliances in R&D and knowledge - p/p partnerships in services and schemes <u>Governance of land and cultural resources</u> | <u>Relational capital:</u> - cooperation capability (trust) - collective action capability (participation) - collective competencies |
| (public goods) | | | | |
| Low rivalry | | <u>Resources:</u> - natural - cultural (punctual) <u>Social overhead capital:</u> - infrastructure | <u>Agencies for R&D transfer</u> <u>Receptivity enhancing tools</u> <u>Connectivity</u> <u>Agglomeration and district economies</u> | <u>Collective action:</u> - conventions - behavioural codes - representations - values |
| | | Tangible goods (hard) | Mixed goods (hard + soft) | Intangible goods (soft) |
| | | Materiality | | |

Figure 2: A classification of territorial capital according to materiality and rivalry
 Source: Camagni (2008)

Agglomeration economies, creativity and entrepreneurial spirit, and the presence of relational and social capital, are all elements that, directly or indirectly, affect the capacity of a region to turn knowledge to its own advantage, and achieve increasing returns. For this reason, among all the

elements mentioned in the innovative cross, we focus our attention on relational capital, relational private service, cooperation networks, and agglomeration economies.

Agglomeration economies play this innovative role in an indirect way: especially in contexts characterised by a plurality of agents – like cities or industrial districts - knowledge evolution “*is not the result of individual efforts in R&D within individual firms, but rather the combination of complementary capacities and of widespread interactive learning processes, which involve many ‘customers’ and ‘suppliers’ along a well-defined filière or supply chain*” (Cappellin, 2003a, p. 307). By the same token, in contexts characterized by a plurality of agents – like cities or industrial districts – knowledge exploitation is not the result of the presence of knowledge creation, but rather the combination of material and non-material assets that open the way to more in-depth exploitation of the available knowledge.

Relational capital, relational private services, or cooperation networks affect cognitive aspects in a more direct way. They can all be seen as part of the social capital which traditionally comprises a network component (what in the milieu literature has been defined as “relational capital”), which has a distinctively individual identity. Relational capital can be differentiated from the aggregate effect that the thickness of social networks and aggregate trust exert on socio-economic interactions. “*While it may be argued that a social capital exists wherever a society exists, ‘relational’ capital may be interpreted as the set of bilateral/multilateral linkages that local actors have developed, both inside and outside the local territory, facilitated in doing so by an atmosphere of easy interaction, trust, shared behavioural models and values*” (Camagni, 2008). Geographic proximity is no longer the mechanism through which socio-economic interactions are fostered; we instead ground our conclusions on a definition of *socio-cultural proximity* – a sense of belonging to a common culture, which in turn fosters mutual understanding, enhances the formation of individual and, in the long run, of aggregate trust, where common cognitive codes help in shaping a more efficient socio-economic environment.

Social capital elements in general affect cognitive mechanisms when linked to the rich literature on transaction costs (Williamson, 2002). When people share the same social language, it becomes easier to understand each other. Estimates from different authors point out that at least some of the process of adding value in modern economies is attributable to talking: McCloskey and Klammer (1995), for example, estimate that “one quarter of GDP is persuasion”. Therefore, reducing the frictions of communicating may be a source of productivity increases. Hence, belonging to a strongly identified community may foster economic activity. Better mutual understanding may also reduce transaction costs: whenever people get together to start a business, this is based on reciprocal trust. When this is not available, people must set up efficient rules and penalties for breaking them; and this process is costly. Knowing other people’s expected behaviour, as in a coherent and homogeneous society, may reduce the risks of ‘cheap talk’ failing to reach stable equilibria (Farrell, 1995). Finally, the concept of herd behaviour is a well-grounded one in the literature, and might represent a further key to understanding the complex mechanisms we want to measure. In countless experiments, sociologists and economists have found that people tend to be influenced by peers

when forming a judgment or an evaluation of a process. People reflect their surroundings when deciding how to act: political beliefs tend to display strong geographical and social patterns (see Shiller, 1995).

From what has been said before, we expect that the higher the presence of the cognitive elements of territorial capital in a region, the higher the capacity to exploit knowledge and to achieve increasing returns in growth processes. The dashed line in Figure 3 (see Section 4) shows the focus of the analysis in this section. Territorial capital, and in particular its cognitive elements, acts as a catalyst to economic interactions. It mediates between factors and long run performance; in other words, it can enhance factors' efficiency in regional growth by making personal interactions more effective. However, as the literature claims for social capital, the positive effects of cognitive elements as catalysts for higher efficiency of knowledge in regional growth might be subject to decreasing returns that may even become negative beyond a certain threshold. Putnam (2000) dedicates a full chapter to this issue and argues that, contrary to the concept of social capital, in the past when the United States enjoyed higher levels of social capital, its abundance also caused society to be exclusive and intolerant. Various empirical data suggest that in periods when most indicators of sociability were peaking, surveys concerning tolerance of diversity (in terms of race, sexual orientation, religion) showed dismal results. In other words, critiques of the concept of social capital claim that the decline of sociability in the US was offset by the positive effects of increased individual freedom. Michael Schudson (1998) wrote "*The decline in organizational solidarity is truly a loss, but is also the flip side of a rise in individual freedom, which is truly a gain*".

Whether decreasing returns affect our data will be further investigated in the empirical analysis of our study.

4. Territorial capital and its returns to knowledge: an empirical investigation

4.1 The model

In this section we present the conceptual and analytical model, in which the effects of knowledge on GDP growth is measured taking into account the level of the cognitive elements of territorial capital in the region. Figure 3 shows the focus of our analysis within the conceptual scheme described in Section 2.

To achieve our goal, we start by presenting and estimating a simple Cobb-Douglas production function with three standard production inputs, viz. physical capital, labour, and human capital. This may be written as:

$$Y_{r,t} = K_{r,t}^{\alpha} L_{r,t}^{\beta} H_{r,t}^{\gamma}, \quad (1)$$

where subscripts indicate the region (r) and time (t) of the analysis. α , β and γ are the parameters to be estimated (in equilibrium equal to the factor shares). Eq. (1.) can be log-linearized to obtain:

$$y_{r,t} = \alpha k_{r,t} + \beta l_{r,t} + \gamma h_{r,t}, \quad (2)$$

where lower-case letters indicate natural logs of the original variables. Let us now assume that human capital adds to wealth production not only per se, but also through the presence of cognitive elements which we include under the general term of ‘territorial capital’. We might think of this as the increasing returns mechanism which is put into practice when societies display high reciprocal trust, strong political participation, careful attention to environmental issues, or positive agglomeration economies that guarantee high interpersonal linkages.

This can be written in economic terms as an assumption about the γ coefficient. Suppose that:

$$\gamma = \gamma_0 + \gamma_1 cc_{r,t}, \quad (3)$$

where “cc” is our measure of the cognitive elements of territorial capital. Inserting equations (3) into (2) we obtain⁷:

$$y_{r,t} = \alpha k_{r,t} + \beta l_{r,t} + \gamma_0 h_{r,t} + \gamma_1 h_{r,t} * cc_{r,t}. \quad (4)$$

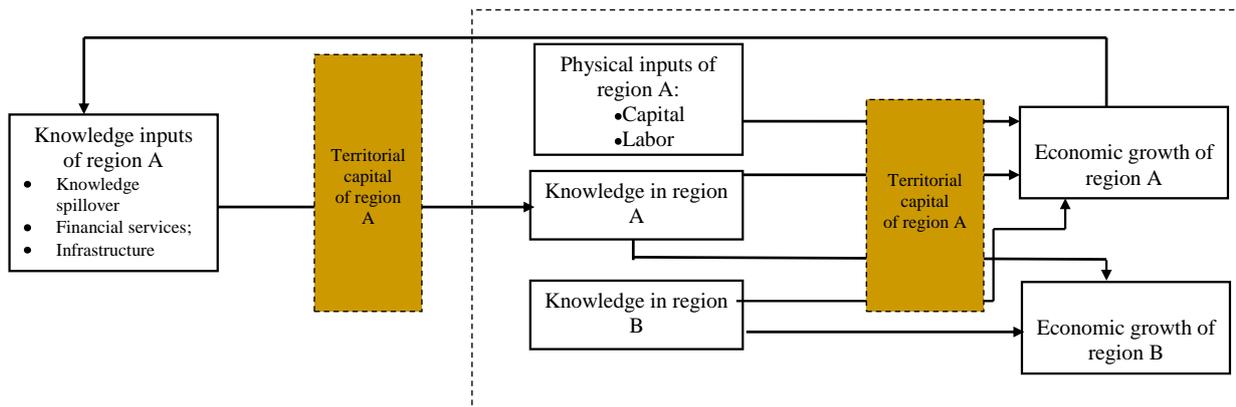


Figure 3: The theoretical framework: territorial capital explaining increasing returns

Equation (4) indicates that GDP is associated with labour, capital and human capital endowment, but the influence of the latter on GDP is dependent on the presence of the cognitive elements of territorial capital (the interaction term); as conceptually expressed by Figure 3, these cognitive elements are expected to play the role of knowledge catalysts, allowing for increasing efficiency of knowledge accumulation in regional growth.

4.2 The database

Equation (4) is our baseline model, which in our empirical analysis is estimated for all European regions (NUTS 2 regions)⁸ with a data set built from two main sources: the EUROSTAT

⁷ We do not impose an absolute role for cognitive capital as a generator of GDP. In fact, we believe that it only works as a filter/catalyst generating increasing returns to knowledge exploitation. For a comprehensive treatment of the contexts where the use of a single level term is allowed, see Brambor et al. (2006).

Regio database and the European Values Study (henceforth, EVS⁹) data set. Data for economic performance have been collected from EUROSTAT. To estimate labour, the total labour force at the NUTS 2 level is used. The stock of physical capital is estimated by means of the perpetual inventory method, starting from the gross fixed capital formation available in the EUROSTAT database.¹⁰ GDP is estimated by using GDP at current market prices. When GDP growth is calculated, this is done for the period 1999-2005.

Various measures for 'soft' or qualitative components are taken from the EVS, by aggregating individual answers across regions, in order to obtain mean values for each region. For countries whose EVS interviews have only a NUTS 1 reference, individual responses have been averaged across NUTS 1 regions, and those values have been assigned to the NUTS 2 regions that constitute the larger NUTS 1. In particular, four questions were taken into consideration, which could be used to interpret in a convincing way collective action and cooperation, namely: i) frequency of time spent in clubs and voluntary associations; ii) participation in any social activity; iii) voluntary work in any community activity; iv) share of people who can be trusted.

To aggregate the different variables of the territorial innovative cross, a principal component analysis was run, taking into consideration proxies for the cognitive elements of the territorial capital of Table 1. Among all possible elements, several elements could be measured using acceptable proxies, namely:

- collective action capability (share of people participating in clubs and voluntary associations; share of people engaged in voluntary work in any community activity and participating in any social activity in 2000);
- cooperation capability (share of people trusting other people in 2000);
- R&D receptivity (share of spatially-lagged patents in neighbouring regions in 1999-2005);
- governance of land resources (share of arable land in 1999-2005);
- agglomeration economies (population density in 1999-2005).

The results of the principal component analysis are presented in Table 1¹¹, where the relative scores for the components in the eigenvectors are presented for the first three components. These findings can be interpreted in the following way. The first component explains 37 per cent of the variance and scores high in frequency of club meetings, engagement in public affairs, trust, and our measure of R&D receptivity. The second vector can be characterized by attention to local areas and

⁸ The data set covers 260 NUTS 2 regions: French overseas departments and Spain's Ceuta and Melilla are missing because of lack of data.

⁹ EVS consists of a set of individual questionnaires administered to European citizens. Data have been collected in four waves: this paper uses the 1999-2000 wave, as it is the first to comprehensively cover the regional dimension of the analysis.

¹⁰ The perpetual inventory method to assesses the stock of physical capital accumulated starting from the gross fixed capital formation level, transformed into a stock by multiplying it by a factor which takes into account capital depreciation, productivity growth (which makes pre-installed capital obsolete) and labour force increase. Calculations assume 1999 as the base year, where data are available – otherwise the first year for which data are available is used. The results do not heavily depend on the chosen base year: by rolling the base year on the 1999-2005 sample and calculating linear correlations, same years' values calculated with different base years correlate around 0.7.

¹¹ The Principal Component Analysis was performed with Stata 9, with a simple correlation matrix.

governance of natural resources. It shows high values associated with voluntary work and the percentage of arable land, which is our measure of attention to the landscape and natural resources. Finally, the third vector is substantially dependent on our measure of district economies (population density).

Table 1 - Results of the Principal Component Analysis

| Variable | 1 | 2 | 3 |
|---|----------|----------|----------|
| Share of people participating in clubs and voluntary associations | 0.31276 | -0.68811 | -0.05502 |
| Share of people participating in any social activity | 0.52907 | 0.3186 | -0.12205 |
| Share of people engaged in voluntary work | 0.43161 | 0.39085 | -0.05227 |
| Share of people trusting other people | 0.44008 | 0.19671 | 0.10651 |
| Share of arable land | -0.13878 | 0.33601 | -0.04823 |
| Spatially lagged patents | 0.47024 | -0.34659 | 0.0162 |
| Population density | 0.04393 | 0.02272 | 0.98255 |
| Eigenvalue | 2.588 | 1.070 | 1.012 |
| Difference | 1.52 | 0.057 | 0.046 |
| Proportion | 0.37 | 0.15 | 0.14 |
| Cumulative | 0.37 | 0.52 | 0.66 |

The first factor obtained, referring to relational capital in an area, can be considered to be a good proxy for the presence of a “cognitive engine”, when the latter is the ability of a region to enable economic actors to work together under conditions of uncertainty, or solidarity, mutual assistance and co-opting of ideas. For this reason, this factor will be used in our empirical analysis.

5. The role of territorial capital as a catalyst for knowledge exploitation: estimation results

We will now proceed by estimating an econometric model. Equation (1) has been estimated using a standard least squares regression as a baseline model, which, however, suffered from spatial autocorrelation of the dependent variable. Tests for spatial autocorrelation have been run and estimates adjusted for spatial lags and spatial errors¹². The results are reported in Table 2 (columns 2 and 3).

¹² As the data set is organized in pooled form (each region is observed over 7 years and then the next region is

observed), our weight matrix is a simple inverse distance matrix. It has a block diagonal form like
$$W = \begin{pmatrix} w & 0 & 0 & 0 \\ 0 & w & \dots & 0 \\ 0 & \dots & \dots & 0 \\ 0 & 0 & 0 & w \end{pmatrix},$$

where a lower-case w indicates a 261x261 weight matrix, repeated seven times across the main diagonal, and the zero matrices indicate that the overall weight matrix W has zero elements everywhere else, as we chose data to cover fixed NUTS definitions in this time span.

Table 2 - Estimates of the equation in levels (equations (4) and (5))

| Dependent variable | <i>GDP at current market prices</i> | | | <i>Labour productivity</i> | | |
|--------------------------------|-------------------------------------|----------------|---------------|----------------------------|----------------|---------------|
| | LS | SAR | SEM | LS | SAR | SEM |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. |
| Stock of capital | 0.65*** | 0.60*** | 0.59*** | 0.65*** | 0.56*** | 0.59*** |
| Labour force | 0.34*** | 0.36*** | 0.40*** | - | - | - |
| Human capital | 0.19*** | 0.11*** | 0.13*** | 0.19*** | 0.04 | 0.13*** |
| Human capital* cog. Capital | 0.12*** | 0.12*** | 0.17*** | 0.12*** | 0.13*** | 0.17*** |
| Constant term | -0.38*** | -1.84*** | 0.07 | -0.41*** | -0.97*** | 0.07 |
| Spat. Autocorr. coeff. | - | 0.22*** | 0.96*** | - | 0.41*** | 0.96*** |
| <i>Number of obs.</i> | 1827 | 1827 | 1827 | 1827 | 1827 | 1827 |
| <i>R</i> ² | 0.9167 | 0.924 | 0.906 | 0.8025 | 0.835 | 0.768 |
| <i>Adj. R</i> ² | 0.9165 | 0.924 | 0.915 | 0.8022 | 0.836 | 0.799 |
| <i>Log likelihood</i> | - | -386.22 | -22.04 | - | -302.1 | -22.08 |
| <i>LM test (lag/error)</i> | - | 188.14 (0.000) | 54.59 (0.000) | - | 457.89 (0.000) | 54.59 (0.000) |
| <i>Moran's I</i> ¹³ | 0.05*** | - | - | 0.05*** | - | - |

Legend *: 90% significance level; **: 95% significance level; ***: 99% significance level.

All coefficients are significant with the expected sign. The interest of our analysis lies in the coefficient associated with the interaction term, γ_1 , which is positive and significant across all specifications. When corrected for spatial autocorrelation patterns, the interaction term results remain stable: the interaction term coefficient shows a positive and significant value.

When moving to the estimates of our labour productivity equation:

$$\frac{y_{r,t}}{l_{r,t}} = \alpha \frac{k_{r,t}}{l_{r,t}} + \gamma_0 h_{r,t} + \gamma_1 h_{r,t} * cc_{r,t} \quad (5)$$

we eliminate any regional size difference in the estimation of the coefficients. Table 2 contains the results (columns 4-6). These remain stable. The interaction term measures a positive and significant sign; for every 1 per cent of additional GDP, about 0.2 per cent more is generated by knowledge. When cognitive capital is present (as an average), the capacity of knowledge to act on GDP increases by 0.12 per cent (column 4). Interestingly, the results remain stable even when accounting for spatial autocorrelation. The relative contributions of human capital and the knowledge catalyst, measured by the interaction term, remain fairly stable, whatever specification we choose, and even when moving from a GDP to a labour productivity model.

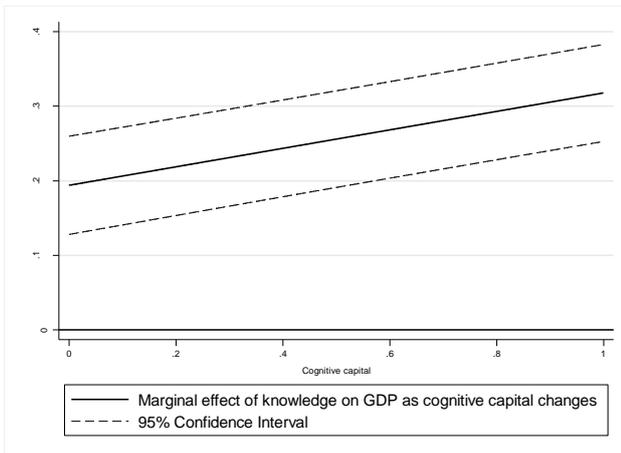
¹³ The reported value has been calculated with Pisati's spatial econometrics routine for Stata (see Pisati, 2001). As the routine calculates Moran's I for different threshold distances, we reported the average value of the statistic across significant levels. The same holds true for the growth equations as well.

In order to measure the marginal effects of knowledge on GDP, the first partial derivative of GDP with respect to knowledge has been calculated as follows:

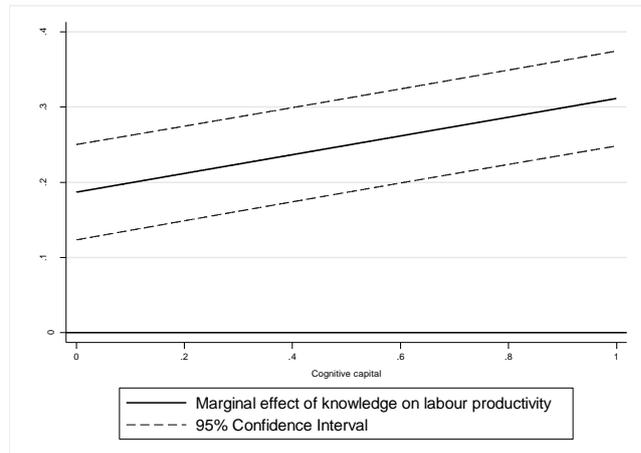
$$\frac{\partial y_{r,t}}{\partial h_{r,t}} = \gamma_0 + \gamma_1 * cc_{r,t} \quad (6)$$

and plotted for different levels of cognitive capital. The results are shown in Figure 4. The positive slope of the line shows that:

- knowledge per se generates a positive effect on GDP production, in line with the relevant literature on human capital;
- its effects are magnified when a consistent stock of cognitive capital is present. In other words, where people easily understand each other, or where they trust their peers, the transfer of knowledge is more fluid, and therefore the positive effects of human capital on GDP production are larger.



4a GDP level model



4b Labour productivity model

Figure 4: Marginal effects of knowledge on GDP (Figure 4a) and labour productivity (Figure 4b) for different levels of territorial capital

The next question is whether this relationship holds in dynamic terms as well. To analyse this point we start by dividing the analysed sample into two symmetrical parts, according to the distribution of our standardized measure of cognitive capital. If dynamic *marginal* returns to knowledge are also positively dependent on cognitive capital, and cognitive capital tends to accumulate over time¹⁴, we should find that the sign of the interaction term remains constant in both samples. If, instead, cognitive capital displays some form of decreasing marginal returns, then we should have a smaller sign associated with higher levels of cognitive capital; in other words, we should detect signs of decreasing dynamic marginal returns.

This is indeed our case. The LS estimates are shown in Table 3. The coefficient associated with the interaction term is positive and significant for both samples. However, its magnitude is larger in

¹⁴ This last assumption is verified by our data. EVS questions administered in 1990 and 2000 show an average positive trend in trust, sociability, and political participation of most EU regions.

the lower half of the cognitive capital distribution. Therefore, it seems that cognitive capital helps to foster knowledge exploitation especially for those regions that lag most behind. Also, the factor shares invert their signs over the two samples, which we may interpret in a neoclassical way. Cognitive capital is positively correlated with the log of GDP (the correlation coefficient is .37): hence a declining capital share may be justified using the concept of decreasing returns to capital.

Table 3 - LS estimates of equation (4), cognitive capital distribution split into the bottom and top 50%

| <i>Dependent variable: log of GDP at current market prices</i> | | |
|--|--------------------------------------|---------------------------------------|
| Quantile | Lower than average cognitive capital | Higher than average cognitive capital |
| | Coeff. | Coeff. |
| Stock of capital | 0.74*** | 0.32*** |
| Labour force | 0.25*** | 0.71*** |
| Human capital | 0.07 | 0.08* |
| Human capital* cognitive capital | 0.23*** | 0.14*** |
| Constant term | -0.50*** | 1.43*** |
| <i>Number of obs.</i> | 879 | 878 |
| <i>R</i> ² | 0.9144 | 0.928 |
| <i>Adj. R</i> ² | 0.914 | 0.9277 |

*Legend *: 90% significance level; **: 95% significance level; ***: 99% significance level.*

This forces us to reflect on the possibility that the positive effects of the cognitive elements of territorial capital on the marginal effects of knowledge on regional growth may be subject to decreasing returns. We investigate this issue in the next section.

6. Returns to scale of territorial capital as a catalyst of growth

In order to investigate the existence of decreasing returns in the role cognitive elements of territorial capital play on the marginal effects of knowledge on regional growth, we will now estimate the following regional growth equations:

$$\Delta y_{r,t} = \alpha \Delta k_{r,t} + \beta \Delta l_{r,t} + \gamma_0 \Delta h_{r,t} + \gamma_1 (\Delta h_{r,t} * cc_{r,t}) \quad (7)$$

and

$$\Delta \frac{y_{r,t}}{l_{r,t}} = \alpha \Delta \frac{k_{r,t}}{l_{r,t}} + \gamma_0 \Delta h_{r,t} + \gamma_1 (\Delta h_{r,t} * cc_{r,t}) \quad (8)$$

We then calculate the derivative of knowledge accumulation on, respectively, GDP and labour productivity growth as¹⁵:

$$\frac{\partial(\Delta y_{r,t})}{\partial(\Delta h_{r,t})} = \gamma_0 + \gamma_1 cc_{r,t} \quad (9)$$

and

$$\frac{\partial \left[\frac{\Delta y_{r,t}}{l_{r,t}} \right]}{\partial(\Delta h_{r,t})} = \gamma_0 + \gamma_1 cc_{r,t}. \quad (10)$$

The results of equations (7) and (8) are presented in Table 4. The interaction term has a negative and significant sign for the GDP growth model, but only for a spatially biased specification (column 1); this may actually suggest a negative effect of the cognitive elements on changes in the marginal effects of knowledge on regional growth. However, after accounting for autocorrelation of the dependent variable, we find that the interaction term becomes positive and loses significance (columns 2 and 3).

Table 4 - Estimates of growth equations (equations (7) and (9))

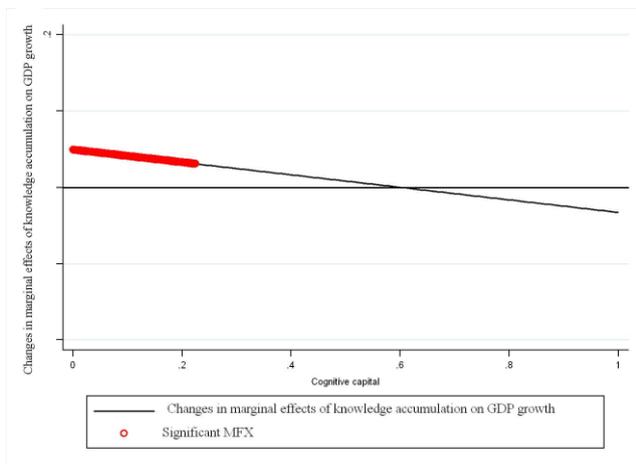
| Dependent variable | <i>Growth of GDP at current market prices</i> | | | <i>Growth of labour productivity</i> | | |
|--|---|----------------|----------------|--------------------------------------|----------------|----------------|
| | LS | SAR | SEM | LS | SAR | SEM |
| Model | (1) | (2) | (3) | (4) | (5) | (6) |
| | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. |
| Growth of capital stock | 0.35*** | 0.08*** | 0.08*** | 0.16*** | 0.14*** | 0.15*** |
| Growth of labour force | 0.17*** | 0.18*** | 0.20*** | - | - | - |
| Growth of human capital | 0.03** | 0.001 | 0.001 | 0.03*** | 0.02*** | 0.03*** |
| Growth of human capital* cognitive capital | -0.06* | 0.03 | 0.04 | -0.06*** | -0.05*** | -0.05*** |
| Constant term | 0.01*** | 0.001 | 0.02*** | 0.001** | 0.003*** | 0.002 |
| Spat. autocorr. coeff. | - | 0.75*** | 0.80*** | - | 0.74*** | 0.83*** |
| <i>Number of obs.</i> | 1351 | 1827 | 1827 | 1827 | 1827 | 1827 |
| <i>R</i> ² | 0.21 | 0.08 | 0.05 | 0.14 | 0.17 | 0.12 |
| <i>Adj. R</i> ² | 0.21 | 0.11 | 0.05 | 0.14 | 0.20 | 0.14 |
| <i>Log likelihood</i> | - | 4048.93 | 4050.98 | - | 5072.02 | 5074.56 |
| <i>LM test (lag/error)</i> | - | 191.64 (0.000) | 197.15 (0.000) | - | 279.19 (0.000) | 326.39 (0.000) |
| <i>Moran's I</i> | 0.02** | - | - | 0.05*** | - | - |

Legend *: 90% significance level; **: 95% significance level; ***: 99% significance level.

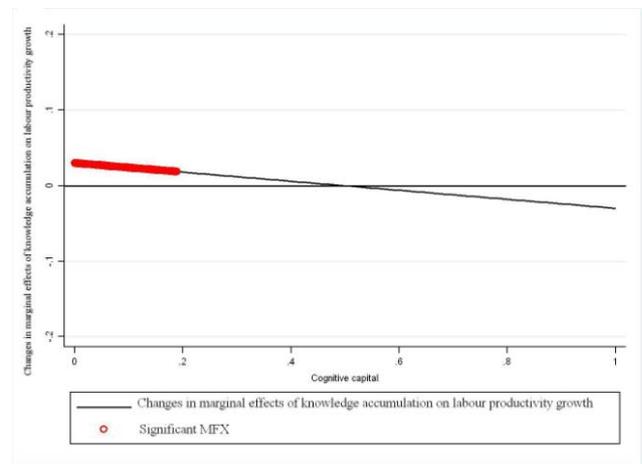
¹⁵ This implies the assumption that it is the *level* of cognitive capital that affects knowledge exploitation, and not its accumulation. In other words, we again impose the restriction on the γ parameter to be equal to $\gamma = \gamma_0 + \gamma_1 cc_{r,t}$.

The values of equations (9) and (10) are plotted in Figure 5, for the different levels of territorial capital. Equations (9) and (10) represent the changes (the second derivative) in the elasticity of, respectively, GDP and labour productivity with respect to knowledge. Their negative slope implies that the elasticity of GDP (or labour productivity) with respect to knowledge can be represented by an inverted U-shaped curve, as in Figure 6. Decreasing *marginal* returns in the role that cognitive elements have as a catalyst for the exploitation of knowledge for regional growth appear to exist beyond a certain threshold of territorial capital.

The statistical significance of the decreasing *marginal effects* of knowledge on GDP holds only for small levels of cognitive capital (less than 25 per cent of its distribution).¹⁶ Figure 6 shows that after increasing in the first half of the territorial capital's distribution, the marginal contribution of knowledge on GDP then decreases again. The maximum contribution of territorial capital to knowledge exploitation seems to be set around the 6th decile of the distribution, where, in Figure 5a, the second-order derivative crosses the X axis. The same patterns of significance characterize the coefficient values of knowledge accumulation on productivity growth (Figure 5b). Thus, from the perspective of a social cost-benefit analysis, the benevolent planner may want to foster mutual trust, the transfer of knowledge, participation in social and common activities, but only up to a certain point. Beyond that threshold, marginal costs may overcome marginal benefits, by creating a set of exclusive, Olson-type groups, where the sense of belonging may even hamper some social interactions and some economic transactions.



5a. GDP growth model



5b. Labour productivity model

Figure 5: Marginal effects of knowledge accumulation on GDP growth for different levels of territorial capital

¹⁶ Statistically significant observations are represented by hollow circles. Statistical significance is calculated as follows. First, we calculate a marginal effect for each observation; this is then divided by the observation's standard error. Statistically significant observations are those for which this ratio exceeds 1.96 in absolute value; the value is chosen according to a 95 per cent confidence level.

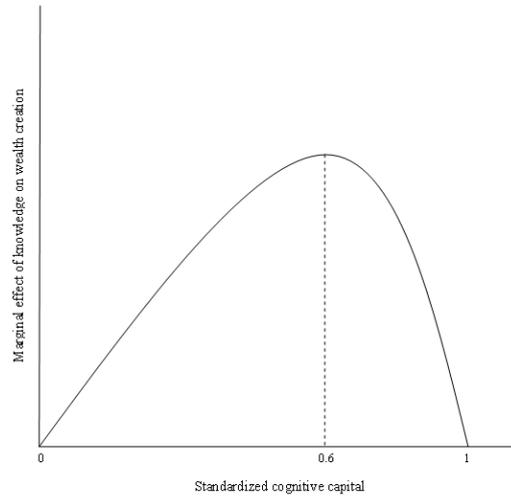


Figure 6: Overall marginal effects of knowledge on wealth creation

To further assess whether region-specific effects may possibly alter our results we can use spatial panel models. These recent theoretical improvements (Elhorst, 2003) have been subsequently operationalized. The idea behind these models is that autocorrelation patterns may not be completely wiped out by spatial econometrics techniques. If region- or time-specific effects are not only characterized by diffusion/contagion mechanisms (as in the Spatial Error Model) or by the omission of relevant, spatially bounded variables (as in the Spatial Auto-Regressive model, henceforth SAR), then region-specific fixed effects may take into account these differences, thus removing most of the autocorrelation coefficient estimated with pooled spatial models.

As the whole set of variables is correlated across space, we adopted the SAR specification and applied it to all the four specifications in the estimation (levels and growth rates of GDP and labour productivity). The results are shown in Table 5.

Table 5: Estimates of level and growth equations with spatial panel techniques, SAR specification

| <i>Dep. Variable</i> | <i>Reg. GDP</i> | <i>Reg. lab. prod</i> | <i>Growth of reg. GDP</i> | <i>Growth of reg. productivity</i> |
|-------------------------------------|-----------------|-----------------------|---------------------------|------------------------------------|
| | (1) | (2) | (3) | (4) |
| | Coeff. | Coeff. | Coeff. | Coeff. |
| Stock of capital | 0.35*** | 0.39*** | 0.16*** | 0.28*** |
| Labour force | 0.15*** | - | 0.21*** | - |
| Human capital | 0.07*** | -0.007*** | 0.04*** | 0.02*** |
| Human capital* cognitive capital | 0.01*** | 0.12*** | -0.05*** | -0.02* |
| Constant term ¹⁷ | - | - | - | - |
| Spat. autocorr. coeff. | 0.006*** | 0.007*** | 0.006*** | 0.007*** |
| <i>Number of obs.</i> | 1827 | 1827 | 1827 | 1827 |
| <i>R</i> ² | 0.66 | 0.57 | 0.46 | 0.48 |
| <i>Loglikelihood</i> | 3.36E+24 | 5.25E+24 | 5.20E+23 | 2.96E+24 |

¹⁷ The term is not shown in the table, as spatial panel models are based on a demeaning technique, much like their a-spatial counterparts.

All coefficients improve their significance because of the better focus of the model on the true impact that each of the variables has on the economic process being explained. Human capital, nevertheless, becomes negative in the labour productivity model in levels (column 2), while the interaction term remains negative in both growth equations, again suggesting nonlinearities in the cognitive capital's capability to generate increasing returns to knowledge exploitation. As expected, the estimated ρ , while retaining its high significance, becomes very small in absolute terms, thus demonstrating the good performance of these models.

7. Conclusions

This paper builds on previous studies which examine the relationship between innovation and economic growth. We first claim that the former does not necessarily lead to the latter. The reason why this step may not be automatic is explained by the presence of cognitive elements in the region: these allow local actors to manage information in order to identify and solve problems, or, more precisely in the economic sphere, to transform information and inventions into innovation, and cooperative or market interactions into productivity and growth increases.

Within the rich territorial capital definition, which highlights all material and non-material elements that characterize a regional system, we identify a particular subset of variables which may be responsible for fostering socio-economic interactions and mutual understanding in a spatially-bounded context: those variables are the cognitive mechanisms that characterize our definitions of agglomeration economies, social and relational capital, knowledge receptivity, and local governance.

We test this hypothesis in a simple neoclassical framework. We explore the role of cognitive elements in explaining the formation of increasing returns to regional knowledge; we find that collective learning, mutual understanding, reciprocal trust, and social commitment all play a major role in determining long-run economic performance, by magnifying the effects of knowledge creation (and accumulation) on wealth formation.

We believe this to be only the first step towards a more comprehensive model of the spatial and territorial characteristics that may enhance or hamper the effectiveness of human capital and knowledge in a modern regional economy. In fact, the results are robust with respect to the way in which cognitive elements act as a knowledge catalyst: the presence of higher cognitive capital is associated with higher impacts of knowledge on GDP. What is still an area in which further fruitful research can be developed is the existence of non-linearities in the role that cognitive elements play as a knowledge catalyst. In this area, our results do not always lead to an irrefutable message: thus we believe there are still possibilities for future research on this issue. But our results certainly confirm the idea that regional growth policy presupposes due interest and appropriate investments in cognitive and territorial capital.

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