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Are Regional Systems Of Innovation Possible In Underdeveloped Countries?

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**ARE REGIONAL SYSTEMS OF INNOVATION POSSIBLE
IN UNDERDEVELOPED COUNTRIES?**

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Abstract

Most of the studies on regional systems of innovation have been carried out in developed countries. The issue discussed in this text, however, is related to the possibility that such systems could constitute a regional base in countries with a noticeable deficit of research and learning institutions, serious financial restrictions and, as in the Brazilian case, continental dimensions. We have carried out a case study on the state of Paraná, in Brazil, characterized by better economic conditions than those of many other states in the country, host to a new automobile industry and possessing a reasonably developed formal apparatus of science and technology. The Siemens/Equitel company was studied as an example of the firms established within the state, considered the most successful in terms of its relationship with the state's formal structures of science and technology. However, we have seen that even for a state enjoying better conditions of development and in the case of a firm that is considered successful, the prospects for the emergence of a Regional System of Development are still far from promising.

Are Regional Systems of Innovation possible in underdeveloped countries?

Cássio Rolim

The emphasis on innovation as the factor responsible for the differentiation of national and regional economies is increasingly present in economic literature. Widely varying approaches coincide insofar as they all present innovation as a key element of their analytical schemas. This is the case in the discussion of national systems of innovation, within what has been referred to as the evolutionist economy (Ludvall, 1992), in the discussion of industrial clusters (Porter, 1990), as well as from the perspective of regulation theory (Amable et al., 1997), authors who have worked with the question of industrial districts (Becattini, 1991) and even authors from the school of neo-classical economics (Romer, 1990).

Since most of this literature emphasizes the importance of territorial aspects of the problem, authors dealing with as well as agents who are responsible for regional politics have shown vigorous and hopeful devotion to the topic, comparable only to the efforts involved where answers to regional development problems seemed to be offered by polarization theory.

These same hopes have once again stirred up the interest of those who deal with problems of development in underdeveloped countries. There has also been an intense effort to comprehend processes of innovation that could contribute toward overcoming underdevelopment.

There are however certain characteristics of the functioning of underdeveloped economies that place restrictions which do not exist in the situations studied by authors dealing with developed countries. In this text we will discuss some of them and their implications with regard to the use of the concept of Regional Systems of Innovation.

The text is divided in four parts. First, we will begin with a brief discussion of changes in the productive base and its implications for territories, and will then follow with a synthesis of the concept of Regional Systems of Innovation, subdivided into three parts that consider theoretical approaches as the concept per se. The third part discusses the case of the state of Paraná, in Brazil, and within it, the specific experiences of a firm that has been considered exemplary as a model for technological innovation and interaction with educational organizations in the state, the *Siemens/Equitel* company. The last part makes some final considerations on the topic.

1) Technological restructuring and territories ¹

The opening up of markets has profoundly modified forms of production and commercialization, distancing them from the paradigms of mass production. This transformation has taken on various forms, qualifying the relationships between economy and territories in diverse ways. Territory is now seen as the matrix of organization and of social interaction and no longer as simply a reserve or supply of technical resources. These changes are at the center of new spatial configurations and particularly, the vitality of large urban areas.

Firms, to the extent that they participate in global competition, must confront a difficult equation in order to survive. Given the relative cheapening of transportation costs, if on the one hand access to distant markets becomes easier, on the other, the firm's closest– and captive – market becomes more vulnerable to competition. Thus in order to attend to markets that have become differentiated even in response to cultural patterns, a firm must be able to produce at reduced costs, with high quality, a wide variability of products, a good capacity to react to detected shifts in demand and, above all, must maintain a wide ability to innovate.

Firms' performance will constantly be tested according to the equation below:

$$\text{Performance} = \text{Cost} \downarrow + \text{Quality} \uparrow + \text{Variety} + \text{Reactive ability} + \text{Innovation}$$

In classic organization these elements are highly contradictory among themselves. In such organizations, oriented by administrative principles that we can refer to as Taylorist, each sector is specialized in the production or fulfillment of a particular task. There is also a presupposition of economies of scale, in other words, greater units of production produce at lower costs.

Contrasting with this form of organization we can speak of the system that has been referred to as Toyotism, in which the coordinated passage from one task to another is more important than the specialization in particular segmented tasks, guaranteeing in this way the efficacy of the productive process as a whole.

These two systems do not in reality provide a faithful picture of any concrete firm. It is more likely that the firms of the real world can be found in some intermediate location between these two extreme caricatures, even because the points that they have in common are much greater than is usually imagined. Thus it can be said

¹ This section is based largely on Veltz (1996).

that there is an ever-increasing tendency for economic activity to be organized according to these more “flexible” production standards.

Thus, global/total performance will increasingly depend on the interaction of internal systems (research sectors, marketing, production, finances, maintenance, etc.) and external factors (clients, suppliers, research centers, competitors, etc.)

In short, the shift to a new form of competition imposes changes in organizational processes for both large and small firms. The essence of these shifts lies in the discovery that the efficiency of production depends primarily on the varied forms of cooperation between firms. This cooperation, in turn, is difficult to program and make routine. Production comes to be organized around these processes of cooperation.

In this context, the location problem is no longer a matter of direct relationships between factors, resources and productive activities. It is now subordinated to the more general question of the relationship between spatial forms and the social structures that permit cooperation.

The important elements for this cooperation are those that are linked to the generating of external, pecuniary and technological economies, present in structures that are similar to those Marshall has pointed out, the so-called industrial districts in which we can find the following elements: concentration of collective goods and social and material infrastructure in particular areas; a common background of knowledge and values that, allied with formal education, raise the technical and cultural level of labor; a network of relationships beyond those of the market which link entrepreneurs and the circulation of formal and informal knowledge that these networks permit.

The geography of productive efficacy is less and less a geography of cost and increasingly a geography of organization. Thus, the attractiveness of a territory or a region becomes linked to the ability that it has to generate these elements.

In turn, these elements are related to complex cultural phenomena in which the systematic interaction between persons and public and private organizations foment the emergence of organizational and technological innovations that are at the root of regional development. This matter will be dealt with in the following pages.

2) Regional Systems of Innovation

The theoretical framework for the concept can be found mainly in the work of Cooke and his colleagues (1997, 1998^a and b). According to the author the first

references to the term appeared at the beginning of the nineties and their evolution has its origin in two major theoretical currents. The first current originates in research on technological innovation, particularly that which refers to National Systems of Innovation (Lundvall. 1992); the second results from advances in theories of regional development.

The discussion of National Systems of Innovation emphasizes the importance of innovations on national processes of development. These innovations are the result of the interaction between firms, clients, and government and research institutions, constituting an environment that is favorable to the learning of new ways of producing and of organizing production. One of the matters that is emphasized in this type of research are the processes through which this learning takes place and the roles carried out by the different actors that are involved.

The concept of innovation that is used in this research is a broad one. It goes beyond new discoveries in activities and products on the frontiers of technological progress, to refer as well to changes in the production of less-elaborated products and to human behavior, including changes in cultural values, routines and habits.

At the same time, there are according to the authors several elements that indicate that the issues dealt with in this discussion can be better understood and analyzed within a more restricted territorial environment, such as the region. This is where the second formative element of the concept of Regional Systems of Innovation enters the scenario.

Regional systems of learning and Regional Systems of Innovation

Through their discussion of national systems of innovation and on regionalism within regional development, the authors move toward the construction of a concept of regional systems of innovation. However, they first go deeper into the discussion of the processes through which learning occurs.

Learning for them refers to a change in a person or organization's capacities. This means that learning is not seen merely as accumulating information but, as in Piaget's approach, a process of interaction between what we know about a particular situation and what we can perceive as new in this situation. Consequently, the formation of knowledge can be seen as made up through two levels of learning. The first is the one that establishes competence – the ability to carry out a particular task –

and the second, which establishes capability – the comprehension of the underlying mechanisms for the solution of a problem that the task involves. (Cooke and Morgan, 1998)

Evidently, a learning system that develops capability is much more onerous than one that merely supplies competence. Thus, a regional system of learning can not restrict itself to the mere transfer of competence coming from elsewhere. This is all the more so due to the fact that all experiences are singular.

From the perspective of economic development, we can not imagine that this whole framework to increase the capability of countries/regions can dispense with intense action on the part of the State (Carleial, 1997). Therefore, state apparatuses, national or regional, must develop an infrastructure that allows for such a system of learning, made up of development agencies, training organizations, sub-regional offices, etc.

To the extent that this regional learning system interacts formally or informally with universities, research institutes, vocational training agencies, technology transference, technological parks and firms in general, it tends to become a Regional System of Innovation.(Cooke and Morgan, 1998)

The authors emphasize the differences between regional systems of learning and regional systems of innovation. This is because learning is the point of departure for innovation. Furthermore, they distinguish between tutoring and learning.

Tutoring can be understood as the mastering of knowledge and of the ability to initiate innovation based on “upstream interaction” (close to the point of origin of the invention or idea) as well as “downstream interaction” (close to the market). This distinction is important because not all countries or regions will be able to master technological frontiers in many sectors. The most probable scenario for the majority of regional economies is downstream innovation, that is, that which flows from the closer interaction of users and consumers. With this in mind, the authors believe that the regional system of learning is most important.

At this point the authors arrive at the current stage of development of the concept of regional system of innovation. They assert,

“Regions which possess the full panoply of innovation organizations set in an institutional milieu (Johnson and Gregersen, 1996; Maillat, 1995) where systemic linkage and interactive communication among the innovation actors is normal, approach the designation of regional innovation system. The organizations can be expected to consist of universities, basic research laboratories, applied research

laboratories, technology transfer agencies, regional public and private (e.g. trade associations, chambers of commerce) governance organizations, vocational training organizations, banks, venture capitalists, and interacting large and small firms. Moreover, they should demonstrate systemic linkages through concertation programmes, research partnership, value-adding information flow, and policy action lines from the governance organizations. These are systems that combine learning with upstream and downstream innovation capability and thus warrant the designation regional innovation systems.” (Cooke e Morgan, 1998, p.71)

In this conceptualization, the existence of several correlated subsystems that constitute a regional system of innovation can be seen. Financial and learning subsystems, as well as one other subsystem related to productive culture, are among the most important. Without the former, possibilities for innovation remain limited, especially for regional structures in which small and medium-sized enterprises prevail. The learning system is fundamental. Restrictions on its functioning means restrictions in access to accumulated knowledge and therefore the annulment of the possibility to generate some type of innovation. (Cooke et al. 1997) Finally there is *productive culture*, which refers to the degree of local involvement with activities that are carried out in the region, the environment and the attitudes regarding these activities that come from the existence of a native technical culture belonging to the region’s inhabitants, as forms of knowledge transmitted from one generation to the next. This is what is expressed in the concepts of *milieu* and *milieu inovateur* as developed by the GREMI² (Maillat, 1994)

Table 1 presents two regional profiles characterized by the administrative structures and the governmental autonomy of each of them. Since they represent extreme stereotypes, most regions should be in an intermediate position with regard to them. Nonetheless, the closer a region is to Profile 1, the greater the probability that constitutes as a Regional System of Innovation (Cooke et al, 1997).

3) The State of Paraná

Brazil is a federative republic with more than 160 million inhabitants, a Gross National Product of close to 777 billions of dollars (1998) and per capita national product of around 5000 dollars. Nonetheless, in spite of its status as one of the ten largest economies in the world, it has one of the highest rates of concentration of

² Groupe de Recherche Européen sur les Milieux Innovateurs

wealth. Almost everything is produced within its borders: from pins to airplanes, and including automobiles, which have been manufactured within the country for close to 50 years already.

Table 1 Two different regional profiles

Profile 1	Profile 2
1) Autonomous capacity for regional public spending	1) A certain degree of administrative decentralization on spending
2) Regional capacity to impose taxes	2) Limited capacity to impose taxes
3) Little need for firms to approach the national capital market	3) Less regionalisable sources of financing
4) High level of regional financial intermediaries	4) Low level of regional financial intermediaries
5) regional government control over financial intermediaries	5) Little local government control over financial intermediaries
6) Development of regional information and promotion policies	6) Slight development of own information and promotion policies
7) Regional control over execution of part of strategic infrastructures	7) No regional control over execution and management of infrastructures
8) Control of shared execution (state/region) of strategic infrastructures	8) Slight influence on execution and management of infrastructures
a) Density and quality of infrastructures for innovations are spread more widely throughout the regional space	a) Density and quality of infrastructures for innovation exist but more in relation to local or metropolitan areas
b) Density and quality of infrastructures for innovations are more highly concentrated in local or metropolitan areas	b) Low density and quality of infrastructures
The region's general competence	
1) Own educational and training system	1) State educational and training system
2) University related to the area	2) University slightly related to the area
3) Research laboratories in the region	3) No research laboratories in the region
4) Regional government	4) No regional government
5) Public procurement made by the regional government	5) State policies on industry, technology, public procurement and science
6) Industrial and technological policies designed and executed by the regional government	6) No regional industrial and technological policy
7) Regional science and technology programme	7) No regional science and technology programme

Apud: Cooke et al., 1997

The country's industrialization dates back to the beginning of the 30s, intensifying in the 50s. One of its characteristics is its extreme concentration in the state of São Paulo, and particularly within the São Paulo metropolitan region (with almost 16 million inhabitants). Nonetheless, beginning in the seventies there was a certain de-concentration of economic activities in the country which, however incipient, was able to incorporate territories and transform the economy of several regions. This de-concentration has since begun to show some signs of stagnation, and the possibility of a certain amount of re-concentration in the state of São Paulo does exist.

The territory that will be studied here, the state of Paraná (map 1), is a member of the federative union, possessing 199.554 square kilometers, 2/3 the size of Italy. Its GNP is around 6% of the Brazilian one. It has a population of close to 9 million inhabitants, and its capital city is Curitiba, with a greater metropolitan area of close to 2 million which is rapidly becoming site of new investments in the Brazilian automobile industry.

The state of Paraná has a history of recent settlement. In the early days of Brazilian colonization, in the 16th century, only the coast and the area which is today Curitiba were inhabited by colonizers. The intensive occupation of the north of the State began in the 1940s, as a spin-off of the São Paulo state coffee growing industry. Until recently, it was one of the richest areas of the state. The occupation of the southeast was initiated only in the 1950s, as a result of migration from Rio Grande do Sul, where family-based subsistence agriculture still prevailed.

Thus, the state was populated along three different fronts of occupation, coming from different parts of Brazil, each in its own historical moment. This created a large problem for state administration, which on numerous occasions had to confront attempts to emancipate parts of its territory. In other words, the way in which the occupation took place became an element that worked against the emergence of a territorial identification, that is, the emergence of a state identity.

Paraná has also been characterized as an agricultural state, and one that for the last 15 years boasts one of the most modern agricultural systems in the country. On the other hand, the state's capital, Curitiba, underwent an industrialization process beginning in the 70s in which traditional industries linked to wood and food production gave way to more modern branches of Brazilian industry, whose products belong to the electrical and electronic and metal and mechanical groups. These new industries, to a large extent branches of multi-nationals and industries from the state of São Paulo, result from the expansion of firms located in the Greater São Paulo metropolitan region, or, in other cases such as that of the Volvo company in the seventies and other automobile industries in the nineties (Renault, Audi, Chrysler, etc.) represent new investments in Brazilian territory. Some locational advantages notwithstanding, the major factor that attracted these firms to the Greater Curitiba is linked to the extremely generous policy of fiscal incentives that has been offered.

3.1) The productive structure of the state of Paraná.

Between 1985 and 1997 the gross product of the state of Paraná rose from 5.96% to 6.13% of the country's GNP. This has historically been the state's rate of participation in the national economy. The state activities that most contribute to sectorial GNPs for the country are agriculture, construction, electricity, gas and water. In terms of the location quotient, activities with a $LQ > 1$ are agriculture, electricity, water and gas, construction, food and lodging, transportation and warehousing. As regards the internal structure of the state, agricultural activities fall from 23.88 to 14.04%. Industrial activities, as a whole, undergo a modest increase from 35.47 to 38.12%, due primarily to the construction industry. However, the greatest growth came for the complex of the service sector, which rose from 40.66% to 47.85%.

The transformation industry in Paraná represents 5% of Brazilian industry, with just three types of goods- food products, chemicals and wood – making up more than 50% of its production in 1985. Throughout the period its structure was gradually modernized. Nonetheless, in 1997 the primary products were foods and chemicals, with mechanical products in third place and wood in fourth. The predominance of these products made the changes that have been occurring less visible. In the newer sectors such as electrical materials, mechanics, transportation materials etc., the state's new industrial structure is emerging; however, although gradually becoming important, it is still obscured by the two major types of production.

These new sectors, however, tend to be located in the Greater Curitiba, which houses more than half of the state of Paraná's industry and the overwhelming majority of new types of production. New industries in Paraná owe their emergence to the process of expansion of Brazilian industry which incorporates new territories (Rolim, 1996).

3.2) Elements of Regional Systems of Innovation in Paraná

Based on the theoretical synthesis of earlier sections we will present here some of the elements that could make up a Regional System of Innovation in the state of Paraná.

Financial subsystem.

At the regional level, there is practically no financial system that can act as a support for the other subsystems. The existing firm-based innovation activities receive support from federal institutions, such as the *Financiadora Nacional de Projetos (FINEP)* and the *Conselho Nacional de Pesquisa e Desenvolvimento Tecnológico (CNPq)*.

Although for the last ten years the State Constitution has included a state fund for scientific development (*Fundo Estadual para o Desenvolvimento Científico*) which is supposed to receive 2% of all tax revenues, it has only recently been regulated. There were difficulties stemming from the relatively small weight that the state government was willing to attribute to local scientific institutions. Although this matter has not been resolved satisfactorily, the fact that the organizational management of this fund has been initiated renews hopes and expectations for the sector.

Within a broadened perspective and if general state expenditures in higher education and research institutes are included, the state spends close to 11% of its tax revenues on these items.

The “milieu inovateur”

The identification of this subsystem is a difficult task that I will not attempt to carry out within the confines of this article. Nonetheless, some elements that are important for its constitution have been long pointed out within the literature. They are related to some type of regional identification (basic to the processes of regionalism) and to the existence of a certain degree of specialization of regional productive activities. They are generally activities that have been the object of study linked to the issue of the constitution of “industrial clusters.”

Various elements encumber the constitution of a Paraná state identity. In the first place, there is the size of the state, which at 199,554 square kilometers is equivalent to 2/3 of Italy and more than two times the size of Portugal. In the second place, there is the fact that the greater part of the state has only recently been settled (that is, for slightly more than half a century). In the third place, this settlement took place on at least three different fronts of occupation, originating in different moments and historical processes. Finally, there are the contemporary transformations which are conducive to the formation of two large economic spaces. One is the Paraná agrobusiness, within the universe of agricultural activities, and the other, within urban Paraná, refers to the universe of national industrial activities (Rolim, 1996). In fact it is much easier to find some local identifications, such as the one that characterizes the southeast of the state (Rolim, 1994) than a more general state identity.

With regard to regional specialization there are also some difficulties to be found. Although they are less represented in the state’s gross product, elements pertaining to the “milieu inovateur” are more easily found within agricultural activities. On the other hand, those industrial activities for which there was in the past

some regional specialization and expertise are today diluted within an industrial universe dominated by the chemical and mechanical industries. The significative weight of the chemical industry is due to the presence of a large *Petrobras* oil refinery in the Curitiba metropolitan region. With regard to mechanical products and, to a lesser extent, transportation materials, the recent installation of several automobile industries incorporating more modern standards of industrial organization has made its imprint. In other words, these are activities that are exogenous to the traditional local productive base. The food processing industry is one of the most traditional within the state, although it is a very heterogeneous agglomeration within which firms with varying degrees of technological sophistication and integration coexist. The wood industry which in the past was very important for the state is in decadence today. In the two remaining sectors, the metal and mechanical industry and that of electrical materials and communications, an “milieu inovateur” can be found, although –primarily in the latter – large foreign firms prevail.

Given these restrictions it is difficult to speak of an “milieu inovateur” in industrial activity in Paraná state. However, we could probably affirm its existence within the realm of agrobusiness.

The learning sub-system.

This is probably the most developed subsystem within the state of Paraná. There are more than 101 organizations linked to Science and Technology within the state, of which 45 are linked to research, extension and development, of private and public character (with the latter belonging to all three levels of government). (Passos, 1998, p. 15)

The other 56 are institutions of higher learning (including 7 universities and a technical/vocational institution, the *CEFET*), serving 119,071 students. The state government runs 16 institutions of higher learning, serving 47, 184 students (five universities and eleven colleges) as well as another 15 organizations devoted to research, outreach and development.

With regard to higher learning, these numbers should be understood in relative terms. Of close to 119,000 students, just 17% are linked to federal institutions. Within the Brazilian educational structure they are the primary producers of research, and have the highest proportions of highly qualified and full time professors. The private institutions tend as an overwhelming majority to maintain courses and programs that merely transmit an existing “book culture”, do not conduct research and employ

most of their professors only part-time and in areas of knowledge with lesser technological sophistication. The state and municipally-run public organizations are in a situation that is somewhere in between.

These organizations of higher learning make up the most visible part of the learning system, that part through which codified knowledge moves. However, other organizations have widely varying functions and types of connections, ranging from basic research involving high technological content such as that carried out by the *SIMEPAR* (Paraná Meteorological System) and the Parana telecommunication network to those that manage local technology incubator projects, such as the *FUNDEPAR* (Cascavel Foundation for Technological Development). The links that are established between these organizations are also widely varied. Some are purely state organizations, whereas others involve a joint participation between states and federal government and business associations. Others are linked to agricultural cooperatives. There are also privates, such as *CITPAR* (Paraná Center for Technological Integration), one of the most active and important. (Passos, 1998)

Cooperation between the organizations is encumbered however by one basic problem. It is usually and with few exceptions limited and sporadic. Furthermore, although there is some important interaction with the entrepreneurial sector, this interaction is largely limited to entrepreneurial class organizations, rather than to firms. At the same time, the type of knowledge that circulates between these organizations is largely not knowledge belonging to the technological frontier. The system is barely equipped to carry out an efficient reproduction of codified knowledge.

There are however other forms of learning that are pointed to in the literature as the most important for the technological development of firms, which refer to the interrelationship of firms and their interaction with other parts of the system in the production of innovation.

With regard to the profiles presented in table 1, Paraná is closer to the first than to the second. Nonetheless, we do not see the emergence of a Regional System of Innovation in the state. From the perspective of the three subsystems that make up a Regional System of Innovation, the financial subsystem is practically non-existent and the emergence of an “milieu inovateur” appears to be suggested solely within the agricultural sphere. The learning subsystem is still precarious, in spite of its good prospects.

3.3) The Siemens/Equitel case

Siemens/Equitel is one of the international firms set up in Paraná that stands out in terms of technological innovation and interaction with the local system of learning. Siemens International was founded in Germany in 1847 and today is one of the five most important firms in the area of Electrical and Electronic Engineering in the world. It has over 305 factories in Europe, 142 in the Americas, 69 in the Pacific region and 11 in other parts of the world. The firm has been present in Brazil since the 19th century, establishing *Siemens do Brasil* in 1905. At present the group is made up of four firms: *Equitel* (today called *Siemens Divisão de Telecomunicações*) and responsible for 50% of the group's net sales; *Siemens*, responsible for 37%; *Osram*, 7% and *Icotron*, 6%. These firms have factories in several parts of Brazil, from the extreme north (Manaus, in the Amazon) to the extreme south (Gravataí, in Rio Grande do Sul). The group has been operating in Paraná in the production of telecommunications centers since 1973. It has a factory in Curitiba and recently installed a factory of electric components for automobiles that is meant to supply several of the automobile plants in Brazil and Argentina (Scatolin et al. 1999)

The technological evolution of the Curitiba Siemens/Equitel factory was influenced, as we will soon see, by two institutional factors. In the first place, it is linked to expansion of the state telephone company, *Telepar*; in the second place, to the policies of protectionism that the Brazilian government has pursued in the area of computers and communications. According to Scatolin et al (1991), the firm's efforts between 1973 and 1978 sought an adaptation to local norms and the nationalization of components that were developed abroad. As of 1978, the phase of the development of specific products for the Brazilian market was begun. In 1989, the development of complex systems for the Brazilian system began, based on technologies obtained abroad, and in 1992 the production of these systems for the international market was initiated. After 1994, as part of the German headquarter's world policy for the implantation of centers of competence, the Curitiba plant became a world center of competence in various areas, linked to the training and development of telecommunications.

Interaction with the state's educational centers has been intense from the start. It has been carried out through agreements for worker training, the donation of laboratories, the joint development of systems and products, high usage of student trainees, etc. Between 1994 and 1998 these agreements with state institutions

represented to close to 41.9 million *reais*³, which when added to other expenses with other research centers spread throughout the country gives a total expenditure of 71.5 million *reais*. In other words almost 60% of these resources were employed in the state of Paraná. One of the reasons for such investment has been the interest in the formation of a potential labor supply for the firm, as well as training for the use of its products. Among the firm's employees, 50% hold high school diplomas and 34% have university degrees; in the latter category, 61% are engineers specialized in Electrical and Electronic engineering (Scatolin et al, 1999).

This trajectory of investment in technology was conditioned, as we have said, by two major factors. Paraná, as a recently settled state, needed to start from scratch in terms of telecommunications. Thus, almost all of its investments in this area were new ones. The coupling of the *Telepar*'s expansion and the Siemens/Equitel company was intense. Many products were developed to service *Telepar* and from there, service other Brazilian telecommunications companies. *Telepar* was considered a model firm for the entire country. Thus, the state's telecommunications network was set up with equipment based on the most up-to-date technologies.

Linked to the former factor are a set of protectionist laws applied to the Brazilian market, amongst which #8248/91 –known as the “informatics law” – requires firms in the sector to maintain a 60% minimum of components made in Brazil, as a condition for the obtaining of credit from state development banks. Furthermore, from 1992 to 1997 firms were entitled to an income tax deduction of up to 50% on expenses in technological innovation carried out within the country, either directly or through agreements with research centers and universities (Scatolin, et. al., 1999)

Scatolin et al. (1999) also point to a cost component that has been important with regard to the decision to invest in research and development in Brazil, which is linked to low costs:

“The cost of collaborating with Research and Development for Siemens of Brazil, considering salaries and infrastructure, is DM 120000 per year and per person, whereas the cost in Germany would be as high as DM 250000.” (op. cit. p. 35)

Evaluating the role of Siemens/Equitel within the context of a Regional System of Innovation is not an easy task. In appearance the processes portray a firm that generates high levels of innovation and interacts intensely with the state's subsystem of formal learning. It gives the impression of a firm that is embedded in

³ At today's exchange rates, US\$1.00 is equal to 1.74 *reais*.

Paraná. The formal agreements and informal interactions that have been established between actors over the course of all these years seems to confirm the presence of some necessary elements (constants in the learning subsystem) for the building of a Regional System of Innovation, as indicated by the literature discussed in section two of this paper.

Nonetheless, going beyond appearances, there are some points that have not been clarified which cast doubt on this process. The first relates to the nature of the innovations developed by the firm. Most of them are merely local adaptations to the obligations imposed by the law, both in terms of safety norms and rates of nationalization. It is also not clear what Siemens means when referring to “centers of excellence” for specific products. Is this excellence a result of knowing how to make these products well or knowing how to develop them? According to the terminology used by Cooke, as presented in earlier sections of this paper, do these centers have “competence” or “capability”? Everything leads us to believe that there is more of the former than the latter.

The second point refers to the fiscal incentives that the firm gets, which are extremely high. In fact, the 71.5 million *reais* that the firm spent in Paraná from 1994-1998 on agreements with research centers and universities represent –when considering what this means in terms of income tax reduction - a disbursement of 4 million dollars a year⁴. Furthermore, a large part of these expenses are related to equipment and the building of laboratories and communication networks whose goal is to facilitate communication between learning institutions and the Siemens company. This makes the expenditures devoted to research and development relatively low. It is almost as if the firm were “sub-contracting” part of its activities. If we take into account the fact that costs are close to 50% cheaper in Brazil than in Germany, we see that research and development costs are genuinely low.

These expenses end up functioning as a way in which the firm finances its expenses, constituting a veritable *ad hoc* financing sub-system. They are not specifically regional, since they refer to exemption from federal taxes, yet they are certainly the most important. Also at the federal level the firm is able to obtain benefits from specific forms of financing furnished by the National Bank for Economic Development (*Banco Nacional de Desenvolvimento Econômico –BNDES*). This firm is also benefited by state and municipal exemptions (it has set up a plant in the *CIC*,

Curitiba's industrial park, which in itself leads to a series of advantages), yet these resources are of lesser value and are available to a wide range of firms, whether or not they invest in research and development. As we can see, there are no strong indications here of anything that looks like a regional subsystem of financing.

To spend a little or a lot is not the most relevant question, from the perspective we are considering. The fundamental issue is to know how this knowledge is being transmitted and who is benefiting from it. Since many of these agreements were made with educational centers, we can hope that they have influenced the quality of teaching, that the majority of student trainees within the firm have become better qualified as workers, and so forth. However, we are again confronted by the problem of not being able to determine to what extent this improvement was not just a way of forming a workforce specific to the firm's own needs.

One further matter is that of a "milieu inovateur" for the region. Throughout its entire trajectory of involvement in the state of Paraná, Siemens/Equitel gradually embedded itself in the local economy, particularly in the Greater Curitiba region. It cannot be argued that there was an already existing "local culture" geared toward telecommunications. Nonetheless, something like this seems to have established itself in the Greater Curitiba region throughout the period that the firm carried out its activities.

There is however one important point that is rarely taken into account by local analysts in order to explain the emergence of this "milieu", which has to do with the relations developed between *Telepar* and Siemens/Equitel. The trajectory of the two firms is similar and the interaction between them was intense. As we have stated, as a recently-settled state, almost all of the infrastructure in Paraná is new. *Telepar* was Siemens most important client and many of the innovations that Siemens carried out may have emerged from the relationship between the two firms, just as a considerable amount of the labor trained through agreements sponsored by Siemens was used by *Telepar*, as also occurred in relation to those agreements established by the latter. At the same time, *Telepar* was made up of a high-level technical corps, many of whose engineers were formed in the CTA, (*Centro Tecnológico da Aeronáutica*), a national center of excellence.

Thus, an intense relationship of the client-supplier type sprang from the encounter between a large multinational firm and a large private firm belonging to the

⁴ At the exchange rate of 1 dollar for 1.74 *reais*.

Telebras system (an old holding company for the telephone firms of different states of the country) and its effects have probably made themselves felt in the relationships that Siemens has established with research and learning centers, both within Brazil and in connection with the demands established through the centers set up by the international headquarters.

In any event, *Telepar's* recent privatization raises some questions about the future of this relationship.

To complement these notes, it is important to emphasize that although Siemens has been one of the most successful firms with regard to interactions with the formal learning system in Paraná, Siemens has devoted close to 40% of its expenditures in this area on research and learning institutions from other states. A large amount of the resources devoted to these expenditures were financed by federal funds, whether through fiscal incentives or credit obtained through the *BNDES*. Furthermore, the firm's major partner, *Telepar*, although a public-sector firm of the state of Paraná, was in reality part of a national holding company. The state government never had complete control of the firm. On the other hand, the innovations that were carried out came in large part from the need to make adaptations compatible with Brazilian norms.

4) Final Considerations

A review of the literature on Regional Systems of Innovation posits firms' ability to innovate as a key determinant of their competitiveness within a specific region or country. This capacity for innovation depends in turn on the mastery of knowledge and abilities that, given their complexity, can be increasingly considered part of a collective patrimony. Within the evolutionist perspective basic elements for a comprehension of this capacity for innovation include financial capabilities, learning and the existence of a production-oriented culture. These elements were initially developed from the perspective of national states, although they reflect some of the specificities of regional cases. The latter is linked to the hypothesis that important elements for the constitution of a national system can be found in concentrated form in particular regions, characterized much more as specificities of these regions than as national elements per se.

Most of the studies on this topic have been carried out in developed countries. The issue discussed in this text, however, is related to the possibility that such systems could constitute a regional base in countries with a noticeable deficit of

research and learning institutions, serious financial restrictions and, as in the Brazilian case, continental dimensions.

We have carried out a case study on the state of Paraná, in Brazil, characterized by better economic conditions than those of many other states in the country, host to a new automobile industry and possessing a reasonably developed formal apparatus of science and technology. The Siemens/Equitel company was studied as an example of the firms established within the state, considered the most successful in terms of its relationship with the state's formal structures of science and technology.

However, we have seen that even for a state enjoying better conditions of development and in the case of a firm that is considered successful, the prospects for the emergence of a Regional System of Development are still far from promising.

In the first place, there is no state financing subsystem. Existing financing is limited to fiscal incentives, tax exemptions and credit with subsidized interest offered by the federal government.

With regard to the spirit of innovation and the firm's "embeddedness" in the state economy, the results of our analysis can at best lead to cautious hypotheses. For the specific case of the firm under consideration, the "culture" was developed after its implantation in the state. Furthermore, it was benefited by the existence of a major client, the state's public telephone company, which in turn cannot be properly characterized as regional, since many of its decisions followed a national policy.

In a general sense this "milieu inovateur" only exists in the state in few sectors such as the wood industry and agricultural activities. However, with regard to industrial activities this "milieu" is most present precisely in the sectors that are most archaic and present the least innovation. The state's most modern industries are of recent installation and to a large extent are branches of international firms.

Although reasonably developed, the learning subsystem suffers at the formal level from a lack of systemic interactions that blocks its efficient functioning. The state maintains a relatively large level of institutions of higher learning and research, yet the interaction between them and the firms tends to be largely formal or is only sporadically intensified.

In the Siemens case, where this interaction is profound and systematic, it tends to occur with institutions from other parts of the country and obviously also with those abroad, where its headquarters is located.

This paper has attempted to show that even within a country that is one of the world's ten largest economies, within a territorial sub-unit that has its own government and formal education system, a territory twice the size of the United Kingdom and possessing a population equal to Portugal's, we still cannot find a Regional System of Innovation similar to what is described in the literature we have analyzed. The topic is rich and promising, yet it is important that more studies be carried out in underdeveloped countries so that we can learn more about these systems' conditions of existence.

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