

# Sustainable Interrelated Growth: A Phenomenal Approach

Alberto Bramanti and Massimiliano R. Riggi

## 1 'Sustainable Growth' and 'Endogenous Development': a Preamble

It is strikingly clear that local contexts are more and more important as providers of rich external economies, shaping the form and sustainability of territorial competitiveness (Camagni 1991; Markusen 1996; Bramanti and Maggioni 1997; Crouch et al. 2001). The process of globalisation has been an important driver of change exposing even the most remote areas to competition, but cognitive and normative resources, as well as social capital and trust, are deeply embedded in the territorial social fabric.

It is thus quite natural to identify the two driving forces of dynamic competitiveness in: (a) the *robustness* of local connections (frequently considered as the 'milieu effect') and (b) the *openness* of the territorial system – made up of actors, firms, and institutions – to the global world, to the long range networks of finance, information and globalised markets.

Robustness refers to a relational space (Camagni 1991) which is the field of social interaction, interpersonal synergy, social collective action, imitation of successful managerial practice, interpersonal face-to-face contact, informal cooperation between firms, tacit circulation of information and knowledge. It is worth noting that the TSPI<sup>1</sup> (Territorial System of Production and Innovation), as a relational space, empowers and guides innovative agents to innovate and coordinate each other. TSPI is the territorial counterpart of what the American economic sociologist Mark Granovetter has labelled the 'embeddedness' of social and economic

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<sup>1</sup> This is a multi-faceted concept deeply rooted in regional analysis. Territorial Production Systems (TPS) have been widely used by a number of scholars and in a dynamic view it brings together a 'production system', a 'technical culture' and a set of actors (enterprises, professional associations, local authorities, universities and laboratories, individuals). The TSPI adds the concept of innovation to the previous TPS, and there are two main mechanisms at work: the first is the creation of innovation and the second is the diffusion of the innovation, which is always a social type of communication (see Bramanti and Fratesi, 2009, in this book).

processes (Granovetter 1973). We are far beyond the notion of external economies as simply scale-related: they are complex outcomes of interaction between scale, specialization and flexibility in the context of proximity.

Openness, on the other hand, refers to the linkages that a TSPI establishes with: leading worldwide institutions (supra-national institutions, major investment banks, global business consultants); state-of-the-art information and knowledge producers (first top universities, research centres, techno parks); global champion firms (market leaders and very demanding clients) and communities of practices (knowledge workers operating within learning organizations).

Through the long-range linkages a TSPI can get in touch and learn ‘newness’ (techniques, styles of life, needs) wherever it springs up. So, within a TSPI ‘gate’ institutions and actors become more and more central to the system success. The presence of a major university, an international fair, a global cultural event are all basic components of the creative economy and a huge source of competitive advantage.

The relevance of the role played by local and global relationships in determining the economic performance of TSPI is witnessed by their current centrality both in the theoretical and empirical literature, as well as in the policy debate. Following Maggioni and Bramanti (2002) we can look at local identity (proximity) and global relationships (networks) as two complementary elements useful to ensure a stable path of ‘sustainable growth’ and ‘endogenous development’.

“These two terms seem to mimic and mix the two buzzwords of mainstream economics: ‘endogenous growth’ and ‘sustainable development’. On the contrary, by sustainable growth we refer to a given set of production and innovation dynamics concerning the existence of enabling conditions for the re-production of the local endowment of resources allowing positive performance and the persistence of the TSPI in the long run. Endogenous development refers to the governance of the TSPI and concerns the capability of local agents to control and guide (at least partially) the patterns of qualitative and quantitative expansion of the system.” (p. 248).

In order to investigate the relational features of development<sup>2</sup>, we look at the TSPI analysed along a ‘phenomenal approach’. Phenomena represent a display of reality within which factors and actors behaviours interact: phenomena are therefore the result of underlying causal connections and actors behaviour (Bramanti and Miglierina 1995). Phenomena are more elaborate concepts than factors, even though they are a bit more ‘vague’; to some extent we can tackle phenomena as ‘meta factors’ and in the present chapter we want to model ‘sustainable growth’ as deriving from the strict interplay of two specific meta-factors, or phenomena: *robustness* and *openness*.

This working hypothesis is far from being neutral, but we are convinced that this approach is a convenient approximation of how sustainable regional growth relies

<sup>2</sup> That are human relations essential to many types of economic coordination and, specifically, human relations, rules and conventions that are at the heart of the economic process today. Many ‘non-economic’ forces – such as institutions, cultures, and social practices – exert a relevant role in economic life; they are central to the economic process as they underpin the mobilization of economic resources and the organization of production systems, the exchange and convergence in international best practices.

on the process of production, accumulation and exchange of knowledge supported and fostered by the interplay of the two cardinal dimensions of ‘internal synergy’ and ‘external energy’.

We address this issue in two steps: *first* we explain, in the space of phenomena, how TSPI growth relies on innovation, which remains the main trigger of territorial growth, and is fostered externally by open worldwide networks and diffused internally and exploited by local dense relations; *second* we model the growth relation by operationalising ‘robustness’ and ‘openness’ phenomena through human capital. Further on in the chapter we deal with alternative ways of looking at human capital accumulation and at the deriving alternative policies.

## 2 From Innovation to Growth: A Phenomenal Approach

The logical frame adopted to explain sustainable territorial growth is quite simple. Innovation is a must in TSPIs operating in OECD countries<sup>3</sup> facing a global competition. We do not have to digress to justify this starting assumption as the theme is fully developed in the Bramanti–Fratesi chapter within the book. We can only remind the reader that innovation is a complex phenomenon in which external and internal information, knowledge, competence and creativity mix together.

While the production and exchange of information are mainly related to a-spatial networks in which codified knowledge is exchanged on a global scale, knowledge and competence feed on both internal and external circuits despite clear evidence of a major role played by proximity and face-to-face contacts. Creativity emerges from the synergetic meeting of the previous stages – information, knowledge and competence – combined in a specific cultural and territorial context strongly embedded in people.

Therefore, an over-emphasis on ‘internal elements’ – and sometime on strong ties<sup>4</sup> – produces an inward looking TSPI in which the innovative potential is reduced to learning-by-doing and learning-by-using activities, generating incremental innovations. When radical innovations are required weak access to external sources (loose external linkages and weak ‘gate’ actors) reduces the spectrum of technological opportunities.

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<sup>3</sup> This is an approximation to indicate TSPIs belonging to an already developed economic macro context. The model supports a wide range of applications but it is not consistent with developing countries in their early stages context.

<sup>4</sup> Strong ties refer to family membership, close friends and long time neighbours or co-workers. They are highly demanding and very selective, marked by trust and reciprocity in multiple areas of life. According to sociologists who study networks most people can make and manage between five and ten strong-tie relationships. But weak ties are indeed more important following the seminal article by Granovetter (1973). Weak ties are a key mechanism for mobilizing resources, ideas and information; weak ties require less investment and we can use them more opportunistically, they allow for rapid entry of new people and rapid absorption of new ideas offering fundamental support to the creative process (Florida, 2002).

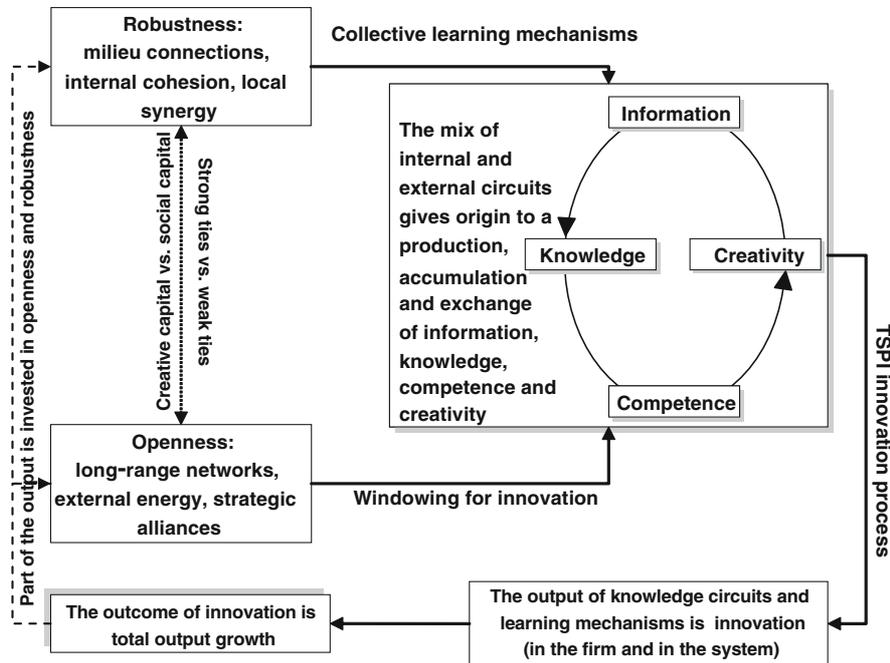


Fig. 1 A diagrammatic view of TSPI sustainable growth mechanism

The reverse occurs with an over-emphasis on external networks and codified knowledge. Here the TSPI will not learn through the interaction of local actors and the most likely result is the loss of local identity, a weakening process of the ‘genius loci’ and a deriving lesser attractiveness of TSPI towards external assets, as far as the possible delocalization of the production process.

The mechanisms at work within the TSPI are captured by the following diagram (Fig. 1):

- *Local robustness* or *internal relationships* is – in the ‘phenomenal space’ – a proxy of the absorptive capacity of the system in terms of innovation, it is here that the so called ‘genius loci’ is at work;
- *Openness* or *external linkages* refers to the general innovation stimuli and refers to information, knowledge and capabilities that affect the innovative capacity;
- The process of blending and mutually reinforcing robustness and openness generates truly *innovative products*, strengthens the competitiveness of TSPI and reinforces the learning mechanisms<sup>5</sup> of the local milieu;
- The outcome of a truly innovative TSPI is increasing *total output* according to the ‘productivity of innovation’, i.e. the capacity to transform advances in the

<sup>5</sup> Learning may be understood as a qualitative change in a person’s way of seeing, experiencing, understanding, and conceptualizing something in the real world. In addition, learning is not something that requires time out from productive activities; it is the hearth of productive activities. To put it simply learning in the new form of labour.

technological field into new products for which there is demand in the market and generate more revenues. In this frame the ‘fundamentals’ of the TSPI (from the production processes to the governance routines) define its ability to exploit innovation within the production function. If the region benefits from a thick institutional setting, valuable entrepreneurs, friendly networks, cooperation between actors (all determinants of *relational development*), it is more able to put innovation at work. On the other hand, if the region suffers from rarefied connections, predatory behaviour, and weak socio-economic environment, potential innovation is difficult to transform into territorial growth.

Openness can be thought of as a fundamental building block of growth because it plays the gate role through which innovation flows into the TSPI; robustness represents the other side of the coin: it strengthens the absorptive capacity of different actors at work within the TSPI and enables them to fully exploit the external stimuli.

There are certainly many different ways of looking at ‘openness’ and ‘robustness’ but we consider the human capital approach a priority. The loops and feed-backs of knowledge production, accumulation and exchange (sketched in Fig. 1) are deeply rooted in organizations and institutions that, in turn, depend heavily on people: skilled human capital, workforce, entrepreneurs. People are at the core of the creative process which marks a wide range of knowledge-intensive industries; people are the subject of learning process, people:

“apply or combine standard approaches in unique ways to fit situations, exercise a great deal of judgement, perhaps try something radically new from time to time (...) engage in work whose function is to create meaningful new forms.” (Florida, 2002: 69).

For the sake of simplicity we distinguish between people (i.e. human capital in the standard economic approach) between ‘internally trained’ human capital (ITHC) – the local production factor – and ‘externally trained’ human capital (ETHC), i.e. people<sup>6</sup> coming from the outside, frequently endowed with superior education, experience, and with different competences from those available within the TSPI.

### 3 The Core Model: A Solowian Approach

Having described the process of innovation (technological, organizational and social) of TSPI – rooted in the balancing of the two ‘building blocks’ (robustness and openness) – we are now able to introduce a simple ‘neoclassical’ model in which the regional total output – the outcome of innovation – is the result of *internal robustness* (hinging on the ‘genius loci’) and *external openness* of the system to global phenomena and stimuli (spurring innovation patterns).

Openness is measured in terms of ETHC – i.e. personnel with higher formal education and international experience in the field of innovation – while robustness

<sup>6</sup> We are here referring to the ‘creative class’ of Florida (2002) distinguishing it from the ‘service class’ – frequently referring to immigrants – which includes workers in lower-wage, lower-autonomy service occupation.

is explained in terms of ITHC – i.e. a workforce well acquainted with local routines and exchanging knowledge tacitly. The basic resource in this model is human capital, which we use/measure as units of input within the regional production function.

We choose to represent the regional production function as a Solowian model of capital accumulation. We therefore define a Cobb Douglas production function with constant returns to scale, such that openness ( $E_t$ ) and robustness ( $H_t$ ) are the two main inputs expressed in terms of externally and internally trained workers respectively, both contributing to the definition of  $Y_t$  that represents the flow of output produced at time  $t$ :

$$Y_t = H_t^\alpha E_t^{1-\alpha}$$

where  $\alpha$  (with  $0 \leq \alpha \leq 1$ ) is the technological parameter expressing the share of total output invested in the local factor (ITHC) and its complement to unity  $1 - \alpha$  represents the share of total output invested in the external factor (ETHC, a proxy for innovation coming from outside).

As in the standard Solowian model, output is a homogeneous good that can be consumed  $C_t$  or invested  $I_t$ ; if we look at total product from an expenditure approach we can therefore state that it is allocated to consumption and internal investment:  $Y_t = C_t + I_t$  where  $I_t$  is the investment in the local factor ( $H_t - H_{t-1}$ ).

Assume that openness is given and is defined by an exogenous dynamic at the growth rate  $g_E$  according to the relation  $E_t = E_{t-1}e^{g_E}$  (with  $E_0 = 1$  for simplicity).

The evolution of human capital deserves further attention; we need to specify the process of its accumulation over time with a law of motion:

$$H_t = H_{t-1} + s_H Y_t - \delta H_t$$

so that the net increase in the stock of human capital at a point in time equals gross investment less depreciation.  $s_H Y_t$  is the share of output invested in local factor accumulation, which depreciates at a constant rate  $\delta > 0$ .

We aim to show that if more output is invested in the local factor (ITHC) the regional development path is biased toward local strong ties while, investment in innovation (ETHC bridging technological advances) is limited: when the level of consumption is sub-optimal, the implication is that the balance between openness and robustness is inappropriate.

In order to do that, we express the model in relative terms, dividing by  $E_t$ : when comparing two regions in terms of output, we are not interested in their absolute size, but in the output they are able to produce with internal factor.

The Cobb-Douglas production function becomes:

$Y_t/E_t = \left(H_t/E_t\right)^\alpha$  which is analogous with the ‘intensive form’ of the Solowian production function. Using lower case for *relative variables* we can write:

$y_t = h_t^\alpha$  where  $y_t$  may be considered as the total attainable output provided a given level of external innovation and  $h_t^\alpha$  the internal/external ratio in terms of knowledge embedded in human capital (something like a tacit/codified ratio in the production and exchange of knowledge).

The equation for the dynamics of human capital then becomes:

$\frac{H_t}{E_t} = \frac{H_{t-1}}{E_t} + s_H \frac{Y_t}{E_t} - \delta \frac{H_t}{E_t}$  or,  $\frac{\dot{H}}{E_t} = s_H \frac{H_t}{E_t} - \delta \frac{H_t}{E_t}$  (dot indicates the variation over time of the underlying variable). Since the variation over time of  $\frac{H_t}{E_t}$  can be expressed as:  $\dot{h} = \frac{\dot{H}E - H\dot{E}}{E^2}$ , the accumulation of human capital over time in relative terms becomes  $\dot{h} = s_H f(h) - (g_E + \delta)h$ , which has the advantage of depending only on  $h_t$ . Both  $E_t$  and  $H_t$  show decreasing returns to scale, so that an equilibrium is reached when  $\dot{h} = 0$ , which implies  $h^* = \left( \frac{g_E + \delta}{s_H} \right)^{\frac{1}{\alpha-1}}$  (\* indicates variables in equilibrium).

Notice that this level of  $h^*$  may be optimal for different levels of  $s_H$  (share of output invested in local factor), each one corresponding to a different value of  $h^*$ . In particular, for growing  $s_H$ , the optimal level of  $h^*$  grows, as shown in Fig. 2.

In order to show the optimal levels of investment – split between openness and robustness – we have to consider that the total output produced allows an optimal level of consumption to be defined, which is the real variable to be maximised in equilibrium to define a wealthy TSPI. The dynamics of consumption in absolute terms is monotonic in domestic investment, the local factor of production: the more that is invested, the more output grows and the more consumption increases. Nevertheless, this occurs at a declining rate, because both inputs show decreasing marginal product. This means that consumption itself can be maximised by choosing from among the different equilibria that  $h^*$  defines. Since output is spent in either consumption or investment in local factor ( $s_H + c = 1$ ) – where  $c$  is the propensity to consume – we can say that in equilibrium  $C^* = (H^*)^\alpha - I_H^*$ , but in equilibrium investment is only made to replace depreciated human capital, then  $c^* = (h^*)^\alpha - (g_E + \delta)h^*$  is the optimal level of equilibrium consumption in relative terms, which can be represented in graphical terms in Fig. 3.

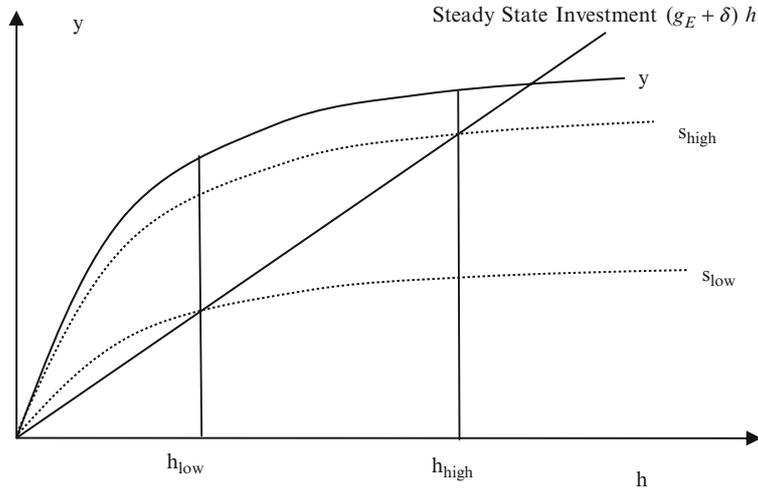
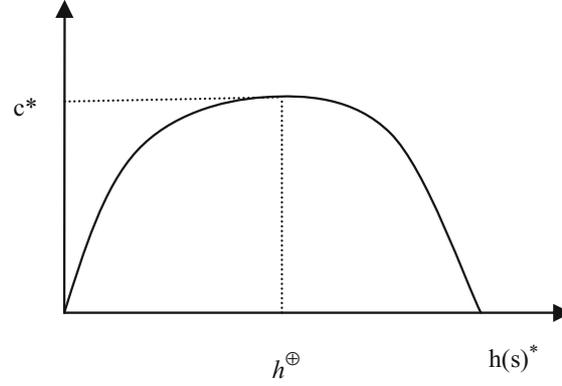


Fig. 2 Low and high equilibria



**Fig. 3** Optimal levels of consumption

Even at this stage an important implication can be drawn. This simple presentation of a model of exogenous growth is consistent with the findings of relational development. Optimal levels of equilibrium consumption stem from a balance between openness ( $E_t$ ) and robustness ( $H_t$ ) or, in the model, human capital and innovation.

Any deviation from  $h^\oplus$  implies a reduction of the equilibrium level of consumption, so unbalanced openness and robustness patterns can provide equilibria, but not all of them are identical. Investments in local factor and innovation are both necessary in a balanced path for an optimal equilibrium (Golden Rule), such as that depicted in Fig. 3. In order to assess how much to invest in the two different factors, regional policy makers should consider the technological parameters of their production processes, here indicated by  $\alpha$  and  $1 - \alpha$ .

When a region shows higher  $\alpha$ , this means that the region is able to gain more advantage from investment in local factor than from investment in innovation, and the optimal balance between  $H_t$  and  $E_t$  is biased towards  $\alpha$ .

Policies aimed at promoting local robustness are then suitable; this does not mean that benefits from opening the TSPI to the outside must be neglected. In fact, policies devoted to ITHC can promote faster growth towards a steady state, but higher levels of consumption in the steady state imply a trade-off between openness and robustness. Optimal policies<sup>7</sup> are identified if  $s_H = \alpha$ .

The simple Solowian model presented, examines the main building blocks of sustainable interrelated growth in a neoclassical framework and, interestingly, the main result still holds good, giving significance to the topic of borders in territorial systems (how local is local development?), what are internal vs. external factors, what are strong vs. weak ties, what are short-range vs. long-range networks, and their implication on growth performances. This confirms that a sustainable growth pattern must balance dynamically the degree of internal robustness – the social

<sup>7</sup> Proof:  $C=Y-I$ . By the Golden Rule  $\frac{\partial C^*}{\partial H^*} = \alpha (H^*)^{\alpha-1} L^{1-\alpha} - (g_E + \delta) = 0$ , then  $\alpha Y = \delta H$ . But we also know that in the steady state  $s_H Y = \delta H$ , then the steady state is compatible with the Golden Rule iff  $s_H = \alpha$ .

embeddedness of the innovation process – with external openness to the rest of the world, the participation in global networks and long-range relations. Moreover, solutions biased towards internal or external investment, engender a crisis in the regional system in the long run.

These two extreme cases can be called, after previous work on relational development (Bramanti and Miglierina 1995) *death by entropy* or *disintegration* of TSPI.

In the first case – a system totally oriented inwards – entrepreneurs only follow established routines and imitate each other, weakening the system. In case of an external shock – implying a drop in the international price of traded goods – the consequence is a firm with no competitive tools in the short run, the only focus being on innovation whose horizon is long.

In the second case – a system totally oriented outwards – delocalisation of important parts of the production value chain is chosen to exploit the opportunities provided by global markets. The end result is a weak case for the territory in attracting and rooting firms and the emergence of ‘isolated’ firms competing as ‘monads’ in the global market.

#### **4 Human Capital and Robustness**

We have assumed that human capital is central in explaining growth patterns. In the current section, we will discuss its importance for regional development and then we will specify the general formulation for its dynamics expressed in the Golden Rule previously reported.

In the twentieth century, a new paradigm of production emerged, characterised by a sharp shift from the relevance of physical elements to the relational dimension of the structure and the dynamics of the economic system (Castells 2000). Those relational aspects, as already discussed, constitute the basic components of regional development. It is currently recognised that disparity in productivity and growth has far less to do with the abundance of natural resources and much more to do with the ability to improve the quality of human capital and factors of production, to create new knowledge and good ideas and embed them in equipment and embody them in people (David and Foray 2002). This perspective stresses the fact that the most valuable assets are intangible investments (human, social and creative capital) and that knowledge, competence and creativity are key factors.

The rise of the knowledge economy is due to information-, knowledge-, and skills-based activities playing an increasingly significant role in economic growth.

Human capital is widely acknowledged as one of the main boosters of economic growth; furthermore, large differences exist within and between regions in terms of both quantity and quality of educational structure and institutions (Wossmann 2002).

Accepting this view, we have stressed the role of human capital – both internally and externally trained – in the process of territorial development. In this respect, the formulation of the ‘Golden Rule’ presented above is quite general and, in particular, it does not distinguish between different ways of setting up human capital.

Two broad families can be identified: formal human capital accumulation (education and accumulation of more general *codified knowledge*) and informal human capital accumulation (stemming from learning-by-doing processes or, broadly speaking, from *tacit knowledge* accumulation). Actually, these two ways coexist and human capital is generated through a mixed process of tacit and codified knowledge accumulation. Which features distinguish these two kinds of learning processes? Basically, codified knowledge can be exogenously transmitted to a region with no need of interaction, whereas personal interaction is peculiar for the process of learning to set up tacit knowledge. In the next sections the two forms of accumulation are presented and then a mix of the two is discussed.

In order to operationalise the resulting three ways of accumulation and make them comparable, the law of motion of human capital accumulation will be made explicit in a slightly different way following to different extents, Mahajan and Peterson (1987), Maggioni, (1997), Maggioni and Riggi (2002), Riggi (2004), Maggioni and Nosvelli (2005).

#### ***4.1 Exogenous Accumulation***

Human capital is developed mainly through education. This may be represented by a mechanism of exogenous learning in which codified knowledge is spread across the region. Mahajan and Peterson (1987) identify the following specification to proxy this phenomenon:

$$\frac{dN}{dt} = a(K - N)$$

Where  $N$  is the skilled population (the share of TSPI population endowed with human capital), whose rate of growth is driven by the parameter  $a$  and  $K$  represents the total amount of human capital that the region can support (carrying capacity). Let us say that the existing population can reach a maximum fixed level of education.

In this dynamic, each actor only learns what he/she observes from the outside, regardless of interactions with other firms within the region that have already innovated. The parameter  $a$  describes the speed at which people learn and innovate through the process of technological windowing, external networking and weak ties. The external learning mechanism is positively influenced by  $(K-N)$ , the distance between the maximum level of human capital and the degree already attained within the population.

#### ***4.2 Endogenous Accumulation***

If education is the main driver for human capital accumulation, it is far from explaining the underlying process in an exhaustive way. In fact, *learning-by-doing* (Arrow 1962), *learning-by-interacting* and any other form of interaction between

workers or different actors (between firms, research centres and public institutions) – occurring in the workplace or at the regional level – are essential channels to build human capital. Internal connections and tacit knowledge are at the base of this process and appear in the formal model for innovation diffusion captured by a parameter  $b$ , across a population ( $N$ ) of dimension  $K$ .

$$\frac{dN}{dt} = bN(K - N)$$

The speed of the innovative process in this second version is then proportional to the quality and quantity of social, economic, technological and productive interactions that take place within a region between actors. Interactions between the population endowed with human capital and potential adopters stem from the product of  $bN$  and  $(K - N)$ .

### 4.3 Comparing Exogenous and Endogenous Accumulation

Although the previous mechanisms for human capital accumulation simplify the two main channels driving the process, both are actually relevant in interpreting the effectiveness of human capital as a production factor. We need, therefore, to include both kinds of accumulation processes.

The simultaneous consideration of the two may give rise to two different features: first it could be argued that their combination can generate positive synergic effects in terms of the creation of new knowledge. On deeper analysis, however, it emerges that the two forms of accumulation echo the two crucial dimensions of territorial sustainable interrelated growth:

- Endogenous accumulation is based on the generation of collective learning processes that flourish within a TSPI, where tacit knowledge, strong ties and social embeddedness can be indicative of original capabilities of the social and economic environment (citizens and not just workers are very familiar with the routines, norms and conventions on which the TSPI hinges);
- The exogenous accumulation process is based on the external openness of TSPI and innovations are mainly grasped from the outside through a process of technological windowing, fostered by codified knowledge exchange and weak ties.

The relative efficiency of the two processes can be analysed using a simulative approach after Maggioni and Riggi (2002). Depending on cumulative interactions and the number of actors involved, the evolution of human capital is better described by either form of learning being a *Pareto superior* situation. In analytical terms, the objective is to identify an accumulation process that, at each point in time, is more efficient in producing human capital at territorial level. In the next sections, we first simulate the case the two processes which are identical in terms of the parameter values ( $a$  and  $b$ ), and then we relax this hypothesis.

### 4.3.1 The Case of Identical Parameters

Even in the case of identical parameters, the initial conditions in both cases need to be discussed. For null initial values, the endogenous model leads in fact to a meaningless case in which no human capital is produced; an initial critical mass is required for the process to show significant results. The exogenous process, instead, allows the accumulation process to start up, even where there is initially no human capital in the region.

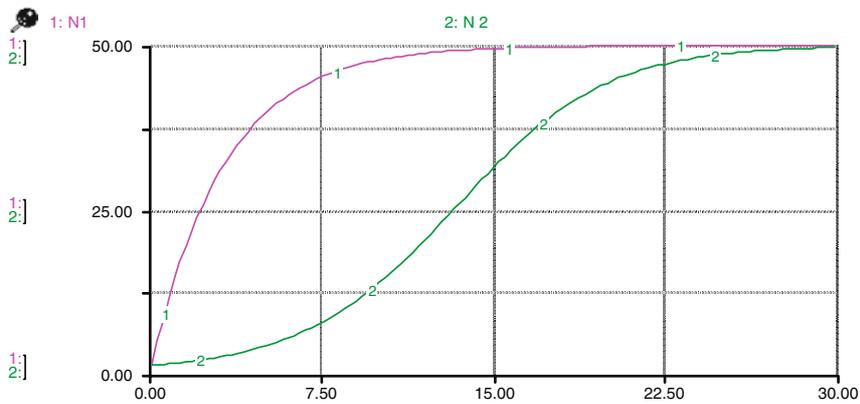
Apart from the special case just mentioned, identical TSPIs with different accumulation processes differ only in the adjustment process towards the ceiling  $K$ ; no intersection between the two lines is possible (see Fig. 4). They have in common the initial value ( $N = 1$ ) and the ceiling  $K$  towards which they both converge.

The reasons for this dynamics appear when the slopes of the two lines representing the two accumulation processes<sup>8</sup> are compared. In case of exogenous process  $\frac{dN}{dt} = b_{exo}(K - N)$ , whereas in the case of endogenous process the equation becomes  $\frac{dN}{dt} = b_{endo}N(K - N)$ .

It is clear that for each finite value of  $N < K$ , we have:

$$N^{\theta_{endo}} < N^{\theta_{exo}}$$

therefore, at each moment in time, the human capital accumulated in an exogenous way is always greater than the one accumulated in an endogenous way. That is, the exogenous accumulation process, in the case of identical parameters, is more efficient in accumulating human capital.



**Fig. 4** Paths of accumulation of human capital from exogenous (line 1) to endogenous (line 2) processes

<sup>8</sup> With reference to the previous section here we indicate  $a = b_{exo}$  and  $b = b_{endo}$ .

### 4.3.2 The Case of Different Parameters

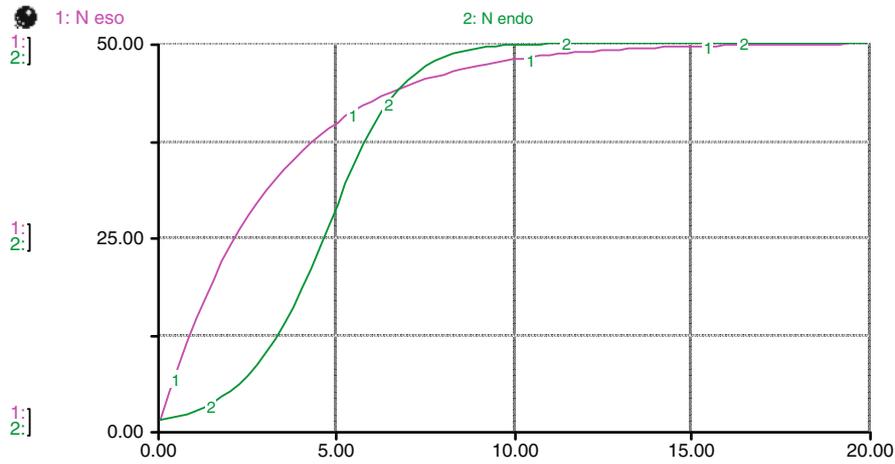
Let us now relax the initial hypothesis of identical parameters and verify the case in which the parameters assume more realistic values in terms of the system that we want to represent.

The basic case consists of different speeds of diffusion of the two processes. In particular, we assume that the endogenous accumulation process is faster than the exogenous process (in the simulation illustrated in Fig. 5  $b_{eso} = 0.3 < b_{endo} = 0.9$ ). This workable hypothesis accounts for the fact that we consider it easier to accumulate human capital through *learning-by-doing* and *learning-by-interacting* mechanisms rather than by formal education or the technological windowing process. Internal accumulation, in addition, on the other hand, consolidates existing routines and is more effective in terms of productivity.

The dynamics of accumulation in the two forms shows a point in which the dominance of either process reverses: first the exogenous process prevails, then the endogenous process is Pareto superior since it relies on higher levels of human capital that make the interaction the best way to accumulate human capital.<sup>9</sup>

The point at which the endogenous human capital ( $N_{endo}$ ) reaches the exogenous human capital ( $N_{exo}$ ) can be expressed as:

$$a - \frac{b_{endo}}{a} + \frac{b_{endo}}{K} a^2 = N_{t-1}^{eso} \quad N_{t-1}^{exo}$$



**Fig. 5** Different propensities to accumulate human capital

<sup>9</sup> For the sake of clarification, we decided to simulate an endogenous parameter three times the exogenous one, so that the dynamics are clearer. The results discussed above, however hold for  $b_{exo} < b_{endo}$ . It is also clear that the greater the gap, the quicker the endogenous process becomes preferable in terms of human capital accumulation.

where

$$a = \frac{N_{t-1}^{exo}}{1 + b_{exo}} + \frac{b_{exo}K}{1 + b_{exo}}$$

Thus, the higher the levels of exogenous human capital, the higher is the ratio  $\frac{b_{exo}}{b_{endo}}$  – of which  $N_{t-1}^{exo}$  is an increasing non-linear function – and the higher is K.

Summing up, the human capital is higher in the case of the endogenous process when the process reaches a considerable size. So, the endogenous accumulation process is more effective if there is a favourable initial situation and if the TSPI is large enough, otherwise accumulation through the exogenous process is more effective.

## 5 Conclusion

The Solowian model presented here offers an interpretation of sustainable inter-related growth in terms of the openness-robustness equilibrium as the only way to pursue growth in the long run. Its sequential and linear structure, nevertheless, causes stationarity, leaving open the question of how innovation is generated within the system (the ‘black box’ of learning mechanisms at work within the TSPI).

Extending the model, a process creating human capital is presented. This involves the acknowledgement of a new way of introducing innovation within the region, and this way has important consequences for the development patterns of the variables involved. The property of stationarity is lost, and the system is able to boost a positive dynamics internally. Anyway, even before the extension of the model, this process is not autarchic, because tight interactions are at work between internal and external forces.

If the blending of internal synergy and external energy (robustness and openness; strong and weak ties; social and creative capital; milieu relations and a-spatial networks) has gained a definite place in the theory of territorial development, economic theory suggests that the equilibrium derives from a trade-off (alternative cost choices), and the present chapter has shown how to reach an ‘optimum’ within a simplified, elementary frame.

As far as the alternative human capital accumulation processes examined in the present frame are concerned, it is not possible to identify *a priori* a ‘superior’ option, since it is contingent on the grounds of some empirical features (the value of the parameters capturing different structural features of the TSPI) that are not examined here. An interesting contribution in this direction is provided by Maggioni and Nosvelli (2005) who apply a similar framework to learning processes aimed at producing and diffusing innovations at regional level.

In the case of industrial districts, for example, given the limited size of firms and their strong specialisation, endogenous and exogenous forms of learning (leading to different quality of human capital) are shown to be substitutes: territories benefit from endogenous factors, setting up a regional specific human capital that represents a competitive factor for the success of the TSPI.

From a policy point of view, it is worth distinguishing policies directed to openness from robustness, which are frequently very difficult to implement, as they need targeted, integrated actions not only on the economic side but also on the structure of the socio-economic system as a whole.

The non-complementarity between the different modes of human capital accumulation suggests that the selection and development of policies suitable to either process of accumulation become crucial for the policy maker.

On a future research agenda, a further step will be a deeper examination of parameter  $g_E$  (the exogenous dynamics of openness) which is certainly determined by the strong 'white noise' of the global relations outside the TSPI, but also co-influenced by the internal process of collective learning and the specific presence of 'gate actors'. The final goal is to capture at least some of the feedback on robustness and openness, up to the endogeneisation of the parameter.

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