Fostering the Growth of Innovation Clusters for Regional Development : Building a Network of Software Clusters in Paraná, Brazil

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ABSTRACT

Competitiveness and growth in the knowledge-based economy are directly linked both to the development of local innovation capacity and connectivity to global resources. Clusters and networks are emerging as significant tools to promote regional development, foster SME growth, reduce spatial and social inequalities, and to activate, diffuse and expand locally generated knowledge. The present work seeks to move toward these objectives by investigating ways to promote the creation and expansion of regional innovation, while contributing to build local research capacity in the field. It is based on the notion that small and medium enterprises (SMEs), particularly technology-intensive ones, can trigger and sustain economic growth and equitable development, strengthen university-industry-government cooperation, and promote technological innovation and regional competitiveness. The general approach is centered on the relevance of two key concepts for SME (Small- and medium-sized enterprises) development: *innovation clusters* and *cooperation networks*. The general approach also involves the application of those concepts to the case of *W-CLASS* (*Paraná World Class Program for Software, E-commerce and E-business*). The research focuses on issues related to building and growing clusters, based on this in-depth study of the Paraná clusters.

1. Introduction

The emerging knowledge-based economy is bound to generate major impacts in nearly every industry, region and country in the world. It is associated with the rapid pace of technological change, the increasing importance of knowledge-intensive industries and occupations, and the globalization of production, markets, information and capital. It reinforces the widespread notion among academia, business and government that knowledge and advanced skills are the fundamental strategic resources of our age: knowledge is now recognised as the driver of productivity and economic growth, leading to a new focus on the role of information, technology and learning in economic performance (OECD, 1996). The divide between more developed and less developed areas is likely to be increasingly defined in terms of their relative ability to innovate, diffuse and apply knowledge rather than their stock of capital or other factor endowments.

The knowledge-based world economy calls for the design of strategies, policies and institutions to support a new model of development based on innovation, the promotion of knowledge diffusion and the development of advanced skills, world-class industries, technologies and products. How to create such policies and institutions is a major challenge for Latin America and the Caribbean (LAC) and for developing areas in general. That is also the central problem to be addressed by this paper.

The general approach is centered on the relevance of two key concepts for SME (Small- and medium-sized enterprises) development: *innovation clusters* and *cooperation networks*. Also, in order to provide a successful action-based perspective, the general approach involves a third element: the application to the case of *W-CLASS* (*Paraná World Class Program for Software, E-commerce and E-business*). Initially, some implications of knowledge-based economy in LAC are designed. Following, the conceptual framework is introduced briefly describing the above three components. Finally, some conclusions are provided as well some indications of future research.

2. The challenges of a knowledge-based economy for LAC

The microelectronics revolution, and particularly, the rapid growth of the Internet and the World Wide Web are providing extraordinary opportunities for the exchange of information and knowledge. Many governments and development agencies recognize the potential of these networking tools to enable developing countries to catch up rapidly with more developed ones. Networks are emerging as significant tools of social change, expanding opportunities for information and connectivity, and erasing the boundaries for research, education and business. Access to global information resources has become an essential condition to maintain international competitiveness and develop a knowledge-based society.

At the same time, LAC's economic structure has undergone dramatic changes, with policy measures that emphasize the role of the private sector and market mechanisms to promote economic development, in parallel with a shrinking role of the state. As a result, during the last decade most Latin American countries have experienced a strong process of industrial restructuring. After decades of protectionism, the old import substitution industries are giving way to a new wave of foreign investment. For example, Brazil was a major recipient of direct foreign investment in 1997, with inflows of US$16 billion; in 1998, the total reached US$28 billion. Foreign trade in LAC has also increased quickly over the past few years, fueled by economic stabilization plans in Brazil and Argentina, the liberalization of trade and investment policies and the establishment of trading blocs such as NAFTA and Mercosur. For example, trade between Canada and Latin America grew by 62% between 1992 and 1996, reaching US$10.7 billion (LTM, 1998).

Despite the region's fairly strong performance in terms of trade, investment and growth, serious doubts have been raised on the sustainability of a development process that is still strongly centered on resource-based exports. This specialization in commodity exports contrasts with the fact that world trade in manufactured goods has been much more dynamic than primary exports. One major factor has been the impact of the information technology revolution on the composition of world merchandise trade. In the first half of the 1980s, office and telecom equipment accounted for 5% of world trade (only one-third of the share of agricultural products). By 1995, the share had increased to 12%, which is slightly higher than the share for all agricultural products (WTO, 1996).

The fundamental feature of international competition is becoming the mastery of skills and know-how. The link between innovation, growth and employment appears to be characteristic of the leading economies, that is, those which invest in education, training, research, innovation and new technologies. It is apparent that the ability to achieve and sustain high growth rates will require a concerted strategy in LAC to add value to domestic products. This in turn will require efforts to improve their human capital endowments and, more generally, to improve their technological base.

However, expenditures in science and technology in LAC lag far behind developed countries expenditure levels, and also behind Asian countries (Peres, 1992). The region's weaknesses include very low levels of R&D investment, the limited participation of the private sector in R&D efforts, and an inefficient utilization of such investments. This is reflected in the limited capacity of LAC countries to convert technological developments into industrial applications and commercial products.

The current situation in LAC raises many concerns about its future development prospects, because access to global information resources, development of advanced skills, continuous innovation and the diffusion of new technologies are now essential to sustain international competitiveness and to build a knowledge-based economy. The globalization process has entailed the diffusion of world-class standards of quality, productivity and efficiency, the rise of global products, process and markets, and the reduction of barriers of time and distance, with increasingly free flows of technology, capital and information. The impact of technological change on competition is closely associated with new forms of industrial organization, management of production and interfirm relations.

At the same time, in the more complex industries, there has been a greater emphasis on non-price factors such as technological and organizational innovations that enable the firms to reduce product development cycles and delivery times, and to increase quality and flexibility. This means that developing country firms are in turn pressed to achieve equally efficient and flexible means of production in order to compete in the global economy.

The experience of industrialized countries and the limited evidence yet available from the developing world show that much work is still needed to clarify the constraints and opportunities that industrializing countries face in trying to develop high-technology clusters, to master advanced technologies and to reach global markets.

3. The Conceptual Framework: Clusters and Networks

The framework is centered on the relevance of two key concepts for SME development: *innovation clusters* and *cooperation networks*. In the cluster/network-based approach, both concepts are joined by a focus on interactive learning and the diffusion of different types of knowledge: tacit / codified, scientific / practical etc. in different spatial and organizational settings. That also implies a focus on the emerging field of knowledge management, that is, the explicit and systematic management of knowledge and its associated processes of creation, organization, diffusion and applications to create wealth and promote development.

SMEs, particularly technology-based ones, have a tremendous potential to accelerate economic growth, expand their share of exports and promote a more deconcentrated and equitable pattern of development in developing countries. However, this potential role is often not fulfilled because of their small scale. As Ceglie and Dini (1999) point out, SMEs are often unable to capture market opportunities that require a large scale of production. They are also unable to achieve economies of scale in the purchase of inputs (such as equipment, raw materials, finance, consulting services, etc.), and the creation of an internal division of labor that could foster cumulative improvements in productive capabilities and innovation.

Small size also constrains the internalization of dynamic functions such as training, market intelligence, logistics and technology innovation. Even innovative technology -based firms tend to lack key skills and resources, such as marketing or business capabilities. Berry (1997) notes that small firms' limitations Atypically fall in the areas of access to technological information, and guidance on quality control; access to finance; assistance in purchase of materials or equipment, in workplace organization, in financial management or in other determinants of effective performance; and market stability (security of demand over a period of time). More importantly, small-scale entrepreneurs in developing countries are often ill prepared to look beyond the boundaries of their firms and capture new market opportunities.

It is widely acknowledged that interfirm cooperation and linkages involving SMEs in a developing economy may have a strong impact on growth and distribution performance, as demonstrated in the successful development of East Asian countries, beginning with Japan, but also including Korea, Taiwan and others. Emilia Romagna, the Italian region most noted for its industrial districts, had the fourth largest increase in per capita income (14%) in the country between 1963 and 1984 (Pyke, 1995). The development of networks can improve the competitive position of SMEs and reduce the problems related to their size through mutual help. For example, firms may establish a localized network to become more specialized and complement each other's capabilities by sharing resources, pooling together their production capacities and purchasing power, thus achieving scale economies to conquer markets beyond their individual reach (Pyke, 1992). Some aspects of SME support (especially credit provision) have evolved considerably, but "linkage-inducing" policy remains largely a new and experimental area. As Berry (1997) notes, "the challenge for policy in this area is to understand the source of potential payoff to increased inter-firm cooperation, the contexts which facilitate it, and the potential instruments to induce it".

Horizontal cooperation and the creation of external economies among SMEs in clusters contribute to generate competitive advantages through "collective efficiency". Schmitz (1995) emphasizes that "external economies are essential to growth but not sufficient to ride out major changes in product or factor markets; that requires joint action". The advantages of cooperation among SMEs are usually connected with collective economies of scale, the benefits of dissemination of information and inter-firm division of labor. These benefits tend to increase when transaction costs are low, and these in turn tend to decrease with geographic proximity and the establishment of shared infrastructure, common norms and tacit rules for cooperation.

3.1 Innovation Clusters

The term is used to indicate a sectoral and geographical concentration of firms and other economic agents which gives rise to external economies and favors the creation of specialized technical and financial services as well as public and private local institutions to support local economic development. This type of arrangement facilitates collective learning and innovation through implicit and explicit co-ordination (Humprey and Schmitz, 1995).

Successful clusters depend both on the private and the public sector (usually universities and research institutions), which join efforts to create innovative environments and to build synergies among agents with complementary capabilities. Their development is gradual and cumulative: over time, the region builds knowledge, skills, institutional support structures, specialized services, financing arrangements, infrastructure and collective norms of cooperation and mutual trust.

Clusters are built on linkages and relationships that integrate the isolated technological capabilities of institutions, firms and individuals into a collective, territorial asset. The establishment of mechanisms to coordinate efficiently these relationships is essential to create a supportive environment for many forms of technical interchange, cross-fertilization, risk-sharing and collective learning. This is essentially a territorially-based process, as people who share the same space discover the advantages of "learning by interacting".

As Bianchi (1993) points out, the crucial characteristic of the «Marshallian» type of cluster or *milieu* is the set of competitive and collaborative linkages among agents in a socially- and historically-defined agglomeration, complemented by a set of collective intangible assets that belong to the production system as a whole. The cluster benefits from its complex web of interactions because innovation rarely happens in isolation. It is an experimental, trial and error activity, and each agent may draw innovation inputs from a wider matrix of institutions to take advantage of a division of labor in the generation of knowledge and skills (Metcalfe and Georghiou, 1997). In that sense, the cluster improves «dynamic» efficiency (or innovative capability) by reducing uncertainty through information sharing and screening, and by establishing a durable relational basis for the construction of competences (Camagni, 1995).

Several generic «locational ingredients» or factors are usually associated with high-tech cluster development. Two factors may be considered as necessary, but not sufficient conditions for a successful cluster. The first is a «critical mass» of human resources, including entrepreneurs, scientists, engineers, technicians and skilled labor. The second is a capable scientific and technological infrastructure, or the «knowledge assets» of a region, including universities, public and private research labs, libraries, technological incubators, innovation centers and science parks. The main roles of these anchor institutions are to promote technology transfers and to support networking.

Other generic locational ingredients that are often associated with technology-intensive clusters include the *business infrastructure*, including institutions such as industrial associations, chambers of commerce, development agencies. It also comprises :

- *financing opportunities* through the availability of seed, venture and investment capital, in addition to grants for training and R&D, and government offices providing a wide range of business support services within the area;

- *physical infrastructure* such as transportation (highways, rail, airports), communications, water and power, etc.;

- *quality of life factors,* or the perceived benefits that certain locations offer to entrepreneurs and the upper segments of technical-scientific workers, such as pleasant residential areas, parks, recreational facilities and absence of pollution;

- *a diversified economic base,* comprising supplier and distribution networks, specialized services;

- *a favorable «business climate»,* usually meaning a reduced cost of doing business due to low tax levels, limited labor union activity, and also other costs such as prevailing wages, housing, food and transportation.

Another component is the existence of government incentives, as well as low cost of infrastructure and loans for start ups.

A second set of high-tech cluster factors refers to less tangible governance or organizational elements, which are expressed mainly by linkages and relationships. Although most of the literature concentrates on the physical aspects of technopoles, this second set of elements of high-technology regions points to an intangible process that is much harder to grasp: the gradual build-up of relationships, informal norms of mutual trust and cooperation, and intense exchanges of information among entrepreneurs and scientists. It comprises (Voyer and Roy, 1996; Quandt, 1997):

- *the existence of «champions:»* political and academic leaders — either individuals or regional governments — who ensure determination and tenacity in defining and pursuing objectives;

- *recognition of the potential* that technology-based industries offer for regional development, and also actions to identify and take advantage of regional assets;

- *a broad support base* for a common development goal in the region from different government levels — including procurement, research grants, regional development aid, etc – as well as from the community, unions and other local organizations;

- *an entrepreneurial culture,* which is widely perceived as essential to create a dynamic business cluster; *strong linkages between the scientific and the entrepreneurial community,* and the establishment of a mutual commitment to partnerships and negotiated agreements; *information networks,* comprising formal and informal contacts as well as wider scientific, technological and business networks.

- Finally, there is a component of *marketing and image building:* the promotion of the region's innovative image is often seen as an important strategy to attract and retain new public and private investments as well as skilled workers and entrepreneurs.

3.2 Regional and Supra-territorial Networks

The process of clustering is similar to the network model in the sense that both are technological learning systems that help to socialize innovation-related knowledge and reduce uncertainty in the environment in which innovative agents operate. The territory of an innovative cluster is an active resource for learning through intense interaction involving a broad set of actors. A firm's ability to create knowledge is strongly related to its interaction with related firms in a process of collective learning, involving exchanges of partly codified and partly tacit knowledge. In fact, the local system may be seen as a locus of integration of tacit (contextual) and codified knowledge, and as an instrument to connect knowledge to production.

However, it should not be seen as a closed system, but as part of a global circuit of knowledge production and learning. Thus competitiveness is shaped in interaction with market structures that may range from the local to the global, with industry-specific technological trajectories, and with regionally specific resources, structures and institutions.

In this broad process of interaction, local, regional and national systems of knowledge creation retain a key role in the global economy (Nelson, 1993). Regional and national systems of innovation may be described as positive externalities that are very difficult to replicate. The sustainability of localized competitive capabilities indeed indicates the existence of strong barriers that prevent immediate or costless imitation of the institutional endowment that exists in successful regions. In addition to the factors mentioned above, the most important barrier to imitation is probably the stock of research- and experience-based knowledge, skilled people and infrastructure that some regions have already accumulated. They are better positioned to generate innovations and accumulate further knowledge than the regions that have not yet achieved such critical mass.

However, path dependent processes of knowledge creation within closed systems can make regional capabilities deteriorate over time, as its collective assets may erode or become outdated. The process of cumulative learning within innovative milieux may require a readiness for radical change when needed to restore regional competitiveness. At the very least, they must remain open for renewal and the creation of new capabilities by absorbing inputs of external «energy» through the establishment of external linkages, such as through participation in wider networks.

The network model is becoming increasingly dominant in modern productive sectors, not only for companies but also for institutions in the area of governance and development. The importance of long-distance linkages and on-line data exchange is growing quickly everywhere. The rise of concepts such as the networked organization and the "virtual enterprise" — which may comprise, for example, transitory teams of freelance or temporary workers organized in flexible ways to develop a specific project — has challenged directly the traditional place-bound, centralized notion of organization of production.

In a network, information is transmitted horizontally, reciprocally and iteratively, rather than following a rigid hierarchy. Hence innovation and competitiveness depend on the ability to integrate different kinds of information and to coordinate them among the different agents, types of activities and firms. Cooperation networks enable firms to position themselves in the trade-off between market-related transaction costs and the high costs related to internal development of know-how. They create opportunities to reach global markets, absorb new technologies, develop joint projects and share human and material resources. Even though high costs and risks are integral aspects of the network form of organization, it is particularly suitable for coping with dynamic processes such as systemic innovation and control over future technological trajectories.

As networks evolve and become more sophisticated, a *learning process* emerges through cooperation, together with increased reliability and trust. These elements constitute a shared intangible asset that helps to reduce both «certain» and hidden costs of the interaction among the partners as well as the probability of opportunistic behavior (Bianchi, 1993).

Isolation is a great problem for most developing-country firms, particularly small ones. Technologically advanced regional systems, and industrial clusters more generally, depend on the development of territorially based networks. However, regional innovation and growth are not restricted to local sources of knowledge, capital or other factors. Supra-territorial networks, particularly with the help of advanced *information and communication technologies* (ICT), expand enormously the spatial scope and the range of opportunities for firms in any given cluster. Hence a cluster/network-based model is particularly promising for LAC precisely because few places in the region have been able to bring together a minimum set of elements to foster the creation of innovative clusters, or to keep them working efficiently.

In sum, the focus on the mobilization of local assets to achieve regional competitive advantages must be matched by a broader focus, on the ability to join increasingly wider spatial networks and to develop alliances, partnerships and opportunities with outside firms and investors as well as incubators, universities and research institutes. This represents a major shift from the established notion of the territorially based concept of innovative cluster, in which local linkages and face-to-face interactions have been always seen as vital components.

However, a network of virtual linkages cannot replace the crucial role of person-to-person contacts, which are generally built on territorially defined norms and relationships of trust. Rather than being mutually exclusive, the two processes (the cluster-based personal contact and the wide network linkage) can complement each other. That is, the local system may interact with a wide range of other nodes or levels through the intermediation of actors that belong simultaneously to the cluster and to supra-territorial networks. These actors then represent a key element of the local system and, at the same time, a vital linkage to external resources and different territorial systems. Much research is still needed to explore the ways in which a cluster may take advantage of wider networks by becoming part of a "virtual region" while preserving its identity and its ability to foster a self-reinforcing process of innovation and growth.

3.3. The World Class Program

The research proposal above described builds on an existing initiative : W-CLASS (Paraná World Class Program for Software, E-commerce and E-business. W-CLASS is a set of coordinated actions from government, enterprises and higher education institutions. The Program is promoted by the State Secretariat for Science, Technology and Higher Education, and was made possible thanks to the partnership of several institutions and enterprises in Paraná.

W-CLASS strategy is inspired on the World Class concept from Rosabeth Moss Kanter (Kanter, 1996), professor from the Harvard Business School, and suggests: (i) the need to satisfy the highest standards on competitiveness to reach a global market, and (ii) the growth of a social class qualified to command assets and to operate beyond the frontiers, in very large territories.

Basically, W-CLASS's model observes the following points (Figure 1):

- Developing World Class assets, investing on Innovation, Entrepreneurship, Quality, Learning, Collaboration, Networking and Funding.

- Focusing actions on three emerging software clusters, namely (1) Software Main Corridor (Curitiba and Ponta Grossa) which is fairly developed with some exporting companies, (2) the incipient Software North Corridor (Maringá and Londrina), and (3) the yet to be developed Software West-Southwest Corridor (Cascavel, Foz do Iguaçu, and Pato Branco).

- Depending on the nature of the asset, the actions are directed to the enterprises, human resources, market, government, entities, and the public in general.

- These initiatives are linked by the State's Integrated Network of Technological Information, which includes the associated state universities (UEPG, UEL, UEM and UNOESTE), as well as several state and local agencies are involved in the program, in addition to private enterprises and business associations.

- W-CLASS comprises 30 different subprograms or lines of action that range from education, training and seminars to support for access to partnerships, capital and markets.

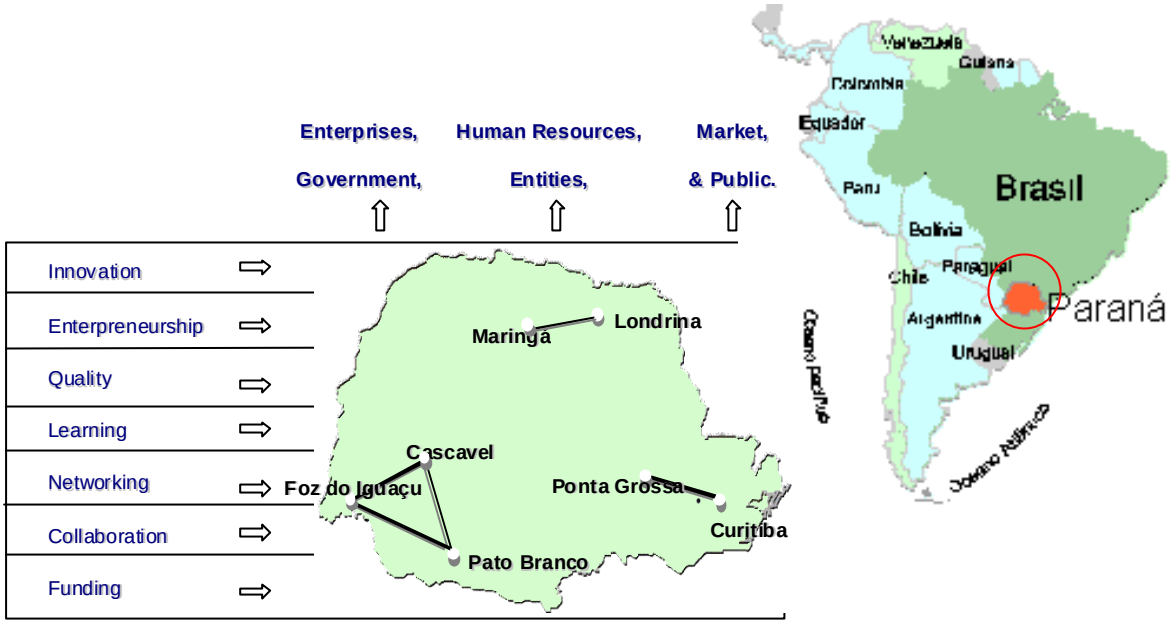

Figure 1 – The W-CLASS diagram model.

The stated goal is to double Paraná software exports by the year 2004, and double the number of software companies in Paraná over the same time period. The regions identified for development of software competitiveness (forming a rough triangle) in the state of Paraná are the three clusters listed above.

The strategy of linking innovation clusters and cooperation issues to the Paraná World Class program offers a unique potential to leverage seed investment on research. The application adds a research and evaluation component to the W-CLASS initiative, which is focused on production and commercialization; they complement each other and are joined by a common focus on improving the capabilities of SMEs.

The research focuses on issues related to building and growing clusters, based on this in-depth study of the Paraná clusters. The competitiveness of local software producers is nurtured by local support of entrepreneurial activity and technology development, and through information exchange and capacity building among distant state agents using the existing ICT network. Furthermore, the project addresses questions of resource and knowledge sharing (networking) with other Regional Innovation Clusters in Brazil and LAC and with mentoring regions in the U.S. and Canada. Network links with regional SME development projects in LAC and international mentoring institutions are incorporated into the network and integrated to the processes of knowledge creation and sharing and building institutional and business relationships.

Another aspect of the cost effectiveness of W-CLASS is its potential to expand the understanding of the key elements of innovation clusters and how they function in this regional context. It will allow to obtain knowledge on three cases of regional innovation clusters in different stages of development, without the added complexity and costs of involving multiple cases across different regions and countries. The inclusion of a component of monitoring and evaluation will also help to understand what activities are more effective to build and sustain innovation clusters, and whether the incubation of «proto-clusters» can be successful. On a broader level, it will allow to assess the importance of innovation clusters for regional development.

3. Conclusions

The paper presents a conceptual framework, which has been designed as an *action-research* work. In other words, the work's outcomes are expected to include not only research results that will be meaningful in terms of their scientific / academic interest, but also actions and products that will have concrete impacts on regional development. Therefore, the proposed method is to integrate the research component – grounded on the cluster/network-based approach – with the action component, that is, an active involvement of the W-CLASS's actions.

The research is guided by some basic assumptions:

1) *Small- and medium-sized enterprises (SMEs)* can play a key role in triggering and sustaining economic growth and equitable development in LAC and other developing regions as well.

2) The creation of *technology-intensive firms* is essential to build local capabilities to compete in the global economy; they are also essential to strengthen academic-industry-government linkages and encourage technological innovation.

3) The regions' development potential can be greatly enhanced by adopting a *cluster/network-based approach* to address its development needs and spatial imbalances, searching for cooperation and partnerships among different government levels, the private sector and international organizations.

4) In order to overcome the isolation and lack of the required institutions, skills and R&D that prevail in individual localities, *information and communication technologies (ICT)* are a key element to establish linkages within each area, among them, and with strategic partners outside the region. As their individual capabilities are expanded and interlinked, they become a collective asset to sustain LAC's path to knowledge-based development.

Those assumptions and the proposed framework constitutes a background for the ongoing research realized by the Strategic Knowledge Management Group at the Pontifical Catholic University of Paraná, which is guided by some of the following questions:

1) What is the importance of innovation clusters for regional development?
2) What are the key elements of innovation clusters and how do they function in this regional context?
3) To what extent can the developed-country models be adapted to specific local conditions?
4) What activities are more effective to build and sustain innovation clusters?
5) How can a cluster/network model contribute to improve the capabilities of SMEs?
6) What are the benefits that a cluster/network model can bring to local universities and other institutions?
7) How can the missing elements of innovation clusters can be supplied by Web/Internet tools?
8) What are the barriers and facilitators to sharing knowledge across regional clusters?

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