TECHNOLOGY PARKS AS INSTRUMENTS OF REGIONAL ECONOMIC DEVELOPMENT: THEORETICAL BASES

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ABSTRACT In this article the focus of attention is on two issues: the study of the convergence of new approaches to endogenous general economic growth and to regional growth, and the drawing up of policies which aim to create technology parks as instruments of regional economic growth. The approach, initially at least, may be situated within the concept of Marshallian externality, but also within the Buchanan clubs theory. The paper dwells specifically on two aspects: the interaction between economic agents in the process of growth and the existence of a threshold value or critical mass capable of generating self-sustaining development.

1. INTRODUCTION

Economic growth has varied greatly from country to country and, within a given country, from region to region. In recent years diverging growth rates, contrary to the predictions of neoclassical models, have injected new life into the development of the theory of economic growth and stimulated a revision of these models.

The general economic growth approach has placed greater emphasis on specialisation and on the identification of growth motors: firstly, the accumulation of physical capital, then technological progress, human capital or the set of knowledge. However the regional economic development approach highlights to a greater degree factors of localisation: the existence of natural resources, external economies, economies of agglomeration, etc.

The above division gave rise to a policy of regional growth grounded on the creation of infrastructures, whereas general growth policies placed greater emphasis on the accumulation of physical and human capital, with technological progress being an exogenous factor. The results obtained have varied greatly. It could be said that adequate physical infrastructure and accumulation of capital are necessary, although not in themselves sufficient, conditions for economic growth.

The focus of this paper is on two issues: the convergence of new approaches to endogenous general economic growth and to regional growth, and the attributes of policies which aim to create technology parks as instruments of regional economic growth. The approach, initially at least, may be situated within the concept of Marshallian externality, but also within the Buchanan clubs theory (Sandler and Tschirhart, 1980). We will dwell specifically on two aspects: the interactions between economic agents in the process of growth (Becker, 1974) and the existence of a threshold value or critical mass capable of generating self-sustaining development (Azariadis and Drazen, 1990).

All of the above will be explained against the backdrop of today's economy, which is characterised, first and foremost, by increasingly open and globalised economies in which regional development is part and parcel of general development; moreover, growing incomes produce a greater diversification of demand. Production is therefore faced with increasingly large and diversified markets.

It is in this context that technology parks are placed as instruments capable of creating the external economies needed to trigger spatially localised economic growth. In the following section the relation between factors of economic growth and their spatial environment is examined. In section 3 we examine the role of technology parks as mechanisms which can create spatially localised externalities. Lastly, we will offer some general recommendations.

2. INNOVATORY SPATIAL ENVIRONMENTS AND THE DECISIONS OF ECONOMIC AGENTS

Analytical approaches to economic growth have viewed the process of growth as a mechanism whereby inputs are transformed into outputs. Economic analysis has focused on the investigation of factors of development, considering the process as a kind of black box or flight recorder. In spite of the complexity of the process of economic development, and in an endeavour to decode this black box, that is, to find the microeconomic roots of growth, a distinction is drawn between decision-making agents and their environment. At the root of the analysis, in an economy featuring decentralised decisions, we can identify a series of individuals who make decisions regarding savings, investment in physical capital, investment in human and technological capital, etc. Secondly, we can identify the physical infrastructure and institutional framework in which these agents operate, and also the existence of mechanisms of cooperation and confrontation (producers associations, contractual regulations, conflict settlement procedures) which regulate relations between them. This second element constitutes the environment. The decentralised location of the agents, in which they actually operate, contribute to the results of such decision-making in a very significant way.

The development of mathematical models of growth and the need to maintain properties of convexity have eliminated in the neoclassical model interaction between economic agents, more emphasis has been placed on the individual decisions of agents than on the way they interrelate, as if these agents operated in isolation (Romer, 1990).

Recent years, however, have witnessed a convergence of the theory of endogenous growth and those of regional economic growth. New endogenous economic growth literature analyses microeconomic growth factors in a given space. In this approach the accumulation of (scientific and technological) knowledge plays the role of the chief motor of growth (Freeman and Palansky, 1992). The fact that the set of knowledge, and hence of information, poses problems of appropriateness and non-rivalry leads to the problem of externalities and collective action (Romer, 1986).

When externalities exist the market with private decisions produces inefficient allocation of resources (Cole *et al.*, 1992). In this case, incentives to invest in human capital or R+D are dependent on private as opposed to social returns and thus, given that the latter are higher than the former, investment is sub-optimal. In the case of situations involving public goods, cooperative behaviour can lead to higher returns than non-cooperative behaviour. Thus, successful economic development policy calls for the design of cooperative mechanisms, that is, ones which encourage economic agents to adopt cooperative behaviour/strategies[1].

Two stages can be distinguished in economic growth which is based on the accumulation of knowledge: in the first and much more risky stage new goods and processes are conceived, designed and experimented with and production of the new product is organised (or an existing productive structure modified). In the second, when the product has become known on the market and is standardised, mass production is commenced, although this is always subject to incremental innovations.

This complete process can be carried out in two different economic activity organisation models: the so-called integrated model, in which both stages are performed in major enterprises, and the flexible or disintegrated model, which we might also call "Silicon Valley", in which the productive process is split among many undertakings, linked by some communication and coordination mechanism.

The integrated model has certain advantages in that it can avail itself of substantial research resources. Moreover it internalises the externalities generated by innovations and has a structure for coordination and information between the different stages of the process. However, it also poses obvious problems such as the risk derived from innovations in a given stage of the productive process, or the risk that the introduction of a new product might endanger the overall organisation. Similarly, they may be a shortage of incentives to innovate, especially if innovation means that important capital goods are to become obsolete. Moreover, certain departments may be reluctant to change their routines.

The advantages and drawbacks of the disintegrated organisation model are the reverse of those just cited for the integrated model. Individual companies have fewer research resources, are less self-sufficient and usually specialise in only one stage of the productive process. Hence they need much closer ties with other companies, etc. In turn this can be advantageous in that innovation risks can be isolated more clearly, there is greater competition in the different stages of production, which might stimulate innovation, or a greater degree of specialisation can be opted for.

In sum, one can say that in the integrated model large enterprises create their own innovative environment, which is internal to the enterprises, whereas in the disintegrated model the external environment, as defined above, creates the incentives for innovative entrepreneurs to appear. For this reason, what we have termed the environment (physical, social, institutional) plays a fundamental role in

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1 The theoretical aspects of mechanisms of optimal allocation have been dealt with in particular by Hurwicz (1973). The more empirical problems of collective action have been addressed by sociologists such as Oliver and Marwell (1988) and Marwell and Oliver (1988).

the disintegrated model by generating incentives for innovation.

New literature on regional economic development has highlighted the role of innovative environments or milieux, that is, areas which are characterised by their particular sensitiveness to innovation[2] and which might be defined as the space in which external economies, communications and interaction mechanisms are created to facilitate the acquisition of knowledge by the various agents. This is consistent with the notion of endogenous growth. The approach can be said to have originated in Marshall's concept of the industrial district, which has been taken up once again both by network literature which examines in depth social networks, networks of flexible environments, and above all by Italian literature on industrial districts (Saxenian, 1990; Scott, 1986; Beccatini, 1988).

This approach to regional economic development takes into consideration investment decisions as well as the inter-relations between economic agents in a given space. Its novelty lies in the fact that it considers simultaneously new factors of economic growth together with their environment. In view of the fundamental role played by knowledge and innovations in new models of economic growth, higher education and research infrastructures form the basis of the link between development and space (Lucas, 1988). It could be said, therefore, that in the face of world demand, innovative spatial environments determine the localisation and specialization of firms.

When speaking of innovative environments reference must be made to two basic elements: on the one hand, the different types of neighbourhood externalities (Jaffe, 1986), which are closely linked to social networks, and, on the other, the existence of threshold values or critical mass in these externalities. The existence of discontinuities or, if preferred, threshold values has been highlighted by Azariadis and Drazen (1990, p. 518) as being the consequence of an accumulation of knowledge. In their opinion, a given level of knowledge permits a given potential growth rate and only when the level of knowledge reaches a new threshold value will new growth be attained by the economy. It is important to stress here the importance not only of the volume but also the composition of the externalities.

This article hopes to bring out the relevance of decision-making agents and the environment in raising levels of economic growth. In particular, in the attainment of the externalities which are necessary to reach threshold values in the function of production a decisive role is played by certain private inputs -innovative entrepreneurs, private R+D centres, private venture capital, etc.- and others of a collective nature, be they public (public R+D infrastructures, higher education, communications networks) or private (associations of different types, networks of personal relationships).

In order to clarify the above, we might express the productive capacity of an innovative environment (Q) as a function of a vector of private inputs (x) and of

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2 Generally-speaking, we understand innovation to be any contribution which tends to improve the price/quality ratio of the goods or services in demand. We are referring therefore to different types of product innovation or process innovation: radical, adaptative and incremental.

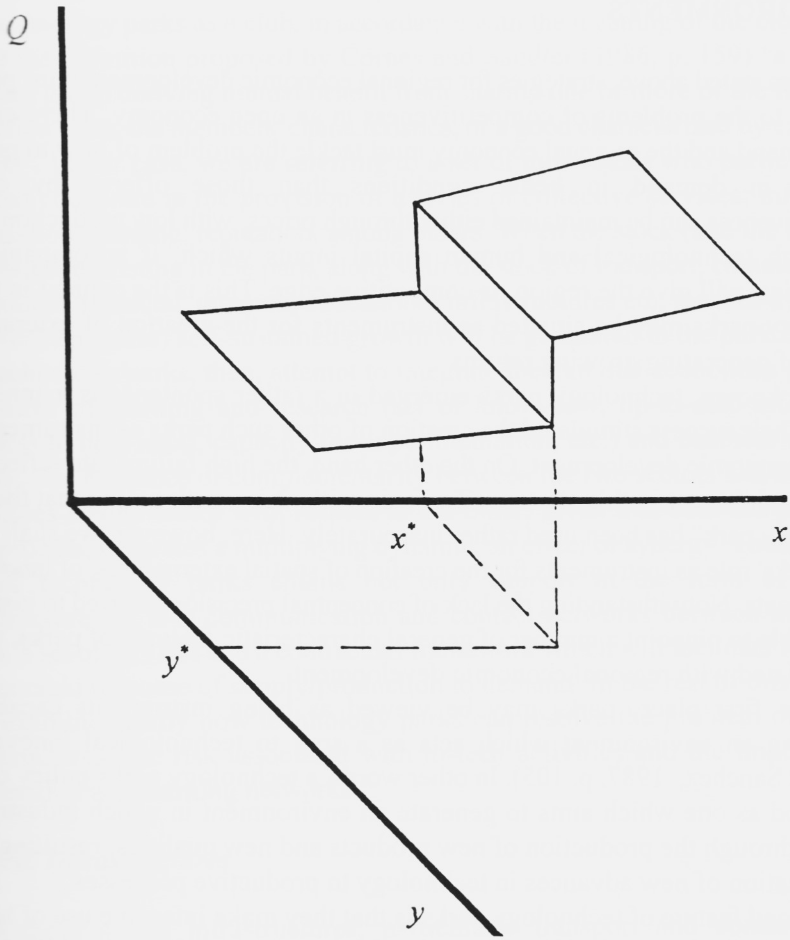

Figure 1. Productive Capacity of an Innovative Environment

another vector of collective inputs (y) as $Q = f(x,y)$. The set of collective inputs (y) can be divided in turn into physical infrastructure inputs (y_1) and institutional infrastructure inputs (y_2). Private inputs (x) (investment in human and physical capital, R+D, etc.) will have to be placed together with the collective inputs. Thus there will be a combination of collective (y^*) and private inputs (x^*) in which, as Figure 1 shows, a jump in the growth rate will occur, that is, a threshold value will be reached. Hence, a spatial area becomes an innovative environment when the conditions necessary to stimulate innovative agents are created.

It could be said, therefore, that in order to be successful a policy of regional economic development will have to create an innovative environment. Put another way, it must solve problems of risk, coordination of decisions, creation/diffusion of information and learning. Depending on the extent to which technology parks are used as a means to solve these problems, they could be said to be an instrument of regional economic development.

3. TECHNOLOGY PARKS AND THE CREATION OF INNOVATIVE ENVIRONMENTS

As was stated above, strategies for regional economic development must provide solutions to the problems of competitiveness in an open economy. There exists a given demand and the regional economy must tackle the problem of how to provide products in demand in better conditions than those offered by others. Competitiveness can be maintained either through prices, with low production costs, or through technological and human capital inputs which, if accompanied by externalities, will give the region its competitive edge. This is the context in which technology parks may be situated as instruments for the creation of externalities capable of generating growing returns.

As is known, technology parks emerged in a rather spontaneous manner and intitially their success stimulated the creation of other such parks as instruments for regional economic development. On the other hand, the high failure rate reflects the difficulties inherent in this strategy. To begin with, it is worth noting that the term "technology park" has been used rather inaccurately. Here, however, we shall focus on the parks' role as instruments for the creation of spatial externalities, of innovative environments. Notwithstanding the lack of conceptual precision referred to just now, it is possible to pinpoint a number of general characteristic features of parks, which are associated with regional economic development.

In the first place, parks may be viewed as being instruments capable of "generating an environment which acts as a spur to technological innovation" (Martinez Sanchez, 1987, p. 105). In other words, a technology parks policy can be understood as one which aims to generate an environment in which industry can compete through the production of new products and new qualities, resulting from the application of new advances in technology to productive processes.

A second feature of technology parks is that they make intensive use of human and technological capital. This means that R+D centres and highly-skilled local labour markets must necessarily exist.

A third characteristic is that they are areas characterised by high-tech economic activities. The term high-tech often proves confusing and has been defined in various ways. Here, we consider high-technology economic activities as those fulfilling certain characteristics (MacDonald, 1983, p. 331): when the use of the afore-mentioned technology represents high risk; situations occur in which substantial profits may be earned; there is a large accumulation of information and a major propensity towards change.

Lastly, one can observe in the functioning of these parks increasingly deliberate coordination between higher education, research and economic activity. This leads to an acceleration of the research-innovation process on the one hand and also a shortening of the duration of both products and processes. In reality, what is occurring is a generalisation of the situation observed in the textile and clothing sectors: products with a short shelf-life which require modifications in terms of substance or design.

Thus, a characteristic feature of technology parks is the creation of externalities which are then harnessed by the enterprises located in said parks. This leads us to view technology parks as a club, in accordance with the meaning of the club theory. To use the definition proposed by Cornes and Sandler (1986, p. 159) "a club is a voluntary group deriving mutual benefit from sharing one or more of the following: production costs, the members' characteristics, or a good characterized by excludable benefits". In our case, we are referring to a set of individuals who participate in a park and cooperate in the provision of a series of collective services: information transmission, learning, reputation, among others. When the stock (and the make-up) of knowledge existing in the park, along with the stock of transport, communication, institutional, financial, research, educational infrastructures etc, reaches a threshold value (critical mass) self-sustained growth will be generated in the park [3].

Technology parks, then, attempt to integrate the external economies generated by centres of learning and research (set of know-how, up-to-date information, openness to new ideas, capacity for experimentation, etc.) and business economic activity. The existence of complementarity between the two sectors and of external economies of one sector with respect to the other, given that both are part of the same process, generates a multiplying dynamic, an effect of synergy. Thus, the chief role of technology parks entails not only support in the form of physical infrastructure but also communication and contact networks between the various agents, a set of services and a contractual framework which will facilitate innovation and the rapid response of supply/production to demand. In the rest of this paper we shall examine briefly how technology parks can resolve the problem of physical infrastructures, the risk associated with hi-tech activities and the importance of coordination and learning networks.

Physical Infrastructures

Without sound infrastructures, particularly transport and communication, modern economic development can be said to be impossible. However, the physical infrastructures which were the chief input of regional development in previous strategies are now a necessary, although not in themselves sufficient, condition. In open and increasingly globalised economies, means of transport and, above all, communication are needed to maintain a competitive strategy.

The importance of parks as means which make up component (y_i) of the collective inputs vector of function $Q = f(x,y)$ is linked very closely to transport and communications. Both are crucial in order to satisfy market demand and also for the passing on of information, which is fundamental if a park is to function properly. The fact that they are highly innovative makes them information-sensitive in two ways: on the one hand, information concerning scientific research carried out or the technologies used in the park itself and, on the other hand, information on segments of demand (niches) not yet satisfied.

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3 This would be the same notion that lies behind concepts such as synergies or growing returns.

The Problem of Risk

In general one can talk of two types of risk: one derived from investment in R+D and another from the introduction of new products on the market.

As regards the first of the two types, scientific research is costly and innovations entail a degree of uncertainty as to the results obtained and priorities. The second source of risk stems from the transition from research to the production and distribution of the new good, which requires substantial investment to create new enterprises or new lines of production in existing ones.

The first type of risk can be attenuated through public sector financing via contracts for specific research. This form of financing has the advantage of permitting coordination between different investments in R+D and producing externalities of information that may lead to spin-offs; in other words, public funding of R+D propitiates both access to and use of the new information by a greater number of people. The second type of risk can be shared by the venture capital institutions to facilitate market entry to new enterprises.

Technology parks take a three-fold approach to solving these problems: through state research contracts, the promotion of venture capital institutions which will participate in the creation of new firms, and the disintegration of the productive process, that is, the putting in place of a contractual framework to diversify risk.

Coordination and Learning Networks

The process of economic development brings about greater specialisation of economic activity, which in turn gives rise to problems of coordination (Edwards and Starr, 1987). In fact a feedback relationship occurs: specialisation accentuates the need for coordination while efficient coordination mechanisms pave the way to greater specialisation.

Technology parks, therefore, are instruments for creating flexible economic environments in their own right, in which contractual flexibility permits fusion (combination of different sub-sets of information) and fission (splitting of a set of information into different sub-sets), or, put another way, the appearance of spin-offs.

In order to propitiate this twin fusion-fission process, technology parks act as producers of relational goods, that is, as a means which facilitates the establishment of channels which permit communication of information and cooperation between the various agents. These social interconnection networks lie at the basis of component (y_2) (social infrastructures) of the collective inputs vector of function $Q = f(x,y)$.

Interaction between agents also entails the passing on of information which, in the case of innovative environments, is new and scarcely codified (tacit knowledge). Moreover, when such relations are maintained between complementary sectors such as centres of higher education, research centres and enterprises and other economic agents, the feedback mechanism produced facilitates coordination and learning.

4. CONCLUSIONS

By way of conclusion, and to sum up what has been said thus far, we might highlight the following.

First, the theories of endogenous economic growth and its regional counterpart can be integrated in one and the same research programme. One could say that for the first time it is now possible to develop a theory of economic growth with spatial support. Economic growth is, therefore, merely the combination of different elements in a given area. Of equal importance to the elements (if not moreso) is their environment, which facilitates interaction between these elements through networks for communication and learning, cooperation mechanisms, etc.

Second, technology parks , which originally at least are spontaneous in nature, really are nothing other than an instrument for the creation of the elements which make up the externalities of innovative environments. Thus, they cannot be used as a single recipe which is directly applicable to any region. Given the differences between regions, the role of technology parks will also have to be different.

Technology parks are based on the notion of the convergence within a given spatial environment of private inputs (innovative firms, private R+D centres, venture capital, etc.) and other collective inputs (public R+D centres, communication infrastructures, etc.) which, as the result of the action of social networks linking up private and public agents, give rise to, spontaneously at times, the coordination/collaboration between both sides which is necessary for success. In other words, they precipitate the quantitative (number of firms, level of production, etc.) and qualitative (level of R+D, incorporation of technological advances to the productive process) improvement which will raise the levels of competitiveness of regional production. Consequently, the notion of technology parks responds to the new direction taken by the theory of regional development and can be understood as being the practical application of our theoretical approach.

Lastly, the main conclusion to be derived from the detailed analysis of innovative environments and technology parks is that the environment in which economic agents operate is akin to a public good and this makes it the focus of collective action. Technology parks are like a club for the private agents (enterprises) located in the park in that there is joint provision and shared use of club goods. In this context, the guidelines to be used to steer public sector action should aim to solve at least the following problems: firstly, they should facilitate communication between the various specialised economic agents, in view of the fact that information on innovations, which is scarcely codified, requires face to face communication or interaction; secondly, coordination is needed between the different decision-makers, ie between those who have a say in investment in human capital (new qualifications), R+D and in the creation of new enterprises; lastly, a third element to be taken into account is the handling of risk derived from innovative activities. If technology parks solve these problems they will be an instrument of regional economic development; if not, they will join the ranks of the abundant arsenal of outdated instruments of regional economic growth policy.

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