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Science, Innovation and Electronic Information Division

The many guises of innovation: what we have learnt and where we are heading

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**The many guises of innovation: what we have learnt and
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SUMMARY NOTES

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Working Papers

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The Science and Innovation Information Program

The purpose of this program is to develop **useful indicators of science and technology activity** in Canada based on a framework that ties them together into a coherent picture. To achieve the purpose, statistical indicators are being developed in five key entities:

- **Actors:** are persons and institutions engaged in S&T activities. Measures include distinguishing R&D performers, identifying universities that license their technologies, and determining the field of study of graduates.
- **Activities:** include the creation, transmission or use of S&T knowledge including research and development, innovation, and use of technologies.
- **Linkages:** are the means by which S&T knowledge is transferred among actors. Measures include the flow of graduates to industries, the licensing of a university's technology to a company, co-authorship of scientific papers, the source of ideas for innovation in industry.
- **Outcomes:** are the medium-term consequences of activities. An outcome of an innovation in a firm may be more highly skilled jobs. An outcome of a firm adopting a new technology may be a greater market share for that firm.
- **Impacts:** are the longer-term consequences of activities, linkages and outcomes. Wireless telephony is the result of many activities, linkages and outcomes. It has wide-ranging economic and social impacts such as increased connectedness.

The development of these indicators and their further elaboration is being done at Statistics Canada, in collaboration with other government departments and agencies, and a network of contractors.

Prior to the start of this work, the ongoing measurements of S&T activities were limited to the investment of money and human resources in research and development (R&D). For governments, there were also measures of related scientific activity (RSA) such as surveys and routine testing. These measures presented a limited picture of science and technology in Canada. More measures were needed to improve the picture.

Innovation makes firms competitive and we are continuing with our efforts to understand the characteristics of innovative and non-innovative firms, especially in the service sector that dominates the Canadian Economy. The capacity to innovate resides in people and measures are being developed of the characteristics of people in those industries that lead science and technology activity. In these same industries, measures are being made of the creation and the loss of jobs as part of understanding the impact of technological change.

The federal government is a principal player in science and technology in which it invests over five billion dollars each year. In the past, it has been possible to say only *how much* the federal government spends and *where* it spends it. Our report **Federal Scientific Activities, 1998 (Cat. No. 88-204)** first published socio-economic objectives indicators to show *what* the S&T money is spent on. As well as offering a basis for a public debate on the priorities of government spending, all of this information has been used to provide a context for performance reports of individual departments and agencies.

As of April 1999, the Program has been established as a part of Statistics Canada's Science, Innovation and Electronic Information Division.

The final version of the framework that guides the future elaboration of indicators was published in December, 1998 (**Science and Technology Activities and Impacts: A Framework for a Statistical Information System**, Cat. No. 88-522). The framework has given rise to **A Five-Year Strategic Plan for the Development of an Information System for Science and Technology** (Cat. No. 88-523).

It is now possible to report on the Canadian system on science and technology and show the role of the federal government in that system.

Our working papers and research papers are available at no cost on the Statistics Canada Internet site at <http://www.statcan.ca/cgi-bin/downpub/research.cgi?subject=193>.

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Preface

Change has been a distinguishing feature of the last three decades. In fact, change has been so pervasive that it has affected, for better or for worse, the life of every Canadian. Most changes have had their origin in the rapid advancement in knowledge generation and in the speedy diffusion and application of this knowledge.

At no time has Canadian society, its environment and economy been more dependent on science and technology as it is today. To maintain a standard of living that is the envy of many, Canadians need to improve their ability to acquire, generate and apply new knowledge. The federal government is committed to assist Canadians meet this challenge.

Innovation and the adoption and dissemination of technologies and practices are vital to economic growth and development. It is through innovation that new products are introduced to the market, new production processes are developed and introduced, and organizational changes made. Through the adoption of newer, more advanced, technologies and practices, industries can increase their production capabilities, improve their productivity, and expand their lines of new products and services.

This workshop is part of a series of foresight exercises that Science, Innovation and Electronic Information Division (SIEID) has undertaken that assist in the production of useful indicators and a framework to tie them together into a coherent picture of innovation activities.

Acknowledgements

Canada owes the success of its statistical system to a long-standing partnership between Statistics Canada, the citizens of Canada, its businesses, governments and other institutions. Accurate and timely statistical information could not be produced without their continued co-operation and goodwill.

This workshop would not have been possible without the enthusiastic participation of our colleagues. We would like to thank all the members of the expert panel for their insights and provocative discussion.

The workshop itself would not have been possible without the contribution of many people including the workshop participants and its organizers, Fred Gault and Louise Earl. The logistical assistance of Carol Poirier, Robert Trudeau, Mary-Ann Clarke-Wilkinson, Claire Racine-Lebel, Rick Lavictoire, Penny Horsburgh and Lucienne Sabourin is gratefully acknowledged.

1. Introduction

For two full days over 20 people talked about innovation from different perspectives and sought common understanding of the issues and consensus on where work on the subject should be going in the medium and longer term. The meeting had a Canadian bias as it was part of the foresight programme of the Science, Innovation and Electronic Information Division at Statistics Canada, but it would not have been as productive had Jan Fagerberg not been able to join the group and to share the work of the Towards a European Area of Research and Innovation (TEARI) project, which he leads. The meeting was further enriched by the insights gained as members of different communities of discourse exchanged their knowledge and arrived at common conclusions.

These notes capture some of what went on in the presentations and the subsequent discussions. For each topic, the principal contributor is given in parentheses but the summary takes account of the discussion that followed. Participants in the process are listed in the Appendix 1 and the agenda of the meeting is in Appendix 2.

2. The Research Context

(Jan Fagerberg)

Work on understanding innovation has been going on for more than 70 years and there have been organized measurement activities for at least 25 years leading to a decade of more formalized measurement, by the Surveys of Innovation in Canada and the European Community Innovation Surveys (CIS). The last decade has also seen the publication of guidelines for measurement and interpretation of innovation data in the OECD/Eurostat *Oslo Manual*. The manual was first published in 1992, the first revision in 1997, and the second revision started in 2003.

While there is a growing body of knowledge about innovation, there are still questions about definition, common language for discourse, and the role of management practices and organizational as well as technological innovation. The *Oslo Manual* results from one community of discourse, but there are others. An example directly relevant to the workshop was the community associated with the Towards a European Area of Research and Innovation (TEARI) project, led by Jan Fagerberg. The TEARI project aims at a holistic understanding of research and innovation and, to communicate that understanding, an outcome of the project is the *Oxford Handbook of Innovation* to be published by Oxford University Press.

As a result of the efforts of various research communities, there is a body of knowledge about innovation in the firm and the explanatory role of industry, firm size, location, absorptive capacity, strategic management of innovative activities, and the organizational memory. What is evident is that innovation results from a dynamic interaction among actors, which include firms, universities, government agencies and international institutions, and it can be described as a system with feedback loops and stocks and flows of knowledge, as well as energy, materials and human resources. The complexity of the system precludes linear relationships between inputs and outputs and makes the analysis of the impact of innovation a difficult task requiring analysis across space and over time.

The change of activities, such as innovation, or technology use, over time, in a complex system, is path dependent and it is the understanding of that dependence that is one of the challenges for the research community.

The research questions still to be answered stimulated the discussion at the workshop. Some of these were:

- the relationship between technological, organizational, and institutional change;
- the impact on growth of innovation, imitation and other means of commercialization;
- the links between firm organization, knowledge generation, absorption and use, and innovation;
- the elaboration of a systems approach to innovation to improve analysis and assessment of policy issues; and,
- the need for a common language of discourse among the multi-disciplinary communities engaged in research related to innovation.

3. The Policy Context

(Renée St-Jacques, presentation by Sundera Gera)

It is now well recognised that technology and innovation are key drivers of productivity and growth performance. Weaker productivity performance in Canada is responsible for our lower living standards relative to the US. If investments in human and physical capital are expected to remain significant contributing factors to growth in the future, it is mainly by increasing our productivity performance that we can hope to stop the deterioration in our living standards relative to the US and start closing the income gap.

But looking ahead, with demographic trends starting around 2010, the falling share of the working-age population and declining participation rate will both make a negative contribution to the growth of our standards of living. Future growth in our standard of living will depend on more productive workers and on our ability to attract and retain a high quality labour force.

Canada has made significant progress in making the transition from a relatively protected economy to one open to international trade, investments and financial flows – and in the process we have become highly integrated with the U.S. But a number of indicators point to a more dynamic economy south of the border. Structural change in Canada has not kept pace with the U.S. – and we can not compete against low cost countries, like China and Mexico, in standard technology products. In effect, we are being squeezed into a narrow middle-ground, with countries like China out-producing us at the lower end and the U.S. outpacing us in leading-edge technologies.

A response of the federal government of Canada is the Innovation Strategy which recognizes the key role of people, the need to compete globally by producing higher value added products, and the importance of communities in the innovation process. The Strategy, and related documents, identifies the need for more highly qualified graduates and immigrants, as well as for skill upgrading and mobility in the existing labour force. The push to higher value added production is addressed through emphasis on the commercialization of knowledge, focusing on the need for risk capital, especially for medium-sized firms, and on the use of strategic technologies.

Community-based policies are targeted on building innovative capacity and on learning how innovative performance, clusters, and communities are linked.

To monitor progress towards the goals and targets of the February 2002 Innovation Strategy and the recommendations of the Innovation Summit which followed in November 2002, a Benchmarking Report has been commissioned from the Conference Board of Canada. It will establish a base line of quantifiable indicators to benchmark the innovation performance of Canada against the world and will identify gaps to be filled in order to improve the assessment of Canada's innovation performance.

The policy context provided a framework for discussion of the papers at the workshop. Some areas where more knowledge was needed were the following:

- determinants of innovation and the link with productivity;
- commercialization;
- characteristics of small, medium and large firms, both innovators and non-innovators;
- relationships, or linkages, within clusters, and the role of communities in the innovative performance of firms;
- organizational structures and management practices and the link with innovation;
- impacts of innovation on skill requirements in firms, and the role of knowledge workers in innovation, especially in service industries;
- impacts of foreign investment and foreign ownership on innovation; and,
- impacts of mobility of the highly skilled and integration of labour markets on human capital accumulation and innovation.

4. What do we know now about the effects and correlates of innovation and technological change?

Productivity (John Baldwin and Bart Verspagen)

Data from the Canadian 1993 Survey of Innovation, linked to data from other surveys in Statistics Canada, showed that innovation and firm performance were linked. Some findings were that larger firms and research and development (R&D) performers have a higher propensity to innovate, as do firms that grow at a faster rate than the average, and firms that develop a technology strategy.

A second paper showed a productivity gap between European core countries and the two non-European G7 countries, Japan, and the US and went on to examine the link between R&D and productivity in light of the EU target of raising R&D spending to 3% of GDP. It made the point that R&D was a small part of the solution and stressed the importance of trade. The indirect benefit of R&D was also discussed and the observation made that Europe benefits more from R&D in the US, than the US does from R&D in Europe. Other possible factors bearing upon productivity include scale economies not yet fully realized in European integration, and the role of institutions.

Developing Countries and 'Catch-Up'

(Jan Fagerberg)

A discussion devoted to the process of catching up of developing countries showed that those that succeeded had pro-active governments (Singapore, Taiwan and Korea for example), and they

invested in education, especially technical education and in R&D infrastructure. The question remained, however, as to what policies are needed to ensure catch-up.

There was a parallel here with the gazelle firm which may be driven by a 'star' or a pro-active manager, which raised a question about how a pro-active government functions. Is it again the individual or is it the ability of government to force coherence upon the system, solving the network alignment problem? This also raised questions about management practices, learning and the role of teams.

Knowledge Management and Innovation

(Elisabeth Kremp)

Innovation is not just about technological change. Firms innovate through change in organization and through the adoption of management practices, including those related to the management of knowledge. Evidence based on the French CIS.3 survey, with the addition of four questions on knowledge management (KM) practices, showed that there are correlations with innovation and knowledge management intensity. The practices were: a culture of knowledge sharing ®; motivating employees and executives to remain with the firm ®; forging alliances and partnerships for knowledge acquisition (A); and, implementing written knowledge management policies (W). For labour productivity, retention and sharing were important, in that order, while the other two policies were not statistically significant. For innovation, what mattered was the number of practices adopted, or the knowledge management intensity.

The KM discussion paralleled discussions held a decade or more ago about the importance of adopting more than one of a list of advanced manufacturing technologies. Now there is more of an interest in the service economy which dominates OECD countries and KM practices are one of the means of supporting innovation and of improving productivity. The question was where to go next.

Space-Time and Theory

(Meric Gertler)

Does space matter? The presentation and discussion noted that economic activity in Canada is becoming more, rather than less, spatially concentrated and it raised the question of what theoretical framework was appropriate for capturing spatial characteristics and explaining the phenomenon of innovation in the firm and its temporal change. Institutional theory, theories of the firm, of the region, or of clusters, were considered as were other ways of describing change, such as evolutionary dynamics, the use of systems theory, and the incorporation of life cycles.

This led to discussion of what the Innovation Systems Research Network (ISRN) has found after two years of interviewing firms in various regions. Local networks, learning from success and failure, skilled labour, leadership in the firm, and in the community, and framework conditions ensuring that laws and infrastructure did not get in the way of innovation were all important. Out of all of this, leadership, or star quality, and linkages were important to innovation at the local level and there were tensions between local and non-local linkages.

A theory to explain the geography of innovation must incorporate the firm, linkages, framework conditions, and path dependence. However, it was not clear that there was a theory that could deal with all of the ISRN findings. One size did not fit all and there was still work to do.

5. Suggestions for Exploration

(Erwin Diewert, Jorge Niosi, Andrew Sharpe and participants)

Innovation is a Social Process

How, for example, can life long learning be measured and used as an explanatory variable for the activity of innovation? The object of interest is no longer just the firm, but the (innovative) community and the technological cluster. This requires measurement of human characteristics, as Florida and Gertler have done, as well as a better understanding of the links between people and organizations: governments, businesses and universities and colleges.

The role of people in effecting change is not always amenable to statistical measurement and may remain the province of case studies. For example the work of Jorge Niosi on biotechnology firms suggests that it is the 'star' that creates the gazelle behavior and that the number of R&D staff does not make good a proxy for star quality.

However, people engaged in research provide an absorptive capacity for the firm, allowing it to adopt and adapt knowledge from outside, in order to create value inside.

While people made the difference in the growth of SMEs, and they provided a capacity to absorb knowledge, there was evidence, released on the second day of the workshop, that one in five Ph.D. graduates from two large Canadian universities were leaving the country on graduation.

Innovation is Multi-faceted

Current measurements of innovation focus on new products and processes, but what about the diffusion of technologies, practices, and organizational structures in the economy and society and their adoption and adaptation. Understanding the role of diffusion and how it influences the users is important in understanding both economic and social change.

As discussed in the workshop, the activity of innovation is linked to the market, but there are also new products and processes developed in education, government, and health services. Also, in these areas the procurement and the diffusion of technologies influence the innovation system.

Language to discuss innovation

There are different languages, different concepts and definitions, and there is a need for one language, if the instruments of policy, the management of behavioral change in firms, and the measurement of the system of innovation, are all to deal with the same thing in a coherent manner. Building a common language is a task for the international organizations, such as the OECD and UNESCO, and the supranational European Union. Much of the relevant language is in the OECD/Eurostat *Oslo Manual* which is now being revised. There is both a need and an opportunity to influence this process.

The Systems Approach

Systems are complex, non-linear, and have many feedback loops. The work of Herbert Simon is still relevant, as is current work by Nick Von Tunzelman on 'network alignment'. Network alignment describes the result of different parts of the system working towards different and possibly conflicting ends. There are policy implications if systems are to be encouraged to function more coherently in pursuit of an objective, such as being an 'innovative community'.

Frameworks for Indicators

Statistics Canada has used its framework document, *Science and Technology Activities and Impacts: A Framework for a Statistical System*, to guide its measurement work since 1998. While the approach of identifying the actors in the system and then measuring the activities, linkages and outcomes has worked well, the application of the framework has to be reviewed in order to deal with new issues and to incorporate the ‘social character of innovation’ and the ‘polyparadigmatic’ shifts that are taking place.

6. The Next Year in Canada

(Frances Anderson and Peter Boyd)

The 1999 Survey of Innovation in manufacturing and selected primary industries, along with other Statistics Canada surveys, gave rise to papers that advanced the knowledge of the subject and which contributed directly to the Innovation Strategy of the government of Canada. Through the facilitated access programme of Statistics Canada, a community of innovation researchers was established and they contributed to a workshop organized by Industry Canada in November 2001. Papers from the workshop, and from the broader community, were brought together in *Understanding Innovation in Canadian Industry* published in November 2003.

The 2003 Survey of Innovation in selected service industries was in the field at the time of the workshop and it took account of much of what was learned in the 1999 survey, especially the need to support sub-provincial statistics. It used an *Oslo Manual* approach, but also included questions on knowledge management practices which would allow comparison with the work of Kremp and Mairesse and questions on human resource management practices. In addition, there were questions on activities which cross the boundaries of industrial classification such as biotechnology, nanotechnology and geomatics.

The questionnaire was developed through a collaborative effort, involving people from policy departments, other parts of Statistics Canada, and respondents through the testing of questions. It does not address questions on social innovation, the link between innovation and trade in the GATS, the impact of the ICT infrastructure on innovation, or the role of adoption and diffusion of technologies and practices, as opposed to innovation.

From the Canadian policy perspective, a survey of innovation in service industries is timely. The OECD is considering embarking upon a project on Enhancing the Service Economy and the Micro Economic Policy Analysis (MEPA) group of Industry Canada has run a conference on Service Industries in the Knowledge-Based Economy.

While many of the research questions are the same as for manufacturing and primary industries, services industries are more active in promoting the flow of knowledge to clients and, in some cases, in absorbing knowledge for the production of new products and processes. Service industry firms tend to be smaller than those in manufacturing and size effects, well established in manufacturing, should be even more prominent in services industries and carry with them, perhaps, different suggestions for policy. Also, as demonstrated in the workshop, geography is a factor in the activity of innovation, and it may be of greater importance for services that provide the linkages between other players in the local or global systems of innovation.

As with the development of the survey, the development of the research agenda will be a collaborative effort, involving as many of the players as possible.

7. Tasks for Theorists, Empiricists and Policy Developers

(All)

Theorists

From the theoretical perspective, there is the New Growth Theory, with the linear model built in to it, and the Evolutionary Theory. However, these are not pursued in isolation as academics involved in them, such as Alfred Kleinknecht and Keith Smith, are also involved in the design of the Community Innovation Surveys.

What appears to be missing is a model which provides some measure of predictive capacity. If there is a model that described a cluster, for example, should it not be possible to populate some of its variables with data from another cluster and infer the values of variables for which data are not available? This presupposes a model that can accommodate data on activities, linkages and outcomes in a cluster, based on some theoretical assumptions. However the cluster was just an example, the question can be posed in terms of regional, national, or global systems of innovation.

Empiricists

The various spectra of the hydrogen atom were well established before the Bohr model of the atom was used to explain them. The role of the empiricist is to identify the systematics of the structures that are being examined and to present them to the theorist for explanation and to the policy developer as a guide to intervention.

Policy Developers

Policy developers need information with which to monitor change and also to benchmark the state of the systems at a particular time so that progress towards targets can be measured. In Canada, the Conference Board has been given the task of providing a benchmark for the federal Innovation Strategy in November 2003 and then of reporting on progress for the two following years. This is one way of involving a broad constituency of industry, NGOs, and governments, in evidence-based policy. Discussion with the statistical office and members of networks, like the ISRN and TEARI, is another.

8. Conclusion

(*Tim Davis and Fred Gault*)

After two days it was clear that there was some common understanding of the activity of firm level innovation and of the factors which affect it:

- industry;
- location;
- firm-size;
- R&D performance;
- invention;
- technology use;
- human resource activities (stars, management practices including strategic planning, knowledge management, training and organization);
- alliances, networks and partnerships, including commercialization, trade and foreign direct investment;
- the economic and social environment, including competition and regulation pursuant to legislation (tax, labour laws, environmental regulation, international harmonization of regulation); and, in the case of Canada,
- the importance of the Canada-US relationship .

There was also common ground on the outcomes of innovation, such as enhanced productivity, and on the link between firm performance and knowledge management practices.

Some of what was learned will be contributed to the discussion on the revision of the OECD/Eurostat *Oslo Manual* and some will be used to improve the measurement and understanding of the activity of innovation in Canada, and the use of that information for policy purposes.

The question remaining is whether a more substantive contribution to the innovation literature should follow, so that the community of discourse can be extended.

Appendix 1

The many guises of innovation: what we have learnt and where we are headed?

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Appendix 2

Workshop Agenda

The many guises of innovation: what we have learnt and where we are heading

October 23-24, 2003
Jean Talon Conference Room
Statistics Canada
Ottawa, Ontario

Thursday, October 23, 2003

<u>Time</u>	<u>Speaker</u>	<u>Presentation</u>
9:30 - 9:50	Continental breakfast	Meet and greet
9:50 - 10:00	Tim Davis	Welcome and introductory remarks

Part 1: Overview of Innovation Analysis

10:00 - 10:45	Jan Fagerberg	Overview of theoretical perspectives of innovation and future directions of research.
10:45 - 11:30	Fred Gault	Overview of STC innovation studies and future directions.
11:30 - 11:45	Discussant John de la Mothe	What we have learned about innovation and what we should do next, both to learn more and to contribute to policy development? The discussion will go beyond productivity and regional development to include improved skill levels in the labour force and the use of linkages in the innovation system to connect the activities of the innovation policy.
11:45-12:15	Discussion	
12:15 - 1:30	Lunch	

Part 2: Innovation and Productivity

1:30 - 2:15	John Baldwin	Innovation and productivity – Canadian perspective.
2:15 - 3:00	Bart Verspagen	Innovation and productivity – European macro and meso-economic perspectives.
3:00 - 3:15	Break	
3:15 - 3:30	Discussant Andrew Sharpe	Improved productivity is one reason for engaging innovation. How well established is the link and where does this analysis go next?
3:30 - 4:00	Discussion	

Part 3: Evidence-Based Policy Research

4:00 - 4:45	Renée St-Jacques	Policy importance of Research based on Canadian surveys of innovation.
4:45 - 5:15	Erwin Diewert	How to co-ordinate the different thrusts of innovation analysis: economic productivity; social objectives; connectedness, and, regional systems of innovation?
5:15 - 5:30	Discussion	What we learned today
6:30	Dinner	See invitation

Friday, October 24, 2003

<u>Time</u>	<u>Speaker</u>	<u>Presentation</u>
8:30 - 8:50	Continental breakfast	Meet and greet
8:50 - 9:00	Chair	Introduction to the day

Part 4: Diffusion, Clusters and Growth

9:00 – 9:45	Jan Fagerberg	Innovation diffusion and the importance of "catching-up".
9:45-10:30	Elisabeth Kremp	Knowledge management and innovation
10:30 –10:45	Break	
10:45 –11:30	Meric Gertler	Technology Clusters: Analysis and Examples
11:30 –12:30	Discussant Jorge Niosi	What do we know about firm characteristics, especially of the gazelles, and the economic and social environment for incubation that would contribute to policy development?
12:30 - 1:30	Lunch	

Part 5: Next Steps

1:30 – 2:15	Frances Anderson	Innovation in the Services Sector – 2003: An update on the survey and the anticipated products.
2:15 - 3:15	Peter Boyd	Measurement and Policy: An overview of analytical initiatives and measurement issues from a policy perspective.
3:15 - 3:30	Fred Gault	Summary of the two days

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