SFU SIMON FRASER UNIVERSITY
THINKING OF THE WORLD

Innovation systems based indicators: Emphasis on human capital and ICT adoption

Mónica Salazar-Acosta
Directora, Observatrio de Ciencia y Tecnologia, (Colombian Observatory of Science and Technology), Bogotá, Colombia

CPROST Report 06 - 03

Paper presented at the OECD Blue Sky 2006 Conference:
"What indicators for Science, Technology and Innovation Policies in the 21st century",
Statistics Canada, Ottawa, September 25-27 2006

CPROST // Centre for Policy Research on Science and Technology

The Centre for Policy Research on Science and Technology (CPROST) at Simon Fraser University is a centre for expertise in innovation and knowledge activities of advanced and emerging economies.

Established in 1988, CPROST engages in research on the relationship between public policy and technology. It brings together practitioners and scholars to study the interaction of advances in science and technology, their implementation in the marketplace, and their impacts on community and individual interests.

The centre brings together scholars from the University and beyond, with interests in:

- **science, technology and innovation policy;**
- **indicators of science and innovation activity;**
- **evaluation of science, research and development;**
- **emerging communications technologies and new media;**
- **management of technology based firms;**
- **political economy of science, innovation and emerging economies; and**
- **factors affecting innovation in regional and local socio-economic systems.**

The Centre has developed analyses for federal and provincial governments.

CPROST can be contacted through the Director Richard Smith smith@sfu.ca and Associate Director Adam Holbrook jholbroo@sfu.ca 515 West Hastings, Vancouver, BC, V6B 5K3.

www.sfu.ca/cprost

Innovation systems based indicators: Emphasis on human capital and ICTs adoption

Mónica Salazar-Acosta
CPROST, Simon Fraser University, and
Directora, Observatorio de Ciencia y Tecnologia
Bogotá, Colombia

Introduction

A lot of evidence has been accumulated, both in developed and developing countries, which explain innovation processes and how the social and economic environment affects innovative performance. Not all that knowledge has permeated the public policy sphere; policy-makers and government agencies should take advantage of this body of scholarship, and improve the design of innovation surveys, indicators and policies.

There are many demands for indicators that really explain and characterize innovation processes (Djellal & Gallouj, 1999; Holbrook & Hughes, 2001; Salazar & Holbrook, 2004). Some of the most frequent claims are:

- Innovation surveys are biased towards the manufacturing sector, high-tech firms, the private sector, and successful firms.
- There are problems associated with industrial classifications, how to characterize the degree of novelty, and who's responsible for responding the survey.
- The firm as the unit of analysis.
- The use of patents as an innovation indicator.
- The importance of normalization and international comparisons.

Jones *et. al*. say that "the main challenge for the future is to develop and apply a comprehensive array of newly developed indicators to understand the dynamics of the innovation process and of knowledge creation in a wide social and economic context. This will demand a multi-indicator approach to analysis, and implies continued challenges for the consolidation of recent advances" (Jones, Sainsbury, Dowie, & Kavanagh, 2003: 30).

Despite initiatives to standardize innovation manuals and questionnaires, it is not clear that simple comparisons are really adequate. For instance, entrepreneurs have different understandings of what is innovation. Data collected on R&D and innovation expenditures tend to vary a lot even among similar economies (Tether, 2001). Some argue that innovation is a fuzzy concept (Godin, 2002), which depends on many variables - some of them intangible and immeasurable. In addition, innovation is about change and, by definition, all innovations are different (Tether et al., 2002). Therefore there are difficulties associated with categorizing innovation results and novelty. So why is it so

important to obtain models of innovative behaviour from the results of innovation surveys?

It seems that output indicators, such as TPP innovation - the main emphasis of innovation surveys – which compare firms, sectors, regions and countries are not enough to characterize the innovation process. The question to ask is how to assess innovation capabilities, innovativeness (attitude and potentiality), and innovation efforts? We need to refine indicators that measure firms' capacities to innovate, and the impact that economic, social and cultural conditions and the environment have upon these capabilities.

The paper uses three bodies of literature - innovation systems, knowledge/ information society[1], and cluster studies - to explore the commonalities between three groups of indicators - innovation, human capital and adoption of information and communication technologies (ICTs). The final objective of the paper is looking for new paths for designing new innovation indicators that better explain innovation processes.

The paper starts by explaining the logic model, followed by some comments regarding the biases and missing aspects in the current measurement of innovation. The third section will deal with the topic of human capital, especially looking at how various human resource management practices are closely related to ICTs adoption and innovative performance. The final section deals with the need to focus more on systemic innovation policies (Guy & Nauwelaers, 2003; Smits & Kuhlmann, 2003) and how innovation indicators should respond to the challenge that this focus impose.

1. The logic model

Innovation systems, regional clusters and knowledge-based economies are analytical approaches that point to similar competitive and learning phenomena. The cluster approach can be seen as a different level of analysis of an innovation system, the former being the locality, and the latter the nation-state or a region. The concept of knowledge-based economies incorporates much of the insights developed by innovation studies, by considering that knowledge is the most important production resource/factor, learning is the principal process to accumulate knowledge, and innovation is based on knowledge production and use, and learning.

Without doubt the innovation systems approach has provided useful insights to a better understanding of innovation processes. Here are some of the conceptual underpinnings of this approach:

[1] Even if the term 'information society' is of wider acceptance and usage, I considered 'knowledge society' a more appropriate and broader term to explain current phenomena because it encompasses the issues at stake (e.g. knowledge over information, people over technologies); therefore I will prefer its usage in this document (Bianco, Lugones, Peirano, & Salazar, 2002; Salazar, 2003).

- Firms do not innovate alone, they create innovation networks and rely on various supporting organizations and institutions.
- Learning is interactive and cumulative, and it is a crucial factor in innovation processes.
- Interaction is central to the process of innovation.
- Evolutionary processes play an important role.
- Innovation occurs in institutional, political and spatial contexts.
- Innovation is embedded in social relationships.
- Innovation capabilities are sustained through local communities that share a common knowledge base and a common set of rules, conventions and norms (Salazar, 2005).

The systemic nature of innovation tells us different things. For instance, it talks about regular interaction among actors and system's overall performance, as Laureen McKelvey explains it: "the concept of NIS encompasses an idea of systematic interactions, which cannot be reduced simply to the actions of specific firms, or to the existing R&D system, or to competitions among firms or institutions" (McKelvey, 1991: 136-137). The question to ask is whether innovation surveys are helping to characterize current complex innovation systems or not, and if they account for the variety of interactions among diverse actors.

The systems of innovation approach has different levels of analysis: national, regional, local, and sectoral; being the territorial dimension the more developed. This focus on spatial aspects has two major advantages; on the one hand, it recognizes that innovation is a *social process* and is shaped by persons and institutions that share a common language, rules, norms and culture (i.e. common modes of communication). On the other hand, innovation is also a *geographic process***,** taking into account that technological capabilities are grounded on regional communities that share a common knowledge base (Holbrook & Salazar, 2004; Wolfe, 2002). This territorial dimension leads us to cluster studies. Some authors, argue that a regional innovation system describes regional clusters surrounded by supporting organizations. They define clusters:

"as places where close inter-firm communication, and social-cultural structures and institutional environment may stimulate socially and territorially embedded collective learning and continuous innovation" (Asheim & Isaksen, 2002).

If as said above, innovation has become an increasingly social process resting on the production and exchange of tacit knowledge, then how close must those participating in the process be to one another for it to work? (Gertler, 2001). The theoretical and empirical literature on the geography of knowledge is clear and unequivocal: spatial proximity is the key to effective production and transmission/sharing of tacit knowledge, where processes of learning-through-interacting take place, and seems to characterize successful innovative clusters, districts and regions.

Fundamentally, a knowledge society is a society with capacity to generate knowledge about its situation and background and to use that knowledge to think, build and recreate

its future. Manuel Castells characterizes the new economy – a term he prefers over knowledge-based economy - as informational, global and networked (Castells, 2000). In relation to innovation, it seems that theoretical knowledge plays a major role considering that innovations are increasingly based on scientific knowledge. In this sense, education and learning, and scientific and technological development should be the basis for building knowledge societies (Salazar, 2003).

"The new economy is also a knowledge-based economy, a digital economy, and informational economy, an internet economy, an innovation-based economy, a high-tech economy, and finally a global economy" (Statistics Canada, 2004).

The logic model - using Susan Cozzens' words – behind this proposal is described in the table below. Taking into account that the table brings together various sets of indicators, designed for measuring different phenomena – innovation, knowledge-based economy and clusters – there is a need to find common elements among them. The core of the proposal is to propose new indicators to measure the role and the impact (incidence) that the human capital has in the knowledge economy. The purpose is not to define which approach is better for supporting the design of new innovation indicators, since it is recognized is that the new economy is an innovation economy, knowledge-based and highly dependent on territorial assets.

	Innovation indicators	**Knowledge-based society indicators**	**Clusters indicators**
Key themes	Innovation and linkage capabilities. Innovation and learning networks.	Individual, organizational, and social learning. Use of ICTs.	Linkage capabilities. Characteristics of the locality. Innovation and learning networks.
Common element: focus on human resources	Highly qualified personnel[2]. Life-long training and learning.	Highly qualified personnel / knowledge workers. Computer literacy	Highly qualified personnel. Attraction and retention of talent
Other important themes	Alliances (formal and informal cooperation agreements). Knowledge transfer between various actors	Work satisfaction. Relations between innovation and introduction of ICTs.	Cultural diversity. Creation and rate of survival of spin-offs. Employment creation. Knowledge transfer between various actors.

[2] Highly qualified personnel are people with a postsecondary level of education.

2. Innovation indicators

According to Tsipouri, when one is selecting indicators for measuring something, there are three criteria: robustness, feasibility and relevance. Usually a robust indicator is easy to collect; its value cannot be contested, and it is usually preferred by policy makers. The feasibility of indicators depends on the cost of data collection and data availability. Relevance implies that the indicators are related to the objectives of the study, but that the degree of relevance is subjective. It is common to make trade-offs between these criteria because it is very difficult that an indicator can meet all those characteristics. Relevant indicators are difficult to measure or the information is confidential. Usually there are trade-offs between relevance and feasibility (Tsipouri, 2000). This author made an analysis of policy instruments to support innovation in regions, and gives a list of possible indicators to measure these instruments, qualifying them using these criteria. Interestingly, he found that the most relevant indicators are those related to clusters – such as survival of spin-offs and employment creation – and those that relate training and employment.

The improvement of innovation measurement exercises should start with a better and broader definition of innovation. The Oslo Manual (OECD/Eurostat, 1997) definition, also adopted in the Bogota Manual (Jaramillo, Lugones, & Salazar, 2001), is long and complicated and does not facilitate understanding by the respondents[3]. Jones and colleagues (2003) propose simpler definitions quoting various studies:

- Innovation is the process whereby ideas are transformed, through economic activity into sustainable value-creating outcomes (Livingstone[4]).
- Innovation is a process through which economic value is extracted from knowledge through the generation, development and implementation of ideas to produce new products, processes and services (Conference Board of Canada[5]).
- Innovation covers "the million little things" which improve the operation of the firms or other institutions (Romer[6]).

It is interesting to see how the definition of innovation has evolved from just measuring technological innovation, to including non-technological innovation, and today's definition that has dropped the 'technological'. The Oslo Manual in its newest version) says that

> *"an innovation is the implementation of a new or significant improved product (good or service), process, a new marketing method, or a new organizational*

[3] Tether et al (2002) argue that a large proportion of the differences between innovators and non-innovators in European countries is due to differences in the interpretation of what constitutes innovation, among other reasons.
[4] Livingstone, C. (2000), Transcript of the Warren Centre´s 2000 Innovation Lecture, Sydney.
[5] Conference Board of Canada (2001), *Investing in Innovation: 3rd Annual Innovation Report*, Ottawa.
[6] Romer, P. (1992), "Two strategies for economic development: using ideas and producing ideas", Proceedings of the World Bank Annual Conference on Development Economics.

> *method in business practices, workplace organization or external relations* (paragraph: 146, Oslo Manual, 2005).

The definitions above point to several issues. First, innovation is a process, which implies that we need to focus on innovation activities rather than results and how firms change over time. Second, innovation is not limited to technological aspects. This raises several questions.

- How to measure innovation capacities at the firm level?
- How to measure innovation attitude or innovativeness?
- How to measure innovation efforts?

Innovation capability is a recurrent theme within innovation scholars. If we look at innovation surveys asking if they are measuring them, we may find a positive answer although not a specific section. For instance, in the Bogota Manual, by putting together different questions and topics, such as technological and managerial training, acquisition of disembodied technology and know-how (patents, licenses, etc.), development of R&D projects, design, modernization of management processes, and percentage of highly qualified personnel, we may answer the question. The questionnaire proposed for Australia by Jones et al under the section of innovation capacities they include questions related to: acquisition of licences, hiring of highly qualified personnel, development of R&D projects internally or externally, personnel dedicated to R&D, training programs (technological and managerial), and assistance to undertake innovation activities (government programs, technical or commercial assistance, etc.). In addition they include two subjective questions: the innovative potential of the firm and what can be done to improve the firm's ability to improve its products/services and processes (Jones et al., 2003). Both cases illustrate approaches used to tackle the problem.

Important in the measurement of innovation capabilities is that the survey frame, the set of firms surveyed in every country stay the same year after year (or whatever the frequency of the survey) - not the number of firms but the actual firms -, in order to make a real and effective follow-up of capacity-building.

Recognizing that innovation is a process, what is more important to characterize it, innovation activities or results? Innovation activities can be defined as all those efforts that a firm undertakes to be competitive, which include not only technological efforts but also in organization, management, and commercialization. This is where Romer's definition fits the best.

The problem is how to measure those efforts. Two basic criteria should be considered, the variety of activities undertaken by the firm, and the intensity of those activities, measured by expenditures or human resources devoted to those activities. Diversity of innovation activities, because of complementarities and synergies between them, seems to be a good indicator of firm's attitude towards change and innovation (Durán *et.al*., 1998). Innovation expenditures as a measure of intensity have proved to have various problems. On the one hand, the actual cost of innovation is the sum of several activities, not only

one (i.e. R&D), and most of them difficult to quantify because of normal accounting practices. On the other hand, the information obtained from R&D surveys is different from the data obtained from innovation surveys (Gault, 2006; Godin, 2002). Expenditures on training also present problems, usually because only formal training is taken into account. Because of all that, innovation expenditures, is not a robust indicator, for that reason, not widely used[7]. Therefore, it seems that developing indicators related to human resources is more appropriate as a measure of intensity, a topic explained in the next section.

Finally, innovation capabilities are also related to the capacity of the firm to establish linkages with other actors of the innovation system (Lall, 1992). Most innovation surveys are attempting to measure and characterize these relationships, hopefully including formal and informal linkages: joint ventures, strategic alliances, market partnerships, R&D collaboration, agreements with suppliers, etc. These relations will be discussed in more depth in the last section about innovation systems and systemic policies.

3. Human resources indicators in relation with innovation and ICTs

> *"Advanced economies are constantly evolving. There is a general sense that the pace of change has accelerated in recent years, and that we are moving in new directions. This evolution is captured by phrases such as the "knowledge-based economy" or "the learning organization". Central to this notion is the role of technology, particularly information technology. The implementation of these technologies is thought to have substantial impact on both firms and theirs workers. Likely related to these technological environmental changes, many firms have undertaken significant organizational changes and have implemented new human resource practices"* (Turcotte, Leónard, & Montmarquette, 2003: 5-6).

Considering the above, greater attention is being paid to the management and development of human resources within firms (*i.e*. education and training), as means to improve prosperity both for firms and individual workers. A good example is the "Workplace and Employee Survey-WES" undertaken by Statistics Canada and Human Resources Development Canada, which attempted to establish the links between what is happening in the workplace and how this affects employees. Some of the questions asked were: How many firms are using information technologies? In what scale? What type of training is associated with these changes? What type of organizational change is happening in firms?

The WES has two components: i) a survey of workplaces about technology adoption, organizational change, training and other human resources practices, firms' strategies, and employee rotation; ii) an employee survey that covers salaries, working hours, type of occupation, human capital, use of technology, and training (Statistics Canada, 2001).

[7] The most recent innovation survey conducted in Colombia (2005) asks for the cost of every single innovation activity, making, making the questionnaire heavy and very long. Results were not very reliable.

The most valuable thing is the possibility of linking the answers of the employees directly to those of the enterprises, thereby measuring the real impact that labour practices and technology adoption have upon workers. The WES was first done in 1999, with results that have been widely analyzed and diffused. Since then, annual surveys have been developed both for employees and employers. All sectors are covered in the WES: primary, manufacturing and services.

What is particularly relevant is the linkages between training and adoption of technologies. The results which relate the use of computers and its effect upon training, job satisfaction and innovation are strong:

> *"Computer use has been found to have a positive impact on both workplace performance (such as innovation and productivity) and employee outcomes (such as hourly wage, job and monetary satisfaction). Interestingly, research based on the WES has shown that sizeable productivity gains can be achieved by combining technology investment with human capital investments, particularly by providing computer training to less-educated workers"* (Statistics Canada, 2003: 165).

Among the analyses based on the WES, an important one is that made by Therrien and Léonard (2003), in which they determined the correlation between innovation and certain human resource management (HRM) practices. These practices consist on new work agreements oriented to the management of human resources, which include: incentives or financial benefits, workers' participation in decision making, and training programs:

> *"the idea of including human resource management practices in the innovation process lies in the supposition that these practice give the correct incentive to the adequate person in order to make improvement in the production process, the product or the service"* (Therrien & Leónard, 2003).

These authors mention several studies that relate human resources and productivity, being the most relevant the one done by Ichniowski and colleagues[8], in which they classify these practices into seven HRM policy areas: incentives and pay, recruiting, teamwork, employment security, job flexibility, training, and labour-management communication. In general these studies found that firms benefit from these practices more if they combine various mechanisms rather than just implementing one at a time. In addition, Therrien and Léonard (2003) found that firms that implement HRM practices are more innovative, based on an econometric model they ran using WES data[9].

The HRM practices included in the WES that should be included in innovation surveys, are those that relate to the employers' practices:

---

[8] Ichniowski, C., K. Shaw, and G. Prennushi, 1997. "The effects of human resource management practices on productivity: A study of steel finishing lines", American Economic Review, 87 (3), 291:313.

[9] It is worth emphasizing that these results do not tell anything about causality between innovation and introduction of HRM practices, even if results (obtained from econometric models) confirm a correlation that exists between innovativeness and HRM practices.

- Financial incentives: individuals incentives, group incentives, merit-pay or skill-based pay, profit sharing, employee stock plans.
- Workers participation or employee involvement: self-directed workgroups, employee's suggestion program, problem-solving teams, joint labour–management committees, flexible job design, information sharing with employees.
- Training: formal (class-room), informal (on the job).

Besides HRM practices, there are other issues related to talent and locality that deserve to be considered in innovation studies. Several studies have proved that the characteristics of the locality, both in terms of quality of life and social and cultural diversity, are fundamental to attract highly qualified personnel and to promote the creation of high-tech firms (Florida, 2000; Gertler, Florida, Gates, & Vinodrai, 2002).

It is also recommended that the following themes and indicators related to human resources and training be included in innovation surveys:

- Firm's strategies to attract and retain highly qualified personnel, which can be translated in HRM practices.
- Measurement of formal and informal training.
- Highest level of education attained by all personnel.
- Follow-up of people that receive the training, trying to determine if they keep the job, have an increase in salary, and job satisfaction.

It is often not possible to run several separate surveys (such as innovation, WES-like, and ICTs adoption). A single survey could cover many of these topics that have proven – at least in developed countries – to characterize innovativeness, while of course, trying to keep to the minimum the number of questions asked, and using simple, straight-forward and easy to answer questions.

The preliminary version of the Lisbon Manual – a guideline for the interpretation of information society indicators in Iberian American countries - recommends that ICT indicators, at the firm level, should take account of three different dimensions: infrastructure, human resources, and systems development (RICyT, UMIC, & ISCTE, 2006). However, reality goes in a different direction, some surveys developed in the region have focused mainly on technologies, that is firm's use of ICTs, rather than measuring how they impact training for instance.

4. Innovation systems, systemic policies and new indicators

As noted above, one of the main concerns, is whether innovation surveys are helping to characterize complex innovation systems or not, and if they can measure the range of interactions among the various actors. Innovation surveys should gather information on the 'linkage capabilities' that a firm posses in order to be part of an innovation

network/system. The concept of 'linkage capabilities', proposed by Sanjaya Lall, is the ability of a firm to establish collaborative and cooperative relationship with other firms, R&D institutes, universities, government agencies, consultants, etc., which are key to its competitive and technological performance (Lall, 1992).

In relation to a firm's capacities to establish linkages with other agents from the innovation system, we need to go a step further, not only counting the number of relations but actually characterizing them, looking at:

- The general objective or type of relationship: production, R&D, development of new product/process/service, design, training;
- With whom is developed the activity: specific institution, name and localization;
- The reasons for cooperation: e.g. diminishing risk, access to other's experience, diminishing costs, expertise or knowledge sharing;
- The outcomes of the activities; and
- The degree of satisfaction.

This allows the analyst to characterize other agents as well as firms. Different levels or areas of influence of the innovation systems approach can be appreciated in reference to innovation policy and practice (Salazar, 2005), and based on this I will try to identify innovation surveys topics and indicators that could take account of those issues.

- Arguably the most of important impact that the systems of innovation approach has had upon innovation policy is to direct the design of policy instruments in a consistent and coherent manner, which means that single policies have to aim to a common goal, that is to improve the nation's innovation performance. The idea is not to propose stand-alone policies, but to help design a portfolio of policy instruments, in order not to just enhance individual elements of the NSI but the system as a whole (Guy & Nauwelaers, 2003). Therefore, innovation surveys should evaluate the efficiency and effectiveness of policy instruments, and establish the complementarities between policies (the latter point not taken into account today, to my knowledge).

- Overcoming the dichotomy of supply vs demand policies has been crucial, giving more emphasis on policies designed to provide effective linkages between supply and demand by attempting to make innovation activities technically and commercially successful. Following this idea, innovation surveys could help to characterize linkages and relations between various actors (e.g. objective of relationship, reasons for cooperation, outcomes, degree of satisfaction) and the continuity of the relationships over time (not just a one time shot) – the latest one not considered in current surveys.

- The need to work on systems failures, not only on market failures. The most recent contribution of the systems of innovation approach to innovation policy-making, still under development, is a new trend labelled 'systemic innovation policies'. The emphasis on the analysis of systemic failures shifts state

> intervention from simple supply-side policies to trying to ensure that the innovation system performs adequately as a whole. In this sense there is a need to identify the causes of lock-in and to eliminate those bottlenecks both at the firm and system levels (Klein *et.al*., 2005: 612).

All the above can be summarized:

> *"From a conceptual perspective, embedding STI policies within the context of a systems framework provides a strong argument for the development of 'systemic' policies in addition to 'reinforcement' and 'bridging' policies. It also necessitates an appreciation of weak spots in current policy mixes and the formulation of appropriate steps to rectify these weaknesses"* (Guy & Nauwelaers, 2003).

Klein *et.al*. (2005) summarize what different scholars have identified as systemic imperfections or failures:

- Infrastructural failures: physical infrastructure.
- Transition failures: failure to adapt to a new technology.
- Lock-in/ path dependency failures: inability to adapt to new technological paradigms.
- Hard institutional failures: related to the legal systems and regulations.
- Soft institutional failures: related to social institutions such as political and social values.
- Strong network failures: "blindness" that evolves if actors have close links and they miss new outside developments.
- Weak network failures: lack of linkages.
- Capabilities failures: lack of learning capabilities.

How can these failures be translated into questions of innovation surveys? It seems that the obvious answer is the section on obstacles or factors hampering innovation. For instance the Bogota Manual has two chapters that could help to this characterization, one that evaluates government STI programs and policies, and the other about obstacles to innovation, especially meta and macro obstacles which characterize institutional infrastructure and the legal and regulatory framework of an innovation system. Similarly, the Oslo Manual includes in the list of factors hampering innovation "other reasons" – besides economic and enterprise factors- that may be related to the environment (i.e. the innovation system). The list provided by the Bogota Manual is more complete than the one given by the Oslo Manual.

Most authors agree that the system of innovation approach has been useful as a benchmarking tool for economic and policy analysis. These benchmarking exercises can be done for different purposes. Even though international comparative exercises are important, the system of innovation approach is, arguably, more useful for bottleneck analysis. If innovation surveys are carried out regularly, bottle-neck analyses can be done (e.g. related to training, funding and intermediation) because of the presence of the same obstacles over time.

The desire to change the unit of analysis from firms to networks or clusters creates problems on how to define the unit. However, we cannot put aside the importance of firm's environment and how it interacts with other agents. Therefore, innovation surveys should give more emphasis to characterizing the innovation system that surrounds the firm, assuming that the environment is common or shared by various firms, not only measuring innovation in individual firms.

5. Conclusions

The main concern with most S&T indicators and statistics is that they are paying more attention to benchmarking and international comparisons, downplaying their goal of being tools for policy analysis. That is the case both with R&D and innovation indicators. R&D concentrates on the measurement of expenditures and innovation on product and process innovations. Experts have demanded changes, looking for indicators on human capital and outcome indicators. As Benoit Godin says:

> *"GERD is the most cherished indicator among OECD member countries, despite the frequent suggestion that human resources are better statistics, and despite unanimous demand for output indicators"* (Godin, 2003).

In relation to comparisons, Jones et al (2003) note that initiatives to promote normalization and international comparisons should not be built exclusively in terms of categorizing performance. It is more important for analysts, when doing evaluation and benchmarking studies, to recognize that there are other experiences from which policy lessons can be learned.

Why do we keep measuring inputs (i.e. expenditures) and outputs? Many reasons can be found. Some indicators are more memorable, simple to calculate, and data is more easily available, in other words they are feasible. This relegates more relevant indicators to second place. There is a political decision to be made, by statistical agencies, governments and policy analysts to give predominance to relevance over feasibility. Innovation indicators are more complicated since demands from policy makers focus on a multi-indicator approach, measuring innovation activities and capabilities, and the interactions among innovation-related agents, attempting to understand networks.

Knowledge in an enterprise is basically embodied in people. In this sense, retention of workers – and to keep them motivated- is crucial for the accumulation of knowledge that leads to innovation (Therrien & Leónard, 2003). Therefore if we want to measure innovation capacities we need to measure people's capacities to innovate, which are partly determined by the type of work they do, their level of education, but also how motivated they are. This is where human resources management practices come into place, as something to be considered in innovation studies and surveys.

It seems that the new paradigms within innovation studies are oriented towards the inclusion, understanding, and characterization of:

- All innovation activities, related to technologies, organization , management and commercialization;
- Innovation in services, not only manufacturing industry;
- Human resource management practices as an important factor in innovation processes;
- Relations between training and adoption of ICTs.

In the words of Fred Gault:

"As the understanding of innovation demands more information on human activities, such as learning by individuals, groups, organizations and regions, indicators of innovation activity should be able to illuminate these areas" (Gault, 2006).

All of these trends recognize that people are the fundamental factor in innovation processes, giving prominence to the social nature of innovation, rather than the emphasis given in the past to the technologies incorporated in machinery and equipment.

References

Asheim, B., & Isaksen, A. (2002). Regional innovation systems: The integration of local sticky and global ubiquitous knowledge. *Journal of Technology Transfer, 27*(1), 77-86.

Bianco, C., Lugones, G., Peirano, F., & Salazar, M. (2002). *Indicadores de la Sociedad del Conocimiento: Aspectos Conceptuales y Metodológicos* (No. 2 Documento de Trabajo; Informe presentado a Colciencias, OCyT y OEA). Buenos Aires: Centro REDES.

Castells, M. (2000). Materials for an exploratory theory of the network society. *British Journal of Sociology, 51*(1), 5-24.

Djellal, F., & Gallouj, F. (1999). Services and the search for relevant innovation indicators: A review of national and international surveys. *Science and Public Policy, 26*(4), 218-232.

Durán, X., Ibañez, R., Salazar, M., & Vargas, M. (1998). *La Innovación Tecnológica en Colombia: Características por tamaño y tipo de empresa*. Bogotá: Departamento Nacional de Planeación.

Florida, R. (2000). The economic geography of talent. *Carnegie Mellon University* Retrieved January 29, 2004, from http://www.heinz.cmu.edu/%7Eflorida

Gault, F. (2006). *Innovation, indicators and policy: A Canadian perspective* Paper presented at the SPRU 40th Anniversary Conference, "The Future of Science, Technology and Innovation Policy: Linking Research and Practice", September 11-13, Brighton, U.K.

Gertler, M. (2001). *Tacit knowledge and the economic geography of context or the undefinable tacitness of being (there)*.Unpublished manuscript, Aalborg, Denmark.

Gertler, M., Florida, R., Gates, G., & Vinodrai, T. (2002). *Competing on creativity: Placing Ontario's cities in North American Context*.Unpublished manuscript, Toronto.

Godin, B. (2002). *The rise of innovation surveys: Measuring a fuzzy concept* (Project on the History and Sociology of S&T Statistics, Working Paper No. 16). Montreal: Canadian Science and Innovation Indicators Consortium.

Godin, B. (2003). *The most cherished indicator: Gross domestic expenditures on R&D (GERD)* (Project on the History and Sociology of S&T Statistics, Working Paper No. 22). Montreal: Canadian Science and Innovation Indicators Consortium.

Guy, K., & Nauwelaers, C. (2003). Benchmarking STI policies in Europe: In search of a good practice, in The IPTS Report No. 71. Retrieved February 17, 2003, from http://www.jrc.es/pages/iptsreport/vo171/english/TEC2E716.htm

Holbrook, J. A., & Hughes, L. (2001). Comments on the use of the OECD Oslo Manual in non-manufacturing based economies. *Science and Public Policy, 28*(2), 139-144.

Holbrook, J. A., & Salazar, M. (2004). Regional innovation systems within a federation: Do national policies affect all regions equally? *Innovation: Management, Policy & Practice, 6*(1), 50-65.

Jaramillo, H., Lugones, G., & Salazar, M. (2001). *Bogotá Manual - Standardization of indicators of technological innovation in Latin America and Caribbean Countries*. Bogotá: RICYT, OAS, CYTED Program, Colciencias, OCyT.

Jones, A., Sainsbury, B., Dowie, N., & Kavanagh, T. (2003). *Measuring innovation performance - current status and future considerations*. Canberra: Department of Industry, Tourism and Resources.

Klein Woolthuis, R., Lankhuizen, M., & Gilsing, V. (2005). A system failure framework for innovation policy design. *Technovation, 25*(6), 609-910.

Lall, S. (1992). Technological capabilities and industrialization. *World Development, 20*(2), 165-186.

McKelvey, M. (1991). How do National Systems of Innovation differ?: A critical analysis of Porter, Freeman, Lundvall and Nelson. In G. M. Hodgson & E. Screpanti (Eds.), *Rethinking Economics: Markets, Technology, and Economic Evolution* (pp. 117-137). Aldershot, Hants, England ; Brookfield, Vt.: Edward Elgar.

OECD/Eurostat. (1997). *Proposed Guidelines for Collecting and Interpreting Technological Innovation Data - Oslo Manual*. Paris and Luxembourg: OECD, Eurostat.

RICyT, UMIC, & ISCTE. (2006). Manual de Lisboa Versión preliminar - Pautas para la interpretación de los datos estadísticos disponibles y la construcción de indicadores referidos a la transición de Iberoamérica hacia la sociedad de la información. Retrieved August 18, 2006, from http://ricyt.centroredes.mine.nu/ricyt/lisboa/manual_lisboa.pdf

Salazar, M. (2003). *Misconceptions and misrepresentations around the information society notion*.Unpublished manuscript, Vancouver.

Salazar, M. (2005). Social and policy studies of technology: A review - CPROST report 05-01, Simon Fraser University. from http://www.sfu.ca/cprost/publications.htm

Salazar, M., & Holbrook, J. A. (2004). A debate on innovation surveys. *Science and Public Policy, 31*(4), 254- 266.

Smits, R., & Kuhlmann, S. (2003). *The rise of systemic instruments in innovation policy.* Paper presented at the ASEAT Conference: Knowledge and Economic and Social Change: New Challenges to Innovation Studies, April 7-9 2003, Manchester, U.K.

Statistics Canada. (2001). *Workplace and employee survey - Compendium 1999 data*. Ottawa: Statistics Canada, Catalogue No. 71-585-XIE.

Statistics Canada. (2003). Canada's Journey to an Information Society. Retrieved April 19, 2004, from http://www.statcan.gc.ca/cgi-bin/downpub/freepub.cgi?subject+=256#2256

Statistics Canada. (2004). Overview and description of publications - Research program "The Canadian Economy in Transition". Retrieved June 8, 2004, from http://www.statcanada.ca/english/studies/eaupdate/trdescrip/htm

Tether, B. (2001). *Identifying innovation, innovators and innovative behaviours: A critical assessment of the Community Innovation Survey*. Manchester: University of Manchester, CRIC Discussion Paper # 48.

Tether, B., Miles, I., Blind, K., Hipp, C., de Liso, N., & Cainilli, G. (2002). *Innovation in the service sector - Analysis of data collected under the Community Innovation Survey (CIS-2)*. Manchester: University of Manchester, Centre for Research on Innovation and Competition, Working Paper No. 11.

Therrien, P., & Leónard, A. (2003). *Empowering employees: A route to innovation*. Ottawa: Statistics Canada, The Evolving Workplace Series, Catalogue No. 71-584-MIE No. 8.

Tsipouri, L. (2000). *Regional innovation indicators: merits and problems.* Paper presented at the Conference on "Innovation and enterprise creation: Statistics and indicators", Sophia-Antipolis, November 23-24 2000.

Turcotte, J., Leónard, A., & Montmarquette, C. (2003). *New evidence on the determinants of training in Canadian business locations*. Ottawa: Statistics Canada, The Evolving Workplace Series, No. 71-584-MPE No. 5.

Wolfe, D. (2002). Social capital and cluster development in learning regions. In J. A. Holbrook & D. Wolfe (Eds.), *Knowledge, Clusters and Regional Innovation: Economic Development in Canada* (pp. 11-38). Montreal and Kingston, London, Ithaca: School of Policy Studies, Queens University.