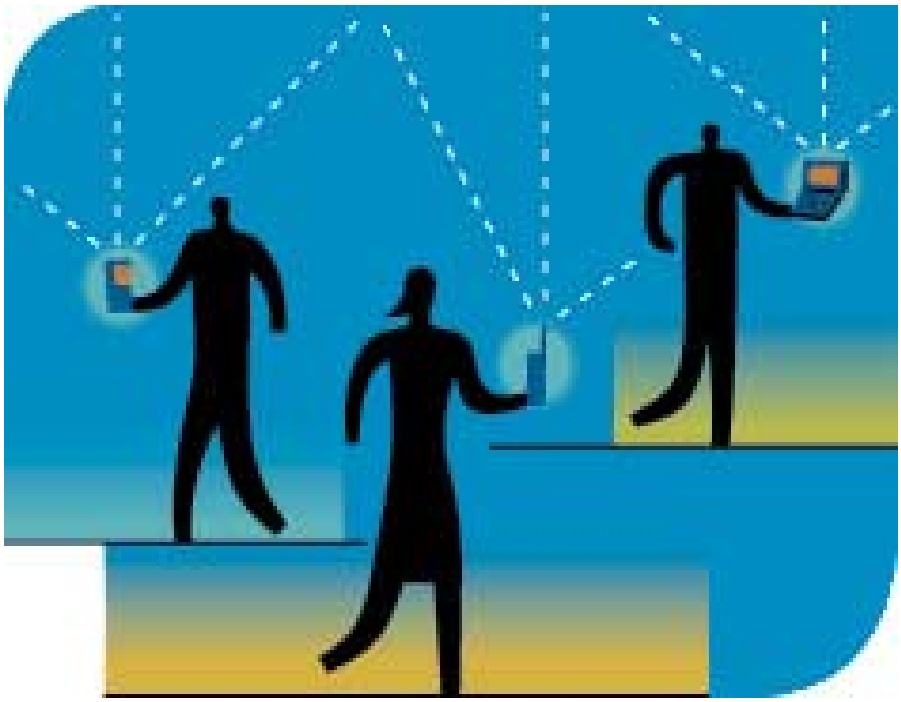
# INNOVATION AND ENTROPY WITHIN THE GLOBAL ECONOMY:
## Accelerating in a “Red Queen” Game



prepared for the Information Technology Association of Canada

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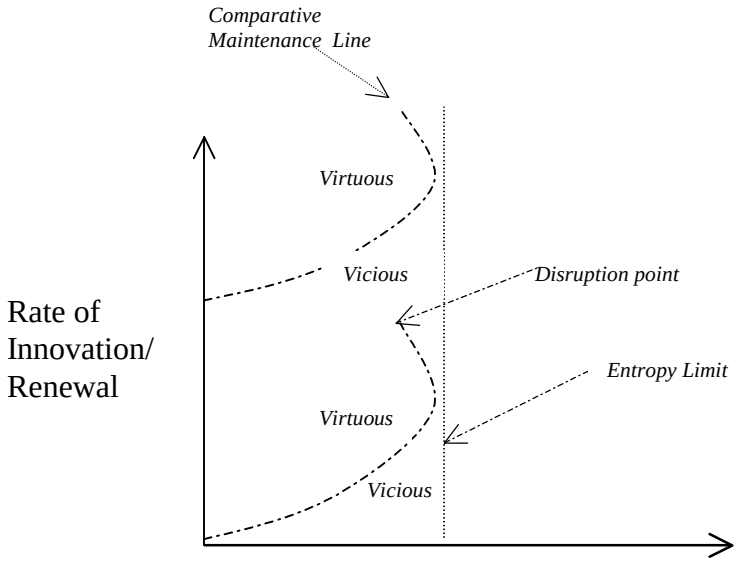
## THE ENTROPY / INNOVATION MATRIX[1]

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[1] This model is explained in Appendix "A"

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## *INTRODUCTION: A Slow or Fast Sort of World?*

> *"Well, in our country," said Alice, still panting a little "you'd generally get to somewhere else if you ran very fast for a long time as we've been doing." "A slow sort of country!" said the Queen. "Now, here, I see. It takes all the running you can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that!"*[2]

Canada's *Innovation Strategy* released in February 2002[3] is reminiscent of the debate regarding 'national competitive advantage' that took place a decade ago.[4] One difference is that in this iteration, explicit consideration of the international perspective appears to be restricted to the role that it might play as a scoreboard by which Canada can measure its performance. Canada wants to be among the top five countries in terms of research and development performance by 2010.[5] It appears to be implicit in the analysis that the development of Canadian innovations by their very nature will reflect an international competitive advantage. The manner in which this international competition will affect Canada's ability to achieve these and other goals has not been dealt with. As a result, the *Innovation Strategy* seems to involve the same discussion that culminated a decade ago, shorn of much of the international analysis that was explicit at that time.

In the twenty-first century, the development of innovation policy should take place in the context of international competition. The chief source of innovation is information that

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2 Lewis Carroll, *Through the Looking Glass,* Dover Thrift Editions, 1999 at 20

3 Government of Canada, *Achieving Excellence, Investing in People Knowledge and Opportunity, Canada's Innovation Strategy,* Industry Canada, February, 2002, Knowledge Matters, Skills and Learning for Canadians, Human Resources Development Canada, February, 2002 , (collectively, Canada's "*Innovation Strategy*")

4 One example of this debate that raged throughout North America is found in Michael E. Porter, *Canada at the Crossroads, The Reality of a New Competitive Environment,* The Monitor Company, 1991, as updated by Robert L. Martin and Michael E. Porter, *Canadian Competitiveness: Nine Years after the Crossroads,* Toronto, Rotman School of Business, January 2000. Also see Robert B. Reich, *The Work of Nations, Preparing Ourselves or 21st Century Capitalism,* Vintage Books, 1992; Kenichi Ohmae, *The End of The Nation State, The Rise of Regional Economies,* McKinsey & Co. Inc., 1995; Lester Thurow, *Head to Head, The Coming Economic Battle among, Japan, Europe, and America,* William Morrow & Co. Inc., 1992,

5 *Ibid.,* at 84

flows easily across borders.[6] The pace of innovation is increasing dramatically in the knowledge based economy[7] and its promise for creating high productivity and better standards of living, coupled with the fear of being left behind, has resulted in the adoption of innovation policies/strategies by most developed nations. Many of them are promoting innovation in the various sectors in which Canada competes and so the pace of innovation in these sectors should accelerate. A paradox might exist in the sense that the quicker the pace of innovation, the faster the erosion of existing competitive advantage and one must run harder simply to stand still. This is the "Red Queen" game in which products co-evolve, with those that fail to do so progressively falling behind.[8] The question is, does such a paradox exist and, if so, does it exist in all market sectors?

In the 1980s, international trade relations were bedeviled by the development of strategic trade theory that viewed trade as a zero sum game, at least in the high technology sectors. A zero-sum game is one in which the only way to get ahead in a competition is to take the initiative from one's competitors. Strategic trade theory arose in the context of intense competition from Japan that was seen as eroding American competencies in key high technology sectors, such as semiconductors and automobiles, among others. Japan was

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6 As information, an "innovation" is a "meme", which was coined by Richard Dawkins as a new form of "replicator" in an evolutionary system. They are complex ideas that are "more or less identifiable as cultural units" that are propagated when communicated to others.

> In the *Selfish Gene*, Dawkins urges us to take the idea of meme evolution literally. Meme evolution is not just analogous to biological or genetic evolution, not just a process that can be metaphorically described in those evolutionary idioms, but a phenomenon that obeys the laws of natural selection exactly. The theory of evolution by natural selection is neutral regarding the differences between memes and genes; these are just different kinds of replicators evolving in different media and different rates … This is a new way of thinking about ideas.

Daniel C. Dennett, *Consciousness Explained*, Little Brown and Company, 1991, at 201-2

7 Research and development spending within the United States increased an average of 6.1% annually from 1995 through 1999, reaching $264 billion in 2000, with companies introducing 35,000 new consumer products in 2001, up from 15,000 a decade ago. Nearly 50% of economic growth recorded by companies in the 1990s "came from lines that didn't exist before." John D. Wolpert, *Breaking out of the Innovation Box*, Harvard Business Review, August 2002, 77 at 78

8 Matt Ridley, *The Red Queen, Sex and the Evolution of Human Nature*, Viking Penguin, 1995

seen as being particularly adept at taking existing technologies and significantly improving production processes to such an extent that the competitive position of the American companies was undermined, even though they had pioneered the technologies to begin with. Contrary to the dire predictions at that time, the 1990s were marked by remarkable economic growth in the high technology industries as a result of new and unforeseen products and services. The expansion of the information economy was seen primarily as an American phenomenon that Japan and other nations could not match due to North America's unique industrial structure.

How should the process of innovation be viewed? Is it a zero-sum game in which strategic trade theory is said to apply, or is it a "Red Queen" game in which everyone competes harder and harder just to maintain their relative position, or is it something else such as a benign "invisible hand?" The answer to the question is important because it will have a profound effect on the way innovation policy should be developed, particularly with respect to the nature and effect of international competition on the ability of Canada to achieve its goals. It is clear that no answer can be provided that characterizes a nation generally. The nature of innovation depends on the maturity of the particular market segment as well as its technology and marketing intensity. Innovation must be understood as a microeconomic phenomenon introducing qualitative changes in the economy in a manner that can transform it in either a radical manner or in a slower more methodical way. The *Innovation Strategy* does not appear to analyze the nature of innovation, its variants or discuss the implications for the development of policy in the context of international competition.

The purpose of this paper is to articulate the international dimension that appears to be implicit in the *Innovation Strategy* and to underscore the fact that the international trade community provides the context in which policy development must occur. The paper is divided into two parts, with the first suggesting a theory of innovation and the second discussing the implications of this theory for policy development in an international

context. The theory is based on the duality[9] or dialectical nature of "entropy"[10] and innovation.[11] The process of innovation is identified as an emergent process that is serendipitous, unpredictable, and vulnerable to many factors including business cycles. A distinction is made between radical innovations and process improvements that have become a systematic activity of major corporations. 'Radical innovations'[12] involve the exploration of new technology[13] most often by independent entrepreneurs[14] and are those that "create such a dramatic change in products, processes, or services that they transform

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9 "Duality" is an Eastern concept – to think of one is to create the other. Fritjof Capra, *The Tao of Physics*, 3rd Ed., (1991) Shambhalla, Boston, at 145.

10 Second law of thermodynamics that holds that heat always moves by itself in one direction only, from the hotter to the colder body. Nicholas Georgescu-Roegen, *The Entropy Law and the Economic Process*, Harvard University Press, Cambridge, 1971, reprinted 1999, at 3.

Academic sources regarding the discussion of entropy in the context of economic theory include: D.R. Brooks and E.O. Wiley, (1988) *Evolution as Entropy: Toward a Unified Theory of Biology*, 2nd Ed (Chicago, University of Chicago Press); D. R. Brooks, J. Collier, B.A. Mourer, J. D. H. Smith, E.O. Wiley (1989*) Entropy and Information in Evolving Biological Systems'*, Biology and Philosophy, 4(4), Oct. pp. 407-32; N.G. Clark (1991) 'Organization and Information in the Evolution of Economic Systems', in Saviotti and Metcalfe (1991), *Evolutionary Theories of Economic and Technological Change: Present Status and Future Prospects* (Reading: Harwood Academic); J. Collier, (1986) "*Entropy and Evolution, Biology and Philosophy*", 1(1), Jan., pp 5-24; P. Coveney and R. Highfield, (1990) *The Arrow of Time: A Voyage through Science to Solve Time's Greatest Mystery* (London: W. H. Allen); E.L. Khalil, (1990), *Entropy Law and Exhaustion of Natural Resources: Is Nicholas Georgescu-Roegen's Paradigm Defensible?* Ecological Economics, 2(2), June, pp 163-78; E.L. Khalil, (1990) "*Natural Complex vs. Natural System", Journal of Social and Biological Structures*, 13(1), pp 11-31; G. A. Lozada (1991) "*A Defense of Nicholas Georgescu-Roegen's Paradigm"*, Ecological Economics, 3(1), Apr., pp 157-160; B. H. Weber, D.J. Depew, C. Dyke, S. N. Slathe, E.D. Schneider, R.E. Ulanowicz, J.S. Wicken (1989) *"Evolution in Thermodynamic Perspective: An Ecological Approach",* Biology and Philosophy, 4(4), Oct pp 373-405; T. Randolph Beard and Gabriel A. Lozada, *Economics, Entropy and the Environment, The Extraordinary Economics of Nicholas Georgescu-Roegen*, Edward Elgar, 1999

11 A broad definition of "innovation" is accepted. "Scholars looking at the 'narrow' National Innovation Systems focus on organizations and institutions involved directly in the processes of scientific and technological exploration. The 'broad' National Information Systems concept includes all economic, political, and social institutions affecting learning, searching, and exploring activities." Philippe Laredo and Philippe Mustrar, *Research and Innovation Policies in the New Global Economy: An International Comparative Analysis*, Edward Elgar Pub. Ltd., 2001, at 3

12 "A radical innovation project is one with the potential to produce one or more of the following: an entirely new set of performance features; improvements in known performance features of five times or greater; or a significant (30 percent) reduction in cost.." Leifer et al., *Radical Innovation: How Mature Companies can Outsmart Upstarts*, Harvard Business School Press, 2000 at 5

13 *Ibid.*, at 4

14 William J. Baumol, *The Free Market Innovation Machine*, Princeton, 2002

existing markets or industries or create new ones."[15] They can occur within corporations, but the importance of the innovation is often missed and the opportunity is commercialized elsewhere.[16] With respect to this kind of innovative activity, government can do little more than concentrate on creating the conditions in which the "combinatorial play" that gives rise to innovative activity can occur. Process improvements may be distinguished from 'radical innovations.' Process improvements are a product of routine research and development spending by major corporations, involving the exploitation of existing technology.[17] They are considered more predictable in nature, requiring methodical spending to improve existing production and managerial processes that are well understood within the organization. This understanding provides an environment in which the value of a given process innovation should be more readily apparent.

The concept of entropy finds its origin in thermodynamics, but has been referred to within the context of economic theory.[18] It is borrowed to represent the erosion in the temporary competitive advantage that a particular innovation represents, the loss occurring through the voluntary or involuntary sharing of information – through mememic evolutionary pressure.[19] The concept of entropy suggests that this value will diffuse such that the ability of a particular innovation to provide a competitive advantage is diminished. Healthy industrial clusters are those that continually upgrade themselves,[20] while those that fail to do so will eventually decline as their competitive position is eroded. The concept of entropy suggests that the direction of entropic decay is fixed, but

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15 *Ibid*., at 5

16 Examples of "Canadian" innovations that fall into this category include the telephone and pablum, among others.

17 Leifer, *op cit., supra,* note 12 at 4

18 Second law of thermodynamics that holds that heat always moves by itself in one direction only, from the hotter to the colder body. Nicholas Georgescu-Roegen, *The Entropy Law and the Economic Process*, Harvard University Press, Cambridge, 1971, reprinted 1999, at 3. Some of the academic sources relating to the treatment of entropy within the context of economic theory is listed in footnote 10, above.

19 Dennett, *op. cit, supra*, note 6 at 200-10

20 Porter , *op cit., supra*, note 4 at 61, 301

its timing is indeterminate in part due to "novelty by combination" which can provide new sources of energy or value. Innovation is a result of creative thought that Einstein described as "combinatorial play." Renewal of a system through innovation highlights the dualism of the two concepts. Entropy is particularly applicable when discussing innovation theory because it stresses the qualitative changes that are not readily predictable in nature. Innovation induces qualitative changes in the economy in a manner that fosters a dynamism that often is unpredictable in nature.

The channels that diffuse information about a particular innovation through the industrial sector establish a pattern that defines the "competitive system." The channels by which information regarding a particular innovation is distributed provide a conduit that, if used properly, can also collect information about innovative activity occurring elsewhere. These channels may be involuntary in the sense of market surveillance and reverse engineering, but they can also exist through voluntary relationships such as informal technology consortia. The inexorable process of technology transfer and information sharing is due in part to market incentives through licensing fees as well as unique network externalities created through the voluntary sharing of information to establish market standards.

Appendix "A" to this paper describes an economic model that I have termed the "Innovation/Entropy Matrix." It is an attempt to visualize the relationship between the dual concepts of innovation and entropy and to try to draw some limited principles to help illustrate certain implications of the development of innovation policies by Canada and other nations. A "paradox" is identified, indicating that as the pace of innovation increases, it becomes more difficult to maintain one's competitive position, as existing competitive advantages are eroded. An "innovation trap" is also suggested in which developing nations may progressively fall behind in industries marked by a steady increase in innovative activity. Technology transfer may well help to offset this with respect to process improvements,[21] but developing nations will remain at a significant

[21] Baumol indicates that the delay in the transmission of information may give rise to a temporary competitive advantage. Baumol, *op cit., supra,* note 14 at 78

disadvantage with respect to the commercialization of radical innovations, at least in the short term. This suggests that the "terms of innovation"[22] may decline for developing nations over time and this underscores the importance of the developed nations opening traditional industries (including textiles and agriculture) to meaningful competition from the developing world.

The second part of the paper attempts to use the analysis of the concepts of "innovation" and "entropic dissemination" to help articulate the international aspects that appear to be implicit in the *Innovation Strategy*. On a sector-by-sector basis, Canada should be able to highlight the potential of Canadian industry to undertake radical innovations or process improvements, as well as identify the gaps that may exist in Canada's innovation system that inhibit its ability to do so. Consideration is also given to the question as to what constitutes a "Canadian" company. It is difficult to define the concept of a "Canadian" corporation, if it is intended by the *Innovation Strategy* to favour "Canadian" companies versus "foreign" companies that operate within Canada.[23] It is suggested that "national" only makes sense in talking about the productivity of Canadians and that it should not matter whether a "Canadian" or "foreign" company exploits the particular innovation, as long as there is a suitable direct or indirect payoff.

Secondly, the commercialization of radical innovations appears to be an important objective of the *Innovation Strategy*. The paper comments that sources of competitive advantage are localized in clusters of corporations that reinforce one another.[24] These local clusters compete against existing and incipient clusters distributed in other nations and Canada has set a target of ten "internationally recognized" clusters by 2010. These clusters will have to have a competitive advantage over their international competitors to

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22 This is an extension of the "terms of trade" analysis well known in economic theory. It has been argued that the innovation mechanism has become as important as the price mechanism at least in the knowledge-based industries, making the concept somewhat meaningful.

23 Nowhere in the *Innovation Strategy* is it proposed that "Canadian" companies should be favoured over foreign companies. However, the concept of a Canadian corporation is discussed but not defined.

24 *Innovation Strategy*, Chapter 8, at 72

establish themselves, grow and thrive. The question is, how many clusters exist in Canada today? If it is less than ten, the *Innovation Strategy* intends to establish new clusters by generating and commercializing radical innovations. This highlights the institutional structure required to recognize the potential of a particular innovation as a radical one. An adequate venture capital industry is necessary and new "innovation intermediaries" may play an important contributing role. These intermediaries engage in market reconnaissance and bring together various industries that might be interested in a particular innovation. They provide a mechanism by which companies can contract out the innovation search function to those with tacit expertise and which are better placed to perform this important function. Inside companies, the concept of an "innovation hub"[25] has been identified as a mechanism by which to attempt to overcome institutional rigidity and highlight innovations that might be "spun-out" if they do not fit within core competencies. Other international systems include companies that perform some of these functions. A company called a *sogo shohsa* exists in the *keiretsu* industrial system in Japan that is truly unique. One of its functions is to carry out market intelligence.

Process innovations also require particular competencies. Research and development spending trends do not explain the quality of the innovation activity that is undertaken.[26] Apparently, the research and development spending that is undertaken by foreign companies can be related to customizing existing products or services for the local market.[27] The implication is that the substantive and important research is undertaken elsewhere. At the same time, it has been suggested that research and development spending figures understate the true value of technology transfer due to "invisible transfers" that are not directly measured. Nevertheless, the existence of some research and development activity within an enterprise is important, because the R&D department

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25 Leifer, *op. cit., supra,* note 12 at 185

26 These figures are also alleged to understate the degree of technology transfer that is undertaken, due to the impact of "invisible" technology transfer that occurs in multinational companies: See K. Palda, *Innovation Policy and Canada's Competitiveness*, 1993, The Fraser Institute

27 Erkki Ormala, *Science, Technology and Innovation Policy in Finland*, Philippe Laredo, Philippe Mustar, *Research and Innovation Policies in the New Global Economy, An International Comparative Analysis,* Edward Edgar Publishing Limited, 2001, at 325

acts as a technology receptor. The ability to adopt innovations depends in large part on the technology transfers that occur within multi-national companies that operate here. This form of innovative activity should be facilitated and encouraged. It is important that research and development spending is undertaken within the multinational sector to facilitate the technology transfer process and to provide training for Canadian workers.

Thirdly, while innovation is not predictable *per se*, the diffusion patterns by which information relating to innovations is distributed within an industrial sector should be more readily discernible. The existence of international competitors should identify other clusters that exist, along with the public institutional factors that support them. This may include national innovation policies and an infrastructure of public institutions that are designed to accelerate the pace of innovation within the cluster that exists. A good example of such a system is Finland's Innovation Policy that was one of the first articulated. It supports, among other industries, the wireless information technology cluster that is world class by any measure.[28] The existence of the cluster and the institutional infrastructure that supports it, provides an opportunity to establish a number of channels between the Canadian and foreign clusters to facilitate the sharing of information and expertise.

The paper concludes with a consideration of the issues that arise when the international dimension of innovation policy is articulated. A list of issues is presented that might be the subject of further study. Developing innovation policy in a turbulent period is a difficult proposition. Canada may have to look beyond its borders and integrate its innovation systems into those that exist in North America, Europe and Asia. Those developing public policy will have to investigate what the implications of such integration are for the Canadian objective of increasing the productivity of Canadian workers. There may be a benefit in Canada encouraging innovations developed here being commercialized within the United States.

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[28] *Ibid.*

The paper begs the question as to what sort of world of innovation exists. The quickening pace of support for innovation by various nations holds out the promise of quickening the pace of the adoption of new innovations, whether they may be correctly or incorrectly characterized as domestic or foreign in nature. In certain industries such as the high technology industries, a Red Queen game is likely to become increasingly the norm. However, the necessity of accelerating the process of co-evolution of "Canadian" companies in such a game can be facilitated by establishing channels of communication to share information (memes) relating to new innovations with other international clusters. It would appear that we are living in a fast sort of world.

What will the first decade in the twenty-first century bring? The 1980s brought strategic trade theory in response to lagging process innovations within North America. The 1990s saw these pressures recede as tremendous growth came about through the introduction of radical innovations in the knowledge-based market segments. Strategic trade theory concepts have yielded to the development of more benign innovation policies, modeling positive growth without apparent concern for international competition. This decade is starting with the bursting of the Internet bubble, the tightening of venture capital and reduced access to the capital markets, but is this a temporary phenomenon or a sea change? It is too early to tell, but well-founded public policy should monitor market developments through a process of continuous feedback allowing adjustments to be made as trends emerge.

## PART ONE:
## THE DUALITY OF ENTROPY AND INNOVATION

### *1.A INNOVATION: CREATIVITY THROUGH "COMBINATORIAL PLAY"*

Traditional or "neoclassical" economic theory has had a difficult time explaining innovation. Until 20 years ago, "the notion was that technologies came at random out of the blue and 'fell from heaven in celestial blocks.'"[29] Technological development was considered external to the economic process and governed by non-economic forces. This failure, combined with its further inability to explain cluster development, or the optimum size of innovative firms,[30] has given rise to increasing dissatisfaction with traditional economic theory. The problem arises in part from its slavish devotion to rigorous mathematical theorems that may be proved.[31] Its simplifying assumptions that markets are in perfect competition with perfect factor mobility, and economic agents act in a perfectly rational fashion with full knowledge of the consequences of their actions, including the reactions of other economic agents, are out of step with everyday experience. Its basic mathematical paradigm fits well with its origins in the 19th Century, but is unsuitable to cope with many 21st century challenges.

The general dissatisfaction with the state of economic theory resulted in movements to deal with areas previously ignored in neoclassical economics.[32] The New Institutional

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29 M. Mitchell Wardrop, *Complexity, The Emerging Science at the Edge of Order and Chaos,* Touchstone Books, 1992,

30 See R. H. Coase, The *Nature of the Firm*, Econometrica, Nov 1937, 386, reprinted in R.H. Coase, *The Firm, the Market and the Law*, The University of Chicago Press, 1988, 33. In 1972, Coase lamented what he considered to be the "appalling ignorance" that economists have regarding the forces that determine the organization of industry. R. H Coase, *Industrial Organization: A Proposal for Research*, reprinted in R. H. Coase, *The Firm, the Market and the Law*, *Ibid.*, at 63-4.

31 As a field of study dominated by rigorous mathematical proof, economics has tended to be resistant to new theories: Paul Krugman, *Peddling Prosperity, Economic Sense and Nonsense in the Age of Diminished Expectations*, Norton, 1994, at 227-9; W. Mitchell Waldrop, *Complexity, The Emerging Science at the Edge of Order and Chaos*, 1992, Touchstone Books, at 39-46

32 The remarkable prescience of Joseph Schumpeter had a significant influence on the various channels of this movement. See R. H. Coase (a student of Schumpeter), Richard A. D'Aveni, *Hyper-Competition, Managing the Dynamics of Strategic Maneurvering*, 1994, The Free Press, at

Economics, which deals with the existence of firms, markets and other economic institutions, finds its origin in 1937 with Ronald Coase's seminal article, *The Nature of the Firm*.[33] Attempts are also being made to challenge the 19th Century mechanistic paradigm by choosing an evolutionary metaphor, to more closely model emergent economic processes.[34] Another example is provided by the revival of "increasing returns" economics as a method to explain economic developments and the dynamic conditions within the information economy, particularly the software market.[35] This initiative is related to what has become known as chaos theory - a sensitive dependence on initial conditions in which prediction becomes impossible because of dynamic properties. This initiative is generally known as "complexity theory" and it is applied in a variety of fields of study, including economics. One of the foremost inter-disciplinary institutions promoting this viewpoint is the Santa Fe Institute founded in New Mexico in 1987.[36]

The Santa Fe Institute replaces the neoclassical static viewpoint of the market mechanism that will mechanically result in the most efficient distribution of resources, with a theory of dynamic complexity where many equilibrium points exist.[37] The economy is seen as an adaptive, nonlinear network in which large numbers of changing agents are subject to intensive nonlinear interactions. Instead of "fixed rational agents that operate in a linear, static, statistically predictable environment," the contact between agents is characterized by limited rationality, adaption through a learning process generated by new situations,

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xviii, Geoffrey M. Hodgson, *Economics and Evolution Bringing Life Back into Economics*, 1996, University of Michigan, at 20

33 Coase, *op cit., supra*, note 30

34 Geoffrey M. Hodgson, *Economics and Evolution, Bringing Life Back into Economics*, The University of Michigan Press, 1996,

35 Hodgson, *Ibid.*, 100, M. Mitchell Wardrop, *op cit. supra*, note 29 at 44; W. Brian Arthur, *Increasing Returns and Path Dependence in the Economy*, The University of Michigan Press, 1994, at 2-3

36 It was founded by such luminaries as Kenneth Arrow, Murray Gell-Mann, Stuart Kaufman and Brian Arthur, among others.

37 W. Brian Arthur, *Self-Reinforcing Mechanisms in Economics*, in Philip W. Anderson, Kenneth J. Arrow, David Pines (eds), *The Economy as an Evolving Complex System*, 1988, Santa Fe Institute Studies in the Science of Complexity, at 9-10

and increasing returns through positive feedback (that which works will be self-reinforced). These agents are not reactive in terms of stimulus and response; they anticipate market trends and competitive behaviour by building up prescriptive, internal models that are used to predict the market.

The concept of an adaptive nonlinear network is also applicable to the concept of technological development within an economy. Instead of the development of new technologies being seen as exogenous to the system, they can be generated from within the economy in a network or web of possible technologies. New technologies emerge from the choices that are created by the particular technological web that exists at the time and the connections within the web that a particular company or researcher may have. A new technology may make possible a cascade of technological change within the web, to allow the economic agents to re-organize and combine to exploit a new technology. When this kind of cascade takes place – such as the impact of the Internet – it is known as an "inflection point" in the economy.

The Santa Fe Institute suggests that the economy is bifurcated into a mature sector in which neoclassical economics still applies (this would include the primary industries such as softwood lumber) and an "increasing returns"[38] sector. This latter sector exists at the edge of chaotic behaviour in which sufficient market stability exists to make predictions within a bounded rationality as to what may happen, but lacks the mathematical certainty to make it determinative. Technological advantages are seen as coming in waves and the goal is to be able to move the locked-in technology through the successive waves. At a microeconomic level, "active management" is necessary to move through successive

[38] Neoclassical economics requires decreasing returns to scale such that the marginal revenue generated from the sale of an additional unit will decrease, while the marginal cost will increase. It is the assumption that brings supply and demand into equilibrium. "Increasing returns" postulates that marginal revenue increases with the sale of an additional unit and marginal cost decreases. This gives rise to "network" effects and results in "path dependency" and "lock-in" such that dominant market positions can be obtained when companies introduce new technologies that capitalize on "first mover" advantages. It has been argued that a theory of increasing returns would "necessarily involve abandoning all pretence of generality." Paul Krugman, *Development, Geography, and Economic Theory*, The MIT Press, 1995, at 15

technological waves to ensure that a technological advantage is maintained.[39] Traditional manufacturing needs its hierarchical structure in order to achieve the best optimization of resources to maximize its return through processes and controls that will eliminate waste. The "increasing return" sector of the economy, on the other hand, needs a new and flatter form of organizational structure reporting directly to the president, with "commando units" being mission-oriented and poised to take advantage of the "next big thing". The "next thing", however, is ill defined, and the rules have not been set.[40] The increasing returns sector functions comfortably with this high level of ambiguity.

Innovation is a dynamic phenomenon that is non-linear[41] and discontinuous in nature, and finds its place within these new movements as an emergent property that is sensitive to its initial conditions. It is serendipitous in nature, and is difficult, if not impossible, to predict. The source of innovation is creative thought that has been modelled as pattern recognition among diverse unrelated objects.

> Psychologists have long believed that creativity results from the formation of a large number of associations in the mind, followed by the selection of associations that may be particularly interesting and useful. In a sense, it's as if the mind is throwing a bunch of balls into the cognitive space, juggling them around until they collide in interesting ways. The process has a certain playful quality to it; in fact, Einstein once referred to creativity as "combinatorial play." If associations are made between concepts that are rarely combined – that is, if balls that don't normally come near one another collide – the ultimate novelty of the solution will be greater.[42]

The ephemeral nature of innovation is illustrated in research that suggests that it is Zen-like, and more an art form than a science. For example, it has been suggested that

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39 W. Brian Arthur, *Increasing Returns and the New World of Business*, 74 Harvard Business Review 101 (1996), at 107

40 *Ibid.*, at 104

41 Vijay K. Jolly, *Commercializing New Technologies, Getting from Mind to Market*, Harvard Business Press, 1997, at *xix-xx*

42 Teresa M. Amabile, Constance N. Hadley, and Steven J. Kramer, *Creativity Under the Gun*, Harvard Business Review, August 2002, 52 at 58

innovation thrives best when cross-functional teams are assembled to draw upon the collective experience of the group. Research seems to indicate that strong social ties among an "innovation team" will actually inhibit the innovative process.[43] It is also difficult to recognize the value that a particular innovation represents, particularly when it does not fit within the company's core products or services.[44] The inability to recognize the value of a particular innovation is further exacerbated when the innovation threatens to disrupt an existing business model.[45] Systemic resistance can occur if the innovation

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43 Richard Florida, Robert Cushing and Gary Gates, *When Social Capital Stifles Innovation*, Harvard Business Review, August 2002, 20:

> "… strong ties create another dynamic. Relationships can get so strong that the community becomes complacent and insulated from outside information and challenges. Strong ties can also promote the sort of conformity that undermines innovation. Weak ties, on the other hand, allow a basic level of information sharing and collaboration while permitting newcomers with different ideas to be accepted quickly into the social network. Thus, social groups with weak ties could be expected to encourage innovative thinking."

It was also found that time pressures tend to reduce innovative activity. "Announcing that a certain number of new products will be developed in the coming year, without a sense of the feasibility of that goal, will probably cause extreme time pressure to ripple through the organization – right down to the people who are actually supposed to be coming up with ideas of those products." As in all things connected to innovative activity, a sensitive balance regarding time pressures is required: Amabile, *op cit., supra,* note 42, 51 at 61

44 In 1995, the only evidence that the Department of Justice relied upon in the *U.S. vs. Microsoft* case when it was required by Judge Sporkin to provide evidence to support the Consent Decree, was an affidavit from Kenneth Arrow to support its position that no restriction upon Microsoft's ability to innovate was warranted. Arrow stated that there is no principled basis upon which the government could intervene because it is difficult if not impossible to predict the course of innovation in a complex self-organizing dynamic system."

> We are dealing with a complex system in which the outcome is not easily predictable. Indeed, predictions in the whole modern history of the information business have been very poor. *AT&T* did not realize the consequences to it of the development of the transistor, which eventually destroyed its monopoly. *IBM* was hesitant about entering the electronic computer industry altogether and failed to understand the potential of PCs; otherwise, it would have made a very different contract with Microsoft. *Xerox* developed the basic ideas that developed into Apple and took no economic advantage of them. This unpredictability is precisely what would be expected of a complex self-organizing dynamic system. But it also means that the government is not in a position to predict either, and interference to pick the winner of this dynamic process is likely to be counterproductive.

Affidavit of Kenneth Arrow, January 17, 1995, *U.S. v. Microsoft Corp.*, 56 F.3d 1338 (D.C. Cir., 1995), affidavit available on Department of Justice website re Microsoft complaint, at 4.

45 Richard D'Aveni advanced the argument that the "primary purpose of this new approach to strategy [hyper-competition] is disruption of the status quo, to seize the initiative through creating

threatens existing products by eclipsing them, especially in circumstances where a traditional, reliable revenue model is put at risk. As an emergent property, innovation is also highly vulnerable to its environment and it is difficult to maintain a consistent focus on innovative activity. A perceived failure of innovation spending "often creates "organizational skepticism about and resistance to future innovation initiatives."[46] It has been suggested that innovation spending is particularly vulnerable to business cycles – such as the turndown in the economy now occurring – as it becomes one of the first expenses that is cut as corporations begin to focus back on their "core" businesses. [47] However, it is unclear the extent to which this vulnerability exists in the information technology sector in which research and development is considered a core competency and this spending may be given up last.[48]

The unique nature of innovation confirms that the government role in sparking innovative activity is limited and to a large extent, indirect. Government can do little more than concentrate on promoting the conditions in which innovative activity can occur. This is

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a series of temporary advantages … and to erode those of competitors." Richard A. D'Aveni, *Hyper-Competition, Managing the Dynamics of Strategic Maneuvering*, Free Press, 1994, at 10 The concept of "disruption" appears to find its origin in Schumpeter's concept of "creative destruction" in which "[n]ew products and processes can destroy the marketability of their predecessors, even those these otherwise would have retained considerable value." William J. Baumol, *The Free Market Innovation Machine*, Princeton, 2002, at 22

46 John D. Wolpert, *Breaking out of the Innovation Box*, Harvard Business Review, August, 2002, 77 at 78

47 The vulnerability of innovation spending is underscored by John D. Wolpert, *Ibid.*, 77:

> Many [innovation programs] have been scaled back, mothballed, or disbanded altogether. As the economy cooled at the start of this decade, companies quickly cut off the flow of funds into innovation efforts. What seemed like mandatory expense just months before suddenly seemed discretionary. Even the rhetoric of business took a turn: Executives began to speak less about 'creating the future' and more about 'protecting the core'.
>
> What happened over the last few years is not an anomaly. It's business as usual. In most companies, investments in innovation follow a boom-bust cycle. For a time, the cash flows. Then, as companies rethink their priorities, the taps go dry. Annual surveys conducted by the Industrial Research Institute confirm the cyclicality of corporate innovation.

48 A rather interesting research study would be to track research and development spending during the current market downturn.

consistent with one of the findings reached in *Research and Innovation Policies in the New Global Economy, An International Comparative Analysis*: it is "not surprising to see that in a number of countries, there is greater emphasis on the conditions for technological competitiveness than on competitiveness itself, which is considered as the responsibility of firms themselves."[49] Government should not be in the business of selecting winners and losers. The market itself has difficulty deciding which innovations have true market potential, even after the "combinatorial play" that gives rise to the innovation has occurred. There are a number of examples in Canada of "missed guesses" and the cost to the economy can be significant in periods of fiscal austerity.[50] Government should concentrate on improving the conditions for innovative activity to occur in its various guises. Increasing funding for Canadian educational institutions is an important aspect, and the government stresses this in the Human Resources Development Canada publication, *Knowledge Matters, Skills and Learning for Canadians*, that forms part of the *Innovation Strategy*.[51]

### *1.B DECAY BY ENTROPY / RENEWAL BY "NOVELTY THROUGH COMBINATION"*

Innovation cannot be considered in isolation, but within the competitive context of the particular industrial segment in which it occurs. The value of a particular innovation in giving rise to a temporary competitive advantage must be understood in terms of the benefits flowing therefrom that may be appropriated by the innovator. In the context of a

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49 Philippe Laredo, Philippe Mustar, *Research and Innovation Policies in the New Global Economy, An International Comparative Analysis*, Edward Edgar Publishing Limited, 2001, at 499

50 Palda, *op cit, supra*, note 26 at 45:

> The difficulty of choosing winners is forcefully illustrated in the Ontario Premier's Council proposal to back threshold companies … On our count by the end of 1990 at least 9 of the 25 companies had either gone into receivership, or had experienced grave difficulties, or had been sold to foreign interests.

It should be noted that the sale "to foreign interests" was equated with failure. The characterization in this manner may result from confusion with respect to the question of what is "Canadian."

51 *Innovation Strategy, op cit., supra,* note 3

national innovation strategy, the benefits that might be appropriated in a manner that benefits Canadian productivity levels, also contributes to the value to be considered.

The value of a particular innovation depends in part on its rate of diffusion through the industrial sector. An innovation that diffuses quickly will provide a competitive advantage of limited duration and thus only a portion of the value can be appropriated. The nature of the innovation is obviously an important aspect, because it might be protected under various intellectual property laws, which allow an exploitation of the innovation over the period that the rights have been granted. Not all innovative activity can be protected under intellectual property, and the effectiveness of that protection is somewhat ephemeral if similar technology may be developed that provides the same functionality or performance without infringing the protection that has been afforded. The concept of innovation is broadly defined. The *Innovation Strategy* provides that "the term 'innovation' refers to both the creative process of applying knowledge and the outcome of that process."[52] It has also been recently defined as "encompassing not just brilliant new products but also distinctive operating practices, managerial tactics, and even business strategies."[53] As a result, there is a great deal of innovative activity that will not be protected under intellectual property laws and will be adopted or imitated relatively quickly.

The concept of entropy highlights the competitive value of a particular innovation and the manner in which that value will erode over time as diffusion occurs. "Entropy" is a scientific concept found in the second law of thermodynamics. It measures the movement from a relatively ordered state to one of maximum disorder or entropy.[54] It is a measure of the extent to which energy is used so that it is no longer available in a given system.[55] In the context of economics, it has been suggested that "information" replaces "energy",

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52 *Ibid.*, at 4

53 Editorial, *The Innovative Enterprise*, Harvard Business Review, August 2002, at 6

54 Hodgson, *op cit.*, *supra*, note 34 at 245.

55 Georgescu-Roegen, *op cit.*, *supra*, note 10 at 5

in the "main propagating role."[56] It is also appropriate to use entropy in the context of considering "value", as thermodynamics is reported to be a physics of economic value.[57] The concept is consistent with the trend to replace the mechanistic analogue of neoclassical economics with an evolutionary/biological one. It reflects qualitative changes in economic systems that are inconsistent with a mechanical system and cannot be reduced to mathematical or "arithmomorphic" quantification.[58] It is consistent with emergent properties because the path and speed of the entropic process is not determinative and is subject to being displaced by "the emergence of novelty by combination."[59] This means simply, that unexpected consequences can arise from combining elements in new ways. This is precisely the definition of "combinatorial play" that underlies the concept of creative or innovative thought discussed above. A system can be invigorated by novelty by combination, and the diffusion process can be extended through the qualitative changes that occur as a result thereof. The economic struggle, therefore, becomes one of finding new sources of "low entropy"[60] - defined as a system with energy or value available to be utilized – through innovation. On a microeconomic level, the struggle is how to maximize the value realized from the particular innovation in question. This may involve commercializing the innovation by itself or as part of a consortium, or through a spinout company, or by sharing or licensing the technology, assuming that intellectual property laws are applicable.

Entropy in the context of innovation policy may be understood as the existence of "competitive value", which is the degree to which the innovative activity in question has

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56 Hodgson, *op cit., supra,* note 34 at 300

57 Georgescu-Roegen, *op cit., supra,* note 10 at 3

58 *Ibid.,* at 3-15

59 *Ibid.,* at 13

60 *Ibid.,* at 5:

> "Entropy is an index of the relative amount of bound energy in an isolated structure or, more precisely, of how evenly the energy is distributed in such a structure. In other words, high entropy means a structure in which most or all energy is bound, and low entropy, a structure in which the opposite is true."

the potential to give the innovator a temporary competitive advantage. In this sense, entropic innovation requires not only the creation of technology but also the ability to capture and exploit it. An innovation that represents "low entropy", involves unique technology or business practices that may be exploited in a manner to provide competitive advantage. Technology or business practices that represent "high entropy" have been diffused such that they are common and no longer a source of competitive advantage. Innovation can take place in any industry, whether in the "mature" or the increasing returns" sector. "Low entropy" innovation can take place in any industry, including the primary industries, if new technology can be developed that tends to renew the innovator's competitive advantage. An example of a "low entropy" innovation in the mature sector is new "air drill" seeding technology developed by an agricultural technology cluster in Saskatoon, Saskatchewan. By utilizing an air drill injection method, productivity in seeding has been increased significantly, permitting the cultivation of much larger land areas by existing farming operations.[61]

Innovation is broadly defined to include "distinctive operating practices, managerial tactics, and even business strategies" which can give rise to a competitive advantage. The exploitation of a new market segment or new international market, for instance, constitutes an innovation that provides a temporary competitive advantage. This can be fleeting in traditional industries when competitors get wind of the new opportunity. In "increasing returns" markets in which network effects are strong, first mover advantages coupled with "path dependency" and "lock-in" can provide a more durable advantage that can last given "active management" through subsequent technological waves. This means simply that, as the network of users grows in numbers, they become dependent on the standards of the particular technology that they are using and as their investment in equipment, software and/or training increases, they become "locked-in" to the particular platform in question.

[61] Mel Annand, Associate, *Estey Centre for Law and Economics in International Trade*

### *1.C THE ENTROPY/INNOVATION MATRIX*

The relationship between entropy and innovation is set forth in a model in Appendix "A" to this paper. The model highlights the innovation paradox that is described by the concept of a "Red Queen" game, as well as a possible "innovation trap" for developing nations that may suffer a decline in the "terms of innovation." This has significant implications for the development of international trade policy and they are set forth in Appendix "A".

## PART TWO: ARTICULATING THE INTERNATIONAL ASPECTS OF THE INNOVATION STRATEGY

Somewhat surprisingly, the *Innovation Strategy* makes only a passing reference to the concept of competitive advantage, to international competition or to the concept of globalization.[62] It does look internationally for benchmarks by which to measure Canada's performance to date and in setting targets. Canada ranks seventh in GDP per capita,[63] "real incomes in Canada have been steadily falling relative to the U.S. over much of the last two decades,"[64] Canada's productivity is approximately 19 percent lower than the U.S.,[65] Canada ranks fifth through seventh on a number of innovation performance indices from external patent applications to government expenditure on R&D,[66] and Canada is similarly ranked against other nations on a variety of other measures.[67] With respect to establishing goals, Canada intends to rank among the top five

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62 Only 3 references can be found to "competitive advantage" (pages 4, 8, 72) and 3 references to the word "international competition" (pages 21, 23, 57). Globalization was found only twice (pages 36 and 64).

63 *Ibid.*, at 13

64 *Ibid.*, at 14

65 *Ibid.*, at 14,

66 *Ibid*., at 16.

67 *Ibid.*, see 17-variety of categories including economy, labour, innovation; 18-Canada's Innovation environment Canada/U.S.; 36- commercialization; 37-share of sales from new or improved products; 41-share of industry-funded R&D performed in universities; 49-technolgoical alliances between firms 1989-98; 55-perentage of the population aged 25-64 that has completed post-

countries in the world in terms of R&D performance by 2010.[68] The only "strategy" that explicitly includes an international initiative appears to be one encouraging small and medium-sized enterprises to form international R&D alliances.[69]

The point is that the *Innovation Strategy* is silent with respect to the implications that international competition has to the fashioning of Canadian innovation policy. An example is provided by extent of the discussion of the concept of globalization that states:

> Globalization poses challenges and opportunities on many fronts. The wide array of goods and services entering the Canadian market is straining governments' capacity to respond to public and business needs. Global competition for investment and highly qualified people is requiring governments to compete against each other for investment and talent in such areas as tax competitiveness, quality of the labour force, health care, and community-based quality of life. Meanwhile, global challenges such as climate change and disease control are requiring increased international cooperation among governments.[70]

The *Innovation Strategy* does imply that the structure of international competition should play an important role in the formation of policy. For example, the goal of creating ten "internationally recognized technology clusters"[71] suggests this. The international perspective must be articulated to begin defining the way in which it might influence the implementation of the *Innovation Strategy*.

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secondary education, 1999; 59-percentage of employed adults aged 25-54 participating in employer-sponsored formal job-related training, 1995; 63-regulatory barriers to entrepreneurship 1998, 68-investment intentions of major multinational firms.

68 *Ibid.*, at 84

69 *Ibid.*, at 85

70 *Innovation Strategy*, at 64

71 *Ibid.*, at 76

## *2.A WHAT ROLE SHOULD NATIONALITY PLAY?*

One aspect that is not dealt with in the *Innovation Strategy* is the role that nationality should play in terms of promoting innovative activity and in capitalizing upon the innovative activity that does occur within Canada. Here, the international dimension becomes significant because the question arises as to the degree to which the commercial potential of "Canadian" innovations must be appropriated within Canadian borders. To what extent must the innovation be "captured" in the sense that it gives rise to factories and jobs here? To what extent should innovative activities be supported even if the company that does have operations within Canada is not "Canadian" *per se*? Michael Porter, Robert Reich (the former labour secretary during the first Clinton administration), and Kenichi Ohmae, dealt with this question from somewhat different perspectives.

Porter's theory indicates that competitive advantage is essentially a function of the quality of certain dynamic factors within the national economy.[72] The primary agent of competitive advantage is the concept of a "business cluster", which is defined as "groups of industries connected by buyer-supplier relationships or strong interrelationships in terms of products and technology ... involv[ing] end products, specialized inputs used in these products, specialized machinery employed in making them and associated services."[73] Competitive economies are those which are able to foster the growth of business clusters in which the "home bases" of companies are located. Porter believes that the location of the home base has the greatest impact on national prosperity as "[i]t is where the most productive jobs reside and where the most fruitful linkages with other

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72 Porter identifies the business conditions essential to the growth of business clusters in proposing his paradigm of a diamond upon which factors critical to continual upgrading in an industry are dependent. The four main determinants are: factor conditions; demand conditions; related and supporting industries and firm strategy, structure and rivalry. In addition to these determinants, the role of government and chance are also important determinants. Together these determinants form a system that dynamically produces competitive advantage:

> Each of the four determinants of competitiveness ... influences the capacity of a nation's industry to innovate and upgrade. Together they constitute a dynamic system that is more important than its parts. Over time, the determinants tend to be mutually reinforcing or mutually undermining. Porter, *Canada at the Crossroads, op cit., supra,* note 4, at 63

73 *Ibid.,* 22

domestic industries are established."[74] In fact, "a nation's ability to upgrade its productivity over time is critically dependent on its ability to provide a good home base for international firms, both domestic and foreign-owned."[75] It is not necessary that the firm's home base for all activities is located within its national borders, if it is possible to have the home base for important activities within the firm.[76]

Robert Reich's theory is that competitive advantage is in essence a function of the value added by American workers to the world economy. He asks the question "who is us?" His answer is that it is restricted to the workers of the United States as the term "American corporation" is losing its meaning in a globalized economy:

> What is the role of a nation within the emerging global economy, in which borders are ceasing to exist? My answer has, I hope, been clear. Rather than increase the profitability of corporations flying its flag, or enlarge the worldwide holdings of its citizens, a nation's economic role is to improve its citizens' standard of living by enhancing the value of what they contribute to the world economy. The concern over national 'competitiveness' is often misplaced. It is not what we own that counts; it is what we do.[77]

Reich recommends a policy which he terms a "positive economic nationalism" in which each nation "takes primary responsibility for enhancing the capacities of their countrymen for full and productive lives". Training is encouraged, the transition from older industries to newer industries is smoothed by government support. It is not based upon a view of the economy as a zero-sum proposition where one nation's welfare is increased at the expense of another. Reich rejects any suggestion that there is a fixed amount of world profit to be divided, or a limited market to be shared. "It is not 'their' corporations against 'ours' in a fight for dominance in world commerce."[78]

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74 *Ibid.*, at 57

75 *Ibid.*

76 *Ibid.*, at 76, note this study was published in 1991

77 *Ibid.*, at 301

78 *Ibid.*, at 312

Kenichi Ohmae takes a somewhat different view, arguing that nation states have been rendered redundant due to the globalization of what Ohmae calls the four "I's", which include the capital markets, industry and its organization, information technology and the profile, knowledge and tastes of individual consumers.[79] The workings of global capital markets have dwarfed nation states' "ability to control exchange rates or protect their currency" and nation states "become inescapably vulnerable to the discipline imposed by economic choices made elsewhere by people and institutions over which they have no practical control."[80] With respect to industry and its organization, Ohmae accepts Reich's analysis of the absence of national corporations.[81] The technological revolution makes it possible for operations in various parts of the world without the creation of a mini-U.N. framework of national subsidiaries. Multinationals are able to create a "horizontal network, the nodes of which - equidistant from the centre - are not arbitrary geographical units but real issue- or area-based flows of economic activity, many of which involve participation by external partners and vendors."[82]

Ohmae accepts Michael Porter's theory of cluster development and the importance of factor endowments existing in close geographical proximity. He argues that it does not follow, however, that to be effective, such geographical groupings must co-exist within the borders of a single nation state. Instead, clusters work equally well if they are regionally based and lying across political borders.[83] Ohmae expresses the importance of region states in the following manner:

> So long as nation states continue to view themselves as the essential prime movers in economic affairs, so long as they resist - in the name of national interest - any erosion of central control as a threat to sovereignty, neither they nor their people will be able to harness the full resources of the global economy. This is not the road to prosperity and an improved quality of life. It is an admission that the cancer of protection, subsidy and the civil

79 Kenichi Ohmae, *The End of The Nation State, The Rise of Regional Economies*, McKinsey & Co. Inc., 1995, at 2-5

80 *Ibid*., at 13

81 *Ibid*., at 99

82 *Ibid*., at 4 and 112

83 *Ibid*., at 64-5

> minimum has grown so large and spread so widely that it has become inoperable. There is, of course, another much happier choice: to embrace the global economy, to react with pleasure to the development of local ports of entry to that economy, and to do everything possible to encourage and nurture the successful operation of those ports - those region states. In other words, there is, indeed, a healthy and vital role for nation states: to be an effective catalyst for the activities of regions.[84]...The only hope is to reverse the post-feudal, centralizing tendencies of the modern era and allow - or better, encourage - the economic pendulum to swing away from nations and back toward regions.[85]

The only role for the nation-state to play is to get out of the way of its regions, which are seen as the "powerful engines of development because their primary orientation is toward - and their primary linkage is with - the global economy."

Here are at least three approaches as to what should constitute "Canadian": Porter speaks of the importance of attracting head office functions to Canada; Reich speaks of the focusing on workers and their training; and, Ohmae stresses the importance of regionalism trumping federalism. The point is that this entire debate has not been addressed by the *Innovation Strategy*, but the Reich viewpoint is implied by the stress placed on productivity and worker training, though there is no clearly expressed support expressed therein for the notion that "it is what we do, not what we own," that counts.

84 *Ibid*., at 136

85 *Ibid*., at 142

*Case study*

*workopolis.com – Competing Globally for Domestic Market Share*

workopolis.com is Canada's biggest Internet job site. Less than one per cent of the company's sales are international. But don't try to tell President Kim Peters that she doesn't run a global business. "If you're on the Internet, you're in a global marketplace," she said. And in the global marketplace, Workopolis is up against a big competitor, a "monster" in fact.

Workopolis originated as globecareers.com, one of the first on-line services of The Globe and Mail. When it became clear in 1998 that the market in this space was ripe for international competition, Peters' team assessed there was probably room for two major players in the Canadian market. And they were determined to be one of them.

What followed was 'co-opetition' (cooperation with a competitor) at its finest. After looking at the success of globecareers.com, Torstar Newspapers Ltd. also independently determined there was only room for two major players in the market and approached its competitor, The Globe and Mail, to propose that the two organizations pool their interests and partner to build the most successful Internet recruitment business in Canada. Torstar combined their employment classifieds online with the existing posting business of globecareers.com to form workopolis.com.

The Workopolis team was up against formidable international competition in the form of Monster.com. Monster is owned by the American firm, TMP Worldwide Inc., the largest recruitment-advertising agency in the world. With 47 per cent of global market share, Monster is the world's leading global on-line careers web site. Having entered the Canadian market in 1996, Monster.ca had a four-year head start on Workopolis.

Peters knew that simply being the Canadian player in the Canadian market wasn't enough to ensure Workopolis' success. The company had to build a service that would be continuously responsive to customer demand and equal to or better than any competitor on the Internet. This meant and still means Workopolis must dedicate a sizable portion of its workforce (15% of its employees) to research and development. It must also place a high priority on competitive intelligence.

In both these areas, a huge multinational can significantly outgun a company focused on a national market. "Monster has much more to spend on product development than we do and they can amortize their investment over a global business that reaches into 21 markets," Peters said. "This means that we really have to stretch our resources and persistently innovate. It also means the innovation cycle is shorter." The Internet also works to shorten the innovation cycle. Being an Internet business means that Workopolis must manage an environment that is transparent to its competitors as well as its customers.

Yet Workopolis successfully competes with Monster. With over 31,000 postings to search daily, it is the largest on-line job site in Canada by a wide margin. The company's commitment to R&D and service development has brought it into new lines of business. It operates a job site especially for students and recent graduates and produces a software solution to help corporate clients build their own corporate career sites.

Going toe-to-toe with a monster has also inspired Workopolis to develop its own strategies for global expansion. It is currently examining ways to partner with other media organizations to build successful Internet recruitment business in markets outside Canada.

## *2.B INTERNATIONALIZATION OF INNOVATION POLICIES/STRATEGIES*

Canada's *Innovation Strategy* co-exists with similar innovation strategies developed by nations around the world. It reflects the importance that all nations are giving to the importance of developing "innovation cultures" that will upgrade their economies. This co-existence and competition between innovation policies and strategies contribute to the "innovation paradox" that the faster that innovation occurs, entropy increases and temporary competitive advantages are eroded. The cyclical nature of the process moves in ever-faster cycles.

The development of these policies and strategies are either a contributing cause or symptom of the process of globalization. It is the result of the incredible growth and integration of capital markets,[86] the convergence of computer and telecommunications policies,[87] and inflection points in the economy such as the explosion of the Internet, that make possible new constellations of supplier and complementary industries. It is facilitated also by the growing network of international and regional free trade

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86 The question arises whether this presumption still holds today, when a global capital market has emerged of its own accord that has facilitated surprising growth in the world's stock of liquid financial assets. Between 1980 and 1994, the world's financial stock grew from $11 trillion to $41 trillion; it is projected to grow to $360 trillion (1992 dollars) by the year 2020. Bradley, Hausman, Nolan, *Globalization, Technology, and Competition, The Fusion of Computers and Telecommunications in the 1990s*, Harvard Business School Press, 1993, at 35 and 156.

87 Apart from the projected growth of the capital markets, the revolutionary advances in information technology and telecommunications are having a profound effect on the economy and the organization of economic activities. For instance, a new form of corporate organization appears to be emerging:

> The predominant form of organization in the Industrial Economy, the divisionalized functional hierarchy, is characterized by a set of management principles centred around the notion of a hierarchy: chain of command, span of control, paper-based memo communications, and so forth. This organizational structure is slowly giving way to an alternative structure, termed the "network" structure, characterized by an alternative set of management principles: point-to-point electronic based communication, teams, and strategic alliances. The network structure is more appropriate for leveraging information technology. Bradley, Hausman, Nolan, *op. cit., supra,* note 86, at 12

Horizontal relationships based upon a network, which are highly flexible, are replacing vertical structures. Outsourcing becomes a more efficient means of production, with ad hoc project-specific teams being assembled quickly when needed and which then can disperse after the particular project has been completed.

agreements. For example, the *World Trade Organization* has increased the pace of market liberalization within China, and the *North American Free Trade Agreement* has removed the post-war distortions in the trade relationship between Mexico and the United States.[88]

The *Innovation Strategy* mentions the existence of these international initiatives in Appendix "B" which provides a brief reference to the policies of the United Kingdom, Australia, the United States and Sweden.[89] There is no apparent analysis of the international competition for research and development or the structure of innovation initiatives within other countries. The Information Technology Association of Canada (ITAC) quite correctly identified the importance of Finland, in one of its earlier position papers on innovation policy. After reviewing Canada's eighth place standing on the technology achievement index,[90] ITAC states:

> Our eighth place standing is miraculous when you examine how well we fare on measures such as patents (we're eighteenth behind Romania and Spain) and receipts from license and royalty fees (we're tenth).
>
> But the strongest message that the Technology Achievement Index delivers is how fast moving the leadership race is and how technology itself levels the playing field. The number one ranked nation in this index is not the United States, but Finland.

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88 Mexico followed an import-substitutional strategy marked by high tariff barriers and a mistrust of American investment. This distorted economically rational trade and investment patterns that, arguably, have been allowed to emerge under free trade. If this argument is accepted, it means that Canada benefited from Mexico's exclusionary policies throughout the post-war period until the implementation of NAFTA. As a result, competition from Mexico is not a by-product of NAFTA per se, but the decision by Mexico to open its market. Canada had no choice but to enter NAFTA, in the circumstances.

89 *Innovation Strategy*, at 89-90

90 "The technology achievement index measures national economics against eight parameters: patents granted to residents, receipts of royalties and license fees, Internet hosts per 1000 people, high and medium technology exports, number of telephones per 1000 people, electricity consumption, mean years of schooling, and enrollment in post secondary science education." Information Technology Association of Canada, *Towards a Culture of Innovation*, October, 2001, at 3-4 (available online at www.itac.ca)

> Finland has a smaller population and domestic market (5 million people) than Canada. Like Canada, it has its economic roots in the resource sector. … In 1985, Finland's input in research and development sat at 1.4 per cent of GDP. It ranked ninth (ahead of Canada) within the OECD. In 1998, R&D investment in Finland doubled to 3 per cent, placing it second only to Sweden in the OECD (we improved slightly to ninth place). This R&D growth was sharply focused on telecommunications, biomedicine and the science of new materials.[91]

There is no mention of Finland in the *Innovation Strategy*[92] even though it represents a rather remarkable success story in terms of a national innovation strategy. Government strategists began focusing on the issue of technology diffusion in the 1980s, and are reported to have gradually developed "new concepts such as the interactive model of innovation, the absorptive capacity of firms and national systems of innovation."[93] It developed a Technology Development Agency (TEKES) in 1983, a Science and Technology Policy Council in 1987, developed regional innovation systems including Finnish universities, technology centres and Centres of Expertise, among other contributing factors, to take advantage of the local aspect of innovative activity. Among other initiatives, it has established a Technical Research Centre of Finland ("VTT") that is funded 70 percent by industry and 30 percent by government.[94] Finland was "able to initiate a strong renewal process in its industrial structure, with a move towards specialization in knowledge-intensive, high-growth sectors and products.[95] The role of research and development spending as a facilitation device is instructive:

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91 *Ibid.*

92 The only reference to be found is at Chart 2 "GDP per capita" – OECD figures, 2001, on page 13. Canada ranks ahead of Finland on this measure. Canada is in seventh place while Finland is in 15th. The various papers prepared in support of the *Innovation Strategy* by Industry Canada or the Department of Foreign Affairs and International Trade have not been reviewed. It is a glaring omission if a review of foreign innovation strategies or policies (acknowledging the fact that all nations have innovation policies, but not all of them have reduced it to a "Strategy" document) was either not undertaken or not considered in the formulation of this policy.

93 Erkki Ormala, *Science, Technology and Innovation Policy in Finland,* published in Laredo and Mustar, *op cit., supra,* Note 11, 325. Finland's *National Strategy* was introduced in 1990.

94 *Ibid.,* at 342

95 *Ibid.,* at 329

> R&D is not only a way to generate new knowledge; it is an essential element of a learning organization, integrating the different types of knowledge needed or innovation. It opens up channels for external sources of knowledge and facilitates participation in strategic alliances and knowledge networks. Finally, R&D seems to strengthen an organization's absorptive capacity and ability to apply new technology. Therefore, the government's decision to increase R&D activity affects the core of the innovation system and is expected to strengthen the innovative performance on an economy-wide basis.[96]

Internationalization of research and development co-operation has also been expanding rapidly. By the mid-1990s, 30 percent of industrial research and development was conducted abroad, "driven by the natural need to expand research near the market." Notably, "no major R&D activities have been transferred abroad" and that, "on the contrary, some multinationals have strengthened their R&D activities in Finland."[97] This is seemingly in recognition of the strength of the "clusters" or "diamonds" within Finland, particularly in the wireless sector. It is also reflective of the technological savvy of the consumer market, which is one of the most advanced wireless communities in the world. International science and technology co-operation is a central development object of the innovation system, to "acquire knowledge needed in Finland."[98]

The importance of Finland as a case study is underscored by the likelihood that companies that are part of the Nokia cluster, as well as other elements of the high technology sector within Finland, compete with Canadian companies. It would be important for Canadian officials to analyze the Finnish innovation policies supporting these industries. It might also be important for Canadian companies as well as universities and other innovation institutions to establish links with similar institutions within Finland, to create diffusion channels by which innovation knowledge can flow to Canadian innovation receptors.

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96 *Ibid.*, at 331

97 *Ibid.*, at 351

98 *Ibid.*

Other case studies highlight the importance of establishing entropic channels with other national innovation policies/strategies and foreign clusters. International research and development trends are growing in importance to the United States' innovation policies:

> U.S. firms expanded offshore R&D operations and as foreign firms expanded their R&D activities within the United States…
>
> The share of industrial R&D performed within the United States that was financed from foreign sources grew substantially during this period, from 3.4% in 1980 to more than 11% in 1995 …
>
> Finally, a number of foreign firms operating R&D facilities in the United States pursued collaboration with U.S. universities. According to Florida (1997), more than 50% of the Japanese R&D laboratories in the United States, more than 80% of the U.S.-sited French R&D laboratories, and almost 75% of German corporate R&D laboratories in the United States were involved in such collaborative agreements.[99]

Similarly, in Japan, international contacts in the field of research and development have become an important initiative. Much of the earlier debate that took place a decade ago resulted from the perceived success of the Japanese model in facilitating improvements in process technologies, permitting Japan to eclipse the United States in innovative technologies that had been developed in the United States. It led to a series of "managed trade" agreements in semiconductors and automobiles that demonstrated little more than the insecurity of North America in confronting this new kind of state industrial strategy. The remarkable aspect of the Japanese economy is its ability to create intense competition within a protected market. It has achieved this since 1953 through the *"keiretsu-fication"* of Japanese industry. It accomplished this task through the banks that were encouraged to take share ownership positions in their clients.[100]

> The structural paradigm for the *[Keiretsu]* was a pattern called *Ichi gyoushuu, issha taisei*, meaning "one firm in each major industrial sector"; this allowed the group to become a semi-autonomous economy unto itself.

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99 David C. Mowery, *The United States National Innovation Systems after the Cold War*, published in Laredo and Mustar, *op cit. supra*, Note 10, 14 at 31-33

100 Kenichi Miyashita, David W. Russell, *Keiretsu, Inside the Hidden Japanese Conglomerates*, McGraw-Hill, 1994, at 37-9

> Even the *keiretsu* that were not based on a well-established *zaibatsu* (e.g. the Sanwa Group) accepted this structure as axiomatic. Thus, the *keiretsu* that came together after the war were heterogeneous, not cartel-like.
>
> ... When a new sector became prominent, all the *keiretsu* would jump into it, whether there was room for six big firms or not. The result was intense competition, much more so than in the good old days when the *zaibatsu* could privately carve up markets among strong players and close everyone else out.[101]

These large bank-centred industrial groups compete in most, if not all, major industrial sectors, which are known as horizontal *keiretsu*. It is possible that the *keiretsu* represent "no less than one-third of the total Japanese economy. And that is a rather conservative guess."[102] The existence of the *keiretsu* provides a structural mechanism through which the Ministry of International Trade and Industry ("MITI") can exercise control through the process of "administrative guidance," by informal advice given to the groups.[103]

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101 *Ibid*., at 39-40

102 *Ibid.*, at 81. To capture the extent of a horizontal *keiretsu*, an equivalent American industrial organization would involve the following group:

> In other words, we tend to use the term "*keiretsu*" too casually. Talking about an IBM-Apple venture is not talking about *keiretsu*. If, for example, Ford, General Electric, Digital Equipment, Metropolitan Life, Morgan Guarantee, Goodyear, Dupont, 3M, Kimberly Clark, Mereck, Reynolds-Metals, Mobil, and TRW were to tie up, exchange small percentage of their stock with other group members, exchange directors, agree to buy from each other whenever feasible, exchange information about their respective markets, cooperate on new ventures that have little direct impact on most of their businesses, cooperate to support political candidates, and lobby for legislation that would further the group's policy goals, that would be an American *keiretsu*. *Ibid*., at 209

103 The best definition that can be given is that it involves a "request made by an administrative body for voluntary cooperation." *Ibid.*, at 39-40 "Administrative guidance is often preferred over more formal administrative decisions, such as directives or orders, because it preserves the important values (which are often illusory) of harmony and consensus between government and industry." *Ibid.* Promotional administrative guidance involves advice and information given to enterprises to advance their own interests, such as the adoption of a new technology. Conciliatory administrative guidance is used to mediate disputes between large and small enterprises. Regulatory administrative guidance is used by government agencies to regulate the conduct of business enterprises, often as a substitute for a more formal order. *Ibid.*, at 32-3 Administrative guidance is a powerful tool to force compliance with directives issued by MITI, given the residual power that it has over the Japanese economy, pursuant to the *MITI Establishment Law* and the *Control Law*. It is most effective when it is based on a consensus within the industry that is the object of administrative guidance, supported by legislation that could achieve a similar purpose by compulsory process, and the government can offer a subsidy or some other economic benefit in return for compliance. *Ibid.*

The 1990s marked a resurgence of American technology, based largely on the advances in information technologies. At the same time, Japan industry suffered some rather embarrassing miscues, such as the choice of analogue high-definition television, along with a competitive disadvantage in producing software due to its unique language and characters. While the competition from Japanese *keiretsu* remained formidable, state industrial policy was somewhat discredited and no longer viewed with the same sense of insecurity.

Japan increased its technology spending to 17 trillion yen in 1996-2000 (roughly U.S.$230 billion) from 12.6 trillion yen during 1990-5.[104] It has also adjusted its technology policy, launching "six reforms" in 1996, representing somewhat of a new approach to science and technology policy.[105] Amongst the reforms, technology policy is now coordinated by a cabinet position above the usual cabinet portfolios that exist.[106] This underscores the fact that the Canadian *Innovation Strategy* falls under the authority of Industry Canada and Human Resources Development Canada, and it is unknown to which degree coordination has occurred with the Department of Foreign Affairs and International Trade. The importance of the development of innovation policy from the standpoint of international trade is underscored by the direct authority that MITI has over certain technology institutions. MITI includes the Patent Office and the Agency of Industrial Science and Technology, which in turn has 15 national research institutes.[107]

From the international perspective, Japan has made science and technology coordination agreements with 24 countries and has established programs to promote international research exchanges. The purpose of these programs is to provide foreign researchers and

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104 Philippe Laredo and Philippe Mustrar, *Research and Innovation Policies in the New Global Economy: An International Comparative Analysis,* Edward Elgar Publishing Ltd., 2001, 47 at 81-2

105 Yukio Sato, *The Structure and Perspective of Science and Technology Policy in Japan, Ibid.,* at 79

106 *Ibid.,* at 81-85

107 *Ibid.,* at 110

research institutes with information on Japan's research activities.[108] One of the challenges identified for Japan is to increase the mobility of researchers, both internationally as well as between academia and private industry and on an inter-disciplinary basis.[109]

The European Community science and technology policy by its very nature is international in scope, promoting the integration of research efforts throughout the community.[110] An "embryonic European system of innovation" is said to be emerging. Seven areas are cited where action is taking place at a European level, including: the emergence of a European policy of spatial planning as well as the rapid development of European measures and institutions for research and innovation policy (among others, the Framework Programs and specific initiatives such as EUREKA, Airbus, Arianspace).[111] Notwithstanding the European Community initiatives, internationalization is a factor in its member states. For example, "Germany is the most important foreign research location and in the EU countries, only in England do the Japanese conduct more R&D than in Germany."[112]

The foregoing is an introduction to the internationalization of innovation policies already taking place in other jurisdictions. It appears to be occurring by design, but also by necessity to establish contacts with clusters that exhibit a particular technological expertise. It is occurring at the institutional level from government institution to institution, institution to private industry as well as between industries in joint

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108 *Ibid.,* at 107-8. This includes support programs for foreign researchers and their family with accommodation in Tsukuba Science City.

109 *Ibid.,* at 108

110 Paraskevas Caracostas and Ugur Muldur, *The Emergence of a New European Union Research and Innovation Policy,* published in Laredo and Mustar, *Ibid.,* 157 at 158

111 *Ibid.,* at 170-2

112 Frieder Meyer-Krahmer, The *German Innovation System,* published in Laredo and Mustar, *Ibid.,* 205 at 210.

collaborative efforts.[113] This leads to the analytical importance of the patterns of innovation dissemination and diffusion amongst international innovation systems.

## *2.C THE CHALLENGE OF POLICY DEVELOPMENT*

Certain distinctions must be made for the purpose of policy development. Radical innovations must be distinguished from process innovations to better understand the characteristics of the innovative activity that the *Innovation Strategy* is attempting to encourage. Developing and commercializing radical innovations is a much more difficult proposition than introducing routine improvements in existing production processes or product characteristics. Although both are important, innovation "creation" factors can be distinguished from "exploitation" factors, and this distinction highlights the different conditions and innovation "agents" that may be required to recognize the commercial potential of a particular innovation, and provide the resources to see that this value is recognized in a manner that achieves the goal of increasing the productivity of Canadians. An additional distinction can be made between positive and negative innovation factors, highlighting that impediments may exist to the process of developing and commercializing innovations.

Radical innovations have been defined as those that have the potential to produce: "an entirely new set of performance features; improvements in known performance features of five times or greater; or a significant (30 percent or greater) reduction in cost."[114] They "create such a dramatic change in products, processes, or services that they transform

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[113] Two major collaborative efforts in the United States during the 1990s were SEMATECH and Microelectronics and Computer Technology Corporation (MCC). Both located in Austin, Texas. The legal framework and the performance of these two domestic institutions, is reviewed in Castel and Gastle, *Deep Economic Integration, Between Canada and the United States of America, the Emergence of Strategic Innovation Policy and the Need for Trade Law Reform*, 7 Minn. J. Global Trade, January, 1998, pages 1 - 44. Professor Castel is Professor Emeritus, Osgoode Hall Law School, York University, Toronto.

[114] Leifer, *op cit., supra,* note 12, at 5

existing markets or industries, or create new ones."[115] Examples of such innovations include: General Electric's digital x-ray imaging system to compete with existing film-based X-ray systems; General Motors' hybrid vehicle capable of drawing power from both electrical and conventional systems; IBM's silicon germanium chips that increase switching speeds and reduce power requirements.[116] A further example that was identified is Nortel Networks' spinoff "NetActive" that allowed digital content to be activated over an Internet link between the consumer and a NetActive server.[117] Entrust Technologies Limited is also a spin-off company from Nortel Networks. PKI provides enhanced security such as persistent encryption and security management that the financial sector and government demand for transmission and storage of information, including virtual private networks that permit them to conduct business with remote officers or suppliers.[118] In 1994, Entrust had entered into a license agreement with Microsoft. By late 2001, Entrust claimed a 39 percent market share as well as responsibility for sparking a global PKI-related industry, which generates an estimated $1.8 billion in annual revenue.[119] Apparently, there are approximately 20 companies worldwide participating in the industry with numerous small companies springing up in local markets, particularly in China.[120]

The "creation" factors for radical innovations identified will be general and indirect in nature, given the sensitive nature of the "combinatorial play". Nurturing and commercializing radical innovations represents a significant challenge. They require a long-term commitment, sometimes lasting as long as ten years, in highly unpredictable, non-linear environments.[121] They will likely involve establishing an environment in

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115 *Ibid.*

116 *Ibid.,* at 9-10

117 *Ibid.*, at 10

118 ITAC Case Study, *Towards a Culture of Innovation*, October, 2001, at 15

119 *Ibid.* at 16

120 *Ibid.*

121 Leifer, *op cit., supra,* note 12 at 18

which the diverse factors can be identified and weighed. The "exploitation" factors may be more predictable, involving the way in which an innovator may signal the existence of the innovation to a select audience that can provide the venture capital and marketing acumen necessary to commercialize the innovation in a manner permitting the innovator to appropriate the value.

Incremental or process improvements involve substantially different "creation" and "exploitation" factors:

> Experience with incremental innovation indicates something very different. A potential marketable improvement to an existing product is quickly placed within a clearly defined time-tested process designed to prove or disprove its value to the corporation. The process, which typically encompasses six months to two years, has organizational sponsorship, funding, and the assignment of a development team. Development and commercialization are directed along a formal orderly stage-gate process.[122]

The exploitation factors for process improvements often involve the voluntary sharing of information relating to the innovation. It can occur through licensing, through informal technology consortia by firms offering complimentary products that may exhibit network effects. In such circumstances, the sharing of information strengthens the product offerings of a shared standard that competes against other platforms. Microsoft's sharing of information with its developer network is a good example of the kind of synergies that can be created through this form of voluntary sharing of information.[123] It also permits rivals to share the risk of developing new and breakthrough technologies,[124] or reduce the risk that rivals might steal a competitive march on each other.[125] Patent pooling is

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122 *Ibid.*

123 Baumol, *op cit.*, *supra*, note 14 at 25-6

124 *Ibid.*, at 33

125 Baumol, *op cit.*, *supra*, note 15 at 86: "Each firm stands ready to reveal technical information to the others, with the implied understanding that the others will reciprocate by providing it with information on the new technology they acquire in the future, technology whose nature is as yet likely to be unknown."

relatively common in the high technology industries.[126] The dissemination of information is said to occur more quickly than one might think. One study reported that "[i]nformaiton concerning development decisions is generally in the hands of rivals within about 12 to 18 months, on the average, and information containing the detailed nature and operation of a new product or process generally leaks out within about a year."[127]

There may well be more than two categories of innovative activity that can be distinguished. The point is that the "creation" and "exploitation" factors differ between these categories, and making the distinction is important to ensuring that appropriate policies are adopted for each kind of activity. Radical innovations require among other things, venture capital arrangements, incubator facilities, and access to public markets. Process improvements require other factors to facilitate the adoption process. It has been suggested that a research and development department within the arms-length receptor company is a contributing factor to technology transfer, in order to have the internal expertise to recognize the value of a particular innovation.[128]

The *Innovation Strategy* does not expressly make this distinction but the analysis it provides may be redefined in this manner. A number of factors are identified that might be considered "innovation creation" factors, as well as establish objective measures by which certain types of innovative activity might be identified. It stresses the importance of the regulatory environment, the educational system and the catalytic role that universities and other post-secondary institutions have in supporting the existence of

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126 *Ibid.,* at 89: "The contract, which normally runs over several years, entitles each firm to use the other firm's current patents in the field covered (the ex post component of the arrangement), as well as other patents issued later during the life of the contract (the ex ante component)… According to the supplier of this information, the reasons such cross-licensing contracts are felt to be important by IBM are that they "level the playing field," save wasteful costs such as outlays on reverse engineering or on inventing around patents of a rival, and enhance the firm's freedom of action by permitting it to introduce new products without fear that it wll be accused of infringing someone's patents."

127 *Ibid.,* at 83

128 Palda, *op cit., supra*, note 26 at 139

clusters. The indices identified include the number of patents, number of researches, and amount of R&D that is spent as a percentage of GDP. There is no discussion of "exploitation factors" which are those mechanisms that permit the innovator to capture and exploit the product of the innovative activity. The *Innovation Strategy* discusses the regulatory environment as well as the importance of clusters,[129] the need to increase venture capital[130] and further highlights the importance of capitalizing upon the financial aid given to universities:

> In return, universities need to focus on areas of excellence, train greater numbers of highly qualified people in the skills required by the private sector and government, and more aggressively seek out commercial applications for publicly funded research. Key commercialization performance outcomes should at least triple over the next decade. This will require the development of long-term innovation strategies, supported by stretch goals and targets. It will require clear intellectual property policies, and aggressive efforts to develop the technology transfer practitioners that are in short supply. Most important, it will require a serious commitment to ensuring that, whenever possible, Canadians benefit from the public investment in research. Universities need to be held more accountable for reporting on the benefits that accrue to Canadians from the very substantial annual public investments in research.[131]

There is no substantive discussion of what may be classified as either "creation" or "exploitation" factors, which is not surprising, given the nature of the *Innovation Strategy* which provides a general policy orientation without significant definition of the underlying strategies.

These factors should be considered from both a positive and negative perspective, as some factors promote as well as inhibit the "creation" and "exploitation" of innovation. They may include the legal regime, intellectual property regime, competition laws, as well as the structure of the industrial segment – competitive market, oligarchy, or

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129 *Innovation Strategy*, at 21, 30, 46, 55, 72-4, 76, 79, 88

130 *Innovation Strategy*, at 48-50, 53, 79, 84, 85

131 *Ibid.*, at 44

monopoly. An example of a negative factor with the potential to inhibit the exploitation of innovation is provided by the countervailing duty mechanism included in the *World Trade Organization Agreements*[132] and enshrined in domestic trade laws of the WTO member countries. These laws permit the United States to impose countervailing duties if a product subsidized by government is exported from Canada into the United States and causes injury to an industry there. Canadian government programs providing financial support for the development of technology are vulnerable to the imposition of countervailing duties by the United States in key industries, particular those in the high technology sectors.[133] For example, the Technology Partnerships Program[134] was determined to be a countervailable subsidy in the Aircraft from Brazil dispute.[135] Another example is provided by an initiative to attract a semiconductor chip processing plant to Quebec in 2000. Reports at the time indicated that the plant was to be heavily subsidized and it appears that no consideration was given to the vulnerability of such an investment to the imposition of countervailing duties. The investment did not proceed, but the proposal and the countervailing duty issue was highlighted in the Joint Report of the United States Trade Representative and Department of Commerce on Subsidies Enforcement, 2001.[136]

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132 *World Trade Organization Agreement on Subsidies and Countervailing Measures, ("SCM Agreement"),* April 15, 1994, Marrakesh Agreement Establishing the World Trade Organization The Legal Texts – The Results of the Uruguay Round of Multilateral Trade Negotiations 264 (1994)

133 Prof. J-G. Castel and C. M. Gastle , *op cit., supra*, note 113

134 The Technology Partnerships program was introduced in 1996 as "an effective, market-driven tool to stimulate the development and commercialization of technologies …[that] share[s] risk with private sector, participants, gain[s] royalties from successful projects and reinvest[s] these repayments to help support new initiatives." *Science and Technology for the New Century A Federal Strategy* Canadian Ministry of Supply and Services, March 11, 1996, at 13

135 An analysis of this dispute is provided in Professor Joseph D'Cruz and Dr. Charles M. Gastle, *Canada-Brazil Trade Relations: an Expedited Arbitral Mechanism may be required to resolve the WTO Aircraft from Brazil/Canada Dispute,* Estey Centre for Law and Economics in International Trade, February 7th, 2002, (available on-line at www.esteycentre.ca )

136 February, 2001, available on-line at http://ia.ita.doc.gov/esel/reports/seo2001/report2001.html

## *2.D DIFFUSION CHANNELS DEFINE THE INTERNATIONAL SYSTEM*

The internationalization of innovation spending demonstrates that linkages are being established between different clusters. These clusters may be existing or incipient, if the cluster is emerging either on its own or as a result of government sponsorship. These links are part of networks by which innovation is diffused through various industrial sectors. The pattern evident in the network includes the competitors within the market segment, but also the institutions that are engaged in the development of innovative activity. Collectively they will be referred to as innovation "actors." The competitive and regulatory environment in which they exist, including the intellectual property regime, shape these patterns. They are international in nature, because the flow of information cannot be confined by any border and it is these patterns of diffusion that represent the international innovation system for each particular market segment. The markets in which the goods or services are sold do not define the diffusion network. Marketing or sales strategies are simply part of the innovative activity undertaken by the actors in the market segment.

For each innovation actor, the diffusion network represents a way in which one's knowledge can be either shared with, or lost to, the other actors within the sector, or a channel through which knowledge can be obtained regarding innovative activity elsewhere. Information may be obtained with respect to radical innovations and the manner in which they are being commercialized. Information may also be obtained with respect to process improvements and the ways in which they might be accessed. The network might also represent a way in which to obtain "tacit" knowledge by identifying key individuals who might be hired, or actors with which a joint venture or other contractual relationship might be established.

By studying the diffusion network and the manner in which innovation occurs, one should be able to identify gaps that might exist within a national innovation system. It may show the kind of support that is provided by other national innovation systems that might be replicated within Canada. It may show whether commercialization takes place

through existing companies or by spin-off activities. If the latter, it will show the kind of institutions that were necessary to achieve the critical conditions necessary for successfully establishing a new entity. It could show the existence and utilization of technology incubators in the commercialization process, the linkages that exist with universities or technical institutes or other educational institutions. It might also identify institutions that might be accessible to help commercialize new Canadian technology, such as venture capital firms. Focusing on the diffusion network allows those who frame innovation policy to concentrate on the existing industrial structure, its strengths and weaknesses and on the local factors that promote (or inhibit) the creation and commercialization of technology.

One trend that should be of interest to those developing innovation policy is the growing role that innovation reconnaissance firms and intermediaries are either playing, or beginning to play, within the United States. A problem that has been identified is the lack of expertise that exists within companies to meaningfully undertake technology reconnaissance, or to find those who might be interested in commercializing a new technology. Companies are reported to go through three stages in pursuing innovation: reconnaissance, evaluation and investment. "Like many activities that involve talent and tacit learning, reconnaissance requires an inherent feel for the work and lots of practice."[137] Innovation can be trapped inside an institution because of an institutional inertia, the fact that it is not related to the company's core enterprise, or the time frame until an innovation pays off, is too far in the future.

Existing companies have been encouraged to develop radical innovation hubs – or a "distributed network of small nimble hubs"[138] - to deal with the special challenge of facilitating idea generation, recognition and evaluation. Informal, ad hoc systems are too sporadic and vulnerable to changes in circumstances including changes in the personnel. Radical innovation hubs involve the appointment of "gatherers" in each business unit and

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137 Christopher Meyer and Rudy Ruggles, *Trend Search Parties,* Harvard Business Review, August, 2002, at 14

138 Leifer, *op cit., supra,* note 12 at 185-6

such other departments as corporate research and development. They serve as "listening posts" or "opportunity hunters" who seek out ideas worthy of note. The hub can take different forms, including a venture capital group within the firm,[139] or a committee with direct access to top management. The function of the hub is to take the ideas, screen and evaluate them and build a business case for those that have the potential to make compelling business propositions.[140] They can then be handed over to project management teams that are supported by virtual venture capital funds within the corporate structure intended to fund the development of these business propositions, and decide whether the innovation is to be commercialized within the corporation's existing structure or spun out. Radical innovations can occur within the domains of the existing business units. It can occur in the "white spaces" between a company's existing business units, as well as outside of a firm's strategic context.[141] Innovation in the "white spaces" or outside of a firm's context is what creates new markets and represents the evolutionary nature of the economic process.[142] Nortel Networks' NetActive initiative is an example of a spin-out of an innovation that did not fit within the company's core competencies.[143]

There is a need to develop the "use of independent intermediaries to facilitate the exchange of sensitive information among companies."[144] A small group of firms is apparently emerging to take on the evaluation and the search for investment capital. It is projected that these companies will move beyond the industry in which they started and expand to other areas.[145] It has also been suggested that existing management consultants such as Accenture and Cap Gemini Ernst & Young operate innovation labs where ideas can be shared among clients. Firms such as Ideo and ISIS International have also acted as

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139 This is the Nortel Networks model in the form of the New Ventures Group

140 Leifer, *op cit., supra,* note 12 at 50-3

141 *Ibid.,* at 6-7, 136-7

142 *Ibid.*

143 *Ibid.,* at 140-1

144 *Ibid.,* at 81

145 *Ibid* .at 78

intermediaries.[146] Other strategies have also been developed to deal with the problem of recognizing the potential that an innovation actually represents. IBM launched alphaWorks, which is an Internet platform that permits downloading of software under development for consideration by computer "enthusiasts." Much like the open source movement, the results have been surprising with new applications for these programs being identified.[147]

The reconnaissance function is dealt with by other mechanisms elsewhere. In Japan, the *keiretsu* structure acts as the platform for both reconnaissance and exploration. In each of the Big Six *keiretsu* there are *soga shoshas* that help coordinate group activities through every aspect of commerce:

> A *sogo shosha* is like no other type of company. It is not defined by the products it handles or even by the particular services it performs, for it offers a broad and changing array of goods and functions. Its business goals are equally elusive, for maximization of profits from each transaction is clearly not the major goal, at either the operating or philosophical level ... Collectively they are the largest purchaser of U.S. exports in the world, accounting for 10 percent of our total overseas sales, 4 percent of world trade, and influencing the jobs and fortunes of tens of millions of people all over the world.[148]

The *shosha* procures raw materials and sells finished products throughout the world. They serve as the eyes and ears of their major clients providing them with global market information and analysis. They are an important entry point to the Japanese market and are "near the top of the ladder of the domestic distribution chain." They play an important financial role by providing credit to small and medium sized companies that the banks do not readily accommodate. Trade credit plays a much greater role in Japan with one study showing the average amount is twice the level in the United States. The *shohsa* receives

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146 *Ibid.,* at 82

147 *Ibid.*, at 82-3. "Within eight weeks, the once-ignored program had become a key IBM program … Launched six years ago, alphaWorks is still a staple of IBM's innovation agenda."

148 Kenichi Miyashita and David Russell, *Keiretsu Inside the Hidden Japanese Conglomerates*, McGraw-Hill Inc., 1994, at 54

its commission by providing insurance to the seller in case of default by the buyer. They operate on razor-thin margins with the largest *shosha,* Itocuhu, recording sales of $160 billion with a profit of only $80 million.[149]

The point is that an analysis of the entropic diffusion pattern or networks can provide important information relating to the kind of gaps that might exist within Canada's industrial structure. Apart from an underdeveloped venture capital system that is highlighted in the *Innovation Strategy,* consideration might be given to the role that innovation reconnaissance and exploration intermediaries might play in the innovation ecosystem. The role of technology incubators should be considered (even though they might have lost some of their allure after the bursting of the internet bubble). Technology consortia should also be considered and there should be a considerable body of data available in the United States based upon the performance of MCC and SEMATECH.[150] Canada might develop its own unique institution that permits the review of technologies in an environment protected by non-disclosure agreements and other arrangements to protect the value of the innovation. ITAC and other industry associations would have a role to play in facilitating such an arrangement by promoting a pool of companies who could review new technologies as well as identify innovators within the information sector who wish to submit technology to be evaluated.

This raises another and more profound issue, and that is the degree to which Canada should look beyond a national innovation policy to a regional or international one. The *Innovation Strategy* does not define its relationship to other national innovation policies or the manner in which it may attempt to integrate with them. The failure to do so gives rise to an inference, likely drawn in error, that Canada requires new technologies to be commercialized within Canada and that there is no benefit to technologies developed here being commercialized elsewhere. Canada is part of a North American innovation system,

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149 *Ibid.,* at 54

150 For example, see David Gibson and Everett Rogers, *R&D Collaboration on Trial,* Harvard Business School Press, 1994. The success of the consortia in the United States appears to have been quite modest and the initiatives have been either scaled back or, in some cases, abandoned. Nevertheless, the mechanism should be studied to learn from the success or failure thereof.

given its close relationship to the United States. Companies or institutions within the United States might well fill any gap that exists in the Canadian innovation system. It might be a source of venture capital funding if Canadian sources are unavailable. They have been and will continue to be necessary to establish links with innovation programs within the United States to facilitate the development of innovation channels within Canada.

The question arises whether Canada must develop a separate Innovation Policy that, in certain circumstances, minimizes contact with the United States, due to the risk of losing the benefits of innovations developed behind national borders. In the past, it has been suggested that Canadian companies have invested research and development funds in the United States, the inference being that the investment in the United States was at the expense of spending in Canada.[151] Research spending trends in the United States by foreign corporations were reviewed in an earlier article for the period 1981 to 1994 and the conclusion was reached that there was no evidence that supported the inference.[152] This study should be updated. The implications of integrating into a North American innovation system must be studied. The questions which must be answered include identifying the existing balance of research and development spending to confirm whether Canada remains a net exporter of research and development spending, assuming that a reasonable definition of what is "Canadian" and what is "foreign" can be established. If Canada is a net exporter, is this balance increasing or decreasing? Case studies should be undertaken to determine the degree to which Canadian technologies have been commercialized in the United States and what the implications were for Canada. Were operations maintained in Canada? Did the commercialization process improve innovation processes within Canada, even if some relocation occurred? It would also be instructive to determine the existing contacts between Canadian industries with clusters in the United States. The question arises whether these clusters are in fact North American in scope and neither "Canadian" nor "American". The question then arises as to whether strengthening the North American diamond is beneficial to Canada.

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151 This is discussed in Prof. J-G. Castel and C. M. Gastle, *op cit., supra,* note 113

152 *Ibid.*

This analysis may point to problems that currently exist in the relationship that might undermine the effectiveness of innovation efforts in Canada. For instance, ITAC reported in its report, *Towards a Culture of Innovation*:

> U.S. investors like Canadian innovations. But they don't like to have their capital spent outside of their direct scrutiny. Canadian entrepreneurs are frequently required to establish U.S. operations as a condition of investment. All too frequently, what starts out as a U.S. office quickly evolves into corporate headquarters. This results in jobs lost and a lost capacity for further innovations in Canada.[153]

The analysis to better understand the relationship between Canadian and American innovation efforts must be undertaken. It should point out areas in which Canada can effectively utilize institutions in the United States to help commercialize Canadian innovations, while realizing a contribution to Canadian productivity levels. ITAC should be in a position to help in undertaking this kind of survey.

153 *Towards a Culture of Innovation, op cit., supra,* note 90 at 6

*Case study*

*Positron - Going Global Makes Positron a Better Company*

The North American market leader in call taking solutions for the 911 emergency system market is based in Montréal. Positron produces a full product line of hardware, firmware and software for the public safety / emergency response market. It has installations of it's 911 systems in 2,500 cities and municipalities, primarily in the United States.

"We do business with all the regional Bell operating companies in the U.S.," said Positron President and CEO Reg Weiser. "In fact we consider the United States our domestic market." From this position of strength in North America, Positron has entered the European, South American and Asian markets.

Weiser says there are a number of reasons for entering new markets. One of them is to stay on top of current technology. "It used to be that North America gave you a solid vantage point on technology," he said. "But that is no longer the case. In order to be a player, you must be a player internationally. There are technologies being deployed in others parts of the world that are more progressive than some of what we see at home." By working actively in other markets, Positron is able to "crossfertilize", bringing new developments in world markets back to the company's R&D lab in Montréal.

Positron's research and development commitment is considerable – it employs 150 engineers (25 % of it's staff) investing about 15 per cent of gross sales in R&D. Positron keeps development in Canada because it has an excellent team of engineers here and because Canada's R&D tax credits make it attractive. It keeps manufacturing operations in Canada because of the skill sets and costs here.

Another reason Positron has expanded into global markets is for growth – both economic and "cultural." Being a North American market leader means a company must look abroad for expansion opportunities. As large as the U.S. market is, Weiser points out that "the world market is at least as significant."

Yet it is not just for revenue growth that Positron is testing itself around the world. Being an international force keeps Positron alive. "Being active in new markets is an insurance policy," Weiser says. "As you grow and succeed in one market, there's a risk of growing complacent. With this type of expansion you must be on your toes, so you retain your edge and protect your base. It makes us a better company."

While the central product development team is based in Canada, Weiser believes it is equally important to employ local teams in the markets Positron seeks to penetrate. "Market intelligence is of paramount importance. You have to design your products to surpass the present and future needs of the end user. To do that, you must thoroughly understand the characteristics of each new marketplace." In addition to the intelligence that Positron's sales and marketing teams collect, the company also benefits from an effective partnership strategy with international giants such as Nokia.

Though Weiser is firmly committed to success in the global market, he recognizes that is not an inexpensive strategy. "Marketing and sales expenses are much greater internationally than they are domestically and that is a barrier for many companies," he said. "R&D tax credits are a brilliant idea that clearly encourages research and development, resulting in a higher standard of living in Canada. If we want to encourage companies to enter new markets, why not look at refundable tax credits for international marketing and sales investments?"

## *CONCLUSION: ARTICULATING CANADA'S INTERNATIONAL INNOVATION STRATEGY*

The lack of discussion of the international context in which the development of innovation policy must occur, leaves much unanswered. The border is not irrelevant but it is of limited importance. Radical innovations provide qualitative, evolutionary changes in the economy, while process innovations provide methodical increases in economic efficiency that are the purview of steady research and development spending. Local research intensity is necessary in multi-nationals located within Canada to facilitate the adoption of technology. Innovation networks establishing channels of communication are international in nature and although influenced by national policies and the regulatory environment, will not be shut off by them. They define the competitive context, and they should be more easily subject to analysis than the process of creating radical innovations that exhibits a sensitive dependence on initial – and continuing - conditions. An analysis of the diffusion channels provides an opportunity to determine the gaps that exist in the Canadian innovation system. In particular, Canada needs to consider whether it need develop reconnaissance or exploration mechanisms. It also requires Canada to consider the degree to which establishing stronger innovation links with international innovation actors and, in particular, those within the United States, would improve the Canadian innovation system and result in greater upgrading of technology. Consideration should also be given to the coordination of the development of innovation policy within Canada. The Department of Foreign Affairs and International Trade should be directly involved as a partner in policy development, as well as the Export Development Corporation and other government institutions dealing with international policy issues.

The role of the Information Technology Association of Canada should be to provide a source of information regarding the process of innovation within the information technology sector in Canada, and the barriers that its innovators experience. It could also provide a valuable source of information regarding an important aspect of innovative activity within Canada – for example, information on research and development spending leading to the creation and adoption of process improvements. ITAC could also

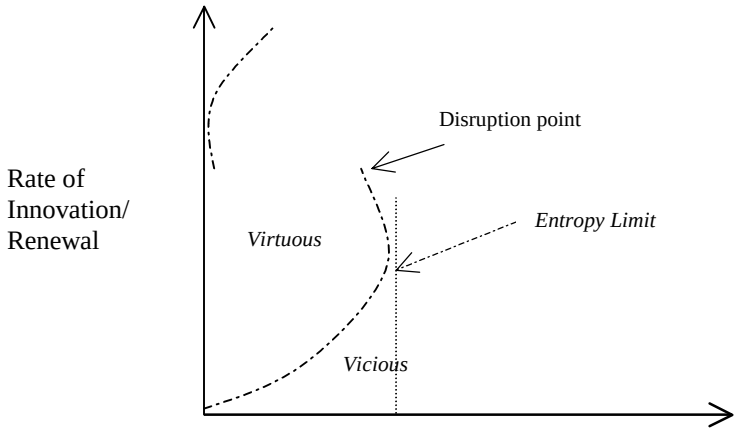
potentially provide an important focal point in developing innovation intermediaries. Its extensive contacts among the high technology industries could provide a showcase forum for technologies created in Canada to be commercialized, whether in Canada or elsewhere.

This points to an important research requirement to better understand what benefits accrue to the Canadian innovation system if innovations developed within Canadian borders are commercialized here or elsewhere. It is important to understand the freedom within which innovation policy can be developed. This policy will be structured differently if Canada receives sufficient benefit from the standpoint of productivity improvement, even in circumstances where commercialization occurs in the United States. ITAC could also identify circumstances in which innovations developed within Canadian borders are forced to the United States to secure venture capital financing. The identification of such problems allows a Canadian strategy to be developed to deal with any impediments.

Red Queen game or otherwise, the *Innovation Strategy* reflects an important commitment by the federal government. It is important that the international dimension of this strategy be fully developed to guide policy development when this framework guideline is supplemented with specific strategies and tactics.

## APPENDIX "A"
## THE INNOVATION/ENTROPY MATRIX

The matrix is a micro-economic phenomenon and must be constructed industry by industry.

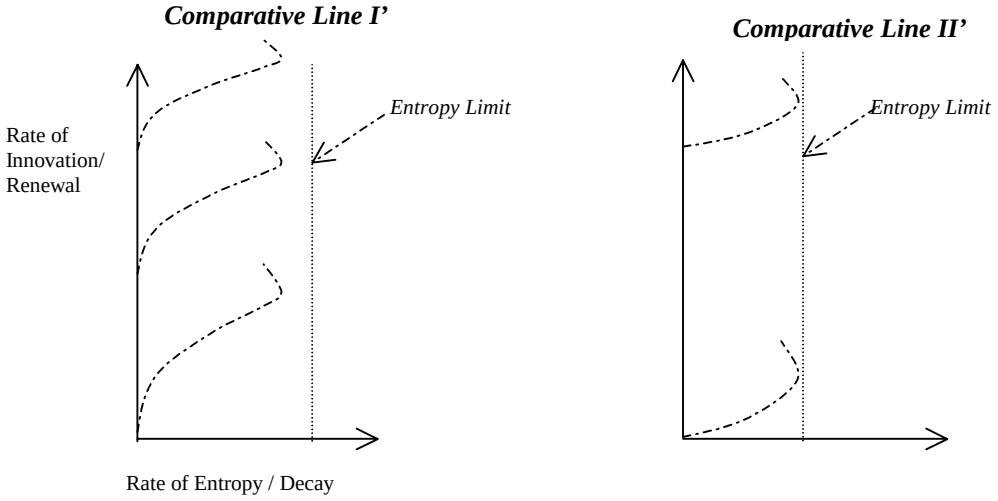



The matrix is restricted to existing products and their close substitutes. Therefore, it will apply to radical innovations, to the extent that these innovations displace existing products or services that perform a similar function. The rate of innovation and rate of entropy will depend on qualitative factors that are unique to that particular segment. The matrix for a particular market segment can be in a virtuous or vicious cycle or in a position of "comparative maintenance". Virtuous cycles exist when the rate of innovation is above the rate of entropy such that the economic system experiences renewal. Vicious cycles exist when the rate of entropy exceeds the rate of innovation so that the economic system decays. A position of "comparative maintenance" involves the rate of renewal being balanced against the rate of decay. The model suggests that there should be a limit to the rate of entropy that will exist in any industry. It also holds that the rate of innovation must increase to approach this limit. Eventually, the rate of innovation will start to change and disrupt the industrial sector and the rate of entropy should begin to reduce until a point is reached where the existing technology/business practices are fully disrupted and the industrial sector renews itself. The rate of entropy disappears, and does not begin to rise again until new market entrants challenge the new innovation and the cycle begins again.

This model is not intended to portray competition in a particular segment necessarily as a zero-sum game. The model is intended to capture the *relative competitive position* between competitors within a particular market segment, whether the particular market segment is experiencing positive growth or decline. The "disruption point" marks the introduction of a "radical innovation" that renews the market segment reflecting an

inflection point in the industrial segment in which it occurs. If the innovation spawns a whole new industry for which there are no close substitutes, the existing market continues its trajectory and a new industrial sector is created. In this sense, it is much like cell division within biology and helps model the biological/evolutionary nature of economic activity.


If there are close substitutes, or competitors begin to enter the market, the competitive advantage represented by the particular innovation begins to erode, especially due to the rate of dissemination of information. Innovation is required to maintain the advantage, and the angle of the comparative maintenance line depends upon the durability of the competitive advantage: the greater the vulnerability, the greater the rate of entropy that may occur (*Comparative Maintenance Line I'*). This shifts the entropy limit outwards and a higher degree of innovation will be required to maintain the competitive position, if the rate of innovation begins to increase. The increased innovative activity may suggest that a disruption point occur before the entropy limit is achieved and more than one disruption point may occur. The smaller the degree of vulnerability, the more limited the rate of entropy that is possible and the entropy limit shifts inward. A lower rate of innovation will be evident and the flatter the comparative maintenance line (*Comparative Maintenance line II'*).



Innovation in a market that is relatively immune to entropy or decay, results in a virtuous cycle in terms of strengthening a company's competitive position at a fairly low level of innovation. Strong intellectual property laws would be one element reducing the vulnerability of a firm's competitive position. Significant barriers to entry and/or a monopoly position would also decrease the margin of vulnerability. The ability to utilize international trade laws as a 'rent seeking' protectionist device would be another factor tending to reduce the vulnerability of a particular competitor, at least for the duration of the imposition of retaliatory duties. It will require a significant increase in the rate of innovation to break the industrial segment out of its existing pattern and renewing it through disruption.

Whatever the relationship, the analysis is not meant to suggest that companies that are in a vicious cycle will immediately be eliminated or that they will immediately sustain a sharp decrease in sales. Competitors will begin to lose market position such that, over time, a failure by competitors to respond by increasing the pace of innovation will result in the laggard facing an erosion of its market position and lost market share to the innovators within the market share and to those competitors that do respond.

It is not possible to develop a mathematical function describing the relationship as innovation itself represents a qualitative change in the market segment that tends to transform and change the market segment. As it is not possible to develop a mathematical function, it is not possible to mathematically accumulate the matrices from the various market segments into a national innovation matrix. It is possible to notionally consider a "Canadian matrix" on the basis of relative productivity performance, and the question arises whether Canada's entropy/innovation matrix has been virtuous or vicious over the past decade. In 2001, Michael Porter's study *Canada at the Crossroads*[154] was updated. Martin and Porter noted that Canada had successfully eliminated its yearly deficit that had been seen as an "insurmountable impediment to growth and capital formation."[155] The Canadian dollar, however, fell from 87 cents to 65 cents by mid-1999 and has fallen further since. They note that Canada's purchase power parity has fallen two places during the nine years, falling behind Denmark and Norway. They conclude:

> By 2000 two things have become clear: First, the roots of international competitiveness lie in the microeconomic fundamentals of an economy. Macro-economic factors play a role in creating the environment for competitiveness but are not sufficient to enhance prosperity. Second, international competitiveness results from firm level choices that produce distinctiveness, not from replicating the choices of other firms, regions or nations.

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154 Porter, *op cit., supra,* note 4. The earlier study undertook an analysis of the Canadian economy and gave policy prescriptions for Canada to upgrade its economy.

155 *Ibid.*

> In 1991, we characterized Canada as standing at a crossroads, facing a choice of whether to tackle serious weaknesses in its microeconomic fundamentals of competitiveness or accepting a lower standard of living. The past nine years show that Canada pursued the latter road.

Canada's lower standard of living relative to the United States tends to suggest that the matrix has been in a vicious cycle for the past decade. The *Innovation Strategy* itself states:

> Most of Canada's standard of living shortfall with respect to the United States is due to our markedly lower level of productivity. Canada's overall productivity level – measured in terms of GDP per hour worked – is about 19 percent lower than that of the United States. Productivity has grown significantly in Canada over the last number of years; *but the gap with the U.S. has continued to widen because we are not improving as fast.*[156]

The answer to the "virtuous/vicious" question depends on one's terms of reference in measuring the "rate" of innovation and entropy. Canada is in a virtuous cycle if the determination is to be made on the basis of absolute productivity levels. Canada is in a vicious cycle if the determination is to be made on the basis of the relative performance of the two nations with respect to either productivity or standard of living. The *Innovation Strategy* itself sets a number of goals, some of which are absolute in nature, but many are relative to other nations. For instance, the first target is to rank among the top five countries in terms of research and development. The third target is to rank among the world leaders in the share of private sector sales attributable to new innovations. The fourth target is to raise venture capital investment per capita to prevailing U.S. levels. The degree to which Canada measures its relative performance against other nations, the virtuous/vicious determination should be made on a similar basis.

The point is that "running harder to stand still," may mean maintaining Canada's existing position among developed nations and not seeing it deteriorate further.[157]

However, even if Canada is able to improve its ranking among nations, it may still be in a "vicious cycle". The economic process, in the form of pollution, such that it may be considered a measurement of "waste", creates the qualitative nature of entropy. It is also a measure by which "free" energy, evident in raw energy is converted to "bound" or spent energy. In this sense, a virtuous cycle would exist only if Canada was utilizing renewable resources or engaging in sustainable development. Nicholas Georgescu-Roegen argued in 1971 that economists failed to realize that the product of economic process is waste, in the form of pollution.

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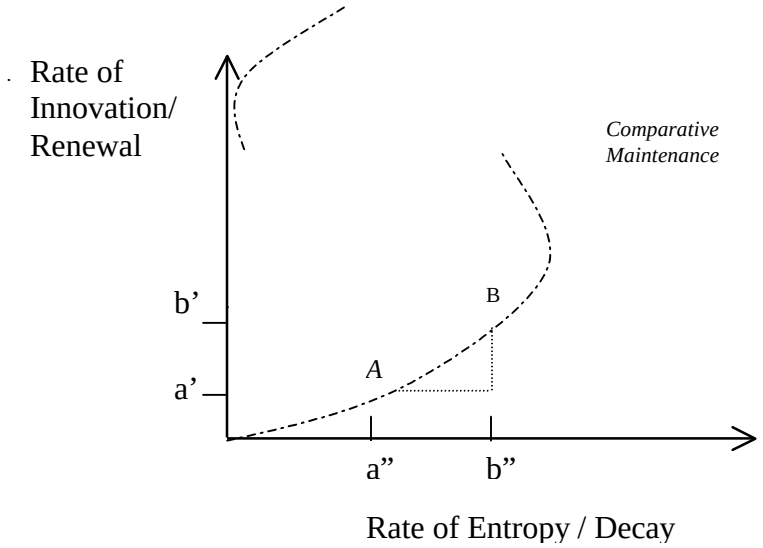
156 *Innovation Strategy*, at 14-15

157 Nicholas Georgescu-Roegen, *The Entropy Law and the Economic Process*, Harvard Univ Press, Cambridge, 1971, reprinted 1999, at 19.

An innovation paradox may exist in the form of a "Red Queen" game:




The *innovation paradox* involves an increase in the rate of innovation. The result is that a temporary competitive advantage is obtained, and the pre-existing technology position decays and the rate of decay increases. Competitors react by adopting the particular innovation and, as innovation becomes the norm, introducing additional innovation. The combined activity increases the rate of innovation from a' to b' and the rate of decay from a" to b". If the pattern of innovations maintains the relative competitive position, the parties move along the comparative maintenance line from A to B.

An innovation trap also may exist and this is a "north-south" issue. It is assumed that the developed nations have a greater capacity for innovation due to established educational systems as well as existing clusters. If "innovation is local," the developed world will have an advantage over the developing world that will likely not have an educational system of the same quality. It will have to develop clusters out of the branch plant manufacturing operations that globalize into the lower cost regions. The developing world may be at an "innovation" disadvantage. As a result, as the pace of innovation quickens in the developed world in both the high technology and even the more traditional industries, the developing world may not be able to match the same pace of innovation. Much like the worsening terms of trade argument,[158] there is a worsening terms of innovation. This depends, however, on the degree of technology transfer from the developed to the developing world and the quality thereof. This leads to a remarkable statistic.

> Yet one must not exaggerate the pervasiveness of dependence upon innovation as a primary tool of competition. There is strong evidence that the bulk of innovation is contributed by a few industries – the economy's

[158] Dennis Appelyard and Alfred Field, *International Economics*, Second Ed., Irwin, 1995, at 31-3

> 'high-tech" industries – and in a very small number of countries. "of the $500 billion (at purchasing power parity exchange rates) in estimated 1997 R&D expenditures for the 27 OECD countries, 85 percent is expended in just 7 countries … The United States accounts for roughly 43 percent of the OECD members' combined investments …."[159]

The question is whether the channels of technology transfer are sufficient to disseminate the new technology to maintain the balance of innovation. One implication of this potential innovation trap is that the developed world must permit the developing world to have market access to the mature industries in which they enjoy a competitive advantage as a result of their structure. Secondly, the developed world must be careful in imposing labour and environmental standards that hurt developing world competitiveness in the industries where they do have an advantage. Thirdly, the developed world has an obligation to ensure that adequate employee retraining programs are in place to transition workers out of those market segments in which the developing world has a comparative advantage. This is necessary to lessen protectionist pressures that will otherwise build to use antidumping and other trade remedies against imports from the developing world.

[159] Baumol, *op cit., supra*, note 14, 35

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